Exploring the Value of Integrating Green Innovations in Business

Report to the
WATER RESEARCH COMMISSION

by

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Executive summary

Background and Rationale

South Africa faces significant challenges related to water scarcity and poor quality in most of its water supply systems. The growing demand for water, coupled with the deteriorating state of water infrastructure, due to lack of adequate investments, poses significant risks to water users. The resultant risks for business, broadly speaking, can be classified as reputational, physical, regulatory, financial and governance risks. The experience of these risks however varies according to sector.

There is increasing recognition by businesses to reduce their water risks through interventions that help to green their operations and value chains in order to respond to the challenges they face. A strategic approach to managing water risk exposure also helps businesses to identify new opportunities and build long-term competitiveness.

Due to the fact that water poses a shared risk to business, the public sector and the general public, there is an opportunity to explore measures that promote action by business to create shared value. Green innovations provide an excellent opportunity to create shared value in the context of water management through promoting interventions that result in improved business performance and the broader landscape and socio-economic outcomes.

The purpose of this study was therefore to begin to explore the opportunities through which companies could create shared value, by effectively understanding their relationship with water and in turn invest in interventions that add value both to the business and to their broader stakeholders.

We envision this report being used by corporate organizations as a guide in assessing the water risks in their value chains and to consider possible interventions. We also envision the report being used, although to a lesser extent, by government to understand the context of water management in business, which in turn can inform policy.

Objectives

Against this background and rationale the project explored linkages between green innovations and aquatic ecosystem integrity and socio-economic development with a view to:

- Review the nature of green innovations and its application in driving corporate sustainability
- Evaluate the effects of green innovations on corporate performance and society
- Investigate the usefulness and appropriateness of metrics or indicators for green innovations
- Recommend specific green innovations that companies should consider to improve the triple bottom-line in South Africa

These objectives were achieved largely through developing a framework that helps better understand corporate water stewardship, and how that can be informed by green innovations in water. The framework is a useful starting point of understanding the effects of green innovations on corporate performance and the impact on the catchment conditions in which the operations of the company are located. However further research on water specific indicators of green innovation would enhance understanding around the impact of these innovations.

Methodology

This study used basic qualitative and quantitative metrics to conduct an analysis of the relationship between water users (business), the water situation (catchment dynamics) and the socio-economic and political context that influence decision-making in water management. The outcome of this analysis was a diagnostic framework that demonstrates the linkages between the various drivers of water risk for companies and green business innovations.

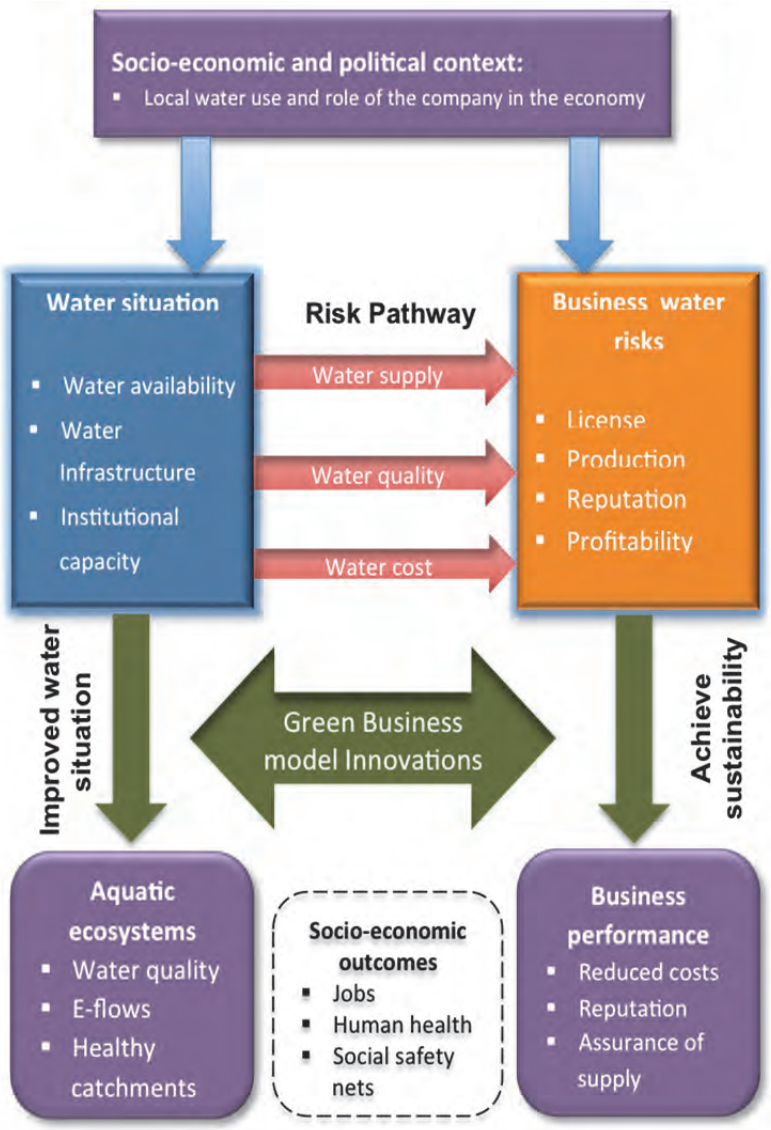
The framework was then tested against specific case studies of green innovations in South Africa as implemented by companies that are thought to provide leadership on water stewardship. The aim of the analysis was to find out the extent to which green innovations as implemented by companies were

strategic and took cognizance of the landscape factors that influence water risk, and socio-economic factors that influence water allocation at a catchment scale.

Results and Discussions

Diagnostic framework for linking aquatic ecosystem and green innovations

The framework below is an illustration of how the water situation in a particular catchment, coupled with the local socio-economic and political context could pose water related business risk to corporate entities. The water risk exposure has direct implications on business performance and aquatic integrity (see the figure below).



The framework acknowledges that water is a complex issue, with various dimensions ranging from the physical availability of water to institutional dynamics to interactions in company supply chains. This framework attempts to pull together these different dimensions to understand the links between green business model innovations with company performance, aquatic integrity and ultimately socio-economic outcomes.

The framework identifies the key pathways through which the external water situation poses water related business risks to companies. Socio-economic and political context has implications both on water situation and the vulnerability of business to water risks. This will in turn determine the responses that a company may undertake to mitigate its risks.
The key elements of the water situation are: (i) water availability, including its variability and quality associated with the use and management of water resources; (ii) the state of water infrastructure operations and development; and (iii) the capacity of institutions responsible for management or infrastructure.

The pathway through which the water situation poses business risks are related to water **supply**, **quality** and **costs**. In assessing these water related vulnerabilities, cognisance must be given to the water value chain, to develop a holistic understanding to respond to these risks through green business model innovations.

In addition to the water situation, the socio-economic and political context plays a key role in determining the vulnerability of business to water related risks. The socio-economic context in this case may relate to the specific location where a company operates, where conflict may arise in the use of local water resources. The perceived role of a company in the economy may impact on how water vulnerabilities may translate into risks for companies in the affected watershed.

The water risk pathways that could trigger a company to adopt green innovation measures to address their vulnerabilities are related to:

- The companies need for water in the right amount for their operations, any physical disruption could jeopardise their operations. The risk to supply is also associated with water quality, which could negatively impact **production** by increasing the cost of water treatment.
- Depending on how companies relate to water, when the water situation in a catchment becomes severe, businesses face a risk of water restrictions by the regulator, thus impacting their **licence** to operate.
- Companies operate in an environment where water is limited and thus competition is intense with other users, and businesses also have negative impacts on water resources. How companies relate to other users and their perceived impact on water could negatively impact on their **reputation.**
- Companies may face significant financial consequences in their attempt to address their water risk exposure such as the cost of treatment, which has direct implication on the **profitability** of companies.

Beyond the direct exposure of companies to water risks, companies with well-developed supply chains could potentially be impacted too. This has direct implication on green innovations. However, a company may use technological solutions in directly addressing water risks in their operations. In many cases such companies do not have control over their supply chains, which requires them to develop innovative non-technological mechanisms to enable them to work with their suppliers and other stakeholders.

This framework enables companies to strategically review their water situation and adopt green innovation measures that would enable them to improve their performance, while securing aquatic integrity and achieving broader socio-economic outcomes.

The nature of green innovations as undertaken by companies in South Africa

A comprehensive analysis of green innovations by six companies listed in the top 100 listed companies on the JSE was undertaken to review the extent to which the green innovations being implemented respond to the various factors as outlined in the diagnostic framework above.

In assessing the green innovation case studies, emphasis was placed on reviewing the linkage between the green innovation and the conditions of the catchment where the business operations are located, and the nature of the water risk being addressed. The analysis was based on publically available information, and through discussions with key informants who are conversant with issues of water risk management in South Africa.

The key outcomes from the review were that the nature of green innovations being implemented by companies was undertaken both for strategic reasons, and as a result of opportunities that they come across. For example companies, whose supply chains were explicitly linked to agriculture, were more likely to undertake innovations that were focused on addressing their water risk exposure in their supply chains. Companies that also use large amounts of water were more likely to adopt green innovation as a cost saving measure and to generally promote resource efficiency in their operations. For these types of companies, they mostly focused their interventions on operations as opposed to the broader landscape.

The green innovations by companies appeared to have been heavily influenced by the catchment conditions in which the operations of the company are located. For example, companies that are located in catchments that have recognised water quality challenges were more likely to focus on interventions that promote water quality. On the other hand companies that are located in catchments that were projected to experience a shortfall between water supply and demand were likely to prioritise interventions that focus on water use efficiency.

Indicators for measuring the nature of green innovations

In seeking to promote green innovations in water resource management and for engaging business, it is important to develop a good understanding of how to measure progress. The development of appropriate indicators is therefore important in informing the efficacy of the green innovations being promoted.

The development of specific water related indicators for measuring green innovations was beyond the scope of this project and we would therefore recommend in-depth research to further explore these indicators. Drawing from the diagnostic framework, these indicators would need to measure well-being not only in terms of business performance but also measurement of environmental (water situation) and socio-economic well-being.

In that regard the study set out to develop a general overview of green innovations, their application in corporate water sustainability strategies and understand the development of indicators in relation to the broader green economy. These green economy indicators explored in this report as a departure point for the development of water related indicators.

Approaches for promoting green innovations

This section illustrates some specific approaches of green innovations that South Africa should promote in order to achieve a higher level of investments in sustainable management of our water resources.

Circular Management: The concept of **circular** management aims to promote more efficient resource use, by encouraging firms to adopt cleaner production, recycle more of their water and cooperate with others (Giurco et al., 2014). The key drivers of circular management are the growing demand for raw materials, growing populations, increased waste generation including associated costs, and significant progress in the development of recycling technologies (Giurco et al., 2014).

Closed loop system: This approach involves the creation of products with no pollutant output and no waste where any materials used are recycled back into the system. **Supply chain management** involves green activities that

focus on upstream flow, cost reduction and innovation in raw materials, components, products and services (Henriksen et al., 2012). To achieve a green supply chain requires significant engagement outside of a company's 'factory' fence, by partnering with suppliers, local communities and environmental organizations, to help companies manage the risks associated with their supply chains.

Take back strategies: These are implemented downstream of the value chain, when companies interact with consumers to influence behavior in the use of their products. The focus here is for the producer to take responsibility in the management of their waste. The aim of tack-back strategies is to reduce the volume and toxicity of waste disposal, increasing recycling rates and prevention of pollution at the source.

Industrial symbioses: These are approaches that promote an integrated industrial economy, where industries cooperate with each other to optimally use available resources. The aim of industrial symbiosis is to reduce costs of operations and the associated environmental impacts. This can be achieved by leveraging resources such as materials, energy, water, capacity, expertise and assets among others.

In addition to the approaches above, below are some of the ways outlined in this research project of how businesses can manage their water footprint through the use of green innovations:

1. Supply augmentation through the use of efficient innovative technologies and infrastructure in a cost effective manner. Localized water enhancement technologies such as rainwater harvesting, storm water capture and small water reclamation provide useful strategies for water supply augmentation and resource planning.
2. Demand management entails the introduction of technologies or business strategies that promote water use efficiency, and conservation. Such technologies or business model innovations reduce the need for new supplies, increase reliability and decrease the cost of pollution control with wastewater control. Technologies that help to

improve demand management range from water efficient appliances to drip irrigation, to smart controllers. Behavior change in water resource management can be encouraged by technologies such as smart metering, for real time sense of water use.

3. Governance of water is important for securing access to reliable water supply and for reducing demand. There are technologies that can help to improve the overall water governance arrangements, which is a key requirement for strategic water management. Methodologies that promote advanced data collection and smart metering are examples of technologies that enable water utilities to accurately measure supply and track demand, identify leaks and other obstacles in their distribution channels

The kinds of technological innovations associated with these broad categories of water resource management principles are wide ranging, comprising of:

- **Smart Water**. These are technologies that focus primarily on improving water accounting and management, and address issues such as leak detection, smart water meters, Internet based water use – solutions and software.
- **Efficiency and conservation**. These are technologies that enable long term demand management in various sectors, such as irrigation sensors, low flow plumbing, and water efficient appliances
- **Purification.** These are technologies that are used to purify, filter, disinfect, and produce water of different quality for the benefit of users
- **Alternative sources.** These types of technologies enable water to be produced from alternative sources, examples include desalination, rainwater harvesting and storm water capture
- **Storage (surface and ground water).** These types of technological advancements focus on improving storage capacity above and below ground
- **Ground water technologies.** These are technologies that enable water infiltration and groundwater banking and recovery.

Recommendations for future research

Even though the business case for green innovation is relatively strong, very few companies are strategically implementing such interventions to mitigate their water risks. There is also lack of clarity in the decision making process of why certain green innovation approaches are adopted and not others. There seems to be also no clarity in terms of the potential impact of implementing a specific intervention both to business and the wider ecosystems.

The diagnostic framework developed in this project can be used by businesses to better understand their relationship with water. The diagnostic framework illustrates the links between the various factors that influence risks to companies and the role of green business innovation. The framework permits companies to strategically review their water situation (associated risks) and therefore adopt appropriate green innovations in order to improve performance and broader environmental and socio-economic well-being. However, various elements of the framework would need to be tested, and steps towards this have been taken.

The following steps are therefore recommended as a follow up to this research:

1. There is need to conduct more research into each element of the framework that links corporate performance and the type of green innovation adopted by companies, on the one hand and its implication on the broader landscape dynamics.
2. Measuring the impact of green innovations is to a large extent determined by well-defined metrics. Considering that there are no clearly measureable metrics for assessing the impact of green innovations, its recommended that a further study look into the opportunities of exploring the development of indicators.
3. From a technological perspective, the slow uptake of green innovations could partly be attributed to a poor pipeline of innovative concepts and products reaching the market place. There is a need to therefore conduct research on how to effectively commercialize or scale up green innovations for wider uptake.

4. There is a need to develop a better understanding of corporate decision making processes, including the interpretation of enterprise risk, to enable better understanding of how to mainstream green innovation tools and approaches in corporate South Africa.

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Abbreviations

AMD	Acid Mine Drainage
CSIR	Council for Scientific and Industrial Research
DWA	Department of Water Affairs
EBIT	Earnings Before Interest and Tax
EIO	Eco-Innovation Observatory
JSE	Johannesburg Stock Exchange
NBI	National Business Initiative
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
UN	United Nations
WEF	Well-being Economics Foundation
WRC	Water Research Commission
WRI	World Resource Institute
WWF	Worldwide Fund for Nature

1 Introduction

1.1 Project background

South Africa faces significant challenges related to water scarcity and poor quality in most of its water supply systems. The growing demand for water, coupled with the deteriorating state of water infrastructure, due to lack of adequate investments, poses significant risks to water users. The resultant risks for business, broadly speaking, can be classified as reputational, physical, regulatory, financial and governance risks. The experience of these risks however varies according to sector.

There is increasing recognition by businesses to reduce their water risks through interventions that help to green their operations and value chains in order to respond to the challenges they face. A strategic approach to managing water risk exposure also helps businesses to identify new opportunities and build long term competitiveness.

Due to the fact that water poses a shared risk to business, the public sector and the general public, there is an opportunity to explore measures that promote action by business to create shared value. Green innovations provide an excellent opportunity to create shared value in the context of water management through promoting interventions that result in improved business performance and the broader landscape and socio-economic outcomes.

The study is intended to inform key stakeholders, including corporate companies and government on the importance of green innovations and to provide a framework for the key stakeholders to engage each other. The specific objectives of the broader study, as conceived by WRC comprise the following:

- Review the nature of green innovations and its application in driving corporate sustainability
- To evaluate the effects of green innovations on corporate performance and society
- To investigate the usefulness and appropriateness of metrics or indicators for green innovations

- To recommend specific green innovations that companies should consider to improve the triple bottom-line in South Africa

1.2 Motivation for this study

There is wide acknowledgement that water scarcity and availability will pose a major threat to the global economy, people and ecosystems. The World Economic Forum (WEF) in its 2013 global risks report, identified water supply crisis as one of the most important risks faced by many countries globally (WEF, 2013). This is primarily linked to an increasing population and the impact of global change. For a water scarce country like South Africa, these additional stressors will exacerbate the situation.

South Africa is already projected to experience a shortfall of 17% in relation to disparity between water supply and demand (2030 Water Resources Group, 2009). This poses a major risk to all sectors of South Africa's economy, including business, local communities and the environment (WWF, 2011). The nature of the risks faced will vary according to the sectors, but broadly speaking water related risks can be classified as physical risks related to quantity and quality of water, regulatory risks, reputational risks, financial and governance risks. What is important to note is that water poses a shared risk, because water is a shared resource, and mitigating these risks will therefore require a shared response (Daniel & Sojamo, 2012; Pegram et al., 2009).

Green innovations are borne partly out of the need of corporate enterprises to mitigate their risks. Such innovations in many cases do not only provide a good opportunity for companies to mitigate their water risks both internally and in their supply chains, while at the same time securing the integrity of freshwater ecosystems, resulting in the of creation shared value (Daniel & Sojamo, 2012; Porter & Kramer, 2011).

Many corporate enterprises both globally and in South Africa have started to recognize that the sustainability of their business is dependent on well-functioning freshwater ecosystems and it is therefore in their interest to secure their protection. As a result there is an increasing attention by corporate enterprises directed towards

investment and participation in water resource management (UN CEO Water Mandate 2012). This form of engagement takes various shapes, including financial investment in water infrastructure and technologies, partnerships with local catchment management authorities and assessing water risks in their supply chains. All these different forms of engagement are motivated by the corporate enterprises' need to better understand and manage their water risks. It is also widely recognized that a major global transition is needed to secure the global economy, while protecting the climate and natural resources that are the foundation for future economic development (Henriksen et al., 2012).

As outlined above, corporate engagement in water policy has been increasing over the last couple of years. This presents an opportunity for collective action in the management of water resources through the deployment of green innovations. However, there has been no comprehensive study conducted in South Africa that explores corporate engagement in water management that considers measurable outcomes in terms of business performance and the integrity of broader landscape within which such businesses operate. This project will help to shed light on this important aspect, and hopefully help to inform policies and strategies geared towards promoting green innovations in the water sector.

1.3 Methodology

1.3.1 Scope of this research

Understanding the role of green innovations for socio-economic development and the integrity of aquatic ecosystems requires an understanding of the motivations of corporate engagement in water management, and the indicators for measuring the efficacy of green innovations. This context highlights some key questions that this study needs to explore:

Green innovations key question

- What are green innovations and how are they applied or implemented in corporate strategies?
- What is the linkage between green innovations and business performance?
- What potential indicators are used in assessing the effectiveness of green business model innovation?
- How can an enabling policy environment be created to facilitate the uptake and mainstreaming of green business model innovation?

This research will address the importance of green innovations, by building understanding on the evolution of green innovation, and how that has been informed by the current discourse on green growth. From a freshwater perspective, the review will look at how business model innovations adapted by businesses help to leverage broader watershed management and associate environmental outcomes.

This report is therefore structured as follows:
Chapter two focuses on the conceptual framework of green innovations, highlighting the role of these in the transition to a green economy for businesses. It discusses the implications that green innovations have on landscape water management issues. Green innovations refer to technological or non-technological interventions whose purpose is to either drive or mitigate negative environmental outcomes. Due to the global environmental challenges there is a collective understanding for the need to transition to a green development trajectory. This also recognizes the need for economic development however with an awareness of planetary limits. Chapter two further discusses how this can be achieved through greening the value chain and highlights the resultant benefits such as reduced production costs, improved productivity as well as improved well-being of people and the environment.

Chapter three focuses on business model innovations, as critical for achieving broader landscape environmental outcomes beyond business performance. This chapter sought to build understanding on the linkages between green water innovations and their link to building aquatic integrity and improving company

performance. In the attempt to demonstrate these linkages a diagnostic framework was developed that shows how the prevailing water situation, in concert with geographical location, socio-economic and political context, present a water risk to companies. The framework draws attention to the complexities that are inherent in water as a shared resource. For instance, businesses need to consider their water use in multi-user landscapes to manage their risks. The water related business risks that companies face range from social license to operate (defined by their relationships companies nurture with surrounding communities), to impact on profitability as a result of associated financial costs of mitigating water risks. Water related business risks are therefore used as a departure point to motivate for green innovations, which would ultimately enable the company to mitigate its water risks resulting in reduced costs, better reputation and assurance of supply. When companies engage in green innovations, there are direct implications on the integrity of aquatic ecosystems, as well as socio-economic outcomes.

We therefore presented case studies of businesses that use green innovations to manage their water risks to illustrate the framework discussed in the chapter. The case studies focused on the specific part of the business where the selected green innovation was being used, the water situation in the catchment area of operations, the risks that the innovation attempts to address and the broader socio-economic impact of these interventions. To enhance these insights on the risks in relation to geographical and socio-economic outcomes, interviews were conducted with selected six JSE listed companies. These companies were selected particularly because they participated in the CDP Water Disclosure Project between 2012-2014 and consented to their data being made publically available.

Chapter four investigates the nature of indicators and metrics required to measure progress towards the transition to a green economy. The chapter reviews the nature of innovations in the water sector that is required for the 3 dimensions of water management as illustrated in the diagnostic framework, namely; water supply, demand and governance. It also provides an overview of the emerging green economy indicators and metrics with the purpose of understanding the nature of parameters that is required to measure progress at a national level. In addition, the chapter focuses more specifically on approaches for measuring innovation with a

particular focus on green innovation. The chapter highlights the importance of a National Innovation Systems (NIS) in promoting innovations. The main shortfall identified in the metrics and indicators for measuring innovation is that it mostly focuses on technological innovations and in most cases and green innovations are not well considered. The final part of the chapter provides a brief list of proposed green innovation indicators that could potentially be used in measuring progress in South Africa.

Chapter five outlines the nature of green innovations that need to be promoted in South Africa that would result in building landscape resilience. To arrive at the proposed innovations, the chapter builds understanding on the concept of green innovations, and the motivation for companies to take up such innovations. The chapter also outlines the nature of indicators that would need to be adapted to measure the potential impact of such approaches.

Chapter 6 summarizes the report and suggests further recommendations on follow-up studies that could explore more around indicators in relation to the link between water system integrity and green innovations.

The purpose of this report is therefore to begin to explore corporate engagement with green innovations linked to water management to produce improved business, landscape and socio-economic outcomes. The overarching goal of the report is also to prompt further and more extensive inquiry into the activities that corporates engage in to manage their water risks for their supply chain and broader catchment area. We envision this report being used by corporate organizations as a guide is assessing the water risks in their value chains and to consider possible interventions as well as being used by government to understand the context of water management in business which in turn can inform policy.

2 An overview of green innovations and their application in corporate water sustainability strategies

The purpose of this chapter is to synthesize international experience and knowledge on green innovations by providing key definitions and outlining the global discourse through an extensive literature review around green innovations. What is the role of green innovations in transitioning to a green economy? What are the types of innovations and their benefits, barriers and opportunities for businesses? It is important to note that the chapter gives a general overview of green innovations as literature specific to water related innovations is limited. However, the chapter is particularly useful for corporate entities looking to understand the types of green innovations and the mechanisms available for greening their value and supply chains. It is also useful for the analysis of green business model innovation through the exploration of value creation and realization as well as the benefits resultant from enterprise and customer interface. This review in turn informed the subsequent assessments of green innovations in South Africa, and the development of recommendations for both the private sector on the nature of green innovations that should be promoted due to their significant benefits discussed in later chapters.

2.1 Conceptual framework for green innovations (Eco-innovation)

The term ‘green innovations’ is used here relative to business operations, where due to various factors companies have been forced to adopt more environmentally friendly measures to either curb their costs of production or to reduce their environmental footprint. The term green innovation is also closely linked to other terminologies such as green growth, green economy, ecological innovation, and sustainable innovation (Schiederig et al., 2011). Consequently, it is important to briefly describe some basic concepts that relate to green innovation, to provide some context.

2.2 The role of green innovations in the economy

There are various definitions of green economy, but the most comprehensive so far is that advanced by UNEP (2011), and is defined as an economy that results in improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities. The green economy concept was derived from the Brundtland Report in 1987 that defined sustainable development as

‘*development that meets the needs of the present without compromising the ability of future generations to meet their needs’.*

The green economy has emerged as an important concept for sustainable development. Also for businesses it emphasizes the issue of resource scarcity and the footprint of business operations on the environment, which are important for the future growth of companies (Henriksen et al., 2012).

The relationship between resource scarcity and economic growth is emphasized more under green growth, which is used inter-changeably in this report. Green growth is about maximizing economic opportunities under conditions of resource scarcity, to ensure that that there is continued economic growth within planetary limits. In many cases this requires a switch from a resource intensive production to a more efficient production system, in addition to using new technologies, services and markets (Henriksen, 2012). Business contribution to green growth is therefore through the efficient use of natural resources to ensure a smooth transition to a green economy. Green innovations can therefore be considered to facilitate this transition.

Participation in the green economy also offers competitive advantages to those countries that commit to policy innovations (Sarkar, 2013). There is a vast market for green products and services that countries could tap into that could help them drive the transition to a green economy. The key requirements for sustained economic growth include: high savings rates, investments in infrastructure and education, effective government, functional capital markets and a good environment for business among others. From a green economy perspective, setting up positive incentives can promote eco-friendly action (Sarkar, 2013).

In order to encourage green innovations, possible measures that could be implemented include the introduction of standards, increasing public sector demand and technology transfers (Sarkar, 2013).

2.3 What is green innovation?

Green innovation relates specifically to new changes that are aimed at having a specific environmental outcome or mitigation against a potential negative impact as a result. The OECD (2010, p10), defines eco-innovation as: "*Activities that produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air, soil, as well as problems related to waste, noise and ecosystems. This includes technologies, products, and services that reduce environmental risk and minimize pollution".*

2.4 Eco-Industry

The eco-industry is diverse with activities where industries or companies have products aimed at environmental protection. These include clean technologies, renewable energy, waste, biodiversity conservation, as well as urban rejuvenation related to building resilience to climate change and other related environmental drivers. Eco-industries are characterized by, but not limited to, the following activities in the economy:

- Air pollution control
- Solid and waste water management
- Renewable energy production
- Green buildings
- Biodiversity conservation

Eco-industries in general may comprise of sets of technologies, goods and services. These may be used to measure, control, restore and research environmental damages. These also include cleaner technologies that prevent or minimize pollution. In assessing eco-industries, it is important to review the lifecycle impact of the company in relation to its value chain and other aspects of the business, specifically in relation to whether such a business is squeezing out other green products (Henriksen et al., 2012). In this regard a business that markets itself as green if reviewed strictly in this lens, might not necessarily qualify as green.

2.4.1 Why are green innovations important?

Innovation is at the core of sustainable growth for most countries, to enable long term growth and sustaining of living conditions in the face of resource scarcity, environmental degradation and climate change. In order to ensure that living

conditions are maintained requires that these issues are addressed at the government, consumer and business level (Henriksen et al., 2012).

Due to the major global environmental challenges being faced, there is recognition for the need to transition to a green development trajectory, where economic development will be attained but at the same time protecting the climate and natural resources. The current path of growth is highly unsustainable, where estimates show that by 2050, we will need at least 3 planets to support the current consumption patterns (WWF, 2013).

Changes in consumption patterns are also mirrored closely with population growth, where it's estimated that by 2050, the world population will be at a staggering 9.6 billion. With that kind of population there are simply not enough resources on earth to support such a system.

Prices on energy, mineral and agricultural resources have also been increasing steadily over the last 10 years, driven largely by growth in demand due to the ever increasing population and consumption patterns. Even though it is not easy to predict future trends in such price increases, it is likely that these trends will be more volatile (Henriksen et al., 2012).

From a business perspective there is increasing recognition of the need to green their own operations and value chains to respond to the above challenges, but also because this could potentially provide new business opportunities, and build long term competitiveness. Businesses can improve their competitiveness by undertaking any one of the following measures:

- Substituting input materials with more environmentally friendly materials
- Focusing on selling green products
- Incorporating cradle-to-cradle production processes, that generate no-waste or products that can be fully integrated into recycle loops.

The transition to a green economy provides enormous business opportunities that forward thinking companies can take advantage of due to the creation of both new products and markets that can be exploited.

2.4.2 Types of green innovations

Resource efficiency and competitive advantage are the main drivers of green innovations for companies. These innovations could be technological or non-technological, and may require changes to the company's business model including products. These might be implemented inside or outside a company's operational boundaries. In general there are two main types of green innovations, namely product innovation and production process innovation.

- Green product or service innovation

The product process innovation is focused on the resource efficiency of a product that for instance consumes less energy, water and materials in general. For example a company that produces LED lighting can be regarded as having developed a green business product, because LEDs use less energy compared to other lighting systems.

A company may also supply green products, but which are in an intangible format such as providing training on greening business, or assess the ecological footprint of a business. Other services such as eco-tourism, help customers to have a reduced ecological footprint (Henriksen et al., 2012), and can thus be categorized as green products.

Some companies may have products that help other companies to be resource efficient, for example offering video conferencing facilities. Even though the product on offer might not have been produced using green environmental process, the fact that it helps customers to reduce their ecological footprint by reducing their travel enables such services to be categorized as green.

- Green production process innovation

Production process innovation is concerned with how goods and services are produced in an environmentally sustainable manner, by ensuring that business can limit their ecological footprint in the production process. This may involve a company installing water filters, air pipes, reducing waste by-products, or using less input materials.

- *Lifecycle models:*

This approach emphasizes a complete analysis of the value chain of a product, providing comprehensive insight into the lifecycle of a product. This enables the business to understand where most of the opportunities lay in greening its production process. Value chains can be greened using various approaches, including (Henriksen et al., 2012):

- Green supply chain management
- Cradle-to-cradle approaches
- Take-back arrangements
- Industrial symbiosis

It is important to emphasize that life cycle models are categorized according to their position in the value chain and the degree to which they are able to green the value chain. Green supply chain management is upstream of the value chain, cradle-to-cradle approaches are in the middle and take-back-arrangements are downstream of value chains.

- *Incentive models:*

This approach to greening business focuses on the company either retaining ownership of the product or the product is paid for by its functionality, for example a retrofitter is paid according to how much energy the customer is able to save from that process (Henriksen et al., 2012). The difference between incentive models and lifecycle models is based on the use of incentive schemes to motivate for good consumer behavior on one hand and on the other, business that would like to partake in the use of the specific green product.

2.4.3 Mechanisms for green innovations

When thinking about the range of green innovations that are of relevance in the context of water management, it is important to distinguish between three key mechanisms of innovations (OECD, 2012):

- *Incremental innovation* focuses on modifying existing frameworks or technologies to make the system more efficient in terms of resource use. Under this type of innovation, there is no change to the core technologies or business models that is undergoing innovation.

- *Disruptive innovation* seeks to fundamentally change how specific tasks are performed, without changing the underlying principles or technologies.
- *Systemic innovation* involves a complete shift in how goods and services are produced in an economy. In the water sector, an example of systemic innovation would be 100% shift into a recycling economy where every drop of wastewater is recycled. This type of innovation tends to be more complex and may involve various actors, and non-technological systems changes. In addition to new technologies, radical innovation may introduce new forms of production such as closed-loop production, industrial symbiosis to name a few.

These types of innovation do not necessarily occur in isolation or in a sequential nature. Often times a combination of these innovations are required to bring about systemic change. This is more pertinent in the environment sector, where the challenges faced are very complex and requires the involvement of various actors to bring about meaningful change. A good illustration of combining the different types of innovation is in the introduction of mass urban transport systems (OECD, 2012). Changes that are required may range from introduction of new control systems, changes to organizational practices, infrastructure, and environmental monitoring.

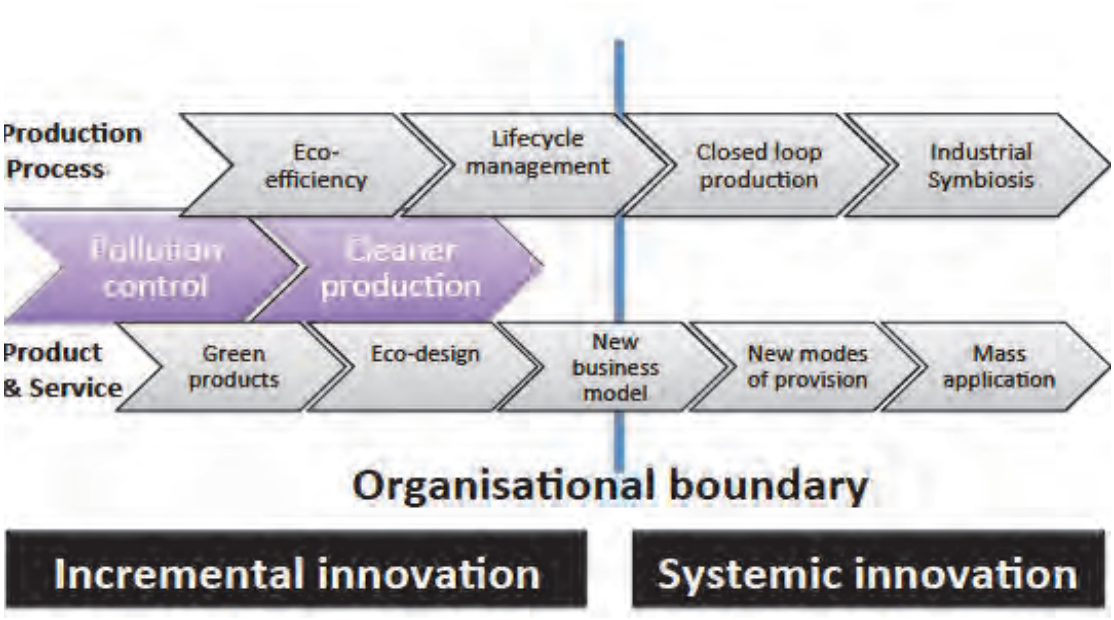

Figure 1: Incremental and systemic eco-innovations (OECD, 2010)

In relation to innovation at the company level that has both business related outcomes and broader landscape implications, a systemic approach to innovation is required (Fig. 1). Such systemic innovations may require engagement beyond the boundaries of one company to establish strategic partnerships, and address other drivers that are beyond the control of a single organization. As a result of its complex nature, systemic innovation may involve substantial risk to the actors, due to the complex arrangements that have to be dealt with including potential clashes between established and emergent points of view, redefining boundaries among others (Scrase et al., 2009).

In seeking to understand the role of green innovations in improving business performance and achieving broader landscape management outcomes, it is important to therefore focus on innovations that will bring about systemic change.

2.4.4 How is a value chain greened?

In addition to producing physical goods and services, companies can partake in greening their value chains, as part of the process innovation. Greening the value chain includes both activities that can be carried out inside the company operations and in their supply chains.

Depending on the stage in value chain different interventions can be applied. For example at the upstream of the value chain, companies can work in their supply chains and interventions here may include supply chain management and circular management (Fig. 2).

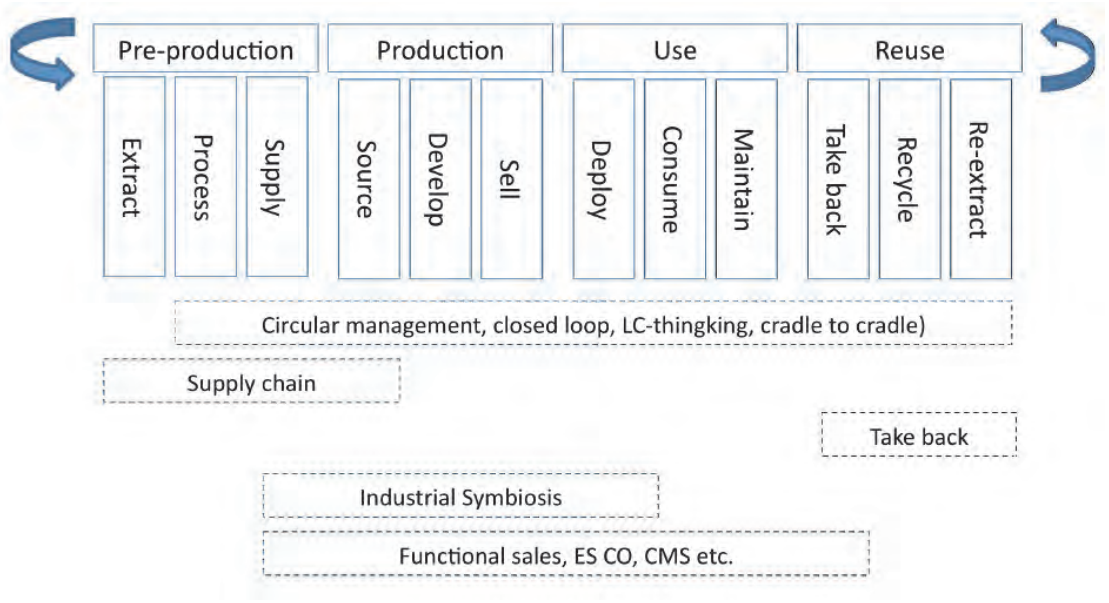

Figure 2: Greening the value chain of companies (The Danish Authority, 2012)

In the production and use stage, the greening interventions may include closed loop production, lifecycle models and functional sales. Downstream interventions with consumers, emphasis techniques such as take-back, which help in recycling used products.

2.4.5 Benefits of green innovations

Green innovations are important for reducing the cost of environmental risks, even though there is no guarantee that benefits will accrue from undertaking green innovations. When innovations results in environmental benefits it is referred to as absolute decoupling. On the other hand, relative decoupling refers to the deterioration in the quality of receiving media such as air, water and soil despite such innovations (Sarkar, 2013). There are numerous benefits that green innovations can achieve, as outlined below:

- Green innovations can produce direct benefits as a result of reduced cost due to improved productivity in the use of resources, and improved sales. Companies could also improve their reputation if they innovate, coupled with improved relationships with other stakeholders such as suppliers and authorities.
- From a social welfare perspective innovations can be beneficial if they result in improved wellbeing of people and the planet, not just economic benefits.

2.5 Green business model innovations and the implications on landscape management

This section will address green innovations in relation to the business models of companies, which is important in driving green innovations in general. Before delving into the nature of green business model innovations that are required, it is important to briefly discuss the concept of business models in general. According to Joller (2012), the term business model may be used to refer to anyone of the four categories below:

- Business model could be an explanation of how a company creates value for itself and its stakeholders
- In some cases a business model could be used to refer to a conceptual framework for current or future planned activities of a firm
- A business model could also be a theoretical layer between business strategy and actual processes in a firm
- A business model could be a tool for managing a company or an intangible asset for supporting strategic decision-making.

In relation to green innovations, the business model concept here is used in relation to value creation of a firm and its stakeholders. This is important because assessing green innovations requires a good understanding of the value proposition of the firm in relation to the tangible products and services that are being offered.

A business model is comprised of four critical elements, which include customer value proposition, profit formula, key resources and key processes (Johnson et al., 2008). These key elements when considered in concert help to create value both for the firm and its stakeholders (Joller, 2012).

2.6 Business case and factors that drive green innovations

The business case for green innovations is anchored on 4 key aspects that act as motivation, namely reduction in costs, opportunities to access new markets and customers, complying with regulations, and building resilience into their business models. For each stage in the value chain, there are specific environmental considerations that have to be taken into account, and a business case can be developed for each of those interventions. The business case for green innovations

is also closely linked to the factors that drive green innovations, which are attributable to market conditions, firm level characteristics and regulations (Fig. 3).

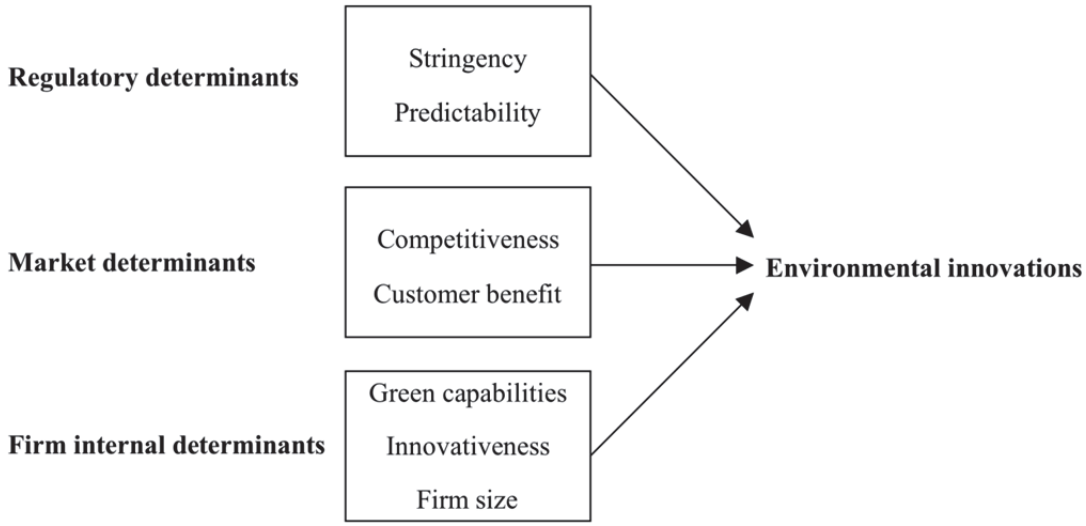

Figure 3: Key determinants of environmental innovations (Bermaeur et al., 2006)

2.6.1 Firm level factors

Green innovations afford companies opportunities to save on costs of input materials and waste management as a result of improved productivity. Approaches that promote cleaner production are increasingly being used to improve productivity. A key motivation for material efficiency is the spiraling costs of commodities, which has forced companies to rethink their approaches, to remain profitable.

There are various internal company factors that determine the effectiveness of green innovations. Company characteristics such as strategy, structure, and core capability are important determinants of green innovations. Company resources, both tangible (e.g. financial) and intangible (e.g. reputation) and linked to personnel (e.g. training) also help companies to effectively implement green innovations.

The competitive advantage of a company may be linked to its relationship with the environment, where companies can achieve reputation benefits from acting in a responsible manner (Bernauer et al., 2006). Key implications of companies' relations with the environment are defined by such issues as pollution prevention and product stewardship. These could also result in companies benefiting in terms of resource efficiency, and product differentiation.

From an innovation perspective, general commitment to innovations creates an enabling environment for research and development (R&D) that promotes the development of new products and services. Such companies commit significant amount of their internal resources for R&D, which is a good proxy for innovation.

2.6.2 New markets and customers

Green innovation products and services, affords companies the opportunity to exploit new markets and build a customer base. As environmental issues are increasingly being mainstreamed, companies that are forward thinking could benefit from a new crop of customers that have become aware of their footprint and would like to be associated with companies that embrace sustainability.

Market factors that drive green innovations are linked to technological development and demand factors (Bernauer et al., 2006). For green innovations, environmental benefits need to be combined with consumers' benefits for them to be effective. Benefits such as reduced energy costs (from implementing energy efficiency measures) product quality, health benefits are all critical for promoting green innovations in the market (Meffert & Kirchgeog, 1998). In general the existence of a competitive market and potential customer benefits in addition to environmental outcomes, are key in driving green innovations.

2.6.3 Complying with regulations

Due to the environmental challenges that many countries face and recognition of the need to protect natural capital, many countries have instituted regulations that companies are expected to adhere to. Such regulations often require stringent standards to be adhered to and as a result, companies are forced to institute internal measures that will make them become more resource efficient. Regulations are essential for enforcing companies to internalize external costs that could otherwise not be included in their operations.

Even though regulations may be perceived as a burden to companies, by increasing their costs of production, regulations also help companies to realize opportunities for investments in their operations that could have been neglected. Regulations force

industries to innovate and thus increase resource efficiency and productivity, leading ultimately to greater profits and sustainability of business operations (Table 1).

Table 1: Environmental considerations and business case for green innovation (EIO & CFSD, 2012)

Life-cycle stage	Environmental consideration	Business case
Resource extraction	• Reduce environmental pressures and impacts by limiting extraction of virgin resources and by limiting "unused" extraction	• Consider renewable and secondary resources (circular economy) • Reduce cost by improving efficiency of extraction • Comply with and anticipate new regulations • Improve your reputation CSR (Corporate Social Responsibility)
Manufacture	• Use fewer resources, including energy • Use materials with less environmental impacts (substitutes) • Produce less pollution and waste	• Reduce production costs by improving material and energy productivity and by material substitution • Build resilience to changes in commodity prices and resource supply • Increase your turnover and profits from sales of resource-efficient products and services • Comply with and anticipate new regulations (including eco-design)

Distribution	• Reduce impacts, for example through:
	  • Better packaging design, reuse, recycling
	  • Fuel and energy use reduction in transportation and storage
		• Cost reduction
		• Regulatory compliance

Use	• Use less resources, including materials, energy, land and water • Cause less pollution and waste	• Shift to selling services from products (i.e. functional sales, including product leasing and sharing) • Improve your reputation and customer relations • Comply with and anticipate new regulations
End of life	• Reduce impacts of waste disposal by decreasing the volume of waste or by improving the quality of waste	• Develop and sell novel products and materials from waste • Reduce costs by reusing, recovering or recycling resources from your own or external waste streams (e.g. industrial ecology, C2C (Cradle to Cradle)) • Comply with and anticipate new regulations

2.7 Components of a business model

According to Ekins (2010) the components of a business model for any product or process that delivers environment outcomes and business value, there are three distinct trajectories that could arise (Fig. 4). The first potential is that such a product or process delivers immediate environmental performance, secondly it could deliver both improved environmental and business performance, or it does not deliver any results at all (Joller, 2012). This is a very useful framework for reviewing the efficacy of green innovations, where some interventions that could be dubbed as green innovations actually deliver no tangible outcomes.

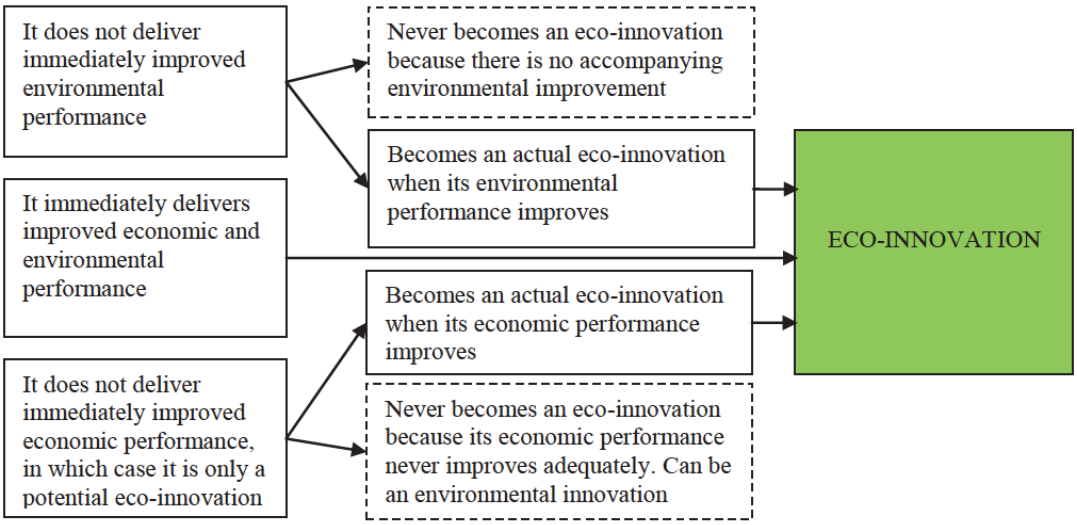

Figure 4: Possible eco-innovation trajectories (Joller, 2012)

2.8 Business model innovation

Green innovations in business models according to Joller (2012) could be regarded as a change in the rationale of how an organization offers value to its customers, while reducing their ecological footprint across the lifecycle of their products or value chains.

2.8.1 Types of green business model innovations

Green innovations could arise as a result of deliberate effort to achieve a specific environmental outcome or it could be an unintended outcome, for example measures that are intended at reducing the cost of waste management.

The approach to green innovations could also be technological or non-technological, and the impact can vary depending on the target. According to Machiba (2010), these can be placed in four distinct categories (Fig. 5):

1) Modification – such as small, progressive product and process adjustments.
2) Re-design – where significant changes are introduced into existing products, processes or organizational structure
3) Alternatives – Under this arrangement, new materials and goods are introduced, to replace those that are deemed unsustainable
4) Creation – this involves the design and introduction of entirely new products, processes, procedures and institutions.

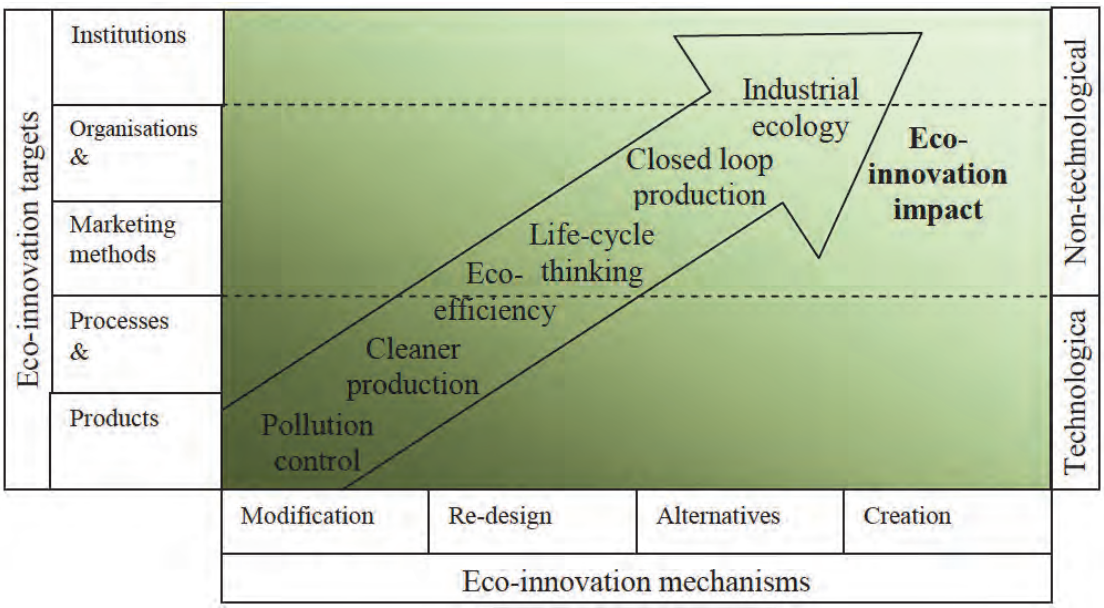

Figure 5: Sustainable manufacturing and eco-innovation conceptual relationship (Machiba, 2010)

2.8.2 Characteristics of the green business models

Green business models are defined to a large extent by the environmental benefits that accrue from such interventions. As a result significant amount of work has been done to research the benefits that have accrued, and although such green models were found to have positive environmental outcomes, these were often modest (Jing & Jiang, 2013).

2.8.2.1 Environmental benefits and sustainability

Some benefits that have been documented as a result of implementing a green business models include the following:

- Reduced energy and resource consumption and associated ecological outcomes
- Reduced CO_2 and chemical emissions into the air
- Reduced spills into water
- Reduced chemical waste and improved disposal
- Change in attitudes to sustainability

A good example of the impact of green business model innovation is through functional sales, where it was been estimated to reduce use by between 50-60%, which is very significant (Jing & Jiang, 2013).

2.8.2.2 Service oriented

Companies need to focus more on providing services to customers that go beyond the product and provide a service or function. In this way relationships between providers and customers will be strengthened and in turn incentivize companies to pay more attention to lifecycle costs, reduce energy consumption and emissions of greenhouse gases (Jing & Jiang, 2013). This however needs to be supported by policies that foster functional procurement.

Green services need to be mainstreamed as a key offering by business, which requires green business models to address issues such as the kind of product offering, showcasing how the product or service be transferred to customers and how value be captured (Jing & Jiang, 2013).

2.8.2.3 Non-technological innovations

Product and process innovations are technologically driven, however, other softer innovations such as marketing and organizational arrangements are mostly driven by non-technological changes.

Green business models act as the value creator for green innovations, and require companies to change from their traditional business models. This would enable companies to restructure their value chains, establish new relationships with customers, and change current consumption culture and use practice (Jing & Jiang, 2013). They are all changes that are non-technologically driven but are still fundamental in effectively implementing green innovations.

2.9 Framework for green business model innovation

This section summarizes a framework for green business model innovation (Jin & Jiang, 2012). The framework consists of four aspects that help to explain how green business value can be created taking into consideration, the customer interface, enterprise, and value realization (Fig. 6).

- Green value creation and realization

Green business value creation and realization are at the core of the green innovation business model. Value creation arises when resources and material use are reduced in the production process, with a positive impact on the environment.

The realization of green business values on the other hand requires companies to focus on the economic, social and environmental benefits simultaneously (Jing & Jiang, 2013). This requires companies to build channels that deliver value around customers' needs, and companies also need to ensure that in the process customer green consumption patterns can be induced. In terms of economic value, companies must be able to diversify their revenue streams through improved product sales and lease. More importantly companies must achieve the stated environmental and societal outcomes that innovation was purported to achieve (Jing & Jiang, 2013).

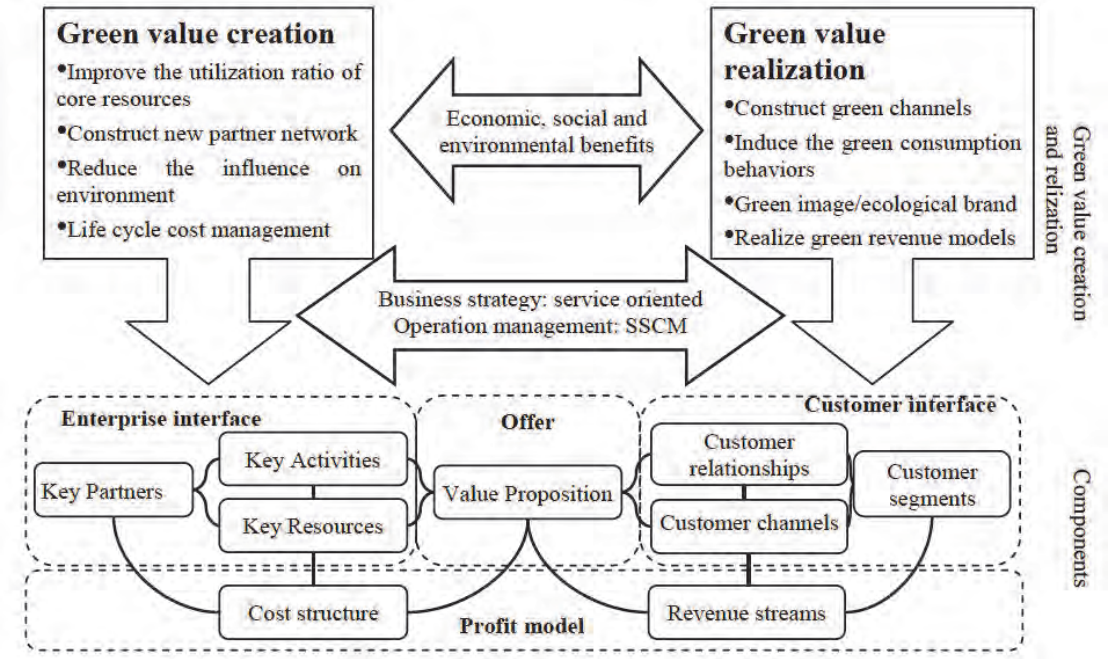

Figure 6: Framework for green business model (Jing & Jiang, 2013)

- Enterprise and customer interface

The enterprise interface is concerned with activities that are organized at the firm level that can help to create value based on the marketing offering of the firm. Key activities in the enterprise interface include the production of tangible products and services, the innovation of core technologies. Strategic partnerships are also established at the enterprise interface, which may include a reconstruction of the traditional partners network (Jing & Jiang, 2013). Many companies have developed partnerships with an environmental organization to help them navigate environmental issues that they have the least experience in addressing, in this way they can tap into existing resources to enable them to innovate.

The customer interphase comprises of customer segments, channels and relations. In the customer segment for example, green value proposition could be marketed to existing customers, while in customer channels new approaches could be developed to reduce waste during the delivery of a product or service. In terms of customer relationships, the green business model can help to improve relationships due to the new value offering resulting in increased customer loyalty (Jing & Jiang, 2013).

- Market offering and profit model

Value proposition to the customer and enterprise are critical for any green business model, and could be behind the viability of any product. The value proposition to customers can be distinguished into economic, environment and social benefits. As stated in earlier parts of this report, to create value it is important to demonstrate the economic benefits to customers. Reduction in cost is at the core of demonstrating value to customers, by developing products that are of high quality and durability resulting in cost reduction overtime. In service-oriented offerings such as functional sales, customers may also benefit by not spending money on the initial cost of investment. Environmental benefits include improved waste management that could have positive health implications. From a social perspective, benefits include improved quality of life, and portraying a green image.

In relation to a profit model, which is key for any green business model, important considerations including a good understanding of the potential cost structure and revenue streams is required. Customers have potential of reducing their costs due to the fact that life cycle cost management could be achieved.

2.9.1 Barriers to green business model innovation

Implementing a green business model is fraught with challenges and barriers that need to be well understood. In a comprehensive survey with companies implementing green business model innovations, Henriksen et al., 2012 identified the following barriers to green business model innovation:

- Lack of knowledge and skills through the value chains, for example in production, sometimes employees may lack knowledge on what substances

are available inside recycled parts, which can have implications on productivity. When new materials or technologies are introduced, employees may not be knowledgeable in their use.

- Further down the value chain, marketing and sales teams may lack knowledge on how to sell sustainable products or services and in many cases suppliers do not understand the new green business models.

2.9.2 The role of policy in fostering green innovations

The role of government is important in creating an enabling environment for green innovations to thrive. National policies that focus on promoting energy and resource efficiency and encourage companies to review their business models and strategies are important. For example the boost in industrial symbiosis in Japan has been considered as a result of the legal framework that the government established to boost the recycling economy (OECD, 2012).

Regulatory stability and certainty is also regarded as an important aspect in catalyzing green innovations. This is because such innovations can be quite expensive and for companies to realize the inherent opportunities requires a clear regulatory framework and positive market signals.

In addition to enabling national policies, water is essentially a local issue as a result companies need to establish strategic local partnerships whether at the level of Municipalities or catchment management authorities. Consequently local government authorities must operate in a manner that encourages participation by the private sector as they seek to implement innovations that have implications on the wider landscape.

Trends in business model innovations show that it is young companies that are at the forefront of promoting these innovations, which has implications on policies that seek to promote entrepreneurship. Making radical changes in established companies can often be difficult, so creating a policy landscape that allows small companies to grow will be critical for the implementation of radical innovation. New and small companies are also responsible for creating job opportunities, creating an enabling policy environment will therefore give rise to multiple outcomes.

As new business models and innovations emerge, governments will also need to determine whether creating specific policies to support such innovations will be necessary or they will be left to market forces to determine their success.

2.10 State of innovation in the water sector

Innovation frontiers in the water sector can be categorized into three main types that seek to enhance water supply, manage water demand, and improve the governance of the scarce resource.

2.10.1 Supply enhancement

Supply augmentation has been the traditional strategy for meeting demand, which remains an important aspect of water management in South Africa. However, the cost of new water infrastructure can be prohibitive, and in many respects there is need for innovative technologies that help to augment supply in a more cost effective manner.

Due to the energy intensive nature of water supply, energy efficiency is a major factor in the cost of transporting water; as a result technologies that promote energy efficiency are an important aspect of water supply enhancement strategies. Localized water enhancement technologies such as rainwater harvesting, storm water capture and small water reclamation provide useful strategies for water resource planning.

2.10.2 Demand management

Due to shift in water management from supply enhancement to demand management, there is need for technologies that promote water use efficiency, and conservation. Such technologies reduce the need for new supplies, increase reliability and decrease the cost of pollution control with wastewater control.

Technologies that help to improve demand management range from water efficient appliances to drip irrigation, to smart controllers. Behavior change in water resource management can be encouraged by technologies such as smart metering, for real time sense of water use.

2.10.3 Governance

Water governance is extremely important for securing access to reliable water supply and for reducing demand. There are technologies that can help to improve the overall water governance arrangements, which is a key requirement for strategic water management. Methodologies that promote advanced data collection and smart metering are examples of technologies that enable water utilities to accurately measure supply and track demand, identify leaks and other obstacles in their distribution channels

The kinds of technological innovations associated with these broad categories of water resource management principles are wide ranging, comprising of:

- **Smart Water**. These are technologies that focus primarily on improving water accounting and management, and address issues such as leak detection, smart water meters, Internet based water use – solutions and software.
- **Efficiency and conservation**. These are technologies that enable long term demand management in various sectors, such as irrigation sensors, low flow plumbing, and water efficient appliances
- **Purification.** These are technologies that are used to purify, filter, disinfect, and produce water of different quality for the benefit of users
- **Alternative sources.** These types of technologies enable water to be produced from alternative sources, examples include desalination, rainwater harvesting and storm water capture
- **Storage (surface and ground water).** These types of technological advancement focus on improving storage capacity above and below ground
- **Ground water.** These are technologies that enable water infiltration and groundwater banking and recovery

It is important to note that innovation in the water sector is linked to specific markets with each of these markets having played a pivotal role in promoting innovation. For example, various water user groups such as industry, residential, commercial and agricultural, have played an important role in promoting some type of water related technological innovation. As a result technological innovations related to water also closely mirror the sectors concerned, for example desalination and water purification has been pushed by sectors such as food and beverage, pharmaceutical.

Residential consumers on the hand have helped to promote innovation in water efficient appliances.

It is clear from the above examples that there have been significant developments in water innovations. However, progress in adopting some of these innovations has been relatively slow in many aspects, and measuring the impact of these innovations has also been quite difficult. In this chapter, we review the approaches for measuring progress in innovation in the water sector, specifically focusing on indicators and metrics for assessing innovation.

2.11 Overview of green growth indicators

Measuring progress in the transition to a green economy is very important; therefore the development of metrics and indicators is an important part of the discourse. In South Africa not much work has been done around the development of green economy indicators that are relevant to the local context. The Council for Scientific and Industrial Research (CSIR) has done some preliminary studies but the country as a whole is still very far from developing indicators for green economy that can be widely adopted. The South Africa green economy modeling report (UNEP, 2013), which modeled the impact of green economy on various sectors of the economy, has been the closest attempt made at trying to measure progress in the transition to a green economy.

3 Diagnostic framework for understanding the linkages between green innovations and business performance

This chapter focuses on the framework that outlines the links between green innovations, water resource integrity and socio-economic development. The link between water related green innovations and socio-economic outcomes can be explained by understanding how corporate water use is linked to prevailing water situation and the existing socio-economic and political context. Case studies of 5 JSE listed companies were used to demonstrate the diagnostic framework, illustrating the link between drivers of water risk and green innovation in business.

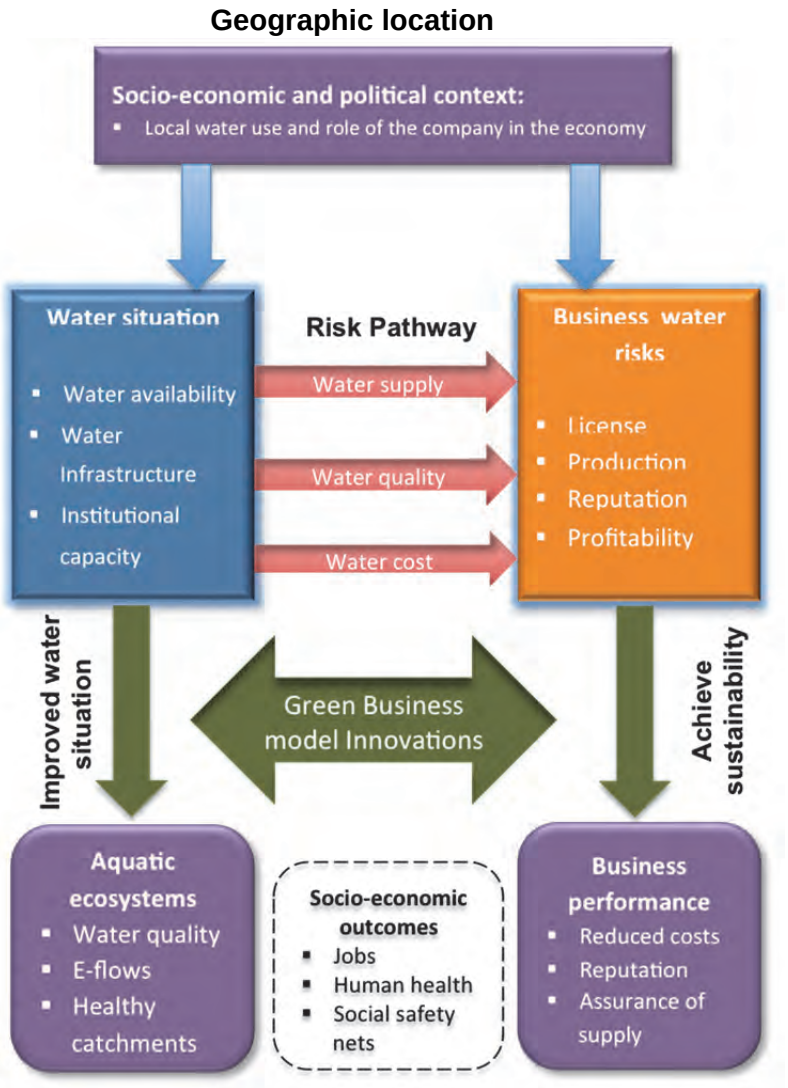

Figure 7: Framework linking green innovations and aquatic ecosystem integrity

The framework for linking green innovations and aquatic integrity (Fig. 7) acknowledges that water is a complex issue, with various dimensions ranging from the physical availability of water, institutional dynamics to interactions in company supply chains which are significantly shaped and impacted by the geographical location. This framework attempts to pull together these different dimensions to understand the link between green business model innovations company performance, aquatic integrity and ultimately socio-economic outcomes.

The framework identifies the key pathways through which the external water situation poses water related business risks to companies. Socio-economic and political context has implications both on water situation and the vulnerability of business to water risks. This will in turn determine the responses that a company may undertake to mitigate its risks.

The key elements of the water situation are: (i) water availability, including its variability and quality associated with the use and management of water resources; (ii) the state of water infrastructure operations and development; and (iii) the capacity of institutions responsible for management or infrastructure.

The pathway through which the water situation poses business risks are related to water **supply**, **quality** and **costs**. In assessing these water related vulnerabilities, cognisance must be given to the water value chain, to develop a holistic understanding of how to respond to these risks through green business model innovations.

Figure 8: Schematic representation of water value chain associated with a business operation

In addition to the water situation, the socio-economic and political context plays a key role in determining the vulnerability of business to water related risks. The socio-economic context in this case may relate to the specific location where a company

operates, where conflict may arise in the use of local water resources. The perceived role of a company in the economy may impact on how water vulnerabilities may translate into risks for companies in the affected watershed.

The water risk pathways that could trigger a company to adopt green innovation measures to address their vulnerabilities are related to:

- Companies need water in the right amount for their operations, and any physical disruption could jeopardise their operations. The risk to supply is also associated with water quality, which could negatively impact **production** by increasing the cost of water treatment.
- Depending on how companies relate to water, when the water situation in a catchment becomes severe, businesses face a risk of water restrictions by the regulator, thus impacting their **licence** to operate.
- Companies operate in an environment where water is limited and thus competition is intense with other users, and businesses also have negative impact on water resources. How companies relate to other users and their perceived impact on water could negatively impact on their **reputation.**
- Companies may face significant financial consequences in their attempt to address their water risk exposure such as the cost of treatment, which has direct implication on **profitability** of companies.

Beyond the direct exposure of companies to water risks, companies with well-developed supply chains could potentially be impacted too. This has direct implication on green innovations, whereas a company may use technological solutions in directly addressing water risks in their operations, in many cases such companies do not have control on their supply chains, which requires them to develop innovative non-technological mechanisms to enable them to work with their suppliers and other stakeholders.

3.1 Understanding water risk pathways

As mentioned earlier the vulnerability of a company to water risk manifests in different ways as highlighted in the above framework (Fig. 8).

3.1.1 Water supply

Vulnerability around water supply is primarily linked to the physical availability of water resources and the reliability of supply. Water supply disruption may be as a result of infrastructure failure, or a result of long-term water stress, which may lead to water restrictions during drought. Future allocations could also pose a risk to a company in the form of legal license constraints. Although the physical consequences of water disruption or supply reduction are similar, the manifestation of the risk as well as the measures a company takes to mitigate these risks differs.

- **Infrastructure failure** results in temporary disruption of supply (i.e. for hours or days), due to inadequate infrastructure (beyond design capacity), poor infrastructure maintenance or a failure event (such as flood damage or pipe-burst). The duration of disruption depends upon the physical robustness of the system (i.e. spare storage or distribution capacity) and the institutional capacity of the service provider to respond to emergencies.
- **Supply restriction** results in a reduction in supply (typically between 10% and 30%) over a period of weeks or months, due to drought linked with inadequate assurance of supply to meet the system demands. The level and duration of restrictions depends on the system assurance of supply, the severity of the drought and the options for system demand management (other users).
- **Future availability** may result in more stringent license conditions or future supply restrictions, due to inadequate infrastructure being developed or over-allocation of (competition for) the available water. This may be as a result of reallocation of water resources, or competition on water supply. Municipalities have preference in allocation, but poor planning may create future problems in assurance of supply.

Water supply disruption may result in production disruption (operational risk), where inadequate water is available for operations, or may result in changing license conditions or public perceptions about a company's water use in the longer-term (strategic risk), requiring further water efficiency or even curtailment of growth prospects. Both of these have financial consequences, either in lost production or in implementing internal company process design (response) options to mitigate their impacts on production and sales.

3.1.2 Water quality

Vulnerability around water quality has the dual dimensions of intake water quality and effluent quality. Both of these relate to the water quality of the water resources, as well as the reliability of the potable or wastewater treatment infrastructure in the water services system. The manifestation of risk to a company is quite different for these aspects of the water quality pathway.

- **Intake quality** may result in product quality deterioration or even disruption or production (if it exceeds a threshold), and is due to catchment water quality deterioration (typically associated with upstream development) compounded by inadequate potable treatment. The magnitude of the concern relates to the level and control of upstream development and discharge (which may be exacerbated by background water quality), as well as the physical capacity of the treatment works and institutional capacity of the service provider.
- **Effluent quality** contributes to downstream catchment water quality deterioration, and is largely related to inadequate municipal wastewater treatment.

3.1.3 Water costs

Vulnerability around water costs relates to both supply and effluent. These are a combination of water resources management charges, infrastructure charge and water services tariffs along the water supply value chain. Water costs may be estimated differently for these two elements and may be associated with different catchments and infrastructure systems, but they both have a direct consequence for the input costs of production.

- **Industrial supply tariffs** are expected to increase in the large urban centers over the next couple of decades as increasing municipal demands require development of more expensive infrastructure, rehabilitation requirements increase and cross-subsidization is expanded.
- **Trade effluent tariffs** are expected to increase in the larger urban centers as municipal treatment works are upgraded to meet increasing sewerage loads, discharge standards are enforced for municipalities, and the waste discharge charge system is implemented in selected catchment.

Water costs have a direct impact on profitability (EBIT). While these costs are typically a relatively small portion of total input costs, they are likely to increase at above inflation in many urban areas. Increasing costs may alternatively prompt the adoption of internal process options to reduce water requirements or effluent load.

3.2 Company performance/business case for green innovations

The business case for green innovations is anchored on 4 key aspects that act as motivation, namely reduction in costs, opportunities to access new markets and customers, and complying with regulations, and building resilience into their business models. For each stage in the value chain, there are specific environmental considerations that have to be taken into account, and a business case can be developed for each of those interventions. The business case for green innovations is also closely linked to the factors that drive green innovations, which are attributable to market conditions, firm level characteristics and regulations.

3.3 Link between green business model innovations and the integrity of water resources

Green business model innovation can have a significant impact on water resources. Technical innovations can enhance the security of water, for instance, membrane technologies improve the quality of water that exits a business' value chain. Non-technological innovations can reduce the cost of maintaining water integrity; security and can prevent future burdens within a catchment area. For instance, businesses within a catchment can share risks in relation to water management, thereby reducing individual costs and increasing effort of maintaining the integrity of the shared resource.

4 Review of selected green innovation case studies in South Africa

4.1 Introduction to case studies

The six companies selected as case studies illustrate how the diagnostic framework could be used to review the efficacy of green innovations by companies in South Africa. The case studies paid particular attention to the:

- Water situation in the catchment of operation – what is the water is quality and quantity? What are the characteristics of other water users in the area?
- Risks faced by the businesses – reputational, production, profitability, license.
- Green intervention and risk it addresses
- Impact on business performance, environmental and socio-economic outcomes.

The methodology of in this chapter was based on a content analysis of various reports ranging from company annual reports, sustainability reports and web-based content. This is in addition to conventional literature review on some of the key background issues outlined in chapter two. We also captured data from selected interviews with key experts on the issues, and representatives of companies, some of whose case studies are presented here.

The primary criterion used to identify the companies was based on their influence as part of the top 100 companies listed on the JSE. The six companies reviewed in this report were also identified to ensure a representative coverage on a sectoral basis, to highlight the challenges unique to different catchment areas in South Africa and how these impact water risk management for businesses. These companies also demonstrated some form of leadership in water management practices by the use of green interventions to manage their water footprint. They also participated in the CDP Water Disclosure Project, between 2012-2014, and have consented to their data being made publically available.

4.2 SASOL's Anaerobic membrane bioreactor technology (AnMBR) to improve water quality

Overview of SASOL and operational areas

SASOL, an energy and chemicals company in South Africa produces liquid fuels from coal, natural oil and gas reserves. They also refine crude oil and sell the liquid fuel through their network of 406 Sasol and Exel service stations.

Water is a major concern to SASOL, because they require adequate supplies in the right quality to run their operations, which primarily focus on generating steam and other cooling processes.

SASOL's operations occur in the Upper Vaal Water Management Area (WMA) which is essential to sustaining the water needs of the Gauteng Province and surrounding areas which house the most important economic hub in the country. In addition to sustaining the water needs of Gauteng, mining and agriculture are other major activities in the WMA. Large areas of irrigation are located in the tributary catchment of the Vaal River receiving water from different sources such as farm dams, large storage dams at varying levels of quantity and quality. Agricultural land in the south and east is predominantly used for the commercial production of wheat and maize. Aside from the commercial use of the dams in this region, some dams such as the Vaal are used for recreational purposes. Large municipalities in the region also draw water from this catchment for domestic use. Mine dewatering/decanting and urban effluent waste influences the quality of the water within the tributaries of the catchment as well as downstream of the Vaal Barrage (DWA, 2011c).

Although the catchment has low levels of rainfall in comparison to other parts of the country it has the highest concentration of urban, industrial, mining and power generation development in South Africa (CSIR, 2010). The emphasis on water management in this region is therefore the imbalance between the available supply and continued growing demand.

Business water risks

Given the number of competitors for water in this catchment area and the water situation, SASOL faces business risks linked to production, profitability, reputation and operating licence. Sasol's production process itself generates significant amount of effluent that poses significant risks to downstream stakeholders and the ecosystem in general. As a result a significant number of their green innovations are concerned with recycling processes to minimize the risk of pollution in catchments where they operate.

SASOL has a complex value chain that extends beyond their operations to urban settlements (fuels, chemicals), agriculture (fertilisers) and mining (explosives) (NBI, 2014**).**

SASOL has a water management strategy that is based on a risk assessment approach, to identify priorities for intervention. Through this assessment approach in 2013-2014, Sasol saved 4, 76 million cubic metres of water, with an economic value of approximately R26 million (SASOL SDR, 2014). According to the SASOL Sustainable Development Report (2014) during the same period, a total of 114 000 households and 94 schools had been visited to repair multiple leaks. Limiting these leaks has resulted in water conservation improvements equating to the equivalent use of 16 000 households, or 22% of the Sasolburg facility's annual raw water needs (Sasol SDR, 2014).

SASOL's green innovation

SASOL uses innovative water risk assessment tools, the most recent being the WRI Aqueduct in conjunction with other national processes. The water strategy is reviewed every year to ensure that it aligns with the prevailing water situation and meets SASOL's goals.

The green innovation being highlighted in this case study is a recent project which involves the deployment of a new technology, referred to as anaerobic membrane bioreactor technology (AnMBR). This technology, which is under development, will help to clean wastewater and also produce biogas as a by-product. AnMBR uses

anaerobic micro-organisms, which thrive in oxygen deficient environments such as sediment at the bottom of lakes, dams and oceans. Unlike traditional treatment technologies which make use of aerobic micro-organisms to convert the organic effluent matter (particularly gas to liquid and coal-to-liquid) into carbon dioxide, the AnMBR enables organic matter to be converted to methane-rich biogas, a very useful energy source. The AnMBR also poses a significant reduction in waste of up to 80% less when compared to other traditional approaches.

Link between innovation and socio-economic and aquatic integrity

The Vaal Water Management Area is characterized by several industrial activities which also provide jobs and significant corporate social investment in communities for millions of Rands per annum offering an important social safety net. However, as mentioned above, these intense activities place tremendous pressure in the Upper Vaal WMA compromising aquatic integrity due to high levels of pollution from effluent in the mining and agriculture sectors as well as the waste from poorly treated waste water in the large municipalities. The AnMBR waste reduction of up to 80% may be small when considering the complex intersections of waste producers in the region however any reduction of waste in the WMA is important to improving the quality of water in the area and working towards creating a healthy catchment area in relation to the environment and people. From a green innovation perspective, while the AnMBR has been used in other waste water streams, Sasol will be the first to do so in a gas-to-liquid environment offering improved business efficiency, competitive advantage (in terms of investor environmental consciousness) with an overall improvement in business performance.

4.3 Farming for the future (Woolworths) to improve water efficiency use

Overview of Woolworths and its operational context

Woolworths is a retail company that is listed on the JSE Limited. It owns a retail chain of stores that focus on clothing, homeware, beauty and food among others. Woolworth's business model is strongly focused on sustainability. According to Woolworths' report on the CDP Water Disclosure, they recognize the significance of promoting environmental sustainability, as exemplified in their sustainability strategy dubbed the Good Business Journey.

Water forms a key focus of the Good Business Journey and encompasses operational targets, engagement with suppliers and engagement in public policy around water across the country South Africa is already a water stressed country with significant economic development and social upliftment challenges. Water availability is one of the most important factors that will affect the socio-politico-economic and environmental well-being of the country. The country's WMAs face high levels of degradation, pollution, demographic pressure and poverty in the majority of the catchment areas which are also affected by climate change and variability (Methner, 2012).

Business water risks

Woolworths' water use encompasses their operations, which includes their head office, distribution centers and stores for sanitation, cleaning and occasional irrigation (NBI, 2014). They have used strategies such as grey water treatment, recycling projects and a water treatment plant at their headquarters. The operational water use accounts for direct water risks that the company faces. Indirect exposure to water risk is associated with Woolworth's food business where more than 95% of their foods are sourced from South Africa. Considering the significant water constraints the country faces, the risk to Woolworths through its supply chains is therefore significant.

Woolworth's green water innovation

The farming for the future program is one of Woolworth's most innovative interventions that was designed to address the water risks in their supply chains, by working with farmers who supply the company. This program was designed to improve farming practices for those farmers who are not certified to produce organic foods.

The intervention involves implementing new farming methods, such as well-scheduled irrigation, which has already resulted in significant water savings and reduced runoff of chemicals into water resources within the catchment areas of business operation.

The development of this program was guided by a technical committee, which comprised of staff from Woolworths, buyers, suppliers, and scientists (**King and Thobela, 2014).** The key priority areas that the program sought to address included:

- Soil management (soil chemical composition, soul nutrient status, fertilization practices, soil carbon content, soil cover)
- Irrigation water management (calculation of irrigation requirements, measurement of soil moisture, water use efficiency, water chemical composition, water health)
- Environmental legal requirements
- Biodiversity management
- Waste and wastewater management (farm waste, agri-industry waste, hazardous waste, process waste water, sewage waste)
- Cooling and energy (measurement of energy and refrigerant used)

Link between Woolworth's innovation and aquatic integrity

From a green innovation perspective, Woolworths is one of the very few companies in South Africa, whose entire business model is framed around green value creation, and also targets a customer segment that is conscious about environmental issues. As a result focusing on delivering green innovations for such a company is critical as it is the basis under which the business has been model.

The focus on supply chains, and catchment wide interventions by Woolworths also presents one of the very good examples of where company interventions have broader implications beyond their own operations. In this case Woolworths derives value both from using such interventions as a currency to consolidate its niche in the market and also to achieve broader conservation goals that go beyond their own needs.

4.4 TOYOTA's water capturing and recycling for water efficiency and optimisation

Overview of Toyota and operational area

Toyota is one of the largest auto companies in South Africa, and is a significant water user, with most of their water use being attributed to manufacturing, especially in the process of painting the cars.

The area in which the bulk of its operations occurs in the Mvoti to Umzimkulu WMA, which consists of two large river systems, have been largely modified by human activities, mainly intensive agriculture, forestry and urban settlements (DWA, 2012). The WMA has about 10.6 million people with the majority living in rural low density areas (DWA, 2012). 54% of the WMA population lives in rural areas and are predominantly women and children (DWA, 2012) which poses challenges in terms of access to resources. Global insight poverty indicators (2005) showed that 5,3 million people (about 50% of the population) lived in poverty with 1,2 million people living on less than $1 per day (in DWA, 2012).

The major industries in this region include mining, forestry, consumer discretionary and fertilizer manufacturing. Coal mining occurs in the area and is exported via Richards Bay. The second largest industrial complex is the Durban-Pietermaritzburg complex in the south (DWA, 2012). Products such as machinery, leather, basic steel and non-ferrous metals are being produced. Other products include sugar, timber, and oil 10 refinery processing. According to the DWA (2012) the manufacturing sector is the largest economic contributor within the WMA. Durban-Pinetown is the largest commercial complex within the WMA with the concentration of banking, insurance and financial institutions predominantly in the Durban area. This sector comprises 20% of the overall economic contribution of the WMA. Commercial agriculture and forestry is located across the WMA and contributes 4% to the overall economy within the WMA. Sugar cane and forestry feed the manufacturing sector in Durban to produce sugar and timber. Other agricultural goods include beef and dairy farming, citrus fruits, nuts and vegetables. Overall, the WMA contributes 17% to the country's GVA (gross value added) and has the third lowest per capita income nationally, only R24 650. This is due to high unemployment and the large number of people living in poverty.

Due to the high rainfall within the area, the area is conducive to large-scale agriculture. This includes sugar cane, especially along the coast, along with dairy, vegetables, nuts and other crops. The WMA also has rain dependent subsistence farming, especially in the inland rural communities. The effects of climate change anticipated across the WMA will especially affect these communities. According to the KZN Provincial Planning Commission (2011), climate change will increase

weather variability, the frequency of extreme events and will thus significantly impact agriculture.

Toyota's water innovation

Over the last 4 years Toyota has made significant progress in reducing their water use by about 8%, through a combination of water efficiency and optimization projects.

The company has also promoted water efficiency through their dealers, by installing water tanks for water recycling water for car wash and capturing rainwater. The water recycling systems capture water and use a process of electrolysis to purify the water for reuse in car wash. The water recycling system is powered by solar power and can store up to 20,000 liters of water per water tank. Some dealers have installed up to 5 tanks, which allows them to wash cars for up to 200 days without relying on rain or other sources of water.

Link between Toyota's innovation, socio-economic and aquatic integrity

Considering the demographics of the population in the area who are largely reliant on subsistence farming (and therefore a consistent supply of water), with high levels of unemployment as well as the competition for water from other water intensive industries, Toyota has to be conscious of its water foot print as well as their economic investment. This impacts the social operating license and reputation that the business could have in turn shaping its profitability and performance. Due to the various industries from agriculture, mining, manufacturing, as well as the large municipalities in the WMA, there is significant competition for water resources. The supply of water is therefore often considered a great risk and misuse of the resource could lead to the compromise of aquatic ecosystems and threaten the availability of water for the surrounding communities. The green innovation outlined above therefore assists Toyota in achieving reduction in water use bearing in mind the WMA situation, improved business performance with reduced production costs and better reputation due to their awareness and actions to reduce their water footprints.

4.5 UNILEVER's Traceability of supply chains

Overview of Unilever

Unilever South Africa is a subsidiary of Unilever, which a multinational company headquartered in Rotterdam and London. Its products line includes food, beverages, cleaning agents and personal care products. In South Africa, Sunlight is Unilever's biggest selling brand, and others include OMO, Lux, Lipton, Ola and Knorr among others.

Unilever's sustainability is guided by its Sustainable Living Plan, which defines their key sustainability goals, which comprise of i) improving health and wellbeing, ii) Reducing environmental impact, iii) enhancing livelihoods. Under the Sustainable living Plan, key strategies for water management are also defined, which states that:

a) Use and recharge rates of water sources for irrigation must be assessed using the best available information to check the sustainability of the source.
b) Rainwater harvesting techniques (such as contour bunding) and drain design **should** be used to maximise water retention in the field and minimise run off.
c) Water harvesting operations **must** be monitored to check they do not adversely affect downstream users, including areas of high biodiversity value.
d) Understanding water catchments/watershed impacts is complex, but the business **should** discuss whether water supply or quality issues exist within the local community *(for example with other farmers, businesses, suppliers, village representatives, Water Boards, Environmental Agencies)*.

What is their green water innovation?

The example of green innovation being reviewed here is the newly built Unilever Factory outside Durban that manufactures some of their products sold under the brand names, Aromat, Knorr, Knorox, Raja and Robertson.

This factory was commissioned in 2011 and is Unilever's 2nd largest plant out of 250 worldwide. The factory is also one of the first factories in Unilever's fold, to be operated on comprehensive green technologies that harness both energy and water use. In relation to energy efficiency, the plant uses the concept of 'zoned lighting', to

reduce its electricity consumption. Heat loads in the plant are reduced by innovative insulation approaches to minimize the use of air conditioners.

In terms of water management, rain is collected from its 22,000 m^2 roof and channeled into a 1.5 million liter tank for treatment and then recycled. Extensive smart water efficiency technologies have been adopted, resulting in the recovery of 70% of water. This has major implications on water resources; it reduces the burden of depending on local Municipalities for water supply.

In addition to rainwater harvesting, and in-house treatment, they also capture and treat condensed water from the air conditioning system and use it to clean toilets. Reverse osmosis and a biological process is used to recycle the process water as well as shower water.

- *Sunflower oil*

Traceability of supply chain is a key sustainability strategy that has been adopted by Unilever, and in that regard the company has been working with one of its suppliers to effect the same. In this case a farming community was identified in Limpopo, to pilot a project that develops hybrid seeds with higher yields. In this way, the goal is for Unilever to be able to produce oil that can be traced right back to the individual farm. In this way consumers can be assured that the products they consume are from sustainable sources. This in turn puts responsibility on the individual farmers to stick to their sustainability practices, with major implications on water management at the local level.

Link between Unilever's innovation and aquatic integrity

Even though the green innovation outlined above only focuses on the operational side, Unilever's water management strategy is embedded within a broader strategy that seeks to double the company's size and business without increasing its environmental footprint. The second example of promoting traceability of sunflower oil also helps to embed sustainable farming practices at the farm level, with major implications on water management at the catchment level. Unilever's associated catchment area challenges are similar to that of Toyota in that there are high levels of unemployment and a largely rural demographic which is dependent on subsistence farming for survival, therefore the water use in the region and the

economic contribution made by the company needs to be cognizant of the socio-economic context. This inherently impacts the social operating license and reputation that the business could have in turn shaping its profitability. Furthermore, due to the various industries from agriculture, mining, manufacturing, as well as the semi-arid conditions found in the Limpopo region, there is significant competition for water resources.

The supply of water is therefore often significantly lower than the demand which could lead to the compromise of aquatic ecosystems in reference to water quality and maintenance of healthy catchments. The green innovation outlined above therefore assists Unilever in achieving improved business performance with reduced production costs and better reputation due to their awareness and actions to reduce their water footprints.

4.6 SAB Ltd.'s Sustainable Barley farming

Overview of SAB's barley farming

South African Breweries (SAB) Ltd is the subsidiary company of SABMiller, which is one of the world's largest brewers of beer by volume. SAB Ltd is South Africa's leading distributor of beer and soft drinks. SAB Ltd operates seven breweries and 40 depots in South Africa with an annual brewing capacity of 3.1 billion litres.

Considering the amount of beer brewed, water is definitely a key issue for SAB and poses numerous risks given South Africa's water scarcity challenges. SAB's sustainable development vision is "a resilient world where our business, local communities and ecosystems share uninterrupted access to safe, clean water". This is in recognition of the growing water scarcity, as a result of climate and demographic change, and changes in consumption patterns.

For this case study we look at SAB's operations in the Gouritz WMA. The Gouritz (WMA) comprises the Goukou and Duiwenhoks, Gouritz and Garden Route rivers. The Gouritz River which is the main river within the WMA originates in the Great Karoo and enters the Indian Ocean at Gouritzmond. Land-use in the area consists largely of farming (sheep and ostrich) in the arid Great Karoo, extensive irrigation of agricultural land (lucerne, grapes and deciduous fruit) in the Little Karoo, and

forestry, tourism and petrochemical industries in the coastal belt (State of the Rivers Report, 2007). Indigenous forests, wetlands, lakes and estuaries of high conservation status are found in the wetter south eastern portion of the WMA (State of the Rivers Report, 2007). According to the State of the Rivers Report upper areas of the Gouritz River in the Great Karoo are mostly in a good ecological state, while the middle and lower reaches are in a fair to poor ecological condition due to the extensive agricultural activities and urban development. Invasive alien plants and fish have had a major impact on the biodiversity and ecological functioning of rivers in the Gouritz WMA and their existence threatens the status of all endemic species. These threats are also likely to be enhanced should fracking be introduced to the WMA. In May 2015, Science and Technology Minister Naledi Pandor announced the beginning of a process to determine the environmental impact as well as the benefit of hydraulic fracturing in the region (Eye Witness News, 12 June 2015). Portions of the area are protected through conservation initiatives such as the Gouritz Biodiversity Initiative and the Garden Route Initiative and these, in conjunction with conservation projects, have improved the conservation status of the area.

What is SAB's green water innovation?

SAB Ltd has been a pioneer in South Africa in terms of promoting water stewardship; being one of the very first companies to assess their water footprint (SABMiller & WWF, 2009). The water footprint assessment found that 95% of SAB's water footprint lay in its supply chains, with only 5% attributed to their operations. In order to address those risks, it was therefore imperative that they focus on better management of water in their agricultural supply chains.

SAB recently launched the better barley initiative, which aims to promote sustainable farming among South Africa's barley farmers through water reduction, alien vegetation clearing and ecosystem restoration. The program is being implemented in the Gouritz WMA and in the dry land areas of the Northern Cape. Over the course of two years, 26 barley farmers in the selected regions will be empowered to implemented better farming practices on their farms, and act custodians of natural capital in their respective locations.

Guidelines on better barley farming will be used to promote sustainable farming in these locations. The guidelines contain key indicators, criteria and verifiers to measure how sustainable particular farmers' practices are. The metrics in the guidelines will enable farmers to track progress over time, to build a business case for sustainable production.

Link between innovation and aquatic integrity

The link to aquatic integrity is quite clear in this initiative, mainly because it focuses on farmers who are operating in water constrained region, and whose activities have a direct impact on freshwater ecosystems. For example the Northern Cape is a dry land; as a result the water related risks that SAB and the farmers are likely to face are quite enormous. Implementing sustainability farming practices will enable farmers to understand their impact on the critical ecosystems and take measures to mitigate those impacts. More importantly if all barley farmers supplying SAB take up the practices being piloted, the cumulative impact on the integrity of freshwater ecosystems will be quite significant.

From the perspective of green innovations, working with multiple partners and testing new approaches and standards represent one of the highest impacts that such innovations can bring to a water catchment, relative to technological interventions for example.

4.7 Mine water reclamation (Anglo American)

Overview of Anglo American

Anglo American is the world's largest producer of platinum contributing about 40% of world output, and they are also a major producer of diamonds, coal and iron ore. Some of their subsidiary companies in South Africa include Anglo American Platinum Ltd, Anglo American Coal, De Beers Ltd, and Kumba Iron Ore Ltd.

Considering the nature of their operations, the company is also a major contributor to South Africa's water challenges since mining accounts for significant amount of water pollution in our critical water catchments (WWF, 2011). Acid Mine Drainage (AMD), which arises from abandoned mines, is the outflow of acidic water from metal or coal mines and has been a major challenge in South Africa. A significant amount

of Anglo American's operations occur in the Olifants WMA characterized my intense levels of mining, agriculture and is the location of large municipalities. Severe erosion occurs in these areas due to the highly erodible soils and over-grazing. The catchment area is also characterised by several large dams which include Witbank Dam, Rust de Winter Dam, Blyderivierspoort Dam, Renosterkop Dam, Loskop Dam, Ohrigstad Dam, Arabie Dam and Phalaborwa Barrage with smaller dams in the area having considerable capacity (State of the Rivers Report, date).

According to research conducted by the CSIR and other organisations (http://www.csir.co.za/rhp/state_of_rivers/state_of_crocsabieolif_01/olif_eco_7.02.html), mining, predominantly for coal and other industrial activities in this area (which produce high levels of acid leachate) are the main contributors to poor in-stream and riparian habitat conditions. Streams are also diverted in this WMA in order to service agricultural and mining activities. In some areas, access roads mostly related to mining and industrial activities have resulted in severe disturbance of river bed habitats, and increased erosion of both land and riparian areas, Challenges of alien vegetation competing with indigenous vegetation along the riverbeds, reducing the viability of water in these parts have also been noted.

In 2009 Environomics Environmental Consultants conducted research in the Olifants and Letaba Catchment with the purpose of ensuring that relevant stakeholders in the

Many mining outfits in South Africa have attempted to manage their water footprint, as well as considered the impact they have in the region of their operations, in order to reduce their risks related to water, and secure their supplies. Since Anglo American's water footprint is quite significant they have also attempted to control the same and have led to the implementation of some innovative approaches, which include wastewater reclamation and water efficiency measures.

According to the company, in 2013 more than 60% of the water used in their operations came from recycled water sources. They are using less water generally and bringing some water resources to the community. The company is a major contributor to South Africa's economy both in terms of job creation, revenue and

sustainability. In 2013 Anglo American contributed R14.1 billion in taxes, employed 99,500 people and contributed more than R600 million in community initiatives.

Anglo American's green water innovation

Anglo American pioneered the concept of water reclamation of portable water from acid mine drainage. This represents a significant green innovation for the mining sector that has a very good potential of being up-scaled and adopted by other mining operations in South Africa to manage their downstream water footprint that significant impact on water resources.

The project being profiled is the eMalahleni Water Reclamation Plant, which converts mine water into drinking water for the local Municipality of eMalahleni. This project was commissioned in 2007 as a pilot with the aim of:

- Using mine water to produce portable water for the local Municipality
- Build a plant that has minimum local impact and can produce 20 Ml/day
- Waste product of less than 3% brine
- Ensure positive waste utilization.

The plant receives its feed water from four coal mines in the eMalahleni area, which have contributed to Acid Mine Drainage (AMD), risking pollution of both surface and groundwater resources in the catchment.

The plant uses the process of **Reverse Osmosis** to concentrate the water and produce supersaturates of brine, and the salts from the brine are then released in simple precipitation process (**Hutton et al., 2009**). The key advantages of this technology are that:

- It has a very high rate of recovery
- Simple system to configure
- Easy operation
- Low operating costs and capital
- Minimum waste.

The key features of the innovation outlined above make it relatively issue to scale up and be adopted by other potential users in the country. So far BHP Billiton and

Glencore Xstrata are replicating this model of water reclamation in the catchments where they operate.

Link between Anglo American's green innovation and aquatic integrity

Treating water before releasing it into the ecosystem has a major implication on the integrity of aquatic ecosystems, because mining poses a major threat to South Africa's key water resources. Coal mining for example directly pollutes both surface and ground water resources by acids, salts and other metals. The acidification of water resources can increase the concentration of metals found in water to extremely toxic levels that is detrimental to both ecosystems and human health.

The Olifants catchment where this green innovation is being implemented is one of the most degraded catchments in South Africa, largely attributed to the impact of coal mining, agriculture and sewage pollution with some activities geared towards conservation.

Most of the industrial activities in the catchment are located in the upper reaches; impact both downstream water users including dams in the catchment (Table 2). For example the Witbank dam started receiving high levels of pollutants as early as 1986, even though some measures have been implemented to help dilute the toxins, the levels of sulphate concentrations in dam still exceed drinking water regulations in many cases (WWF, 2011).

Table 2: Water quality of AMD polluted water spilling into one of the dams in the Olifants, benchmarked against agricultural water quality guidelines (WWF, 2011)

		SA drinking water quality guidelines[73] mg/L		SA Agriculture Water Quality Guidelines[73] mg/L	
Determinand	Blesbokspruit Water quality Average mg/L (1990 – 1996)	Target	Short term (poss. chronic effects or symptoms in sensitive users)	Target	Max acceptable (short term)
TDS	3 091.7	0 – 450	2000	220	1 485 – 2 970 (mod salt tolerant)
pH	2.7	6 – 9	4.0 – 11.0	6.5 – 8.5	< 6.5
Sulphate (SO4)	2 292.9	0 – 200	400 – 600		
Magnesium (Mg)	62.2	0 – 30	70 – 100		
Iron (Fe)	162.8	0 – 0.1	1 – 10	5	20
Manganese (Mn)	14.2	0 – 0.05	14 – 20	0.02	10
Aluminium (Al)	104.5	0 – 0.15	0.5	5	20

As mentioned above the upper regions of the catchment area are heavily utilised. However, in order to deliberate on the ecological state, the interests of the

downstream users and to ensure sustainable development of the entire catchment, great measures should be taken to ensure that these regions are not compromised. The effluent from mining and other heavy industry will have to be treated before release into the river. In the case of Olifants, it's therefore clear the green innovations being implemented by industry are critical for alleviating the water situation in the catchment. The green innovation profiled in this case study is also an excellent example of how the effectiveness of green innovations need to be assessed in concert with the prevailing water situation in the catchment, to ensure that it is geared towards addressing the critical issues in that catchment.

5 Indicators and metrics for measuring green innovations

5.1 Overview

This chapter investigates the metrics and indicators that are used for measuring green innovations, with a view of developing a holistic understanding of the suit of tools and metrics that are being used and how they could be applied to South Africa's context. The review covers broadly the suit of indicators and metrics that have been proposed broadly for assessing progress in the transition to a green economy, and how innovation in general is measured, and concludes with a generic table that outlines the potential list of indictors that could be considered for South Africa.

5.2 Metrics for measuring water related green innovations as illustrated by diagnostic framework

Water situation indicators can be measured against the minimum requirements for business operations, human consumption and sanitation and for the sustainability of ecosystems. However, assessing the availability alone would prove inadequate and therefore indicators that assess accessibility of these resources would take into consideration the infrastructure and institutional capacity for water management per catchment area.

Socio-economic indicators can be used to measure the benefits derived from the use of green innovations for business outcomes and human and environmental wellbeing in an area. These outcomes vary significantly, depending on the beneficiary. For business, indicators that assess the impact of green innovations on the triple bottom-line would be most useful in addressing business risks. For people, the creation of jobs, a general better quality and quantity of water (also for ecosystems) could be used to assess the impact of green innovations.

Business performance. The sustainability of a business is directly linked to accessibility of capital such as labour and natural resources. The indicators for business performance and water resource management in relation to water would therefore assess 1) the natural asset base (availability) 2) impact of operations on

well-being of people and environment 3) profitability 4) economic opportunities presented by the green innovation.

5.3 Conceptual framework for green growth indicators

The OECD developed a green growth framework for indicators that was based on 4 major features of green growth (Table 3):

- Environmental and resource productivity of production and consumption;
- The natural asset base;
- Environmental dimension of quality of life
- Policy responses and economic opportunities

The above features were arrived at based on a conceptual framework for green growth that seeks to understand how the economy operates, with the starting point being the production phase of goods and services to their consumption.

5.3.1 Indicators monitoring the environmental and resource productivity of production and consumption

The production of goods and services is directly responsible for economic growth, through the injection of capital such as labour and the use of machinery. The production phase also benefits from significant services from natural assets, which need to be accounted for, which gives rise to the first set of indicators for green growth. The indicators that have been proposed for this set group monitor the use of environmental services (use of natural resources and materials, including energy, generation of pollutants and other residuals) in relation to the generated output as well as the tracking decoupling in trends of production and environmental services.

The set group of indicators address two major themes of green growth that have been identified by the OECD; (1) Carbon and Energy Productivity and (2) Resource productivity.

Table 3: Indicator groups and topics covered for green innovations (OECD, 2011)

INDICATOR GROUPS	TOPICS COVERED
1. The environmental and resource productivity of the economy	- Carbon and energy productivity - Resource productivity: materials, nutrients, water - Mulit-factor productivity
2. The natrural asset base	- Renewable stocks: water, forest, fish resources - non-renewabal stocks: mineral resources biodiversity
3. The environmental dimension of quality of life	- Environmental helath and risk - Environmental services and ammenties
4. Economic opportunitis and policy responses	- Technology and innovation - Environmental goods & services - International financial flows - Prices and transfers - Skills & training - Regulations and management arpproaches

5.3.2. Indicators describing the natural asset base

The second set of indicators specifically monitors the natural asset base, with motivation being the fact that a declining natural asset base will pose a major risk to economic growth. The green growth strategy requires that investments in the natural asset base result in positive investments, i.e. more needs to be done to the asset in the form of investment or natural regeneration.

- The environmental dimension of quality of life

The third set of indicators is focused on the environmental dimension of quality of life. This group of indicators captures the direct impact of the environment on people's lives as a result of environmental degradation that is associated with modes of production. According to the OECD (2011) examples of this could include human

health being affected “through air and water pollution, exposure to hazardous substances and noise, as well as through indirect effects from climate change, transformations in the water cycles, biodiversity loss and natural disasters that affect the health of ecosystems and damage the property and life of people”. (p. 97). The indicators that have been proposed in this section reflect two major themes; (1) Human exposure to environmental pollution and environmental risks and (2) Public access to environmental services and amenities.

- Indicators for measuring economic opportunities and policy responses

This group of indicators can inform stakeholders and policy makers about the effectiveness of policy in delivering green growth and where the effects are most marked. The indicators that have been proposed by OECD for this set address three main issues; (1) Technology development and innovation, (2) Production of environmental goods and services (3) International finical flows and (4) Prices and finical transfers.

5.4. Methods for measuring innovation outputs

Measuring innovation outputs is very challenging, because innovation outputs are wide ranging and differs according to the sector being reviewed. Measuring innovation requires an assessment of the extent to which new products and services that have been introduced, as a product of innovation is capable of creating value, and can be adopted widely.

Based on the wide innovation outputs, it means that various metrics and approaches can be used to measure its outputs. There four main approaches that have been proposed for measuring eco-innovation broadly and specific to the water sector (OECD, 2007; Ajami et al., 2014). These approaches include: -

- Survey analysis
- Patent analysis
- Digital and documentary source analysis
- Capital venture investments

5.4.1 Survey analysis

Surveys are important for monitoring and understanding innovation. Regular community surveys of key sectors of the economy are very useful for understanding

the level of innovation activities in a country. Innovation surveys can be conducted using output measures innovations surveys, or using new product announcements.

5.5 Output measures in innovation surveys

Information in this type of survey is gathered from company managers, through surveys. The focus of such surveys is to understand the innovation behavior of the company and related activities of the firm (Kemp & Person, 2011). Information that is sought also includes building understanding on factors that may influence innovation and the effects of innovation (Kemp & Pearson, 2011).

5.5.1 Using new product announcements

This approach is referred to as literature based innovation output indicator (LBIO). Such databases track new product announcements, through journals that cover technology issues. To develop a long-term view of the new products that have been introduced into a specific market requires the compilation of such information over the specific period of time under review. Even though this is a cumbersome task, it is possible to use this approach to track innovation.

5.5.2 Innovation surveys in South Africa

In South Africa four innovation surveys have been conducted in the past, the first one was carried out between 1992-1994, and covered only the manufacturing sector. The second survey was conducted between 1998-2000, and the third one between 2002-2004.

The Centre for Science, Technology and Innovation (CeSTI) on behalf of Department of Trade and Industry (DTI) conducted the most recent survey in 2008. Innovation activities were by definition regarded as activities that include acquisition of machinery, equipment, software, licenses, engineering and development work including training and R&D (HSRC, 2011). Results from that survey that covered more than 22,000 enterprises, showed that 65.4% of firms that were survey reported undertaking innovation activities (Table 4). 27.2% of the companies that were regarded as innovative have implemented technological innovations, which involved either product and/or product innovation (HSRC, 2011).

Table 4: Percentage of innovative and non-innovative enterprises 2005-2007 (HSRC, 2011)

Type of innovation	Total (%)	Industry[a] (%)	Services[b] (%)
Enterprises with innovation activity	*65.4	68.8	61.3
Product only innovators	8.9	7.6	10.4
Process only innovators	10.3	4.5	17.2
Product and process innovators	7.9	8.8	7.0
Enterprises with ongoing or abandoned activities	38.2	47.9	26.7
Enterprises without innovation activity	34.6	31.2	38.7

The survey distinguished between technological and non-technological innovations, and divided them into 4 categories of product, process, marketing and organizational innovations. The results showed that overall rates for innovation were 65.4% for technological innovations, 51% for organizational innovations and 27.1% for marketing innovations.

Product innovations played an important role in enterprise development, where it was found that 8.5% of turnover of product innovators were generated by innovations that were new to the market. In terms of the size of enterprises, small and medium enterprises generated the highest percentage of turnover based on product innovations that were new to the market (HSRC, 2011).

Process innovations; focus on improving methods and approaches for production or supply of goods and services. Product innovations often lead to better quality products, due to efficiency in the production process, quality control and compliance with regulations and wastage. The survey found that 34.5% of innovations were linked to process innovations (Fig.9).

Regarding the financing of innovation in South Africa, national funding agencies such as such the National Research Foundation (NRF), with its Innovation Fund appear to have played an important role in supporting innovation. It was shown that 2.5% of innovators received some funding from national funding agencies. However, South

Africa compares poorly with other countries in offering support to innovators, where the country offered the lowest percentage of public funds for innovative enterprise compared to 22 other countries.

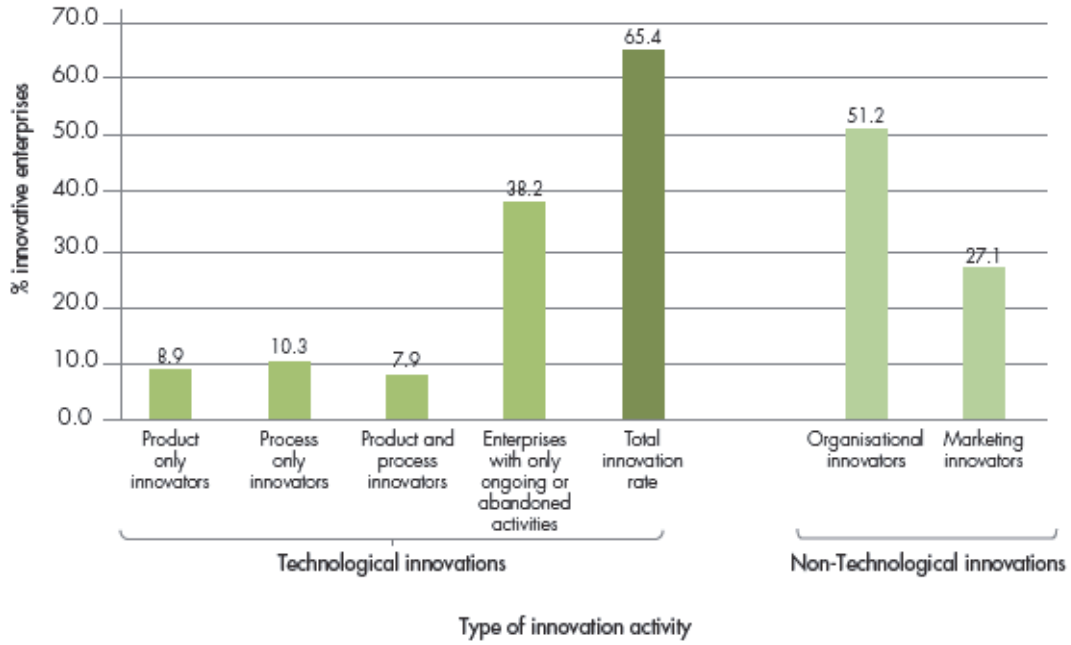

Figure 9: Results showing types of innovation activities in the innovation survey (HSRC, 2011)

The main shortfall of the South Africa innovation surveys is that it did not focus specifically on green innovations which particularly help companies to be environmentally sustainable and to be able to control their footprint. It would have been very useful if environmental issues were treated separately in these surveys, to help in highlighting the enterprises that are providing leadership on the critical environmental and climate risks that companies are facing.

5.6 Patent analysis

Patent analysis is an important source of analysis eco-innovation activities. A patent is defined as an exclusive right to exploit an invention over a limited period of time, within the country where the application is made (Kemp and Pearson, 2007). Patents are assigned to novel inventions that have industrial applications and are thus useful.

Patent data provide a useful indicator for measuring the level of innovation in an economy. Patent data is considered an *output* indicator of innovation, while investments in R&D are considered as an *input* indicator. Due to the fact patent data

is publically available compared to information on investments; it is therefore a more robust indicator of innovation. The fact that patents also represents an output; it is therefore a more accurate indicator of innovation, because investments in R&D do not necessarily guarantee innovation.

Patent data is also a useful indicator of the level of innovative activity, because patents are often filed very early in the research process **(Popp, 2005).** Patents are also thought to stimulate R&D linked to the objectives of patent legislation, where for example in the use there is a strong link between patents and R&D in alternative energy in the US.

5.6.1 Patent classification

Patents are classified according to the International Patent Classification (IPC), which is a hierarchical system that divides the entire value chain of technology into sub-sections. Such a system allows for microeconomic analysis of a specific innovation to be carried out, and the approach also allows for distinction of the different technological types, namely radical or incremental technology (Kemp & Pearson, 2007).

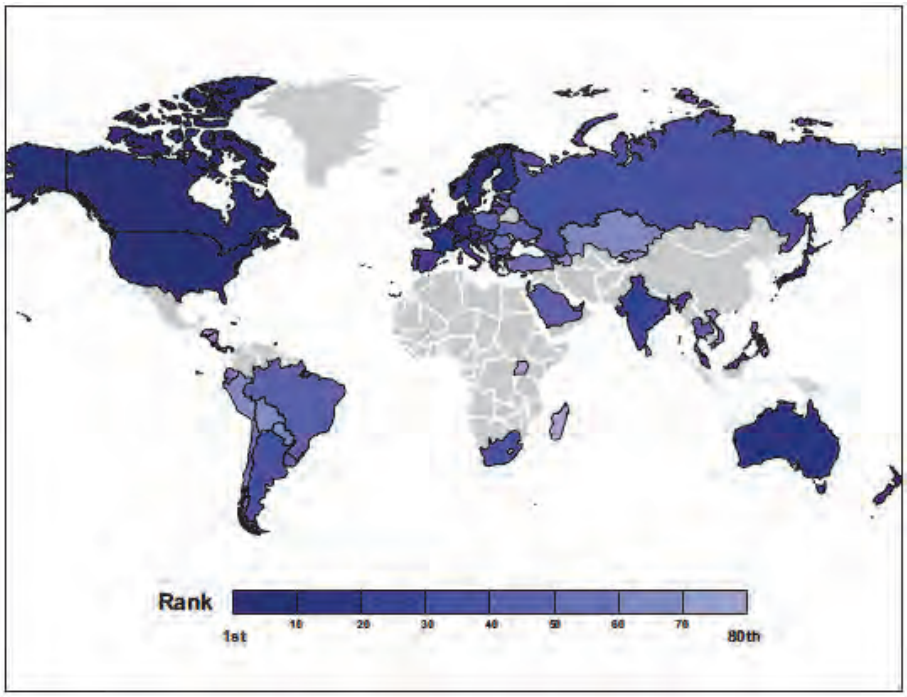

Figure 10: The global innovation map (Florida et al., 2011)

An important aspect of the use of patent analysis is that it can give a very good indication of the technology leadership of a nation. Based on the number of patents and the state of R&D, countries like the United States, Germany and Japan rank very highly in terms of innovation (Fig. 10). In addition to determining overall innovation capacity of a country, patent analysis can be used to determine the innovation position of countries in a specific technology area.

Other potential uses of patent data analytics for measuring innovation include:

- It is application for tracking technology diffusion to various countries
- Used for tracking source of invention, based on the bibliographic data in the patent. With this information, researchers can learn the home country of the invention, the inventor and the applicant of the patent. This information enables researchers to use patent data to assess the role of various organizations in innovation e.g. public institutions and private companies.
- Technological spillovers and knowledge relatedness. Patent data has been used to assess relatedness among different technological fields, and to find appropriate measure of knowledge spillovers (Kemp & Pearson, 2011).
- Novelty of invention. Patent analysis can be used to assess the novelty of an invention, where for example important patents are cited more than less important ones, take the into account the age of the patent.

5.6.2 Limitation of patent data for measuring innovation

Even though patent data contains a lot of information, there are numerous limitations in its application as an indicator of innovation. Some of the key limitations include the following (Kemp & Pearson, 2011): -

- Patent data only captures a limited proportion of all innovations, simply because not all innovations have been patented.
- Smaller firms have a lower probability of applying for patents, due to the associated costs and a result patent data is biased towards larger organisations.
- The value of distribution of patterns is skewed, with only a few patents having very high value, but most have low value.

- Patent analysis is also constrained by methodological challenges, because it is very difficult to categorize patents according to economically relevant sectors.
- In terms of green innovations, patent data analysis is quite limited in revealing the level of innovation, because they can only do so for specific green products, with specific environmental impact. Other types of green innovations may thus be very difficult to measure.

5.7 Digital analysis and documentary source analysis

This is an example of a downstream innovation indicator, which measures innovation output as opposed to input approaches, such as R&D and patent analysis. This approach relies on the power of the Internet to keep track of new innovation products and processes that are introduced to various markets. The two main types of online databases that can be used to gather innovation information are:

- New product announcement' databases, and
- Production information databases.

New product announcement databases specifically track announcement of new products in the market. For example, the paper industry market trends and analysis (PIRA) is a database that keeps track of announcements in the paper industry. PIRA explores market trends and in-depth industry analysis to provide accurate and well research information on the sector.

Product information databases on the other hand offer consumers information on a specific product and can be a good measure for eco-innovation. Due to increased interest in eco-products by consumers, some companies are seeking to demonstrate the efficiency of their products and as a result display this information on product catalogues. In some cases specific legislation requires that information on specific products such as fuel economy of cars and carbon dioxide emissions is made available to consumers. In this way product catalogues become a useful platform for measuring eco-innovation, as new products become available or existing ones are improved through incremental innovation.

5.8 Assessing the capacity for green innovations using a systems perspective

5.8.1 Systems approach to assessing innovation

Societal characteristics such as beliefs, values, knowledge and the network of actors, is an important determinant of innovation (Kemp & Pearson, 2011). Since innovators interact with this wider society and are often informed by societal needs to innovate, a good understanding of the wider context within which innovation takes place is important. There are six approaches that can be used to review the wider context within which innovation takes place:

- Innovation system frame
- The National Innovation system concept
- National innovative capacity concept
- The technological innovation system concept
- The system innovation approach
- A socio-cultural perspective

A common characteristic of all the above approaches is the acknowledgment that innovation takes place as a result of specialized knowledge producers, who need to collaborate for efficient innovation to take place (Kemp & Pearson, 2011). In South Africa this is reflected by the government's policy, which seeks to nurture innovations that promote sustainability. The National Cleaner Production Centre (NCPC) is a good example of government initiatives that seek to promote innovation in the industrial sector in South Africa. The program is specifically seeking to make South African industry to become competitive and sustainable through efficient and greener production.

5.8.2 Innovation systems frame

The innovation systems deals with factors that address capacity issues, and is categorized into 4 different categories, comprising of i) framework conditions, ii) Science and engineering base, iii) Transfer factors, iv) Innovation dynamo (Fig. 11).

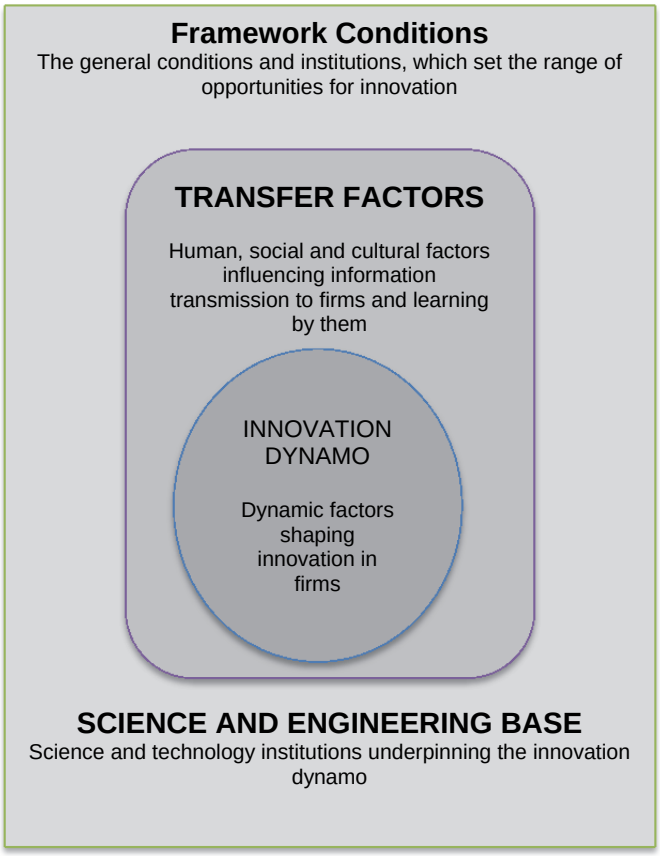

Figure 11: The innovation system frame (EUROSTAT, 2005)

The Framework Conditions, which is represented in the external ring comprises of conditions, which have developed on the ground regardless of innovation. These factors, such as education and communication infrastructure in turn define the broader parameters within which firms operate (EUROSAT, 2005). Key elements of the framework conditions comprise of:

- The basic educational system of a country
- Communication infrastructure
- Financial institutions
- Legislative and macroeconomic settings
- Market accessibility
- Industry structure and competitive environment

Science and engineering provide the basis of business innovation, and the public sector is mostly responsible for developing this capacity. In South Africa for example, the Department of science and Technology (DST), is tasked with the responsibility of

developing the countries science capacity, to ensure the country is competitive and achieve economic development.

Transfer factors comprise of human, social and cultural dynamics which impact innovation at the firm level. These factors are related to the ease of communications within organization, information sharing, skills development and social and cultural factors which impact innovation activities and operations of firms (EUROSTAT, 2005). Specific examples of these transfer factors are listed below:

- Formal and informal linkages between firms
- The presence of expert technological gatekeepers or receptors
- International links
- The degree of mobility of expert technologists
- Ease of industry to access public R&D
- Spin-off company formation
- Ethics, community value-systems, trust and openness
- Codified knowledge in patents, specialized press and scientific journal.

Innovation dynamo is the complex system of factors that are shaping innovation at the firm level (EUROSTAT, 2005). The role of the firm in promoting innovation is extremely important, understanding the factors which can influence firms to be innovative, and how innovation is generated within firms is essential. According to the Oslo Manual (EUROSTAT, 2005), there are three factors, which help companies that want to be innovative:

- **Strategic factors**: Firms have to explicitly make a decision on whether they want to engage in innovation activities, by clearly identifying the type of market they would like to serve, seek or create and the types of innovations.
- **R&D**: Firms can undertake basic research to extend their knowledge on key process and products, engage in strategic research, and can develop product concepts.
- **Non-R&D:** These are activities that a firm might undertake, although not directly related to R&D, play a critical role in promoting innovation at the firm level.

5.9 National innovation systems

The concept of National Innovation Systems (NIS) seeks to advance innovation from the firm level to a more holistic strategy at a national level to influence the direction of the national economy as a whole. The premise for an NIS is the understanding that innovation is critical for economic development and should therefore be framed in a more integrated and interactive fashion with various elements of the economy.

The NIS concept was first developed in the 1990s and has since gained significant traction. The NIS has narrowly been defined in terms of Science and Technology policy, R&D and knowledge and technology transfer (Lundvall et al., 2009). If viewed broadly, NIS is a framework or a set of policy tools for institutions and resources for knowledge diffusion to enhance economic growth (Cooke et al., 1998, Kramer-Mbal, 2006).

5.9.1 Indicators for National Innovation Systems (NIS)

Measuring NIS is extremely important, and the OECD has undertaken various studies to help in advancing the concept of NIS, and develop indicators for measuring progress. The most comprehensive study in that regard, is the project entitled ‘monitoring and implementing national innovation policies (MONIT) (Remoe et al., 2005). The indicators that were developed as part of the MONIT project are very comprehensive, ranging from innovation systems at the company level, to knowledge generation and to overall performance of the nation. These indicators are as follows: -

- **Innovation in the company**. This set of indicators assesses the range of innovation activities at the firm level and comprise of eight parameters as follows:
    - Innovation expenditures (% of all turnover in manufacturing);
    - Patents in triadic patent families per million population;
    - SMEs share of nation R&D performance (% of total business R&D)
    - Employment in medium and high tech manufacturing (% total workforce)
    - Employment in high tech services (% of total workforce)
    - Stock of inward FDI (% GDP)
    - Business expenditure on R&D

- Direct government funding of business R&D

- **Knowledge generation through education and research system.** Four indicators are used to assess progress of knowledge generation at a national level.
  - New science and engineering graduates (% of 20-29 years of age class);
  - Number of PhD's per 10,000 inhabitants;
  - Number of publication per million population;
  - Basic research as percentage of GDP;
  - Share of annual government budget allocated to research
- **Industry-Science linkages.** This group of indicators measures the uptake of science by industry, and the wider set of institutions in the country.
  - Business financed R&D performance by higher education as a % of GDP
  - Business financed R&D performed by government as a % GDP
  - Percentage of innovative firms cooperating with other firms, universities or public research institutions
- **Absorption capacity (aspects of demand, infrastructure and framework conditions).**
  - Population with tertiary education (% of 25-64 years age classes)
  - Participation in lifelong learning (% of 24-54 years old)
  - Investment in knowledge as percentage of GDP
  - Seed and start-up venture capital (investment per 1000 GDP)
- **Overall performance.** This group of indicators measures the extent to which the entire system has achieved its goals of creating an innovative environment.
  - Share of innovative firms as a percentage of all firms (manufacturing)
  - Share of innovative firms as a percentage of all firms (services)
  - Labour productivity/CAGR, GDP per hour worked
  - Average annual growth of value added in high and medium tech as compared to average annual growth of GDP
  - Average annual growth of employment in high and medium tech as compared to average annual growth of total employment.

5.9.2 National innovation system in South Africa

South Africa has a well-developed National Innovation System (NIS), being one of the first countries globally to adopt this approach. This concept was first articulated in terms of the *Science and Technology White Paper (1996)*. Other documents that have informed the NIS includes *The National Research and Technology Foresight (2000),* and *The National Research and Development Strategy (2002).* The government also published the *10 Year Innovation Plan (TYIP)*, which was designed to shift South Africa's economy from one that is dependent on resources, to a knowledge-based economy.

The South African NIS specifically acknowledged the need to transition the country into a low carbon economy, in recognition of the sustainability challenges that many countries are faced with as a result of climate change, population growth and environmental degradation.

Even though South Africa has made significant progress in terms of acknowledging the importance of NIS in promoting sustainable economic development, the country is faced with significant challenges liked to a poor education system, leading to skills shortage, unemployment and social unrests. Accelerating the nation R&D agenda is therefore constrained by the prevailing framework conditions.

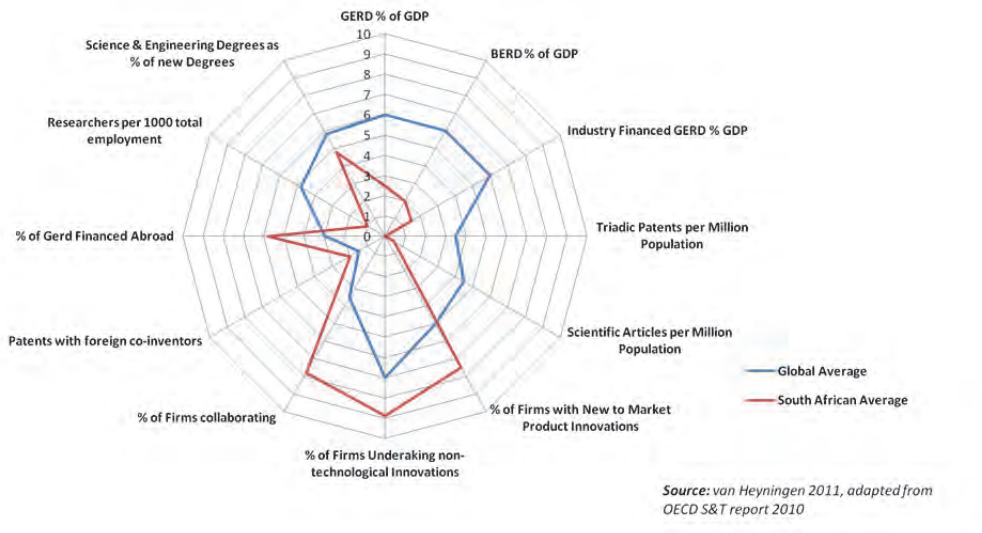

Figure 12: Indicators of South Africa's R&D and innovation capacity vs world average

The figure 12 above compares South Africa's R&D to global standards, and has identified some strengths and weakness in the country's R&D. The comparison shows that South Africa is weak in terms of % of GDP spent on R&D, and the number of patents per million of population.

5.10 The Technological Innovation Systems (TIS) approach

The key feature of the TIS approach is the use of the actual technological innovation as a reference point, instead of the firm or enterprise. The approach is defined in reference with the scope of other systems, to address the shortfalls of innovation systems that focus on structure. The TIS approach also specifically demonstrates and interest in green innovations, which makes it an important approach for measuring innovation.

The set of indicators that have been suggested for measuring TIS, are covered in Hekkert et al. (2007), and are briefly outlined below:

- **Entrepreneurial activities.** This approach acknowledges the critical role entrepreneurs play in advancing innovation and states explicitly that there would no innovation without entrepreneurs. As a result it is important to measure the number of new entrepreneurs, the diversification of activities by incumbent actors and the number of experiments with technologies.

- **Knowledge development.** This is a measure of the degree to which a practical approach to knowledge development is being carried out, such as 'learning-doing' or 'doing by searching'. The parameters to measure are the number of R&D projects over time, number of patent application of time and investment in R&D overtime

- **Knowledge diffusion**. The rate of knowledge transfer is a critical determining factor for the success of an innovation system. This can be measured by the number knowledge dissemination events such as workshops, conferences, and seminars that deal with a specific technology issue. The second parameter is the size and intensity of network related to a specific technology.

- **Guidance of the search**. This refers to how investments are guided to the development of certain aspects of technology. This is based on the premise that due to limited resources, prioritization of some components of technology may need to be developed further, with support from a divergent group of stakeholders such as government, private sector, or individual. The specific indicators for measuring the guidance of search include (Kemp & Pearson, 2007): Success achieving of government or industry in designed targets for use of specific new technology, number of articles on future development of new technology, ration of position to negative articles regarding expectation of future technology development.

- **Market formation.** Market access is a major challenge for new technologies, due to their inability to compete with well-entrenched technologies. Sometimes for a new technology to be embedded, it might require the formation of a niche market, or the disruption of existing markets for such a technology to be entrenched. Creating an enabling environment, such as tax incentives for renewable energy technologies, pollution or waste management, may create market access for new technologies. Indicators for this parameter include; the number of niche markets introduced, number of specific tax regimes for new technologies, number of new environmental standards that improve chances for new technology.

- **Resource mobilization**. Access to capital, both financial and human is a key factor in the successful development and deployment of new technology. Potential indicators for this parameter is funding allocation for R&D, and funding allocation for testing of new technologies in niche experiments (Hekkert et al., 2007). It's important to note however, that this function is difficult to measure using specific indicators overtime (Hekkert et al., 2007).

- **Creation of legitimacy/counteract resistance to change**. For a technology to succeed it must overcome resistance within existing markets, for it to become and incumbent. Legitimacy is therefore critical for a technology to become incumbent, and to achieve legitimacy may require the building of coalition of advocates in the political and public agenda (Kemp & Pearson,

2007). Advocacy coalitions can help innovating organizations to put a new technology on the agenda, lobby for resources, and favorable tax regimes (Hekkert et al., 2007).

5.11 Potential indicators for innovation programs in South Africa

The previous sections of this report outlined quite generically the potential metrics and indicators for measuring innovation in general. The shortfall of that has been identified in the innovation literature is the fact that there are very few studies that have focused specifically on developing metrics and indicators for measuring green innovation.

The table 5 below is a proposed set of broad green innovation indicators modified from Kemp & Pearson, 2007, who initially proposed the set of indicators for the OECD. Even though the proposed indicators were not specific to South Africa, most of the parameters are highly applicable with the exception of data sources.

The proposed indicators in the table are just a preliminary list which we recommend be investigated further in a follow up study to this project. The list below just provides a rough guide of the nature of indicators that could potentially be used in South Africa, taking into cognizance that the context of South Africa and the OECD, for which these indicators were first introduced are quite different.

Table 5: List of proposed green innovations indicators for South Africa (Modified from Kemp & Pearson, 2011)

	INDICATOR
THE COMPANY	
1.	R&D expenditures for environmental production in industry
2.	% firms with ISO 14001
3.	% of firms with environmental mission statements and/or officers (water)
4.	Managers opinion on green innovation
ENABLING ENVIRONMENT FOR GREEN INNOVATIONS	
5.	'Green Tax' as percentage of government expenditure
6.	Government expenditure on environmental R&D as: ▪ % of total R&D expenditure ▪ % of GDP
7.	Financial support for green innovations from public programmes
8.	Environmental expenditure in college/university research
9.	Number of MScs or PhDs
10.	Waste management costs (landfill tariff etc.)
THE LINKAGES	
11.	Frequency of green innovation workshops/conferences and number of people attending
12.	Value of green funds made available by financial institutions for innovating companies
13.	Managers perception of overall quality of environmental research in scientific institutions
RADICAL/INCREMENTAL INNOVATION INDICATORS	
14.	Ration of green start-up incumbents in the market
15.	Frequency of new entrants to the market
16.	Diversification of activities of incumbents, investment in small operations outside core business
17.	Seed and start-up venture capital for green innovation firms (investment per 1000 GDP)
OVERALL PERFORMANCE INDICATORS	
18.	Eco-patents in triadic patent families per million population
19.	Material productivity of green innovative firms (TMR per capita or GDP)
20.	Share of green innovative firms as percentage of all firms.

Developing indicators for monitoring the effectiveness of green innovations is a very complex task, because it is very difficult to measure the outcomes of innovation. As a result indicators for monitoring green innovations tend to be response indicators as opposed to outcome indicators as commonly used in environmental sector (Rizos et al., 2015). Green innovation indicators therefore tend to be response indicators that evaluate the green innovation developments at various levels in Society (Rizos et al., 2015).

5.11.1 Some key barriers and enablers for companies to implement green model business innovations

Undertaking green innovations is by no means without any challenges; as a result companies need to be cognizant of these challenges in order to develop effective response strategies (Fig. 6). However, the challenges in many cases also present opportunities, and there a numerous enablers that can be implemented to illustrate how such challenges can be overcome.

Table 6: Key barriers and enablers faced by companies in implementing green innovations (modified from Roos, 2014)

Barriers	Enablers
▪ Technological: Barriers connected to specific technologies (e.g. recycling technologies, product design) that hinder companies to fully adopt the concept	▪ Leadership: Leadership that appreciates the new strategic direction, understand its benefits but also its risks.
▪ Legal: Complexity of regulations, discrepancies between international regulations and their outdated or rigid characteristics	▪ Collaboration: Companies need to work with others to effectively implement green innovations, and unlock some of the systemic barriers they face.
▪ Economic: Difficulty in defining the business case for adopting green innovation.	▪ Motivation from the concept of green innovation: A concept such as circular economy presents exciting opportunities, and can unlock creativity that can improve morale and foster the implementation of new models.
▪ Change in Mindset: reluctance to acknowledge that business-as-usual cannot proceed and change to a long term perspective is necessary.	▪ Customer behavior. Increased consumer awareness about environmental and social challenges, is putting pressure on companies to adopt more sustainable approaches.

6 Guide and Recommendations of Green Innovations and Indicators appropriate in South Africa for improving water resources and business performance

6.1 Overview

This chapter investigates the metrics and indicators that are used for measuring green innovations, with a view of developing a holistic understanding of the suit of tools and metrics that are being used and how they could be applied to South Africa's context. The review covers broadly the suit of indicators and metrics that have been proposed broadly for assessing progress in the transition to a green economy, and how innovation in general is measured. These indicators in conjunction with the diagnostic framework discussed in chapter 3 are essential in the development of indicators specific to water in relation to green innovations. The indicators could assess business performance, socio-economic outcomes and water integrity.

6.2 Recommendations: Green innovations approaches that improve business and environmental performance

6.2.1 Circular management

The concept of circular management is based on the premise that we live in a resource constrained world, and current approaches to production are highly unsustainable due to the fact that most of the world's resources are finite, and thus the systems of production needs to acknowledge this. The concept of circular management aims to promote more efficient resource use, by encouraging firms to adopt cleaner production, recycle more of their water and cooperate with others (Giurco et al., 2014). The key drivers of circular management are the growing demand for raw materials, growing populations, increased waste generation and associated costs, and significant progress in the development of recycling technologies. (Giurco et al., 2014).

6.2.2 Closed loop production

A closed loop system is an approach where a product is created with no pollutant output and no waste. Any materials that are used in the production are recycled back

into the system, without discarding. Closed loop production also uses renewable energy to minimize its environmental footprint.

6.2.3 Supply chain management

This is an integrated concept of green activities in the supply chain with a focus on upstream flow, cost reduction and innovation in raw materials, components, products and services (Henriksen et al., 2012). To achieve a green supply chain requires significant engagement outside of a company's 'factory' fence, by partnering with suppliers, local communities and environmental organizations, to help companies manage the risks associated with their supply chains. Many companies that have assessed their environmental risks found out that their supply chains account for most of their risk, of up to 90% for some companies (WWF, 2011). As a result supply chain management has become an important part of companies addressing their risks, in concert with other stakeholders.

6.2.4 Take back strategies

Take back strategies are implemented downstream of the value chain, when companies interact with consumers to influence behavior in the use of their products. The focus here is for the producer to take responsibility in the management of their waste. The aim of tack-back strategies is to reduce the volume and toxicity of waste disposal, increasing recycling rates and prevention pollution at source.

In South Africa at present there is no strategy for 'take back', in essence companies are not obliged to track down their by-products once goods are sold to consumers. If the government had a policy that ensures companies put in place take back strategies, companies would put more effort in changing consumer behavior, which would in turn lead to reduced waste finding its way into the environment.

An excellent example of take back strategy is that by the clothing manufacturing company Patagonia, where they take back their old used clothes and use them to make new ones. In this way they up-cycle their products, which makes the company not only more profitable but also sustainable. If many companies adopted such business models, the problem of waste would managed more effectively.

6.3 Industrial symbiosis

This approach promotes an integrated industrial economy, where industries cooperate with each other to optimally use available resources. The aim of industrial symbiosis is to reduce costs of operations and the associated environmental impacts. This can be achieved by leveraging resources such as materials, energy, water, capacity, expertise and assets among others.

Industrial symbiosis, a relatively new concept, requires significant cooperation between stakeholders, but ultimately yields outcomes that can be transformative to a business and its ecological footprint. This is still an emerging concept and there are still very few successful case studies that have been documented.

The Western Cape Province, Gauteng and KwaZulu-Natal are piloting industrial symbiosis projects with select businesses in the provinces, which could be replicated in the rest of the country. The Western Cape Industrial Symbiosis Programme (WISP) is a facilitation program that helps to connect companies by identifying residual resources such as water, energy and materials and supplying those resources to a company that needs in a form of barter trade. In one year of the programme implementation, more than 100 companies participated in the facilitation programme, with 11 successful exchanges of resources having taking place (Wcape, 2014). This approach results in creation of new business opportunities, as the residual resources can be used to make completely new products of a higher value, but they also results in resource efficiency during industrial production. In this way the industrial symbiosis is a pragmatic green innovation that needs to be incentivized and supported by a policy framework to promote its effective implementation.

6.4 Market opportunities for green innovations

The kinds of technological innovations associated with these broad categories of water resource management principles are wide ranging, comprising of:

- **Smart Water**. These are technologies that focus primarily on improving water accounting and management, and address issues such as leak detection, smart water meters, Internet based water use – solutions and software.

- **Efficiency and conservation**. These are technologies that enable long term demand management in various sectors, such as irrigation sensors, low flow plumbing, and water efficient appliances
- **Purification.** These are technologies that are used to purify, filter, disinfect, and produce water of different quality for the benefit of users
- **Alternative sources.** These types of technologies enable water to be produced from alternative sources, examples include desalination, rainwater harvesting and storm water capture
- **Storage (surface and ground water).** These types of technological advancement focus on improving storage capacity above and below ground
- **Ground water.** These are technologies that enable water infiltration and groundwater banking and recovery

It is important to note that innovation in the water sector is linked to specific markets, with each of these markets having played a pivotal role in promoting innovation. For example, various water user groups such as industry, residential, commercial and agricultural, have played an important role in promoting some type of water related technological innovation. As a result technological innovations related to water also closely mirror the sectors concerned, for example desalination and water purification has been pushed by sectors such as food and beverage, pharmaceutical. Residential consumers on the hand have helped to promote innovation in water efficient appliances.

It is clear from the above examples that there have been significant developments in water innovations. However, progress in adopting some of these innovations has been relatively slow in many aspects, and measuring the impact of these innovations has also been quite difficult. In these report, we review the approaches for measuring progress in innovation in the water sector, specifically focusing on indicators and metrics for assessing innovation.

6.5 Improving water infrastructure

South Africa has failing water infrastructure, where a third of water is lost due to the poor state of water infrastructure. The cost of maintaining South Africa's deteriorating

water infrastructure is estimated to costs a large amount of money that the gov't alone cannot afford to finance.

Even though hard engineering might be costly, there is an array of solutions around natural infrastructure that could help in rehabilitating wastewater, drinking, and storm water infrastructure. South Africa is leading globally in championing the concept of natural infrastructure, there is a need to however mainstream this approach at the local level, as a tool for Municipalities to incorporate suit of solutions for addressing the water infrastructure challenge.

The value of promoting natural infrastructure approaches is that it does not only result in economic outcomes, but also environmental and social outcomes. Urban areas more specifically, would benefit a great deal in mainstreaming natural infrastructure challenges.

6.5.1 Recovering nutrients

Excessive nitrogen and phosphorous are one of major sources of pollution in South Africa, with point source (e.g. wastewater treatment works) and non-source pollution such as agricultural runoff, urban storm water, and septic systems) being major contributors of pollution.

Nutrient treatment and recovery solutions play a major role in fighting point source pollution emanating from wastewater treatment works, but the uptake of such technologies is still relatively low. The cost of nutrient recovery is still high; as a result there is need for innovations to reduce the cost of such technologies.

Nutrient recovery can be implemented both at a large scale, such as at a treatment plant or in individual buildings, urine can be processed into urea (fertilizer) and distilled water that can be reused.

Table 7: A USA example of the revenue that could be generated from recovering nutrients (WERF, 2010)

Resource	2009 Est Price US$/Kg	Potential Recovery Opportunity 10 MDG Wastewater treatment plant	
		Min	Max
Silver	$471,61	$8, 849	$3, 904, 664
Cadmium	$2, 69	$5	$307
Nitrogen	$0, 26	$9,978	$74,835
Phosphorous	$0, 14	$1, 313	$9,850

Recovering nutrients from wastewater, offer a good business opportunity, where such nutrients can be used elsewhere in agriculture and other sectors of the economy (Table 7). This business opportunity however, appears to be not well recognizes by entrepreneurs. The challenge in exploiting these business opportunities may also be attributed regulatory hurdles. For example wastewater treatment facilities are government property, accessing them might be a hurdle, requiring special permits to be issued before they can be accessed.

6.6 Water conservation and reuse

Water scarcity and drought and prolonged incidences of drought are driving the need for water conservation efficiency and reuse. Even though technologies for water reuse are widely available, South Africa has still not adopted their wide usage. For example Israel reuses more than 70% of their domestic water.

The technologies for water reuse and conservation that are available can be used both at home and in offices premises. In the South African context, where water infrastructure maintenance is a key priority, technologies that prioritize mains replacement, detects leaks can help to improve water efficiency.

6.7 Improve water monitoring

Monitoring of water for drinking in South Africa is governed by policies and regulations based on international standards, which require water services authorities, specifically Municipalities and District Municipalities to regularly report their performance (Rivett et al., 2012). The Blue Drop Certification System (BDS) is the reporting framework against which local water authorities in South Africa report.

Over the last couple of years there has been marked improvement in the standards of reporting, with many Municipalities showing an improvement in their water management. Many under resourced rural Municipalities however, are falling behind which is a major concern (Rivett et al., 2012).

Effective water monitoring in rural areas of South Africa is plugged by many challenges including sparse population distribution, lack of capacity and inadequate financial resources.

Innovations that could help to simply water quality monitoring in rural areas are required. Below is an illustration of simple technology that could be used to improve water quality monitoring in rural areas of South Africa. The Water Quality Report (WQR) was tested in 4 local Municipalities in South Africa, with the aim of improving water quality reporting in those underperforming Municipalities (Fig. 13) (Rivett et al., 2012).

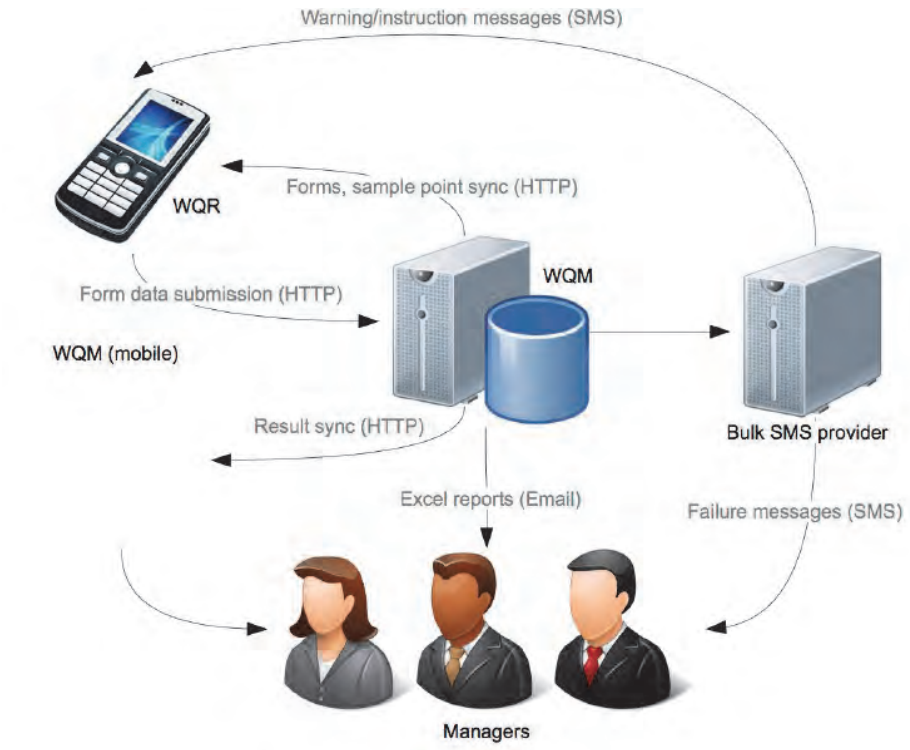

Figure 13: an illustration of the water quality report (WQR)

The WQR uses a cellphone to collect water quality data in field, which is sent via GPRS to a central server. Once the data has been logged in the central server, the water quality expert verifies the information, and the system sends feedback to the data logger in the field acknowledging the receipt of the data. In this way data can be accurately logged in the system, without the need for complex infrastructure.

The cellphone also enable water quality managers to check the status of various water quality-monitoring sites. The system could also generate spreadsheets that can be downloaded from the Internet for reporting purposes. This is very important because data standardization is a major challenge in South Africa; as a result a unified reporting framework is critical for standardizing data collection.

This is just a simple illustration of the kinds of technologies that could have a significant impact on water management in South Africa, as they help to accurate assess the state of affairs, which is critical for prioritizing action.

6.7.1 Improve rural water supply through promoting small drinking water systems

Rural areas in South Africa bear the brunt of inadequate water supplies in South Africa, where studies have shown that the majority of small water works provide inadequate water treatment, posing a health risk to consumers (Momba et al., 2006).

Even though provision of clean water is a top government priority, the challenge of ensuring that every rural community is covered is quite daunting (Fig. 14).

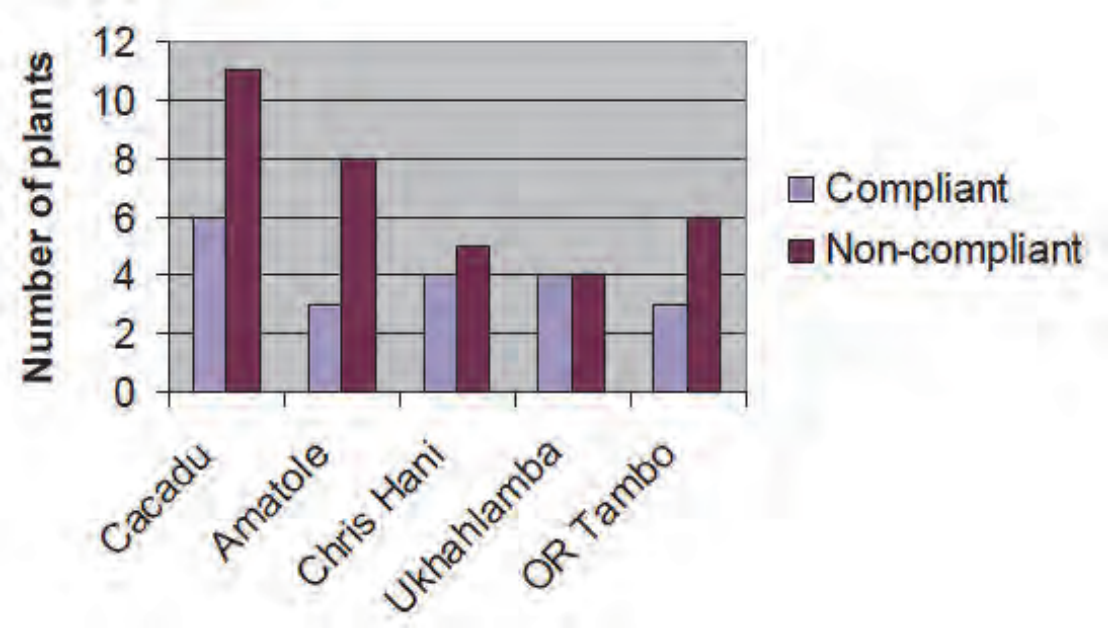

Figure 14: Compliance in rural water treatment plants in South Africa (Momba et al., 2006)

A driving factor for current state of affairs is partly linked to lack of capacity and financial resources to manage some of these systems. The nature of innovations required therefore in most instances is not technological but rather managerial or institutional arrangements. For example management innovations are required to make rural water supplies to be managed as a sustainable business. This would not only attract potential investors, but would enable effectiveness and a higher return on investments. Innovative management arrangements that would allow more private sector involvement in rural areas could include private-public partnerships, concessions agreements and others such as Build-Operate-Transfer (BOT). Such arrangements help in securing more water infrastructure and the transfer of skills from the private sector the public sector.

7 Conclusion and further research recommendations

Green innovations are very important in promoting sustainable water management, regardless of whether it is a product or process innovation. In seeking to promote the uptake of approaches that promote green innovation by companies, it's important not to put too much emphasis on a single technology or approach. This is because water presents a very complex challenge that cannot be addressed by a single approach.

It is important to note that green innovations are both technological and non-technological. Non-technological solutions in most cases require interventions to be implemented in multi-stakeholder platforms beyond the control of a single stakeholder. Even though this may present enormous challenges, the outcomes of non-technological interventions, such as innovative partnerships are often more sustainable and are of higher impact. In relation to managing water risk for companies, technological interventions are often critical for product and process modification, while non-technological interventions are concerned with organizational and institutional arrangements.

Non-technological innovations also tend to be implemented at the landscape level, d therefore present the best opportunity for meeting business and environmental goals. Interventions that focus on industrial ecology, lifecycle thinking and closed loop production are important in promoting resource efficiency that could have direct implication on building landscape resilience.

Even though the business case for green innovation is relatively strong, very few companies are strategically implementing such interventions to mitigate their water risks. Very few companies have shown leadership in seeking to understand their relationship with water and have actively sought to assess their water footprint and the water risks they face. This lack of effective engagement by companies in adopting green innovations may also be as a result of the lack of a regulatory framework that fosters such innovations.

It is therefore recommended that businesses in South Africa begin to meaningfully and intentionally engage in practices that improve environmental and by extension business outcomes. Such practices, mostly featured in the value chain, include

circular management, closed loop production, supply chain management, take back strategies and industrial symbioses.

Even though the business case for green innovation is relatively strong, very few companies are strategically implementing such interventions to mitigate their water risks. There is also lack of clarity in the decision making process of why certain green innovation approaches are adopted and not others. There seems to be also no clarity in terms of the potential impact of implementing a specific intervention both to business and the wider ecosystems.

7.1 Recommendations for future research

The diagnostic framework developed in this project can be used by businesses to better understand their relationship with water. The diagnostic framework illustrates the links between the various factors that influence risks to companies and the role of green business innovation. The framework permits companies to strategically review their water situation (associated risks) and therefore adopt appropriate green innovations in order to improve performance and broader environmental and socio-economic wellbeing. However, various elements of the framework would need to be tested, which provides a good opportunity for further research.

The following steps are therefore recommended as a follow up to this research:

1. There is need to conduct more research into each element of the framework that links corporate performance and the type of green innovation adopted by companies, on the one hand and its implication on the broader landscape dynamics.
2. Measuring the impact of green innovations is to a large extent determined by well-defined metrics. Considering that there are no clearly measureable metrics for assessing the impact of green innovations, its recommended that a further study look into the opportunities of exploring the development of indicators.
3. From a technological perspective, the slow uptake of green innovations could partly be attributed to a poor pipeline of innovative concepts and products reaching the market place. There is a need to therefore conduct research on how to effectively commercialize or scale up green innovations for wider uptake.

4. There is need to develop a better understanding of corporate decision making processes, including the interpretation of enterprise risk, to enable better understanding of how to mainstream green innovation tools and approaches in corporate South Africa.

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9 APPENDIX

Stakeholder perspectives on the adoption of green innovations

This section provides a summary of the various engagements with key stakeholders in the private, public and civil society sectors held in various locations in South Africa, and telephonically between July 30th and 15th December 2014 (Table 8). The objective of the engagement was to get the perspective of key stakeholders on green innovations in South Africa, ranging from basic understanding of the concept to the policy framework for green innovations.

Key stakeholder participant list for stakeholder engagement on perspectives of green innovations.

Table 8: Stakeholder participant list for stakeholder engagement on perspectives of green innovations

Entity	Date
National Treasury	19th August 2014
Department of Science and Technology	5th August 2014
UNISA	5th August 2014
National Business Initiative (NBI)	13 August 2014
University of Stellenbosch	16th August 2014
TIPS	15th August 2014
WWF	29th August 2014
SALGA	1st September 2014
Climate Innovation Centre	5th August 2014
Standard Bank	7th August 2014
Toyota	19th November 2014
Impahla Clothing	19th November 2014

What specific role is your organization playing in relation to promoting green water related innovations in South Africa?

Responses to this question were mostly informed by the respective mandates of the organizations that were interviewed. In the case of the public sector, the Department of Science and Technology (DST) is mandated to promote green innovations in South Africa, and thus spearheads many of the interventions that have been implemented. DST specifically has developed a comprehensive water research and innovations roadmap for South Africa, which seeks to position South Africa as a leader in water technologies in developing countries, and increase the number of SMMEs operating in the water sector.

Private sector institutions such as commercial and development finance institutions play a critical role in providing financial support to promote green innovations. For example the Industrial Development Corporation (IDC), views its role as that of catalyzing industrial development in South Africa and Africa, with the green economy that encompass most innovations viewed as a key sector. The commercial banks on the other hand are key for providing finances to businesses that are critical for operationalizing the green economy in South Africa, including entities whose business models are based entirely on green innovations. In this regard, the commercial banks are critical for helping green companies transition from being start-ups to fully viable commercial entities.

How important is water quality and quantity in the operations of your organization?

Regarding exposure to water risks in relation to their operations, many stakeholders especially the private sector report that the worrying water situation in South Africa presents a massive challenge to their operations. As a result their engagement on water issues is not only a corporate responsibility stance but rather an attempt to address potential risks that threaten the sustainability of their core operations. In response to their water risks many of the companies have developed internal water management strategies to mitigate their risks, and have assessed their water footprints as well.

In an attempt to manage their water risks, and implement innovative green technologies, transparency in relation to information appears to have been a critical factor in ensuring success of interventions. This is because water poses a shared

risk, and in many cases requires companies to engage external stakeholders and expertise to be able to effectively address their water risks. This leads to corporate in between companies that in some go beyond addressing the water challenges they face.

In terms of priorities in addressing water challenges, innovations linked to improving water quality are viewed as critical, especially in relation to AMD. AMD threatens the integrity of many freshwater ecosystems in some of South Africa's most critical catchments, and pose a threat both to human health and the economy. Considering that the source of this dangerous AMD is abandoned mines, it poses major reputational risks to companies, and as a result they are keen to seek major interventions to curb this scourge in order to secure their social license to operate.

Priority catchments that organizations are concerned in relation to water challenges

The catchments that are viewed as critical for managing water resources are linked directly to the countries' economic hubs. This is understandable, because these catchments pose the greatest threat to South Africa's economy in relation to challenges of water quality and quantity. Some of the catchments that were regarded as critical based on the current water situation on the operations of many companies include the following:

- The Vaal
- Pongola Umzimkulu
- Olifants
- The Berg river
- Limpopo

These catchments will be used to analyze the impact of green innovation on aquatic integrity at the catchment level, on the hypothesis that green innovations being implemented by individual companies should reflect the priority water issues in the catchment where they are located.

Financial resources for supporting green innovations

Financial resources dedicated to promoting green innovations varied widely depending on stakeholders, but in general there appears to be a relatively poor understanding of how much financial resources have been dedicated to green

innovations by individual companies and collectively. This corresponds directly to the green economy and climate sector in general in South Africa, where tracking climate finance has been a major challenge for some time now.

Monitoring mechanisms for green innovations

Monitoring of green innovations is done at various levels by the organizations interviewed, depending on the nature of their operations. Organizations that support active green innovation projects on the ground, reported challenges with the implementation of effective monitoring systems, especially for small projects compared to large projects. In the case of large projects, in many cases they have internal mechanisms for monitoring progress, such as well-defined indicators that are aligned to measurable outcomes.

Key barriers for implementing green innovations

Numerous barriers were identified by the stakeholders, that if addressed could potentially unlock numerous challenges that are currently being faced in the implementation of green economy in South Africa

- Most stakeholders expressed the opinion that there no consistent narrative of the green innovations. Different sectors and players have their own interpretation of the green innovations, even “different government departments interpret the green economy differently”. This perceived lack of a national narrative and was seen as a major barrier in the implementation of green economy initiatives.
- Lack of capacity, specifically at local government level was consistently identified as a barrier. This lack of capacity is making it extremely difficult to implement green innovation initiatives at the local level, which in turn has impeded service delivery.
- The discourse around the green innovation was perceived to be using complex ‘language’ and terminologies that do not resonate with many people as a result it has made it difficult to mainstream the green innovation agenda into society.

Other barriers that were identified include issues to do with intellectual property (IP), procurement challenges and choice of technologies to be adopted. Many key players also view green innovation initiatives as ‘nice to have’, and therefore are not prioritized and given the urgency they deserve. Regulatory hurdles in some cases

disincentivise the uptake of green innovations, which became apparent in the implementation of solar water heaters for example.

Overview and Summary

In summary, an integration of various conditions are required for proper ecosystem functioning, the supply and availability of quality water and other services for industries and local communities. One or more of these various conditions may drop as a result of poor river health which in turn may lead to disruption of the ecosystem balance, increased levels of toxicity, reduced ability to regulate the quality and flow of water as well as reduced availability of water to support domestic, agricultural and industrial processes. When water quality is compromised, it can become unfit for human consumption (drinking, cooking, and sanitation) as well as agricultural processes (soil pH). Severe reduction in water quality may render it unfit for irrigation of crops or for industrial processes. Lack of water to meet these needs constrains our human subsistence and development.

These impacts have other knock-on effects such as increased expenditure and effort on water treatment, loss of biodiversity and increased dependence by humans on a few species of plants and animals to meet food, fibre and construction needs. It also renders ecosystems more vulnerable to change. Extreme events such as flooding and drought can be more frequent and more severe, when river ecosystems are compromised. In addition, reduction in river health in one part of the river may have knock-on effects downstream, such as increased siltation and blocking of river mouths. The cumulative effects of poor river health upstream will have a far greater impact on downstream stretches, and if downstream stretches are themselves compromised, the river may not be able to tolerate and recover from the effects. For this reason it is important to monitor the pressures and the management responses as well as actual river conditions, in order to establish if conditions are likely to improve or worsen, and if the responses are being effective. The importance of sustainable water use cannot be over-emphasised for long term economic, political, social and environmental security

This chapter sought to build understanding on the linkages between green water innovations and their link to building aquatic integrity and improving company

performance. In any an attempt to demonstrate these linkages a framework was developed that shows how the prevailing water situation in concert with socio-economic and political context present a water risk to companies. The water related business risks that companies face range from social license to operate (defined by their relationships companies nurture with surrounding communities), to impact on profitability as a result of associated financial costs of mitigating water risks.

Water related business risks are therefore used as a departure point to motivate for green innovations, which would ultimately enable the company to mitigate its water risks resulting in reduced costs, better reputation and assurance of supply. When companies engage in green innovations, there are direct implications on the integrity of aquatic ecosystems, as well as socio-economic outcomes. These linkages are demonstrated by the fact that business that engage in water stewardship will generally contribute into broader outcomes at the catchment level, and also create opportunities for their stakeholders including community members.

The case studies that were identified therefore attempted to demonstrate the linkages between key water related issues that companies are concerned with, such as assurance of supply and good water quality and catchment level dynamics. To achieve this the case studies attempted to link company water related interventions, either in their operations or supply chains, to priority water issues at the catchments where the interventions is being carried out. The assumption is that by aligning company interventions to specific issues that have been identified in the catchment, the company is in a better position to contribute to the integrity of aquatic ecosystems at that level.

Table 9: Summary of the case studies profiled in this report

The table below (Fig. 9) provides a compressive summary of the case studies review and their linkages with catchments in which they occur, including the nature of risks faced and how it can be addressed through green innovations.

Company	Description of green innovation	Associated catchment	Business risk	Role of green innovation	Catchment value add
Toyota	- Water optimization projects - Recycling water for car washes - Rain water capture	Umvoti to Umzimkhulu - Average high rainfall - Subsistence farmers (3rd lowest per capita income in SA) - Commercial agriculture	- Reputational - Regulatory - Water supply - Production - Profitability	- Reduce amount of water used in operations - Recycle water for operational use	- More water made available for various users
SABMiller	- Better barley for beer	Gouritz - Low rainfall	- Reputational - Regulatory - Water supply - Production - Profitability	- Promote sustainable farming	- Better monitoring of ground water and stakeholder engagement
SASOL	- Anaerobic membrane bioreactor used to clean wastewater and also produce biogas as a by-product	Upper Vaal - Low rainfall - Highest concentration of urban, industrial, mining and power generation in South Africa	- Production - Profitability - Reputation - Regulatory	- -Reduction of up 80% of waste production of biogas to be used in plant - improve business efficiency - offers competitive advantage -	- Improved water quality,
Woolworths	- Farming for the future program - Implementing climate smart farming -	National - Focus on supply chains	- Reputational - Profitability - Water supply quality and quantity - Regulatory	- Addresses water risks in supply chains	- Co-operation in water management - Increased water savings - Stakeholder engagement
Anglo-American	- Mine water treatment	Olifants - Extensive mining, agriculture	- Reputational - Profitability	- Production of potable water for municipality	- Improved water quality

			and large municipalities	-	Water supply quality and quantity - Regulatory	-	Reduce waste product - Positive waste utilization	-	Reduction of waste in water supply
Unilever	-	Smart water efficiency technologies - Traceability of supply chains	Limpopo, Umvoti to Umzimkhulu	-	Reputational - Regulatory - Water supply - Production - Profitability	-	Smart technology allowed for 70% of water recover - Recycle process and shower water	-	More water made available for various