THE ROLE OF ORGANISATIONAL NESTING IN RISK-SHARING – A CASE STUDY OF WATER SECURITY IN THE SOUTH AFRICAN SUGAR INDUSTRY

Busani Masiri

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Faculty of Arts, School of Social Science, Monash South Africa

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Abstract

One of human society's priorities is to achieve water security. However, this securement will require farsighted collective action. For many organisations, the dynamic process of maintaining an effective alignment with the environment while managing internal interdependencies is complex, encompassing decisions and actions at several organisation levels. Alignment of stakeholder behaviour towards common goals is important in the governance of common-pool resources such as water. This thesis is based on the premise that organisational nesting and polycentric governance enable stakeholders in the South African sugar industry to align their behaviours and manage risk collectively based on their perception of the rules and expected benefits from the outcomes. It is also based on how they affect interpretation and management of risk in the industry, with particular reference to water scarcity.

The objective of this research was to gain insight into how the sugar industry achieves the farsighted collective action required for progress toward water security. Because water security is a reflection of exposure to risk, I postulated that organisational structure and governance would be consciously adapted to manage risk. One approach to promoting learning and adaptation in complex systems, such as the sugar industry, is to implement polycentric governance.

The design of the study was qualitative in nature. In this research, I used a case study approach to investigate the role of organisational nesting in risk-sharing among sugar industry members within the uMngeni River Basin in KwaZulu-Natal, South Africa. I used semi-structured interviews with industry stakeholders to gain insight into their perceptions of water security and how it was affected by institutional design. The interviews were conducted with twenty two respondents from the sugar industry. These respondents included sugarcane growers and their representatives, millers, extension services, and natural resources management representatives of the sugar industry.

Respondents based their perceptions of water security on issues such as quality, quantity, and broader sustainability, including the nature of resource development and its social and economic consequences. I use these responses to interpret how perceptions of risk have influenced the evolution of governance, particularly polycentric governance, in the industry. Findings from this research suggest that in its response to risk to water security, the South African sugar industry is using polycentric governance. In addition, these findings show that organisational nesting and polycentric governance have facilitated the development and implementation of programmes that contribute to attaining a sense of water security within the industry. These results provide an insight into the wider relevance of risk-sharing and organisational nesting among actors in social-ecological systems regarding water security.

Keywords: *polycentric governance, collaborative decision-making, nested enterprises*

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signature: [redacted]

Print Name: **Busani Masiri**

Date: **11th June 2016**

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Dedication

To the Masiri family

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Acronyms

BTI	Board of Trade and Industry South Africa
CANEGROWERS	South African Cane Growers' Association
CARA	Conservation of Agricultural Resources Act (Act no. 43 of 1983)
CAS	Complex Adaptive Systems
CEO-WM	CEO Water Mandate, United Nations Global Compact
CPR	Common-pool Resources or Common Property Resources
CSIR	Council for Scientific and Industrial Research South Africa
DAFF	Department of Agriculture, Forestry and Fisheries South Africa
DWA	Department of Water Affairs South Africa
FAO	Food and Agricultural Organisation of the United Nations
GWP	Global Water Partnership
KZN	KwaZulu-Natal
LEC	Local Environmental Committee
LGC	Local Grower Council
MEA	Millennium Ecosystem Assessment
MGB	Mill Group Board
NAMC	National Agricultural Marketing Council South Africa
NGO	Non-Governmental Organisation
NSA	Natal Sugar Association
NSMA	Natal Sugar Millers Association
OECD	Organisation for Economic Co-operation and Development
SACGA	South African Cane Growers' Association
SACU	Southern African Customs Union
SASA	South African Sugar Association
SASMA	South African Sugar Millers' Association
SASMRI	South African Sugar Millers' Research Institute
SASRI	South African Sugar Research Institute
SES	Social-Ecological Systems
SUSFARMS®	Sustainable Sugarcane Farm Management System
WEF	World Economic Forum
WRG	2030 Water Resources Group
WWAP	World Water Assessment Programme

CHAPTER ONE
INTRODUCTION

Managing risk is central to organisational sustainability; the better organisations are at sensing and constructively responding to emerging risk, the better they are able to cope with change. This reality is particularly apparent in complex systems where actors experience risk differently. Yet how each actor (or interest group) responds can have profound influences on all stakeholders. For example, how growers respond to water insecurity affects sugarcane production, which in turn affects others along the value chain, from processors to retailers and consumers. And, how consumers respond to product availability as well as to their own perceptions of water security can feed back down the value chain, directly and indirectly, to exert influence on how growers use and conserve water. Furthermore, the success of risk management by each group ultimately depends on how risk is managed collectively. The effects of water insecurity on stakeholders help us appreciate the need for a collective approach to governance, one in which there are multiple levels of governance and where collective learning is advanced through coordination and integrated decision making.

1.1 BACKGROUND

Risk is a threat, laced with uncertainty, to something of value (Fischhoff and Kadvany, 2011). Technically, it may be conceived as the extent of damage or harm that a hazard entails, multiplied by the probability of that hazard's occurrence (Conca, 2015). Risk is increasingly recognised as a social construct, having different meanings for different people. As such, risk assessment then becomes more than a technical endeavour involving social judgments of importance of varying events, along with equity issues related to the distribution of costs and benefits (Mazaika et al., 1995). Thus, a need for collaborative action arises.

These collaborative efforts towards environmental governance and nested institutions (discussed below) reduce exposure to failures and losses through a degree of independence. For example, the inclusion of non-governmental organisations (NGOs) in a governance system provides a diversity of ideological positions and policy ideas (Schoon and York, 2011). These multiple centres of authority in a nested structure provide opportunities for successful experimentation to spread and failures to remain isolated (Schoon et al., 2015).

Organisational nesting is a structure where there are groupings that are separately identifiable but are also part of a larger organisation (Ostrom, 1990; V. Ostrom, 1999; Marshall, 2007). Once a group of resource users (actors) have established an organisation to accomplish collective goals, organisational structure evolves to increase the effectiveness of the organisation's control of the activities necessary to achieve its goals (Jones, 2013). Organisational structure is thus the formal system of task and authority relationships that control how actors coordinate their actions and use resources to achieve collective goals (Barnard, 1948; Etzioni, 1964). Jones (2013, p. 30) posits that 'the principal purpose of organisational structure is one of control: to control the way people coordinate their actions to achieve organisational goals and to control the means used to motivate people to achieve these goals'. Hence, an organisational structure can be used to align the behaviour of actors towards a common goal – in this case, water security.

This type of organisational structure may contribute to the proactive efforts that are necessary to sustain the coordination and integrated decision making required for equity in the distribution of benefits and risks from environmental changes (Lebel et al., 2006). Thus, unsurprisingly, there is growing recognition of the importance of self-organisation among resource users to constitute their own local jurisdictions and associations, using the knowledge and experience they have concerning the public issues they encounter (Ostrom, 2009). However, as these jurisdictions and associations develop and strengthen, the requirement for collective action and governance to manage interdependencies among groups becomes even more pressing.

One approach to risk presumes that the biggest risk is sub-optimal water use, rooted in poor coordination, a lack of information, and weak stakeholder participation (Conca, 2015). Thus, most of the institutional adaptations to manage this risk have involved creating greater administrative complexity (Conca, 2015). Yet for many organisations, the dynamic process of maintaining an effective alignment with the perceived needs of the environment while managing internal interdependencies is complex, encompassing decisions and actions at several organisation levels (Miles et al., 1978). However, when smaller decision making units are nested within a larger unit, it enables a system of polycentric governance, in which there are multiple decision making centres that retain considerable autonomy from one another (Ostrom et al., 1961; V. Ostrom, 1999; V. Ostrom et al., 1999). In so doing, the governance system optimises learning and application of knowledge generated at different scales of, in this case, the sugar industry.

While the practice of water allocation has always faced and addressed risks, mounting influences from stakeholders and recognition of the resulting, ever changing amount of available water within a given area are leading to a changing landscape of risks (Baroang et al., 2009). Organisational nesting provides a way for collective action and promoting behaviour alignment to enhance equity in risk-sharing. In such a mode of institutional design, the representation of interests increases from the base units to the upper level. As such, each level (or nest) can identify the risk it faces and the best way to mitigate such risk within the context of the larger organisation. This research was informed by the eighth of Ostrom's design principles for community-based natural resource management. Ostrom (1990, p. 90) noted that; 'appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organised in multiple layers of nested enterprises'.

This network of nested enterprises is also known as 'organisational nesting'. According to Marshall (2009, p. 44), 'such a nesting of enterprises results in a polycentric governance system: a system comprising multiple decision making centres'. Each centre retains substantive autonomy from the others.

In this thesis I define 'organisational nesting' as the way actors are ordered on a spatial scale with respect to the sugar industry as a whole. In this regard polycentric governance describes the manner in which authority is distributed among actors and interest groups. Polycentric governance thus defines the relationship and manner of interaction among and between different actors and interest groups.

Organisational nesting may occur between user groups and larger governmental jurisdictions or between user groups themselves (Cox et al., 2010). The South African (SA) sugar industry provides an example of both vertical (connections between multiple jurisdictional levels) and horizontal (intercommunity connections) organisational nesting. In an ideal system, each governing unit interacts and links with other authorities both horizontally and vertically to achieve a balance of collaboration and autonomy (Schoon et al., 2015). For example, growers associate around a mill closest to their operations, so at a local level there is horizontal organisational nesting between the millers and the growers. Thus, owing to their interdependence, a fundamental relationship exists between these two interest groups. This relationship finds expression as a Mill Group Board (MGB) at a local level.

Furthermore, in the SA sugar industry, organisational nesting provides a structure under which the various interest groups are organised and represented locally, regionally, and nationally. Organisational nesting is how the various actors within the industry are ordered in relation to each other and the South African Sugar Association (SASA). These multiple collaborative networks form a polycentric system of environmental management that is coordinated (Schoon et al., 2015). Polycentricity then describes the relationship between the different actors and interest groups in the resource system.

In a nested organisation, the goal is to involve local as well as higher organisational levels, with the aim of finding a balance between decentralised and centralised control (Imperial, 1999; Folke et al., 2005). Thus polycentricity is an inclusive way of governing a nested structure. The concept assumes an organisational structure where multiple, independent actors mutually order their relationships under a general system of rules (Ostrom, 1972; Araral and Hartley, 2013). Such a decentralised design serves to increase the legitimacy of the governance system at a given level through the participation of the local resource users who have an input into decision making (Engle and Lemos, 2010). The overall effect of pushing the decision making authority and responsibility down to the lowest level possible is the increase in legitimacy and accountability among resource users (Schoon et al., 2015). This ordering of responsibility benefits the monitoring and enforcement of locally designed and implemented rules (Schoon et al., 2015).

1.1.1 Shared Risk Approach and Water Security

Individuals, governments, and businesses share water scarcity risks even if they conceptualise them differently. Water scarcity, pollution, and other water-related risks bring about a state of water insecurity. The perceptions of these risks at an individual level, group level, and government level drive resource users' behaviour towards mitigating the associated risk and management of the impact of water insecurity. Risk is what connects these groups together, aligning them towards collective action. The aim of such collective action is to collectively mitigate the risks that may impact the resource users. The goal is water security, a state where there is sustainable use of water resources.

Water scarcity risks are subjective and vary from time to time and from place to place. Thus there can be no single response to risk management. However, according to Orr et al. (2009, p. 35) there are four key outcomes that can be achieved through risk-sharing:

- Interventions that reduce long-term scarcity and risk (such as protecting environmental flows for rivers);
- Water allocations that prioritise water for those people and ecosystems that are least equipped to cope with water scarcity;
- Flexibility to change, including the ability to use water more productively, which can reduce the risk generated by the physical phenomenon of water scarcity and the uncertainty caused by climate change; and
- Progressive public policy, strong water management institutions, and active involvement of a broad range of stakeholders, which can be achieved through organisational nesting.

These outcomes can be achieved through organisational nesting and polycentric governance because of the participation of the various actors in issues that affect them, from identification of risk to finding solutions on how to mitigate it.

1.2 RESEARCH ISSUE

The third World Water Development Report examined several drivers of change, including climate change and demographic, economic, social, environmental, governance, and technological drivers, as well as their interactions as they relate to the sustainability of water-use patterns (WWAP, 2009). These drivers of change, along with natural processes, define and shape water-related risks such as water scarcity, water quality degradation and pollution, loss of water-related ecosystem services, and the impact of extreme weather events. While some drivers of change might increase both water-related and other critical risks (e.g. global economic collapse); others may result in positive outcomes beyond water resources, but exacerbate water-related risks (for example, economic growth that leads to increased water use and consumption) (Baroang et al., 2009).

Ecosystem services are the benefits people obtain from ecosystems (MEA, 2005b, p. v). As more actors lay claim to ecosystem services, a need arises for a governance system that takes into account the input, views, and concerns of the additional stakeholders. The diverse ways in which stakeholders benefit from common-pool resources (CPRs) result in a complex configuration of resource users, and problems in benefit sharing are bound to be experienced in such a resource system as risks to the social-ecological system (SES) emerge. Anderies et al. (2004) define a SES as an ecological system intricately linked with and affected by one or more social systems. CPRs as defined by E. Ostrom (2008b, p. 3) 'are resources that are sufficiently large that it is difficult, but not impossible, to define who are the recognised users and to exclude others'. Examples of CPRs are water basins, fisheries, and forests. It takes the input and actions of multiple actors to achieve outcomes that elicit supportive actions from all actors.

In terms of this study, production within the sugar industry is dependent on water; therefore water scarcity and the need to collectively manage risk associated with scarcity are key issues. Collective management is necessary because sugarcane growers and millers are co-dependent: the growers need millers to sell their crop to and the millers need the growers for their raw material supply. Water scarcity thus poses a risk to the entire production system within the industry. Indeed, because of the co-dependence among actors in the sugar industry, the risk experienced by one group influences actors throughout the value chain. In other words, risk to one affects risk to the others, so they need to act collectively in their response to risk. Another issue is that of the perceptions the market (for the industry's products) has of how the industry manages the use of water and other environmental services, because of the influence it has for exposure to risk by actors outside of the industry. So the key issue that the industry has to address is collective management of risk to production and to demand.

However, groups within the industry may sense risk at different times and in different ways. Thus nested institutions enable the creation of rules for social engagement and collective action to fit the problem they are meant to address (Schoon et al., 2015). As noted by Schoon et al. (2015, p. 227), 'good governance requires active engagement of individuals in the problems that directly affect them and allows them to participate, share their knowledge and resolve social and environmental dilemmas in their lives through participation in collective-choice arrangements'. Because water is a shared resource (a CPR), perceptions of and approaches to risk management have to take into account direct risk to production but also indirect risk that arises from perceptions others have of how responsibly agriculture uses water and other natural resources.

The issues described above have arisen as a result of a changing environment. Climate change brings changing patterns of precipitation and evaporation, which will alter run-off, with consequences for water availability and ecosystem functioning (Conca, 2015). These changes have an impact on soil moisture, altering the availability of 'green water' in the plant root zone, with consequences for soil moisture, ecosystem functions, and agricultural productivity (Conca, 2015). Warnings about the water-related consequences of climate change typically contain three premises: 'that significant effects are likely, that they are unpredictable in their precise spatial and temporal manifestation, and that they will be disruptive of the existing ways societies use and interact with water' (Conca, 2015, p. 301). Taken together, these three presumptions frame the climate-water problem as one of an emergent risk to be managed through adaptation (Conca, 2015). Climate change thus adds important elements of uncertainty to the challenges of water governance, and the likely changes in the water cycle pose many hazards. Framing the problem as one of risk management, however, begs the question of which risks are in fact being managed or are likely to be managed, and towards what end (Conca, 2015).

Indeed, the management of risks affect the multiple actors in the SA sugar industry, who are part of an even larger SES, which includes other actors outside of the sugar industry who lay a claim to the water resources in the uMngeni River Basin. Therefore, because organisational structure provides a way of aligning actors' behaviour, the focus of research in this study is how organisational nesting evolved within the sugar industry and how it is being used for the alignment of behaviour towards the collective management of risk with the goal of water security.

1.3 RESEARCH OBJECTIVES

This research considered the contribution that organisational nesting makes to the development, improvement, implementation, and adoption of water security programmes, within the context of risk-sharing among multiple actors. It was directed by the proposition that organisational nesting and polycentric governance enable stakeholders in the sugar industry to align their behaviours and manage risk collectively, based on their perception of the rules and expected benefits from the outcomes and how they affect interpretation and management of risk in the industry, with particular reference to water scarcity. The objective was to investigate the role of organisational nesting in risk-sharing among the various actors in the SA sugar industry within the uMngeni River Basin in South Africa.

1.3.1 Research Questions

- Is organisational nesting in the industry a consequence of the need to share risk?
- In what ways does organisational nesting enable risk-sharing mechanisms in the industry?

1.4 STRUCTURE OF THE THESIS

The thesis is organised into eight chapters. Chapter One introduces the study. The second chapter develops the theoretical framework that guided the study. Of particular importance here are the concepts and perceptions of risk posed by water insecurity towards agriculture, and theories of organisational nesting and polycentric governance and their influence on natural resource use and management.

Chapter Three describes the self-organisation within the SA sugar industry. This discussion is necessary because the governance structures within the industry play an important role in shaping industry members' perceptions of risk. It also plays a role in the collective management of risk through polycentric governance among its nested units.

Chapter Four describes the case study area, and Chapter Five details the approaches, methods of data collection, and the analysis tool employed for this study, including an overview of the research paradigm. This chapter also presents on how the issues of reliability and validity of the research findings have been considered when interpreting the findings.

Chapter Six presents the research results, and the implications of these results are discussed in Chapter Seven. The discussion particularly focuses on the research objective and key questions. Chapter Eight offers conclusions for the thesis.

CHAPTER TWO
LITERATURE REVIEW

The purpose of this chapter is to develop the concepts and theoretical background that underpinned this study. The argument presented here is that in the agricultural industry, water-related risk and organisational nesting are linked through the absolute requirement for water, risk associated with the inherent variability of supply, and how the industry organises to manage risk. I develop these concepts and illustrate how they might be applied in the SA sugar industry.

2.1 RISK

Because natural resource systems are complex, we can never have a complete understanding of them. Subsequently, natural resource systems are not stable; they are in a constant state of evolution and, consequently, high levels of uncertainty amongst stakeholders are common. The International Energy Agency (IEA) projects that the water consumption needed to meet the needs of energy generation and production would increase by 85% by 2035 (IEA, 2012). Faced with increasing demands for water from various resource users, actors adopt an integrated risk management approach that incorporates the views and opinions of the various stakeholders and interest groups. The purpose is to arrive at allocative decisions that are equitable and offer best options for sustainability in the long term.

Thus, in the context of changing environments, managing risk becomes an act of following a strategy that incorporates the understanding that the likelihood and consequences of hazards cannot be known with full precision. The hazards, or risks, are difficult to specify with precision because, as Lidskog and Sundqvist (2012, p. 1002) point out, 'risks are always situated in a social context and are necessarily connected to actors' activities'. Risk management is thus a socially constructed way of countering vulnerability (Zinn, 2006).

Because global water requirements are projected to go beyond sustainable water supplies by 40% by 2030 (2030 WRG, 2009), the World Economic Forum (WEF) named water crises in its 2015 Global Risks Report as the top global risk in terms of impact (WEF, 2015). Moreover, water crises and failure of climate-change adaptation are perceived as having more impact on the environment when compared to other risks (Figure 2.1). The environmental risks identified in the figure below are related to water;

- Man-made environmental catastrophes
  The unsustainable use of water resources can lead to environmental disturbances e.g. the eutrophication of water bodies due to nutrient loading from pollution.

- Extreme weather events

  Climate change has an effect on rainfall patterns thus the amount of available water. This can be experienced as instances of flooding or periods of drought.

- Biodiversity and ecosystem collapse

  Over-abstraction of ecosystem goods and services with no regeneration leads to the collapse of an ecosystem. The collapse of an ecosystem comes with biodiversity losses. Availability of water has a direct effect on this. This is so because water is a central resource necessary for the resilience of both aquatic and terrestrial ecosystems.

- Failure of climate change adaptation

  A readily discernible indicator of climate change is the change in the rainfall pattern in a given area. Changes in available water should prompt actors to develop adaptation measures. A failure to plan and initiate adaptation to climate changes impacts on the effectiveness of actors to cope with environmental risks e.g. droughts.

Because climate change comes with changing patterns of precipitation and evaporation, there is an impact on soil moisture, altering the availability of 'green water' in the plant root zone. The effect of climate change has consequences for agricultural productivity, run off, and ecosystem functioning (Conca, 2015). Agriculture already accounts for 70% of total water consumption (through irrigation) and the World Bank (2015) estimates that food production will need to increase by at least 50% by 2050,yet climate change could cut crop yields by more than 25% (Hanjra and Qureshi, 2010; World Bank, 2015).

Over the past decade, awareness has grown regarding the threats posed by environmental change to social, political, and economic security (WEF, 2015). As the Global Risks Perception Survey 2014 highlights, three of the top ten risks in terms of impact over the next ten years will be environmental risks, water crises, and failure of climate-change adaptation as well as biodiversity loss (see Figure 2.1) (WEF, 2015). Because water is a shared resource, perceptions of and approaches to risk management have to take into account direct risk to agricultural production but also indirect risk that arises from perceptions others have of how responsibly agriculture uses water and other natural resources. These different types of risks bring to fore issues of governance and how the actors are ordered in a resource system.

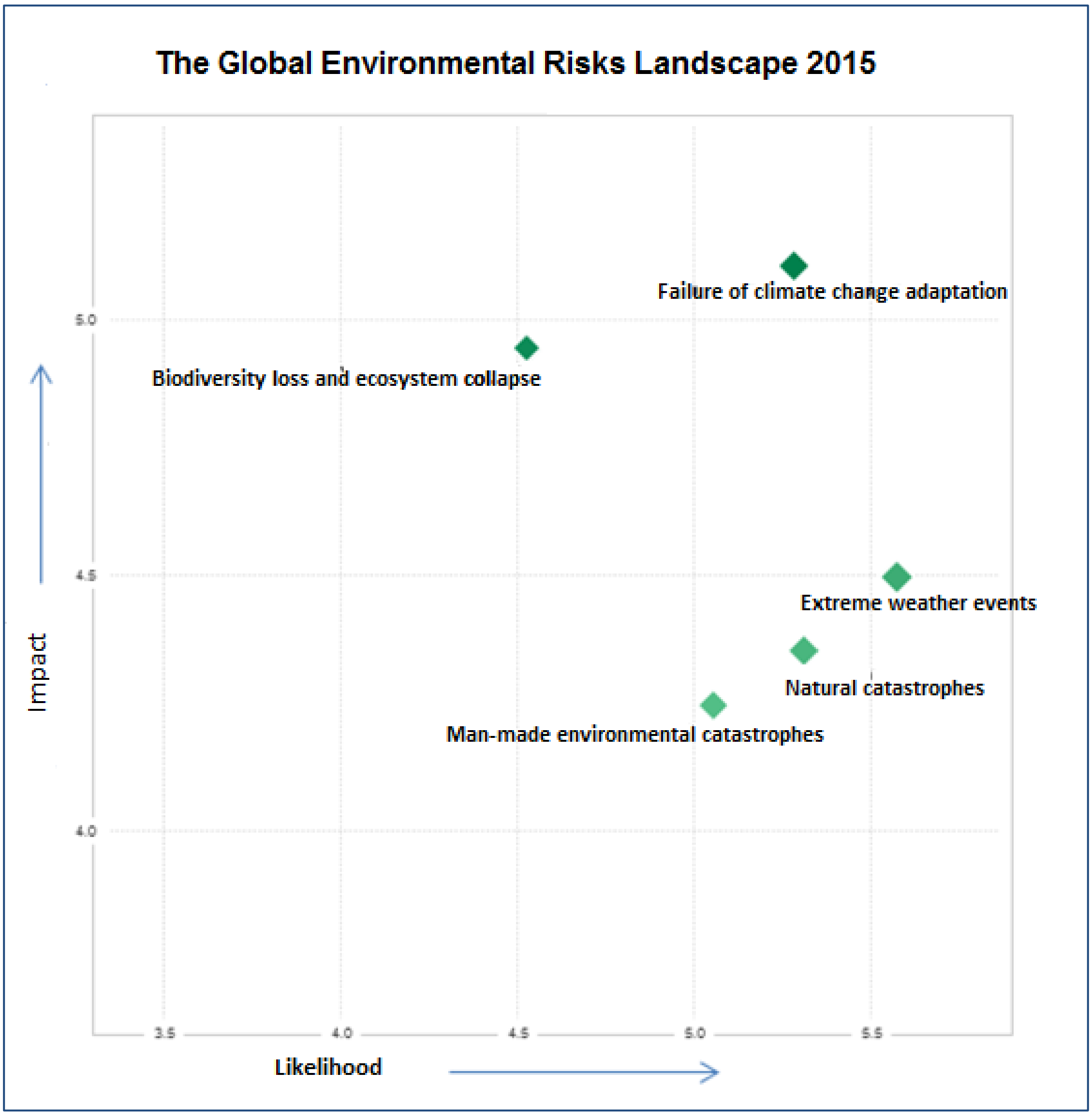

Figure 2.1: The global environmental risks landscape (WEF, 2015)

2.2 ECOSYSTEM SERVICES FOR AGRICULTURAL PRODUCTION

Agricultural ecosystems both provide and rely upon important ecosystem services (Zhang et al., 2007). Daily (1997, p. 3) defines ecosystem services as ‘the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life’. Ecosystem services can be classified into four main categories: provisioning, supporting, cultural, and regulating services (see Figure 2.2) (MEA, 2005a).

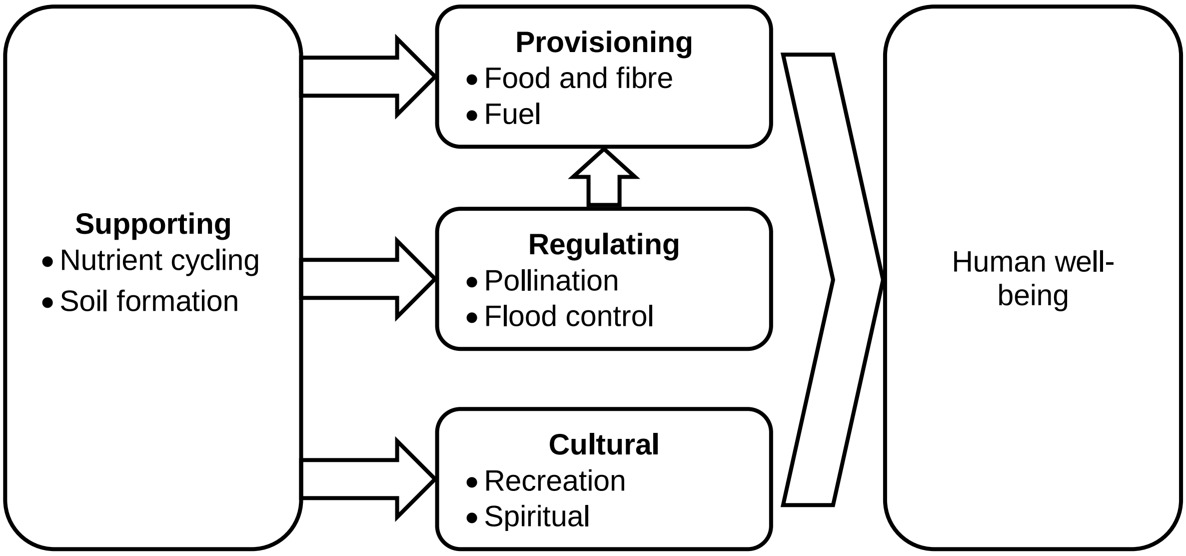

Figure 2.2: Classification of ecosystem services from the Millennium Ecosystem Assessment (Alcamo et al., 2003; Zhang et al., 2007)

Agriculture suffers an array of ecosystem dis-services, which reduce productivity or increase production costs (Figure 2.3). These dis-services manifest as risk to the production system. The flows of these ecosystem services and ecosystem dis-services rely on how agricultural ecosystems are managed at the site scale and on the diversity, composition, and functioning of the surrounding landscape (Tilman, 1999). Moreover, agricultural ecosystems are primarily managed to optimise the provisioning ecosystem services of food, fibre, and fuel (Zhang et al., 2007) and also to mitigate the risk caused by ecosystem dis-services such as competition for water and pest damage. In the process, they depend upon a wide variety of supporting and regulating services such as soil fertility and pollination, which determine the underlying biophysical capacity of agricultural ecosystems (Wood et al., 2000; Heal et al., 2005; MEA, 2005a). Ecosystem dis-services are functions of ecosystems that are perceived as negative for human well-being (Lyytimäki and Sipilä, 2009).

Management of ecosystem services at site scale needs to be congruent with actions taken at a regional and national level. Having the necessary common outlook would require a governance system that is inclusive and takes into account input at the various levels of governance.

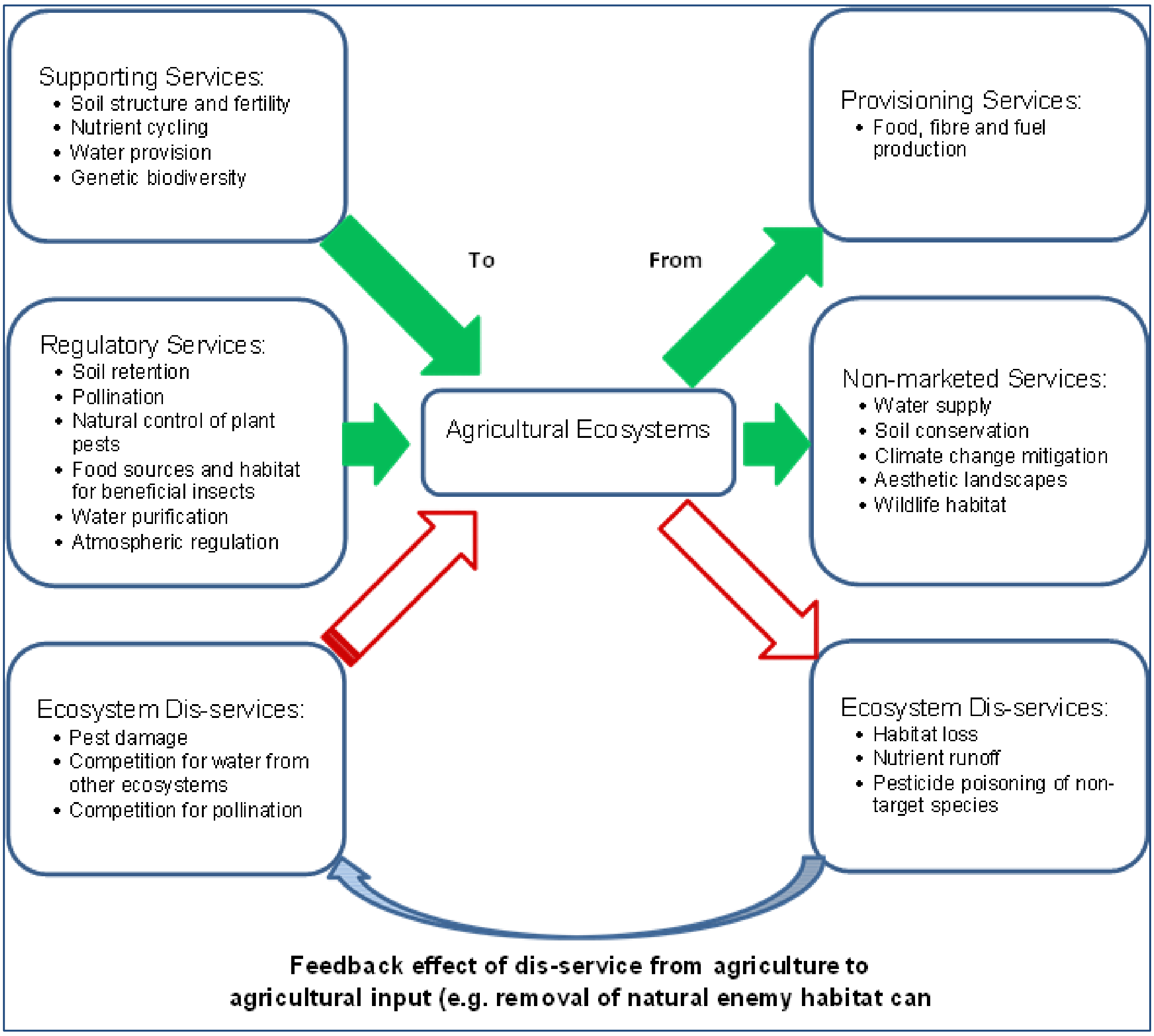

Figure 2.3: Ecosystem services and dis-services to and from agriculture (Zhang et al., 2007). Solid arrows indicate services, whereas the unshaded arrows indicate dis-services.

2.2.1 Risks to Agricultural Production

The production of agricultural goods is highly dependent on the services provided by natural ecosystems. Some services that are essential to crop production include biological pest control, pollination, and water provision. However, such services are under threat from ecosystem dis-services of pest damage, competition for water from other ecosystems, competition for pollination, habitat loss, nutrient runoff, and pesticide poisoning of non-target species (Zhang et al., 2007).

The first such essential service that is under threat is that of biological control of pest insects in agroecosystems. This ecosystem service is important, and is often supported by natural ecosystems (Power, 2010). Non-crop environments provide the habitat and diverse food resources required for arthropod predators and parasitoids, insectivorous birds and bats, and microbial pathogens that act as natural predators to agricultural pests and provide biological control services in agroecosystems (Tscharntke et al., 2005). These biological control services can reduce populations of pest insects and weeds in agriculture, thereby reducing the need for pesticides and the risk to crop and environmental damage. In addition, biological pest control provided by natural agents can substitute directly for insecticides, thus resulting in financial savings for farmers (Power, 2010). For example, an analysis of the value of the biological control of the soya bean aphid in soya bean crops indicated that this ecosystem service was worth a minimum of US$239 million in four US states in 2007 to 2008 (Landis et al., 2008).

In sugarcane production, natural ecosystems can be used in the control of the eldana pest. Eldana (*Eldana saccharina*) is a stem-borer endemic to sub-Saharan Africa and is found in wetland sedges. It was first identified in sugarcane in South Africa in the 1940s and is a growing risk to sugarcane production (Cockburn and Conlong, 2011). Eldana is the most harmful insect pest to sugarcane production in South Africa (Joubert, 2012). The South African Sugar Research Institute (SASRI) has thus been exploring habitat manipulation ('push-pull' method) as an additional measure for the integrated approach to eldana control (Cockburn and Conlong, 2011, p. 12). Push-pull plants can be used to control the sugarcane pest, eldana, while simultaneously nurturing wetlands (Joubert, 2012). Push-pull works by managing the behaviour of the female moth so that fewer eldana eggs are laid in sugarcane, thereby reducing damage to sugarcane (Cockburn and Conlong, 2011).

Plants used for the 'push-pull' approach give off volatile chemicals that discourage the female moth from laying eggs in the sugarcane, whilst also attracting natural predators to the moth into the crop lands. Indigenous plants in wetlands – the original habitat of the insect – entice the female to lay her eggs there instead of the sugarcane crop in the field. When the eldana pest is in its natural habitat among host plants in wetlands, the pest is more accessible to its natural predators and populations can be controlled naturally (Joubert, 2012). The diagram (Figure 2.4) below shows the push-pull concept of using a wetland in its natural state and vegetation to control the eldana pest.

Pollination is the second important ecosystem service to agriculture that is provided by natural habitats in agricultural landscapes. Approximately 65% of plant species require pollination by animals (Klein et al., 2007). As such, a loss of such an ecosystem service is a risk to agricultural production. An analysis of data from 200 countries by Klein et al. (2007) indicated that 75% of crop species of global significance for food production rely on animal pollination, primarily insects (Klein et al., 2007).

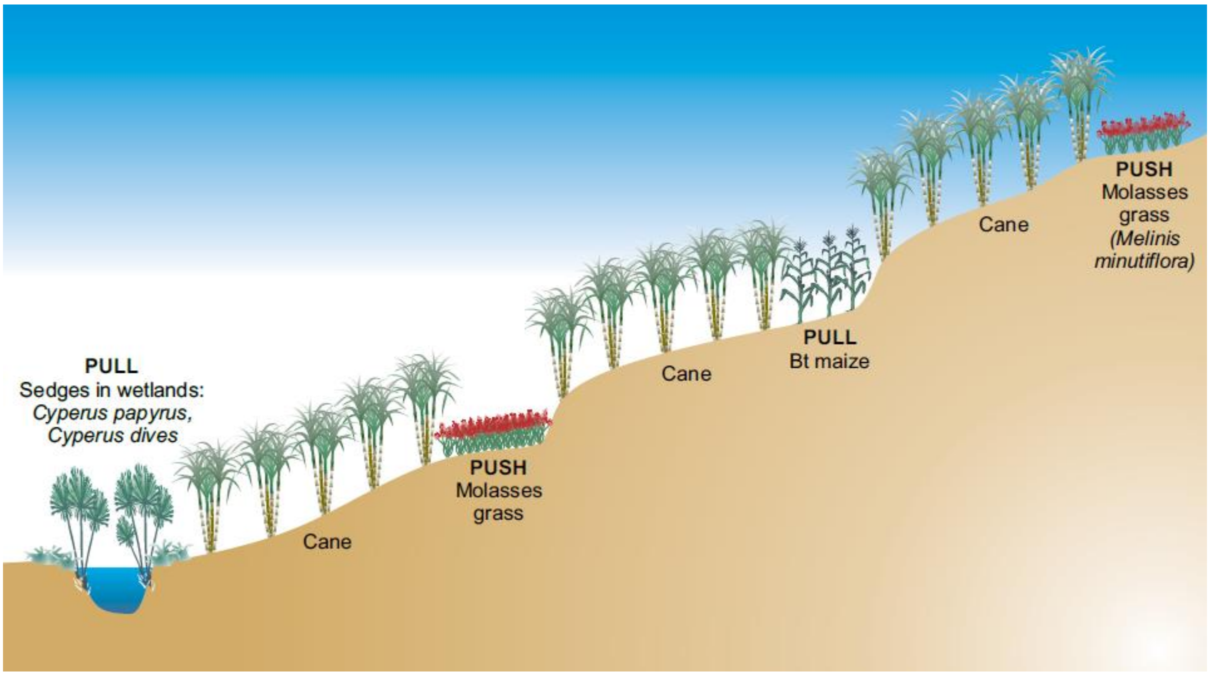

Figure 2.4: Using wetlands and natural vegetation for pest control in sugarcane farming (Cockburn and Conlong, 2011).

The provision of water is a third essential ecological service provided to agroecosystems. Perennial vegetation in natural ecosystems such as forests can regulate the capture, infiltration, retention, and flow of water across the landscape (Power, 2010). The vegetation plays a central role in regulating water flow by retaining soil, modifying soil structure, and producing litter (Power, 2010). Forest soils tend to have a higher infiltration rate than other soils, and forests tend to reduce peak flows and floods while maintaining base flows (Maes et al., 2009). These characteristics have a net effect of reducing the rate of soil erosion, resulting in good water quality. An exception to this generalisation would be fast-growing plantation forests (Power, 2010). Although, they can help regulate groundwater recharge, they may also reduce stream flow and salinize or acidify some soils (Jackson et al., 2005).

Water availability in agroecosystems depends not only on infiltration and flow, but also on soil moisture retention, a fourth ecosystem service enjoyed by the sugarcane growers. Plant cover, soil organic matter, and the soil biotic community (bacteria, fungi, earthworms, etc.) regulate water storage in soil (Power, 2010). The trapping of sediments and erosion are controlled by the architecture of plants at or below the soil surface, the amount of surface litter, and litter decomposition rate (Power, 2010). Thus invertebrates that move between the soil and litter layer influence water movement within soil, as well as the relative amounts of infiltration and runoff (Swift et al., 2004). These soil processes provide essential ecosystem services to agriculture.

Wetlands are thus perceived by society as having particular significance in both biodiversity conservation and in water resource management. By sustaining wetlands and by applying in-field push-pull strategies, communities can enhance the sustainability of ecosystem services within their purview. For example, modifying the tillage regime or mulching can reduce soil evaporation by 35 – 50% (Power, 2010). Rainwater harvest and on-farm storage in ponds, dykes, or subsurface dams can allow farmers to redirect water to crops during periods of water stress, recovering up to 50% of water normally lost to the system (Power, 2010).

By incorporating moderate values (25%) for reductions in soil evaporation and water harvesting into a dynamic global vegetation and water balance model, Rost et al. (2009) predict that global crop production could be increased by nearly 20% from on-farm green water management practices. This value is comparable to the contribution of irrigation (Power, 2010). Thus on-farm management practices that target green water can significantly improve water availability and reduce the risk caused by ecosystem dis-services (Rost et al., 2009). In this regard, 'on-farm' practices become an important approach to managing risk to water security and influencing perceptions of others who share the water resource of a basin.

2.3 WATER SECURITY

Water is essential to agricultural production – from purely rain-fed to purely irrigated – with the majority of crops produced from rainwater (Rosegrant et al., 2009). The goal of adaptive and collaborative governance of water resource use is water security. One of human society's priorities is to achieve water security, without which people and economies find themselves in a state of increased vulnerability (Grey and Sadoff, 2007). Grey and Sadoff (2007, p. 545) define water security as 'the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies'. From this definition, water scarcity presents a condition of water insecurity.

A state of water scarcity refers to a situation where there is insufficient water to satisfy human and environmental water needs for food, feed, drinking, and other uses, implying an excess of water demand over available supply (Hanjra and Qureshi, 2010). Moreover, water scarcity reduces agricultural production and negatively impacts food security. However, demands for water for agricultural production activities have been put under scrutiny, owing to increasing competing demands from urban and industrial uses (Hanjra and Qureshi, 2010). This increased competition calls for a more integrated approach, a polycentric approach, to governance of water resources.

With the increased attention on the concept of water security over the past years, multiple definitions of this concept have arisen. According to Cook and Bakker (2012), various fields of study and organisations define water security differently, depending on their framing of the concept and focus. An example of how different fields of study have an effect on the perception of water security is the difference in perspective between the legal and agricultural subject areas. From a legal perspective, water security refers primarily to security of entitlement to certain quantities of water and is bound by allocation rules that seek to guarantee such quantities (Tarlock and Wouters, 2010). In contrast, from an agricultural perspective, protection from flood and drought risks are also considered key determinants of water security. Defining water security is thus dependent upon one's perspective, which informs the mitigation measures taken to avert the risk of water insecurity.

Cook and Bakker (2012) noted that, in general, the definitions of water security used in the 1990s were linked to specific human security issues, such as military security, food security, and, to a lesser extent, environmental security. At the turn of this millennium, the Global Water Partnership (GWP) provided the following definition of water security:

> *"Water security at any level from the household to the global means that every person has access to enough safe water at affordable cost to lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced"* (GWP, 2000, p. 12)

Since the GWP introduced their definition of water security, which considers access and affordability of water as well as human needs and ecological health, at the Second World Forum in 2000, a number of other definitions for water security have been put forward.

Cook and Bakker (2012), for instance, identify 'human needs' as a theme of water security, a term which they posit covers a range of issues, including access, food security, and human development-related concerns. This perspective of human needs focuses on human vulnerability in relation to water security, and the concept of risk is inherent. This perspective on human needs is also evident in earlier definitions of water security. In 1999, Witter and Whiteford (p. 2) defined water security as 'a condition where there is a sufficient quantity of water at a quality necessary, at an affordable price, to meet both the short-term and long-term needs to protect the health, safety, welfare and productive capacity of position (households, communities, neighbourhoods, or nation)'. This definition places more emphasis on the social system. Jansky et al. (2008, p. 289) go further, defining water security as 'all aspects of human security pertaining to the use and management of water'. However, Cook and Bakker (2012) argue that such human-centred definitions of water security have a tendency to deemphasise the importance of the ecosystem as an integral component of both human and water security.

This study will thus focus on the GWP definition of water security given above. This definition includes seven variables: meeting basic needs, securing the food supply, protecting ecosystems, sharing water resources, managing risks, valuing water, and governing water wisely (Cook and Bakker, 2012). This definition, the GWP argues, implies the need for baseline requirements for water resources management in a watershed on a continuous basis and demands access to adequate quantities of acceptable quality of water for both humans and the environment (GWP, 2000). By extension, since water is a primary requirement for food production, this also means meeting the requirements for production systems.

The need to manage water resources on a continuous basis brings to fore the theme of sustainability. Environmental sustainability is the maintenance of natural capital through protecting the sources of raw materials used for human needs (Goodland, 1995; Goodland and Daly, 1996). Environmental sustainability is a state in which the rates of renewable resource harvest, pollution creation, and non-renewable resource depletion can be continued indefinitely with regeneration within the resource system (Goodland and Daly, 1996). Because the actions of one group of resource users are bound to affect the benefits drawn by others from the same resource system, regeneration is bound to be difficult to achieve if resource users do not collaborate with each other for a collective goal of environmental sustainability. This difficulty owes primarily to the possibility of conflict and competition for resources.

In as much as framings of water security can depend on geographical location, as noted by Cook and Bakker (2012), an analysis of these definitions shows that they are also depend on whom the water security is for – a community, a farmer, or a commercial entity. In considering for whom water security is intended, the issue of temporal scale has to be taken into account. The issue then is about water security for whom and when. Farmers might define water security with the GWP (2000) definition, but their concern is bound to be heightened during the growing season rather than when harvesting their produce. For sugar milling operations, the definition of water security can be aligned to water supply, as defined by Xia et al. (2007, p. 242):

> "*Water security is the ability to supply water, according to a specified quality, to homes and industry under conditions satisfactory to the environment and at an acceptable price*".

This focus on water supply highlights the sugar milling operations' concern of the consistency of water supply during the sugarcane crushing season, which is harvesting time for sugarcane growers. Thus these variable concerns, owing to the manifestation of different risk to different actors at different times, further complicate the governance of resources and the risk management efforts. There is thus a need for actors to adopt collaborative efforts in water resource governance.

Furthermore, a given water resources system will have a dynamic range of water-related states (in terms of water quantity and quality), defined at a range of spatial and temporal scales. Associated with those states will be outcomes for human health and well-being, the economy, and the natural environment (Hall and Borgomeo, 2013). Yet the possibility of harmful conditions of the aquatic environment (droughts, floods, water quality degradation, etc.) can seldom be eliminated. Risk management therefore involves weighing likelihoods and consequences of a range of possible outcomes and engaging in discussion of the tolerability of risks and the willingness to pay for risk reduction, recognising that risks are socially constructed and that there is a range of factors that determine individuals' perception of risk (Slovic, 1987).

Water-related risks have already stimulated societal and political action. As noted by Hall and Borgomeo (2013), this action can be seen in how Ethiopia has been coping with the chronic effects of hydrological variability on the economy (Brown et al., 2011); the damaging effects of floods on the Mississippi (Changnon, 1998; De Bruin, 2006); and the degraded aquatic environment in Europe, which led to the Water Framework Directive (OECD, 2013). The realisation among actors that they face shared risk results in the building up of social capital for the collective management of risk.

In their development of indicators of water security, Lautze and Manthrithilake (2012) identify five components that they consider to be critical to the concept of water security: basic needs, agricultural production, the environment, risk management, and independence. The 'risk-management' indicator is associated specifically with prevention of water-related disasters. Hall and Borgomeo (2013) further argue that risk is the defining attribute of water security. In their analysis, they posit that each of Lautze and Manthrithilake's indices can be taken as an indicator of risk:

- of not satisfying basic needs (for given proportions of time and quantiles of the population);
- of inadequate agricultural production, owing to water-related constraints;
- of harmful environmental impacts; and
- regarding the reliability of water supplies from the actions of neighbouring countries.

These indicators translate into risks to production systems within the sugar industry. Although the risks may not manifest at the same time for all the actors, the interdependence among the industry members makes the collective management of risk important for the sustainability of the industry.

The framing of water security in terms of risk reflects an increasing emphasis on risk-based approaches in policy making and governance (Hall and Borgomeo, 2013). The definition of water security in terms of tolerable risk is reflected in decision making that seeks cost-effective ways of reducing risks to tolerable levels (Hall and Borgomeo, 2013). Within such framings of water security, the challenge for actors then is what system and structure of governance they can introduce that will lead to decision making that enables ongoing review, adaptation, and adjustment necessary to achieve the goal of water security.

Cook and Bakker (2012) also identify four framings of water security: water availability; human vulnerability to hazards; human needs (development-related, with an emphasis on food security); and sustainability. Consequently, Hall and Borgomeo (2013) suggest that three of these (water availability, human vulnerability to hazards, and human needs) can be recast in terms of tolerable risk, while sustainability is a broad catch-all for a range of different issues. But then the question to be asked is 'who determines tolerable risk, and for whom?' This question is why we have to move beyond framings of water security to governance.

2.4 CLIMATE CHANGE AND GOVERNANCE

Worldwide, about 1.1 billion hectares of agricultural land is rain-fed, with no irrigation systems (Hanjra and Qureshi, 2010). Thus rain-fed agriculture is practiced on about 80% of world's agricultural area and generates about 60% of the world's staple food (FAO, 2008). Irrigated agriculture covers only 19% of cropland (Thenkabail et al., 2010), but contributes 40% of agricultural output. It also accounts for about 70% of water withdrawals from global river systems (Molden et al., 2007). The key drivers that have recently impacted and will continue to impact on food production and supply include: water crisis and climate change crisis (Hanjra and Qureshi, 2010).

Climate change affects agriculture and food security by altering the spatial and temporal distribution of rainfall and the availability of water resources (Hanjra and Qureshi, 2010). It heightens uncertainties throughout the food chain, from farm to consumers. Some of the water-related climate changes include changes in the volume, intensity, and variability of precipitation (Rosegrant et al., 2009). The impacts of climate change on food production at a global scale are small, but are geographically unevenly distributed (Hanjra and Qureshi, 2010). The impact is more obvious at a local scale, particularly in poor countries with low capacity for adaptation (Kurukulasuriya et al., 2006). It is predicted that South Asia and Southern Africa will be the most vulnerable regions to climate change-related food shortages by 2030 (Lobell et al., 2008).

Although agriculture requires water to sustain production, it has to compete with other demands for its allocation of water. Uncertainty over future rainfall patterns and water availability thus present challenges for both water management and agricultural systems (Kundzewicz et al., 2007; Bates et al., 2008), requiring resource users to act. Decision makers, from the farm-level to the policy-level, must be able to factor in uncertainty into their decisions and choose options that are capable of dealing with multiple alternative futures. The combination of uncertain supply and competing demands frames risk in a context of polycentric systems of governance.

Despite climate change and the management of water resources being a global phenomenon, and even though there is a need for global action, it does not mean that the appropriate scale of governance is global for all related climate change issues (Adger, 2001). There is a role for local, regional, and national response in managing the associated risk. In the management of natural resources, climate change is thus a challenge to structures of governance at all temporal and spatial scales (Adger, 2001). Advances in understanding of the nature of observed and future climate change has led to a realisation that future impacts are inevitable; hence it is prudent to understand the governance systems within natural resource systems (Adger, 2001).

Adger (2001) notes that some responses by individuals or groups are planned while others may be spontaneous reactions to a changing environment, related to resource use, changing economic constraints or opportunities, and the risks that they face. Hence, there is a need to understand how actors coordinate their actions towards a common goal because it is the risks that prompt the actors to take action. Such responses find expression in a governance system that enables the creation of rules for social engagement and collective action among actors who are confronted by environmental challenges (Schoon et al., 2015).

2.4.1 Water Scarcity as a Risk

Water scarcity can lead to a number of risks. Below are some risks that are a consequence of water scarcity (Orr et al., 2009, p. 10):

- Risk from insufficient water resources to meet the basic needs of people, the environment, and economies;
- Higher energy prices, loss of competitive advantage, political and economic instability, population migration, etc. (OECD, 2003); and
- Risk from poor water management decisions taken in reaction to water scarcity, with negative consequences for some or all users. Such decisions may be a result of political or economic expediency, short-term thinking, lack of knowledge or capacity, or simply desperation and lack of choice.

Discussions of risks presented by water scarcity must involve all actors within a water resource system who are responsible for and/or are affected by the problems of water scarcity. Therefore, resource users must be organised in a governance system that allows for their active engagement in resolving challenges that they face and for knowledge exchange through collective-choice arrangements (Schoon et al., 2015). Furthermore, because water is a public, a private, and a social good, a water scarcity event will have both private impacts and public repercussions, affecting stakeholders differently at both spatial and temporal scales (Le Quesne et al., 2007). Accordingly, it is necessary in any risk analysis involving water to establish who is at risk, with the understanding that the risk for an individual might be very different than risk for a society or business, and that certain groups will be more vulnerable to water-related risk than others.

In terms of this study, water scarcity is a risk to agricultural production. Increasing competition requires actors to develop new approaches to adaptive management of allocations that are efficient and yield justice in development, infrastructure, and other policy decisions and plans. This requirement demands better coordination across multiple institutions and information services that reach multiple stakeholders and decision makers (Nhemachena and Hassan, 2007). Managing this risk then becomes an issue of governance among the multiple actors in a resource system.

Competition for water resources among sectors, regions, and countries, and associated human activities is already occurring (Hanjra and Qureshi, 2010). Consequently, according to Hanjra and Qureshi (2010, p. 367), water scarcity and declining quality of water in many areas of the world pose key challenges, including:

- Increased competition for water within and between sectors, transferring water out of agriculture, and leaving less water for food (Molden et al., 2007);
- Deterioration of freshwater ecosystems, impacting ecosystem health and services (Scanlon et al., 2007);
- Tension over the use and control of water and potential for conflict at local, national and transnational levels, with a potential to afflict harm on the agricultural communities dependent on water for food (Yoffe et al., 2004; Giordano et al., 2005);
- Reduced rainfall and enhanced vulnerability to extreme wet and dry events, which can potentially reduce crop yield, and cause short-term crop failure and long-term production declines (Ragab and Prudhomme, 2002); and
- Constraints on human capacity for crafting institutions and policies for responding to emerging food security challenges (Gilman et al., 2008; Lobell et al., 2008).

The human capacity for crafting institutions and policies for responding to risk diminishes if actors work individually. To improve on this capacity, actors need to be ordered and organised in a way that galvanises their collective efforts towards the integrated management of risk and water security.

2.5 RISK MANAGEMENT IN CONTEXT

Water-related warnings from climate experts and advocates typically stress altered flows of water in a physical sense. Yet, for many influential water decision makers, those physical changes are only one part of the water-risk equation (Conca, 2015). Larson et al. (2012) identify some of the sources of risk as not only stemming from impacts on supply and quality but also from sources as diverse as price volatility, regulatory uncertainty, and reputational or political damage created by water-related controversies. For governments and communities, the risks resulting from such hazards may be viewed in terms of net social welfare or political legitimacy (Conca, 2015). For commercial industries, the same hazards are likely to translate into risks to profitability, market share, and corporate reputation. These actors are all part of the same SES, thus their actions have an impact on the ecosystem services that others enjoy: they are all interconnected, be it governments, communities, and industries. Since all are affected by the state of the resource system, there is a need for collaborative efforts and inclusive governance.

The diagram below shows a number of responses actors can adopt in response to water-related risks.

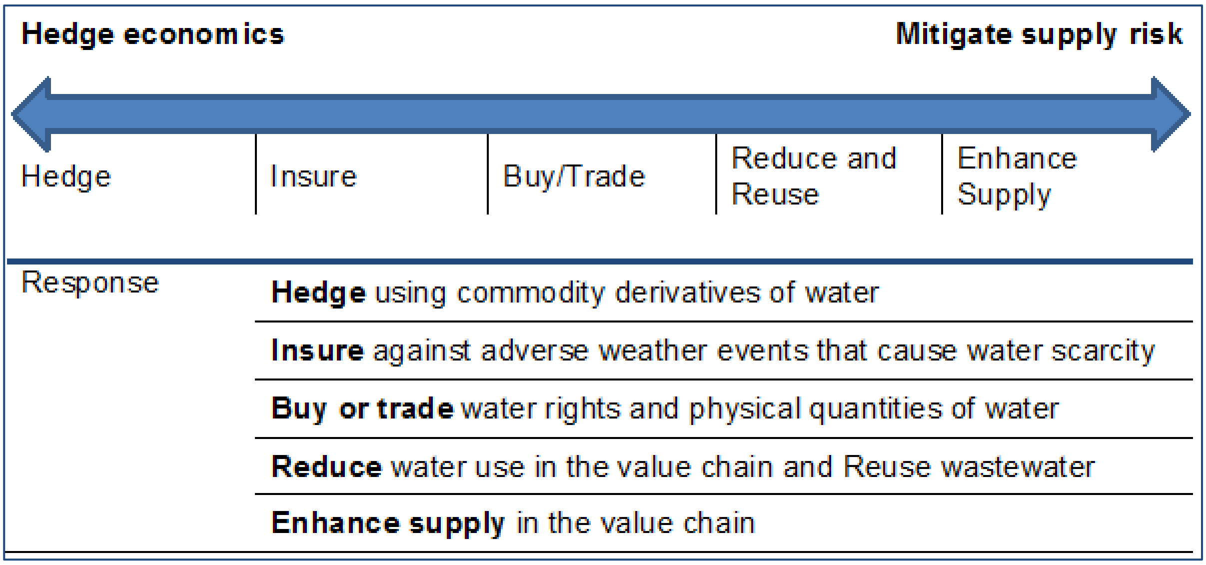

Figure 2.5: Spectrum of corporate responses to water risk (Larson et al., 2012).

For businesses, there is a growing engagement with the physical environment in which they operate (Larson et al., 2012). With this engagement has come an array of ‘new tools’, financial as well as conceptual, for businesses to manage water-related risks. Larson et al. (2012) identify a number of such instruments, which they group into four clusters: water-use accounting tools, business risk-assessment frameworks, reporting and disclosure protocols, and standards and certification frameworks. What is not clear though is what system of governance is to be used, because in a complex system such as natural resources management, there is a need for more than just ‘tools’.

Globally, there has also been an increase in the scrutiny of water-related business risks, especially in regions where water supplies are already under stress or where governments do not have the capacity to manage water-related problems (Morrison et al., 2009). These risks can be placed into three categories of water-related risks: physical risk, regulatory risk, and reputational risk (Larson et al., 2012; CEO-WM, 2015).

Physical risk relates to water quantity, too little water availability (scarcity), and flooding. It also refers to a state where the water is unfit for use through pollution (Pegram et al., 2009). Furthermore, Pegram et al. (2009) note that even when water is available, physical risk can emerge from poor management, not necessarily natural changes in the resource. Each of these conditions of physical risk is associated with management of the availability of, use from, and discharge to a water resource, which is a governance issue. Water-related risks are subjective and vary from time to time and from place to place, thus there can be no single response to risk management that is likely to suit all situations.

Reputational risk stems from the exposure of companies to customer purchasing decisions, associated with perceptions around business decisions, actions, or impacts on water resources, aquatic ecosystems, and communities that depend upon them (Pegram et al., 2009). Inefficient water use or pollution by a company, whether real or perceived, can be damaging to a brand's reputation and its ability to conduct business (CEO-WM, 2015). Moreover, affected communities, civil society, investors, consumers, and the general public are increasingly engaged in issues of water sustainability.

Finally, the imposition of restrictions on water use by government brings about regulatory risk. This risk may include the pricing of water supply and waste discharge, licenses to operate, water rights, quality standards, infrastructure development, and water allocation (CEO-WM, 2015). The failure of government regulation and self-regulation among resource users can exacerbate risk.

These risks – physical, reputational, and regulatory – inform the way users react to water insecurity. In as much as an individual farmer may want to respond to the physical risk of water availability, a miller has to consider not only the physical risk but also the reputational risk associated with the perception consumers and other actors in the SES might have on their use of water. Because farmers are also reliant on the share of proceeds from the sale of sugar products, they too indirectly face reputational risk. These varied impacts of water-related risk gives rise to a need for an integrated risk management approach. Hence a shared-risk approach and, in the sugar industry, SASA potentially provide a structure and framework for water-related risk management.

Larson et al. (2012) developed a model for managing water-related business risks. This model is depicted below, as an example of a smaller model of risk management.

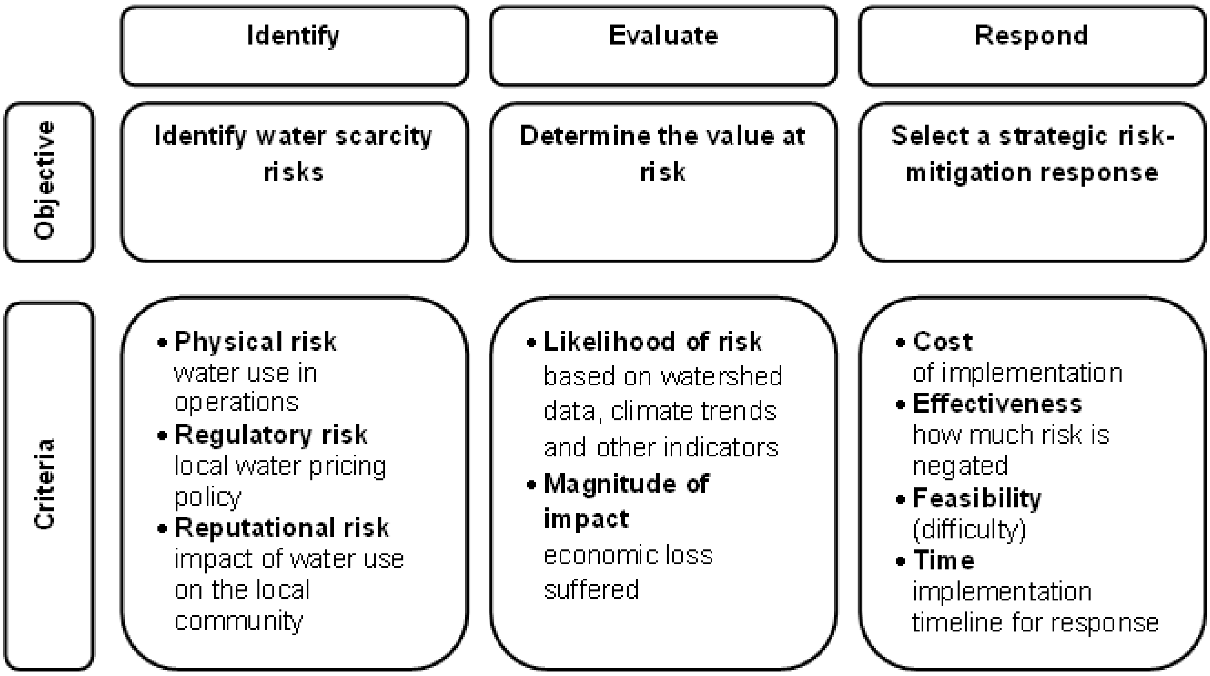

Figure 2.6: A model of managing water-related business risks (Larson et al., 2012).

Such a model would work for an individual business entity because it is inward-looking. It does not, however, deal with the issue of allocation and what is required to reach decisions on allocation (governance issues). This model would thus only apply to a mill or a farm (for example) that has an allocation and is required to manage the risk associated with such allocation, with no need for collaboration with other actors in a resource system outside of the business entity.

However, to manage water-related risks on a greater scale, it is necessary to perform a risk analysis. In any risk analyses involving water, it is important to establish who is at risk, with the understanding that the risk for an individual might be very different than risk for a society or business, and that certain groups will be more vulnerable to water risk than others. In this case, collaborative work would help in;

- Reducing the cost of implementation of a response strategy;
- Enhancing the effectiveness of such a response strategy;
- Enhancing the feasibility of a chosen response strategy through a diversity of input from multiple actors; and
- Reducing the response strategy implementation timeline through the engagement of multiple actors within a value chain.

Because of the interdependence and connections between farmers and millers both groups face risk, even though it may be indirect or at different temporal scales. Nevertheless, risk experienced by one interest group transcends the whole sugar supply chain, thus giving rise to a need for an integrated risk management approach. SASA potentially provides a structure and framework for such an approach.

2.6 SHARED-RISK APPROACH

Communities, consumers, suppliers, and governments are all exposed to risk because of common water issues such as scarcity, pollution, aging infrastructure, floods, droughts, and climate change (Orr et al., 2009). Although resource users have different risk profiles and exposure in a specific water management context, the nature and manifestation of the risk is commonly shared (Pegram et al., 2009). This collective risk calls for collective action, and a shared-risk approach in the collective management of risk. The collaborative effort is borne out of the realisation that the source of risk for resource users is the same and such risk transcends the value chain.

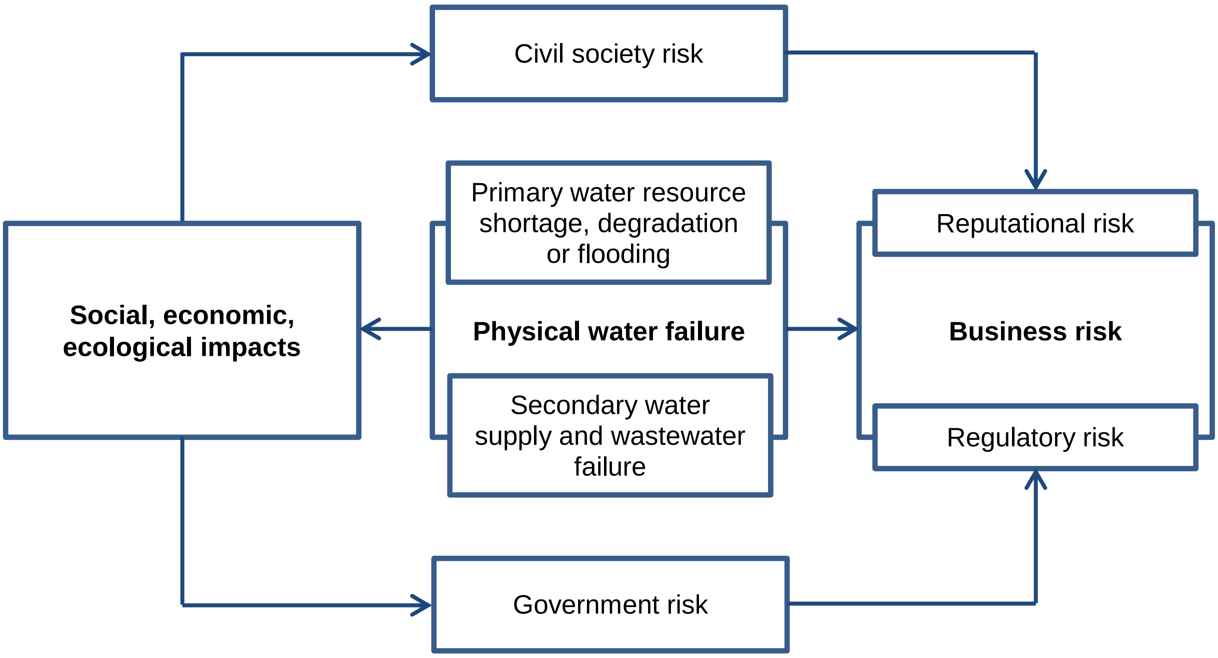

Figure 2.7: Interactions between different types of risk (Pegram et al., 2009)

Physical water risks such as water resource shortage, degradation or flooding, and failure of water supply and wastewater management manifest as business risk; both in the form of reputational and regulatory risks from the actions of consumers and government respectively (see Figure 2.7). Because physical water failure results in social, economic, and ecological impacts, there are negative effects on communities. Such effects then inform the perceptions of consumers, which manifest as reputational risk to business entities. Social, economic, and ecological impacts of water risk prompt governing authorities to intervene in social-ecological systems, usually through regulatory instruments, and present regulatory risk to businesses (Pegram et al., 2009).

Risks to multiple actors in a resource system are typically divergent. When looking at natural resources governance, government's focus is on broad social, economic, and ecological imperatives, a focus that diverges from that of the private sector, which has a profit outlook (Pegram et al., 2009). Yet despite the diverging points of focus among the different actors, Pegram et al. (2009) identify a number of commonalities in the exposure to water-related risk:

- Water scarcity poses challenges on government's ability to maintain economic growth and ensure public health and welfare, social development and ecological sustainability, whereas for corporates, water scarcity poses challenges for production and supply chains. Neither corporates nor government have an interest in the uncertainty and potentially instability that can ensue, and conversely have an interest in continued economic growth supported by water.
- For government, inadequate availability or access to water for social and ecological purposes can result in political opposition, which has its parallels in the reputational risk to which corporates are exposed.
- Water stress and supply failures are often linked to inadequate public sector management capacity, which can contribute to incoherent, unpredictable, and inconsistent water policy (and regulatory) revision and implementation, which in turn is at the heart of corporate regulatory risk.

These areas of shared risk provide opportunities for the collaborative management of water resources and risks, towards a common goal of water security. Because of the essential requirement for water, scarcity impacts all users of a water resource and many who benefit indirectly. Thus everyone benefits from sustainable water management, towards further respective objectives and mitigating risks. As such, shared risk provides a strong argument for business, government, and civil society to cooperate and collaborate to promote sustainable water management (Orr et al., 2009).

Because there are multiple actors in a SES, there are many locations of decision making affecting demand and use of water. These factors make water a CPR. The implication is that the common good ultimately takes precedence over individual good. Water allocation systems thus need to accommodate the inherent 'polycentric nature' of such systems.

2.7 NESTED GOVERNANCE AND POLYCENTRIC THEORY

Analysis by Ostrom (1990) of fourteen cases in which a CPR had been managed over multiple generations by a long-enduring regime of common property offers a source on which hypotheses can be based for this research. Ostrom expressed this finding as the following design principle distilled from larger scale cases: 'Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities [of long-enduring common property systems of common pool resource management] are organised in multiple layers of nested enterprises' (Ostrom, 1990, p. 90). From Ostrom's (1990) definition, it can be concluded that organisational nesting is the way in which the governance units are structured as part of a SES. In this regard, polycentricity then refers to the way the actors interact amongst themselves and other governance units.

2.7.1 Organisational Nesting

Organisational nesting is the way actors are ordered on a spatial scale with respect to a larger organisation or community in which they are part of. The transfer of authority from national organisations sideways to semi-autonomous actors and downwards to local level authorities has transformed both the structure and capacity of resource users; necessitating them to come up with solutions for the environmental risks they face (Bache and Flinders, 2004). Within the context of water resources management, multi-level governance offers an opportunity through which we can understand the dynamic inter-relationship within and between different levels of governance and the actors in a SES.

Most multi-level systems of governance remain essentially monocentric, with at least the key decisions undertaken through a centralised command structure (Marshall, 2007). In contrast, a nested system comprises multiple decision making centres that retain considerable autonomy from one another (Ostrom et al., 1961; V. Ostrom et al., 1999). Coordination of decisions across the system relies substantially on collaboration between multiple centres. Such collaboration 'involves individuals or groups moving in concert in a situation in which no party has the power to command the behaviour of others' (Wondolleck and Yaffee, 2000, p. xiii). Accordingly, nested governance is co-management applied across two or more levels (Marshall, 2007). Co-management can also be extended throughout groups at the same level through horizontal nesting.

Furthermore, Marshall (2007, p. 79) notes that it is important to improve our understanding of the concept of nesting, given that:

- co-management is the most widely discussed institutional arrangement for coping with commons management at more than one level (Berkes, 2006);
- its adoption is growing, as states increasingly reach the limits of their authority and come to pragmatically negotiate agreements giving lower-level actors a real voice in decision making (Young, 2006); and
- efforts to establish nested systems remain handicapped by weak development of the relevant theory (Berkes, 2002).

The potential advantages of a nested organisational structure for large-scale, common-pool resource complexities are evident from various perspectives, including a 'collective action' perspective and a 'robustness' perspective (Marshall, 2007). The collective action perspective was presented by Olson (1965). As a solution to the 'free rider problem' faced by a large group perceiving a shared problem, Olson proposed that a large group needed to reorganise itself as a federated system. The 'free rider problem' refers to a situation where some actors within a resource system abstract a benefit more than their 'fair share' of a CPR.

Ostrom (1990) explained this logic by observing that collective action problems faced by large groups are often decomposable into smaller problems, among which some are typically surmountable, given pre-existing trust between some members. Hence, as Marshall (2005, p. 47) notes, multi-level governance of large groups can be explained from this perspective as;

> *"…the eventual result of larger, more inclusive organisational units emerging from, and then 'nesting'... smaller, more exclusive units that manage to self-organise sooner. Smaller organisations thus become part of a more inclusive system without giving up their essential autonomy".*

The robustness perspective recognises that the social-ecological systems normally addressed in community-based environmental management are complex adaptive systems, for which optimal management decisions cannot be identified precisely at the outset (E. Ostrom, 1999; Berkes et al., 2002; Anderies et al., 2004). McGinnis (1999) argues that the complexity of many natural resources requires sophisticated multitier or polycentric governance systems rather than a reliance on a single type or level of governance.

Lebel et al. (2006) thus conclude that in some circumstances – not all – nested governance may contribute towards the robustness of social-ecological systems involving larger-scale common-pool resources. In his analysis, Marshall (2007) posits that these potential contributions arise in part from the increased scale, as compared with monocentric multi-level arrangements (where coordination is expected to occur through a single, integrated command structure), and that nesting allows for decentralised decision making.

One advantage of this type of structure, as Liesbet and Gary (2003, p. 235) note, is that the 'dispersion of governance across multiple jurisdictions is more flexible than concentration of governance in one jurisdiction'. They point out that large jurisdictions are not suitable when they impose a single policy on diverse ecological systems or territorially heterogeneous populations because social-ecological conditions vary over space and time. To accommodate diversity in social-ecological systems, a nested structure is more suitable than a centralised one. The flexibility in a nested structure makes it easier to respond to change in social-ecological systems across spatial scales. Multi-level governance (which is an attribute of polycentricity) allows decision makers to adjust the scale of governance to reflect heterogeneity in social-ecological systems (Liesbet and Gary, 2003).

The advantages of decentralised (nested) decision making include (E. Ostrom, 1999):

- enhanced access to local knowledge;
- increased likelihood that informal institutional arrangements can be harnessed to exclude untrustworthy individuals;
- increased feedback on the performance of rules to be captured in a disaggregated way;
- rules that are allowed to be devised that are better adapted to each local, common-pool resource than any general set of rules;
- lower enforcement costs, by strengthening local perceptions of the legitimacy of rules, and also by making it easier to fashion rules that can affordably be monitored; and
- situations that are created where 'multiple units are experimenting with rules simultaneously, thereby reducing the probability of failure for an entire region' (E. Ostrom, 1999, p. 526).

A nested organisational structure complements a decentralised system with higher governance levels capable of dealing with problems that exceed the capacities of at least some lower-level units to solve by themselves (e.g., intractable problems of biophysical spill-overs, discrimination, and inter-group conflict) (Marshall, 2007). The overlapping and redundancy of management units in nested arrangements may contribute to robustness: it enables information about rules that have worked for one unit to be conveyed more easily to other units. Also, it means that 'when small systems fail, there are larger systems to call upon – and vice versa' (E. Ostrom, 1999, p. 528).

In addition, a nested structure can provide a number of advantages to a social-ecological system, such as providing more complete information of constituents' preferences and being more adaptive in response to changing preferences and more open to experimentation and innovation, and facilitating credible commitments (Weingast, 1995; Majone, 1998). Coordination is necessary to avoid socially perverse outcomes, because with nested governance comes possibilities of policy spill-overs (i.e., negative or positive externalities) from one jurisdiction to another.

Despite the advantages of decentralisation in capturing local feedback on rules, which might strengthen the robustness of a social-ecological system against localised disturbances, there exists a potential weakness at the same time. Decentralisation might weaken the robustness of a social-ecological system to larger-scale disturbances if feedforward from larger-scale disturbances does not reach governance levels capable of responding satisfactorily to such disturbances in a timely manner. Although organisational nesting ensures the participation of actors in issues that affect them locally it also limits the response to environmental disturbances. This can be experienced in cases where there is conflict and issues of power dynamics. Despite building redundancy into the structure, organisational nesting does not delegate responsibilities and this is a source of conflict in times of environmental disturbances.

It must also be noted that because risks manifest differently for multiple actors in a complex SES, it is important to understand the effects of any disturbance to the system and coordinate the response from actors who lay a claim to the resource system. To have such an understanding, the system of governance must be inclusive and collaborative. As shown in Figure 2.7, the source of risk in any aquatic ecosystem is the physical availability of water. Despite each actor or group in an SES experiencing risk in a different way, the way they respond to the risk individually or as a group has an effect on how the others benefit from the resources. To manage these resources for an equitable and sustainable use calls for collaborative management of risk in a polycentric governance system.

2.7.2 Polycentric Governance

There is a growing recognition of the importance of self-organisation (Liesbet and Gary, 2003; E. Ostrom, 2009). Self-organisation is particularly important in the management of CPRs. Ostrom (2005, p. 2) defines a self-governed CPR as one where actors, who are major users of the resource, are involved over time in making and adapting rules within collective choice arenas regarding the inclusion or exclusion of participants, appropriation strategies, obligations of participants, monitoring and sanctioning of resource use, and conflict resolution. However, in most modern political economies, it is rare to find any resource systems governed entirely by participants without rules made and enforced by local, regional, national, and international authorities, which also affect key decisions (V. Ostrom, 1997, 2008). Thus, in a self-governed, polycentric system, participants make many, but not necessarily all, rules that affect the sustainability of the resource system and its use (E. Ostrom, 2008a).

The solution of most collective problems requires finding ways of providing diverse goods and services at multiple scales. Polycentric governance tends to reduce chances of behaviour counterproductive to the aspirations of a group or community with respect to the provision and production of collective goods (Toonen, 2010). It does so by allowing communities to form small scale collective governance units, thereby encouraging face-to-face discussion and the achievement of common understanding. Larger units also can more effectively cope with goods and services that have large-scale effects and real economies of scale (Nagendra and Ostrom, 2012).

Polycentric theory was conceived from theoretical work that indicated that metropolitan areas that were characterised by a mixture of very large-, medium-, and smaller-scale organisation outperformed those served by very large or very small units alone (McGinnis, 1999). V. Ostrom et al. (1999) defined polycentric governance as a system where many units are capable of making mutual adjustments for ordering their relationships with one another within a general system of rules, where each unit acts independently of other units.

Nagendra and Ostrom (2012) argue that these polycentric institutions provide a useful framework for governance, which enables aspects of preferred solutions to be used together in efforts to protect the long-term sustainability of diverse social-ecological systems. They further state that by considering the interaction between actors at different levels of governance, polycentricity contributes to a more nuanced understanding of the variation in diverse governance outcomes in the management of CPRs based on the needs and interests of actors and the complexity of resources and governance systems at local, regional, national, and global levels (Nagendra and Ostrom, 2012).

Polycentricity is characterised by governance systems in which political authority is dispersed to separately constituted bodies with overlapping jurisdictions that do not (necessarily) stand in hierarchical relationship to each other (Skelcher, 2005). For example, despite the formation of the SASA in the year 1919, the various local-level groupings retained independence, thereby attaining a nested structure and polycentricity within the South African sugar industry. Polycentric governance within the SA sugar industry relates to ecosystem services through;

I. The way the actors self-organise as decision making centres to benefit from their preferred resource units (ecosystem services); and
II. The way the industry relates to actors within the resource system but external to the industry.

Adopting a polycentric governance system helps solve issues in environmental management by developing systems of governance at multiple spatial and hierarchical scales, with an emphasis on local participation. One result is multi-layered institutional arrangements, which can be important for handling scale-dependent governance challenges as well as cross-scale interactions (Young, 1994; Berkes, 2002; Anderies et al., 2004).

Importantly, polycentricity recognises the self-organisation among actors in an SES. The common understanding that can be achieved among actors in a given resource system or nest results in alignment of behaviours toward a common goal as defined by the actors, in this case water security. Given the multiple decision making centres that characterise a polycentric system, it is possible to gain input from various actors with local knowledge. This input is important in understanding the risks that actors face in their locality and how actions from others within (and outside of) their respective SES affect the benefits they receive. A polycentric system of governance also helps bring a sense of legitimacy to the collective action towards the mitigation of water-related risk through the participation of actors in an SES.

Although polycentric governance harnesses area-specific knowledge of resource systems that could be vital for decision making it might be a disadvantage when it comes to responding to risks that afflict the resource system as a whole. This disadvantage is due to compartmentalised responses and resource availability. The system of governance also makes it prone to conflicts for each group of actors or interest group is bound to demand parity in allocation of resources and this only deflects attention from implementing mitigation measures to risks actors face.

2.8 SUMMARY

Agriculture requires water to sustain production. However, it has to compete with other demands for its allocation. Climate change further complicates this dynamic through the increased variability of water resources. The combination of uncertain supply and competing demands from multiple actors in an SES requires that risk be managed by polycentric systems of governance. Organisational nesting and a polycentric governance system increase the actors' capacity to craft institutions and policies for responding to emerging water-related risks that they face in their efforts to attain a state of water security.

Polycentric ordering has been shown to harness indigenous knowledge. It enhances the understanding of the local geography and social landscape in water resources governance, thus enabling the development of locally specific and relevant rules and regulations. In addition, nesting creates opportunities for networking, horizontally across spatial scales and vertically across levels. This networking creates an enabling environment for social learning. Thus, a nested organisational structure and a system of polycentric governance can be used for the collective management of shared risk with the goal of water security.

The agricultural systems that were part of Ostrom's (1990) study were under irrigation. This study adds to the body of knowledge by looking at how actors practicing dryland agriculture are responding to risk individually and collectively within the industry. To accomplish the goal of this study, I explore the proposition that organisational nesting and polycentric governance enables stakeholders in the sugar industry to align their behaviours and manage risk collectively.

An analysis of the structure of the sugar industry in South Africa and the governance system for the management of natural resources will enable understanding on how a shared-risk approach is achieved in practice and its importance for the management of social-ecological systems. In the following chapter, I thus describe the South African sugar industry, and show why it provided an empirical scenario to test the theoretical framework described above.

CHAPTER THREE
THE SUGAR INDUSTRY IN SOUTH AFRICA

In this chapter I describe the organisation of the SA sugar industry. The objective here is to demonstrate the rationale for selecting it as the entity on which to empirically test the research's proposition. In order to gain an in-depth understanding of how organisational nesting and polycentric governance enable stakeholders to align their behaviours and manage risk collectively this study required that I identify an entity that had particular attributes. These attributes were;

- having a history of risk exposure that threatened viability;
- having a history that could be used to illustrate the evolution of organisational nesting and polycentric governance;
- interested in and supportive of the research; and
- generic enough in its structure, organisation, and governance to allow insights to be relevant to other entities.

3.1 INTRODUCTION

Self-organisation in the SA sugar industry started with the formation of the sugarcane planters' associations along the sugarcane growing belt of Natal (now KwaZulu-Natal). This self-organisation within the sugar industry was borne out of a need to exploit economies of scale in the manufacturing and export spheres of the business (McMartin, 1948; Richardson, 1982). Now, as the industry consists of the primary activity of sugarcane production and the secondary operations of sugar milling and marketing, the primary production sector is represented by the South African Cane Growers Association (SACGA) and the millers by the South African Millers Association (SASMA) (SASA, 2015). The two organisations cooperate in a partnership that is the South African Sugar Association (SASA, 2013). This partnership is an equal one, and each member (i.e. SACGA and SASMA) elects eleven councillors to sit on the SASA Council.

Moreover, SASA is an autonomous organisation and operates free from government control. Statutory powers of self-governance are granted to the industry through the Sugar Act and the Sugar Industry Agreement. The industry is regulated within the wider context of; inter alia, the following legislation and agreements (Conningarth Economists, 2013):

- Agricultural Act, No. 70 of 1970;
- The Marketing of Agricultural Products Act, No. 47 of 1996;
- Sugar Act No. 9 of 1978 as amended;
- Sugar Industry Agreement of 2000;
- ANNEX VII of the SADC Protocol on Trade as amended; and

- The SASA Constitution as formulated by the members of the sugar industry.

The SA sugar industry is regulated through the provisions of the Sugar Act of 1978 and the Sugar Industry Agreement, 2000, which empower SASA to export bulk raw sugar. Equitable exposure to the world market is established by way of a quarterly redistribution of local market proceeds (Conningarth Economists, 2013).

3.2 INDUSTRY MILLING AREAS IN SOUTH AFRICA

There are approximately 23 866 registered sugarcane growers, mostly in KwaZulu-Natal (KZN) and Mpumalanga, who on average produce 18.8 million tons of sugarcane annually from the fourteen mill supply areas identified in Figure 3.1 (SASA, 2015). The milling industry's operations are dependent on the state of the natural resource systems in a given area and, because resources such as water are shared, each resource system is complex. Thus the state of the SES in any given area of operation poses a risk to production within the industry. Moreover, there are multiple actors in each area who lay a claim to the resources, be it other crop growers, urban and rural settlements, industries, and the environment itself. Below is a map showing the sugar milling areas in South Africa.

Figure 3.1: The fourteen milling areas within the South African Sugar Industry (SASA, 2013)

Milling companies produce 7.94% of the sugarcane crop from their own sugar estates; the rest is supplied by individual farmers (SASA, 2015). The sugar milling companies and the farmers are interdependent. The millers are dependent on the growers for their factory input supply and, in turn, the growers have a guaranteed market for their crop. Around this symbiotic relationship a structure exists, involving both the sugarcane farmers and the millers. This structure supports sugarcane farming, extension services, milling, research, and sugar marketing and it can be described as a nested structure.

3.3 ORGANISATIONAL STRUCTURE

The structure of the sugar industry finds its roots at the local level among farmers and millers. The Sugar Industry Agreement of 2000 recognises the establishment of Mill Group Boards in each milling area within the SA sugar industry. The agreement states that; 'there shall be established for each mill, other than Union Co-op, a board to be known as a Mill Group Board (MGB) comprising respective representatives of the mill and the growers concerned' (SASA, 2000, p. 15). Union Co-op is an exception because the mill is a cooperative of sugarcane growers. Because of the geographical proximity of Dalton, where Union Co-op has a sugar milling plant, and the Noodsberg milling area, there is interconnection in the subcommittees of the MGB. The MGBs are thus nested within SASA, having as their principal objective the promotion of the interests of the mills and growers to which the respective MGBs relate.

In each of the growing areas there are also Local Grower Councils (LGCs). The LGCs represent the interests of the sugarcane farmers in a given location, and are nested within the SACGA. Because the industry relies on the natural resources in a given area for production, knowledge of the state of the resources is important. As such, the MGBs and the LGCs play a role in the governance of natural resources – in this case, water. SASA thus provides the integrated industry view with the MGBs providing the area specific view.

Such organisational nesting can be described as an institutional design where there is devolution of power and responsibility from the upper organisational level to the base units at a local level. The base level units are fully contained within the bigger unit. In such a mode of institutional design, the representation of interests increases from the base units to the upper level (Marshall, 2007; Nagendra and Ostrom, 2012; Araral and Hartley, 2013), as illustrated in Figure 3.2, using the SA sugar industry.

The SA sugar industry has multiple decision making centres. SASA is the principal centre with the industry-wide perspective. At the local level, the growers associate around the mill they supply, with their interests represented in the LGCs. The LGCs make up the SA Cane Growers' Association, which is nested within SASA. At a mill level, there is coordination and interaction with the farmers through the local MGBs. Within the MGBs there are a number of sub-committees, for example, the Local Environmental Committee, which is responsible for the coordination of environmental management programmes. The sugar mills are nested within the SASMA, which is in turn also nested within SASA.

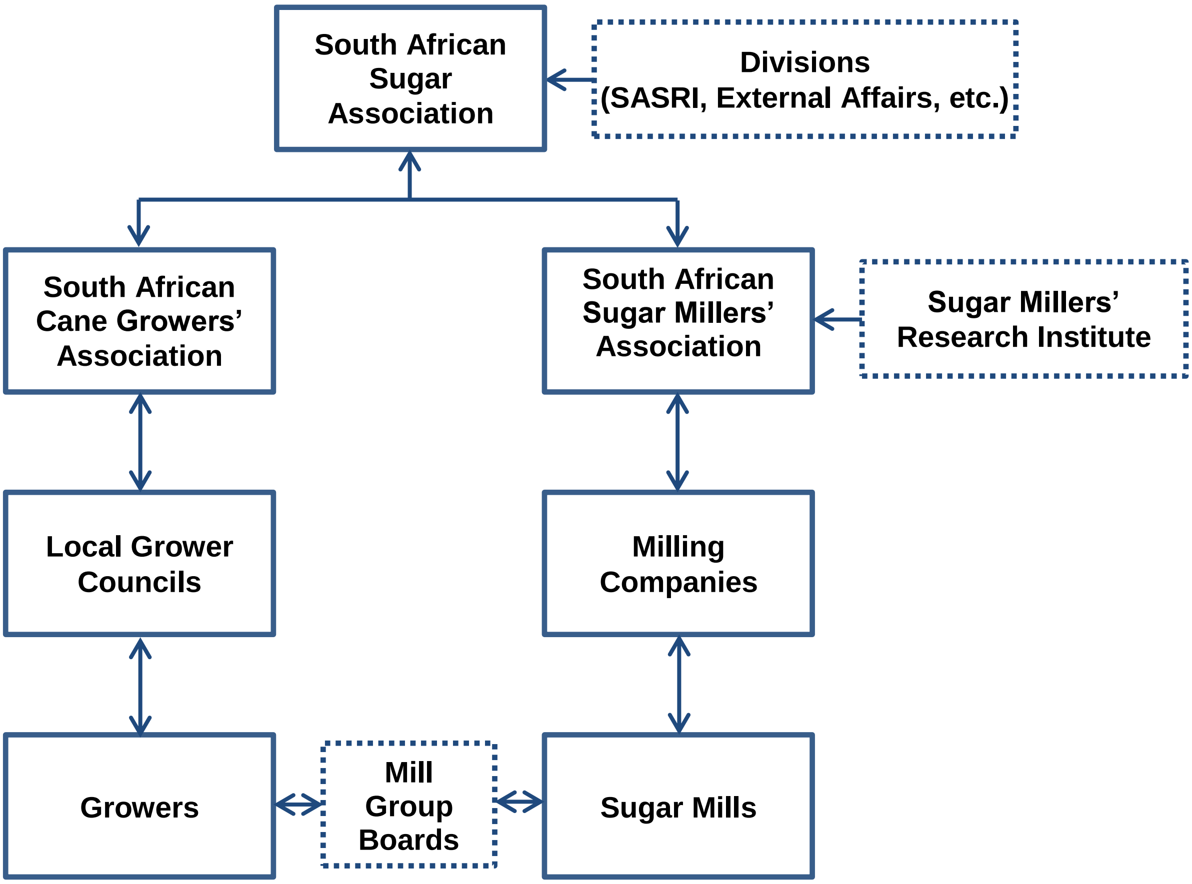

Figure 3.2: Organisation of the South African Sugar Industry. Adapted from SASA (2015)

The structure of the sugar industry thus exhibits a nested, polycentric system since it comprises multiple decision making centres that retain considerable autonomy from one another. The LGCs and MGBs have considerable influence on the operation of the industry. Indeed, coordination of decisions across the system relies substantially on collaboration among multiple centres.

Polycentricity is a governance system that can be used to manage this institutional structure. Each level (or nest) can identify the ecosystem services (benefits) it draws from the resource system. The larger group can then coordinate the benefit appropriation with an overall outlook that encompasses the various local level groupings and external influences while striving for equitable solutions to environmental challenges such as water insecurity.

3.4 CONTRIBUTION TO SOCIO-ECONOMIC AND ENVIRONMENTAL DEVELOPMENT

The SA sugar industry contributes, in various ways, to the social and economic development of the communities in which it is based and the South African community at large. The sugar industry is mostly situated in rural areas and directly employs approximately 79 000 people, which represents over 11% of the total agricultural workforce in South Africa (Conningarth Economists, 2013; SASA, 2013).

Economic Contribution

Sugarcane is a strategic crop for the KwaZulu-Natal and Mpumalanga provinces, where sugarcane production is located, comprising nearly 50% of field crop gross farming income across the two provinces (SASA, 2013). The industry thus makes an important contribution to the national economy, given its agricultural and industrial investments, foreign exchange earnings, high employment and linkages with major suppliers, support industries, and consumers. It is a diverse industry, combining the agricultural activities of sugarcane cultivation with the industrial factory production of raw and refined sugar, syrups and specialised sugars, and a range of by-products (SASA, 2015).

Furthermore, sugarcane is the second largest South African field crop by gross value, surpassed only by maize (SASA, 2013). Based on revenue generated through sugar sales, in the Southern African Customs Union (SACU) region and world export market, the SA sugar industry is responsible for generating an annual average direct income of R12 billion and contributes an estimated average R2.5 billion to the country's foreign exchange earnings on an annual basis (SASA, 2015). The 2011 Abstract of Agricultural Statistics by DAFF showed that the value of sugarcane production represents 17.4% of total gross annual field crop production value (Conningarth Economists, 2013). The contribution of the sugar industry to the economy is thus significant; hence there is a need for concerted efforts to ensure its sustainability.

Environmental Sustainability

The environment is a crucial element for sustainable development and any form of environmental degradation inevitably is linked to negative social impacts on the community and the industries within it. As such, SASA has an environmental programme, with the objective of supporting the environmentally friendly, community-based development initiatives. Through collaborative work, SASA promotes sustainable environmental practices and education through activities such as (Conningarth Economists, 2013; SASA, 2013):

- Funding projects that have environmental objectives e.g. the Dokodweni Eco-tourism Development Programme in KwaZulu-Natal, North Coast, and the planting of indigenous trees through the Sukumani Community Empowerment Project based in Mpumalanga;
- Support for environmental education in schools in the sugarcane farming belt sugarcane through the internationally recognised Eco-Schools programme; and

- Partnering with environmental organisations with regards to environmental protection, with emphasis on the conservation of fresh water, estuarine habitats, and the promotion of biodiversity.

Through such collaborative efforts there is potential to engage in joint sustainable environmental management projects and assist local environmental committees with appropriate and better management programmes. Such collaborative actions are essential in promoting and implementing environmental sustainability practices, and related education and social learning processes that will strengthen environmental and social change within the SA sugar industry. A drawback with the programmes mentioned above is that they take the primary active part of implementation and practice to other actors outside of the industry. For these programs to have a potential as methods to mitigate reputational risk the sugar industry has to act and lead the effort.

3.5 RESEARCH ISSUE IN CONTEXT

The world is undergoing climate change, and with it comes changing patterns of precipitation and evaporation. Southern Africa is one of the regions that have seen a decrease in rainfall owing to climate change (Ragab and Prudhomme, 2002). This change in rainfall patterns will alter run-off, with consequences for water availability and ecosystem functioning (Conca, 2015). These consequences have a further impact on soil moisture, altering the availability of 'green water' in the plant root zone, affecting soil moisture, ecosystem functions, and agricultural productivity (Conca, 2015). With these changes taking place in river basins, there is a need to understand how actors associate, organise themselves and propose institutional arrangements that encourage the alignment of behaviour towards the common goal of water security.

System Framework

Acknowledging the sugar industry as a complex system, I adopted and adapted the framework of Anderies et al. (2004) to depict my preliminary understanding of the influence risk and water security has on industry governance (Figure 3.3). Economic and social development impact water demand, which, together with climatic conditions, determine water security as depicted in the framework. How the government perceives water security influences dialogue with other actors – the sugar industry, in this case – and as a collective, they determine the policies and regulations (the public governance infrastructure) that are required to promote water security. Government action is also influenced by lobby groups and other stakeholders who have a claim to the water resource system in the area. These stakeholders can be NGOs, other agricultural and industrial sectors, and municipalities.

From an industry perspective, water insecurity poses a risk to production, which, in turn, means a supply risk to the sugar markets. Thus, what drives the industry's approach to water security is the risk of supply to the sugar markets and the industry is aware of the need to manage water to manage the risk.

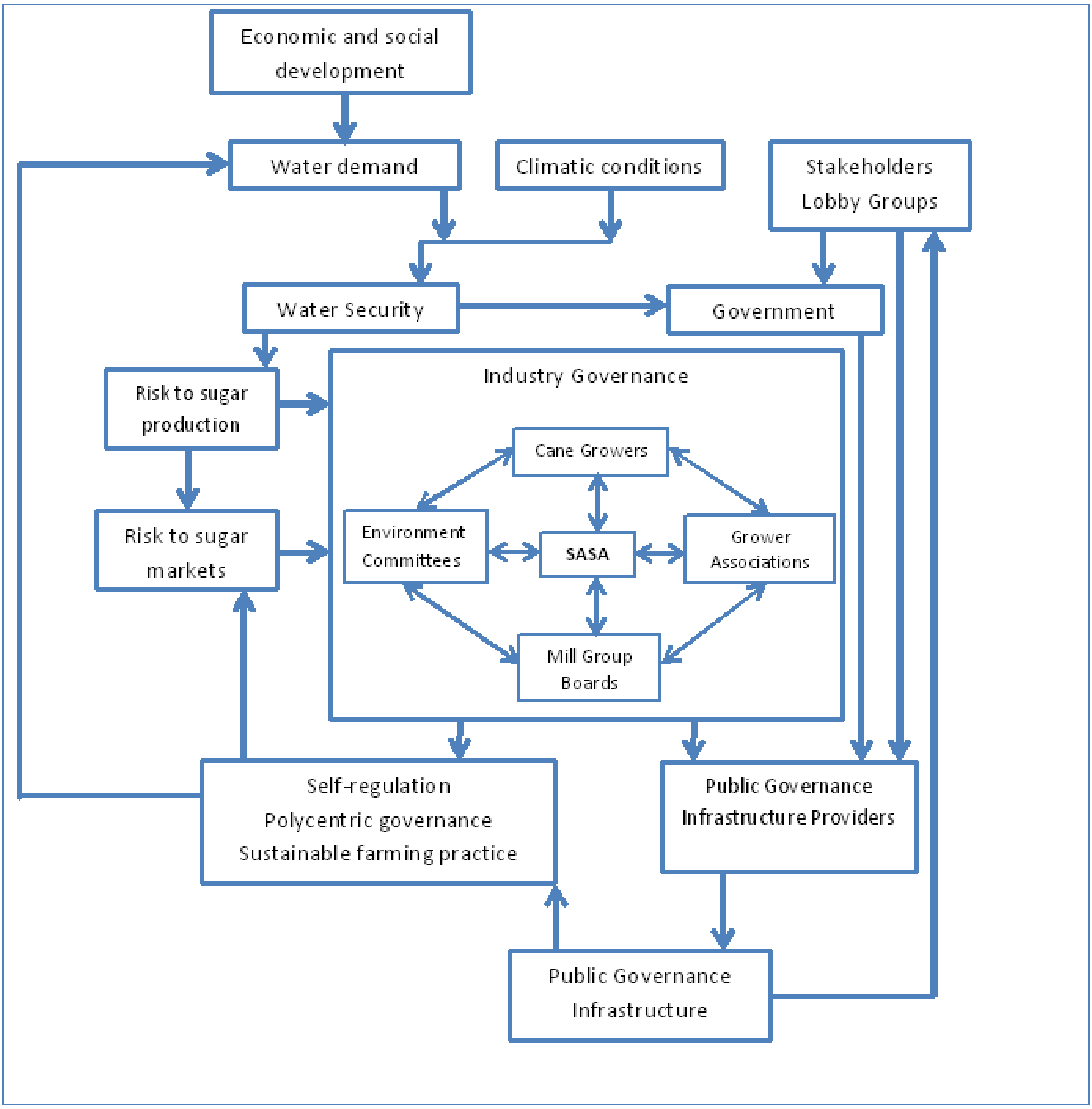

Figure 3.3: System framework adapted from Anderies et al. (2004)

The industry actors are interdependent. What connects them are the risks they face, from farm-level to consumers. So, the industry is organised in a nested structure, which acknowledges the importance of local level groups to the industry. It promotes self-regulation by: using polycentric governance to make decisions and to regulate actors within the complex system; promoting sustainable farming practices; and by engaging with other public governance infrastructure providers to make sure that the industry's views are taken into account when the infrastructure is developed and implemented. Ultimately, the success of managing water demand and improving water security depends on how the industry responds to self-regulation within the context of its exposure to risk and prevailing public infrastructure.

3.6 SUMMARY

The sugar industry operates within an institutional structure that has developed over time. It is governed in a polycentric system with multiple decision making centres, which allows for the development of area-specific interventions to ensure the sustainability of the natural resources on which the industry relies upon. Such a structure and system of governance provides an opportunity to investigate how it is currently being used to manage risk, particularly risk related to water security.

The industry has almost a century of evolution of organisational nesting and polycentric governance; it also has a history of exposure to risk arising from diverse sources – international, national, and local. Because of its primary reliance on water resources for production processes, the sugar industry has significant exposure to water-related risk, consequent upon variable rainfall, growing demand, and environmental awareness. Risk is what connects the multiple actors together, which is reflected in the Sugar Industry Agreement of 2000, and the proceeds sharing model contained within the agreement. It is risk that drives the spread of ideas among actors because an impact on one group's operations can have further effects along the value chain.

The sugar industry, given its organisation and self-governance, provided a suitable case study for this research. The structure and organisation of the industry provided an opportunity to test the research's proposition – that organisational nesting and polycentric governance enable stakeholders to align their behaviours and manage risk collectively. Therefore, insights from this study can further understanding on the role of organisational nesting and its dynamics in the collective management of risks regarding water resource systems among multiple actors. In the next chapter, I describe a suitable empirical site in which to test the research proposition.

CHAPTER FOUR
STUDY AREA OVERVIEW

In this chapter, I place the sugar industry in the context of my study and provide the rationale for site selection by presenting the background of the case study – in particular, the uMngeni River Basin.

4.1 INTRODUCTION

South Africa is located in a predominantly semi-arid part of the world. The climate varies from arid and semi-arid in the west to sub-humid along the eastern coastal area. The average rainfall for the country is about 450 mm per year, well below the world average of about 860 mm per year, while evaporation is comparatively high (DWA, 2013). As a result, South Africa's water resources are, in global terms, scarce and extremely limited (DWAF, 2004). Over the coming decades, South Africa will face constraints associated with water availability that will have a broad impact on its economy and could temper economic growth. Agriculture, which remains the country's largest water-consuming sector, will likely face additional limitations to its current water allocations, owing to increasing demands from other sectors and human settlements (Stratfor Global Intelligence, 2015).

What exacerbates issues of water availability is that water resources are unevenly spread across South Africa. The variable rainfall distribution and characteristics give rise to uneven run-off and distribution of water resources across the country, with more than 60% of the river flow arising from only 20% of the land area (DWA, 2013). To overcome the uneven spread of water resources and to manage floods and droughts, more than two thirds of the country's mean annual rainfall is stored in dams (DWA, 2013). At present, there is a well-developed infrastructure, with more than 4 395 registered dams in South Africa, of which 2 528 are water supply-related (DWA, 2013). Yet, despite the good infrastructure, the occurrence of floods and droughts are part of the 'normal' water cycle and water restrictions and flood management are a critical part of the water business (DWA, 2013). Such disruptions pose a risk to agricultural production.

Moreover, despite the developed infrastructure, most areas of South Africa are approaching a state where all the easily accessible freshwater resources are fully utilised, including the Crocodile and Marico water management area (DWA, 2013). The resource users must recognise this situation and the inherent risks it presents so that necessary steps are taken to assess current and future demands for water. Managing this risk will not be an easy task, but with the necessary resolve to plan and implement the required interventions, a secure water future can be achieved (DWA, 2013). Efforts and governance structures in environmental management within the SA sugar industry can provides lessons on how to approach water-related risks.

4.2 RESEARCH SITE SELECTION

Most of the sugarcane crop in South Africa is grown in the sugar belt of KwaZulu-Natal (Figure 4.1).

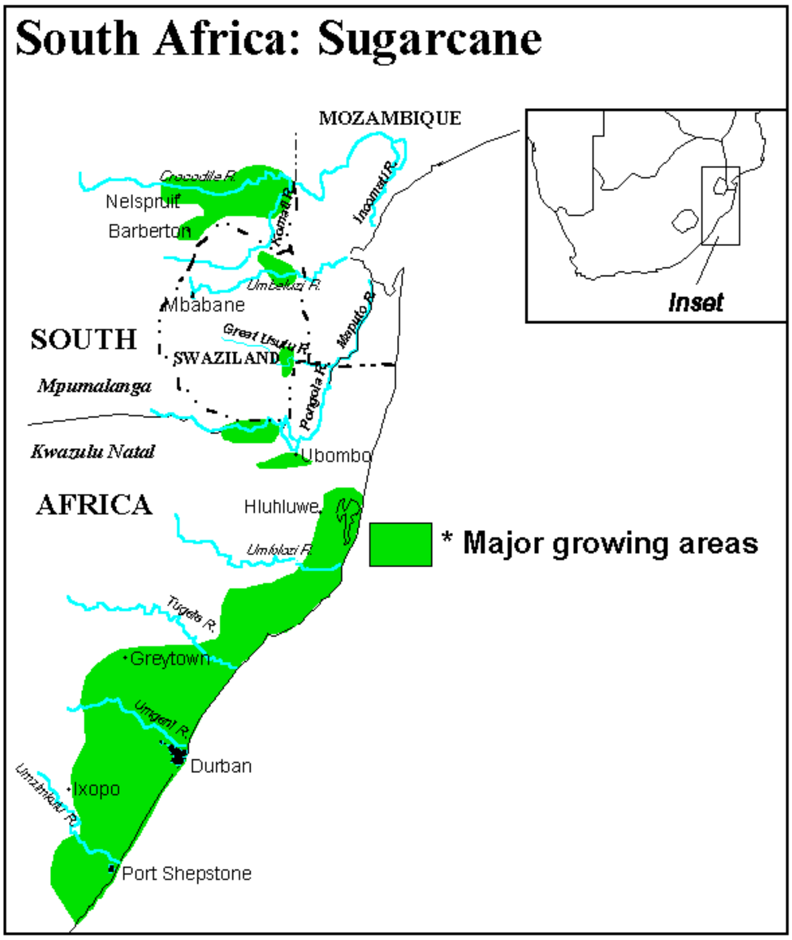

Figure 4.1: Main sugarcane growing areas in South Africa *[courtesy of Spectrum Commodities (2015)]*

The study was conducted in the uMngeni River Basin in the province of KwaZulu-Natal, South Africa. The focus was on the sugarcane growing areas of Dalton, Eston, and Noodsberg, where most farming is rain-fed with little supplementary irrigation. The basin is a source of economic livelihood for the urban centres within the basin, such as Pietermaritzburg, and the greater Durban area (Figure 4.2).

The uMngeni River Basin (Figure 4.3) encompasses an area of 4 416 km^2 (0.36% of South Africa) and the river is 255 km in length from its source at uMngeni Vlei to its mouth at Durban (Mitchell et al., 2014). It has several tributaries, of which the most important is the Msunduzi River, with its source in Vulindlela and passing directly through Pietermaritzburg (Mitchell et al., 2014). The basin is of significant socio-economic importance locally, regionally, and nationally. The uMvoti to uMzimkulu Water Management Area, in which the uMngeni River Basin falls, contributes approximately 11.5% to national GDP, with an estimated 80% of this coming from the Durban-Pietermaritzburg area (Mitchell et al., 2014).

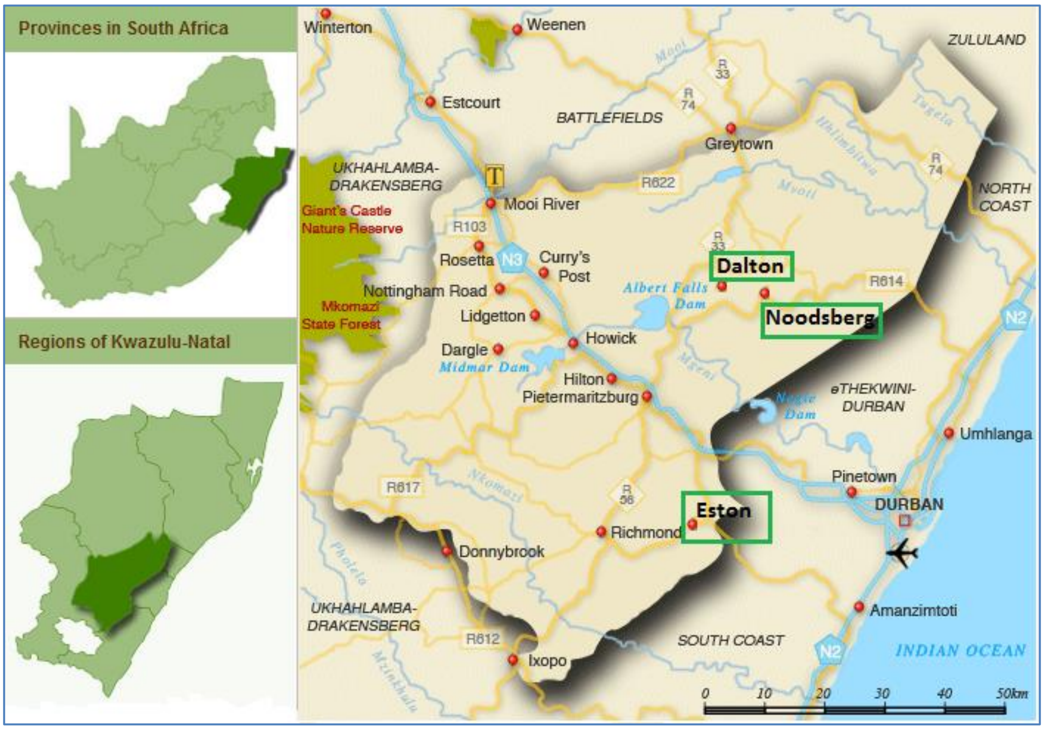

Figure 4.2: The KwaZulu-Natal Midlands area *[source: Rooms For Africa (2015)]*

Environmentally, 40 to 50% of the uMgungundlovu Municipality's landscape has been transformed from its natural condition, primarily for urban residential and industrial use and large-scale commercial agriculture, particularly sugarcane, timber, beef, and dairy (Mitchell et al., 2014). Because of climate change, the region will experience an increase in magnitude and frequency of extreme weather events, including droughts, violent storms, and floods (Mitchell et al., 2014).

Water quality is declining throughout the river basin, primarily owing to poor sanitation infrastructure, inappropriate land-use (especially overgrazing), agriculturally-based organic inflows, and industrial waste (Mitchell et al., 2014). In addition, infestations of alien invasive plant species are increasing, especially in riverine habitats, despite significant investment in clearing and habitat restoration (Mitchell et al., 2014).

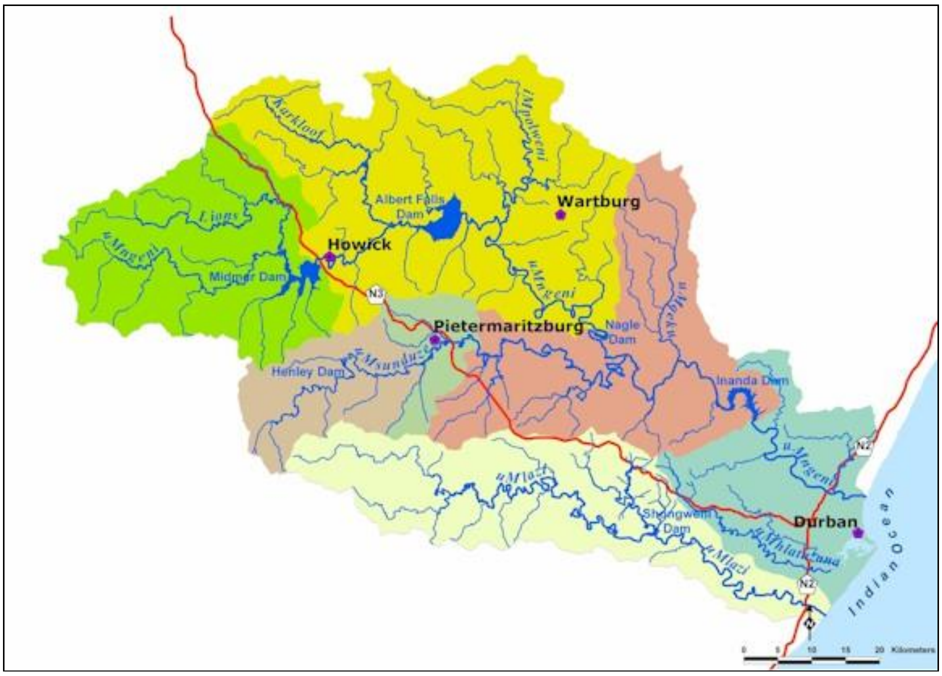

Figure 4.3: The uMngeni River Basin *[source: CSIR (2015)]*

To address these issues of declining water quality, infestations of alien invasive plant species among others, Mitchell et al. (2014) identified initiatives regarding water resource governance within the uMngeni River Basin. These initiatives include:

- River health research and monitoring by numerous organisations;
- Conservation stewardship programmes in the upper-basin;
- Wetlands conservation and management programme;
- Practical alien invasive clearing and natural system restoration;
- Various citizen/community-based initiatives aimed at establishing conservancies, improving water quality, reducing pollution, and improving land-use practices; and
- An Ecological Infrastructure Partnership aimed at restoring and maintaining ecological infrastructure in the basin so as to enhance water security.

These initiatives may be necessary, as the three sugarcane growing areas in the KwaZulu-Natal Midlands (Dalton, Eston, and Noodsberg) are all located within the Greater uMngeni River Basin. The three milling areas contribute about 20% of sugarcane crushed in South Africa (SASA, 2015).

Ultimately, water scarcity is a significant constraint to economic and social development goals and the sustenance of ecological systems. A 2009 study by the 2030 Water Resources Group estimated that within individual freshwater catchments in South Africa, the gap between supply and demand could range between 20 and 50% by 2030 (2030 WRG, 2009). As demands for access to and use of ecosystem services derived from water resources grow and become more diverse, relative scarcity will increase, fostering competitive rather than the cooperative behaviours necessary for sustainable and equitable allocation of the associated benefits (Mitchell et al., 2014). Given the growing gap between supply and demand potential, it is imperative for water resource users to adopt equitable risk-sharing practices as they move towards a collective goal of water security.

4.3 SUMMARY

Industry members within the Midlands find themselves operating in a changing environment, faced with growing rainfall variability and increased demand on water resources. With such changing conditions, it is prudent to investigate how the industry has responded and how they have managed to influence behaviour towards the collective management of risk.

This study looks specifically at the uMngeni River Basin, which is important to the socio-economic development of South Africa, KwaZulu-Natal, and its immediate environs in particular. Production sectors such as manufacturing, forestry, and agriculture (e.g. dairy, poultry, and sugarcane) are reliant on the uMngeni water catchment area. All these sectors contribute to the socio-economic development of the province. In addition, millions of people rely on the water in this catchment area for their drinking water supplies. This level of co-dependence on a shared resource (water) emphasises the importance that should be attached to water security in agricultural enterprises. As such, actors within the basin need to ensure the sustainability of the social-ecological systems from which they draw benefits.

One of the largest agricultural and economic activities within the basin is the sugarcane industry, hence it is imperative to understand how these actors are organised and are participating towards water security efforts. This case study will provide an examination of organisational nesting and polycentric governance in the sugar industry and how this is being used to manage risk to water security in particular. Although a single case may not be used to generalise about the broader class, the outcomes of this research may be useful in providing a hypothesis, which may be tested systematically with a larger number of cases (Abercrombie et al., 2006, p. 34). I will use findings from this case study to illustrate their general applicability to other sectors and natural resources management in the coming chapters. Having described the industry in relative detail in this chapter and the preceding one, I describe the methodology followed in probing the research proposition in the coming chapter.

CHAPTER FIVE
RESEARCH METHODOLOGY

In this chapter I describe the approach I employed to investigate the role of organisational nesting in risk-sharing in the sugar industry within the uMngeni River Basin. I outline the research methodology, detailing the research type and paradigm, the focus of the study, methods of data collection and analysis, ethical considerations, and measures taken to ensure validity and reliability of the data and findings.

5.1 RESEARCH STRATEGY: QUALITATIVE

In this research I used qualitative methodology, employing a case study approach, because it allowed me to make sense of and interpret phenomena in terms of the meanings different actors bring to them (Holloway, 1997; Malterud, 2001). I sought to understand the perceptions of the risk to water security among the actors in the sugar industry and the role of organisational nesting in order to understand, describe, and explain the process of risk-sharing from the perspective of the study participants.

Although findings from qualitative data can often be extended to people, and areas with characteristics similar to those in the study population, gaining a rich and complex understanding of a specific social context typically takes precedence over eliciting data that can be generalised to other geographical areas or populations (Mangal and Mangal, 2013).

Research Paradigm: Interpretivism

To assess the role of organisational nesting in risk-sharing among multiple water resource users and its wider relevance to water security, I adopted an interpretivist approach. This approach is hinged on understanding the meanings that motivate actions of individuals (Halperin and Heath, 2012). For example, it might be predicted that actors within the basin are motivated to align their behaviours based on their perception of risk and its perceived impacts (positive or negative) on their operations. Such perceptions are also influenced by the state of their relationships with others who influence their well-being, and the state of their resources – specifically for this study, water.

I relied on naturalistic methods of data collection (interviewing and observation and analysis of existing texts). Using these methods, I was able to have a dialogue with key actors within the case study area in order to construct a meaningful, collaborative perception of reality.

5.2 SAMPLING

For this study I used purposeful sampling, where participants were able to recommend potential respondents for the study (snowball sampling) (Marshall, 1996). Snowball sampling was more appropriate to recruit respondents not easily accessible to me than other sampling methods, such as random sampling. Respondents were drawn from the three operational areas within the catchment (Figure 4.2), Dalton, Eston, and Noodsberg. They comprised SASA, SASRI, milling company representatives in the study area, SACGA (local and national representatives for the respective organisations), and individual farmers.

A preliminary meeting in November 2014 with key stakeholders helped establish rapport and facilitated access to relevant individuals in the identified organisations. In line with the ethical requirements of the study, research contact was made with SASA to seek permission to conduct research within the organisation. This contact also served as an opportunity to brief respondents on the research, obtain consent, and set dates for the interviews. Contact with participants was made through the office of the Natural Resources Manager of SASA in April 2015 after a field scoping trip. Twenty two participants drawn from SASA, SASRI, and from the growers and millers within the three grower regions of Dalton, Eston, and Noodsberg were interviewed. The research used open-ended questions to explore three themes: organisational nesting, its role in risk-sharing towards water security efforts, and sustainable farming practice.

Data saturation

Data saturation is the point when no new information is obtained from additional qualitative data (Morse, 1995). The point at which saturation occurs defines sample size in qualitative research, since it is taken to indicate that sufficient data has been collected for a comprehensive and credible analysis to be conducted (Kerr et al., 2010). While data saturation informs the qualitative sample size, other factors can dictate how quickly or slowly this is achieved in a qualitative study. Charmaz (2006) suggests that the aims of the study are the ultimate driver of the project design, and therefore the sample size. Ritchie et al. (2003, p. 84) outlined seven factors that might affect the potential size of a sample:

> *"…the heterogeneity of the population; the number of selection criteria; the extent to which 'nesting' of criteria is needed; groups of special interest that require intensive study; multiple samples within one study; types of data collection methods use; and the budget and resources available".*

Factoring in the limitations of time and financial resources the number of participants was twenty two. As indicated above, for this study the participants were drawn from SASA, SASRI, and the two interest groups that make up the sugar industry, i.e. the sugarcane processors and the growers. These interest groups were further subdivided into representatives within the three milling areas under study.

5.3 INTERVIEW DESIGN

For this study in-depth interviews provided a means of collecting data in its natural context which fits well with the interpretive approach to research (Blanche et al., 2006). Interviews were used to capture the views of the participants on organisational nesting, the role of SASA, the state of the water resources within the basin, and their response to the risk of water insecurity. The interview design adhered to the following process: identification of respondents; initiating contact with identified respondents; and conducting of interviews. Using documentary evidence in this research served to confirm or disconfirm any claims made by respondents during interviews.

Interviews were the appropriate tool for this study because the phenomenon under study involved sensitive topics such as the views of individuals on their representative organisations, which are better explored individually than in a group (Charmaz, 2014). In research of this type, it is important that the interviewee feels comfortable with the process as this facilitates the expression of meanings and understandings. To achieve this I made a conscious effort to:

- develop empathy with interviewees and win their confidence;
- be unobtrusive, in order not to impose my own influence on the interviewee;
- make it known to the participants that they reserved the right to withdraw from participation in the research; and
- ensure the confidentiality of the data gathered by using codes to de-identify the participants in the study.

An interview should be a two-way conversation between the interviewer and the participants, where, through questions and exchanges, the researcher is able to collect information and learn about perceptions, and behaviour related to the research subject (Nieuwenhuis, 2007). The in-depth nature of the interviews enabled each respondent to talk about their interpretation of their experience.

I also took care not to ask leading questions that might influence the respondent. I thus started the interviews by raising general points as prompts, and then drawing on those points that came up in the natural course of the discussion as the interviewee spoke. Interviews were conducted at places of each respondent’s choice. The interviews lasted between 30 and 45 minutes.

In accordance with ethical requirements for conducting research with human respondents, all interview notes and recordings were anonymous, with respondent information held separately. Reference of the interviewees was by date and pre-set code, which de-identifies the participants, serving to ensure the confidentiality of responses from participants (Louw, 2014). Interviews were recorded with the agreement of the interviewee. See Appendix A-3 for an example of the interview schedule used.

I transcribed the interviews and, to ensure accuracy of the transcriptions, interview audios were replayed whilst comparing to the transcribed interviews. In order to be fully immersed in the field data from the interviews, I read and analysed the transcripts several times before coding.

For this study, denaturalised transcription was adopted. Of importance during the transcription process were the meanings and perceptions created and shared during a conversation. As such, the word ‘um’, and repeated speech, whenever they appeared in a transcript, were excluded from the quotes. Also excluded were any references that might identify a particular participant or individual outside of the research.

5.4 DOCUMENTARY SOURCES

In this research I made use of documentary analysis to complement the interviews. Documentary analysis refers to the systematic collection, reviewing, and evaluating of documents – soft and hard copy – in order to interpret meaning (Bowen, 2009). Documentary sources used in this study included official documents and periodicals published by SASA and distributed to industry members. I expected documentary sources to: provide context in which research participants operate through historical insight; provide a means of refining interview questions based on new insight of the phenomenon; and provide a way of tracking change and development (Bowen, 2009). Documentary analysis also served to confirm or disconfirm any information gathered from the interviews. Documentary materials were made available by the industry members in their official capacities and as individuals. Each item was recorded as soon as it was collected (i.e. title, date and file number were necessary).

5.5 DATA ANALYSIS

Data analysis in qualitative research involves a thorough and careful reflection and interpretation of the data within the context it was collected (Blanche et al., 2006). The methodology adopted by this study was based on the constant comparative method, described by Maykut and Morehouse (1994), who draw on the work of Glaser and Strauss (1967) and Lincoln and Guba (1985) in their development of this approach in data analysis.

Four stages of data analysis were used in this research:

- familiarisation;
- inducing themes;
- coding; and
- interpretation.

Familiarisation

During familiarisation, I worked to understand the transcribed texts (i.e. field notes, interview transcripts) beginning with the dominant discussion themes that came out of the interviews and document analysis in order to understand emerging ideas from the interviews and documents provided by the participants (Silverman, 2010).

Themes

Data collection was based on predetermined themes of organisational nesting and its role in risk-sharing in water security efforts and sustainable farming practice. The recorded interviews were transcribed and analysed for themes identified in the interview schedule and others that could have emerged during the interviews and analysis. Data analysis provided a means to identify and reflect on the meaning of the texts (Ryan and Bernard, 2003). The responses were grouped according to salient categories of meaning, and relationships between categories were established from the data through a process of inductive reasoning. The constant comparative method offered the means through which I accessed and analysed these perspectives to explain the social processes under study.

Thematic analysis was applied to the data, using QSR NVivo software and manual coding for analysing and coding of texts. In order to avoid preconceived assumptions in the study I consciously sought disconfirming evidence from the data set before a relationship was made.

Coding

I coded the data using the pre-set themes of organisational nesting and its role in risk-sharing regarding water security efforts and sustainable farming practice. Coding refers to the marking of different texts of data according to relevant themes and subthemes (Blanche et al., 2006). This process meant breaking the data sets from the linear order in which it was recorded to a sequence that highlights relationship between data sets. I used the QSR NVivo software package and manual coding to align themes and subthemes emerging from the transcripts and notes, through the analysis of common interview threads and, in some cases, the uncommon ones, which warranted further analysis.

Interpretation

The coded data were interpreted by developing a written account of the phenomenon using themes as subheadings (Silverman, 2010). This stage provided an opportunity to reflect on the researcher’s bias in collecting and interpreting the data. In addition, the theoretical framework of the research given in Chapter Two played a role interpreting the data. Care was taken not to overlook concepts and relationships not reflected in the theoretical background included in Chapter Two.

5.6 VALIDITY AND RELIABILITY OF THE DATA

Validity and reliability in qualitative research culminate into the question of the quality of the research (Blanche et al., 2006). Following Creswell and Miller (2010), validity and reliability were addressed from three perspectives:

- from the researcher's perspective;
- from the participants' perspective; and
- from the perspective of parties external to the study.

In order to minimise the influence of preconceived assumptions in the collection and analysis of data, I consciously sought disconfirming evidence from the data set before a relationship was established. Hence, during interviews and data analysis, I reflected on alternative meanings of responses and themes for either consistency or disconfirming of evidence.

Interpretive research assumes that social phenomena are constructed and perceived by participants (Blanche et al., 2006). Hence, I aimed to reconstruct each participant's reality in his/her setting in order to understand the attachment between subjective perceptions and actions. Because qualitative research is naturalistic, the phenomenon under research is closely tied with the setting in which it is found (Oliver et al., 2005). To improve credibility of the research, particular attention was given to describing and understanding the setting, the participants, and the themes, as suggested by Creswell and Miller (2010).

In research of this, nature data collection and analysis may be influenced by the researcher's subjective experiences and bias towards interpreting a phenomenon. To reduce the implications of personal bias I also encouraged my research supervisors to challenge assumptions I made in interpreting the data.

5.7 ETHICS

The Monash University Human Research Ethics Committee (MUHREC) approved the research with the SA sugar industry as well as interviews with sugar industry members (approval number CF15/1015 - 2015000473 – see Appendix A-4). Since the research was to be conducted within an organisation, prior approval was sought and granted from the SASA (see Appendix A-5).

Ethical standards of research were observed at all levels of the execution of the study, from design to the final reporting of results. Adhering to ethical requirements involved ensuring that there was full consideration on issues of: free and informed consent; ensuring no harm and risk to respondents; and ensuring privacy, confidentiality and anonymity. To safeguard the privacy, confidentiality and anonymity of the respondents participating in the study, codes and not names were used to identify respondents and particular responses identifying respondents or individuals were de-identified on reporting.

In order to ensure free and informed consent, the researcher made the necessary information regarding this study known to the respondents before they decided on participating in the study through a letter of informed consent and explanatory statement. The two documents highlighted the purpose of the study and how the findings were to be used; description of any reasonable benefits expected from the study; the risks or discomfort associated with the research; how confidentiality and anonymity in the study was to be guaranteed; and potential use and storage of the data collected (See Appendices A-1 and A-2).

5.8 LIMITATIONS OF THE STUDY

Qualitative samples must be large enough to assure that most or all of the perceptions that might be important are uncovered (Mason, 2010). However, if the sample is too large, data becomes repetitive, reaching a point of saturation when the collection of new data does not shed any further light on the issue under investigation (Mason, 2010). Sample size can be considered as a potential limitation for this study, as a consequence of the structure and geographical dispersion that is a feature of sugarcane growing and milling. However, in qualitative research, the focus is not on the size of the sample but rather on the quality and depth of the information obtained. For this study, the sample size was influenced by the groups of special interest that required intensive study, types of data collection methods used, and the budget and resources available (Ritchie et al., 2003).

Participants in this study were located in different areas within the uMngeni River Basin. The sampling strategy described in the preceding sections of this chapter was designed to minimise limitations imposed by the complexity of the industry and the geographical spread of the participants, and financial and time constraints. These factors had to be taken into consideration in choosing the total number of participants.

5.9 SUMMARY

In this research I employed a qualitative methodology approach, using in-depth interviews and documentary sources for data collection. I adopted an interpretive research paradigm, thus the research was descriptive. The research adhered to all ethical considerations as prescribed by the MUHREC. In this research I deliberately designed a strategy that would allow adequate sampling and data collection within the constraints imposed by finances and time. Thematic analysis was applied to the data, using QSR NVivo software and manual coding for analysing and coding of texts. In order to avoid preconceived assumptions in the study, I consciously sought disconfirming evidence from the data set before a relationship was confirmed. The findings from the field research are presented in the coming chapter.

CHAPTER SIX
RESULTS

In this chapter I present the results of the research. The aim of the research was to investigate if organisational nesting in the SA sugar industry was a consequence of the need to share risk and how it can be used to enable risk-sharing mechanisms in the industry.

Because perception and acceptance of risk have their roots in social and cultural factors (Douglas and Wildavsky, 1982; Short, 1984), I postulate that organisational nesting and polycentric governance bring about alignment of behaviours among actors because they have the authority to formulate rules and institutional arrangements. Thus, actors are allowed to manage risk collectively.

6.1 A HISTORICAL PERSPECTIVE ON SELF-ORGANISATION IN THE SOUTH AFRICAN SUGAR INDUSTRY

In this section I present the results of the document review on the history and evolution of organisational nesting within the sugar industry. The purpose of this section is to demonstrate that exposure to risk influenced the evolution of organisational nesting within the sugar industry.

The sugar industry started in the then Natal region (now KwaZulu-Natal) ca. 1850. The principle at the time was that every farmer was his own miller (Osborn, 1964). With each farmer responsible for his own value chain, there were no difficulties regarding cooperation and self-organisation, and each farmer managed his/ her own exposure to risk. With the growth of the sugar industry and an increase in users who laid claim to the natural resources came complexity and the need for a collective approach to organising the industry.

The earliest form of self-organisation in this industry was the formation of the Umhlanga Planters' Association in 1875, even though the Association had been unofficially active since 1865 (Osborn, 1964). The Umhlanga Planters' Association enlarged its interests and grew in importance in the latter half of the 1870s by merging with growers in other areas to form the Victoria Planters' Association. The industry was organised in that way until 1905, when the then Natal government decided to open up the Zululand lands for sugarcane planting (Union Parliament of South Africa, 1938). The government entered into an agreement with millers who had to establish mills and with planters who had to grow sugarcane on leased lands. Another set of agreements was entered into between the farmers and the millers, whereby the millers undertook to purchase and mill the sugarcane grown by the farmers (Union Parliament of South Africa, 1938). These arrangements established interdependence, wherein risk became a collective issue requiring collective action. However, even though there was communication among the various sugar growing regions – both the North and South Coasts – there was no coordination of activities or promotion of the idea of organising as an industry and having a representative body to protect the industry's interests until the year 1910, when the Natal Sugar Association was formed (Osborn, 1964).

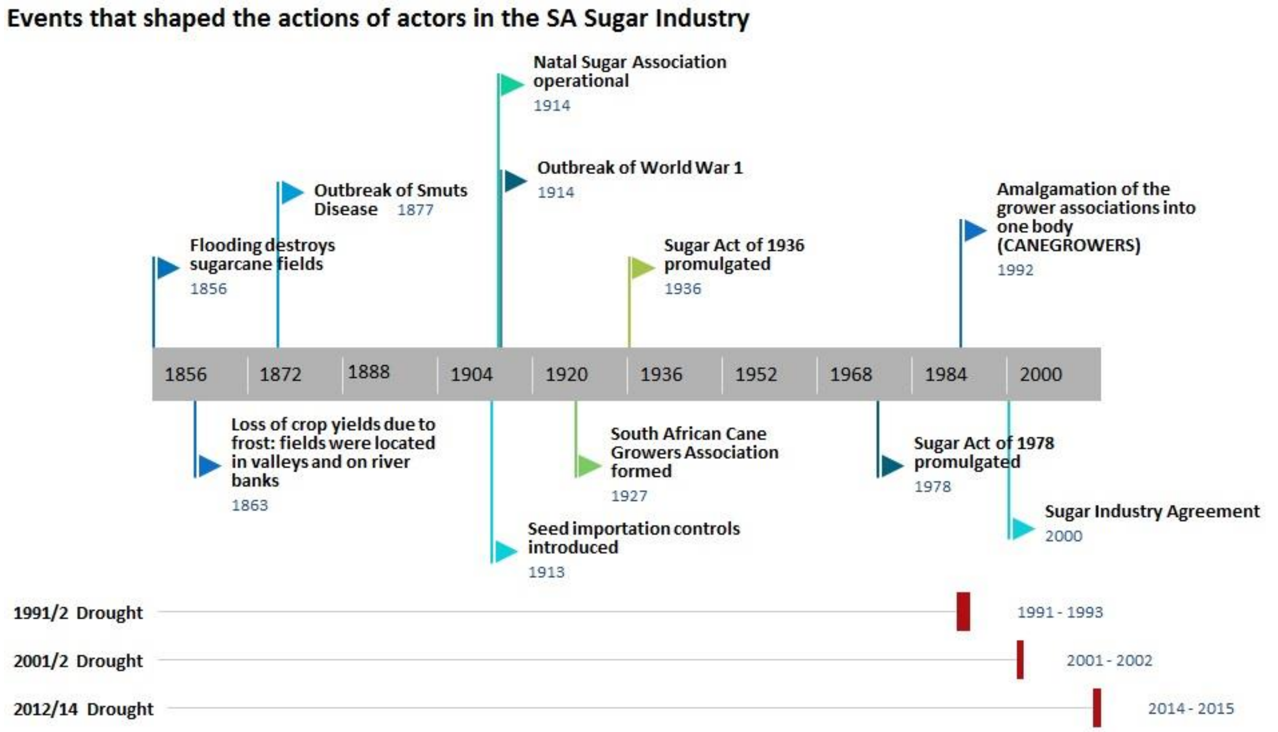

Figure 6.1: A timeline of events leading to action in the SA Sugar Industry

Attributes of Self-organisation in the Sugar Industry

The mutual agreement among the actors in the sugar industry played a role in the self-organisation of the industry. The formation of SASA in 1919, the Fahey Conference Agreement of 1926, and the Sugar Industry Agreement leading up to the promulgation of the Sugar Act of 1936 have contributed to the self-organisation in the industry. The recognition of self-organisation within the sugar industry by the Sugar Act gives legitimacy to the governance processes of the industry members.

Mutual Agreement

Through meetings throughout the sugar belt, advocacy for an association for all stakeholders in the sugar industry grew. Stakeholders needed to collaborate in addressing challenges they were facing and sharing resources in developing the industry. They had to do so through the most economical yet profitable lines consistent with the country's welfare. Osborn (1964, p. 170) writing in his book on the history of SASA noted that:

"…Further progressive steps were taken in the form of meetings attended by representatives from the entire sugar belt on both North and South Coasts. But while such a getting together surely moved some to acknowledge the value of this with cooperation on national issues, no effective promotion of the idea occurred until 1910.

In that year the ice was broken, and the Natal Sugar Association was formed… and immediately following World War One the Natal Sugar Association performed what was perhaps its first major job. It represented to the Government that the lack of control on the price of sugar was leading to speculation, with consequent unwarranted high prices on the local markets. The industry was earning better money, but would be sacrificing its good name. The Government agreed, and assisted accordingly."

The industry was facing a risk to its reputation owing to the high prices of sugar in the local markets at the time. To stem the speculative behaviour of consumers, members had to come together and act for the common good of the industry. Further erosion to the reputation of the industry could have seen the importation of cheaper sugar from other countries, which would have impacted on the profitability of the SA sugar industry. Furthermore, to have better representation, industry members had to consolidate their associations. Following an agreement between the planters' union, the millers, and the brokers, the South African Sugar Association was formed in 1919 (Osborn, 1964).

Birth of the South African Sugar Association

World War One brought mixed fortunes for the sugar industry but generally they had higher returns on investments (Lincoln, 1988). However, the end of war did see the introduction of price controls on sugar, which presented a risk to the commercial viability of sugar enterprises. Collective action was needed in mitigating this risk. Writing in the Journal of Natal and Zulu History, Lincoln (1988) noted;

"…These investments [in sugar mills] reflected the generally high returns to sugar capital during the war despite the constraints imposed on the sugarocracy's sphere of production and foreign sales. War-time strictures coming so soon after Union's dilution of the sugarocracy's political influence were doubtlessly part of the incentive behind the sugarocracy's commitment to new organisational enterprises, notably in the shape of the British Empire Producers' Organisation and the South African Federated Chamber of Industries."

Thus, after the actors in the sugar industry had formulated the constitution and rules, SASA came into being in December 1919. From this beginning, SASA evolved into a network of interrelated executive bodies representing some vital parts of the industry (Osborn, 1964).

The formation of SASA was in part a response to the need for a collective approach towards the actors' perceptions of commercial and political risk that accompanied with the economic depression following World War One. This awareness of risk can be seen in the engagements the industry had with the government in trying to secure a higher price for sugar;

> *"…Yet another miller/grower deputation travelled to Pretoria the following month [September 1919]. When the Cabinet responded by pushing up the price fixing, the increment fell short of what the sugar-producers had hoped for"* (Lincoln, 1988).

From its infancy, SASA had arranged itself polycentrically, with small units at local levels nested in even bigger units at farming region level to national level, a structure the organisation has retained for almost 100 years. From its inception, SASA was designed as a body for the farmers and millers by the farmers and millers (Osborn, 1964). Furthermore, the formation of SASA in the year 1919 paved a way for other collaborative efforts and mutual agreements among industry members. One such agreement was the Fahey Conference Agreement of 1926.

Recognition of Self-regulation

SASA is an autonomous organisation and operates free from government control. In terms of the Sugar Act and Sugar Industry Agreement, statutory powers of self-governance are granted to the sugar industry (Conningarth Economists, 2013). The Sugar Industry Agreement demonstrates recognition of self-organisation through the establishment of local Mill Group Boards and the concept of risk-sharing through the share of proceeds agreement.

In 1934, the Natal Sugar Millers' Association and the SACGA presented a joint memorandum to the Board of Trade and Industries (BTI) (SACGA and NSMA, 1934). The objective was to secure the approval of the BTI (and by extension government) of a proposal that government should pass legislation that would have provided for:

(a) The compulsory settlement of all questions of mutual interest to millers and planters collectively by majority agreement between them, with judicial arbitration as a last resort.

(b) The application of any such agreement or decision throughout the industry, in the discretion of the proper Minister, and subject to such safeguards as he may impose.

The associations were of the view that such legislation was essential for the success of the industry. This belief was owing to the prevalent perception of commercial risk among the members. This perception was so prevalent that a lobby group for the industry emerged in parliament. As Lincoln (1988) noted;

> *"The strengthened sugar lobby (with Saunders and Heaton Nicholls in the Assembly and F. Reynolds in the Senate) helped to win two more price increases in 1920.*
>
> *Still frustrated by the price ceilings, and perturbed by the possibility of an imminent renewal of the Moçambique Convention which might prolong the flow of duty free imports, the sugar producers sent their representatives to Cape Town in April 1921. This was a vain bid and when it was followed later in the year by two price reductions, the industry's representatives visited the Prime Minister. The upshot of this meeting was the Government's appointment of a Commission of Inquiry into the sugar industry [through the BTI]."*

In recognising the diverse interests of the industry, the BTI recommended that the then Minister of Commerce and Industry should introduce legislation or regulations for the industry (Union Parliament of South Africa, 1938). However, the Minister at the time intimated that he was not prepared to act upon the advice of the BTI and introduce legislation unless the industry actors came to an agreement by themselves (Union Parliament of South Africa, 1938).

As shown by the formation of SASA in the year 1919, the Fahey Conference Agreement of 1926, the Sugar Act of 1936, and the Sugar Industry Agreement of 2000, the self-organisation in the sugar industry was driven by the need to manage risk to the industry collectively. These risks included disease manifestation, price fluctuations, reputational risk and legislative risk. As such, the way the industry is structured is an outcome of exposure to risk. It can be postulated that this organisational structure can be used to respond to environmental risk.

Commercial Pressure and Risk-sharing

An analysis of the agreements among industry members (the Fahey Conference Agreement, the Sugar Industry Agreement) shows that the concept of risk-sharing motivated the coming together of the actors in the industry. These agreements provided a basis for collective action for the sustainability of the industry, and will be discussed below.

Following the outbreak of World War One in 1914, the sugar industry suffered from speculative sugar pricing world over. The Natal Sugar Association then made representations to government that the lack of control on the price of sugar was leading to speculation, with subsequent price instability and unwarranted high prices on the local markets (Union Parliament of South Africa, 1938). Huntley (1966) (Chairman of the Sugar Industry Central Board) wrote;

> *"The first important step towards the development of the South African sugar industry into a properly organised undertaking was taken in 1926 with the coming into operation of the Fahey Conference Agreement. Prior to 1926 there had been growing dissension*

between the milling and planting interests in the sugar industry largely due to the dissatisfaction of planters with the conditions under which they were supplying cane to the mills. Matters came to a head in 1924/25 when there was a record world production of sugar accompanied by falling prices and when South Africa itself was faced with an export of 70,000 tons of sugar at reduced values. An appeal was made to the Government to assist the industry in arriving at a solution to its problems and the Government authorised the Board of Trade and Industries to investigate the economic position of growers and millers."

With commercial pressures emerging in the 1920s (depressed world sugar price, raw sugarcane price – which was based on weight rather than sucrose content – and export risks, among others) weighing down on the industry, the stakeholders in the industry signed an agreement, which came to be known as the Fahey Conference Agreement (Union Parliament of South Africa, 1938). The Agreement, which came into effect in 1926, was valid for a period of ten years and was set to expire in April of 1937.

Under the Fahey Conference Agreement, the theme of risk-sharing and coordination began to emerge. The farmers and sugar processors agreed to share in any losses or profits on exports. The need to share risk among the industry members can be attributed to the perceptions of risk to the industry caused by the price instability of sugar after the outbreak of World War One.

Currently, in order to share the risk associated with the world market equitably amongst growers and millers, a redistribution of proceeds is effected through SASA. The Sugar Act and the Sugar Industry Agreement provide regulatory support for the redistribution of proceeds (Conningarth Economists, 2013). The sugar millers, under the same agreement, agreed to share the export proportionally to their individual production levels: 'In respect of each year the quantity of sugar required shall be allocated proportionately to the respective mills in relation to their sales on the local market (excluding carry-over stocks) in that year' (SASA, 2000, p. 56). There is no obligation on any mill to export.

The mutual agreements among the industry actors demonstrate the realisation of the shared risk to the industry posed by the commercial pressures the industry was facing at the time and how organisational nesting can be used to address perceived risk. The same structures can be used to mobilise collective action in order to mitigate the risk of water insecurity. In the following section, I consider how organisational nesting and polycentric governance are currently being used to help manage risk.

6.2 RISK AND ORGANISATIONAL NESTING

The SA sugar industry illustrates both vertical (connections between multiple jurisdictional levels) and horizontal (intercommunity connections) organisational nesting. Growers associate around a mill closest to their operations, so at a local level there is horizontal organisational nesting between the millers and the growers. The perceptions at a farm-level or mill-level drive industry members' behaviour and, because risk motivates innovation, the degree of autonomy that they have through nesting enables the emergence of risk mitigation measures appropriate at a given level. Risk at industry scale may be identified by SASA, who would then formulate frameworks for the implementation of mitigation measures at the local level.

In this section, I use my results from data collection to assess how organisational nesting is used for risk-sharing. I do this by examining how organisational nesting influences the response of actors to risk, particularly the risk related to water security, pests, and national regulations.

6.2.1 Water Security

Sugarcane in South Africa is grown under dry-land conditions and irrigation. Irrigated land accounts for 20% of the sugarcane grown in South Africa (Interviewee OVM21). In the case study area, only 8% of the total area under sugarcane crop is irrigated; the rest is rain-fed (Interviewee OVS5).

Sugarcane Farmers

Risk is framed by the influence it has on those who are affected. Nests are able to frame risk in terms that relate explicitly to the risk they experience and, consequently, are able to develop approaches appropriate to their experiences. The perception among farmers is that they face the risk of water insecurity as custodians of the natural resources from which they derive a benefit. It is those who rely directly on the water resources that tend to be most conscious of the risk to water security:

> *"That's your number one risk factor for a farmer because without rain you can't farm. That is out of your hands; a lot of other risks on a farming enterprise can be measured and calculated, [and] rainfall is number one. If you don't get rain you don't grow cane"* (Interviewee IVF9).

These views were echoed by other growers when commenting about water insecurity. Reduced rainfall impacts on the sugarcane crop output from the growers and this risk can manifest throughout the industry, owing to the interdependence among the actors:

"I think rainfall patterns have changed. Certainly we are getting fewer [amounts of rainfall]. The last few years we have been very dry and we have intense storms, but maybe longer periods of droughts in between them, so I think we got to make allowance for the intense storms with the hope to make sure we don't have any damage to the watercourses or basically the wetlands and things like that. I think there has been a shift in the seasons. I am pretty sure there has been a slight shift. We just got to be aware of them and alter accordingly" (Interviewee IVF10).

"My assessment would be surface water quality is quite low; some of it because of poor agricultural practices, peri-urban areas occupying the catchments, the rainfall is erratic and it's unreliable. So it's got all the negatives about water security" (Interviewee IVF8).

The views above reflect how the growers view the availability of water and the changes they have been experiencing. Because of their reliance on rain-fed agricultural practices and with no control on the rainfall patterns, sugarcane growers in the study area had to find a way of responding to the risk of water insecurity. Such practices include land-use planning and riparian zone protection, as the following comment shows:

"So our water use plan has become more effective, our waterways have been widened and grassed, proper contours and strip roads have been put into place so any new plants, new developments, access roads, contours, and waterways are all in place. It's efficient" (Interviewee IVF9).

The outcome has been an improvement in the quality of available water:

"We have eliminated that risk [water quality] with land-use planning and riparian zone preservation, so the quality of the water that leaves this property is quite high. We have stored water to eliminate the risk in terms of erratic rainfall and because we have a pretty well implemented land-use plan the quality of that water is quite high, is good for irrigation and what we use it for now" (Interviewee IVF8).

Land-use planning has thus been implemented as a way of responding to risk posed by water insecurity, soil erosion and related risks. The issue of land-use planning came out from the response of a few participants. It seemed to be a concept that was being developed rather than practiced. Furthermore, from the above quotes, agricultural practices are understood to some extent to be a means to mitigating the risk to water security. Sustainable farming methods are an integrated strategy for risk management, thus farmers developed the Sustainable Sugarcane Farm Management System (SUSFARMS®).

One of the principles of polycentricity as identified by Schoon et al. (2015) is learning and experimentation. The self-governance and structure of the sugar industry created an enabling environment for the development of SUSFARMS® by the growers in the Noodsberg area. As one respondent acknowledged;

> *"…the grower leadership here, amongst the Noodsberg Cane Growers, some years back, I think just before the year 2000, as you can see on the wall there, that's the Noodsberg Cane Growers Environmental Policy. They decided that they will draw up a document like that so that they would probably say as a grower group we want to be proactive in terms of environmental conservation and minimising the impact of sugarcane growing and timber and whatever they are doing has on the environment within our mill supply area"* (Interviewee OVS5).

With the independence – derived from the structure and governance system within the industry – to develop programmes to respond to risk and customer demands, the farmers experimented with SUSFARMS® and only after its successful adoption within the Noodsberg area did it get the attention of other sections of the industry:

> *"Yes, there is a programme that we developed in the Midlands, actually the area where I am from. There is a programme up there called SUSFARMS® (Sustainable farming). SUSFARMS® has a process about managing, amongst other things, surface water management. It was developed by the Noodsberg cane growers and it's now being rolled across the industry in all grower areas, and that's all being promoted by this organisation, the South African Cane Growers Association"* (Interviewee OVM21).

As noted in Chapter Two, resource users improve their management of risk by learning from other units in a nested system. Thus learning from the experience of the Noodsberg local growers, the Eston and Dalton growers adopted the SUSFARMS®. Commenting on the adoption of SUSFARMS®, a respondent said;

> *"I think it's just a matter of time, it's a learning thing, they will understand that SUSFARMS® is now not a Midlands specific thing. It has BMPs [better management practices] there which are related to Midlands's dryland conditions as well as coastal conditions and irrigated conditions, so the SUSFARMS® that you see nowadays is definitely a document that has been adapted to the whole of the South African sugarcane growing region, whether you are dryland or irrigated"* (Interviewee OVS5).

Thus, in response to the risk posed by water insecurity, innovation took place at a local scale, because the sugarcane growers felt they needed to change or improve their farming practices.

Several participants acknowledge that SUSFARMS® is a farmer-led initiative. One responded reflected that;

> *"… the industry decided that SUSFARMS® had been developed from the grower up, it was an ideal vehicle to be continued, developed into become the industry's tool. So that's where it is at now. SUSFARMS® will continue to develop as practices change, technology changes"* (Interviewee OVS22).

Furthermore, SUSFARMS® has been adopted in the areas of Dalton, Eston, and Noodsberg owing to the networking among the three milling areas. Adoption of SUSFARMS® results from an alignment of behaviours to collective goals, particularly the management of risk to water security. To achieve an alignment of behaviour, stakeholders need to be aware of incentives for adopting better natural resource management practices. For other farmers and the SA sugar industry as a whole, an incentive to promote SUSFARMS® could be an improved market for the sugar products, as shown by the following comments:

> *"[Sigh] Like everything in life there's got to be an incentive and those of us who advocate for SUSFARMS® would say the incentive to the grower is that it will improve your management. We all hope that one day it will make our sugar more marketable because it comes from a sustainable source. That's not happening just yet, perhaps one day… We will get there one day"* (Interviewee IVF11).

Because of the autonomy that 'nests' enjoy in a polycentric system they can devise rules and regulations to effect the alignment of behaviour. Thus, because shortage of sugarcane is perceived as a threat, millers promote SUSFARMS® because it mitigates risk of supply to the mill:

> *"So in terms of its adoption, I think there's recognition across the industry of its potential value as a BMP [Better Management Practices] tool, but in terms of adoption and of people actually using it with the express purpose of improving themselves I can say it's really adopted in two mill areas and that's because the miller has said you will not deliver cane unless you have adopted SUSFARMS® and anyone who has adopted SUSFARMS® knows there's a progress tracker where they can measure themselves. If you can submit the progress tracker you can deliver your cane. So that has got growers to adopt [SUSFARMS®]".* (Interviewee OVS2).

Self-organisation is thus an attribute of the SA sugar industry that is recognised at the MGB level. As such, sanctions cannot be imposed industry-wide without the input of the local actors. Actors within a certain 'nest' have to collaboratively come up with their own rules and regulations that will promote the alignment of behaviour. Industry-wide, SASA can create frameworks and define the industrial goals that will guide the alignment of behaviours within local governance units. To this end, SASA has recognised the role of sustainable farming in responding to the risk of water security. They have facilitated the involvement of SASRI in the development of SUSFARMS® and have started to promote it:

> *"The industry has fully supported this tool (which is a farm management tool) by housing it through SASRI to develop it, to update it and to then roll it out and implement SUSFARMS® throughout the industry"* (Interviewee OVM1).

While such on-farm management practices are promoted by SASA as the principal centre within the governance structure of the industry, implementation is at a local level:

> *"When it comes to implementation for example of management practices as mentioned previously, one arm of that is done through the South African Sugar Research Institute, which does have extension officers that are out in the regions. These extension officers are then obviously engaging with the growers and with the local industry members and stakeholders at local level… If we use the Midlands North area as an example, much has progressed in that areas a result of close collaboration between our local industry members, growers, and millers in that area with our SASRI extension officers together with other key stakeholders such as [NGOs] to say how do we manage our water resource in this area and what effect can we have on our resources"* (Interviewee OVM1).

The autonomy afforded to governance units within the sugar industry therefore resulted in the development of SUSFARMS®. As the name implies, it has gone on to evolve into a way of responding to calls for sustainable farming, hence also manages the reputational risk the industry may face. Because of the SUSFARMS® integrated approach to sustainable farming practices, it has become a tool for the collective management of water resources towards water security through the involvement of sugarcane growers and millers. Achieving the collective management of water resources is only possible with an alignment of behaviours towards collective outcomes – in this case, water security.

Yet despite the gains made with alignment of behaviours by the development of SUSFARMS®, how farmers frame risk can prevent the spread of a new initiative. For example, in areas where irrigation is predominant a respondent observed;

> *"The guys in the north coast have said, 'SUSFARMS® is for Noodsberg isn't it?' The guys in Mpumalanga said, 'They don't have irrigation in Noodsberg, why would we need something like that?'"* (Interviewee IVF8).

Where sugarcane is produced under irrigation, water security is framed more by the efficiency of water use than it is by the availability of water, particularly where stored water is a resource shared among farmers and, in some instances, other users. Inefficient use brings censorship from other users and results in sub-optimal production. Through the nested system and polycentric governance, growers in irrigated areas have started promoting programs such as irrigation scheduling and MyCaneSim in order to use the minimal amount water necessary for optimum sugarcane yields. These programs are also a response to increasing demands for water resources from other actors outside of the industry.

> *"There has been a very considerable development in water conservation and again on two parts: one on the irrigated use of water and the sugar industry has a number of projects involved around irrigation scheduling. There is the MyCaneSim (a simulator) which is used on an SMS based system where people can get information on whether they must irrigate and how much they must irrigate"* (Interviewee OVM21).

Risk then connects the individuals and groups. Consequently, shared risk promotes learning and the spread of ideas – it is possible to extend ideas into other domains because of nesting. This spread of ideas is achieved through the self-organisation at mill group board level and stakeholder participation. As stated by Schoon et al. (2015), nested institutions enable the creation of rules for social engagement and collective action to fit the problem they are meant to address. Therefore, the development of SUSFARMS® within the Noodsberg area and of irrigation scheduling and MyCaneSim in other areas were responses to emergent risk of water insecurity. To align the behaviour of actors, they had to collectively devise rules and regulations to foster the adoption of these within their 'nest'. Since the SA sugar industry has a share of proceeds agreement, achieving this alignment of behaviours and collaboration becomes an industry aim.

Sugar Millers

The milling process draws most of its requirement for water from the crushed sugarcane. Consequently, millers perceive water security differently than do farmers. If a mill receives sufficient sugarcane, it is largely independent of other sources of water although it does have to manage the impact discharges have on receiving streams:

> *"… adequacy of supply, quality of supply, quality of discharge and these are the main touch points at the moment"* (Interviewee CMV23).

> *"… you try to use the water as much as humanly as possible and as often. So it gets recycled within the mill as much as possible simply because it is a cost factor, you don't want to pump in. Most of the water that we obviously receive is actually from the cane itself, not pumped up"* (Interviewee CMV16).

Sugarcane supply is thus the principal source of risk for millers, which explains their support for land-use practices and SUSFARMS® in particular to mitigate risk to supply of sugarcane.

Collaborative action between the sugarcane growers at the millers is achieved through the Mill Group Boards:

> *"Each cane growing area has a Mill Group Board, so Noodsberg has a Mill Group Board, of which I am on the Mill Group Board plus another two members from the mill here and the rest is represented by the growers that we have a meeting with monthly"* (Interviewee CMV20).

Because of the interdependency among farmers and millers, water insecurity is thus framed as a collective risk. This framing is despite the fact that farmers view water security mainly as an issue of quantity whereas millers see it in terms of quality risk. Nevertheless, taking action in isolation can be impacted by inaction by others. Thus the interdependency between the farmers and millers within the sugar value chain makes the millers as liable to risk as farmers. This reason explains why they were willing to reach agreement with sugarcane growers, i.e. where only sugarcane produced on farms implementing sustainable farming practices would be accepted for milling:

> *"… it's really adopted in two mill areas and that's because the miller has said you will not deliver cane unless you have adopted SUSFARMS® and anyone who has adopted SUSFARMS® knows there's a progress tracker where they can measure themselves. If you can submit the progress tracker you can deliver your cane"* (Interviewee OVS2).

A risk to production for farmers translates to a risk of sugarcane supply for miller. The networking between 'nests' then helps in raising awareness of risk through the sharing of information and a shared-risk approach. Organisational nesting within the sugar industry is strongly oriented towards a 'learning network'. The nesting among the millers facilitates the spread of knowledge, from process improvement to better environmental management practices, and the efficient use of water resources. Hence, the role of organisational nesting is to spread ideas and information among actors. This information and ideas can be generated at any level of the industry.

The South African sugarcane crop in the 2014/15 season was adversely affected by drought conditions that prevailed for most of the season. Sugarcane production declined by more than 11% from the 2013/14 season to 17 755 537 tons (CANEGROWERS, 2015). As a response to the drought, SASA has started to promote sustainable farming practices at an industry level through its extension services. Indeed, the increased variability of rainfall is predicted and perceived by sugarcane growers to be leading to greater risk of drought;

"The last couple of years have been – there has definitely been – a change in climate, where the storms have been slightly more severe; they happen less often. Many years ago thunderstorms used to come on a regular basis. Now they are not regular but when they do come they are far more severe. That is my opinion. I think we have had a decade of drier periods as it shows with our rainfall records as compared to the average" (Interviewee IVF9).

Although these effects will vary regionally, climate change is expected to increase complexity and unpredictability in water resource management making water security harder to attain (Morrison and Gleick, 2004), hence the need to have collective action towards water security and sustainable farming by the stakeholders in the industry – the growers and the millers.

Individual actors or groups cannot successfully respond to this risk independently. Because of the established interdependency among the actors in the industry, collective action is the only way to respond to water-related risk. In this regard, organisational nesting and polycentric governance play an important role in aligning behaviours towards the collective goals of the industry, as illustrated by the following response;

"I think right now it's facing us; it's facing us now at a strategic level. Involuntary consequences of drought or the lack of water; in the South Coast it has led to a decreased crop, which has led us having been forced to a decision to not crush at one of our mills this year. So actually one of our mills has actually closed this year and the cane that would have been sent there is currently diverted to a nearby site, 30km away. So it is a top agenda in terms of business risk currently" (Interviewee CMV12).

Millers thus face the consequences of water insecurity too. It has socio-economic consequences for the affected areas, because if there is no security of sugarcane supply, a mill may close, thereby impacting on the employment levels in an area and related economic slowdown. In this case, water insecurity manifests as a risk to the economic viability of the mill. This effect alone hastens the millers to collaborate with farmers towards water security.

South African Sugar Association

At SASA level, the perception of risk to water security is at a national scale, rather than area specific. The following two responses provide insight into the relationship between organisational nesting and risk to water security. The first quote illustrates how SASA responds to the SUSFARMS® initiative (bottom up) and the second how it responds to risk emerging from national legislation (top down):

"… there is a programme that we developed in the Midlands, actually the area where I am from. There is a programme up there called SUSFARMS® (Sustainable farming). SUSFARMS® has a process about managing, amongst other things, surface water management. It was developed by the Noodsberg cane growers and it's now being rolled across the industry in all grower areas, and that's all being promoted by this organisation the South African Cane Growers Association" (Interviewee OVM21).

Even though the sugar industry enjoys self-governance, they still have to take cognisance of legal requirements, such as those relating to the Conservation of Agricultural Resources Act (Act no. 43 of 1983). This Act requires landowners to keep riparian areas free from invasive alien plant species. Because SASA can be held accountable by government, it frames risk in terms of national legislation, for example, as a risk to industry reputation. It discharges its responsibility by informing farmers of the requirement for keeping riparian zones and wetlands free of invasive plants and educates growers on the benefits of planting sugarcane away from wetlands:

"... we encourage our growers to clear alien invasive species along our river channels, watercourses, because we know alien invasive species take up water from our watercourses. We also make them aware of legal requirements in terms of CARA (Conservation of Agricultural Resources Act) to say this is the distance away from a riparian edge which you should not be planting any cane or undertaking any production" (Interviewee OVM1).

By promoting respect for the law, the industry mitigates reputational risk. But despite these efforts, some growers still plant sugarcane in a wetland because of the yields they attain:

"So the sugar industry has been put under spotlight to say how are you guys altering these natural processes and how can we help sugarcane [farmers] to revert some of those natural processes back to normal, which has implications because if an area is cultivated under sugarcane is productive and profitable if you want that area to be removed outside of sugarcane it means there's a loss of profit for the farmers" (Interviewee OVS3).

This quote highlights the challenge of aligning behaviour at farm-level without the involvement of the local institutions. Perhaps borrowing from the adoption of SUSFARMS®, SASA can take advantage of the power local institutions have in aligning behaviours of actors towards collective goals. But, as shown above, SUSFARMS® has yet to achieve industrywide support.

The results of this study suggest that while the different framings of water security have led to significant innovation, spread of learning and practice throughout the industry is hampered by the location-specific framing of water security. From the interviews conducted it is apparent that actors in the sugar industry frame water security differently. Rain-fed sugarcane growers, mainly located along the KZN Coast and Midlands areas, view it terms of rainfall availability as shown by their sensitivity to the drought conditions. Irrigated sugarcane farmers, predominantly located in the north of KZN and in Mpumalanga, view it in terms of assurance of supply. For millers water security is directly linked to the security of sugarcane supply.

Herein is an opportunity for SASA to develop and promote an industrywide framing, policy, and strategy for addressing the varied risks that attend water security. The results also suggest an increasing influence of reputational risk driven by the growing scarcity of water in the country and global trends towards sustainable farming practices. More conscious use of organisational nesting and polycentric governance would assist in achieving an integrated approach to managing risk throughout the industry.

6.2.2 *Eldana Saccharina*: A Risk to Production

From the above section, it is evident that response to water availability was initiated at the local level. This response can be attributed to the fact that the sugarcane growers face the risk to water security directly. However, responses to risk can also be devised at SASA level. Examples include the response to the regulatory risk in the form of national legislation, such as the Conservation of Agricultural Resources Act as well as the responses to the risk to production owing to eldana pest manifestation on the sugarcane crop. These responses, devised at SASA level, take advantage of the nested structure in order to initiate implementation at farm-level or mill-level.

Because the sugarcane growers and millers all draw benefits from the natural resource system, the threat to these benefits presents risks to the industry. To sustain such benefits, the industry has developed and implemented sustainable farming methods, as shown in the previous section. The impact of the sustainable farming methods is reflected in the following comment:

> *"I think that SUSFARMS® will be able to help with the impact of our agriculture on the pollution of our natural water systems and the preservation of the water system (ecosystems), protection of wetlands, limitation of silt-loading of discharge water, limitation of insecticide and herbicide pollution in runoff water"* (Interviewee CMV23).

The statement above reflects a perception that SUSFARMS® could assist in reducing impact. Perhaps further research is needed to measure the impact of SUSFARMS® in the mitigation of environmental risk. The preservation of wetlands relates to the fact that although wetlands are productive sites for the cultivation of sugarcane, putting wetlands under sugarcane has resulted in the manifestation of the eldana pest, resulting in huge costs for the operations of the industry. These costs are not only environmental, but are also financial, as the following comment highlights:

> *"… and that's the point, if you have a major problem like that you will have a major problem of eldana. We have spent 30 years researching this pest and we know because it's an indigenous pest, we are not going to get rid of it; we have to manage it, we have to control it. So as a quick fix we can spray chemicals, which we have eventually got to because we used not to in the older days but now we have registered chemicals, some more benign than others, and that's a quick fix but that's just one element. Eldana cost us nearly a billion rands a year (900 million/ year)"* (Interviewee OVS2).

The risk to production from the eldana pest is felt directly by the growers but they cannot, on their own, respond to it effectively. To mitigate the risk presented by this pest, actors make use of the technical expertise and capabilities of SASRI. Unlike the risk to water security, the local actors could not respond to the risk from the eldana pest because they had no understanding of how to deal with the risk. As such, the response had to be passed to another nest within the sugar industry, SASRI, which had the capacity and resources to find the mitigation measures to the risk. Once they had found the mitigation measures, these measures had to be transferred back to farm-level.

The threat posed to production has provided lessons on why not to plant sugarcane in wetlands. It is an economic risk that when combined with the legal requirements (e.g. the Conservation of Agricultural Resources Act) has prompted an alignment of behaviour. Although the risk is experienced at a farm-level, the industry had to call upon the expertise of a 'nest' that has the capability and resources to respond. To respond to this risk, the industry relies upon SASRI, a 'nest' responsible for research and information exchange. As findings of this study show, organisational nesting within the context of water security is a learning network, which is also the case when it comes to eldana pest control. Here, organisational nesting and polycentric governance play a role in the dissemination of information of the benefits of rehabilitating wetlands. Through this learning network, risk mitigation measures can spread among the actors.

Because SASRI has the capacity and resources to conduct research, it was able to develop a response that could be implemented at a farm-level. This information has spread vertically and across to reach other nests in the industry and has now been tied to the SUSFARMS® initiative for implementation at a local scale. Through the rehabilitation of wetlands and land-use planning efforts towards the natural control of eldana have been enhanced. This result is expressed in a response from one participant:

> *"What happens in terms of that is that the attention to conservation structures and conservation practices on farms enable much clear and clearer water to flow from farms into waterways and that's an important change. The contribution that we make to*

try and sustain clean water and waterways is increasing in that the attention through SUSFARMS® of wanting to rejuvenate waterways, vleis, all those water areas in the old days, back in the days sugarcane was grown into waterways, into vleis, we know that and there has been a significant pullback from those waterways in the last 30 years. So I think there has been an attention into recognising that there's a role to play to sustain those watercourses and water supply for people and to make sure it's clean" (Interviewee OVS2).

Although the response was targeted at pest control, outcomes from the management and control of the eldana pest also result in the improvement of water availability through the rehabilitation of wetlands. The net result is that by rehabilitating wetlands, actors are restoring the ecosystem services otherwise destroyed when the wetland was under cultivation. Ecosystem services like natural filtration processes and water provisioning become a benefit to the SES. As one respondent noted:

"That's an additional ecosystem service, often they get forgotten about or overlooked but yes they act as filters, they act as habitants for natural predators of pests so there's many, many reasons to mention soil conservation issues. There are so many services that they provide" (Interviewee OVS5).

Information on how to manage the risk of eldana to sugarcane production is relayed to farm-level through the nested structure. This flow of information further enhances the role of organisational nesting as a learning and information exchange network.

Even though the sugar industry enjoys self-governance, they still have to take cognisance of the legal requirements of the Conservation of Agricultural Resources Act (Act no. 43 of 1983), among others. This need to adhere to the law further motivates SASA through SASRI to support the rehabilitation of wetlands. They have done so by taking action on the clearing of alien invasive plants from riparian zones and educating growers on the benefits of planting sugarcane away from wetlands and respecting national laws on cultivating in wetlands. These initiatives bring about alignment of behaviours with the goal of managing the regulatory and reputational risk they face.

6.3 REACHING OUT BEYOND THE INDUSTRY

The sugar industry does not exist in isolation. Through its value chain and its use of shared resources, such as water, it is connected to markets and opinions that can affect its value – to industry and society. Conceiving the SA sugar industry in this way as a larger system, a system with multiple external linkages, leads to a need for appreciation of risks to the industry that are framed by people and organisations (nests) who are 'outside of the sugar industry'.

For example, responding to public scrutiny and experiences of water insecurity (quantity and quality) and risks, sugar industry stakeholders in the KZN Midlands have adopted environmental stewardship. Stakeholders within the study area have made conscious efforts to engage and form alliances among themselves and actors outside of the industry. Indeed, several participants mentioned the role of the industry's customers in pushing for environmental stewardship: the risk to the industry's reputation and market prompts actors to reach out to other nests external to the industry to mitigate the threat. Through co-learning it becomes possible to align behaviours, which ultimately mitigates the risk. In response to a question about which stakeholders (outside of the industry) have had the most influence on water security and how they have exerted this influence, one respondent commented:

> *"…so there was a lot of pressure globally then and questions being asked globally about the sugar industry and what practices the sugar industry was using to prevent environmental harm. SUSFARMS® has now been recognised by a number of parties … who are the buyers of sugar"* (Interviewee OVS22).

> *"… clearly water is integral to the environmental element, so it is covered within that structure and we have organised ourselves locally within the Midlands covering [Dalton], Noodsberg and Eston around the 'SUSFARMS® 2018 Collaboration', which is a multi-stakeholder collaboration in which [an NGO] partnered with us. The agenda is clearly their freshwater programme. We also have a social NGO, in that consortium, we have our competitor miller in that consortium, ourselves as [a sugar miller] are there, all our growers are represented, and [the industrial sugar consumers] are represented as sugar customers"* (Interviewee CMV23).

The thrust is towards the implementation of BMPs to conform to customer requirements while at the same time managing risk to sugarcane supply posed by a reduction in crop output. By conforming to customer requirements, the industry also responds to the risk of demand of its products. As indicated above, the system that is being implemented is known as the SUSFARMS® and, while some mills require certification of implementation of SUSFARMS® before they accept sugarcane for crushing, this is not yet an industry requirement. For the industry to conform to customer (rather than mill) requirements, independent certification would be desirable, as intimated in the following comment:

> *"They [bulk buyers of sugar] have set a target that by 2020 they want 100% of their raw materials to be sustainably supplied, so they want proof that the sugarcane that they are getting is farmed in a sustainable manner and for us what better way is there than to have all our growers complying with the system like SUSFARMS®"* (Interviewee OVS5).

This exogenous pressure helps to mobilise social capital through polycentric governance, which is reinforced by the feedback from implementing sustainable farming practices. My findings show that such collaborative work is mainly initiated at a local level rather than nationally. But collaboration can also arise at a national scale, as actors realise that collective action for a common goal brings better results. Through SASA, the industry engages other actors within the basin for collective action towards the sustainable use of natural resources, mainly at a policy level. These actors include: Catchment Management Agency, uMngeni Ecological Infrastructure Partnership, and SUSFARMS® 2018 Collaboration (Interviewee CMV23). The respondent further commented that such collaborative work:

> *"…provides a platform for information sharing regarding a finite resource; opportunity for alignment of multi-stakeholder initiatives; reduces risk of duplicated effort; establishes a forum for discussion about conflicting/opposing efforts or impacts; elevates the water agenda; reduces water risk or at least highlights the water risk in order to initiate mitigation strategies"* (Interviewee CMV23).

This comment shows how polycentricity has been useful for learning even though there has not been a more explicit industry-wide strategic response to water security. The lack of a more explicit industry-wide strategic response to water security could, in part, be due to the dominance of rain-fed agriculture for the bulk of the sugarcane production. Without control over rainfall patterns, thus available water, actors then use sustainable farming practices (through SUSFARMS®) as the integrated response to water security and other risks.

Through the self-organisation and collaboration with other stakeholders that characterise the multiple decision making centres within the industry, actors have identified and developed risk mitigation measures at a local level (for example, the adoption of SUSFARMS®). These measures are developed and implemented at a local level even though they can be used at higher levels to improve the image of the industry. Furthermore, the autonomy of these decision making centres has allowed the development of rules for the alignment of behaviour and collaborations with actors outside of the sugar industry who also experience the risk to water security within the same basin. Indeed, risk mitigation must be measured against implications for those within and those outside of the industry. Thus, recognition of such interdependencies with nests beyond the formal boundaries of the industry system allows engagement and development of collective approaches to risk mitigation, while polycentric governance ensures that the autonomy of those inside and outside is not compromised.

6.3.1 SUSFARMS® as a brand

The principal motivation for the development of SUSFARMS® among the sugarcane growers was the need to respond to emergent environmental risks of water insecurity and soil erosion, among others risks, through the adoption of sustainable farming practices. SASA is now marketing SUSFARMS® within the industry as an approach to managing the multiple risks that the industry faces. From a farm-level risk mitigation program it has evolved to become a brand, as one respondent acknowledged:

> *"… anyone who takes any care just to get into it, one page, would realise that it's not a localised programme. Maybe it needs a rebirth or renaming but SUSFARMS® is recognised globally now (that brand). It's mentioned in the [top business schools], it's mentioned in international sustainability circles, the big buyers [of sugar], [and an NGO] have been huge contributors to SUSFARMS®* (Interviewee IVF8).

Kapferer (1992) defines a brand as an identity system; 'a brand is not a product. It is the product's essence, its meaning, and its direction, and it defines its identity in time and space'. In this regard, SUSFARMS® is an identity for the SA sugar industry. It has become ubiquitous in response to the various risks the industry faces.

SUSFARMS® as a risk reducer

De Chernatony and Dall'Olmo Riley (1998) contend that a brand can be a risk reducer. SUSFARMS® has the potential to be such a brand. As results show, it has been used to respond to risks the industry faces. In other words, through the adoption of sustainable farming methods, the industry has not only responded to the risk posed by water insecurity but also reputational and regulatory risk. A brand can instil confidence among the regulatory infrastructure providers by acting as a guarantee of consistent sustainable farming practices. Such confidence further enhances the recognition of self-organisation within the industry. Furthermore, it was the autonomy to develop institutional arrangements relevant to local settings that made it possible for a group of sugarcane farmers to develop a sustainable farming method and align behaviours:

> *"Now what we've done in our area because in order to get compliance we have said to our growers (because fortunately in our growers there's leadership there) you got to comply with this thing [SUSFARMS®] and we are giving you an opportunity to either speed it up but we are setting deadlines for compliance, it's going to happen like this, like that and if you don't meet these minimum requirements we withhold your cane from going to the mill. It's quite drastic but that's what our growers agreed to do"* (Interviewee IVF8).

"Obviously because it's our product it's been easier for us to get our growers all on board, to get them to buy into it …" (Interviewee IVF8).

Because of the success of the programme in the three milling areas of Dalton, Eston, and Noodsberg, it is now being promoted industry-wide as a way to respond to calls for sustainable farming. Within the context of risk management, SUSFARMS® is a way of responding to:

- Production risk through the rehabilitation of wetlands thus managing the eldana pest, which is a major threat to sugarcane production. The added outcome is improved ecosystem services from wetlands, such as provisioning of water and natural filtration systems.
- The reputational risk owing to perceptions sugar consumers and other actors might have on the use of water resources within the sugar industry. Perceptions about farming practice and its link to water security has led to alignment of behaviours, first among some farmers in a particular 'nest' and then by SASA with consequent application of polycentric governance to bring about alignment across the industry.
- Regulatory or legal risk through the incorporation of the legal requirements as part of the SUSFARMS® initiative.
- The financial risk owing to the loss of markets. By collaborating with other industrial sectors, NGOs, and consumers in general in developing sustainability practices, the industry is creating a market for its produce. In so doing, it mitigates risks that threaten the viability of its operations.

Though SUSFARMS® is recognised at the local level in the KZN Midlands as a brand and identity, this is not the case at SASA-level. Rather, they seem not to be consciously aware of the 'brand' as not only a farming practice manual but more of an integrated method for risk mitigation.

6.4 ROLE OF ORGANISATIONAL NESTING

Risk, whether related to water security, pests such as eldana, government regulations, or to the reputation of the industry, are framed in ways that reflect how the risk is experienced. For example, farmers frame risk to water security mostly as a quantity issue whereas for the millers it has more to do with water quality. Furthermore, not all farmers frame it in the same way; for some it is an issue that can best be addressed through implementing sustainable farming practice (SUSFARMS®), whereas for others the focus is on optimising irrigation (MyCaneSim). These framings illustrate the opportunity that organisational nesting creates for situation-specific responses to arise.

Because of the interdependencies among farmers who supply the same mill and millers who require sugarcane, even when risk is framed differently, it poses a collective risk. This sense of bearing risk collectively motivates the need to learn about and promote risk mitigation among nests. It encourages the contagious spread of ideas and practices, as has been illustrated with SUSFARMS®. However, despite the success of SUSFARMS®, the results show that how a risk is framed can also inhibit learning across nests, thereby slowing uptake. But they also show that when risk is framed more generically than water security, as in the case of reputational risk with implications for marketing, it leads to more widespread adoption. This example illustrates the significant role for autonomy in organisational nesting while at the same time exposing the important opportunity interdependence presents for reframing risk collectively and enabling the spread of ideas and practices across the industry.

Another role organisational nesting can play is to enable risk in one nest to be mitigated through innovation in another. For example, the pest eldana poses a threat to sugarcane production. Researching the lifecycle of the pest and its relationships with host plants, and discovering why it has become such a destructive influence requires specialist research. The threat of declining production owing to eldana thus encourages farmers to look beyond their own expertise and source innovation in SASRI.

The findings also illustrate a role for organisational nesting in mitigating reputational risk. How stakeholders outside of the industry view the acceptability of the industry's practices can affect the market and thus profitability. As noted before, a principle of organisational nesting is that nests have autonomy and so actors need to establish a common goal if behaviours are to become aligned across nests. And, importantly, when this happens, reputational risk can be mitigated. An example of this role for organisational nesting can be seen in the evolution of SUSFARMS®. Although the original motivation was to address risk to water security, as the framing of risk broadened and reputational risk became more explicit, the process increasingly drew upon external, independent organisations, such as WWF and the customers to the industry (Coca Cola and SABMiller among others). These linkages provided opportunities to develop SUSFARMS® in a way that would mitigate risk to reputation, not only for the sugar industry but also for other actors participating in it, and, in the longer term, allow for certification and improved marketing prospects.

6.5 POLYCENTRIC GOVERNANCE

Polycentricity is a way of governing the use of a resource system so that it creates a foundation for learning and experimentation, enables broader levels of participation, and improves connectivity between the nested groups (Schoon et al., 2015).

6.5.1 Learning and Experimentation: SUSFARMS® and Eldana

One of the principles of polycentricity as identified by Schoon et al. (2015) is learning and experimentation. The self-governance and structure of the sugar industry created an enabling environment for the development of SUSFARMS® by the growers in the Noodsberg. The development of SUSFARMS® was in part motivated by the lessons the sugarcane growers in the area were drawing from the experience of timber farmers, who, in responding to external pressure for certification of good practice had adopted sustainable practices in the forestry industry (for example, through the Forest Stewardship Council) (FSC, 2016),:

> *"In the late 90s (1998) the farmers in Noodsberg questioned some things because its diversified – they don't just grow sugarcane; a number of farmers there have avocado, pears for export, oranges for export, charcoal for export, timber for export, so they were getting exposed to a whole lot of certification systems that they needed to…, EureGAP, FSC, these sort of things. They said you know there's going to be a period in time where just like the timber industry there will be a focus on sugarcane. So they embarked on a project to develop a set of management practices that would prevent negative environmental impact and that first attempt at producing these management practices or BMPs was called SEMIS, System for Environmental Management in Sugarcane and it was loosely based on the ISO 14000"* (Interviewee OVS22).

The autonomy the growers enjoyed within their 'nest' enabled them to develop the program until it became to be known as SUSFARMS® through collaborations with other actors. And, because polycentric governance facilitates interaction across nests, the learning network expanded leading to wider adoption of the best practices whilst improving on others. As other nests engaged, the process and sustainable farming became a shared goal; the initiative that had a predominantly local identity transformed to provide for a collective identity within the industry, which also gained recognition and support from beyond the industry. Yet sometimes solutions to the risks that actors face are better developed in different nests, as in the case of mitigating the risks associated with eldana. Yet while establishment of SASRI as a nest within the industry was a response to risk, polycentric governance provides the mechanism through which such a unit can be sustained within the industry. Furthermore, exposure to risk of eldana motivates farmers to learn from the experimentation within SASRI and to share experiences, which has led to adoption of natural management of eldana through rehabilitating wetlands and using the 'push-pull' method.

6.5.2 Enabling Broader Levels of Participation

Water insecurity is a collective risk requiring the action of all actors, despite the fact that farmers and millers view water security differently. The primary reason is that taking action in isolation can be impacted by inaction by others. The interdependency between the farmers and millers within the sugar value chain makes the millers sense the risk as much as farmers. Thus, self-organisation among actors results in collective action for the common good of actors in an SES. This collective action between the sugarcane growers and the millers is achieved through the MGBs.

By recognising the self-organisation among local actors through MGBs, the industry has encouraged the broadening of participation from actors. This encouragement gives actors a platform to participate in the governance of resources within their purview. As seen from the adoption of SUSFARMS® and MyCaneSim, innovations at local-level can be scaled up to be adopted at industry-level. Hence, broadening participation enhances the diversity of responses to risks while supporting autonomy, allowing nests to innovate. How this can be formalised through polycentric governance is illustrated in the following responses:

> *"[The role of SASA] at the industry level [is] in making sure the right framework and systems are in place…, fortunately in the South African sugar industry we are very well organised and structured to have the systems which are implemented or supported at industry level then implemented out in the regions"* (Interviewee OVM1).

> *"Each cane growing area has a Mill Group Board… of which I am on the Mill Group Board plus another two members from the mill here and the rest is represented by the growers that we have a meeting with monthly… So you have a Mill Group Board represented by the growers and the miller that deals with issues around this area and cane supply around this area"* (Interviewee CMV20).

An MGB has subcommittees that deal with different issues. For example, there is a Local Environmental Committee and a Pest and Disease Committee. Issues of water security, environmental rehabilitation, and other related issues are dealt with through the Local Environmental Committee. By drawing actors from different nests together, polycentric governance acting through the MGBs provides opportunities for collective experimentation and alignment and promotion of progressive behaviours among the actors within a milling area.

Furthermore, because organisational nesting is a learning network through which ideas spread and innovation arises, it is enabled through polycentric governance that manages the evolution of structure, function, and operation within the industry. As such, the promotion of sustainable farming methods through SUSFARMS® represents such spread of ideas and alignment of behaviours. In moving towards sustainable farming methods, actors also move towards water security. Hence, sustainable farming becomes a way for the integrated management of risk.

In must also be emphasized that opportunity and risk motivate connectivity. Connectivity refers to the way in which parts of an SES interact with each other (Dakos et al., 2015). Thus, in a polycentric governance system, the nests interact in a network of peers because of the autonomy they enjoy. This structure brings a sense of value to the different nests, thus making participation in resource governance a necessity because actors then feel that their opinions are valued. The autonomy the nests enjoy also allows them to develop networks with other nests, either within the industry or without, as seen with the development of the 'SUSFARMS® 2018: Midlands Sustainable Sugar Supply Chain Collaboration' between the growers, millers, and industrial sugar customers. This diversified connectivity brings improved knowledge and skills base, thus developing the industry through collective action is a shared-risk approach.

The need for such collaboration lies in the fact that communities, consumers, suppliers, and governments are all exposed to risk because of common water issues such as scarcity, pollution, aging infrastructure, floods, droughts, and climate change. This collective risk calls for collective action in developing mitigation measures, which is only possible if there is an enabling environment for information sharing and collaborative action. Furthermore, collaborative efforts to reduce shared water risks can emerge through common understanding, strategies, and solutions, and are often the most effective path towards sustainable water management. In essence, everyone benefits from sustainable farming methods to further respective objectives and mitigate risks. As such, shared risk provides a strong argument for water resource users to cooperate and collaborate to promote sustainable farming methods, motivated largely by water security issues.

In essence, because of the devolution of power to the various decision making centres in a polycentric governance system, actors are able to self-organise and self-regulate. This structure brings legitimacy to the rules and regulations that the actors might develop in their efforts to manage risk. Thus polycentric governance plays a role in risk mitigation through the opportunities it offers for diverse responses to risk actors face, and is possible because of the linked multiple decision making centres that make up the polycentric system.

6.6 SUMMARY

Organisational nesting and a polycentric governance approach within the industry reflects a response to risk. This reality can be seen from the calls for collective action during the early years of the industry as they faced problems of disease outbreaks owing to unmonitored importation of sugarcane varieties. Also, when the industry faced commercial risk because of the price instabilities following the economic depression after World War One, the industry used its structure to strengthen social capital towards the collective management of risk.

Now, with climate change water, insecurity is a risk to many sectors. The SA sugar industry faces emergent risks to water security because of the climate change as well as growing demands for water resources. But the key issues then are: do actors perceive it as a 'collective' risk or are the perceptions strongly related to core business? If it is perceived, at least by some', as a collective risk; is their effort to use organisational nesting and polycentric governance to develop a collective position on water security an industry strategy?

The results show that organisational nesting and polycentric governance provides a platform for the formulation of area-specific intervention measures that ensure the sustainability of the environment and natural resources, on which the industry very much depends. This action is possible because nesting allows actors to self-organise around defined interests, for example, growers self-organising according to geographical locations. Even though actors self-organise into different nests, there is interdependence within the industry, allowing nests to network and engage in collective work in order to tap into the capacity of other nests in the quest to mitigate risks. A result of such collaborative work is the SUSFARMS® 2018 initiative. It is a collaboration between the sugarcane growers, the millers, sugar consumers, and NGOs. Such collective action is possible because actors perceive water insecurity as collective risk because they all enjoy benefits from the same SES and, as such, risk to one group of actors can negatively affect others.

Risk thus connects the individuals and groups. Consequently, shared risk promotes learning and the spread of ideas. It is possible to extend ideas into other domains because of nesting, which is achieved through: the self-organisation at mill group board level and stakeholder participation. Nested institutions enable the creation of rules for social engagement and collective action to fit the problem they are meant to address (Schoon et al., 2015), including the promotion of land-use planning and wetland rehabilitation by SASA to deal with the reputational and regulation risk the industry faces owing to growers planting sugarcane in wetlands.

The mutual agreements among the industry actors show realisation of the shared risk to the industry posed by the commercial pressures they were facing at the time and demonstrate how organisational nesting was used to address perceived risk. The same structures can be used to mobilise collective action in order to mitigate the risk of water insecurity through the alignment of behaviours. Collaborative action thus fosters the alignment of behaviour among resource users towards a common goal of water security and collective management of risk.

Furthermore, it was the autonomy afforded to governance units within the sugar industry that resulted in the development of initiatives such as SUSFARMS®, which has gone on to evolve into a way of responding to calls for sustainable farming, hence managing the reputational risk the industry may face. Coordinating with other stakeholders in an SES is thus a way of managing the reputational risk that the industry may face through building trust and relationships, and facilitating the learning and collaborative efforts needed in risk-sharing. In the risk management process, stakeholder participation can occur in all stages, from risk identification to implementing risk mitigation measures and monitoring and evaluating outcomes. The result is the building up of social capital for collective action, and ensuring a diversity of responses to risks that actors face.

Ultimately, organisational nesting within the sugar industry strengthens the alignment of behaviours towards organisational goals by placing monitoring activities with the local governance units. Through polycentric governance, the industry is able to forge a learning network through the nested governance units. This network can be extended to actors outside of the industry, thereby enhancing the diversity of responses to emergent risks actors face. Thus the strength of organisational nesting and polycentric governance towards risk management is that it galvanises collective action and instils a sense of shared risk.

Perhaps a weakness of polycentric governance within the sugar industry is that it is being used ‘subconsciously’. Conscious use of polycentric governance within the industry can allow for the integration of the various intervention measures (such as SUSFARMS® and MyCaneSim) developed within different nests. Such integration will result in defined industry goals; hence align behaviour towards a common outcome.

These findings show that in the context of water security in an agricultural ecosystem, organisational nesting is important. It is useful in the spreading and promoting of better farming practices, efficiency in water use, and land-use planning knowledge. In this case, organisational nesting then becomes a way of creating a learning network among the actors. Likewise, the nesting among the millers is about the spread of knowledge, from process improvement to better environmental management practices, and the learning network is about the efficient use of water resources. Hence, the role of organisational nesting is to spread ideas and information among actors. This information and ideas can be generated at any level of the industry. The following chapter puts the study results within the context of existing literature.

CHAPTER SEVEN
DISCUSSION

In this chapter I discuss the findings and their implications for water resources governance and put the study results within the context of existing literature on organisational nesting and risk-sharing. The objective of the study was to provide an insight on the wider relevance of risk-sharing and organisational nesting to water security through an investigation into the role of organisational nesting in risk-sharing among actors in the SA sugar industry within the uMngeni River Basin in South Africa. To this end, I discuss why organisations exist and what keeps them organised and functional whilst giving particular attention to risk.

Because I conclude that organisational nesting is, in large part, a response to risk, I argue that it should also offer the prospect for preparing an industry for emergent risk. To analyse this idea, I use the concept of resilience. I posit the sugar industry as a complex social ecological system and use the seven principles elucidated by Biggs, Schlüter, et al. (2015) to assess how these are finding expression in the sugar industry and risk-sharing. I then consider the wider relevance of the findings.

7.1 WHY ORGANISATIONS EXIST

Organisations exist because of their ability to create value and acceptable outcomes for stakeholders (see Figure 7.1). As organisations grow and more actors lay claim to a resource system, the stakeholders must decide how to control and coordinate the activities that are required in order to maintain and improve the ecosystem services that they enjoy. Thus, the sugar industry is organised in a nested structure and the actors interact through a polycentric governance system.

Self-organisation in the sugar industry started with the formation of the Umhlanga Planters Association in 1875 (Osborn, 1964). With the growth of the sugar industry and an increase in users who laid claim to the natural resources came complexity and the need to organise, culminating in the formation of the NSA and, ultimately, the SASA in the year 1919. In the formative years of the sugar industry, individuals could import their own sugarcane cuttings for seeds (McMartin, 1948; Richardson, 1982). This practice put the industry at risk of crop disease outbreak because such cuttings would not have been necessarily tested for their suitability to the South African environment. In the year 1877, there was an outbreak of Smuts disease. In response to such disease outbreaks, the Natal Department of Agriculture began to introduce sugarcane varieties and, subsequently, in the year 1913, controls over the importation of sugarcane varieties were introduced (McMartin, 1948; Osborn, 1964; Richardson, 1982).

Actors in the sugar industry self-organised in order to engage in collaborative work. An acknowledgement of the interdependence among the industry members and the need for a collective voice resulted in the formation of the NSA. As Jones (2013) posits, organisations can be a way of exerting power and control, and taking advantage of economies of scale. The sugar industry, upon the formation of the NSA, started to exert power and control (with the collaboration of the Natal Department of Agriculture) in the importation and introduction of sugarcane varieties. This control created value for the actors through the introduction of more disease resistant sugarcane varieties.

Organising, as evident for them above, allows stakeholders to institutionalise what would have been otherwise compartmentalised or localised knowledge for the good of the industry. By adopting a nested structure, resource users can institutionalise local knowledge and skills. This structure is necessary in the management of water resources, as local knowledge is pertinent to the management of risk at site scale because local actors (farmers) face risk directly. The reduced incidences of disease outbreaks within the sugarcane crop after 1914 following the introduction of disease resistant sugarcane varieties was an outcome of the efforts of the Sugarcane Experiment Station (now SASRI). This venture succeeded by harnessing the knowledge pool within the industry by developing and testing new varieties at the Experimentation Station. As such, the industry started to manage the risk to production posed by disease outbreaks by exerting power and control over the importation and introduction of sugarcane varieties.

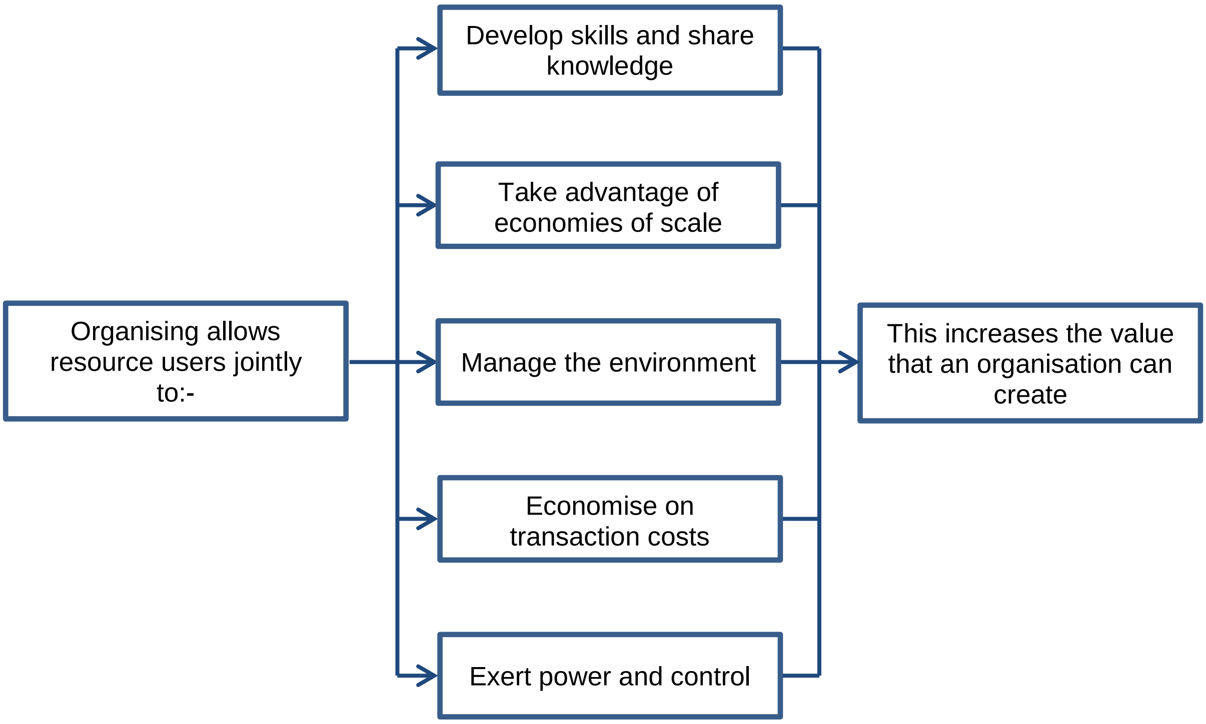

Figure 7.1: Why organisations exist (adapted from Jones (2013))

For an equitable distribution of benefits, actors need to manage their environment collectively. Organising brings stakeholders together, with a diversity of responses to environmental issues that they may be facing. For example, because environmental issues can pose a risk to production among actors in the industry, the result of collective action is the concerted efforts towards the management of risk through agreed actions.

Ultimately, the reason to organise among resource users is to exert power and control. Organisations can exert pressure on individuals to conform to set norms in order to achieve collective goals because the design of an organisation makes actors behave in certain ways (Blau, 1964; Jones, 2013). This principle is evident in the introduction of SUSFARMS® among the Noodsberg sugarcane Growers. The locally developed rules and regulations resulted in the shaping of behavioural patterns among actors. When individuals work in isolation they only need to address their own needs but being part of a collective makes them consider the needs of the collective as well.

Once a group of actors has established an organisation to accomplish collective goals, the organisational structure evolves to increase the effectiveness of the organisation's control of the activities necessary to achieve its goals (Jones, 2013). The sugar industry has evolved from the uncoordinated first days prior to the formation of the Umhlanga Planters Association to the integrated and coordinated organisation following the formation of SASA in 1919. The nested structure within the sugar industry can be adapted for the management of water resources towards the common goal of water security.

In elaborating on the principle of organisation, Jones (2013, p. 30) states that 'the principal purpose of organisational structure is one of control: to control the way people coordinate their actions to achieve organisational goals and to control the means used to motivate people to achieve these goals'. As such, for any organisation an appropriate structure is one that facilitates effective responses to problems resource users face (Lawrence and Lorsch, 1967; Scott, 1981). In this regard, a nested structure is appropriate for the sugar industry as it allows for the alignment of behaviour at farm- and mill-level as well as at an industry-level, owing to the self-organisation and freedom to formulate rules and regulations at the local level (MGBs and LGCs). The interdependence between the various nests results in knowledge and skills pool, which can be used for the collective management of water resources towards the goal water security through knowledge sharing and skills transfer among the collective.

7.1.1 What Keeps the Actors in the Sugar Industry Organised

While there may be many contributing factors prompting actors in a resource system to self-organise, at least for the sugar industry, there are three principal determinants: interdependence, exposure to risk, and the purposeful management of risk.

The South African sugar industry derives direct and indirect benefits from water resource systems. One of the direct benefits is the sugarcane output from the farms. Financial benefits then accrue from the sale of the refined sugar and by-products on domestic and international markets. The financial proceeds are shared accordingly among the stakeholders in the industry. Recognising that water is a common pool resource from which they draw their primary benefit, the sugar industry has adopted sustainable farming practices to ensure the longevity of their operations. Polycentric governance then is a tool that can be used to achieve an equitable distribution and management of the ecosystem services necessary to the industry and to manage the risk posed by a lack of water security to the industry. The diagram below shows how risk transcends the value chain in the sugar industry.

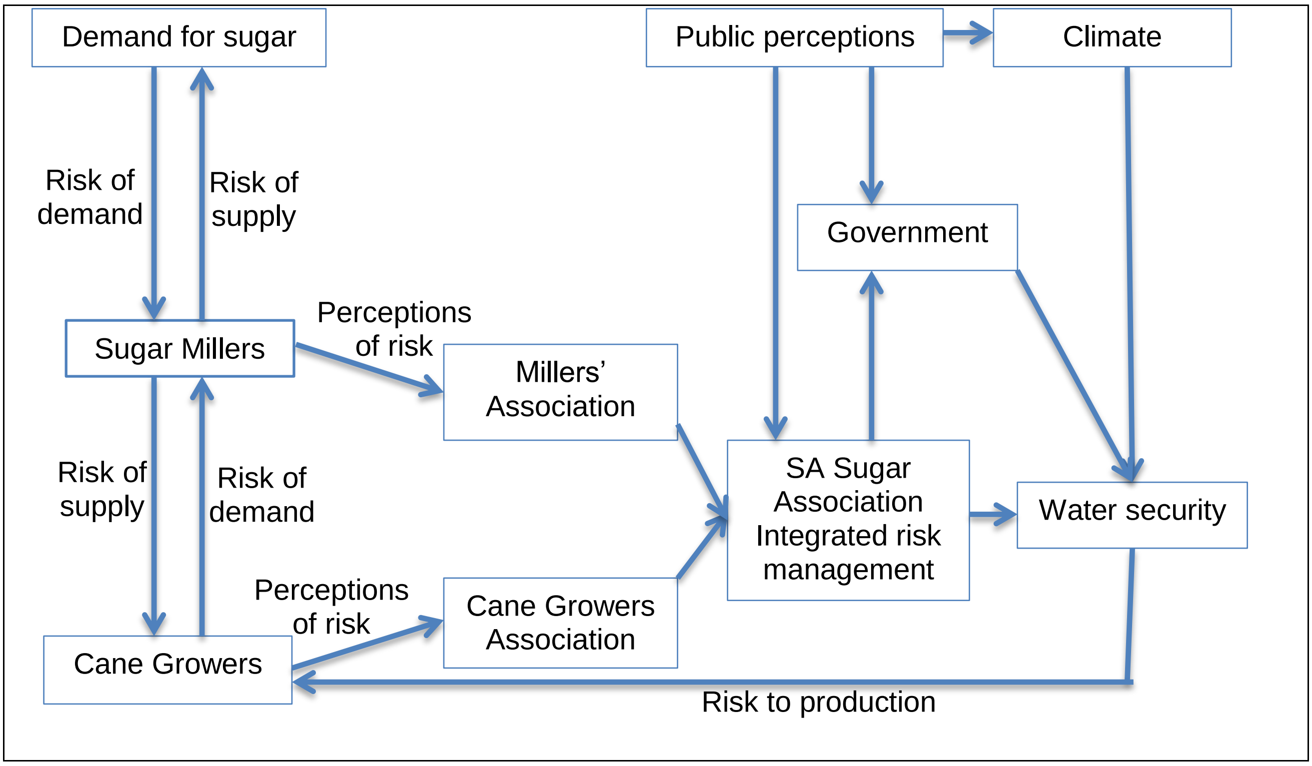

Figure 7.2: How risk transcends the supply chain in the sugar industry

With the manifestation of water-related risks such as droughts and increasing pressure from external interest groups, the industry identified SUSFARMS® as an appropriate instrument to respond to environmental risk since it can be adapted to the various sugar growing regions. The program can be integrated with other environmental management programs that are run by the millers, thus allowing a coordinated response to environmental risk from farm to mill.

From the results, what makes organisational nesting function in the sugar industry are three principal determinants: interdependence, exposure to risk, and the purposeful management of risk.

- **Interdependence**
  The farmers need millers and vice versa. The deterioration of the sucrose content of the sugarcane crop soon after harvesting and the need to minimise transportation costs to get sugarcane to the mill drives the investment in mills that are located in sugarcane growing areas. This need results in spatially distributed sugar production systems. So, to gain the benefit of economies of scale (marketing, negotiation, research, among others) the millers and the farmers are connected at a larger scale through SASA. Whilst being interdependent, actors still retain autonomy at their scale of operation. A nested system has evolved within the sugar industry that operates through a polycentric approach to governance.

- **Exposure to risk**
  Interdependence changes exposure to risk. The farmer's exposure to risk increases if the demand for sugarcane from the mill decreases; the mill's exposure to risk increases if the supply from the farmers decreases; and the exposure of both interest groups increases if at a larger scale (SASA and SASRI), solutions cannot be found to governance issues (within the industry and between the industry and other actors) and issues that need research for resolution. Because of this interdependence, it is in everyone's interest that exposure to risk is purposefully managed across all interdependencies.

- **Purposeful management of risk**
  The nature of the risks experienced by the farmers and the millers, SASA, and SASRI is different. So, each actor, or nest of actors, must purposefully identify and assess potential risks, interpret as shared risk, develop appropriate protocols, and mitigate risk towards a collective goal. Because of the interdependence among the actors, exposure to risk by one group transcends across the value chain, thus the industry engages in a collective and purposeful management of risk

The SA sugar industry is faced with the challenge of managing risk in complex and ever changing social-ecological systems, where they have to take cognisance of the varied perceptions among the stakeholders within and outside of the industry (Figure 7.2). Along with the interdependence among actors, this helps the industry stay organised for a purposeful management of risk. Risk is thus what connects the actors together, which is reflected in the Sugar Industry Agreement of

2000, and the proceeds sharing model contained within the agreement. It is risk that causes the spread of ideas because an impact on one group's operations can have effects along the value chain. With interdependence, exposure to risk, and the purposeful management of risk and 'keeping the system organised and active', resource users must take action to sustain resilience in the face of emergent risk. Such action can be taken within the bounds of the nested structure of organisation and polycentric governance. Once established, organisational nesting and polycentric governance can be applied to promote a collective approach to risk management through spreading awareness of risk, developing collective approaches and implementing 'controls' to ensure compliance while at the same time allowing for innovation that is relevant for different groups.

7.2 RESPONDING TO ENVIRONMENTAL RISK: PROMOTING RESILIENCE IN THE SUGAR INDUSTRY

Human activities are impacting and shaping ecosystems at local to global scales, posing a challenge to providing for the well-being of people (MEA, 2005a; Schlüter et al., 2015). According to Schlüter et al. (2015, p. 252), in order to meet the needs of society in a rapidly changing environment, 'one of the critical issues is ensuring the adequate and reliable provision of essential ecosystem services, such as freshwater, food and climate regulation'. Social-ecological resilience provides a way of addressing this challenge. Social-ecological resilience is premised on the assumption that the functioning of ecosystems and the provision of ecosystem services cannot be understood without accounting for the actions of people who live in these systems (Schlüter et al., 2015, p. 252).

The sugar industry is part of a social-ecological system that behaves as a complex adaptive system. Such a system is characterised by dynamic interactions across scales and self-organisation (Schlüter et al., 2015). The organisational nesting and polycentricity that characterises the sugar industry provides capacity to act on changes in SES, particularly emergent risks. On such change, environmental change, pose a risk to the production and sustainability capacity of the sugar industry. There are seven principles that have been suggested to sustain the capacity to respond to environmental changes by Biggs, Schlüter, et al. (2015), and these are:

- Maintaining diversity and redundancy;
- Managing connectivity;
- Managing slow variables and feedback;
- Complex adaptive systems thinking;
- Encouraging learning;
- Broadening participation; and
- Promoting polycentric governance systems.

7.2.1 Maintaining Diversity and Redundancy

Organisational nesting builds redundancy into water resources management. Redundancy means a replication of governance subsystems (or whole systems) at each nest and level (Naeem, 1998; Kotschy et al., 2015). In the sugar industry, redundancy is built into structures through the MGBs. In each MGB, there is a Local Environmental Committee tasked with environmental management. One such task is water security. This redundancy is further illustrated at the national level, within SASA through the Natural Resources Committee, whose task is to provide the framework and direction for sustainable natural resources use and management.

The purpose for building redundancy into a system is to provide a backup for system functioning by allowing some system elements to compensate in case of primary system failure (Naeem, 1998; Kotschy et al., 2015). Building a nested organisation by no means guarantees the success of sustainable use and management of a water resource. However, the redundancy of management units built into the system, owing to the presence of different levels of governance, makes it more suited for adaptive management. It means that when small units fail, there are larger units to call upon.

On such case where larger units needed to be called upon was the clearance of alien invasive plants from watercourses. This activity was spearheaded by SASA, rather than the LECs, thus tapping into the knowledge and resource pool of SASA. This process was conducted through the engagement of the sugarcane growers, who are at the site-level and face the risk of water insecurity because of the presence of the invasive plants, which alter the ecosystem services they enjoy. However, the engagement of the farmers imply that when larger systems fail, the smaller systems can manage the resource system within their area of jurisdiction and this success can then be scaled to build more resilient governance structures (E. Ostrom, 1999; Schoon et al., 2015).

Redundancy also allows for experimentation at small scales, for example, in policy reform, to provide less disruptive learning experience. With SUSFARMS®, experimentation was at the local scale where they were experiencing risk but experimentation can also take place at a larger scale, as shown by the response to the threat of eldana to sugarcane production. With eldana, experimentation was done at SASA level through SASRI. This 'nest' is removed from the site of risk experience but they have the expertise and resources to devise risk mitigation measures. Information from this experimentation is then fed to the site of risk experience through the network of nested units. Lessons from such experimentation can also be used to inform the adoption and improvement of policy positions, as evident in the development of SUSFARMS® in the Noodsberg area and its subsequent contagious spread and adoption as a sustainable farming tool by the industry. Such collective learning is advanced through the coordination of the decision making processes in the various units of the organisation in a polycentric system.

Multiple actors with different roles thus bring response diversity to an integrated risk management approach. Such roles include: ‘knowledge carriers and retainers; interpreters and sense-makers; networkers and facilitators; stewards and leaders; visionaries and inspirers; innovators and experimenters; and followers and reinforcers’ (Kotschy et al., 2015, p. 56). The sugarcane growers provide the local environmental knowledge, SASRI provides the technical expertise, and SASA provides the frameworks and direction. The development of SUSFARMS® shows the importance of response diversity. The growers in the Noodsberg milling area became the innovators and experimenters. Now, SASRI has become the ‘knowledge carriers and retainers’ as SUSFARMS® is implemented industrywide.

In an ideal polycentric system, each individual public infrastructure provider interacts and links with other authorities, both horizontally and vertically, to achieve a balance of collaboration and autonomy (Schoon et al., 2015). For example, the three MGBs within the study area managed to network and implement the SUSFARMS® initiative. Such a network has been made possible through their SUSFARMS® 2018 Collaboration. This collaboration includes customers to the industry. Such a network and collaborative work can help bring a diversity of solutions to collective action challenges presented by water-related risks. Such diversity in response is essential, since the perception of risk is bound to be different in complex system with multiple actors.

Through the frameworks that enable response diversity and redundancy, SASA thus creates opportunities for networking within and outside of the sugar industry. A nested structure and polycentric governance provide a way of managing and coordinating this connectivity among and across governance units through the engagement of local resource users.

7.2.2 Managing Connectivity

Connectivity refers to the way in which parts of an SES interact with each other (Dakos et al., 2015). According to Dakos et al. (2015), connectivity is the way by which (structure) and the extent to which resources, species, or social actors disperse, migrate or interact across scales in any ecological or social landscape. Structures in an SES can be random, nested, or modular. The sugar industry is composed of nested networks. Nested networks are made of nodes that belong to a distinct group (Dakos et al., 2015). For example, within the sugar industry, these nodes are the millers, the sugarcane growers, and SASRI. These distinct groups have nodes within according to their geographical locations (milling areas and sugarcane growing areas).

The findings of this research concur with the assertion of Dakos et al. (2015) that in SES, connectivity facilitates the flow of material or information necessary for the resilience of ecosystem services. Actors in the sugar industry are dispersed in a nested structure. To facilitate the flow of materials and information for water resources management, an inclusive governance system is necessary. In this regard, polycentric governance provides a way of managing the interaction, hence material and information flow, within the nested network.

In most resource systems, it is rare to find governance being defined entirely by users without rules made and implemented by local, regional, national, and international authorities also affecting key decisions (Ostrom, 1997). Thus in a self-governed, polycentric system, participants make many, but not necessarily all, rules that affect the sustainability of benefits that accrue from the resource system and their distribution among stakeholders. The sugar industry is no different. Polycentricity provides a way of managing connectivity with other actors outside of the industry such as government, who are part of the regulatory infrastructure providers.

Through these various instruments available to them, regulatory infrastructure providers devise rules and regulations that govern the use of the water resources and the benefits that accrue from them. SASA, via its local level units (LECs, MGBs, and LGCs), implements some of its rules and regulations through SUSFARMS®. Government also influences the regulatory infrastructure through policies, for example, water use licenses and legislation, such as the Conservation of Agricultural Resources Act.

In addition, through the use market instruments, customers of sugar can and are influencing the regulatory infrastructure and ultimately the state of the water resources through the demand for sustainable sugarcane farming and milling operations. They do so through the incentive of a guaranteed market for the processed sugar whose proceeds the industry shares in an agreed manner. This element brings a new dimension to the concept of risk within the sugar industry – that of risk of demand (Figure 7.2). The risk of demand affects all industry members; a depressed demand for sugar products results in less demand for the sugarcane crop. This risk is precipitated by the perception of the state of the water resources within the SES and the actors within the system then demand action to address any deterioration in conditions. These pressures from customers and government and the need to have sustainable operations have made the industry more conscious to the state of the water resources within the area and the need to purposefully manage connectivity.

Among its many initiatives, SUSFARMS® illustrates the roles of organisational nesting and polycentric governance in progress toward a state of water security in the basin. Managing connectivity through the nested structure and polycentric governance contribute to ecosystem recovery after the experience of environmental risks such as water insecurity through the provision of new information and building trust in social networks (Dakos et al., 2015; Schlüter et al., 2015). This networking is essential for progress towards water security. The recognition of MGBs and how the industry has extended its networking to other sectors (SUSFARMS® 2018 Collaboration) shows that there is purposeful management of connectivity through organisational nesting and polycentric governance.

7.2.3 Managing Slow Variables and Feedback

A SES consists of and is affected by a number of variables that change and interact on the temporal scale (Biggs, Gordon, et al., 2015). Provisioning ecosystem services such as crop production and freshwater, which are important to the sugar industry, represent 'fast' variables. These ecosystem services are affected by slow variables such as soil composition and phosphorus concentrations in lake sediments (Biggs, Gordon, et al., 2015). According to Biggs, Gordon, et al. (2015) 'slow' variables are those that change at a slower pace than the 'fast' variables. In the social domain, as identified by Biggs, Gordon, et al. (2015), such slow variables are legal systems, values, traditions, and world views. These variables inform the choices of ecosystem services for actors within an SES.

Furthermore, building 'shadow' networks and social capital may be particularly important to grasp windows of opportunity for transformation (Biggs, Gordon, et al., 2015). With feedback from the resource system, actors can develop governance structures that can respond to this information in a timely manner, strengthening feedbacks that maintain the resource system in a desired configuration whilst weakening feedbacks that trap the system in an undesired state (Biggs, Gordon, et al., 2015). Findings from this research show that within the structure of the sugar industry, the MGB fulfils this role. Feedback from the opportunities and challenges that growers and millers face are shared at the local level for collaborative action in mitigating risk to production. This information can be relayed to other 'nests' and levels within the industry through networking and learning. This aspect demonstrates the importance of self-organisation at a local level, and its relevance in location specific and contextual knowledge, which is important in water resources management and risk-sharing since actors do not experience risk in the same way.

Feedbacks occur when a change in a particular variable or process in an SES leads to changes in the system that eventually loop back to affect the original variable or process (Biggs, Gordon, et al., 2015), for example, the demand for sustainable use of water resources from sugar consumers. This demand has compelled industry members to adopt sustainable farming methods and water stewardship programs in order to retain customers. Feedbacks thus can either be reinforcing – if the effect creates more change of the same type (often negative) – or dampening – if they counteract further similar changes (Biggs, Gordon, et al., 2015). Informal or formal social sanctioning when someone breaks a rule, such as not submitting a 'progress tracker' for SUSFARMS® acts as a dampening feedback. Such feedback makes the actors align their behaviours with those of the collective. My findings show that within the three milling areas of

Dalton, Eston and Noodsberg, a sugarcane grower needs to submit a 'progress tracker' to be allowed to sell their crop to the mill in their area. A 'progress tracker' is a self-assessment tool (which is subject to verification) used to measure a sugarcane grower's progress and improvements towards SUSFARMS®.

Access to an assured market is thus used as a way of aligning behaviour towards the achievement of collective goals of environmental stewardship. This factor further shows the role of self-organisation and nesting in achieving integrated risk management and water security. The effectiveness of such sanctioning is shown by the close to 100% adoption of SUSFARMS® within the milling areas of Dalton, Eston, and Noodsberg. As such, the conscious management of slow variables and feedbacks through organisational nesting and polycentric governance make the alignment of behaviours more explicit.

7.2.4 Fostering Complex Adaptive Systems Thinking

According to Schlüter et al. (2015), complex adaptive systems (CAS) thinking may increase resilience of ecosystem services by emphasising the need for more integrated approaches, the existence of diverse perspectives, the potential for non-linear change, and the pervasiveness of uncertainty in the management of natural resources. Engaging multiple stakeholders and knowledge systems is a key component of fostering CAS thinking in practice (Bohensky et al., 2015; Schlüter et al., 2015). Findings from my research show that the sugar industry engages multiple stakeholders (the sugarcane growers, the millers, SASRI, the sugar consumers, NGOs, and governmental departments), especially in coming up with environmental strategies, water resource management in particular, in their efforts towards water security. An outcome of such engagement is the 'SUSFARMS® 2018 Collaboration', which is an initiative between the industry members within the KZN Midlands, the sugar consumers, and the environmental NGOs in the area. The aim of the initiative is to achieve sustainable use of water resources, hence water security, by the year 2018.

Organisational nesting and polycentric governance in the industry lead to the appreciation of the complex nature of the system and the need to adapt in a changing environment. In this regard, organisational nesting and polycentric governance have played a role through the recognition of self-organisation at a local level, thus allowing the development of innovative intervention measures towards the collective goals of risk management and water security.

7.2.5 Encouraging Learning

Knowledge of SESs is always incomplete and it is in constant need of renewal, owing to the ever changing state of the resource system it represents (Cundill et al., 2015). Hence, there is a constant need to revise existing knowledge to enable adaptation to change in a SES, as well as to maintain valued ecosystem services in the face of risks and change (Walker and Salt, 2006; Jones, 2013). This learning in support of decision making is achieved through a variety of both planned and unplanned processes, including active experimentation and monitoring, multi-actor collaboration, and through inter-generational interactions with the environment. Thus learning can support the resilience of ecosystem services and risk management primarily through influencing decision making processes and governance (Cundill et al., 2015). In this study, the sugar industry members engage in collaborative work with other actors within the uMngeni River Basin such as NGOs in programs such as the 'SUSFARMS® 2018 Collaboration', providing a learning opportunity by opening up the governance processes to a diversity of responses.

Actors can thus learn from the experimentation of other stakeholders. In addition, the development of SUSFARMS® was borne out of lessons from the timber industry certification program by the FSC. Using the information from the experiences of the timber growers, the sugarcane growers in the Noodsberg area experimented on the development of a sustainable farming programme for themselves. Successes of the 'experimentation' have been carried on to other milling areas and now SUSFARMS® is recognised as the sugar industry's response to calls for sustainable use of natural resources especially water. Thus SUSFARMS® is a way of establishing common goals for the achievement of water security through sustainable farming practices.

Furthermore, to support learning and enhancing of the resilience of ecosystem services, the industry through SASRI adaptively creates tests and designs experiments to explore alternative management options. To accomplish this, there are study groups in each growing area where the growers discuss and seek solution to challenges they face. The learning process is also shown by the continuous update of the SUSFARMS® manual to reflect the knowledge and requirements at a given time.

The results of these study groups in the form of projects can arise out of location-specific risks or management needs (for example, the scheduling and efficient use of irrigation water and a need for sustainable farming practice) (Table 7.1). They can also arise from risk that all experience, or a risk that may be unintentionally caused to others, such as fire. In such instances where risk is pertinent to all in the industry, the learning resulting from exposure to risk spreads vertically and horizontally across and within groups, enabling evolution of appropriate institutional arrangements for risk to be managed at all scales in all locations.

These area-specific programmes act as experiments whose results can be used to determine the suitability of such programme in other regions. Success in these programs can then be replicated in other governance units. Adoption of SUSFARMS® is widespread within the three sugarcane growing areas of Dalton, Eston, and Noodsberg. In other sugarcane growing areas SUSFARMS® is not as widespread; instead the local actors developed other methods which they deemed more appropriate and suited to their environments and farming practices. Examples include MyCaneSim and Irrigation Scheduling for irrigated sugarcane farming. The development of successful programmes can result in their wider adoption, thereby contributing toward the goal of achieving a state of water security.

Table 7.1: Programs being promoted in different regions

Programme	**Application**	**Main area of promotion**
• MyCaneSim • Irrigation Scheduling Calendar Decision Support Programme (ISCDSP)	Irrigation scheduling and water budgeting	Irrigated North: Umfolozi, Pongola, Komati, Malalane
• SUSFARMS®	Sustainable farming	KZN Midlands: Noodsberg, Eston, Dalton
• Sugarcane burning at harvest	Fire control and air quality management	The whole sugar industry through SASRI

A nested structure and polycentric governance provide the platform for actors to form these smaller-scale collective governance units that encourage discussion among the users and the achievement of common understanding. This attribute can be seen in the development and adoption of the SUSFARMS® program. Larger units then can more effectively cope with goods and services that have large-scale effects and economies of scale (Nagendra and Ostrom, 2012). Results from this study show that organisational nesting and polycentric governance have facilitated the spread of learning within and beyond the industry, particularly in response to emergent risk.

7.2.6 Broadening Participation

Participation refers to the active engagement of relevant stakeholders in the management and governance processes (Stringer et al., 2006; Leitch et al., 2015). For the risk-sharing process to succeed, participation has to occur from the identification of risks and goals to implementing policy and monitoring and evaluating outcomes (Leitch et al., 2015).

Participation is thus context-specific and individuals, groups, and organisations choose to take an active role in making decisions that affect them (Stringer et al., 2006; Reed, 2008; Leitch et al., 2015). My research findings support this contention. Perceptions held by some within the industry are that SUSFARMS® is a program that was developed for dryland sugarcane farming conditions in the KZN Midlands and therefore not applicable to irrigated sugarcane farming practiced in other growing regions. Because of such a perception, participation in the improvement of the program is mainly from the farmers in the KZN Midlands because they feel it addresses the challenges of water security and risks that they face. Likewise, the participation of farmers practicing dryland agriculture is limited when it comes to programs such as MyCaneSim, Irrigation Scheduling Calendar Decision Support Programme (ISCDSP), which are more pertinent to irrigation agriculture.

Indeed, higher levels of governance can be detached from the situation prevailing in an area, which has an effect of reducing the ability of such levels to exert any influence in aligning behaviour. Broadening participation allows local actors and their representatives who may possess more relevant knowledge because of their specialised information about the local context and resources to contribute towards the sustainable use of water resources and the integrated management of risk (Ostrom et al., 1993). This feature gives local stakeholders acting collectively the ability to shape and inform behaviour within their area of influence because of their access to contextual knowledge, as evident from the differences in practices between irrigated and dryland agriculture.

Risk is thus context specific. It can be contextualised at farm scale, mill scale, and industry scale and wider. With contextualised knowledge, the risks and incentives to the actors within a resource system become apparent. The common understanding that can be achieved amongst actors in a given resource system or nest results in an alignment of behaviours towards a common goal as defined by the actors. Thus polycentricity contributes to the sugar industry’s efforts to align behaviour towards sustainable environmental practices and risk management by providing a governance structure that facilitates the autonomy of the various interest groups within the industry and recognising the self-regulation that prevails in such groups. In this way, organisational nesting and polycentric governance in the industry enable participation to broaden, to accommodate and address risk at appropriate scales.

7.2.7 Promoting Polycentric Governance Systems

Polycentric governance consists of multiple governing authorities that interact across different levels of the policy process (Ostrom et al., 1961). In such a governance system, each governing authority (public infrastructure providers, see Figure 3.3) has the autonomy to make and enforce rules within a circumscribed policy arena, for a specific location (Ostrom and Hess, 2007). For instance, while SASA as the national representative body for the sugar industry has the legitimate authority to make rules that are binding on all industry members, the various MGBs and LGCs have the autonomy to self-organise within their own domain.

Polycentric governance within the SA sugar industry relates to water security through:

I. The way the actors self-organise as decision making centres to benefit from their preferred resource units (ecosystem services) and the development of restoration measures; and
II. The way the industry relates to actors within the resource system but external to the industry.

Thus polycentricity provides a governance structure that enables risk to be understood as 'collective risk' and thereby stimulate innovation in all nests exposed to the risk. It may be one or two mills (as they transfer sugarcane to another mill when one is closed owing to drought, and low sugarcane crop output in drought conditions). At other times, it may be everyone in the industry, as experienced with the response to eldana manifestation.

Polycentricity also provides a governance structure that enables the spread of ideas through learning and experimentation, participation in water resources governance, connectivity among actors in an SES, a diversity of responses to challenges in the SES, and a redundancy of governance structures in each nest and level. Polycentric arrangements are enhanced through coordination amongst governance units (nests), negotiation of trade-offs between users, and social capital and trust (Schlüter et al., 2015; Schoon et al., 2015). All these are exhibited in the interactions within and across nests in the sugar industry.

The goal of many of these governance structures, indeed, one of human society's priorities, is to achieve water security, without which people and economies find themselves vulnerable and poor (Grey and Sadoff, 2007). However, an analysis by Cook and Bakker (2012) shows that various actors within a resource system frame water security differently and this is likely to vary geographically. Polycentric governance thus captures such location-dependent framings and allows for the relationship between local resource users and their environments to find expression at different levels of organisation. It connects the political and economic dynamics of geographical and historical contexts of an area to a wider context, giving stakeholders in resource system the right to participate in reshaping policies to suit their locality (Sneddon and Fox, 2007; Wampler and McNulty, 2011).

The development and adoption of programmes such as SUSFARMS® highlight the notion that local resource users are the custodians of natural resources, thus explaining their efforts in managing the resource in order to attain a state of water security. The promotion of SUSFARMS® from a local level to be an industry-wide programme and its subsequent inclusion of industrial sugar consumers and environmental NGOs shows the role of polycentric governance in broadening participation across scales. This increased participation has seen the incorporation of local and scientific knowledge through the participation of different actors who all have a claim to the resource system.

The way the industry has thus evolved particularly in its response to risk has led to a nested structure and polycentric governance system that seems well suited to its operations. Yet perhaps it might be helpful to more consciously manage water resources in support of the seven principles of resilience. When applied consciously, organisational nesting and polycentric governance can build resilience within the governance units. This issue is one of policy that SASA should be more conscious of and promote the seven principles within the nests.

7.3 IMPLICATIONS AND WIDER RELEVANCE OF THE STUDY

Exposure to risk played a determining role in the evolution of organisational structure and governance in the sugar industry. It will continue to do so. But, increasingly, risks are emerging that require collective response at scales much larger than a particular industry. Appreciation for this issue is evidenced, for example, in the Anglo Coal's eMalahleni Water Reclamation Project. Given the water risks the company faces, it recognised that it needed to work beyond itself and in the catchment (Oliphant's River) in order to reduce the risks to the company (Goga et al., 2016).

There is also growing awareness for the connectivity among risks. For example, one cannot separate risks from climate change, water security, or population growth. What is emerging is appreciation of the existence of industries within much larger complex adaptive systems. At these scales, industries such as the sugar industry, Coca Cola, and SABMiller can be envisaged as nests within an organisational structure, the effective harnessing of which requires the formalisation of a polycentric system of governance that fosters the experimentation, innovation, and learning that has been exhibited in the sugar industry.

Results of this study also show that though the local-level units are independent of SASA, they still plays a strategic role in shaping the behaviour of industry members through the devolution of power to self-organise to the nested governance units. This role builds a sense of custodianship and trust among actors and elicits a diverse response to collective challenges. As a result, there is an emergence of locally relevant innovations to water resource governance and risk management.

Natural resources management, more so water resource management, involves a number of actors whose views and perceptions might not be in congruence. In such systems, it then becomes imperative to adopt a nested structure with polycentric governance in order to take into account the local contextual knowledge. Lessons can then be drawn from the successes (and failures) of any policies or institutional arrangements that would have been tested in a limited geographic area. Any successes can then be scaled up for implementation in other nests. Thus, from the successes of only a portion of the water system, lessons can permeate other nests, leading to collective management of water resources across a river basin.

Success of any water resource governance hinges on monitoring and aligning behaviours towards collective goals. Actors self-organise into nests based on a common interest or geographical location. This organisation allows for the alignment of behaviours through the local development of rules and regulations with local monitoring. Because the nests are still connected to the industry as a whole, industry goals find influence and expression through the local governance units.

Furthermore, organisational nesting and polycentric governance are beginning to find expression at a much larger scale through inter-sectoral collaborations, for example, the SUSFARMS® 2018 Collaboration between Coca Cola, SABMiller, WWF, and the sugar industry. Indeed, the sugar industry actors cannot act in isolation because other sectors also lay claim to the water resources within the uMngeni River Basin, thus what connects these actors is the risk to their operations as a result of water insecurity. Thus organisational nesting and polycentric governance can be extended to other sectors and build networks, thus building resilience within the SES. The collective efforts towards the management of this risk results in the better management of water resources with the goal of water security.

Moreover, the management of natural resources is increasingly being put in the hands of the actors in a resource system. The management of natural resources such as water under the circumstances of climate change present a collective action challenge regarding water-related risks. Solutions to such challenges can be realised through the alignment of behaviour among the actors. This research sought to add to the body of knowledge by exploring how Ostrom's 'nesting principle' and polycentric governance have been put into practice within the SA sugar industry in aligning behaviour for the realisation of industry goals towards the sustainable use and management of natural resources, water in particular.

7.4 SUMMARY

Polycentric governance allows the relationship between local resource users and their environments to find expression at different levels of organisation. It connects the political and economic dynamics of geographical and historical contexts of an area to a wider context, giving stakeholders the right to participate in reshaping policies to suit their locality (Sneddon and Fox, 2007; Wampler and McNulty, 2011).

Furthermore, collective action challenges faced by large groups are often decomposable into smaller problems, among which some are typically surmountable given pre-existing trust between some members (Ostrom, 1990). From this perspective, water security challenges can be broken down to basin-level and the locals can then participate in efforts to solve problems they face within the wider context of the resource system. MGBs thus become part of a more inclusive SASA system without giving up their autonomy, making it possible for actors to align their behaviour to the overall goal of the unit because of their participation in the formulation and implementation of the collective rules. In this case study of the South African sugar industry, it is therefore apparent that collective action can be seen through the participation of the sugarcane growers, millers (at a MGB-level), and industry customers in implementing sustainable farming practices at a local level with the guidance of the national association.

In addition, organisational nesting, which is a key attribute of the sugar industry, allows redundancy to be built in the structures of the industry. This attribute is an advantage and critical result of nesting. Redundancy allows the scaling up of successes in risk-sharing in one nest to other levels and nests through horizontal and vertical networking. Nesting also gives an opportunity for the isolation of any failures in governance at any particular level or scale, hence resulting in other levels or scales taking over the governance process for the success of the industry. The result is that of integrated risk management.

Also, polycentric governance incorporates area-specific and contextual knowledge in the management of natural resource system and the appropriation of associated ecosystem services through the representation of local stakeholder interests and the development of network amongst the various decision making centres that characterise it. As shown from this case study, polycentricity can be used as a tool to achieve a diversity of ideas and structural redundancy, connectivity, governance feedback, fostering CAS thinking among actors, the participation of actors in the governance, and management of water resources and manage the risk posed by a lack of water security to the industry.

This case study has wider significance for the role of organisational nesting and polycentric governance in the management of natural resources. Studies have shown that water governance challenges in changing environments are best dealt with at local level with the national level providing the industry outlook and dealing with the problem at a scale that allows for the consideration of other stakeholders within the system who might not necessarily be represented (but are affected) at the local level.

This research demonstrates also the role of on-farm interventions towards water security and how local actors can develop programs that embrace different features of the water security issue and work them into their own priorities and concerns. Furthermore, this research shows that organisational nesting and polycentric governance allow industries to connect at wider scales to harness their collective assets and address common risks without compromising their autonomy and resilience.

CHAPTER EIGHT
CONCLUSION

In the preceding chapter I discussed the findings of the study with reference to existing literature on organisational nesting and polycentric governance in water resources management. In this chapter I present the conclusion of the study as well as the study implications. The study reviewed literature pertinent to the subject matter at hand and collected field data through interviews and on which the conclusion and recommendations for further study are based.

This research sought to add to the body of knowledge by exploring the role of Ostrom's 'nesting principle' in risk-sharing and how this has been put into practice within the SA sugar industry in aligning behaviour for the realisation of industry goals towards water security. A secondary intention was to elucidate the wider relevance of the findings given the emergence of risks, such as that to water security, that require collective action at scales larger than a single industry.

8.1 SUMMARY OF FINDINGS

Results of this study show that within the sugar industry, organisational nesting is a learning network through which ideas spread and innovation arises. This network is enabled through the polycentric governance that manages the interaction among the actors and the evolution of the structure, function, and operations within the industry. The promotion of sustainable farming methods through SUSFARMS® represents such spread of ideas and alignment of behaviours. In moving towards sustainable farming methods, actors also move towards water security. Hence sustainable farming methods become a way for the integrated management of risk.

8.1.1 Organisational Nesting and Risk-sharing

This research was based on the proposition that organisational nesting and polycentric governance enable stakeholders in the sugar industry to align their behaviours and manage risk collectively based on their perception of the rules and expected benefits from the outcomes, and how they affect interpretation and management of risk in the industry with particular reference to water scarcity. It was found that the nested structure of the industry was borne out of the need to have the interests of the different members of the industry represented adequately. The agreements amongst the industry actors, although financially directed, were motivated by the need to share risk. The structure and governance system has evolved to one can be adapted for integrated water-related risk management. The same structures can be used to manage in an integrated way the risk to water security through the participation of all industry members and actors within the basin through inter-sectoral linkages.

With regards to water security, organisational nesting plays a role as a learning network in disseminating information and ideas about sustainable farming methods. The learning network plays a role in the spread ideas and information, thus enabling the various governance units to devise response measures that are more appropriate to the local settings and environment. Examples include SUSFARMS® in the KZN Midlands and MyCaneSim and the ISCDSP in the predominantly irrigated areas. In addition, the nested structure is being used as a tool for the alignment of behaviour towards the collective goal of water security and risk-sharing through locally devised rules and regulations, for example, rules devised for the adoption of SUSFARMS® in the Noodsberg region.

Because the area under study practices dryland agriculture, actors have little control over the patterns of rainfall. To manage the risk to water security, they engage in sustainable farming practices. These on-farm interventions such as collective wetland rehabilitation result in restoration of ecosystem services and mitigation of the risk of water insecurity. From the results of this research, organisational nesting has a role in risk-sharing through:

- The bearing of risk collectively by the actors in an SES thus motivating the need to learn and progress risk mitigation among nests;
- Enabling risk in one nest to be mitigated through innovation in another, for example, the research into mitigation of risk owing to eldana manifestation in the sugarcane crop; and
- The alignment of behaviour among actors within their nests, which is possible through the recognition of self-organisation among actors in a nest, thus allowing local monitoring of behaviour for a collective outcome.

Owing to the interdependence between the growers and the sugar processors, a fundamental relationship exists between these two interest groups. This relationship finds expression among the millers at a local level as a MGB (horizontal nesting) and as SASA at the national level (vertical nesting). Among the farmers, vertical nesting occurs between the LGCs and the SACGA. At a national level, there is horizontal nesting between the respective interest groups, with this relationship finding expression as the SASA.

The argument in the study was that risk is a social construct, holding different meanings for different actors in a resource system. As such, the response to risk is mediated by social influences from friends, family, and respected public officials', hence alignment of behaviour. Given the social capital that SASA already has within the industry, it plays an important role in shaping industry members' perceptions of risk and its integrated management through the decentralisation of decision making to local levels in a nested organisational structure under a polycentric governance system.

With the independence and recognition of the self-organisation that is evident within the various Mill Group Boards, locally developed innovations receive more acceptance and participation because the affected actors within a given resource system see the need and relate to a given intervention program for the realisation of the collective goal. Thus behaviour alignment and monitoring of compliance with set rules and regulations become the task of the locals, with the framework and policies being set by the upper level(s).

This collective action owes partly to the fact that risk transcends the value chain, and the perception toward it is informed by the primary economic activity of the actors involved. The risk borne out of a state of water insecurity drives innovation among actors in a SES. The economic and reputational risks posed by water insecurity then become a cohesive factor, owing to the industry's sharing of proceeds agreement. Because there are multiple actors within a resource system, polycentric governance provides a platform for the integration of the varied views for an integrated risk management that furthers the environmental sustainability goals of the industry and the benefits that accrue from the ecosystem services.

Indeed, studies have shown that water governance challenges in changing environments are best dealt with at local level with the national level providing the industry outlook and dealing with the problem at a scale that allows the consideration of other stakeholders within the SES who might not necessarily be represented (but are affected) at the local level. This research demonstrates how local actors can develop programs that embrace different features of the water security issue and work them into their own priorities and concerns. But sectors cannot work in isolation; there is a need to expand nesting to include other sectors in order to have a river basin-wide alignment of behaviours. As such, organisational nesting and polycentric governance allow actors to connect at wider scales to harness their collective assets and address common risks without compromising their autonomy and resilience.

8.1.2 Response to Risk and Water Security

Collective action, learning, and networking among industry actors has resulted in an increased awareness of water-related risk such as water insecurity owing to scarcity and unpredictable rainfall patterns. Interpretation of such risks has seen the institutionalisation of a range of responses. Perhaps the most important development within the sugar industry, however, is the growing engagement of growers, manufacturers, and corporate customers with discussions of risk management around water through sustainable farming practices. This development mirrors findings by Hepworth (2012, p. 543-4):

> *"Over the past decade the level of activity on water and interest in water policy by corporate actors has grown at a formidable pace. Distinct from established debates about private sector involvement in water service provision, this new agenda concerns*

multinational commercial entities that use significant volumes of water to produce goods and services, and their adoption of new tools, partnerships, initiatives and roles to drive changes in the way they, and wider society use and manage water".

The decentralisation of decision making in a polycentric system has given birth to the industry's response to the risk born out of the effects of climate change (i.e. droughts and related water scarcities) and deterioration of ecosystem services. The industry has responded through SUSFARMS®. The initiative is a collaborative action between sugarcane growers, millers, sugar consumers, and NGOs towards water security. This response has now been institutionalised within the sugar industry.

This research found that the adoption of the SUSFARMS® initiative was driven by the MGB at Noodsberg. Through networking with other MGBs, this innovation has now been adopted as an industry-wide program. In this regard, organisational nesting and polycentric governance provided a platform for the independent development of this initiative and its implementation by the Noodsberg Cane Growers before being up-scaled to an industry level. This spread of the project owes to the fact that the structure of the SA sugar industry is inclusive, with governance at multiple scales providing experimentation for different policies at localised levels.

Furthermore, the study findings show that different actors within the industry have different definitions of water security; hence they place importance on different attributes of water security. Because sugar processors can draw water from the sugarcane plant and use it within the industrial processes, they tend to place importance on the quality of water effluent discharged from their operations. This concern is also informed by the national environmental legislation requirements; hence there is investment toward water treatment facilities among the sugar processors. For sugarcane growers, especially within the study area, because they grow their sugarcane under rain-fed conditions their concern and definition of water security is based on the availability of water (quality and quantity of influent). Despite these divergent framings of water security, the interdependence among actors in the industry, their exposure to risk, and the need for the purposeful and collective management of water-related risks keeps the sugar industry organised as they engage in collective action towards water security.

SUSFARMS® is one such response to widespread awareness of risk, even though this risk may be framed differently. Through wider adoption it has become a tool for the industry to respond to environmental risks, such as water scarcity, and to public perceptions of the industry. Organisational nesting and polycentric governance has allowed lessons from different contexts and scales to be drawn together and applied to align behaviours in a collective approach to risk management.

8.1.3 Integrating Risk Management

The SA sugar industry is faced with the challenge of managing risk in complex and ever changing SESs, where they have to take cognisance of the varied perceptions among the stakeholders inside and outside of the industry. An integrated approach to environmental risk management then requires a governance system that enables risk to be distributed equitably and for the common good. Such a governance system must also enable adaptive management of risk. Following Schoon et al. (2015), I conclude that organisational nesting and polycentric governance within the sugar industry provides an ideal platform for management of risk through:

- The provision of opportunities for experimentation and learning;
- The increase of chances of response diversity;
- The enabling of broader participation of actors who lay a claim to a resource system; and
- The increase in accountability in instilling a sense of custodianship of natural resources among the actors.

Because of the interdependencies among farmers who supply the same mill and millers who require sugarcane, even when risk is framed differently it poses a collective risk. This sense of bearing risk collectively motivates the need to learn and progress risk mitigation among nests. It encourages the contagious spread of ideas and practices, as has been illustrated with SUSFARMS®. However, despite the success of SUSFARMS®, the results of this study show that how a risk is framed can also inhibit learning across nests, thereby slowing uptake. But they also show that when risk is framed more generically than water security, as in the case of reputational risk with implications for marketing, it leads to more widespread adoption. This example illustrates the significant role of autonomy in organisational nesting while at the same time exposing the important opportunity interdependence brings for reframing risk collectively and enabling the spread of ideas and practices across the industry.

Through initiatives like the SUSFARMS® 2018, collaboration between Coca Cola, SABMiller, WWF, and the sugar industry, organisational nesting and polycentric governance can be extended beyond the sugar industry. Such inter-sectoral linkages result in a river basin-wide management of water resources with a common goal. These linkages then provide a network through which ideas and information permeate, thus aligning behaviours for the benefit of all actors in a river basin through purposeful collective management of risk.

8.2 ORGANISATIONAL NESTING AND RESILIENCE

Organisational nesting and polycentric governance are responses to risk and can be used to mitigate risk. As a consequence, the organisation should be better prepared to respond to emergent risk – to be more resilient in the face of risk. How it does this is described below.

Firstly, organisational nesting and polycentric governance devolve power and responsibilities to the various nests within the industry. Because of this transfer of power, most of the actors (sugarcane growers and millers) in the industry who face risk more directly are able to identify risk and proactively work towards its mitigation.

Secondly, besides the spread of ideas, organisational nesting builds redundancy into the governance structures of the industry. This feature provides a fail-safe when a governance unit or nest cannot manage risk by itself. A case in point was the management of the risk to production posed by eldana. Sugarcane growers could not adequately respond to the risk but because SASRI had the expertise and resources to conduct research on the pest they managed to develop sustainable ways of managing and controlling eldana. Thus, organisational nesting builds resilience into an SES through governance units at different levels so that when one unit fails, the system can still recover through the efforts of other governance units.

Key attributes of polycentric governance include: dispersal of political authority, separately constituted bodies, overlapping jurisdictions, increased self-governing capacity of local communities, and increased cross-scale linkages between horizontal and vertical levels of organisations (Berkes, 2002; Ostrom, 2005; Huitema et al., 2009). From the findings of this research, it is apparent that these features exist within the sugar industry. The way the industry has evolved particularly in its response to risk has led to a nested structure and polycentric governance system that seems well suited to its operations. Thus, thirdly, organisational nesting might be helpful to more consciously manage water resources in support of the seven principles of resilience:

- Maintaining diversity and redundancy;
- Managing connectivity;
- Managing slow variables and feedback;
- CAS thinking;
- Encouraging learning;
- Broadening participation; and
- Promoting polycentric governance systems.

Previous studies and literature point to benefits of polycentric governance systems as more resilient and adaptable to change for two reasons (Sternlieb and Laituri, 2015):

- Issues from a range of geographic scales/areas can be managed at different levels; and
- Owing to a high degree of overlap and redundancy, they are less vulnerable (Ostrom, 2005; Huitema et al., 2009).

These advantages are evident within the sugar industry. The recognition of self-governance within the sugar industry results in the promotion and building of resilience within the governance units. The nested structure and polycentric governance system within the sector have made the industry resilient and adaptable to change through the harnessing of local and contextualised knowledge from its various levels and scales. This contextualised knowledge comes with a diversity of responses to the strategies for an integrated risk management within the industry and the basin at large. The redundancy built into the nested structure of the industry makes it possible for the other governance units (nests) to take over should governance at one nest or level fail.

Finally, De Chernatony and Dall'Olmo Riley (1998) contend that a brand can be a risk reducer. SUSFARMS® has evolved to be considered a brand or identity for the sugar industry. As results show, it has been used to respond to risks the industry faces. Through the adoption of sustainable farming methods, the industry has not only responded to the risk posed by water insecurity but also reputational and regulatory risk. A brand can instil confidence among the regulatory infrastructure providers by acting as a guarantee of consistent sustainable farming practices. Such confidence further enhances the recognition of self-organisation within the industry. A more conscious adoption of SUSFARMS® can help build resilience within the sugar industry. It is the role of SASA as the principal centre and governance infrastructure provider to build social capital and promote the conscious use of seven principles of building resilience for the advancement of water security goals for the industry.

8.3 STUDY IMPLICATIONS

Exposure to risk played a determining role in the evolution of organisational structure and governance in the sugar industry. Now, increasingly risks are emerging that require collective response at scales much larger than a particular industry. Already, there is an appreciation for this issue evident in, for example, Anglo Coal’s eMalahleni Water Reclamation Project and the SUSFARMS® 2018 Collaboration. Spreading connectivity beyond sectoral confines gives actors in a basin a platform to participate in the collective governance of water resources, thus bringing a diversity of responses to common challenges.

However, natural resources management, more so water resource management, involves a number of actors whose views and perceptions might not be in congruence. My findings suggest that in such systems, it is beneficial to adopt a nested structure with polycentric governance in order to take into account the local contextual knowledge and draw lessons from the successes (and failures) of any policies or institutional arrangements that would have been tested in a limited geographic area.

There is also growing awareness for the connectivity among risks. For example, one cannot separate risks from climate change, water security, or population growth. What is emerging is an appreciation of the existence of industries within much larger CASs. The sugar industry actors cannot act in isolation because other sectors also lay claim to the water resources within the uMngeni River Basin. The SUSFARMS® 2018 Collaboration between Coca Cola, SABMiller, WWF, and the sugar industry shows that organisational nesting and polycentric governance can be extended to other sectors.

Polycentric governance was first explained in the realm of local government management and has now found application in natural resources governance. Organisational nesting can be applied in any resource system in which the actors are determined by geographic location. This study found that although the local level units are independent of SASA, they still play a strategic role in shaping the behaviour of industry members. As such, other sectors and communities should adopt a polycentric governance system, as it helps build a sense of custodianship among actors. Because of the organisational nesting's inclusiveness, the structure builds trust among stakeholders and elicits a diverse response to collective challenges.

The dairy industry, for example, upon deregulation through the Marketing of Agricultural Products Act, No 47 of 1996, developed into one of the freest dairy markets in the world, but there was no coordination between the milk producers, processors, and the marketers (NAMC, 2001). Reasons proffered for the lack of coordination were changes in governance structures and lack of enforcement of regulations. Indeed, despite having associations representing the interests of the various actors within the dairy industry, association was fragmented between the farmers, the processors, and distributors with no formal collaboration. Such a challenge to the dairy industry can be attributed to the absence of organisational nesting and the incorporation of polycentric governance within the industry as a whole. Incorporating the structure and governance system in the dairy sector and other sectors (and communities) can help in the development of environmental measures that further the attainment of the sector's environmental goals, including water security. This governance will also enhance the collaborative efforts between the various actors within and outside of the sector.

8.4 AVENUES FOR FURTHER RESEARCH

Simply establishing polycentric institutions is insufficient; the social processes enabling polycentric governance are essential to its success. These social processes include building trust and social capital and maintaining or developing strong leadership, social learning, and bridging scales through the use of explicit strategies (Folke et al., 2005). The SA sugar industry has managed to retain its structure for almost 100 years now. It will be important if the role of trust and social capital in the continued relevance of SASA could be explored.

It is also worth mentioning that although this study sought to investigate the aspect of organisational nesting and governance toward water security, it falls short of some insights that can expand the understanding of the role structure and governance type play in managing water resources and natural resources at large. As such, the following are avenues for further research:

- The scope of the study can be expanded to consider the perceptions of industry members who are located in other areas, especially where irrigation is the norm.

- The study treated industry members as an economically homogeneous group when, in reality, the reality is much more complex. Disparities among financial capabilities may exist, where poorer members may find it difficult to incorporate all the better management practices advocated for through SUSFARMS®. There is therefore a need for a study with a focus on how the economic capabilities of a member influence his/her action towards the collective management of risk.
- Given that the industry is located in an area where multi-cropping is practiced, the activities of other farmers who might be outside of the sugar industry but within the same river basin can have an impact on every actor. It will be important to gain some insight into how the response of the sugar industry towards the risk of water insecurity through SUSFARMS® can be used in other sectors within the same river basin and even further afield.
- Looking at SUSFARMS® provides a new dimension for research. An insight into the relationship between the perception of risk by customers and brand recognition can shed some light on the role of branding in attaining environmental sustainability.

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APPENDICES

APPENDIX A-1 CONSENT FORM

(South African Sugar Association)

NB: This consent form will remain with Monash University researcher for their records.

Project: 'The role of organisational nesting in risk-sharing – A case study of water security in the South African sugar industry'
Chief Investigator: Prof. Charles Breen
Student Investigator: Busani Masiri

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project.

I consent to the following:	Yes	No
I agree to be interviewed by the researcher	☐	☐
I agree to allow the interview to be audio-taped	☐	☐
I agree to make myself available for a further interview if required	☐	☐
I agree to provide documents that may be of material importance to the study	☐	☐

Name of Participant ______________________________

Participant Signature ______________________________ Date ______________

APPENDIX A-2 EXPLANATORY STATEMENT

South African Sugar Association

Project: The role of organisational nesting in risk-sharing – A case study of water security in the South African sugar industry

Chief Investigator
Prof Charles Breen
Water Research Node
[redacted]

Student's name: Busani Masiri
[redacted]

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses listed above.

What does the research involve?

The aim of this study is to analyse the role of organisational nesting in risk-sharing and its wider relevance to water security in the South African sugar industry.

The study involves you participating in an interview that focuses on issues of origin, structure, organisation, and operation of organisational nesting; how organisational nesting is used to apportion risk in an equitable manner; how perceptions of risk influence the structure and operation of organisational nesting; how organisational nesting and risk determine water security, risk assessment processes, formulation of collective choice rules and implementation of agreed decisions. The interview process will also seek to understand the importance placed on water-related risk in your 'risk hierarchy'. It will last approximately 30 minutes. The interview will be audio recorded (with your consent); your identity will remain anonymous. If you wish, you may request a copy of the transcribed interview script to be provided to you for confirmation before being included in the research findings. Interviews will be conducted at a specific location convenient to you.

Why were you chosen for this research?

I am seeking the views of members of the South African Sugar Association within the uMngeni river basin to better understand the role of organisational nesting in risk-sharing and water security in the South African sugar industry. Given the national outlook of the organisation and your position, the direct dependence of members of the association on water resources; your contribution to this study will be invaluable. Your contact details were obtained from the South African Sugar Association website.

Consenting to participate in the project and withdrawing from the research

Participation in the project is voluntary and you can choose not to participate in part or all of the project and you can withdraw at any stage of the project without being penalised or disadvantaged in any way. If you agree to participate in the project, a consent form on which you will append your signature will be provided to you. The consent form will be retained by the researcher. You may ask at any time prior to publication/ prior to giving final consent for your data to be withdrawn from the project.

Possible benefits and risks to participants

There are no foreseeable risks associated with the study. However, this research will contribute indirectly by informing policy and practice. Outcomes of this study should help shade some light on how to leverage the linkages and organisation in the sector to promote water security programmes and also highlighting how self-organisation can be used as a way to achieve mutual interest.

Confidentiality
All aspects of the study, including results, will be completely confidential. All reference to the respondents in the transcribed interview notes will be anonymous. No findings will identify to any individual. To guarantee anonymity, codes will be used in a way that does not reflect the order in which the interviews will be conducted.

Storage of data
Data collected will be stored in accordance with Monash University regulations, kept on University premises, in a locked filing cabinet for five years. Within this period, you may request a copy of the collected data. A report of the study will be submitted for publication, but individual participants will not be identifiable in such a report.

Results
If you would like to be informed of the aggregate research finding, please contact Busani Masiri on [redacted] The findings are accessible for five years. The results of the study will be available through the Monash Library after successful completion of the examination process around mid-2016.

Complaints
Should you have any concerns or complaints about the conduct of the project, you are welcome to contact the Research Coordinator, Monash University (South Africa Campus):
Hester Stols
Research Coordinator
Office of the Academic President
Monash South Africa
144 Peter Road, Ruimsig
[redacted]

Thank you,
[redacted]
Prof. Charles Breen

APPENDIX A-3 INTERVIEW SCHEDULE

I. Water Security

1. In your years in the industry how have you seen the evolution of the association's policies and practices relevant to water security?
2. Is there a purpose for water security within the sugar industry?
   - If so, why?
3. What is the main benefit – for the industry – of achieving water security?
4. What has been the most significant policy changes affecting water use and water security in the uMngeni River Basin?
5. What are the most significant examples of water security programmes that you are aware of in the uMngeni River Basin?
6. Which stakeholders (government, users, third parties, etc.) have had the most influence on water security, and how have they exerted this influence?

II. State of the Water Resources & Water-related Risk

7. How would you describe the state of the water resources in the area (surface water, groundwater, rainfall patterns)?
   - What risks do you think the state of the water resources pose to the industry?
   - How has the association (or its units) responded to such risks?
8. How does collaboration between different stakeholders affect water security and risk-sharing?

III. Organisational Nesting

9. How have administrative structures of the organisation and processes and the coordination between them affected water security?
10. How does the coordination of water security programmes between different stakeholders at different scales affect water resource management?
11. Are water security programmes carried out in different organisations (or units)?
12. If water security functions are carried out by separate organisations what means are used to coordinate their activity?

Are there any other issues that haven't been covered yet or observations you would like to make?

APPENDIX A-4 ETHICS APPROVAL CERTIFICATE

MONASH University
Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project Number:	CF15/1015 - 2015000473	
Project Title:	The role of organisational nesting in risk sharing - A case study of water security in the South African sugar industry	
Chief Investigator:	Prof Charles Breen	
Approved:	**From:** 20 April 2015	**To:** 20 April 2020

Terms of approval - ***Failure to comply with the terms below is in breach of your approval and the Australian Code for the Responsible Conduct of Research.***

1. The Chief investigator is responsible for ensuring that permission letters are obtained, <u>if relevant</u>, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash University letterhead and the Monash University complaints clause must include your project number.
6. **Amendments to the approved project (including changes in personnel):** Require the submission of a Request for Amendment form to MUHREC and must not begin without written approval from MUHREC. Substantial variations may require a new application.
7. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
8. **Annual reports:** Continued approval of this project is dependent on the submission of an Annual Report. This is determined by the date of your letter of approval.
9. **Final report:** A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
10. **Monitoring:** Projects may be subject to an audit or any other form of monitoring by MUHREC at any time.
11. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

[redacted]

Professor Nip Thomson
Chair, MUHREC

cc: Mr Busani Masiri

Monash University, Room 111, Chancellery Building E
24 Sports Walk, Clayton Campus, Wellington Rd
Clayton VIC 3800, Australia
[redacted]esearchadmin/human/index.php
ABN 12 377 614 012 CRICOS Provider #00008C

APPENDIX A-5 PERMISSIONS SOUGHT

A-5.1 PERMISION TO USE IMAGE

Busani Masiri[redacted] 15/10/2015

to info

I would like to seek permission to use the image on your site below for my thesis which is based on the sugar industry in South Africa:
http://www.spectrumcommodities.com/education/commodity/maps/sugar/safsugc.gif
Looking forward to your response

Kind regards,
Busani Masiri
Sent from Mail for Windows 10

Louise Gartner [redacted] 15/10/2015

to me

Yes, you have my permission.

Louise Gartner

From: Busani Masiri [redacted]
Sent: Thursday, October 15, 2015 5:23 AM
To:[redacted]
Subject: Use of image

A-5.2 APPROVAL TO CONDUCT RESEARCH

SOUTH AFRICAN SUGAR ASSOCIATION

DATA/INFORMATION AGREEMENT BETWEEN

The South African Sugar Association

and

Institution: Monash South Africa

Address: 144 Peter Road, Ruimsig, 1725

Collaborating scientist/authority: Professor Charles Breen
Student: Busani Masiri

In consideration of the South African Sugar Association (hereafter SASA) supplying data (as herein defined), the parties agree as follows:

1. Data include:

   Interviews and data / information to develop an understanding of the role of organisational nesting plays in risk sharing among the various actors in the sugar farming community within the uMngeni River basin in South Africa.

   Supplied to:

   Professor Charles Breen / Busani Masiri

2. No material will be distributed or disclosed to third parties except for the official supervision of the research study, who have agreed to abide by the terms of this agreement. And no one will be allowed to distribute this material to any other person or location unless written permission is first obtained from SASA.

3. It is understood that the material will be exclusively used for research work carried out under the supervision of the scientist upon the following subject:

   "The role of organisational nesting in risk sharing – A case study of water security in the South African sugar industry."

4. The material supplied will not be used either directly or indirectly for commercial purposes unless specifically agreed by both parties to this agreement.

5. Upon request the scientist and student will keep SASA informed of research results obtained using the material/data/information.

6. Research findings will be permitted to be presented at symposia or professional meetings or published in reports, dissertations or journals provided that SASA shall have been furnished with copies of any such proposed presentations or publication at least sixty (60) days in advance of the submission date of such material to a journal, editor or third party. SASA shall have thirty (30) days to object in writing, on receipt of such notice to proposed presentations or publication either because there is patentable subject matter or confidential information regarding SASA contained in the proposed material.

7. SASA has no liability in connection with material supplied under this agreement.

8. SASA will be furnished with a copy of the dissertation/thesis for review prior to submission to the University for Examination.

9. This agreement shall be effective from the date of last signature and remain in force until notice of termination is given.

10. Each party to this agreement is entitled to give thirty days notice of termination of this agreement to the other party.

11. Termination of this agreement, for whatever reason, shall not prejudice or affect the accrued rights, claims and liabilities of either party to this agreement.

12. Both parties undertake to perform their obligations under this agreement in the utmost good faith.

Signed in the presence of the subscribing witnesses at .. [redacted] ...... on the ..6th..... day of ....March.................... 2015.

Signatures

For and on behalf of the ***South African Sugar Association***

[redacted] ______ Witness: [redacted] ....

Witness: 2. ....

Director: External Affairs

[redacted] ***sh South Africa***

Witness: 1. . [redacted]

Professor Charles Breen[redacted] Witness[redacted]

Adjunct Research Fellow

[redacted]

Research Student

Busani Masiri

MONASH South Africa
A campus of Monash University Australia

LAUREATE INTERNATIONAL UNIVERSITIES®

Permission to Conduct Research

<u>Ref: Application for permission to conduct research on organizational nesting within SASA</u>

Title of Study:	The role of organisational nesting in risk sharing - A case study of water security in the South African sugar industry
Principal Investigator:	Prof Charles Breen, Adjunct Research Fellow, Water Research Node, Monash University
Student Principal Investigator:	Busani Masiri, MPhil Student, Water Research Node, Monash University
Faculty Supervisor:	Prof Bimo Nkhata, Director, Water Research Node, Monash University

To whom it may concern,

We hereby apply for permission to conduct research within your organization as part of an MPhil study being conducted by the student (Busani Masiri) at Monash University. The student will be conducting a study on “The role of organisational nesting in risk sharing - A case study of water security in the South African sugar industry”. The research is part of an international water security research project funded by the Lloyds Register Foundation (see www.watersecuritynetwork.org). The uMngeni River Basin is the case-study in South Africa where we are researching sector-based self-governance and self-regulatory systems with a focus on water security. Our research is premised on the understanding that the sugar industry is ‘organised in multiple layers of nested enterprises’ and that optimizing risk management requires collaborative and integrated decision-making.

The purpose of this research project is to develop an understanding of the role of organisational nesting plays in risk sharing among the various actors in the sugar farming community within the uMngeni River basin in South Africa. The study will provide an insight on the wider relevance of risk sharing and organisational nesting for water security. Should you choose to participate, we will ask you to participate in an interview lasting 30 minutes at most. The interview will cover the following topics;

Postal - Private Bag X60, Roodepoort, 1725, South Africa Location - 144 Peter Road, Ruimsig,1724
[redacted]

1. Origins, structure, organisation and operation of organisational nesting;
2. How organisational nesting is used to apportion risk in an equitable manner;
3. How perceptions of risk influence the structure and operation of organisational nesting and the importance they place on water-related risk in their 'risk hierarchies'.
4. How organisational nesting and risk determine water security, risk assessment processes, formulation of collective choice rules and implementation of agreed decisions.

We intend that this research should inform discourse among members of the South African Sugar Association by illustrating how to leverage the linkages and organisation in the sector to promote water security and also highlight how self-organisation can be used as a way to achieve mutual interest.

If you have any questions, please feel free to contact me (see below for contact information).

Thank you,

[redacted]

Prof Charles Breen
Adjunct Research Fellow

[redacted]

Busani Masiri
MPhil in IWM Student
[redacted]

Faculty Supervisor
Associate Professor Bimo Nkhata
Director: Water Research Node
Monash South Africa
144 Peter Road, Ruimsig 1725
[redacted]