A WATER REPORTING FRAMEWORK FOR THE SOUTH AFRICAN DAIRY INDUSTRY'S UPSTREAM VALUE CHAIN

by

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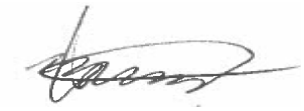

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ABSTRACT

Water scarcity, which refers to both the quantity and quality of water, has increased stakeholder demand for improved water reporting. Notably, this is not just in an organisation's direct operations but throughout the value chain, particularly upstream, where most of the water is consumed. The main aim of this study was to develop a framework to assist in improving water reporting in the upstream value chain of the South African dairy industry. Since no existing frameworks or tools in the public domain are specifically designed for this context, a context-specific framework is needed.

An interpretive, qualitative approach was used, with design science research being the overarching research design. Data collection involved two transect walks on two dairy farms and a first round of semi-structured interviews with 17 participants. Using these findings, along with insights reflected in the two literature review chapters, a draft framework was developed. Thereafter, a second round of semi-structured interviews with five participants was undertaken to evaluate the draft framework. The information gathered from these interviews resulted in the final framework. Frugal innovation, along with its interlinked dimensions of social, technological and institutional innovation, was used as the theoretical lens in this study.

The findings revealed important drivers and limitations on water reporting which, if addressed, could enhance such reporting. The proposed framework also accommodates farmers who are not already reporting on water by introducing basic reporting requirements, while offering a systematic path to more advanced reporting over time. The study findings could be of value to several stakeholders, including farmers, food processors, non-governmental organisations, organised agriculture, government agencies, shareholders and investors.

Key terms: dairy industry; drivers of water reporting; frugal innovation; limitations of water reporting; transect walks; value chain; water reporting; water scarcity

OPSOMMING

Waterskaarste wat na beide die kwantiteit sowel as die kwaliteit van water verwys, het belanghebbendes se vraag na verbeterde verslagdoening oor water laat toeneem. Wat opvallend is, is die feit dat dit nie net binne ’n organisasie se direkte werksaamhede is nie, maar regdeur die waardeketting en veral stroomop waar die meeste water verbruik word. Die hoofdoel van hierdie studie was om ’n raamwerk te ontwikkel om te help om waterverslagdoening in die stroomop-waardeketting van die Suid-Afrikaanse suiwelbedryf te verbeter. Aangesien daar geen bestaande raamwerke of hulpmiddels in die openbare domein is wat spesifiek vir hierdie konteks ontwerp is nie, word ’n kontekspesifieke raamwerk benodig.

’n Interpretatiewe, kwalitatiewe benadering is in die studie gebruik met ontwerpwetenskapsnavorsing as die oorkoepelende navorsingsontwerp. Data-insameling het twee transekstaptogte op twee suiwelplase en ’n eerste rondte semigestruktureerde onderhoude met 17 deelnemers behels. Hierdie bevindinge, in samehang met insigte wat in die twee literatuuroorsighoofstukke gereflekteer word, is gebruik om ’n konsepraamwerk te ontwikkel. Daarna is ’n tweede rondte semigestruktureerde onderhoude met vyf deelnemers onderneem om die konsepraamwerk te evalueer. Die inligting wat uit hierdie onderhoude verkry is, het tot die finale raamwerk aanleiding gegee. Spaarsame innovasie tesame met sy gekoppelde dimensies van sosiale, tegnologiese en institusionele innovasie is as die teoretiese lens in hierdie studie gebruik.

Die bevindinge het belangrike dryfvere en beperkinge op waterverslagdoening blootgelê wat, indien dit hanteer sou word, sodanige verslagdoening sal bevorder. Die voorgestelde raamwerk akkommodeer ook boere wat nie reeds oor water verslag doen nie deur basiese verslagdoeningsvereistes in te stel onderwyl dit met verloop van tyd ’n sistematiese pad na meer gevorderde verslagdoening bied. Die studie se bevindinge kan waarde inhou vir verskeie belanghebbendes insluitend boere, voedselverwerkers, nieregeringsorganisasies, die georganiseerde landbou, regeringsinstansies, belanghebbendes en beleggers.

Sleutelterme: suiwelbedryf; dryfvere van waterverslagdoening; spaarsame innovasie; beperkings op waterverslagdoening; transekstaptogte; waardeketting; waterverslagdoening; waterskaarste

NKOMISO

Ku pfumaleka ka mati, leswi kombetelaka eka nhlayo na ntikelo kumbe nkoka wa mati, swi engetele xilaveko xa vakhomaxiave eka ku antswisiwa ka ku vikiwa ka mati. Lexi xiyekaka, leswi aswi endli ntsena eka matirhelo yo kongoma ya nhlangano kambe eka nxaxamelo hinkwawo wa nkoka, ngopfu ngopfu ehenhla ka nambu, laha mati yotala ya dyiwaka kona. Xikongomelonkulu xa ndzavisiso lowu a ku ri ku tumbuluxa xiyenge xo pfuneta ku antswisa ku vika mati eka nxaxamelo wa nkoka wa le henhla wa bindzu ra masi wa Afrika-Dzonga. Tanihi leswi ku nga riki na swivumbeko leswi nga kona kumbe switirhisiwa eka ndhawu ya mani na mani leswi endleriweke xiyimo lexi hi ku kongoma, xiyenge lexi kongomisiweke eka xiyimo lexi xa laveka.

Ku tirhisiwile endlelo ro hlamusela, ra xiyimo, laha ndzavisiso wa sayense ya dizayini ku nga dizayini ya ndzavisiso leyi heleleke. Ku hlengeletiwa ka datha swikatsa ku famba ka transect kambirhi eka mapurasi mambirhi ya masi na xirhendzevutani xosungula xa mimbulavurisano ya semi structured na 17 wa vatekaxiave. Hi ku tirhisa swikumiwa leswi, kun'we na vutivi lebyi kombisiweke eka tindzima timbirhi ta nkambisiso wa matsalwa, ku tumbuluxiwile rimba leri tsariweke. Endzhaku ka sweswo, xirhendzevutani xa vumbirhi xa mimbulavurisano leyi nga hlelekangiki ngopfu na vatekaxiave va ntlhanu xi endliwile ku kambela rimba ra xitshuriwa. Rungula leri hlengeletiweke eka mimbulavurisano leyi ri endle leswaku ku va na rimba ro hetelela. Vumaki byo hlayisa mali, xikan'we na swiyenge swa byona leswi hlanganisiweke swa vutumbuluxi bya ntshamiseko, thekinoloji na nhlangano, swi tirhisiwile tanihi lensi ya thiyori eka ndzavisiso lowu.

Swikumiwa swa ndzavisiso swi paluxe leswaku swivangelo swa nkoka na swipimelo eka ku vika mati leswi, loko swo langutisiwa hi vukheta, swi nga ndlandlamuxaka no antswisa swiloswa nkoka kufana na ku vika .Swibumabumelo leswi ringanyetiweke swi tlhela swi amukela van'wamapurasi lava nga si vikaka hi mati hi ku nghenisa swilaveko swa masungulo swa ku vika, loko swiri karhi ri nyika ndlela leyi hlelekeke eka ku vika loku yaka emahlweni swinene hi ku famba ka nkarhi. Swikumiwa swa ndzavisiso swi nga va swa nkoka eka vakhomaxiave vo hlayanyana, ku katsa na van'wamapurasi, vaendli va swakudya, minhlangano leyi nga riki ya mfumo, vurimi lebyi hlelekeke, tiejensi ta mfumo, vini va maxavelo na vavekisi.

Marito ya nkoka: indasitiri ya masi; vachayeri va ku vika vukorhokeri bya mati; vutumbuluxi lebyi hlayisaka mali; swipimelo swa ku vika mati; ku famba ka kulavisisa; nxaxamelo wa nkoka; ku vika mati; ku pfumaleka ka mati.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS III
ABSTRACT IV
OPSOMMING V
NKOMISO VI
LIST OF FIGURES XIII
LIST OF TABLES XIV
LIST OF ABBREVIATIONS AND ACRONYMS XV
CHAPTER 1: INTRODUCTION AND BACKGROUND TO THE STUDY 1
1.1 BACKGROUND 1
1.2 LITERATURE REVIEW 4
1.2.1 Corporate water accounting 4
1.2.2 Supply chain versus value chain 7
1.2.3 Value chain-oriented corporate water accounting and water reporting 8
1.2.4 Sustainable Value Chain Management 10
1.2.5 The dairy industry 11
1.2.6 Theoretical perspective 13
1.3 PROBLEM STATEMENT 16
1.4 RESEARCH OBJECTIVES 17
1.5 RESEARCH QUESTIONS 17
1.6 THESIS STATEMENT 18
1.7 DELINEATION AND LIMITATIONS 18
1.8 DEFINITIONS OF TERMS AND CONCEPTS 18
1.9 UNDERLYING ASSUMPTIONS 19
1.10 RESEARCH METHODOLOGY 19
1.10.1 Research philosophy 20
1.10.2 Research approach 21
1.10.3 Research strategy 22
1.10.4 Research design 22
1.10.5 Data collection 23
1.10.5.1 Population and sample 23
1.10.6 Data analysis 27
1.11 ETHICAL CONSIDERATIONS 27
1.12 SIGNIFICANCE OF THE STUDY 28
1.13 STRUCTURE OF THE THESIS 28

CHAPTER 2: THEMATIC AREAS OF CONSIDERATION IN RELATION TO THE RESEARCH SETTING AND CHOSEN THEORETICAL ORIENTATION 30
2.1 INTRODUCTION 30
2.2 GLOBAL WATER SCARCITY 31
2.2.1 Climate change and water 33
2.2.2 Sustainable development goals and water 35
2.3 SOUTH AFRICA'S WATER SITUATION 36
2.4 DAIRY INDUSTRY'S IMPACT ON WATER SCARCITY 40
2.4.1 Global dairy industry 40
2.4.2 South African dairy industry 43
2.5 FRUGAL INNOVATION THEORY 46
2.5.1 Social innovation 47
2.5.2 Institutional innovation 49
2.5.3 Technological innovation 50
2.6 CORPORATE WATER-RELATED RISKS 51
2.7 CORPORATE WATER STEWARDSHIP 54
2.8 VALUE CHAIN ENGAGEMENT 57
2.8.1 Upstream value chain 58
2.8.2 Downstream value chain 59
2.9 SUSTAINABLE VALUE CHAIN MANAGEMENT (SVCM) 59
2.10 DIGITAL TECHNOLOGIES AND CORPORATE WATER REPORTING 62
2.11 SUMMARY 64
CHAPTER 3: THEMATIC AREAS TO CONSIDER IN THE CONTEXT OF WATER REPORTING AND THE CONCEPTUAL FRAMEWORK 66
3.1 INTRODUCTION 66
3.2 DEVELOPMENTS IN SUSTAINABILITY STANDARD-SETTING BOARDS 67
3.3 INTERNATIONAL INTEGRATED REPORTING COUNCIL 69
3.4 KING REPORTS ON CORPORATE GOVERNANCE IN SOUTH AFRICA 72
3.5 THE GLOBAL REPORTING INITIATIVE 73
3.6 TASK FORCE CLIMATE-RELATED FINANCIAL DISCLOSURES 74
3.7 ENVIRONMENTAL, SOCIAL AND GOVERNANCE REPORTING 75
3.8 GLOBAL CORPORATE WATER TOOLS AND DECISION SUPPORT FRAMEWORKS 78
3.8.1 Tools for assessing organisational risks and opportunities 78
3.8.1.1 Global Environmental Management Initiative water sustainability tools 78
3.8.1.2 World Business Council for Sustainable Development Global Water Tool and India Water Tool 79

3.8.1.3 World Resources Institute's Aqueduct 80
3.8.1.4 Worldwide Fund (WWF) Water Risk Filter (WRF) 81
3.8.2 Water use and impact assessment tools 84
3.8.2.1 Water Footprint Assessment 84
3.8.2.2 Life Cycle Assessment 86
3.8.2.3 International Organisation for Standardisation 87
3.8.3 Water reporting 88
3.8.3.1 United Nations Global Compact – CEO Water Mandate 88
3.8.4 Investor-led water stewardship initiatives 90
3.8.4.1 Carbon Disclosure Project (CDP) - Water Disclosure Project 91
3.8.4.2 Ceres Aqua Gauge™ 91
3.8.5 Water governance 92
3.8.5.1 The Water Governance Indicator Framework of the Organisation for Economic Co-operation and Development 93
3.8.6 Summary of corporate water tools and decision support frameworks 95
3.8.7 Empirical studies on value chain-oriented water reporting frameworks 97
3.9 CONCEPTUAL FRAMEWORK 97
3.10 SUMMARY 99
CHAPTER 4: RESEARCH METHODOLOGY 101
4.1 INTRODUCTION 101
4.2 RESEARCH PHILOSOPHY 101
4.3 RESEARCH APPROACH 104
4.4 RESEARCH STRATEGY 105
4.5 RESEARCH DESIGN 106
4.6 DATA-COLLECTION METHODS 108
4.6.1 Sampling methods 108
4.6.2 Transect walks 109
4.6.3 Semi-structured interviews 110
4.7 DATA-ANALYSIS TECHNIQUES 115
4.7.1 Data management within qualitative data analysis 118
4.7.2 Establishing themes to develop a conceptual framework 120
4.7.3 Triangulation of data sources 123
4.8 ETHICAL CONSIDERATIONS 124
4.9 LIMITATIONS OF THE RESEARCH DESIGN 126
4.10 DEVELOP A CONCEPTUAL FRAMEWORK 127
4.11 SUMMARY 127

CHAPTER 5: PRESENTATION AND INTERPRETATION OF THE RESEARCH FINDINGS 129
5.1 INTRODUCTION 129
5.2 TRANSECT WALKS 130
5.2.1 Settings and observations from the transect walks 131
5.2.1.1 Farm 1 131
5.2.1.2 Farm 2 137
5.3 SEMI-STRUCTURED INTERVIEWS 144
5.3.1 Overview of participants 145
5.4 DATA ANALYSIS DISCUSSION BY THEME – THEME 1: WATER STEWARDSHIP 146
5.4.1 Water conservation and the desire to gain knowledge and innovate 147
5.4.2 Water information and metrics 149
5.4.3 Accuracy of water-related measuring and reporting 151
5.4.4 Water quality 152
5.4.5 Wastewater 153
5.4.6 Water-related areas requiring further attention 154
5.4.7 Value in water reporting 155
5.4.8 Assurance/audit of water information 155
5.4.9 Awareness of water frameworks and tools 156
5.5 THEME 2: DRIVERS AND LIMITATIONS OF WATER REPORTING 156
5.5.1 Drivers of water reporting 156
5.5.1.1 Processors have the power to influence water reporting in the upstream value chain 158
5.5.1.2 Water measurement and reporting provides opportunities for benchmarking and innovation 159
5.5.2 Limitations of water reporting 161
5.6 THEME 3: SYNERGY BETWEEN VALUE CHAIN STAKEHOLDERS 162
5.6.1 Identification of risks and opportunities in the value chain 163
5.6.2 Engagement between value chain members 164
5.6.3 Innovation in the value chain and through engagement with other stakeholders 165
5.6.4 Sustainable Value Chain Management (SVCM) 167
5.6.5 Government systems and interrelationships 168
5.7 DRAFT FRAMEWORK 172
5.7.1 Drivers and limitations of water reporting 174
5.7.2 Water reporting progression 175

5.7.2.1 Basic/current level water reporting 175
5.7.2.2 Intermediate-level water reporting.....176
5.7.2.3 Advanced-level water reporting.....177
5.7.3 Frugal, social, institutional and technological innovation 178
5.8 SUMMARY 179
CHAPTER 6: CONCLUSION, IMPLICATIONS AND OPPORTUNITIES FOR FUTURE RESEARCH 180
6.1 INTRODUCTION 180
6.2 OVERVIEW OF THE LITERATURE AND EMPIRICAL STUDY.....181
6.3 EVALUATION AND RECOMMENDATIONS ON THE FRAMEWORK 184
6.4 CONTRIBUTION TO KNOWLEDGE 189
6.5 RECOMMENDATIONS 191
6.6 IMPLICATIONS FOR FUTURE RESEARCH.....192
6.7 THE LIMITATIONS OF THIS STUDY 192
6.8 CONCLUSION.....193
REFERENCES 195
ANNEXURE A: RESEARCH ETHICS APPROVAL CERTIFICATE FOR PROPOSAL .238
ANNEXURE B: RESEARCH ETHICS APPROVAL CERTIFICATE TO CONDUCT TRANSECT WALKS 239
ANNEXURE C: RESEARCH ETHICS APPROVAL CERTIFICATE TO CONDUCT SEMI-STRUCTURED INTERVIEWS.....242
ANNEXURE D: INTERVIEW SCHEDULE FOR DAIRY FARMERS 244
ANNEXURE E: INTERVIEW SCHEDULE FOR DAIRY PROCESSORS 249
ANNEXURE F: INTERVIEW SCHEDULE FOR ORG AGRI & NGO IN THE SOUTH AFRICAN DAIRY INDUSTRY 255
ANNEXURE G: PERMISSION LETTER TO CONDUCT RESEARCH.....259
ANNEXURE H: PARTICIPANT INFORMATION SHEET.....261
ANNEXURE I: CONFIDENTIALITY AGREEMENT – TRANSCRIPTIONIST.....265
ANNEXURE J: CONFIDENTIALITY AGREEMENT – EXTERNAL INDEPENDENT CODER 266
ANNEXURE K: INTERVIEW SCHEDULE TO VALIDATE FRAMEWORK.....267
ANNEXURE L: LANGUAGE EDITING CERTIFICATE.....268

LIST OF FIGURES

Figure 1.1: Comparison between a value chain and a supply chain 8
Figure 1.2: Goods that drive South Africa's agriculture sector 12
Figure 1.3: Theoretical orientation of the study 14
Figure 1.4: The research onion 20
Figure 1.5: Design science research process for this study 22
Figure 1.6: Graphic depiction of the upstream value chain of the South African dairy industry 26

Figure 2.1: Understanding water-related risks in a farm catchment area 43
Figure 2.2: Number of dairy farmers per province in South Africa as at January 2025 45
Figure 2.3: Social innovation capability and its dimensions 48
Figure 2.4: Types of water risks 52
Figure 2.5: Water stewardship steps 56
Figure 2.6: Process steps of SVCM 60

Figure 3.1: Aligning the SDGs with the value-creation process 70
Figure 3.2: Market actors that should enhance the awareness of ESG elements 76
Figure 3.3: WWF WRF scenario analysis for South Africa, water scarcity for major river basins, based on current trends for 2030 and 2050 82
Figure 3.4: WWF WRF scenario analysis for South Africa, water quality for major river basins, based on trends for 2030 and 2050 83
Figure 3.5: Contribution of the various components to the total dairy water footprint 85
Figure 3.6: CEO Water Mandate Corporate Water Disclosure Framework 89
Figure 3.7: OECD principles on water governance 93
Figure 3.8: Initial framework 98

Figure 4.1: How theory fits into research 105
Figure 4.2: Qualitative data-analysis process 119
Figure 4.3: A streamlined codes-to-theory model for qualitative inquiry 123

Figure 5.1: Aerial view of a portion of Farm 1 131
Figure 5.2: Aerial view of a portion of Farm 2 138
Figure 5.3: Framework for advancing water reporting 173

Figure 6.1: Framework for advancing water reporting in the upstream value chain 188

LIST OF TABLES

Table 1.1: Minimum non-probability sample sizes 24

Table 3.1: S&P ESG sector scores for 2020 77
Table 3.2: WRI Water Aqueduct 3.0 country and province rankings for South Africa's provinces 80
Table 3.3: Summary of corporate water tools and decision support frameworks, and value chain inclusion 95

Table 4.1: Semi-structured interviews conducted 112
Table 4.2: Alignment between interview schedule sections and research objectives 114
Table 4.3: Data analysis of semi-structured interviews using thematic content analysis 116
Table 4.4: Overarching themes, sub-themes and their sources 121
Table 4.5: The four dimensions criteria of trustworthiness 125

Table 5.1: Transect walk of Farm 1 132
Table 5.2: Transect Walk of Farm 2 138
Table 5.3: Participant groups from the upstream value chain in the dairy industry. 146

Table 6.1: Mapping the research objectives to the relevant thesis chapters 181

LIST OF ABBREVIATIONS AND ACRONYMS

ACCA	Association of Chartered Certified Accountants
AMD	acid mine drainage
AWS	Alliance for Water Stewardship
CDP	Carbon Disclosure Project
CDSB	Climate Disclosure Standards Board
CEO	Chief Executive Officer
CERES	Coalition for Environmentally Responsible Economies
CFO	Chief Financial Officer
CIMA	Chartered Institute of Management Accountants
CMA	Catchment Management Agency
COO	Chief Operating Officer
COP	Conference of the Parties
CSR	corporate social responsibility
CWR	corporate water reporting
DAFF	Department of Agriculture, Forestry & Fisheries
Dairy NZ	Dairy New Zealand
DALRRD	Department of Agriculture, Land Reform & Rural Development
DSA	Dairy Standards Agency
DSR	Design Science Research
DWS	Department of Water and Sanitation
EPA	Environmental Protection Agency (US)
ESG	environmental, social and governance (strategies)
EU	European Union
EIC	external independent coder
FAO	Food and Agriculture Organisation

FDC	Four-Dimensions Criteria
FI	Frugal innovation
FMCGs	fast-moving consumer goods
FOEN	Federal Office for the Environment
FRC	Financial Reporting Council
FSB	Financial Stability Board
GCEW	Global Commission on the Economics of Water
GCI	Global Change Institute
GDP	Global Dairy Platform
GEMI	Global Environmental Management Initiative
GHG	greenhouse gas
GIS	geographical information system
GPS	global positioning system
GRI	Global Reporting Initiative
GSIA	Global Sustainable Investment Alliance
GSSB	Global Sustainability Standards Board
GWC	Green Water Credit
GWT	Global Water Tool
IAPs	invasive alien plants
IDF	International Dairy Federation
IET	independent external transcriber
IFRS	International Financial Reporting Standards
IIRC	International Integrated Reporting Council
IIRF	International Integrated Reporting Framework
IoDSA	Institute of Directors South Africa
IOSCO	International Organisation of Securities Commission
IoT	Internet of Things

IPCC	Intergovernmental Panel on Climate Change
<IR>	International Integrated Reporting
IRF	Integrated Reporting Framework
ISO	International Organisation for Standardisation
ISRIC	International Soil Reference and Information Centre
ISSB	International Sustainability Standards Board
IT	information technology
IWT	India Water Tool
JSE	Johannesburg Stock Exchange
KPI	key performance indicator
KPMG	Kleinfeld Peat Marwick Goerdeler
LCA	Life Cycle Assessment
LEPA	Low Energy Precision Application
LWT	Local Water Tool
Milk SA	Milk South Africa
MPO	Milk Producers Organisation
NFC	near-field communication
NGO	non-governmental organisation
NPV	net present value
NWA	National Water Act
OECD	Organisation for Economic Co-operation and Development
OrgAgri	Organised Agricultural Organisation
PWC	Price Waterhouse Coopers
RFID	radio-frequency identification
RSA	Republic of South Africa
S&P	Standard and Poor
SAI	Sustainable Agriculture Initiative

SAMPRO	South African Milk Processors Organisation
SASB	Sustainability Accounting Standards Board
SASDT	South African Society of Dairy Technology
SBTNs	Science-Based Targets Networks
SDG	sustainable development goal
SI	social innovation
SOP	standard operating procedure
SRS	Sustainability Reporting Standard
Stats SA	Statistics South Africa
SVCM	Sustainable Value Chain Management
SWAN	soil, water, atmosphere and nutrients
SWPN	Strategic Water Partners Network
TCFD	Task Force on Climate-Related Financial Disclosures
TI	technology innovation
TRWG	Technical Readiness Working Group
TWP	Troubled Waters Partnership
UCT	University of Cape Town
UK	United Kingdom
UN	United Nations
UNGC	United Nations Global Compact
Unicef	United Nations Children’s Fund
USDA	United States Department of Agriculture
UWaSP	uMhlathuze Water Stewardship Partnership
VNR	Voluntary National Report
VPF	Value Reporting Foundation
VRF	Value Reporting Framework
WAS	Water Administration System

WAVE	Water and ValuE (tool)
WBCSD	World Business Council for Sustainable Development
WEF	World Economic Forum
WF	water footprint
WFA	Water Footprint Assessment
WFN	Water Footprint Network
WHO	World Health Organization
Wits	University of the Witwatersrand
WRC	Water Resource Commission
WRF	Water Risk Filter
WRI	World Resources Institute
WTWs	water treatment works
WUAs	water user associations
WWF	World Wide Fund for Nature
WWF-SA	World Wide Fund for Nature – South Africa
WWTWs	wastewater treatment works

CHAPTER 1: INTRODUCTION AND BACKGROUND TO THE STUDY

"If there is magic on this planet, it is contained in water" (Eiseley 1957:15)

1.1 BACKGROUND

"If climate change is a shark, then water would be its teeth" – this is a good illustration, coined by James Bruce, of how the impact of climate change will predominantly be directed towards the water cycle (World Bank 2016:vi). On top of an ever-growing demand for water, climate change will increase water-related shocks. Rainfall is expected to become more unpredictable and, at the same time, warmer seas will induce more violent floods and storms (World Bank 2016:vi). The Carbon Disclosure Project (CDP) reports that, for more than a decade, water has been at the forefront of the environmental crisis due to increasing demand, worsening pollution, and poor governance of water sources by both the public and private sectors (CDP Global Water Report 2019:2). Globally, 80 per cent of wastewater is discharged and untreated, which ignores the fact that three out of every four jobs worldwide are reliant on a secure supply of water (CDP Global Water Report 2019:2). A global water deficit of 40 per cent is predicted by 2030 (Global Commission on the Economics of Water [GCEW] 2023:10). South Africa is a water-scarce country, and this realisation was brought to the world's attention in early 2018 when the term "Day Zero" was coined at a time when the city of Cape Town's taps almost ran dry (Millington & Scheba 2020:116).

Industries and people will always require a certain quantity of water to survive and thrive (CDP Global Water Report 2018:13). Not only does the planet have to be a life-support system for its human population, it also needs to support the whole industrial process, which requires inputs from natural resources that produce outputs that must divert back into the environment (Beder 2006:22). Water, as a natural resource, is critical for food production (World Bank 2016:vi). The demand for food is expected to increase by 50–60 per cent by 2050, due to population growth and changes in dietary habits (Frona, Szendaráket & Harangi-Rákos 2019:12; Falcon et al 2022:921). In the South African context, the World Health Organisation (WHO) projects that the population will grow to approximately 79.2 million by 2050 (WHO 2024:2). Population growth means that food production and/or imports must substantially increase, while using as many (or fewer) natural resources (Goldblatt 2010:3).

In terms of water resourcing, the agriculture sector is a major role player. As the sector expands, so it places increasing pressure on water resources, given that it consumes more water than any other industry and is simultaneously the most common cause of global water pollution due to the run-off of fertilisers and pesticides from fields (Roberts & Barton 2015:7; Jia, Hubbard, Zhang & Chen 2019:1170). In the agriculture sector, dairy farming is considered water intensive since it not only uses water for animals to drink and for cleaning purposes, it is also embedded in the production of animal feed (Hawkins & Stanway 2013:2; Thakur et al 2018:2). The more than six billion people who consumed dairy products worldwide in the period 2005–2015 prompted an increase of 30 per cent in global milk production (World Wide Fund for Nature [WWF] 2019:online). In 2024, global milk production reached 982 million tonnes, which constituted a 1.4 per cent increase from 2023 (Food and Agriculture Organisation [FAO] of the United Nations 2025:2).

As the need for dairy products increases, so does its effect on the environment. Dairy production contributes negatively to climate change, since dairy cows emit vast quantities of greenhouse gases which are released into the atmosphere (WWF 2019:online). Greenhouse gases have a warming effect on the planet, causing climate change which, in turn, is proven to increase droughts and floods (Adzawla, Sawaneh & Yusuf 2019:2). In addition, more than two-thirds of the globe's agricultural land is used to sustain livestock (which includes dairy cows) – an acknowledged cause of soil erosion (WWF 2019:online). This is significant, since healthy soil captures and stores more water (Nichols 2017:online). Adverse weather conditions due to climate change have also been a significant contributor to the 67 per cent decrease in South African dairy farming enterprises reported from 2011 to early 2025 (Milk Producers Organisation [MPO] 2020:24; 2025:4). These statistics indicate that the number of South African dairy farmers has declined from 2 686 to 885 during the same period (MPO 2025:4). Based on the information presented, the environmental footprint of the dairy sector is substantial, especially when it comes to water usage, and for that reason has been chosen as the focus of the present study. Although dairy farmers can also be referred to as milk producers, in this study the term "dairy farmer" is used.

William Thomson famously said: "If you can't measure it, you can't improve it" (Kuhle 2016:1325) – a dictum which may be applied to the management of water resources in organisations. The CDP Global Water Report (2018:6) mentions that investors rely on corporate reporting to adequately assess whether organisations are managing their water-

related risks effectively. Over the years, several reporting frameworks have been developed which can assist with the management of scarce resources and the disclosure of related information to stakeholders. The Global Reporting Initiative (GRI), International Integrated Reporting <IR> Framework, Sustainability Accounting Standards Board (SASB), CDP and the Task Force on Climate-Related Financial Disclosures (TCFD) are the dominant reporting frameworks which aim to guide organisations on how to measure, manage and report on their environmental, social and governance (ESG) strategies (Nordea 2020:online). There is increasing evidence that organisations that take their ESG duties seriously, report higher profits (Ademi & Klungseth 2022:421). This has obviously been brought to investors' attention, motivating them to exert pressure on organisations to improve their ESG initiatives, lest investors move their investments elsewhere (Keddie 2021:online). ESG issues are becoming financially material, with greater figures at play and being required at speed (World Economic Forum [WEF] 2020:5). Despite several reporting initiatives, the CDP Global Supply Chain Report (2020:22) states the following regarding water reporting in the value chain: "Trickling improvements [have been made] but a wave of change is needed throughout the value chain to build a safe water-secure future." To the researcher's knowledge, no water reporting framework exists that has been specifically designed exclusively for the value chain.

An organisation's maturity in respect of water management is apparent in the quality and scope of its water disclosures, with the scope not only needing to include its own operations, but also those of its value chain (Morrison et al 2014:14). Linneman, Hoekstra and Berkhout (2015:4342) agree that since the problem of water scarcity is a complex issue, it requires organisations to go beyond their own operations, in order to consider water management in their value chain. The CDP Global Supply Chain report of 2020 echoes this, stating that for organisations to better understand the environmental impact of their economic activities, they are duty bound to engage with their entire value chain (CDP Global Supply Chain Report 2020:4). The report warns that organisations' value chain environmental practices are coming under increasing scrutiny (CDP Global Supply Chain Report 2020:4). As Christ and Burritt (2017a:237) found, many organisations' water accounting and water reporting in their value chains tend to remain a "black box" (i.e., an unknown, complex system).

The majority of organisations' value chains can be separated into either up- or downstream value chains (Chaffey 2002:335). Whereas the upstream value chain deals with the buying side (from suppliers, i.e., materials entering the organisation), the downstream value chain

deals with sales (to the customer, i.e., mainly finished goods exiting the organisation) (Chaffey 2002:335). This research will concentrate on a water reporting framework which is tailored for the upstream dairy sector, which encompasses the milk processors and their upstream value chain, which includes their associated dairy farmers.

Frugal innovation (FI) theory served as the lens through which this study was conducted. Here, “frugal” refers to “the art of overcoming harsh constraints by improvising an effective solution using limited resources”, according to Prabhu and Jain (2015:847), while “innovation” implies that a whole gamut of novel technological and other means or methods can be used to achieve this. Water is considered a limited resource globally – and especially in South Africa. As it is a critical resource in the production of milk, that further motivated the use of frugal innovation theory for the purposes of this study.

In the next section the literature review lays the foundation for the topics to be discussed, the gaps identified in the literature, and the problem this study sets out to solve with the assistance of the research objectives and research methods.

1.2 LITERATURE REVIEW

Corporate water accounting and value chain-oriented corporate water reporting will be discussed, to establish their importance in the management of water. The difference between the terms “value chain” and “supply chain” are explained, as are the reasons for selecting the dairy industry within the South African context as the unit of analysis for this study. Finally, the theoretical lens used throughout this study is introduced, as is the conceptual framework.

1.2.1 Corporate water accounting

Organisations are more cognisant of the fact that if they do not have access to the requisite quantities of water, of a sufficiently high quality, their operations could be suspended or even closed down, resulting in a substantial loss of revenue (CDP Global Water Report 2014:8). The incremental changes that some organisations are undertaking as regards water management are unlikely to have much of an impact, considering the vast scale of the water-related challenges facing the world today (CDP Global Water Report 2018:13). Providing a future that is water secure not only requires improved water management, but also (more

importantly) improved business management (CDP Global Water Report 2018:13; Sojamo & Rudebeck 2024:314). There is a growing need for organisations and value chain stakeholders to be more transparent and accountable about their water management, which is enhanced through corporate water accounting, “an umbrella term for the practice by which organisations can quantify and account for their water use” (Christ & Burritt 2017a:217). In the 2000s, demands on the part of businesses for improved water management led to a new discipline that has evolved into what is known as corporate water accounting (Christ & Burritt 2017a:217).

Corporate water accounting can be defined as a process that allows organisations to measure and manage their water consumption, wastewater discharge and the impacts thereof on both the environment and their suppliers (Morrison, Schulte & Schenck 2010:14). Corporate water accounting allows organisations to strategically plan, analyse their management practices, track their performance and provide external stakeholders with information to assist them with decision-making (Morrison et al 2010:14). Christ and Burritt (2017c:144) emphasise the importance of corporate water accounting in guiding organisations to manage periods of water scarcity. However, Morrison et al (2010:36) warn that gathering and distributing meaningful water-related information is both a complex and a challenging task. Furthermore, for any sustainability reporting to give rise to better decision-making it should become mandatory, while at present it remains mostly a voluntary practice (Segal 2020:online). Notably, since 2010 it has been mandatory in South Africa for all organisations listed on the Johannesburg Stock Exchange (JSE) to submit an integrated report (Association of Chartered Certified Accountants [ACCA] 2012:3), albeit with certain limitations, such as the fact that numerous companies offer only limited information on specific elements of water sustainability (Osman 2021:77). As a result, some organisations and non-governmental organisations (NGOs) have developed a range of guidelines to help entities with water reporting (Meurer & Van Bellen 2024:7). These guidelines are discussed below.

Various frameworks and methodologies, referred to as “tools”, have been developed over the past ten years to help organisations, financial institutions and investors understand and react to water challenges and risks, and to support their water accounting and reporting efforts (Morgan, Laporte-Bisquit, Williams & Maggo 2020:4). Christ and Burritt (2017a:222-225) discuss 11 water tools which facilitate the water accounting process, all of which include the

value chain in their focus. Morgan et al (2020:4) caution, however, that while these various tools have assisted in many ways, they have also caused confusion due to overlaps and discrepancies between them, and their definition of water risk assessment. According to Morgan et al (2020:4), the three leading water tools are the World Business Council for Sustainable Development (WBCSD) Global Water Tool (now known as the WBCSD India Water Tool); the World Resources Institute (WRI) Aqueduct; and the WWF Water Risk Filter. As Morgan et al (2020:8) point out, water risks in the value chain can be assessed at either the site level, the portfolio level (number of sites) or across the entire value chain (corporate level), yet the three leading water tools are unable to cover a full value chain in their structure. Although Morgan et al (2020:8) claim not to be aware of an existing water tool that can be used to conduct a full value chain evaluation, in their view some water footprinting tools might be capable of undertaking such an assessment. For the purposes of this study, a water footprint is taken to be a calculation of the volume of freshwater used to produce a product, measured over the entire value chain (Hoekstra, Chapagain, Aldaya & Mekonnen 2011:2).

Several scholars have reported a lack of harmonisation in the methods organisations use to measure and report on water-related issues and their impacts (Morrison et al 2010:7; Hewawithana, Hazelton, Walkerden & Tello 2021:337; Mesa-Pérez et al 2025:3). Chapagain and Tickner (2012:575) as well as Daniel and Sojamo (2012:652) note that most reporting tools and initiatives are created as independent devices, and plagued by inconsistent features and functions that are in competition with one another. As Christ and Burritt (2017b:379) point out, there is no widely applied framework through which corporate water accounting can be evaluated. Furthermore, despite growing academic attention, corporate water accounting remains in its early stages (Panero, De Bernardi, Marcacci & Bresciani 2025:39). Vardon, Lien, Martinez-Lagunes, Pule and Schenau et al (2023:3) note that water management and governance require a variety of information, which is frequently insufficient or of low quality due to a number of factors: (1) different agencies are custodians of the environmental data pertaining to water; (2) different professions have developed their own theories, practices and terminology; and (3) limited resources are available for data collection, curation and integration.

The value chain component of corporate water accounting was lagging, which is often due (in part) to the difficulty of collecting and managing data from countless suppliers (Morrison et al 2010:7). The inclusion of water accounting in an organisation’s value chain is an area

that has drawn a great deal of attention and interest and, therefore, requires greater scrutiny (Morikawa, Morrison & Gleick 2007:1). Additionally, there is a significant gap in the research regarding value chain sustainability, as the entire value chain is exposed to operational and contextual risks stemming from water scarcity, yet despite this, water is not a significant area of research in value chain management (Cole, Narayanan, Connors, Tewari & Onda 2022:1597, 1599).

The review of the literature revealed that although there are several water tools and initiatives to assist organisations with water risk assessments in both direct operations and their value chains, there is still a lack of value chain engagement and value chain-oriented corporate water reporting.

1.2.2 Supply chain versus value chain

The terms “supply chain” and “value chain” do not denote the same thing. Reddy (2013:4) and Hoeyi (2023:471) point out that it is important to differentiate between these concepts, despite the general inclination to use the terms interchangeably. The concept of a supply chain was developed first, referring to all activities that source raw materials and subassemblies into a production operation in a smooth and economical manner. Reddy (2013:4) and Linkov et al (2020:1464) note that a value chain focuses on activities that add value at every step of a process – from the raw materials to the end user, and including disposing of the product and its packaging after use. In each stage of the value chain, various stakeholders add value to improve the overall value of the end product. As Feller, Shunk and Callarman (2006:4) mention, supply chains predominantly focus on reducing costs, while value chains are more focused on product innovation. Reddy (2013:4) goes a step further by stating that the objective of a value chain is to deliver maximum value to the final user at the lowest possible cost, which makes a supply chain a subsection of a value chain.

Michael Porter first introduced the concept of a value chain in 1985, in his book *Competitive Advantage* (Porter 1985). In his opinion, a value chain encompasses a combination of value-adding activities (e.g., in- and outbound logistics, marketing, and sales and service) operating within an organisation to provide value to the customer (Feller et al 2006:5). Figure 1.1 is a graphic representation of the comparison between a value chain and a supply chain. With the value chain, organisations need to develop an awareness of, and appreciation for,

customer needs and values, in addition to organising the organisation's activities to successfully meet these needs as quickly and appropriately as possible, at the lowest cost (Feller et al 2006:2). This confirms the appropriateness of Frugal Innovation as a suitable theoretical lens to frame the current research study.

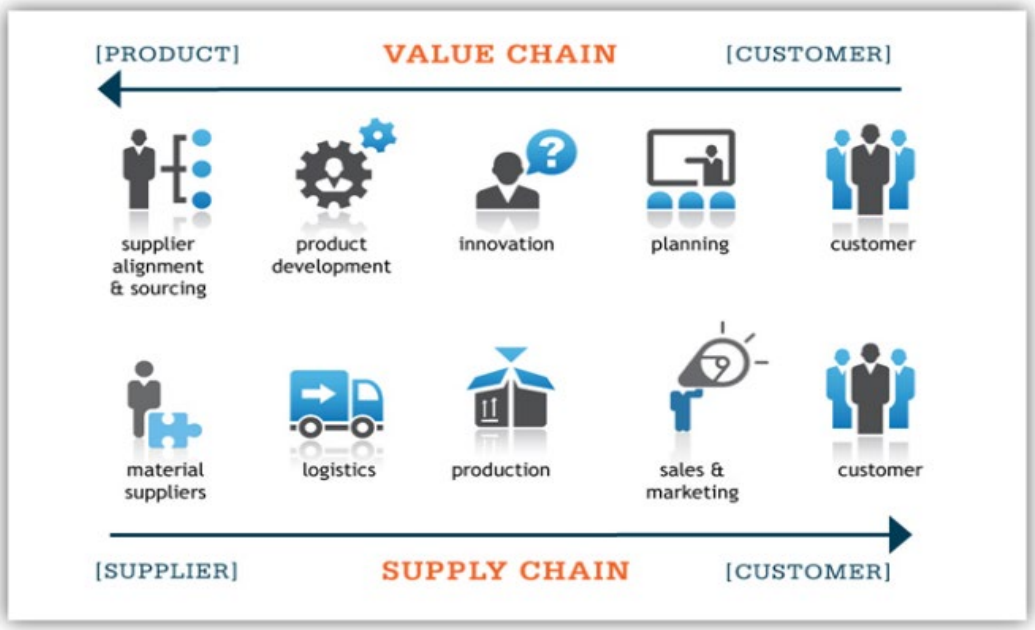


Figure 1.1: Comparison between a value chain and a supply chain

Source: Feller et al (2006:2)

As this study's main aim was to increase value throughout the South African dairy industry's upstream value chain by enhancing water reporting therein, the term "value chain" will be used as far as possible. However, in instances where the word "supply chain" is applicable as an industry-wide term, it will be used.

1.2.3 Value chain-oriented corporate water accounting and water reporting

A focus on water-related issues in an organisation's direct operations was once considered the only or main priority, yet attention is now shifting towards the entire value chain. Barton (2010:19) warns that, for many large organisations water use is embedded in their value chains, which accounts for a significant proportion of their water footprint. The CDP Supply Chain report (2015:9) confirms that water use, water-related risks and impacts are accounted for in the value chains of most organisations. The report (CDP Supply Chain 2015:9) continues by providing examples of the global shoe and apparel company, Nike, with its direct facilities only accounting for six per cent of its water footprint, while 73 per cent is associated

with its production of raw materials. Molson Coors, the world's fifth-largest brewer, reported that 98 per cent of its water footprint is embedded in its value chain (CDP Supply Chain Report 2015:9). Importantly, organisations predominantly report on their own water use at the company level, thus neglecting to address the effects in their value chains (Bateman, Blanco & Sheffi 2017:120). Botha, Middelberg and Oberholzer (2022a:393) found that, on average, organisation's disclosures regarding their value chain's water practices remain largely deficient. Ceres and Sustainalytics (2014:45) recognise that it is exceptionally difficult to gather water-related information from suppliers, as the majority do not monitor their own water use and lack the motivation to do so, since water is free in many parts of the world. As Marshall et al (2016:2) observe, the absence of a standardised reporting approach, vaguely defined standards, the unavailability of a common technology platform and a lack of supplier education, can also discourage organisations from improving transparency in their respective value chains.

Research conducted by Christ and Burritt (2017a:219) found that one critical issue which is consistent across the literature on corporate water accounting, is the demand to examine water use and concomitant impacts in the value chain. As Burritt and Schaltegger (2014:339) claimed more than a decade ago, the value chain was a "new entity for accounting", requiring a shift from limited accounting for just the principal organisation, to broader measurement and disclosure. Their recommendation was that the trending topics of water measurement and disclosure in the value chain be afforded further research (Burritt & Schaltegger 2014:339).

The GRI's updated standard, GRI 303: Water and Effluents, prescribes that organisations report on water impacts in their value chains (GRI 2018:6), thereby signifying the increased importance of this undertaking. According to Intel Corporation (cited in the CDP Global Supply Chain Report 2018:27), disclosure and transparency are vital for attaining successful water strategies, which is why the public disclosure of suppliers' water-related information is encouraged. To that end, Christ and Burritt (2017a:237) observe that several corporate water accounting tools and initiatives have been developed to assist with water-related disclosure, which include the value chain in their focus.

The CDP Global Water Report (2019:34) states that only 30.5 per cent of its respondents actively engaged with their value chains on water issues, which is an almost ten per cent

decrease on the 2018 figure, which reported that 40 per cent of respondents did so. A subsequent CDP Global Water Report (2023:26) noted that a total of 72 per cent of respondents were engaging with their value chains – a significant improvement on the 2019 figure. Despite this, a number of studies still found that water and value chain management are lacking (Barton 2010:9–10; Money 2014:55; Askham & van der Poll 2017:12; Bateman et al 2017:126; Topp-Becker & Ellis 2017:26; Askham 2019:120). This study sought to develop a framework with the aim of improving water reporting in the upstream value chain of the South African dairy industry.

1.2.4 Sustainable Value Chain Management

Value chains incorporate all the steps associated with turning raw materials into a final product, prior to delivering it to the customer. As mentioned, the stages in the value chain are normally divided between up- and downstream operations. Reducing costs and improving service, with very little concern for the environment, was how value chains were traditionally managed (Sarkis, Zhu & Lai 2011:2). As Sarkis and Dou (2018:6) explain, the traditional description of value chain management implied a linear relationship that flowed up and down the value chain, but their recommendation is that a value chain become nonlinear and more circular, to better integrate sustainability-related and environmental issues. Pagell and Shevchenko (2014:4) argue that even though the topic of sustainability has moved from the fringes of value chain management to an over-researched topic over the past two decades, the question of how to truly create a sustainable value chain – especially taking water-related issues into account – remains unanswered. Cole et al (2022:1597) conducted a systematic literature review of water stress from a value chain perspective, synthesising over two decades of research and concluding that the entire value chain is vulnerable to operational and contextual risks arising from water stress, yet the field of value chain management still lacks a substantial research stream on water. Pagell and Wu (2009:38) define a truly sustainable value chain as follows:

> [It] would at worst do no net harm to natural or social systems while still producing a profit over an extended period of time; a truly sustainable value chain could, customers willing, continue to do business forever.

To guarantee its sustainability, traceability is required to ensure good practice and consideration for people, animals and the environment, all along a value chain. It is a complex issue for organisations to trace the journey of a product each step of the way, requiring the engagement of, and collaboration with, different systems and actors. However, advances in technologies are making transparency and traceability more manageable (United Nations Global Compact [UNGC] 2014:8). Sustainability in value chains is more important in certain industries, such as the food and beverage sector, because of the distinct qualities and perishability of the products used (Shakuri & Barzinpour 2024:5). The dairy industry is one such sector, as milk is produced daily and is a highly perishable commodity (Francesconi, Heerink & D'Haese 2009:60).

1.2.5 The dairy industry

Since farmers work in nature every day, nurturing and growing crops and livestock, they are among the most important guardians of our planet's natural resources. It is therefore key to work in partnership with farmers to find solutions to urgent environmental issues, such as climate change and water scarcity (Vijn 2020:1). As the worldwide demand for proteins such as dairy increases, it is becoming increasingly important for dairy farmers to incorporate and maintain best (management) practices, inter alia by maintaining healthy soils, helping to regulate our climate, storing carbon and reducing water use and run-off (Vijn 2020:1). The Organisation for Economic Co-operation and Development/Food and Agriculture Organisation (OECD-FAO) Agricultural Outlook 2025-2034 predicts that global agricultural production will increase by 14% over the next decade, reinforcing the urgency for farmers to adopt environmentally responsible practices (OECD & FAO 2025:13).

According to the FAO of the United Nations (2016:1), one of the agricultural commodities which is most produced and valued globally, is milk. The world-wide dairy industry consists of 116 million dairy farms (MPO 2024:14), which contribute to the livelihoods of an estimated one billion people (UN 2016:1). The South African dairy industry has 885 commercial dairy farmers (MPO 2025:4) who employ approximately 60 000 farm workers, and maintain another 40 000 indirect jobs in the dairy value chain (United States Department of Agriculture [USDA] 2025:4). In 2019, South Africa's gross domestic product was R5.1 trillion in nominal terms, with nominal dairy retail sales valued at R50 billion, equating to a contribution of one per cent of the total (Van Heerden 2020:email). Milk production ranks as South Africa's fourth largest

agricultural sector. The milk and dairy industry make significant contributions to the South African economy through food security and dairy product exports (Department of Agriculture, Land Reform & Rural Development [DALRRD] 2023:3). Figure 1.2 depicts the goods that drive South Africa's agriculture sector.

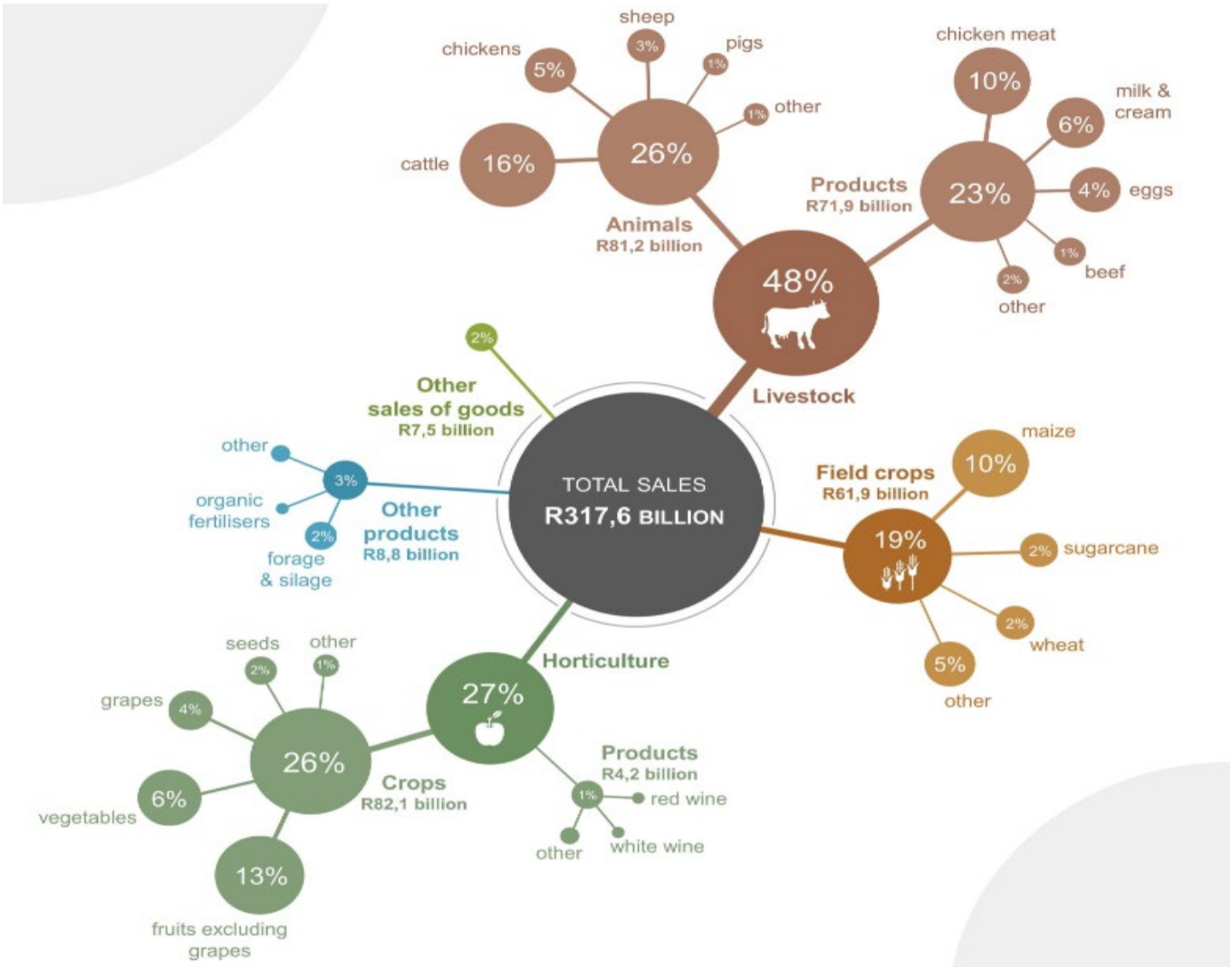


Figure 1.2: Goods that drive South Africa's agriculture sector

Source: Statistics South Africa (Stats SA 2021: online)

As shown in figure 1.2, in 2019 the sales of milk and cream accounted for six per cent of the total agricultural sales of R317.6 billion. Globally, and locally, the dairy industry is an important contributor to the economy and a creator of employment. As mentioned, the dairy industry uses significant quantities of water (FAO 2016:3): Hoekstra (2012:5) states that the global average water footprint for one litre of milk is 1 020 litres of water. The mere fact that the dairy industry is so water intensive, justifies further research into this sector. The complexity

of water-related reporting, especially in the dairy industry's value chain, necessitates that an appropriate theoretical perspective frames the study.

1.2.6 Theoretical perspective

The creation of knowledge, which is a key research objective, occurs predominantly by constructing new theories or expanding on existing theories (Handfield & Melnyk 1998:321). Two of the most valued theories in social accounting studies are stakeholder and legitimacy theory (Gray, Owen & Adams 2010:25). In Touboulic and Walker's (2015:26) study of the theories used in sustainable value chain management from 1995–2013, they found that theories imported from other disciplines – such as the stakeholder, institutional, transaction cost and resource-based view theories – were most popular in sustainable value chain management research. Notably, Clayton and Radcliffe (1996:12) promote a systems approach to sustainability studies, as it allows for the adoption of a framework that is multi-dimensional, meaning information from various disciplines can be integrated into it. A systems approach is another lens through which the present study could be viewed. However, since none of the aforementioned theoretical frameworks specifically consider resource scarcity, another theoretical lens was required.

Natural resource scarcity, and water scarcity in particular, is influenced by several interrelated components, namely the environment, technology, social issues, policies and regulations, and the economy (Yatskovskaya, Srai & Kumar 2018:1). All of these factors, combined with changing levels of water availability, make water scarcity a complex problem calling for a more innovative theoretical perspective (Yatskovskaya et al 2018:1). To solve modern-day complex issues, Kantola et al (2017:S1) advocate the use of effective innovative solutions, for which Bhatti, Basu, Barron and Ventresca (2018:xxi) suggest frugal innovation as an appropriate approach for studying these phenomena. Frugal innovation is categorised as a "resource-scarce solution" (Hossain, Simula & Halme 2016:133), since it promotes the ability to "do more with less" (Radjou & Prabhu 2014:xv). It requires a mindset change, where resource constraints are not viewed as barriers but as opportunities, and values agility over efficiency (Radjou & Prabhu 2014:xvii). This might require products and services to be redesigned and value chains to be reconfigured, to create value (Bhatti et al 2018:68).

Figure 1.3 depicts the proposed conceptual framework for the current study. One of the suggested key prerequisites for a doctoral candidate is that s/he engage with a conceptual framework in their study (Leshem & Trafford 2007:103), as it can offer an overview of the theory applicable to the intended research, and bring order to the process (Leshem & Trafford 2007:96).

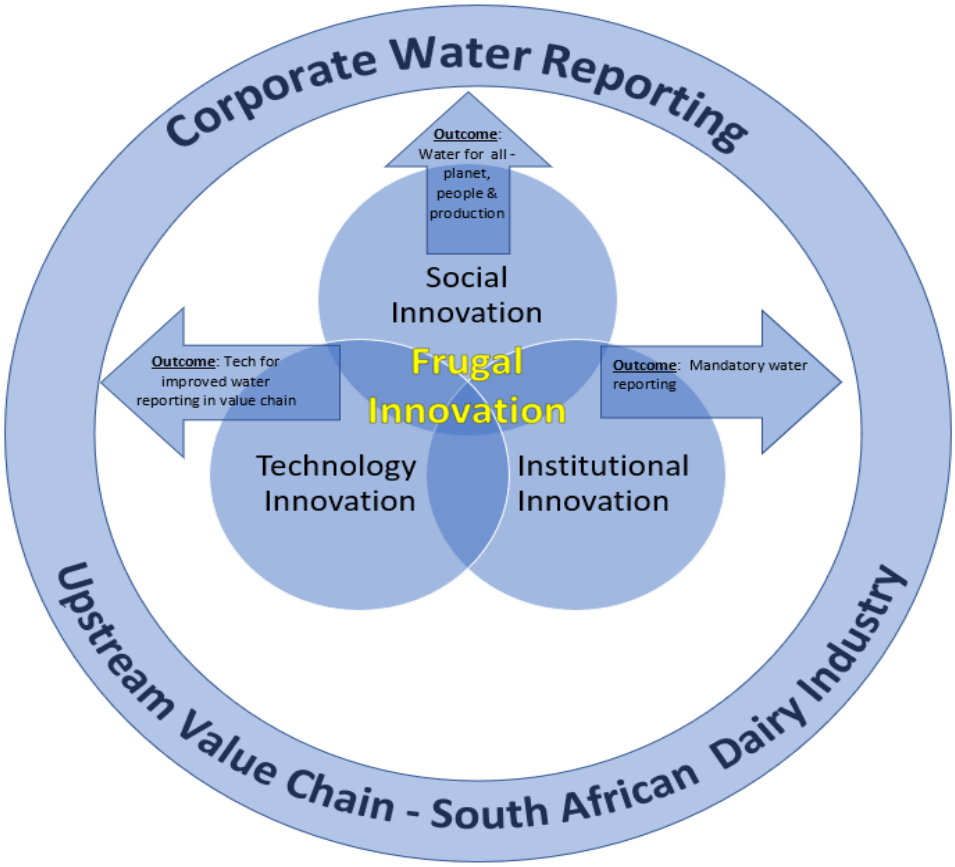


Figure 1.3: Theoretical orientation of the study

Source: Adapted from Bhatti et al (2018:109)

In figure 1.3, the researcher adapted the Bhatti et al (2018:109) framework by removing the examples contained in the original and relating them to the envisaged outcomes of this study. Frugal innovation requires a combination of institutional, social and technological innovations (see figure 1.3) in an effort to address resource constraints (Bhatti et al 2018:109). In this case, social innovation refers to the creation and implementation of new solutions aimed at improving the wellbeing of individuals and communities alike (Organisation for Economic Co-operation and Development [OECD] n.d.:online). Sustainable Development Goal (SDG) six (UN 2016:online) describes the human right to water and sanitation – a goal which is

fundamental to the achievement of all other human rights. In fact, water is the “common currency” which connects many of the SDGs (World Bank 2016:vi).

Information technology (IT) is imperative for effective value chain management (Deloitte 2017:4). Rotz, Gravely, Mosby, Duncan and Finnis et al (2019:112) mention that, in agricultural food industries, digital technologies are being advanced by decision makers as the answer to growing social and environmental crises. If digital technologies such as global positioning systems (GPSs) and sensors are combined with automated technologies, for example, in smart tractors, drones and robots, these would assist farmers on a wider scale to be more accurate with their inputs when it comes to seeds, water, fertilisers and pesticides (Wolfert, Ge, Verdouw & Bogaardt 2017:74). Digital technologies such as Blockchain, the Internet of Things (IoT) and cloud computing all assist with decision making and traceability in value chains (Deloitte 2017:3). It is thus envisaged that digital technologies could assist with the collection of water-related information in the value chain, which will be further investigated in this study. Institutional innovation enables organisations to redesign themselves along with their products, services, business models and management systems (Hagel & Brown 2013:2). None of these types of innovations – social, technological or institutional – can be used separately to deal with the challenges of resource scarcity, meaning a combined approach to sustainability is needed, with frugal innovation, to show how these three innovations intersect.

In summary, from the literature the identified contextual gap revealed a lack of corporate water reporting across various value chains (Christ & Burritt 2017a:231). From a theoretical perspective it was found that the application of frugal innovation in the agriculture sector has remained largely ignored, and has primarily been based on the monetary resource constraints of low-income customers, rather than natural resource constraints such as water scarcity (Hossain 2017:199-205). The problem to be investigated in this study, is discussed below.

1.3 PROBLEM STATEMENT

The planet has reached (or is very close to reaching) its maximum limits of water use (GCEW 2023:10). Various factors have influenced the challenges of water scarcity, including increases in population numbers, economic advances, urban growth and climate change (GCEW 2023:21). Compounding an already precarious situation, climate change is contributing to altered rainfall patterns and creating distressed and fragile ecosystems, due to increasingly severe droughts and floods (CDP Global Water Report 2019:2). South Africa's water crisis has been exacerbated by stronger demand from a growing population, failing water infrastructure, a lack of maintenance and investment, corruption in the sector, a shortage of experienced water engineers, declining water quality, and unequal disparities in access to water and sanitation (Department of Water and Sanitation [DWS] 2018:2; DWS 2023a:1).

As a result of agricultural industries consuming vast quantities of water, consumers, investors, environmental groups and government have issued calls for the sector to extend its knowledge of water use and practices beyond the factory/farm gates, by including value chains (Kayatz, Baroni, Hillier, Ludtke & Heathcote et al 2019:1163). Global food chains are becoming increasingly complex and interconnected, meaning the impacts of water supply are felt far away from where the consumption of the food takes place (Ridoutt, Juliano, Sanguansri & Sellahewa 2010:1720).

The problem is, therefore, that despite water becoming increasingly scarce and critical as an input in the agriculture sector, agricultural food producers have been slow to undertake value chain-oriented corporate water reporting, or have failed to report on it. This is also true for dairy farmers, whose enterprises are regarded as significant consumers of water. Since corporate water reporting is vital for assessing whether organisations are adequately managing their water risk, several reporting frameworks have been made available to assist with this. Notably, they are not designed exclusively for the value chain, and any issues relating to the water in the value chain are normally deemed a supplementary activity, rather than an essential part of the reporting framework. In addition, existing frameworks are not industry specific, but rather generic in nature. Hence, there is no niche framework for specifically addressing corporate water reporting in the value chain of the dairy industry. Given contextual challenges such as resource scarcity and operational constraints,

innovation is required. Since agriculture (and, in particular, the dairy industry) is heavily impacted by resource constraints and water limitations, this study adopted frugal innovation for its theoretical lens, so as to explore the problem in greater depth.

1.4 RESEARCH OBJECTIVES

The main objective of this study was to develop and evaluate a water reporting framework for the upstream dairy industry, informed by frugal innovation principles and constructed through the triangulation of literature, transect walks and semi-structured interviews. To achieve the main objective, the following secondary objectives were identified, namely to:

1. explore existing corporate water reporting frameworks, with a specific view to identifying niche areas and gaps for water reporting within the upstream dairy value chain.
2. identify, through literature, transect walks and semi-structured interviews, the key drivers and limitations associated with water reporting in the upstream dairy value chain.
3. identify existing and future elements of frugal innovation in water management within the upstream dairy value chain in South Africa and assess how these elements may support water reporting.
4. integrate and triangulate findings from the literature, transect walks and semi-structured interviews to develop and evaluate the relevance and applicability of a water reporting framework for the upstream dairy industry.

1.5 RESEARCH QUESTIONS

To address the main objective of this study, the following research questions were formulated:

1. What insights can be gained from existing corporate water reporting frameworks regarding niche areas and gaps for water reporting within the upstream dairy value chain?
2. What are the key drivers and limitations associated with water reporting in the upstream dairy value chain, as identified through literature, transect walks and semi-structured interviews?

3. What existing and future elements of frugal innovation in water management are evident within the upstream dairy value chain in South Africa, and how may these elements support water reporting?
4. How can findings from the literature, transect walks and semi-structured interviews be integrated and triangulated to develop and assess the relevance and applicability of a water reporting framework for the upstream dairy industry?

1.6 THESIS STATEMENT

Organisational value chains, particularly in the dairy industry, consume vast quantities of water and directly contribute to the ever-increasing scarcity of water, while exacerbating water-related risks. Nonetheless, much of this is minimally disclosed, and is often overlooked because organisations tend to only report on their own water usage, while failing to examine water-related issues within their value chains.

1.7 DELINEATION AND LIMITATIONS

This study was limited to the upstream value chain of the dairy industry, which includes dairy farmers and milk processors. The researcher did not include suppliers to dairy farmers, such as companies which supply fertiliser and seed. Nonetheless, the findings could offer insights into, and generic guidelines on, how to improve water reporting throughout the value chain, across multiple industries. Since a qualitative approach was employed, the research cannot be generalised. Furthermore, frugal innovation provided the theoretical lens for this study, whereas other theories may yield different insights. The limitations of the study are discussed in greater detail in section 6.7.

1.8 DEFINITIONS OF TERMS AND CONCEPTS

Frugal innovation	This refers to designing products and services by doing more with less, for more people (Pansera 2013:474).
Supply chain	A supply chain is a collection of three or more entities (organisations or individuals) that are directly engaged in the up- and downstream movement of products, services,

	finances and/or information, from a source to a customer (Mentzer, De Witt, Keebler, Min & Nix et al 2001:4).
Value chain	The concept, developed by Michael Porter in the 1980s, refers to primary and secondary value-adding activities in an organisation, which are involved in bringing a product or service to the customer. Here, creating value and ensuring customer satisfaction are core aims (Badenhorst-Weiss, Cilliers, Dlamini & Ambe 2018:6).
Upstream value chain	Transactions occurring between an organisation and its suppliers (CIMA 2022:153)
Downstream value chain	Transactions occurring between an organisation and its customers (CIMA 2022:153)
Water footprint	"The water footprint of a product (good or service) is the volume of freshwater used to produce the product, summed over the various steps of the production chain" (Hoekstra 2009:4).
Wetland	A portion of land that is covered by, or swamped with, water. It is usually groundwater that flows up from an aquifer, spring, river or lake, or even seawater (United States Environmental Protection Agency [EPA] 2025:online).

1.9 UNDERLYING ASSUMPTIONS

The underlying assumptions of this study were that water is a scarce resource for all dairy farmers who are expected to (at least) report to the dairy processors who purchase their milk on water-related issues on their farms.

1.10 RESEARCH METHODOLOGY

The research methodology selected, must be suitable to address the research problem with the purpose of turning the data which are collected into acceptable, valid and reliable information (Taylor, Sinha & Ghoshal 2006:8-9). The six layers of the so-called "research onion" (Saunders, Lewis & Thornhill 2023:131) was used to guide the development of the research methodology used in the present study, moving from its philosophical foundation to

the practical methods of data collection and analysis. Figure 1.4 presents a summary of the research methodology used in this undertaking.

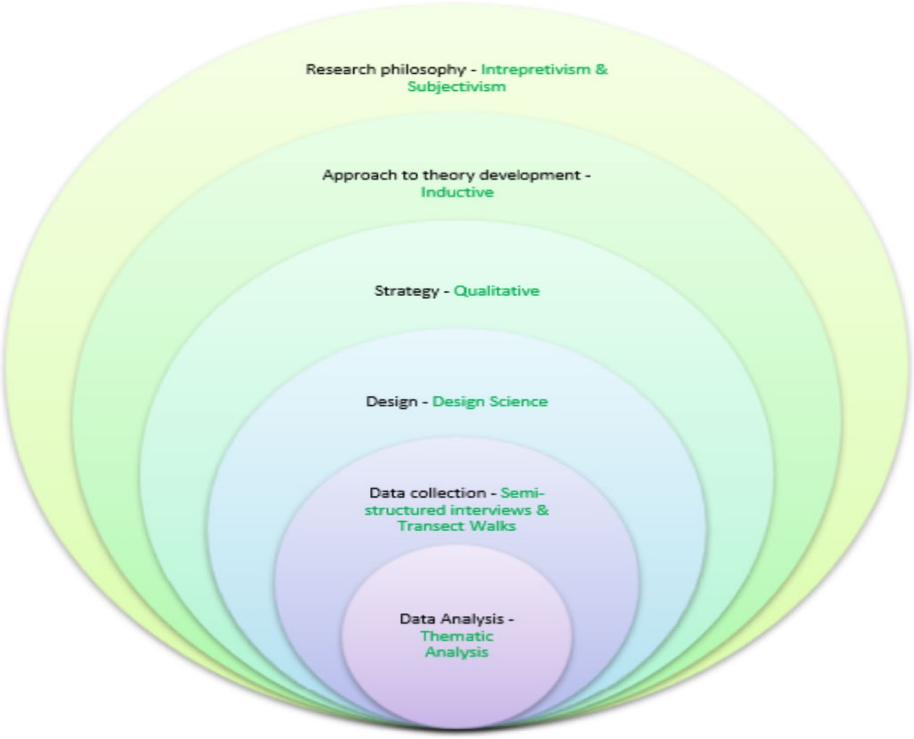


Figure 1.4: The research onion

Source: Adapted from Saunders et al (2023:131)

The layers of the "research onion", depicted in figure 1.4, have been adapted to specifically apply to this study. Each of the elements is discussed in more detail as it pertains to the research methodology applied here.

1.10.1 Research philosophy

As Proctor (1998:73) explains, the commencement of a study involves much thought, consideration and planning, and for that reason a clear understanding of the research philosophies is important. Chua (2019:3) differentiates between three paradigms in accounting research, namely positivist, critical and interpretive. Each of these considers separate beliefs on how the world operates, the nature of knowledge, and suitable methods of obtaining new knowledge. The philosophy behind this study was an interpretive paradigm. The methodological question, according to Guba and Lincoln (1994:108), asks, "How can the inquirer go about finding out whatever they believe can be known?" The researcher's central methodological assumption was subjective in nature, as the world is known through what

people say and how they interact in their specific context. Guba and Lincoln (1994:108) also point out that there are three fundamental questions for any given paradigm, namely the ontological, epistemological and methodological.

The ontological question (Guba & Lincoln 1994:108) asks, “What is the form and nature of reality?” Consequently, in the case of a real-life example, the question is “What can be known about it, [regarding] how things really are and how things really work?” O’Gorman and Macintosh (2015:51) classify ontological assumptions as either adopting an objective or a subjective view. Lichtman (2014:37) encourages a view which is subjective, as the researcher is the one who designs, collects, analyses and records the findings of a study. Subjectivity formed part of this study, as one of the core functions was to assist the researcher and other stakeholders in understanding the object of investigation (Drapeau 2002:10). In his seminal work, Peshkin (1988:20) recommends that researchers develop a heightened awareness of their subjectivity, as that will result in greater self-regulation. In this instance, measures were put in place to control for bias, due to the subjective view adopted in this study: the triangulation of data, not using a single data-collection source (interviews and transect walks), ensuring that the researcher made her research intentions clear to the participants beforehand (see Annexure H) (Miles, Huberman & Saldaña 2020:292, 293) and the services of an external independent coder (EIC) (Cofie, Braund & Dalgarno 2022:75) were employed.

1.10.2 Research approach

Qualitative research is predominantly directed towards exploring, discovering and doing inductive reasoning (Patton 1990:44; Creswell & Poth 2018:45). In an inductive approach, researchers start with the data, using these to obtain insights into the phenomena under study (Lichtman 2014:41). The researcher commences with specific observations, then builds towards general themes in a process known as inductive reasoning (Patton 1990:44). This study followed an inductive approach, which created unambiguous connections between the objectives of the study and the summary of the findings drawn from the empirical data, all while ensuring that these connections were both transparent (able to be shown to others) and defensible (justifiable in light of the objectives of the study), as recommended by Thomas (2003:2).

1.10.3 Research strategy

An epistemological question, according to Guba and Lincoln (1994:108), asks “What is the nature of the relationship between the knower or would-be-knower and what can be known?” Biggam (2011:137) explains that, in terms of the interpretive view, an understanding of the world can only be gained through social interaction. For Chua (2019:3), the interpretive view is normally linked to qualitative methods. In this instance, the researcher adopted an interpretive qualitative strategy, as it seeks to gain in-depth knowledge through interactions with others (i.e., through semi-structured interviews and transect walks).

1.10.4 Research design

Design science research (DSR) was the all-encompassing research design selected for this study. To solve real-world issues, this method requires the design of an innovative artefact (Kotzé & Van der Merwe 2015:2). Here, the main objective was to design a water reporting framework for the upstream dairy industry, with a view to improving water management in a water-scarce world. Figure 1.5 is a diagram of the DSR process and the steps followed in this study.

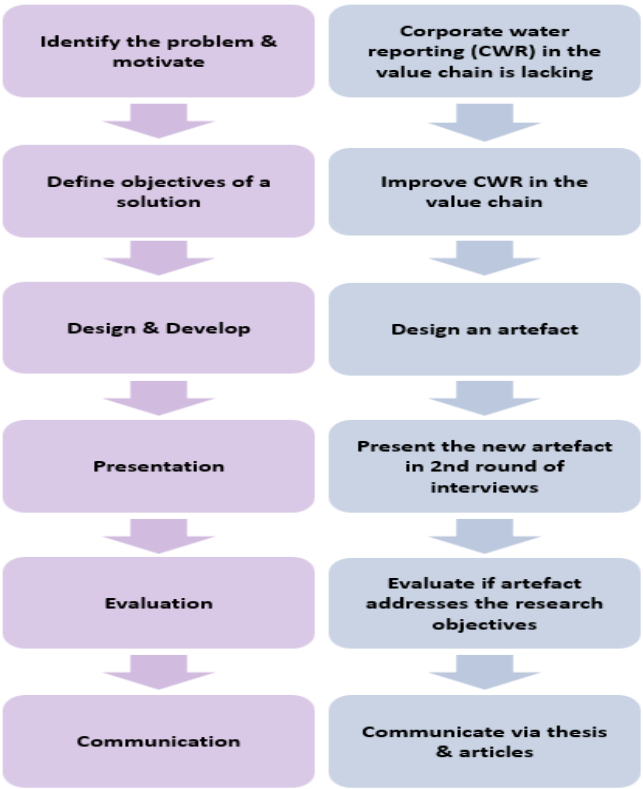


Figure 1.5: Design science research process for this study

Source: Adapted from Peffers, Tuunanen, Gengler, Rossi and Hui et al (2006:97)

Figure 1.5 was adapted using the DSR process of Peffers et al (2006:97) (first column) and depicts the process followed in the current study (second column). It is important to note that although the framework was evaluated by a number of the participants, it was not longitudinally tested in practice, since this could take several years.

1.10.5 Data collection

For the purposes of triangulating the data, transect walks were undertaken: these consisted of structured walks along a specific path (transect), with a view to establishing and exploring (Keller n.d.:online) how the upstream value chain measured and reported on water use. Two transect walks were conducted at two dairy farms, so that the researcher could familiarise herself with the water-related aspects of dairy farming. The transect walks permitted her to observe, ask questions and listen to explanations, to determine where water was used on the farms in question. The transect walks were recorded and fieldnotes were taken: while the first transect walk served to inform the interview questions, the second formed part of the data-collection process during the interview phase of the fieldwork, and was aimed at achieving study objectives 2 and 3.

Following the transect walks, the qualitative data were, for the most part, obtained through semi-structured interviews. The sample size of this study comprised 17 participants in the first round of interviews, and five in the second round. The semi-structured interviews provided an opportunity to discuss with various stakeholders how they engage with entities in the upstream value chain, and how they view water management and water reporting. Two rounds of interviews were conducted – the first, to inform the development of a draft framework on water reporting, and the second to discuss and refine the draft framework based on the input of the interviewees. The interviews began with specific open-ended questions, with follow-up questions to probe for a deeper understanding, depending on the responses and cooperativeness of the interviewees.

1.10.5.1 Population and sample

Of late, new schools of thought have emerged with regard to the population and sample size used in qualitative research studies. Englander (2019:6) proposes that qualitative research not investigate commonalities in a population, but rather what is common about a phenomenon. Sim, Saunders, Waterfield and Kingstone (2018:630) believe that when

undertaking inductive, exploratory research (which this researcher did), defining the sample size is fundamentally problematic. In the view of Saunders, Sim, Kingstone, Baker and Waterfield et al (2018:1904), specifying how many participants are needed to create a suitable understanding of what is as yet unknown, is often challenging and illogical. This applied to the current research undertaking, which investigated phenomena of which the key themes could not be identified in advance. In this respect, Saunders, Lewis and Thornhill (2016:297) offer guidelines on sample sizes (see table 1.1).

Table 1.1: Minimum non-probability sample sizes

Nature of study	Minimum sample size
Semi-structured/In-depth interviews	5–25
Ethnographic	35 +
Grounded Theory	20–35
Considering a homogeneous population	4–12
Considering a heterogenous population	12–30

Source: Saunders et al (2016:297)

Since this investigation involved conducting semi-structured interviews, a sample of at least five to 25 participants (see table 1.1) was deemed a minimum requirement for this data-collection method. If a homogeneous population is interviewed (i.e., role players in the dairy industry), then four to 12 participants would be considered a minimum sample size. The first row in table 4.1 thus depicts the appropriate sample size and category of interviewees participating in a study of this nature.

In the first round, 17 interviews were conducted with dairy farmers, milk processors and organised agricultural organisations (OrgAgris) and an NGO. As indicated in table 1.1, a sample of five to 25 participants is considered appropriate for semi-structured interviews, while four to 12 participants is deemed sufficient when interviewing a homogeneous population, such as role players in the dairy industry (Saunders et al (2016:297). The sample of 17 participants in the first round, therefore exceeded both minimum thresholds, providing sufficient justification for the sample size adopted in this study. The researcher contacted dairy farmers to whom she was referred by the milk processors; thereafter snowball sampling was used, where dairy farmers were asked to recommend other dairy farmers. In qualitative research, snowball sampling is often used for interview-based research (Atkinson & Flint

2001:2). Purposive sampling was subsequently used for the interviews with the milk processors, OrgAgris and the NGO, it being a non-random method where the researcher determines what needs to be known, then finds the participants who can and are prepared to impart the necessary information (Etikan, Musa & Alkassim 2016:2). The second round of interviews conducted, included those already interviewed in the first round, in an effort to review the draft framework.

Several OrgAgris make up the South African dairy industry. The primary purpose of these bodies is to represent all farmers, be they large scale or small, and to serve their interests (Nwoko 2019:34). Milk South Africa (Milk SA) administers statutory regulations on behalf of the government, the MPO (the body that represents dairy farmers), and the SA Milk Processors Organisation (SAMPRO), the body that represents milk processors and manufacturers of dairy products. Another organisation worth mentioning is the Dairy Standard Agency (DSA), which facilitates compliance with food safety regulations, quality standards and product composition requirements for milk and other dairy products. The South African Society of Dairy Technology (SASDT) encourages and promotes the use of scientific and technological advances in the industry. The MPO, SAMPRO, the DSA and the SASDT resort under the umbrella organisation of Milk SA. Figure 1.6 illustrates the role-players in the upstream value chain, from the perspective of the milk processors.

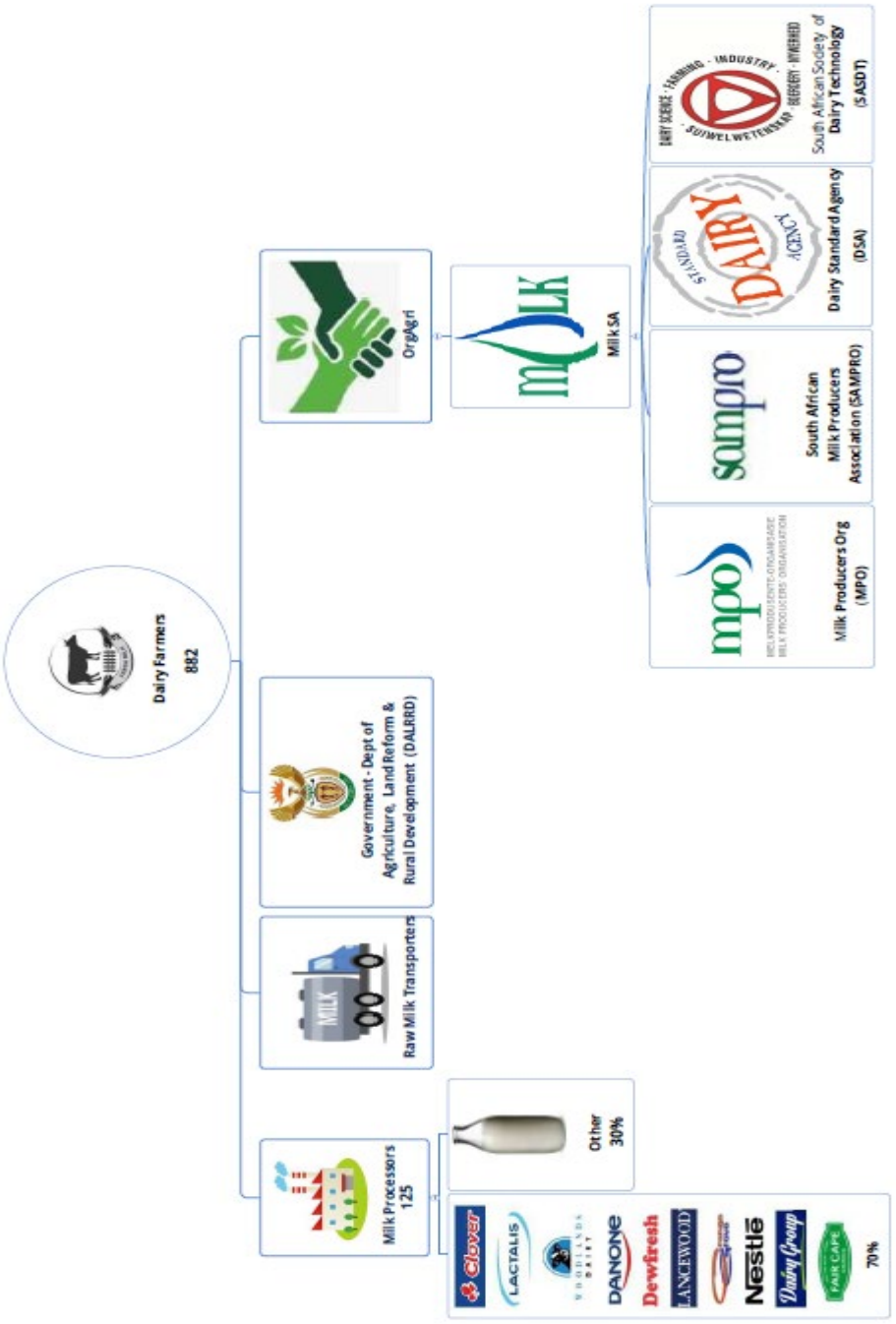


Figure 1.6: Graphic depiction of the upstream value chain of the South African dairy industry

Sources: USDA (2025:12) and the MPO (2025:4)

Figure 1.6 depicts the upstream value chain of the South African dairy industry, which is the focus of this study. Notably, not all organisations represented above, were interviewed in the course of this undertaking.

1.10.6 Data analysis

Thematic analysis was used to analyse the data collected. This technique is used to identify, examine, and interpret meaningful patterns or themes in qualitative data (Clarke & Braun 2017:297). Data analysis allows a researcher to proceed beyond merely describing the data collected, by interpreting, explaining, understanding and even making predictions (Dey 1993:31). One of the core tasks of qualitative data analysis is to assign the collected data to categories – a process widely known as coding (Dey 1993:59). Once the first round of interviews had been conducted, the researcher identified themes with the assistance of an independent qualitative expert, after which the data collected were analysed and coded using Atlas.ti™ Version 23 (hereafter Atlas.ti). The assistance of an experienced independent expert is considered integral in broadening a researcher's insights and learning (Williamson et al 2020:9).

1.11 ETHICAL CONSIDERATIONS

Credibility and trustworthiness are fundamental to qualitative research (Cope 2014:89). In this case, the researcher ensured that the study was undertaken in alignment with Unisa's institutional Policy on Research Ethics (Unisa 2024). The researcher ensured that every effort was made to avoid plagiarising material, and that the contents of this thesis were her own work. Since the researcher conducted semi-structured interviews and transect walks on two dairy farms, she obtained ethics approval from the Unisa College of Accounting Sciences Ethics Review committee before any fieldwork was conducted (see annexures B and C). Permission was also obtained beforehand from the participating farmers, dairy processors, OrgAgris and NGO. All study participants received a participant information sheet (Annexure H) explaining the purpose of the study, and signed an informed consent form prior to taking part in the study (see Annexure G). This study adhered to the principles of the Belmont Report and Nuremberg Code, which protect participants in research studies (Amdur & Bankert 2011:8, 23). All participants were made aware that they were free to withdraw from participating at any time, and that they had the right to anonymity and confidentiality. The consent form was explained by pointing out any potential benefits or negative consequences emanating from their participation in the study.

The collection, storage/archiving, use and disposal of any personal information gathered

during this study adhered to the Protection of Personal Information (POPI) Act, 4 of 2013 (Republic of South Africa [RSA] 2013), which came into force on 1 July 2021.

1.12 SIGNIFICANCE OF THE STUDY

Population growth and the changing dietary habits of humans place global food security under threat, and will continue to do so unless agricultural food producers and farmers can produce more with fewer natural resources, particularly water. This can be achieved through a collaborative effort which involves value chain engagement, knowledge sharing and transparency. To that end, the researcher proposes a framework aimed at enhancing water reporting, developed in the course of this study, which will potentially allow for improved water management in the upstream value chain of the South African dairy industry, and possibly elsewhere. The findings will be of particular interest to dairy farmers, milk processors, OrgAgris and NGOs.

1.13 STRUCTURE OF THE THESIS

The outline for each chapter is discussed below.

Chapter 1: Introduction to the study
This chapter provided background information to this academic undertaking, a brief high-level literature review of the fundamental topics relating to the study, the problem statement and research objectives, and an overview of the research methodology adopted. The theoretical lens and conceptual framework were also introduced.

Chapter 2: Thematic areas of consideration in relation to the research setting and chosen theoretical orientation
This chapter unpacks the context within which the study took place, focusing on global and local water scarcity problems, water stewardship and water-related risks. The impact of climate change on water supply and the interrelatedness of water and many of the SDGs are highlighted. Issues around the international and national dairy industries, their water consumption and how various dairy processor organisations measure, save and report on water usage in their value chains, are addressed here. The theoretical lens on which this study is based is examined more closely, being that of frugal innovation theory, along with its

interrelated dimensions of social, institutional and technological innovation. Value chain engagement, sustainable value chain management, down- and upstream value chains, and how digital technologies can assist in improving water reporting in the value chain, are all explored in this chapter.

Chapter 3: Thematic areas of consideration in relation to the context of water reporting and the conceptual framework

Corporate water reporting frameworks and initiatives, as well as water-reporting tools are analysed here. These aspects are then mapped to find common and unique value chain requirements and activities which can contribute to the design of the initial framework for an upstream value chain in the dairy industry.

Chapter 4: Research methodology

This chapter presents and discusses the research philosophy, approach and strategy adopted in this study. The researcher describes the design process used to develop the water-reporting framework, before presenting the research methodology used, namely to undertake transect walks and conduct semi-structured interviews. The data-analysis process is also addressed, along with the population and sample size, and ethical considerations.

Chapter 5: Findings

This chapter presents the findings from the empirical research, gleaned from semi-structured interviews and transect walks. By relying on these findings and considering the information outlined in Chapter 3, a draft framework is formulated and explained.

Chapter 6: Conclusions and recommendations

This chapter presented the final framework, along with the findings of the second round of semi-structured interviews undertaken to evaluate the draft framework. A summary of the research study is provided, along with an explanation of how this thesis contributes to the extant body of knowledge, its implications for future research and, finally, its limitations.

CHAPTER 2: THEMATIC AREAS OF CONSIDERATION IN RELATION TO THE RESEARCH SETTING AND CHOSEN THEORETICAL ORIENTATION

"Thousands have lived without love, not one without water" (Auden 1957:38)

2.1 INTRODUCTION

The importance of water for the planet, its inhabitants and commerce, was highlighted in the preceding chapter. The researcher touched on the relationship between water and climate change, water-related issues such as water pollution, waste-water discharge and water usage, as well as the importance of measuring, managing and communicating related information to organisational stakeholders. Limited water reporting and transparency in the upstream value chain, as well as how large quantities of water are integrated in product value chains, informed the gap which this study seeks to close. The theory of frugal innovation was introduced as the lens through which this study will be viewed, given its description as a "resource-scarce solution" (Hossain et al 2016:133) to what water is a scarce commodity, particularly in South Africa. The South African dairy industry was identified as the unit of analysis, since it is a significant consumer of water. The problem statement, research objectives, thesis statement and research methodology employed in this study were briefly discussed, before the researcher addressed possible ethical considerations and the significance of the study.

The key purpose of Chapter 2 is to review existing and relevant literature to support the research problem and assist in achieving the objectives of this undertaking. To begin, the researcher establishes that, globally, water scarcity presents a real problem, exacerbated by the impact of climate change on the quantity and quality of water supply, and then focuses on the importance of water in achieving most of the envisaged SDGs by 2030 (Ortigara et al 2018:3). Water-related issues in the dairy industry, particularly in this country, are addressed. The research problem is viewed through a lens of frugal innovation theory, which incorporates social, institutional and technological innovation. This chapter also reviews corporate water-related risks and stewardship as an approach to mitigating shortages. Value chain engagement, along with sustainable value chain management is presented, and the chapter

concludes with a discussion on how digital technologies can assist with corporate water reporting, followed by a brief summary.

2.2 GLOBAL WATER SCARCITY

Water is of inestimable value, and most ecosystems would not exist without it. Despite this, every day, throughout the world water is taken for granted, wasted and polluted (United Nations [UN] 2021:iv). Global freshwater withdrawal rates rose by 14 per cent between 2000 and 2021, or at an average annual growth rate of 0.7 per cent (UN 2025:xvi). This scenario seems unlikely to change in the face of global population growth. Areas most at risk of severe shortages of food and water typically have high population densities and rapid growth rates (O'Sullivan 2023:547). The global population is projected to keep increasing over the next 50–60 years, potentially reaching approximately 10.3 billion by the mid-2080s – up from 8.2 billion in 2024 (UN 2024:vii). If future water management practices continue as they have to date, with only gradual or incremental improvements being made, the world is fated to witness serious water shortages (Biswas & Tortajada 2018:4). Since there is no real alternative, more and more countries are compelled to improve their water management practices (Biswas & Tortajada 2019a:729).

Good water management practices are paramount. In 1965, when Singapore became independent it faced significant water problems, yet with good planning and sound management, Singaporeans have not experienced a water crisis since the 1980s, despite the fact that its population has continued to grow (Biswas & Tortajada 2019a:728). In New Zealand and India, many native communities are realising the true value of water, which has prompted water and waterways to be given special status. In New Zealand, the Whanganui River, and the Ganges and Yumuna rivers in India, are regarded as living beings that are entitled to the same care and protection as humans (UN 2021:vi). Saudi Arabia (which is ranked as a country that faces extreme water stress) incentivises water conservation by correctly pricing water and aiming to reduce consumption by 43 per cent in the next ten years (Hofste, Rieg & Schleifer 2019:9–10). Namibia, which is located in southern Africa and is considered to be one of the driest countries in the world, has been recycling wastewater into drinking water for the past 50 years (Hofste, Rieg et al 2019:10). The UN (2015:3) has identified the protection and restoration of water-related ecosystems and resources as one

of its fundamental sustainability goals (SDG 6), to meet the urgent environmental and economic challenges confronting the world.

In many regions, population growth and economic development are increasing the demand for water (Gleick, Iceland & Trivedi 2020:4). The WRI found that, since the 1960s, global water withdrawals have more than doubled due to growing demand, and this rate of increase is not expected to slow down anytime soon (Hofste, Rieg et al 2019:2). Currently, more than two billion people live in water-stressed areas, and by 2030 the world will face a water deficit of 40 per cent (UN 2021:vi). In many countries pollution and inefficient wastewater treatment facilities have rendered vast quantities of local water unusable, if such facilities exist at all (Gleick et al 2020:4). Water management should thus not only focus on water in terms of quantity, but also its quality, since the health of humans and ecosystems is dependent on both (Opperman, Oyare, Baleta, Fahrbach & Camargo 2021:38). Due to quality concerns, fewer people now drink water straight from the tap, even in developed countries (Biswas & Tortajada 2019b:913). For instance, in the United Kingdom (UK) only 14 per cent of waterbodies in England, 46 per cent in Wales and 31 per cent in Northern Ireland are graded as being of a good or sufficiently high quality (Troubled Waters Partnership [TWP] n.d.:7).

As Biswas and Tortajada (2019b:914) explain, water quality management is a complex undertaking, one of the key reasons being that thousands of new chemicals are developed annually which find their way into waterways, making water quality parameter measurement a virtually impossible task. Increased water pollution has a direct correlation with an increase in population and economic growth (Boretti & Rosa 2019:2). A further concern is microplastics which are entering water systems and soils: sludge from wastewater treatment plants (often used as fertiliser in the agricultural sector) is known to contain vast amounts of microplastics (Browne et al 2011:9176). A significant source of greenhouse gas (GHG) emissions is untreated or badly treated wastewater: when disposed of in surface water it stimulates the release of methane and other gases, causing surface water to become a source of GHG, which in turn causes global warming (Kerres, Servos, Kramer, Hattermann, Tanzler & Pilz et al 2020:15). As Kerres et al (2020:13) note, the water cycle is a vital part of the climate system, therefore sustainable water management practices will play a substantial role in helping to realise efforts aimed at mitigating global warming.

2.2.1 Climate change and water

The 2015 Paris Agreement on climate change, which was ratified by 195 parties, envisaged limiting global warming to below two degrees Celsius, but preferably to below 1.5 degrees, compared to the pre-industrial levels of average global temperatures (Intergovernmental Panel on Climate Change [IPCC] 2018:5). This constituted a landmark agreement, as it was the first binding agreement aimed at combatting climate change (IPCC 2018:5). The 2022 report from the IPCC, which was one of the most extensive studies on the impact of climate change, reported that the effects of global warming are already more severe and widespread than expected, threatening the food security and livelihoods of millions due to extreme heat and droughts, and record flooding (Levin, Boehm & Carter 2022:2). These scientists warn that the world is already locked into a cycle of climate change and its associated impacts, since the current GHGs in the atmosphere will have a marked impact, despite any accelerated decarbonising initiatives (Levin et al 2022:3). The impact of climate change is global in terms of its scope and extreme in scale, driving changing weather patterns that put food production at risk, and cause rising sea levels that compound the odds of devastating floods occurring (FAO & Global Dairy Platform [GDP] 2018:6).

The effect of climate change is evident in all aspects of water availability and provision, but despite this it is seldom mentioned in global climate agreements (UN 2021:iv). Global water quality is significantly affected by climate change which creates conditions that exacerbate algal blooms, especially in dams, rivers and along coastlines, causing “dead” zones in oceans that are unable to sustain any marine life (FAO 2020:xiv). On land, heightened soil temperatures are predicted to accelerate the absorption of heavy metals such as arsenic and mercury. Worryingly, pesticide application is expected to increase as climate change alters the life cycles of pests, and elevated temperatures reduce the efficacy of the pesticides applied by entities in the agriculture sector (FAO 2020:xiv). Going forward, the future of agriculture will be shaped by its response to climate change; new innovative solutions will have to be developed to modify crop varieties and monitor the movement and numbers of pests (Zilberman, Lipper, McCarthy & Gordon 2018:49). As an illustration of frugal innovation, a citrus farmer in South Africa has developed a smart phone application that allows the user to take photographs of a pest or disease, and upload the image to a real-time database for instant identification and proposed treatment (Den Hartigh 2016:1).

Research has shown that certain regions in South Africa are expected to warm at twice the global rate, meaning that this already water-scarce country is likely to become even drier, to lose biodiversity and witness the deterioration of water catchment areas (World Wide Fund for Nature - South Africa [WWF-SA] 2021a:19). In terms of the Paris Agreement, developed countries should take the lead in reducing GHGs, however developing and low-income nations are now also accountable for lowering those emissions, which implies that they must strike a balance between their development mandate and climate change policies (Ismail, Wiropranoto, Takama, Lieu & Virla 2021:693). South Africa is extremely vulnerable to climate change, and is particularly reliant on agriculture and subsistence farming, especially in rural areas where smallholder farms are vital for sustaining communities (Knight 2018a:287).

The dairy industry, which is the focus of this study, has been identified as a significant contributor to GHG emissions (Guzmán-Luna, Mauricio-Iglesias, Flysjö & Hospido 2021:1). Dairy farms are both major contributors to greenhouse gas emissions and extremely vulnerable to the effects of climate change. When dairy cows are under heat stress, their methane footprint increases due to decreased milk production efficiency, increased susceptibility to disease, and decreased animal welfare (Da Rosa, Ferreira, Oliveira, Moreira, & Battisti et al 2025:1). GHG emissions rose by 18 per cent from 2005 to 2015, driven by a significant 30 per cent increase in milk production, to meet growing consumer demand. In the absence of enhancements in efficiency, however, the overall GHG emissions from the dairy industry would have risen by 38 per cent (FAO & GDP 2018:7). According to Guzmán-Luna et al (2021:4), different sources of GHG emissions have been identified along the dairy value chain, yet dairy farms were found to be a major contributor to global warming with a carbon footprint of 80 per cent, the remaining 20 per cent being attributed to the other stages in the value chain, such as the transportation of milk, the processing of dairy products, their distribution and retail, and their eventual consumption by consumers. Enteric fermentation (the methane produced during digestion), feed production, manure management, energy and wastewater management have been identified as the main sources of GHG on dairy farms (Guzmán-Luna et al 2021:4-6). To transform the dairy industry, a combination of innovative technologies and the use best practices related to water management will be essential for reducing emissions (FAO & GDP 2018:33; Panchasara, Samrat & Islam 2021:11). Innovative examples include separating the solid and liquid out of manure by putting it through a press, after which the solids are used as compost in the soil and the liquid as irrigation: this results in less methane being released into the atmosphere, and also allows farmers to grow their

own feed while saving water on irrigation (Berkhout 2021:5). Seemingly insignificant changes in the climate can have considerable impacts on water availability. Climate change is considered a “defining challenge of our time” (Stern 2016:407), therefore it seems apropos that the UN’s SDG 13 states: “Take urgent action to combat climate change and its impacts” (Campbell, Hansen, Rioux, Stirling, & Twomlow et al 2018:13).

2.2.2 Sustainable development goals and water

In September 2015, the 2030 Agenda and its 17 SDGs were accepted by all UN member countries (UN 2015:1). Viewed as quintessential actions for humanity, the SDGs are intended to apply to all countries and stakeholders, since the goals are all interlinked. The SDGs undertake to leave no one behind, to ensure that development is risk-informed and that signatories work together as governments and UN member states (Klingspor 2018:1-5). Ingildsen (2020:47) suggests that the SDGs are an innovative means of managing the sustainability crisis. One of the 17 SDGs which is particularly relevant to this study, is SDG 6, which strives to “ensure [the] availability and sustainable management of water and sanitation for all” (UN 2015:14). Another pertinent development goal, given the setting of this study, is the dairy industry which relates to the achievement of SDG 2, “Zero Hunger”. Sustainable water management is closely linked to food security due to the agricultural industry being sensitive to water scarcity, given that it is one of the biggest users of water (FAO 2012:1).

Water is accepted as being central in meeting all the SDGs, since it can be tied to most (if not all) of the goals (Ortigara, Kay & Uhlenbrook 2018:3). However, with regard to attaining the various SDGs, water is commonly overlooked as the crucial connecting element (UN 2021:2). Each of the SDGs is defined by targets, and each target by indicators for the purpose of tracking progress. SDG 6, for instance, consists of eight targets (amongst them, drinking water, sanitation and hygiene, wastewater treatment and ambient water quality) and 11 indicators (including the proportion of population using safely managed drinking water services, proportion of wastewater safely treated) together with two implementing mechanisms (international cooperation and community participation) (Guppy, Mehta & Qadir 2019:501). According to the 2024 UN SDG progress report, major obstacles continue to stand in the way of universal access to clean drinking water and sanitation, therefore most targets are not on track to be reached by 2030, and specifically not the ability to address the problem

of water scarcity brought on by climate change (UN 2024:20). Additionally, the 2025 UN SDG Report affirms that none of the SDG 6 targets are on track to be met and that, at the current rate, the world will not achieve sustainable water management until at least 2049. To meet the 2030 targets, progress rates for safely managed drinking water must increase sixfold, and sanitation must increase fivefold (United Nations Statistics Division [UNSD] 2025:online). Based on statistics from nations with extensive monitoring programmes, the decline in water quality since 2017 is a worrying trend (UN 2024:20). Given poor wastewater treatment rates in many low-income nations, this tendency might be universal, but there are insufficient data to substantiate it.

In 2019, South Africa submitted its first Voluntary National Review (VNR) to the UN on the country's SDG progress, thereby showing its commitment to achieving the SDGs, however progress towards reaching the SDG 6 targets by 2030 is far too slow, and indications are that this country will fall considerably short in meeting those goals (University of Cape Town [UCT] 2021:1). The 2019 VNR was unable to report on the support provided to, and participation in, the water and sanitation management of local communities, and failed to mention any private–public partnerships in relation to the SDG 6 targets, which is concerning given that those can be achieved only with the cooperation of every water user in this country (UCT 2021:2). In its 2023 SDG report – the third presented by South Africa – it was noted that significant economic and environmental issues are preventing this country from achieving SDG 6 (Stats SA 2023:96). Limited investment and financing earmarked for infrastructure related to water and sanitation has slowed progress in achieving the set goals and has constrained agricultural output, as have the effects of climate change on water resources, the destruction of infrastructure, and the effects of extended droughts and sporadic flooding (Stats SA 2023:96).

2.3 SOUTH AFRICA'S WATER SITUATION

The DWS is responsible for planning and managing South Africa's water infrastructure (Knight 2018b:96). The National Water Act 36 of 1998 (RSA 1998) specifies the legal framework for the successful and continuous management of this country's water resources (see also MPO 2017:1). The aim of the Act is to safeguard, enhance, protect, administer and govern water resources collectively, by advancing the integrated management of water resources in collaboration with all stakeholders (MPO 2017:2). The National Water Act 27 of

2014 (RSA 2014) amends and modifies the Act of 1998 concerning the management of water resources and activities related to prospecting, exploration, mining or production. It also addresses the lodging of appeals to the Water Tribunal, and represents an agreement between the ministries of water, mineral resources and environmental affairs, referred to as the One Environmental System for the country in relation to mining (RSA 2014:2). According to Odendaal (2025:online), as of August 2025, South Africa's cabinet has approved the Water Services Amendment Bill and the National Water Amendment Bill proposed by the DWS. The revisions of these bills are aimed at reversing the deterioration of South Africa's struggling water sector.

Water scarcity is especially prevalent in South Africa (Nyam, Kotir, Jordaan, Ogundeji & Turton 2020:2). Rainfall is the primary source of freshwater in this country, but rainfall levels are low compared to many other countries. The nation's water supply mostly comes from dams (WWF-SA 2017:8), with an estimated 5 000 registered dams, the vast majority (3 832) of which are small dams used to service farms and municipalities (DWS 2022b:43). The DWS report (2022b:43) states that there is a potential 4 500 million m^3 of accessible groundwater in South Africa, with between 2 000 and 3 000 million m^3 at this stage being used. According to data from the WRI's Aqueduct, South Africa is ranked 48th out of 164 countries on the national water stress ranking, falling under the medium-to-high baseline of water-stressed states (Hofste, Rieg et al 2019:13). Admittedly, South Africa is confronted with many additional challenges that exacerbate its water situation. One of the key risks is sustaining the availability of sufficient and clean freshwater in the face of increasing urbanisation, population growth, higher standards of living and climate change, and a growing demand for water (Jordaan, Ogundeji, Nyam, Ilbury & Turton et al 2021:iii).

In developed countries, access to clean water is taken for granted, whereas in developing countries economic growth is a challenge, and water use is often detrimental to the environment (Masindi, Chatzisymeon, Kortidis & Foteinis 2018:794). In excess of three million people in South Africa do not have access to clean water and a reliable source thereof; approximately 14.1 million people do not have access to safe sanitation; and an estimated 43 per cent of households do not have reliable water and sanitation services (DWS 2021:10). In urgent need of rehabilitation and replacement are the country's 963 water treatment works (WTWs) and 1 010 wastewater treatment works (WWTWs), where 44 per cent of WTWs and 56 per cent of WWTWs are in critical condition (DWS 2021:11).

An indebted government and political instability have led to a lack of investment in infrastructure and maintenance, resulting in the inadequate capture of rainfall and loss of dam water (WWF-SA 2017:12). In the not so distant past, democratic South Africa was viewed as a worldwide leader in the management of water resources and services, and in 2015 the country achieved the Millennium Development Goal of ensuring domestic water supply (Muller 2020:12). However, the country's water sector has since deteriorated considerably, mostly due to corruption in the sector (Muller 2020:14). Corruption has even resulted in deaths when funds intended for maintenance and upgrades were embezzled, causing communities to suffer (Adam 2024:online). Water is too precious a resource to be mismanaged, and corruption in South Africa's water sector must be confronted and eradicated, in order for larger water issues to be solved and managed, instead of wasting valuable resources on policing corrupt ministers and government officials, as Muller (2020:10) avers.

Since 1994, skilled water engineers have been driven out of water boards and municipalities (Turton 2015:1). The DWS No Drop Progress Report (2025:15) confirms that this crisis persists, with 7426 (28%) of positions in municipal water departments currently vacant and only 370 professionally registered engineering staff serving the entire country. It is deemed that approximately 47.4 per cent of drinking water is lost through municipal water entities either not fixing leaking pipes, or communities creating illegal connections (non-revenue water): this is considerably higher than the recommended international best practice average of 15 per cent (Knight 2018b:96; DWS 2021:8; DWS 2023:xi). In addition, in excess of 70 per cent of the drinking water supplied to poorer communities is lost due to water leaks (Muller 2020:26). The largest user of water in South Africa is the agriculture sector (61%), followed by municipal users (27%) and the industrial sector (12%) (WWF-SA 2017:8; DWS 2021:8). The fact that agricultural water consumption is mostly unmetered leads to illicit withdrawals and wastage by a sector which also pays a much lower tariff for untreated water (i.e., not chemically treated, filtered or boiled) than other users (DWS 2021:8). As a result, there may be little incentive on the part of this sector to treat wastewater or save water by, inter alia, adopting efficient irrigation practices. Since nationwide agricultural water consumption is mostly unmetered, scientists make estimates by relying on satellite images to chart irrigated areas and assess water usage by considering crop varieties, climatic conditions and irrigation techniques. Additionally, precipitation, river discharge and alternative water sources are

evaluated to ascertain what quantity of water is accessible and consumed by various sectors, agriculture included (Water Research Commission [WRC] 2018:27).

Approximately half of South Africa's wetlands have been lost due to poor governance, pollution, water abstraction (permanent removal) and changes in land use, and what is left – 3.2 million hectares (>5% of this country's land cover) – is already in poor condition (DWS 2021:10). Wetlands are one of the world's fundamental environmental assets, acting as sponges by slowing down floodwaters, preventing soil erosion, assisting during droughts, improving water quality by acting as filters, and serving as home to many plants, fish, birds, insects and other creatures (Department of Agriculture, Forestry and Fisheries [DAFF] n.d.:1-2). Another issue that requires careful consideration in an arid country such as South Africa is the management of invasive alien plants (IAPs) (Preston, Le Maitre, Blignaut, Louw & Palmer 2018:1). Anyone who owns or manages land in South Africa will be familiar with the challenge of water-thirsty, fast-spreading invaders that disrupt natural ecosystems and consume large quantities of freshwater resources (Martens, Deacon, Ferreira, Auret & Dorse et al 2021:6). A large invasive tree can, for instance, consume between 100 and 1 000 litres of water in a single day; agricultural land is reduced as IAPs spread, and managing them is a costly exercise for farmers (Martens et al 2021:10). At the launch of the Status of Biological Invasions and their Management in South Africa, then Minister of the DFFE, Ms Barbara Creecy, mentioned that three to five per cent of surface water per annum is consumed by invasive trees, and that Cape Town's "Day Zero" was pushed forward by 60 days due to IAPs. She also explained that, nationwide, 70 per cent of grazing land – a precious natural asset – could be lost due to IAPs (South African Government News Agency 2021:1).

South Africa is a mineral-rich country with much of its wealth created through mining, especially gold mining that has helped to develop the country, yet many mines have since either closed or are reaching their "end of life" (McCarthy 2011:6). It is estimated that there are over 6 000 abandoned mines across South Africa (Munnik, Hochmann, Hlabane & Law 2010:8). At mining sites, especially abandoned ones, acid mine drainage (AMD) is considered one of the most serious environmental issues (Ochieng, Seanego & Nkwonta 2010:3351), being caused by both gold and coal mines. A result of AMD is when the extremely acidic water which discharges out of a mine seeps into waterways, leaches into the soil and enters the water table, spreading widespread pollution in both groundwater and surface water (Morodi & Mpofu 2018:1182). In June 2021, the government suspended its

R10-billion long-term plan to treat AMD through desalination, due to funding limitations and the significant cost of establishing and operating treatment plants (Bega 2021:14). In this country it is more about effective and efficient water management than solely water availability, but this requires investment in new dams, grey-water reuse systems, desalination plants and a reduction in the loss of non-revenue water (Knight 2018b:98). Since the dairy industry is pivotal to this study, the section below provides an overview of the global and South African dairy industries, and their dependence on water.

2.4 DAIRY INDUSTRY'S IMPACT ON WATER SCARCITY

To ensure the future sustainability of the dairy industry, the global production of milk and dairy products has to be achieved through the careful consideration of its water consumption (Shine, Murphy & Upton 2020:2).

2.4.1 Global dairy industry

The dairy industry provides the world with multiple benefits – dietary, economic and social (Üçtuğ 2019:104). In excess of 80 per cent of the world's population (i.e., around 6 billion people) frequently consume milk and/or other dairy products (FAO & GDP 2018:11). These nutrient-rich foods contain high levels of protein, fat, vitamins and minerals, constituting the third greatest source of protein and fat, and the fifth greatest source of energy in the human diet (FAO & GDP 2018:11). The dairy industry is thus vital for achieving SDG 2 "Zero Hunger" and SDG 3 "Good Health and Well-being" (Bellamy & Bogdan 2016:2). The social benefits of dairy farming include empowering women – over 25 per cent of cattle-keeping households (around 37 million farms) dairy cows are owned or managed directly by women, which contributes to SDG 5 "Gender Equality through Empowering Women" (FAO & GDP 2018:3).

India is the largest milk producer in the world, with 56 million cows (Kotni, Bogala, Giribabu, & Vemula 2022:355), yet it trades very little on the global milk market because the milk produced is for domestic consumption. The three major exporters of dairy are New Zealand, the European Union (EU) and the United States, while the People's Republic of China is the greatest importer of related products (typically traded as processed dairy products) (OECD & FAO 2020:175). Due to the short shelf-life of milk it cannot be stored for more than a few days, but the production of milk powders has permitted a worldwide industry to develop

(Burke, Zacharski, Southern, Hogan, Ryan & Adley 2018:3). Global milk production is estimated to increase by 1.6 per cent per annum over the next decade, which exceeds the growth expected of other key agricultural commodities (OECD & FAO 2020:175).

Water is a core processing medium in the dairy industry, being used extensively throughout the entire process (Andrade, Mendes, Espíndola & Amaral 2015:735). Dairy farming is water intensive, and in the milk life cycle from farm to fridge, approximately 90 per cent of water consumption lies at the farm level, as pasture irrigation for animal grazing and as drinking water for cows, for cleaning and disinfecting dairy parlours and equipment, and for cooling milk (Owusu-Sekyere, Scheepers & Jordaan 2016:6, 9). Crops can either be rain-fed (known as green water), irrigated (blue water; surface or groundwater) or a combination of the two (Sustainable Agriculture Initiative [SAI] 2013:4).

There are contrasting types of dairy farm systems: those where cows are held in a shed or single camp and all their food is brought to them (known as confinement farming) and pasture-based dairy farming (where cows graze freely on grass grown in pastures) (O'Brien, Capper, Garnsworthy, Grainger & Shalloo 2014:1835). These cows eat in one area and are then moved on so that the grass can rest and grow again – something which requires strict grazing management, and a full-time commitment by the farmer (Smith, Lacefield, Burris, Ditsch & Coleman et al 2011:2). On pasture-based dairy farms, water is a limited resource and thus needs to be used efficiently, thereby making effective irrigation management essential (WWF-SA 2021b:23).

Vast quantities of water are wasted on over-irrigation and uneven application, both of which are indicative of poor irrigation management (Martin, Thomas, Stevens, Zyskowski & Moot et al 2006:158). Flood irrigation is a careless method, especially in a water-scarce world – drip irrigation is deemed a better method, and irrigation scheduling can be applied based on soil moisture measurements, making use of a number of technologies to assist with this (WWF-SA 2021b:23). Other determinants that influence water requirements at the farm level are crop varieties, soil condition, climate and season, and land slope (SAI 2015:10). Healthy soil holds 10–20 times more water (Nestlé 2021:6) than unhealthy soil.

Apart from the dairy industry using vast quantities of water, it also generates enormous amounts of wastewater and effluents (Andrade et al 2015:735). Dairy farming, in many

instances, has an impact on local water supply, especially where slurry is dumped in rivers and other water sources. Slurry contains a variety of pollutants, including animal waste, cleaning products, the remains of milk and milk products, fertilisers, pesticides and insecticides (Boguniewicz-Zabłocka, Kłosok-Bazan & Naddeo 2019:1209). The average dairy cow can produce approximately 45 litres of manure each day (Chastain & Camberato 2004:2) which, when spread on fields as untreated fertiliser, seeps into the groundwater (Chalmers 2021:6).

New Zealand is a good example of where a boom in the country's dairy industry has coincided with a reduction in water quality, with an estimated two-thirds of its rivers and lakes not being swimmable and 75 per cent of indigenous fish species at risk of extinction (Roy 2019:2). As the number of cows has increased, so have the amounts of fertiliser: for example, nitrogen being applied to New Zealand soil increased by 629 per cent from 1990–2015 (Ministry for the Environment & Statistics New Zealand 2019:58). In the United Kingdom, it has been reported that some farmers spread effluent on their fields before heavy rains so that it will wash into the rivers, and some pump slurry straight into waterways at night – these are examples of deliberate water pollution by dairy farmers (Monbiot 2021:online).

Water stewardship is a fundamental element of sustainable farming, with two core objectives in the agriculture sector being to safeguard farming activities from water-related risks and to reduce the negative impacts of farming activities on the natural environment and other water users (SAI 2015:1). The SAI report (2015:2) describes a catchment approach as a fundamental requirement for water stewardship at the farm level, noting that water management on a farm is essential as it not only impacts the farm itself, but also the surrounding environment. This concept is depicted in figure 2.1.

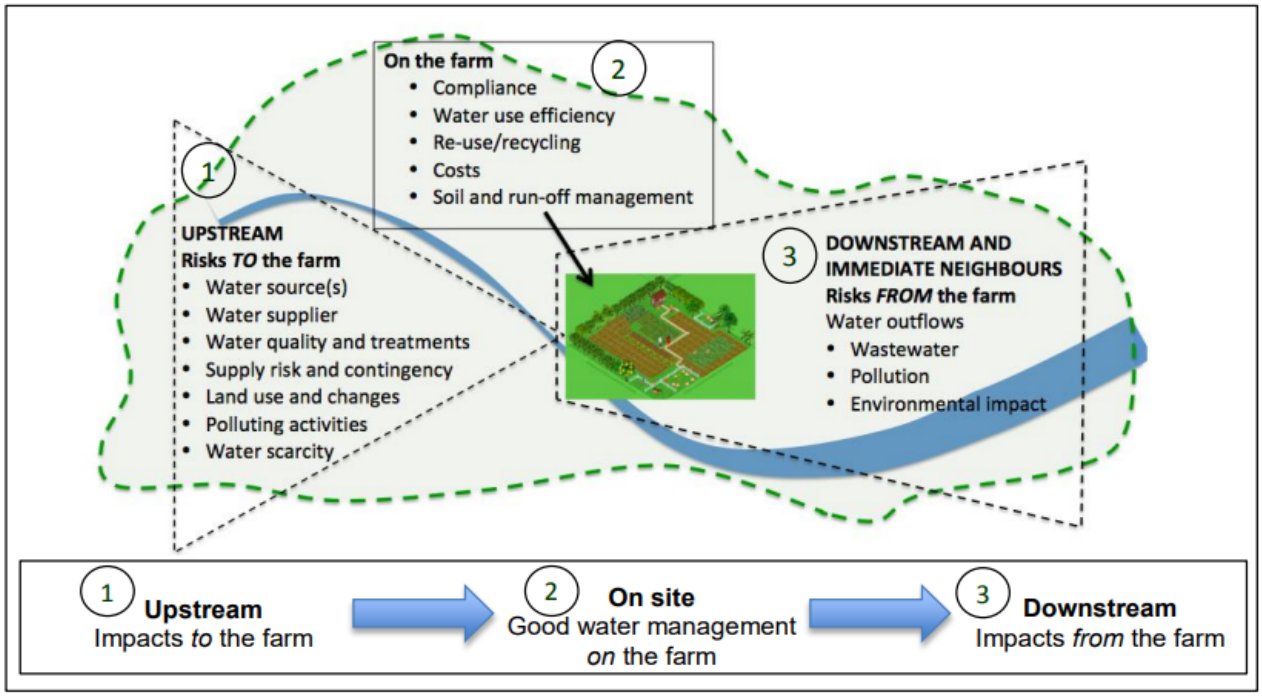


Figure 2.1: Understanding water-related risks in a farm catchment area

Source: SAI (2015:2)

Many stakeholders are implicated in a catchment area, meaning the actions of one can have an impact on others. Upstream water impacts to the farm (see figure 2.1, no. 1) mean farmers need to know the source and the quality of the water being used on the farm, and to adhere to government policy and regulations. At the farm site level (no. 2), the pollution of surface and groundwater by fertilisers and chemicals, animal waste and veterinary pharmaceuticals can contaminate watercourses downstream, while the over-utilisation of water by the farm has the effect of lowering water levels for other users downstream (no. 3). The terms "upstream" and "downstream" in respect of farm catchment should not be confused with their use in describing a value chain. Here, the upstream value chain pertains to the milk processors (dairy farmers, milk transporters and milk processors).

2.4.2 South African dairy industry

Until 1996, the dairy industry (much like most other agricultural industries in South Africa) was state-run and controlled by agricultural boards that managed the pricing and marketing of produce; yet once these boards were disbanded, this previously highly regulated industry was exposed to extreme competition, causing the sector to consolidate (Das Nair 2020:3). Almost overnight, farmers had to cope with international competition with no protection, as import controls and tariffs were scrapped and the government ceased paying subsidies

(Goldblatt 2010:18). In contrast, the governments in the EU, that of the UK and of countries in Eastern Europe continue to pay substantial subsidies to their dairy farmers and dairy producers, which is impractical and unfair to this country's dairy industry, especially when competing against cheaper imports, which is one of the many reasons why some local dairy farmers have ceased production in recent times (Van Heerden & Kirsten 2022:29). The EU has five different funds that support agricultural and rural development, for example, with subsidies for reducing costs in the value chain and implementing sustainable energy initiatives (Van Heerden & Kirsten 2022:29).

Due to increases in production costs, the scarcity of natural resources, regulation and overseas competition, there has been a substantial consolidation of South African dairy farmers over the past 20 years, with large farms now accounting for 80 per cent of total milk production in this country (Who Owns Whom 2021:1). Figure 2.2 depicts where in South Africa dairy farms are situated. The dairy industry is made up of primary and secondary industries, consisting of 63 per cent liquid and 37 per cent concentrated products (Who Owns Whom 2021:1). The primary industry is made up of farmers and processors, farmers who produce milk, and processors who purchase raw milk, pasteurise, homogenise, package and sell it to retail stores as fresh or long-life milk or milk powder (MPO 2020:217). The secondary industry includes processors that produce six categories of dairy products made from raw milk – milk and cream, concentrated milk, yoghurt and buttermilk, cheese, whey, and butters and oils (MilkSA 2024:4). The secondary industry also produces ice-cream and inputs into the manufacture of chocolate and baby foods (Das Nair 2021:16 & 70). As Das Nair (2021:14) remarks, a few large multinational processors operate nationally, including Nestlé, Clover, Danone and Lactalis (Parmalat), with large national processors including Woodlands as well as Coega Dairy, and numerous smaller processors that operate in particular areas.

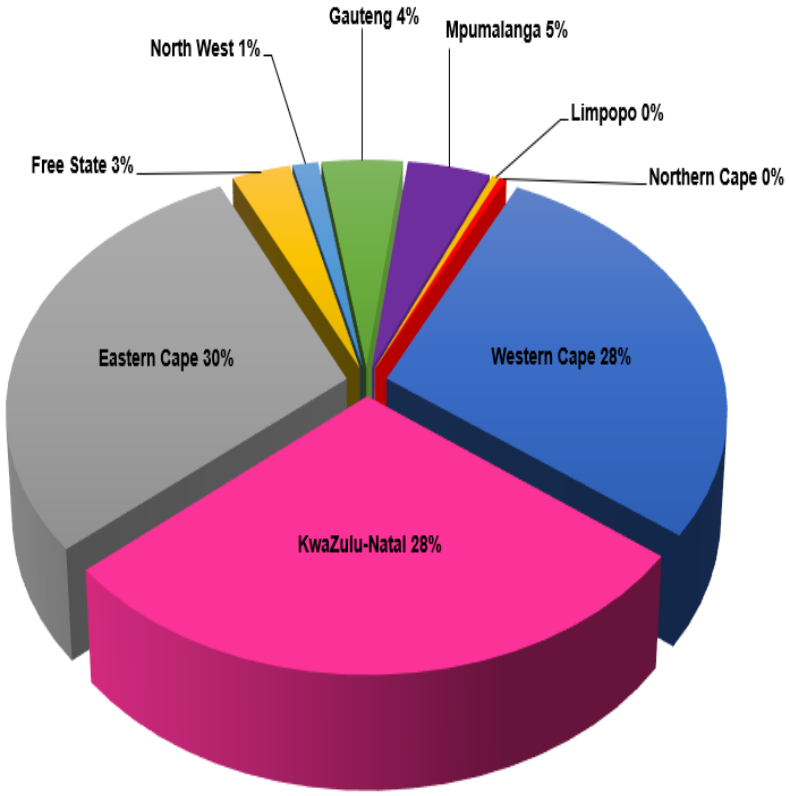


Figure 2.2: Number of dairy farmers per province in South Africa as at January 2025

Source: MPO (2025:21)

As shown in figure 2.2, the majority (86%) of dairy farms in South Africa are concentrated in the coastal provinces (Western and Eastern Cape and KwaZulu-Natal) where there is normally higher precipitation than in the arid interior, allowing for pasture-based grazing (MPO 2025:21). To protect South Africa's scarce water resources, the government legislated the agriculture sector to take responsibility for water conservation by installing water meters at farmers' own cost by March 2021 (MPO 2021:1). Farmers were urged not to see this as a disadvantage, since the meters can be used to track water usage for value chain reporting, to verify whether water-saving initiatives are working, and to encourage water stewardship (Phillips 2020:2). According to Dairy New Zealand, the most effective way of monitoring water consumption is to install water meters which can also detect water leaks and losses on the farm (DairyNZ nd:1). In addition, there is an opportunity for local farmers to enhance their reputations and gain a competitive advantage if they promote advanced water management and transparent water reporting in the future.

Water stewardship, which is a fundamental element of sustainable farming (SAI 2015:1), should be reported on. The Trace and Save System was developed for any soil-based form of agriculture, to advance water stewardship. It is a sustainability analysis platform combined with a management system and online platform that tracks, measures and reports at farm level on sustainability, allowing farmers to track indicators pertaining to sustainability on their farms in exchange for advice on how to become more sustainable (WWF-SA 2021b:5). The indicators measured in the Trace and Save System include soil, water, atmosphere and nutrients (SWAN), which include soil health, water management, CO_2 gas emissions, nutrient management, biodiversity conservation, and human and animal welfare (WWF-SA 2021b:6). The WWF-SA report (2021b:8) refers to a collaborative case study in which all farmers who supply milk to Woodlands Dairy (a processor in the Eastern Cape) were required to adopt the Trace and Save System. Notably, the case study undertaken by WWF-SA excluded the water management component, since the data reported over eight years were approximate figures. One of the recommendations was that farmers install water meters for more accurate water usage reporting in the future. This will hopefully be corrected under the government's initiative which mandates the installation of water meters on farms, yet it might conceivably lead to farmers having to pay taxes on their water usage. The primary goal of water stewardship is sustainability, and through innovation, sustainability can be advanced without excessive additional costs (Ingildsen 2020:57). The premise of frugal innovation is "doing better with less" (Radjou & Prabhu 2016:12).

2.5 FRUGAL INNOVATION THEORY

One of the most important elements of the research process is the theoretical framework, which acts as a "blueprint" for the entire thesis (Grant & Osanloo 2014:13). Frugal innovation is a theory that centres on satisfying the needs of more people, using significantly fewer resources (Prabhu 2017:3). It promotes the redesign of products so they require fewer inputs yet deliver optimal use, without depleting Earth's resources and causing an environmental breakdown (Radjou & Prabhu 2016:12; Prabhu 2017:3). Importantly, frugal innovation is not just about redesigning products, it is also about reassessing organisational processes and business models in their totality (Sarkar & Mateus 2022:3). It assumes that resource scarcity should not be an obstacle to innovation, but rather promote opportunities and efficiencies (Bhatti et al 2018:14), by focusing on improving the operations of not only the target

organisation but also the various stakeholders interacting with it along its value chain (Prabhu 2017:5).

Frugal innovation is focused on being environmentally and socially sustainable, being sufficiently comprehensive to scrutinise processes around both supply (production) and demand (consumption). It involves examining developing and developed countries alike, to bring about innovative change by concentrating on large organisations and smaller start-ups, as it seeks to address the changing needs of consumers (Prabhu 2017:6-7). Many innovations emerge where inventors draw inspiration from other innovations (March & Simon 1993:210). For example, frugal innovation can draw from institutional, social or technological innovations, to provide a lens through which today's so-called "grand challenges" (e.g., water scarcity and climate change) can be viewed (Ahuja & Chan 2016:10; Bhatti & Prabhu 2019:358). The three key dimensions of frugal innovation theory, namely social, institutional, and technological innovation as proposed by Bhatti et al. (2018:109), were chosen as the theoretical lens for this study, given their applicability to addressing water reporting challenges in the South African dairy industry's upstream value chain. The next section explains how frugal innovation emerges from the synergy between social, institutional and technological innovation (Bhatti et al 2018:109).

2.5.1 Social innovation

Social innovation focuses on new innovations that address those social problems which count amongst the grand challenges of our time (Bhatti & Prabhu 2019:354). Also known as "wicked problems" (Rittel & Webber 1973:160), water scarcity and climate change are primary amongst the environmental issues, presenting social dilemmas too (Cerutti 2017:156). Social innovation involves not just the development of novel products and services, but also the establishment of new social collaborations aimed at addressing societal needs (Murray, Caulier-Grice & Mulgan 2010:3). Organisational ecosystems are social collectives in which participants work together to overcome institutional deficiencies and resource constraints (Ahuja & Chan 2016:2). Social innovation can be improved by an emerging innovation model such as frugal innovation (Bhatti & Prabhu 2019:354). When viewed against a frugal backdrop, social innovation is expected to go beyond mere corporate social responsibility (Radjou & Prabhu 2014:82) to where social purpose is at the heart of an organisation's

strategy (Radjou & Prabhu 2014:82). Figure 2.3 demonstrates the social collectives in social innovation.

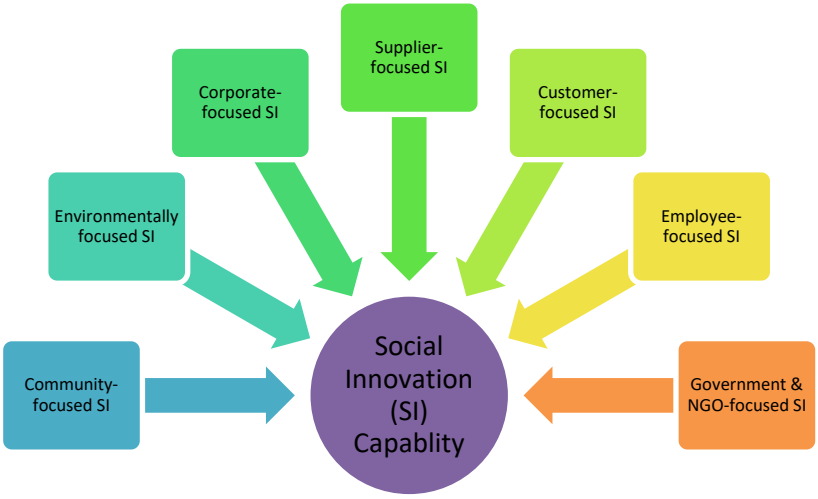


Figure 2.3: Social innovation capability and its dimensions

Source: Adapted from Orlitzky, Louche, Gond and Chapple (2017:36)

Looking at figure 2.3, community-focused social innovation relates to the local communities in which an organisation operates, or a region or nation that could be affected by its operations and actions; environmentally focused social innovation relates to the organisation's responsibility to the environment, in the form of reduced use and limited harm to resources and the environment; corporate-focused social innovation refers to good corporate governance; and supplier-focused social innovation relates to the organisation's outsourcing policies, transparency and traceability in the value chain. Customer-focused social innovation relates to satisfying customer needs by providing quality products that are affordable, whereas employee-focused social innovation pertains to the organisation's responsibility to prioritise health and safety, diversity, etc. Government and NGO-focused social innovation relates to the organisation building relationships with local and foreign governments, and private and public bodies (Orlitzky et al 2017:36). It is therefore apparent that social innovation relies on the ability to bring together the diverse knowledge and resources of participants who have different objectives and belong to a range of organisations (Crespin-Mazet, Goglio-Primard & Grenier 2017:35).

Social innovation can meet social needs while also conserving natural resources. Examples include the Tata Swach and the Unilever Pureit Classic – devices that purify water for

households without electricity or running water (Levänen, Hossain, Lyytinen, Hyvärinen & Numminen 2015:5). Another example is a project launched in China to address small-scale rural farmers' lack of easy entry into markets through innovation hubs (Huang & Tsai 2021:3). In that project, the first step was to develop an online platform where small-scale farmers could directly market their products to urban buyers. A farmer–consumer exchange platform was created to develop trust and engagement, and a farmer–technical specialist app was developed to effect instant communication in support of farmers during their production and distribution activities (Huang & Tsai 2021:3). These examples are illustrative of social, institutional and technological innovation intersecting in what is known as frugal innovation (Bhatti et al 2018:109).

2.5.2 Institutional innovation

In the past, large organisations benefited from manufacturing great quantities of a product, with the aim of reducing costs and improving margins, in what is known as "scalable efficiency", however the downside of this was their inability to effect rapid change or try new approaches (Hagel & Brown 2013:2). The pace of change has been exacerbated by the adoption of new digital technologies, and success is no longer quantified by scale – instead it is measured by the potential to learn more rapidly, with institutional innovation requiring a new philosophy of "scalable learning" – something which has resulted in smarter organisations flourishing in our rapidly changing world (Hagel & Brown 2013:8). Institutional innovation can include change in an existing organisation, or the creation of an entirely new entity (Raffaelli & Glynn 2013:4).

Bhatti et al (2018:126) insist that for institutions to bring about change and for innovation to occur, infrastructure must be in place for a market to exist, to establish prices, communicate with customers and suppliers, and arrange distribution channels. For entrepreneurs to create radical new technologies, they must engage with others in collective action to establish organisations such as Ebay, which has changed how society trades by allowing people to sell their unwanted second-hand goods online and connecting people in a convenient way (Bhatti et al 2018:126). In the agriculture sector, institutional innovation has prompted the formation of associations, groups or cooperatives which can help small farmers manage a range of constraints, for example, through collective investments to purchase agricultural equipment (FAO 2012:4).

By ensuring transparent and equitable law enforcement, policymakers can build trust and reduce the risk of unintended consequences such as organisational inefficiency or the abuse of power (Muller 2020:31-32).

2.5.3 Technological innovation

One of the key principles of frugal innovation is simple, easily sourced and abundantly available technologies (Sharma & Iyer 2012:601). Due to the availability of new digital technologies, many products and services can be frugally made, instead of necessitating significant investments in hardware, much of which can be replaced with software – applications (apps) being installed on smartphones is one example (Leliveld & Knorringa 2018:9). Apps facilitate the distribution of more affordable products and services to lower-income groups living in remote areas. As Ahuja and Chan (2016:2) argue, technological innovation takes on a pivotal role in frugal innovation, despite its success being dependent upon a number of environmental role-players: not just the organisation in question, but also its suppliers, customers, government, service providers, logistics, alliance partners and even it competitors. This demonstrates the overlap between social and technological innovation.

Innovation in technology can assist the agricultural and agro-processing value chains: for example, blockchain technology can ensure the real-time traceability of products to enhance the transparency of suppliers across the value chain, while allowing emerging and small farmers to participate in that value chain exactly because technologies succeed in lowering barriers to entry (Das Nair & Landani 2020:1). Other examples given by these authors (Das Nair & Landani 2020:17) include breeding technologies (e.g., gene editing) that allows fruit and vegetables to adjust to climate change, increasing their resistance to pests and diseases while improving their yields on the same land, yet requiring fewer inputs such as water, fertilisers and chemicals. Farmers are progressively using agricultural robots (agbots) for harvesting, picking fruit, soil maintenance, ploughing/weeding, planting and irrigation at the processing stage, while production and packaging are also being automated. In dairy farming, feed technologies are assisting farmers to ensure yields of good-quality milk (McGlynn & Walters 2019:944).

Irrigation technology uptake and precision farming are increasing due to water scarcity and uncertain weather conditions; crop sensors are being used to apply the correct amounts of

irrigation and fertiliser, while drones are being used to view crop health across the farm (Das Nair & Landani 2020:17). The standard “farmgate” price (the price the processor pays for raw milk delivered to their factory door) has increased over the past decade, yet the cost of milk production for the farmer has witnessed a much steeper increase, albeit that technology can assist in reducing man-hours and improving efficiency (Open Dairy 2021:3). The Open Dairy report (2021:6) proposes that by inventing new technologies and sharing knowledge, stakeholders can speed up the sustainability of dairy production, specifically in developing countries. Numerous technologies can be adopted to mitigate against the risks connected to climate change (such as water scarcity) (Bucci, Bentivoglio & Finco 2018:3). Frugal innovation and technology transformation can facilitate the achievement of “affordable green excellence” (Tiwari 2021:273), which confirms the significance of technology-enabled innovation for environmental development (Van Tuijl, Zambrano & Knorringa 2024:3)

2.6 CORPORATE WATER-RELATED RISKS

The WEF’s 2022 *Global Risk Report* identifies the top 10 risks deemed to pose the most severe threat on a global scale, over the coming decade. Of the top 10, half of the risks identified relate to the environment, while worryingly the top three risks – in order of severity – are climate action failure, extreme weather and biodiversity loss, which all have a direct influence on water and the availability thereof. Human environmental damage ranks in seventh place, notably because as the global population increases, so does the impact on the environment; eighth on the list is natural resource crises, both of these issues being water-related (WEF 2022:14).

Focusing on water-related risks is fundamental to organisations. Such risks include, amongst others, water scarcity, flooding, drought, poor water quality and infrastructure decay (James & Linstead 2018:7). Where an organisation’s assets and value chain are situated, the nature of its operations and how it manages its water, are all factors which can all exacerbate water-related risks (Granzo, Morgan & Shahyari 2019:4). It is essential to evaluate an organisation’s water dependency, water risk vulnerability and capacity to respond or adapt, according to Granzo et al (2019:4). Water-related risks take on three inter-related forms, namely physical, regulatory and reputational risks, or they can be divided into two classifications, namely basin-related and operational-related risks (more on these below), with a significant financial impact (James & Linstead 2018:7). Figure 2.4 displays the different types of risks.

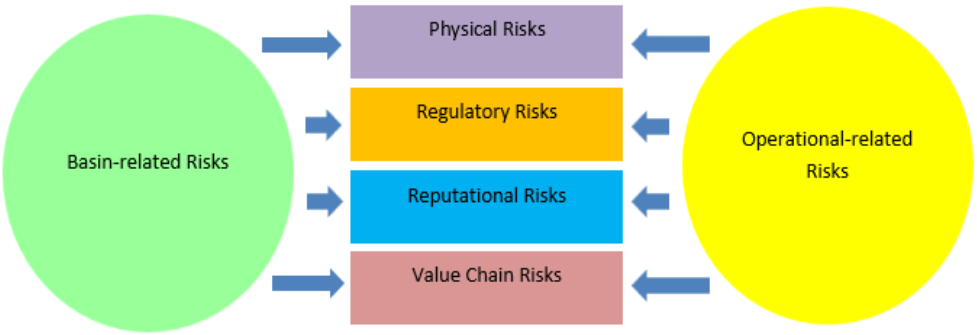


Figure 2.4: Types of water risks

Source: Adapted from WWF (2013:11)

Basin-related risk refers to the watershed/river basin from which the organisation sources its water. Since it is linked to a location, these risks cannot be addressed by making changes in the organisation's operations (Schulte & Morrison 2014:5). Operational-related risks, by contrast, are a consequence of how the organisation and its suppliers operate, thus they are linked to behaviour (Schulte & Morrison 2014:5). Both basin- and operational-related risks can be either physical, regulatory, reputational or value chain-related (or a combination of these). Physical risks refer to differences in the flow, quality or accessibility of water, that have a direct impact on the operations of an organisation (Morgan & Orr 2015:18). Operations in water-stressed regions might see assets becoming stranded temporarily or even permanently, for instance falling groundwater levels in Germany and prolonged droughts have delayed (or may even stop) automaker Tesla's $5.7 billion project in Brandenburg (Federal Office for the Environment [FOEN] 2022:4).

Regulatory risks, which relate to government legislation, include the laws and policies an organisation needs to adhere to, in order to retain its legal licence to operate. Failure to adhere to regulations could see the organisation receiving fines and/or penalties, and even losing access to water, which could result in operations being suspended or not getting off the ground at all (Morgan & Orr 2015:18). If governments do not enforce laws or regulate fairly, it can open the door to corruption and create barriers for organisations (Muller 2020:41). Clearly, regulatory risk will be unusually high where organisations cannot forecast adherence to, or the enforcement of, laws, regulations and policies (Granzo et al 2019:10).

Reputational risks are particularly prevalent in regions that are water scarce or where water sources are polluted, compelling organisations to contend with other entities and local communities for water (Granzo et al 2019:12). A pertinent example is that of Coke and Pepsi, beverage makers which were accused of abusing groundwater resources in the Indian state of Tamil Nadu in 2017, prompting consumers and retailers in the region to stop buying their products. Younger consumers – especially millennials born post-1982 (Howe & Strauss 2000:4) – tend to understand that their actions have environmental consequences, hence they are socially aware and motivated to work towards achieving greater sustainability (Naderi & Van Steenburg 2018:290). An organisation's reputation may thus be severely affected by its environmental and water stewardship.

The researcher adapted figure 2.4 by including value chain risks which can occur due to complex value chains being dispersed across the globe in remote locations, where the focal organisation and its suppliers do not have collaborative technologies, thus making monitoring and nurturing supplier relationships difficult, with disastrous consequences (Wilhelm, Blome, Bhakoo & Paulraj 2016:42). An example is in 2007, when the toy manufacturer Mattel had to recall toys that were coated with hazardous paint, and the source was found to be a subcontractor of Mattel's first-tier supplier (Hora, Bapuji & Roth 2011:767). The multi-tiered nature of many value chains diminishes the influence and visibility of the focal organisation, nonetheless, where a tier 1 supplier is the main supplier to the focal organisation, many of those suppliers source their materials/components from tier 2 suppliers, making them a critical link in the value chain (Weissman 2016:2). As Weissman (2016:2) explains, below tier 3 the supply network escalates into a maze of global tier X suppliers, that is a breeding ground for value chain risks.

One of the key findings contained in the 2020 CDP Global Water Report, is that the possible monetary impact of water-related risks is more than five times greater than the cost of addressing them (CDP Global Water Report 2020:12) (which may have been the case in the Coke, Pepsi and Mattel examples). Water risks have direct and significant financial impacts, for example, in times of drought production volumes could be reduced, while flooding could cause operations to shut down (Granzo et al 2019:12). An organisation's first response is to recognise water risks in its direct operations, making it clear that its value chain water risks are far more vulnerable than expected, with the extent of their vulnerability being much more challenging to assess (Pegram, Orr & Williams 2009:25).

Water scarcity is a localised problem. It is highly geographical and, as a result, should be addressed in a focused way. Organisations need not address water use across every region in which they or their value chain operate, they only need to focus their attention where water basins are water stressed or projected to become water stressed (Hundertmark, Lueck & Packer 2020:4). Water risks are global and complex, and no single public or private organisation can establish a water-secure future – the best it can hope for, is a collective water stewardship approach aimed at mitigating water-related risks (WWF 2013:9)

2.7 CORPORATE WATER STEWARDSHIP

There are a number of definitions for water stewardship, which can be described as the responsible management and future forecasting of water resources (Jones, Hillier & Comfort 2015:273). The WWF (2013:1) defines corporate water stewardship as

> a progression of increased improvement of water use and a reduction in the water-related impacts of internal and value chain operations. More importantly, it is a commitment to the sustainable management of shared water resources in the public interest through collective action with other businesses, governments, NGOs and communities.

Water stewardship opens the door for corporates to understand water-related risks and the need for a long-term strategy, by bringing organisations face to face with other water users and policy makers, to make a positive contribution to water security (Orr & Sarni 2015:19). Water stewardship calls for an appreciation that water is a strategic and key business issue that is significant for long-term opportunities, growth and profit (WWF 2013:9).

The global Alliance for Water Stewardship (AWS), founded in 2009 with the goal of promoting water stewardship mainly through an internationally accepted water stewardship standard, identifies five steps in establishing and maintaining a continual improvement cycle (WWF 2014:1; AWS 2019:6). Step 1 involves gathering and understanding data on shared water problems; step 2 calls on entities to commit and plan by developing a water stewardship plan; step 3 involves implementing the organisational plan; step 4 evaluates performance against the plan; and step 5 communicates and discloses the organisation's actions (AWS 2020:6-39). The AWS report (AWS 2017:2) claims that if organisations follow these five steps it will

deliver positive outcomes such as improved water governance and water quality, sustainable water balance, safe water, sanitation and hygiene for all. All these outcomes align with the targets of SDG 6 (AWS 2022b:5). In addition, the AWS has devised 28 monitoring and evaluation indicators (AWS 2022a:1) and while none of them specifically mention the value chain, the AWS's 2022–2030 strategic document highlights three strategic priorities: the adoption of the AWS standard in value chain hubs, ensuring commitment to value chain hubs and continually advancing knowledge for stewardship in those hubs (AWS 2022b:2). The AWS standard serves as a universal metric for organisations wanting to take the initiative in water stewardship, in addition to being a legitimate external auditing certification strategy (Bulcke, Vionnet, Vousvouras & Weder 2020:249).

Nestlé, the largest multinational food and beverage company in the world, is an AWS member, with 403 factories in 84 countries ((Galli & Vousvouras 2020:1097-1098). As a global leader in water stewardship, Nestlé advocates for a more outward-facing approach, noting that projects outside the factory gates tend to offer a higher return on investment in terms of cubic metres of water saved (Galli & Vousvouras 2020:1097-1098). Furthermore, Nestlé runs a Farmer Connect programme, where the company works directly with more than 550 000 farmers worldwide to assist with issues such as the effects of climate change and how to implement sustainable farming methods. Nestlé recognises that water is essential to its operations, and by the end of the period 2010–2019, the company had reduced its overall water withdrawal per tonne of product by 31 per cent (Nestlé 2019:42). Mars, a multinational producer of pet food, other food products and confectionery, is also a member of AWS and it assists rice farmers by introducing effective irrigation methods, specifically a wet–dry system that is anticipated to reduce water consumption by just less than a third (CDP Global Water 2020:26). In similar vein, the WWF developed a water stewardship ladder (see figure 2.5) that organisations can use to better comprehend water-related activities.

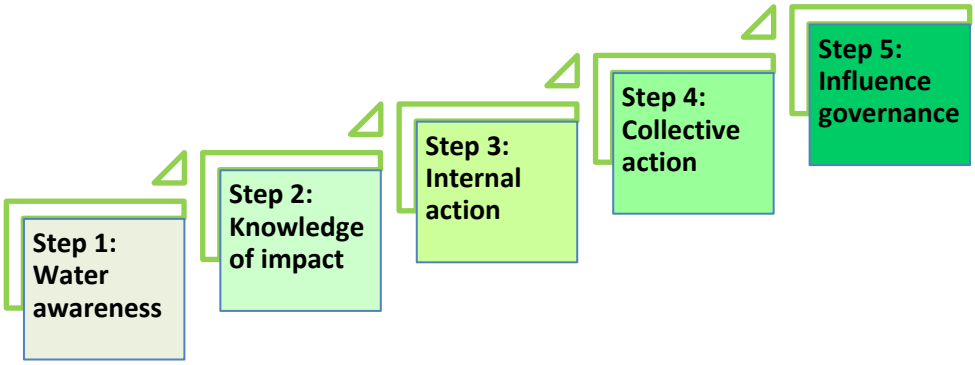


Figure 2.5: Water stewardship steps

Source: WWF (2013:14)

The steps in the WWF's water stewardship ladder, depicted in figure 2.5, entail the following:
Step 1 – Water awareness is where organisations and their value chain gain a high level of awareness of world-wide water problems and the extent of their dependence on freshwater.
Step 2 – Knowledge of impact is related to organisations having a comprehensive understanding of the impact they and their value chain have on water sources.
These first two steps are important before taking internal action (Step 3) and require companies to "get their house in order" by improving water efficiency and reducing water pollution.
Step 4 – Collective action calls on stakeholders, organisations, governments, NGOs and communities to engage and work together collectively to manage water-related issues.
Step 5 – Influence governance requires governments to be galvanised and encouraged to invest and take control of water basins, by adopting a sustainable strategy.

In South Africa, several water stewardship partnerships are currently in effect. One such initiative is the Breede Water Stewardship Project in the Western Cape, which involves a number of private and public organisations (Schachtschneider 2016:3). The Breede catchment was identified as a "water risk hotspot", bringing together farmers and local authorities who initiate water stewardship activities, such as farmers clearing IAPs, an online web tool to link farmers to provide guidance on the AWS Standard, and so on (Schachtschneider 2016:3-4). This project evolved into the Breede-Gouritz Catchment Management Agency (CMA) and having extended into other areas, it is now called the Breede-Olifants CMA and incorporates the Berg-Olifants water management area (Breede-

Olifants CMA 2024:4). Another water stewardship initiative between public and private organisations is the uMhlathuze Water Stewardship Partnership (UwaSP) Partners Platform (Gautier 2019:6), started in 2015 and formalised in 2016. This innovative multi-stakeholder partnership is donor funded to improve water security and mitigate water scarcity impacts on the north-eastern coast of KwaZulu-Natal (Gautier 2019:6). This programme is ongoing, because uMhlathuze is a high-risk catchment area (WWF-SA 2025:1). Water stewardship is an all-inclusive approach that calls for an analysis of the sustainability of water usage throughout the whole value chain (Hoekstra 2017:80).

2.8 VALUE CHAIN ENGAGEMENT

Over the past few decades, multinational organisations have increasingly embarked on outsourcing services and operations to third parties in developing and low-income countries (where labour and manufacturing costs are lower than in developed countries), and this has given rise to large and complex value chains that stretch across the globe (Muñoz-Torres, Fernández-Izquierdo, Rivera-Lirio, Ferrero-Ferrero & Escrig-Olmedo et al 2018:3). With the aim of having a transparent value chain, value chain engagement is imperative (Brun, Karaosman & Barresi 2020:6). Value chain engagement is dependent on the extent to which the focal organisation works with other core stakeholders in its value chain to manage various sustainability and social issues. The exchange of accurate information is essential for engagement as well as collaboration between value chain partners (Dahlmann & Roehrich 2019:1633). It has become increasingly evident that no organisation is more sustainable than its value chain (Krause, Vachon & Klassen 2009:18).

Value chain engagement and collaboration drive change, which in turn encourages the development of innovations that could lead to enhanced sustainability (Dahlmann & Roehrich 2019:1633). The Dahlmann and Roehrich (2019:1639) study identified three levels of value chain engagement, namely basic, transactional and collaborative. Basic engagement reflects the minimum information required by the focal organisation, motivated by a customer requesting the information or the focal organisation deciding to gather environmental data – a method which is considered reactive and short term. Transactional engagement is more proactive on the part of the focal organisation, once it seeks to calculate its carbon or water footprint and/or to drive environmental performance initiatives in the value chain by setting targets. The collaborative engagement approach includes upstream (see section 2.8.1) and

downstream (see section 2.8.2) partners; it is relational, based on shared value, forward-looking, proactive and long-term. Such collaborations react to environmental issues like climate change and water scarcity to drive new product and process innovations, thereby creating a competitive advantage or barriers to entry into their particular market (Porter & Van der Linde 1995:107; Dahlmann & Roehrich 2019:1639-1643).

When considering value chain resilience, water is not the first thing an organisation takes into account, although it should be top priority. It is fundamental for organisations to exert their influence on their suppliers and the suppliers of their suppliers, in order to reduce water stress (Hundertmark et al 2020:5). Once an organisation has defined its value chain, it is sensible to further classify the value chain into upstream (related to suppliers) and downstream (related to the movement of finished goods from the organisation to its customers) (Dobson & Morgan 2021:13).

2.8.1 Upstream value chain

The upstream value chain encompasses those activities that are closely associated with the exploitation of natural resources, and the outputs are primary products or raw materials (Singer & Donoso 2008:669). An example would be raw milk that has not undergone any processing. The upstream value chain, for dairy processors such as Nestlé and Clover, starts at the dairy farmers. According to ProCon.org (2020:1-7) the upstream dairy process is as follows: milk is collected from cows twice a day, then pumped through stainless steel pipes into refrigerated bulk tanks which quickly cool the milk. Milk trucks usually visit dairy farms on a daily basis, however, depending on the size of the farm it could be several times a day. The milk truck driver, a licensed milk grader, is the link between the farm and the dairy processor. The milk that is collected is tested before being loaded into special stainless-steel tankers, to ensure that the quality is acceptable for collection. The driver collects samples of each farm pickup, and tests the milk again once it arrives at the dairy processor's factory. A sample is tested by the processor's laboratory, before being off-loaded. After the milk has been collected, all the storage tanks and pipes on the farm are thoroughly cleaned (before milking is done again), as are the tankers on the collection trucks before the next load is collected. Having a value chain which functions smoothly is imperative, both locally and internationally, due to the perishable nature of milk and dairy products (OECD & FAO 2020:177). Although this study focuses on the upstream value chain, which only includes dairy farmers and dairy processors, the dairy industry's downstream value chain will also be discussed here.

2.8.2 Downstream value chain

The downstream value chain encompasses all activities that enhance the value of a product through manufacturing or modification (i.e., the end product distributed to the customer) (Singer & Donoso 2008:669). Once the milk has been approved by the dairy processor it is pumped into their storage tanks to undergo pasteurisation, homogenisation, separation and any other additional processing, for example, the manufacturing of long-life milk, cheese, butter and yoghurt (ProCon.org 2020:5). The processed dairy product is then packaged, an expiry date is stamped on it and the item is finally ready for the end customer (ProCon.org 2020:6). The downstream value chain, which starts once the product leaves the processor's factory, comprises distributors, wholesalers, retailers and customers (outside of the scope of this study).

Both up- and downstream actors are required to work in a collaborative fashion to ensure the sustainability of the value chain – from the production of raw materials to the recovery or recycling in an environmentally responsible manner, to the final product after its use (Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety 2017:6). One of the most important topics in the field of value chain management is sustainability, therefore organisations are increasingly taking related issues into consideration in their short- and long-term strategies (Motevali Haghighi, Torabi & Ghasemi 2016:581).

2.9 SUSTAINABLE VALUE CHAIN MANAGEMENT (SVCM)

The concept of a modern value chain has become fundamentally associated with an organisation's care for the environment and its commitment to sustainable development (Zimon, Tyan & Sroufe 2020:219). A sustainable value chain is no longer a "nice to have" – stakeholders demand action as the planet's ability to keep replenishing natural resources is not infinite, and the inevitable outcome is that social and environmental performance is equally as important as (or even more important than) economic performance (Pagell & Shevchenko 2014:45). As Yang, Movahedipour, Zeng, Xiaoguang and Wang (2017:4) found, in traditional value chain management it is a challenge to adopt sustainable concepts. A number of critical success factors were found to be evident in organisations that successfully adopted a sustainable value chain: top management commitment and support; a strong culture of ethics in the organisation; a rapid return on (sustainable) investment; endorsement by customers; the participation and cooperation of suppliers; pressure by government and

NGOs; organisational competitiveness and a “no fear of failure” attitude; and the efficient measurement, monitoring and sharing of good-quality information through comprehensive reporting (Yang et al 2017:4).

The Federal ministry for the Environment, Nature Conservation, Building and Nuclear Safety in Germany developed a seven-step process outlining how an organisation can gradually introduce SVCM. Figure 2.6 gives a graphic depiction of this.

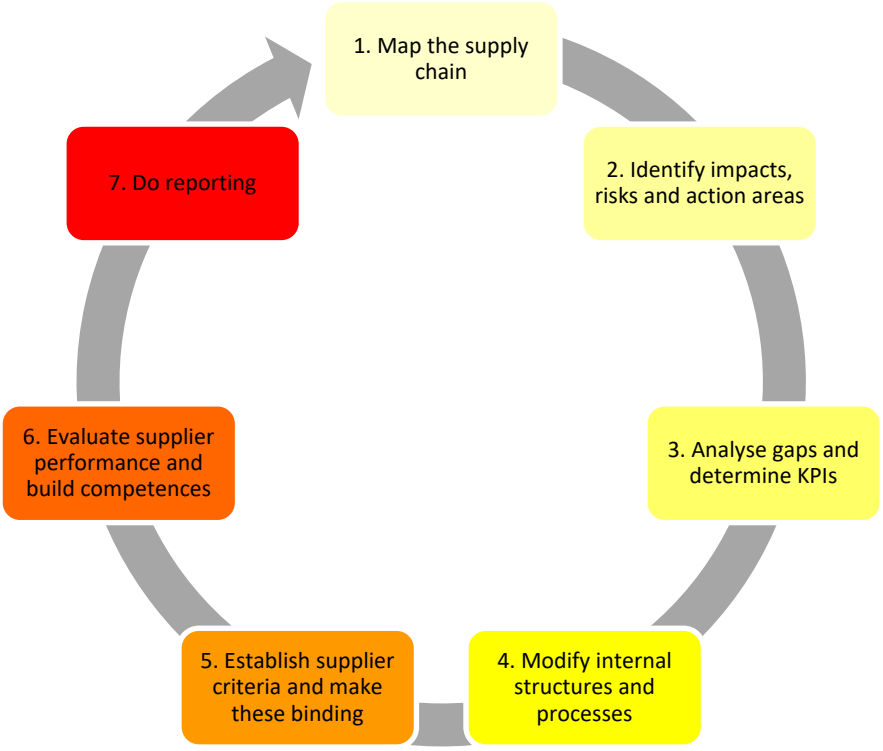


Figure 2.6: Process steps of SVCM

Source: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (2017:6)

The process depicted in figure 2.6 reflects a journey, not a race. It starts by mapping the whole end-to-end value chain, taking an aerial view and using internal and external information. Step 2 involves identifying sustainability issues along the value chain, to determine potential impacts on the environment and who would be affected. The organisation should assess related risks and prioritise them by preparing a materiality analysis. Discussions, surveys, document analyses, dialogues with NGOs and government, and a lifecycle assessment are all valuable techniques for analysing value chain impacts. Step 3 is

to undertake a gap analysis, comparing existing objectives, processes and measures that can be adapted within the new SVCM framework, then determining new measures (key performance indicators or KPIs) which should extend beyond direct suppliers. A new mission statement for a sustainable value chain should be developed. Step 4 calls for new business processes to be formulated and current processes to be adjusted; and for financial, human and technical resources need to be freed up. Building on existing processes and structures by integrating SVCM requirements will ensure a successful implementation. Step 5 is where the focal organisation needs to develop a code of conduct for its suppliers, stipulating communication and assessment requirements. The code of conduct must be included in the supplier contract, to guarantee that sustainability requirements are binding to direct suppliers and sub-suppliers. Step 6 involves evaluating the sustainability performance of suppliers. This calls for on-site audits and inspections (ISO 14000) and supplier self-assessments. Step 7 deals with the disclosure of information via reporting (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety 2017:6). This is usually done through sustainability reports, which should adhere to reporting standards and guidelines for organisations. Examples include the Global Reporting Initiative (GRI), the Sustainability Reporting Standards (SRS), and Environmental, Social and Governance (ESG) reports. These reporting standards and frameworks are discussed in Chapter 3.

One component of SVCM that has been subjected to increased scrutiny is value chain reporting, as a consequence of organisations extending their international supplier networks and outsourcing certain elements of their activities (Bayne, Ng & Wee 2022:3875). In a quest to establish a transparent value chain, the buying organisation’s preference would be to independently monitor the relationships of its upstream suppliers, but this is a complicated and complex undertaking, since those suppliers are more often than not globally dispersed, in remote locations and/or may not have access to synergistic technologies (Wilhelm et al 2016:42). These circumstances force a buyer organisation to lose control of the management of relationships further upstream in the value chain, which could have far-reaching consequences (Wilhelm et al 2016:42). An example of this is a recent exposé where Cadbury’s chocolate was produced using cacao grown by Ghanaian suppliers that use child labour (Ungoed-Thomas 2022:1). Organisations are increasingly being held accountable by their stakeholder groups for both environmental and social impacts in the organisation’s value chain (Bayne et al 2022:3).

SVCM in the agriculture sector has attracted particular interest over the years, for having mistakenly been deemed to negatively affect the environment, despite streamlining food production processes that the global population relies on, and providing employment and a steady income to many in the world's developing economies (Thompson & Amoroso 2011:3). Transparency and traceability in value chains are crucial where highly perishable foods such as dairy products are involved, as they are susceptible to rapid deterioration (Pant, Prakash & Farooquie 2015:386). However, it is important to consider the advantages for farmers who supply to entities with a sustainable value chain, as such contracts have the benefit of allowing them to receive sustainable pricing for their produce. Among the disadvantages are the fact that there are prescriptions on where they have to make investments on their farms – something which might make them feel they have lost control over their farms and evoke high levels of stress (Glover 2020:1821). Importantly, Glover (2020:1821) warns that if farmers fail to secure sustainable value chain contracts they run the risk of going bankrupt, as they will not be protected if there is a commodities milk price decrease, for instance. Through these contracts, producers and specifically retailers confirm their dominance by exerting further power and control over their suppliers, while improving their sustainability rankings (Glover 2020:1821). Nevertheless, the benefits of SVCM far outweigh the drawbacks: it increases product quality, as having an unreliable upstream supplier has the potential of an inferior product being supplied; that runs the risk of public scandals erupting, stakeholders earning a bad reputation and having to deal with long-term negative financial impacts (Weiss, Hajduk & Knopf 2017:7). Collaborating with suppliers can create innovative solutions, and transparency can be improved by adopting technology that grants consumers easy access to product information (Weiss et al 2017:7). Such collaborations and innovations are in line with the tenets of frugal innovation theory.

2.10 DIGITAL TECHNOLOGIES AND CORPORATE WATER REPORTING

Digital technologies grant real-time visibility into each part of the value chain, enabling organisations to respond much quicker to disruptions and proactively recognise risks. This communication framework of sharing information both up- and downstream in the value chain is called a digital thread (BDO Digital 2020:5). In the coming years, global agriculture will encounter a number of challenges in meeting the demand for food, meaning it will have to increase food production while using the same number of (or fewer) natural resources and without further polluting water, soil and other agroecology systems, and for that reason digital

farming is envisioned as a means of managing these challenges (Cole, Augustin, Robertson & Manners 2018:14). Rapid developments in digital technologies such as artificial intelligence (AI), big data analytics, and the Internet of Things (IoT) are driving a significant revolution in agriculture (Khwidzhilli & Ijatuyi 2026:1).

Digital technologies facilitate a more collaborative approach, which will motivate farmers to become more proactive in the overall monitoring process (OECD 2019:15). As the OECD report (2019:15) explains, the ease of using digital technologies to report on farm activities and environmental impacts may encourage a change in policy design. The adoption of digital technologies should not limit farmers but should continuously be monitored and evaluated on a cost/benefit basis.

In terms of sustainability reporting, blockchain technology has the ability to deliver reliable track-and-trace information related to water use and GHG emissions across the value chain (Bakarich, Castonguay & O'Brien 2020:408). Blockchain technology represents "a decentralised and distributed ledger technology, ensuring transparent and secure transaction recording across networks" (Bidry, Quaguid & Hanine 2023:1). Bakarich et al (2020:401) point out that blockchain technology would do away with the conventional silos that exist in value chains. It does, however, need to be integrated with other technologies, as illustrated in precision farming, where tools such as radio-frequency identification (RFID), near-field communication (NFC), bar codes and sensors are used to connect with a physical product. Every stage of the value chain, across the life span of the product, must be digitally labelled (Laaper, Fritzgerald, Quasney, Yeh & Basir 2017:9). For sufficiently detailed information to be stored in a cloud-based system, all stakeholders in the value chain must be registered in the blockchain system (Vp, Singh & Chauhan 2022:53). In 2019, Nestlé, in collaboration with OpenSC (a blockchain platform), piloted a programme to trace milk from farms in New Zealand to factories and warehouses in the Middle East, to provide Nestlé with information on how viable and scalable such a system is (Nestlé 2019:1).

There are notable drawbacks to digital technologies, for instance, a lack of connectivity on farms is the first obstacle to consider, as farm holdings are typically located in rural areas (Bacco, Barsocchi, Ferro, Gotta & Ruggeri 2019:1). Data privacy, security and the sharing of data are also of concern to farmers and others in the value chain (McFadden, Casalini & Antón 2022:3). There are more opportunities for hackers to gain access to value chain

partners' networks, which increases cyber security risks (BDO Digital 2020:9). As with most systems, the output is only as strong as the inputs, but given the development of complex value chains the end-reporting organisation would need to ensure that sustainability information is accurate by, for instance, incentivising performance through financial rewards (Bakarich et al 2020:404). The cost, time and expertise involved in providing such information could be a temporary drawback, but all parties in the value chain must be willing to invest, otherwise the focal organisation will have to assist (Bakarich et al 2020:406). If done correctly, the introduction of digital technologies to aid corporate water reporting will increase responsiveness, visibility and resilience across the entire value chain ecosystem (BDO Digital 2020:3). This aligns with initiatives associated with frugal innovation.

2.11 SUMMARY

The chapter started by describing the significance of water to the planet and its inhabitants. The importance of good water management in global water security, and the link between climate change and water as the principal way in which climate change is experienced, were communicated. The chapter focused on the centrality of water in meeting all the SDGs of the UN. Next, the focus fell on South Africa's water issues – from water scarcity to corruption in the sector, the loss of skilled water engineers and the fact that more than three million people in this country do not have access to clean water.

The chapter also described the dairy industry's impact on water scarcity at the global and local levels. The spotlight also fell on how frugal innovation, with its encompassing components of social, institutional and technological innovation, can assist with the increased demand for food despite using fewer resources. Another important aspect was discussed under the heading of corporate water-related risks.

The chapter dealt with water stewardship and its five-step process, as well as the imperative for value chain engagement. The researcher focused on the difference between the up- and downstream value chains, before discussing sustainable value chain management, and how digital technologies can assist with corporate water reporting.

The next chapter will discuss the latest developments in sustainability standard-setting boards, sustainability reporting frameworks and disclosure requirements such as the integrated reporting framework, South Africa's King Report on Corporate Governance, the

GRI and ESG factors. Corporate water-reporting frameworks will be reviewed and mapped with the specific goal of identifying whether provision is being made for value chain reporting.

CHAPTER 3: THEMATIC AREAS TO CONSIDER IN THE CONTEXT OF WATER REPORTING AND THE CONCEPTUAL FRAMEWORK

"The greatest threat to our planet
is the belief that someone else will save it" (Swan n.d.)

3.1 INTRODUCTION

In the preceding chapter, the global water crisis was discussed in some detail, highlighting that the challenge not only pertains to the quantity of the available water, but also the quality thereof, noting that water is central for achieving many of the SDGs. South Africa's own water situation, along with the global and local dairy industry's water-related issues, were discussed. The theoretical lens for this study, being frugal innovation and its three interlinked dimensions (social, institutional and technological innovation), was examined. Water risks, water stewardship, value chain engagement and digital technologies were also explored in Chapter 2.

The notion that the greatest threat to our planet is the conviction that someone else will save it, as Swan (n.d.) states, seems apropos when it is increasingly clear that, to successfully address water scarcity, all of society must collaborate and coordinate their efforts (United Nations Children's Fund [Unicef] 2021:16). As the demand for water increases, so it will become even more important to take into account how it is sourced and utilised (Chalmers & Godfrey 2012:13). Since water is a scarce resource, the need for corporate water reporting has grown out of a demand for sound information which will promote accountability and support decision-making (Chalmers & Godfrey 2012:13).

As a result of growing concerns around water scarcity, investors are increasingly expecting organisations to report not only on their own water-related risks, but also to include those of their suppliers, in addition to disclosing their progress in mitigating these risks in their annual reports (Schaefer, Udenio, Quinn & Fransoo 2019:637). Over the years a number of tools and frameworks have been designed to assist organisations with the various aspects of measuring and managing water-related risks (World Business Council for Sustainable Development and World Wide Fund for Nature [WBCSD & WWF] 2020:4). Admittedly, the

number of organisations reporting and using these tools and frameworks remains low (Schaefer et al 2019:637). The main aim of this study is to develop a corporate water-reporting framework for the upstream dairy industry. To achieve this, the current chapter will review the various reporting frameworks which are in use, specifically the water-reporting tools and decision frameworks, to ascertain whether they include the value chain in their focus (this being a secondary objective of the study). In so doing, the aim is to arrive at an initial conceptual framework.

This chapter offers an overview of developments in sustainability standard-setting boards, the International Integrated Reporting Framework (IIRF), and how that aligns with the SDGs. A review of disclosure initiatives, such as South Africa's King Report on Corporate Governance, the Global Reporting Initiative (GRI), Task Force Climate-Related Financial Disclosures (TCFD), and Environmental, Social and Governance (ESG) reporting will be conducted to ascertain whether water-related disclosures are included in their guidelines. Thereafter, several water-related tools and decision frameworks are evaluated and reviewed, to determine whether they include the value chain in their initiatives. The initial conceptual framework for this study will be introduced and explained, before the chapter concludes with a summary.

3.2 DEVELOPMENTS IN SUSTAINABILITY STANDARD-SETTING BOARDS

In November 2021, at the Conference of the Parties (COP) 26, the International Financial Reporting Standards (IFRS) foundation (2021:online) announced important advances that it believed would assist with the request by the International Organisation of Securities Commission (IOSCO) to provide consistent global sustainability-related disclosures. Those developments included the following:

- A new International Sustainability Standards Board (ISSB) would be formed to develop high-quality comprehensive sustainability disclosure standards. The ISSB will produce IFRS sustainability disclosure standards.
- In June 2021, the International Integrated Reporting Council (IIRC) and the Sustainable Accounting Standards Board (SASB) would merge to form the Value Reporting Foundation (VRF 2021:3).

- The publication of a prototype of climate and general disclosure requirements developed by the Technical Readiness Working Group (TRWG), constituted by the IFRS foundation. The mandate of the TRWG would be to consolidate all the core characteristics of the content of all the different boards into a set of unified recommendations, for analysis by the new ISSB.
- In March 2022, the exposure drafts of IFRS S1 General Requirements for Disclosure of Sustainability-related Financial Information and IFRS S2 Climate-related Disclosures was published for comment by 29 July 2022.
- In March 2022, the IFRS and the GRI communicated a collaborative agreement under their corresponding standard-setting boards, namely the ISSB and the Global Sustainability Standards Board (GSSB), aimed at coordinating their standard-setting and work processes (IFRS 2022:online).
- In June 2022, the VRF and Climate Disclosure Standards Board (CDSB) (an initiative of the CDP) were consolidated into the new ISSB (IFRS 2021:online).
- In June 2023, the ISSB released its first standards – IFRS S1 (General Requirements for Disclosure of Sustainability-related Financial Information) and IFRS S2 (Climate-related Disclosure). IFRS S1 and S2 are designed to be used in conjunction. These standards, which constitute a common language for reporting on climate-related risks and opportunities for organisations, came into effect on 1 January 2024 (Price Waterhouse Coopers [PWC] 2023:1).

The above changes have materialised due to the demand for high-quality, transparent, dependable and comparable reporting on the part of organisations, when it comes to climate and other ESG issues, by a growing number of international investors with global investment portfolios (ISSB 2022:5). The stated goal of the new ISSB is to provide a thorough, worldwide baseline of sustainability-related disclosure standards to inform investors and other capital market players about the sustainability-related risks and opportunities facing organisations, so as to enable them to make educated decisions (ISSB 2022:5). In addition, the vision of the IIRC (now part of the IFRS foundation) is to make integrated reporting and thinking the standard in both the public and private sectors, with a view to fostering better corporate conduct and capital allocation in support of a more efficient and sustainable global economy (Integrated Reporting 2021:2).

3.3 INTERNATIONAL INTEGRATED REPORTING COUNCIL

Investors, capital providers and stakeholders have an ever-increasing demand for information, transparency and accountability, as that will allow them to form a holistic view of a company's capacity to create value over the short, medium and long terms (Moolman, Oberholzer & Steyn 2016:601). EU directives, Johannesburg Stock Exchange (JSE) listing requirements and various other regulations governing corporate disclosures, coupled with the UN's SDGs, exert more pressure on companies to disclose the risks they face, and to indicate how they intend to create value in the future (Guthrie, Manes Rossi, Orelli & Nicolò 2020:1150). The IIRC responded to these requirements by issuing disclosure guidelines for the reporting of financial, non-financial and sustainability information in a single report, when it issued the first version of the IIRF in 2013 as a guideline (De Villiers & Hsiao 2018:13).

Integrated Reporting <IR> is an innovative form of corporate reporting (De Villiers, Rinaldi & Unerman 2014:1055). The IIRC (2021:10) defines an integrated report as "a concise communication about how an organisation's strategy, governance, performance and prospects, in the context of its external environment, lead to the creation, preservation or erosion of value over the short, medium and long term". The IIRC's core approach to integrated reporting is the concept of using various classifications to designate the type of capital involved, namely: financial capital (reserve of funds), manufactured capital (tangible objects), human capital (people skills), intellectual capital (knowledge-based intangibles), natural capital (environmental resources) and social capital (relationships with stakeholders) (Flower 2015:3). As Flower (2015:4) indicates, the IIRC's concepts of capitals not only include the organisation's capital but also that of society (i.e., the environment), therefore several of the types of capital included in integrated reports are not owned by an organisation. The IIRC's action of integrating multiple corporate reports into one, demonstrates how an entity can use the range of capitals in the value creation process across the entire value chain (IIRC 2013:26). The <IR> framework can be used to assist in raising awareness of the relationship between value creation and sustainable development (Adams 2017:10). As Adams (2017:12) explains, aligning organisational approaches to the SDGs and integrated reporting can serve to divert investments to increase value creation and enhance understanding of the effects which organisational operations have on sustainable development (see figure 3.1)

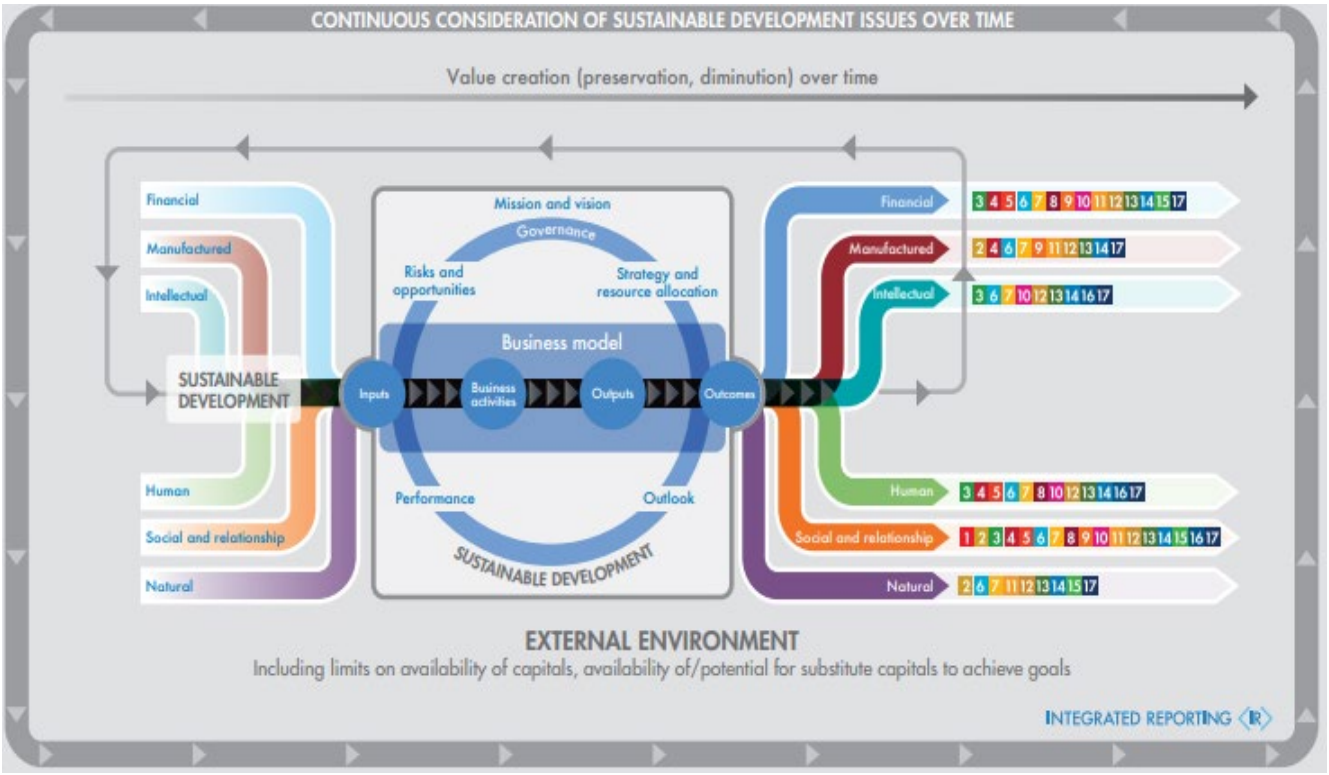


Figure 3.1: Aligning the SDGs with the value-creation process

Source: Adams (2017:14)

For the purpose of this study, the six types of capital of the IIRC are all deemed to apply to SDG 6 namely, “ensure availability and sustainable management of water and sanitation for all” (Adams 2017:14). Figure 3.1 depicts how an organisation requires inputs from the six capitals to conduct its activities to produce outputs, which in turn produce outcomes in terms of the six capitals. Notably, issues relating to sustainable development could limit one or more of the capitals. Adams (2017:22) further recommends using a framework consisting of five steps, to assist reporting organisations in contributing to the SDGs through <IR>. Step 1 – in the context of the organisation’s external environment, understand the sustainable development issues; step 2 – determine the materiality of the sustainable development issues that could influence value creation; step 3 – create strategies to support related and fundamental SDGs through the organisation’s business model; step 4 – develop integrated thinking, relationships with stakeholders and governance; and step 5 – prepare the integrated report.

Integrated reporting requires a sustainable change in organisations, through the application of innovation strategies that will help them to start taking into account the components of

sustainability (Barbieri, De Vasconcelos, De Andreassi & Vasconcelos 2010:147; Lombardi & Secundo 2020:1180; Dicuonzo, Donofrio, Ranaldo & Dell'Atti 2022:1193). Nestlé's zero water dairy factory, which opened in Mossel Bay in 2018, is an example of an innovative sustainability change (see section 2.7). There are a number of ways in which organisations can implement innovation, one of which is frugal innovation in dealing with a scarce resource (Hossain, Simula & Halme 2016:133). One such scarce resource, that relates to this study, is water.

The IIRC (2021:7) sets out seven guiding principles that should inform the content of an integrated report, namely: (1) be strategically focused and future orientated, (2) connect information that shows the full picture of how organisations will create value over time, (3) provide insights on stakeholder relationships, (4) contain material information, (5) be concise, (6) include reliable and complete information (whether good or bad), and (7) be consistent and comparable over time. The effectiveness of integrated reporting as a framework depends on an organisation's ability to embed integrated thinking, with such a report serving as the final output of the process (La Torre, Bernardi, Guthrie & Dumay 2019:26). La Torre et al (2019:30) expand on this by stating that integrated thinking is one of the central concepts – if not the core concept – of the IIRC's agenda. Importantly, integrated thinking takes into account how organisations adjust and adapt their business models and strategies to the risks and opportunities they encounter from the external environment (IIRC 2013:2). A study conducted by Botha, Oberholzer and Middelberg (2022b:272) concluded that integrated reporting and integrated thinking enhanced the water disclosures in the food, beverage and tobacco industries, when compared to traditional stand-alone sustainability reporting.

South Africa has long been acknowledged as a pioneer in championing corporate governance and integrated reporting, taking the lead in integrating sustainability issues into governance and corporate reporting by way of the King reports on corporate governance (Solomon & Maroun 2012:6; Malola & Maroun 2019:115; Steenkamp, Maroun, Padia & Ecim 2025:2). As with the <IR> framework, the King III report urges organisations to adopt integrated thinking, and promotes the principle that governance, strategy and sustainability are intertwined. (De Villiers et al 2014:1047).

3.4 KING REPORTS ON CORPORATE GOVERNANCE IN SOUTH AFRICA

The first King Report on Corporate Governance (King I) was published in 1994 by the Committee on Corporate Governance led by Mervyn King, before being updated in 2002 with the publication of King II (King 2020:124). The second report recommended that organisations produce sustainability reports by following the GRI guidelines, and this then became a requirement for listing on the JSE (King 2020:124). The third King report, which appeared in 2009, proposed integrated thinking and the production of an integrated report; this too became a JSE listing requirement, within an “apply or explain” governance framework (PWC 2009:6). King IV was issued in 2016, but the rule changed to “comply and explain”, requiring organisations to comply with 16 basic principles (King 2020:125). The King V draft, a revised and updated version of King IV, was open for public comment until 4 April 2025 (Institute of Directors South Africa [IoDSA] 2025:online).

Although King IV reaffirms sustained support for integrated reporting, it is not a requirement to prepare reports based on the IIRF (Deloitte 2016:16; Dumay, Bernardi, Guthrie & La Torre 2017:464; Botha 2019:32). King IV does, however, acknowledge and discuss sustainable development, without offering specific guidance or recommendations on the disclosure thereof (JSE Ltd 2022:1). The same can be said for the <IR> framework, which offers broad guidelines to adopters without providing specific indicators or disclosure matrixes, therefore organisations could use other reporting guidelines such as the GRI framework (De Villiers & Hsiao 2018:17). Notably, the JSE does offer sustainability disclosure guidance by recommending board oversight of sustainability-related risks, opportunities and impacts, and how these will and have affected the organisation’s strategy and management processes, in addition to suggesting that there be targets to measure and monitor these (JSE Ltd 2022:30). The JSE report (2022:3, 52, 54) points out that these disclosure guidelines are aligned with a comprehensive range of frameworks and standards. In particular, the disclosure guidance that links to this study on water security, is aligned with GRI 303: Water and Effluents, while the value chain disclosures are aligned with GRI 308: Supplier Environmental Assessment. The GRI initiative is discussed in the next section.

3.5 THE GLOBAL REPORTING INITIATIVE

The GRI, which is viewed as one of the most recognised standard-setting bodies for sustainability reporting, remains the standard or framework that is most commonly used globally (Threlfall, King, Shulman & Bartels 2020:25; De Villiers, La Torre & Molinari 2022:2). Spurred by the environmental destruction caused by the Exxon Valdez oil spill in Alaska, the GRI was founded in 1997 by joint collaboration between the Coalition for Environmentally Responsible Economies (CERES) and the UN Environmental Programme (Brown, De Jong & Lessidrenska 2009:187). In 2000, the first global sustainability reporting framework was published, entitled the GRI Guidelines (G1). These were updated to G2 in 2002, G3 in 2006 and G4 in 2013, however in 2016 the GRI shifted from providing guidelines to establishing the first international standards for sustainable reporting, which are updated on a regular basis (GRI 2022:online). Standards are imperative for establishing accountability in sustainability reporting (De Villiers et al 2022:743).

The GRI standards enable organisations to report the impact of their activities in a structured and transparent way, to all their stakeholders. These standards are a modular system consisting of three series (Zhou, Cao & Perzylo 2024:193): the first is the universal standard series, which applies to all organisations; GRI 1 outlines the requirements and principles when using the standards, GRI 2 deals with general disclosures, and GRI 3 focuses on material topics and management approaches (Adams, Alhamood, He, Tian & Wang et al 2022:27, 28). The second set is the sector programme series, envisaged to include 40–45 sectors, beginning with those with the greatest impact on the environment, GRI 11 Oil and Gas (effective 1 January 2023) and GRI 12 Coal (effective 1 January 2024) (GRI 2020:1, 5). GRI 13, Agriculture Aquaculture and Fishing (effective 1 January 2024) is applicable to this study (GRI 2022:2), while the GRI 14: Mining Sector 2024 standard will be effective from 1 January 2026 (GRI 2024:3)

The third set, the GRI topic standard series, consists of disclosures in respect of specific topics. The organisation selects a topic that is material to it, and then uses it for reporting (GRI 2021:4). GRI 200 topic-specific standards relate to economic issues, the GRI 300 series relates to environmental issues, and GRI 400 relates to social issues (GRI 2018:3). For example, GRI 303: Water and Effluents, relates to this study. GRI 303 of 2018 is set out as follows: Management approach disclosures, which include 303-1 Interactions with water as

a shared resource, and 303-2 Management of water discharge-related impacts (GRI 2018:5). As the GRI 303 report (2018:5) elaborates, topic-specific disclosures are: 303-3 Water withdrawal, 303-4 Water discharge and 303-5 Water consumption. Water withdrawals should provide a breakdown of the water withdrawn from the following sources: surface water, groundwater, seawater, produced water and third-party water (GRI 2018:11).

The 303 standard, which was updated in 2018, now recommends that the reporting organisation include water use across the value chain, which is defined in the standard's glossary as the full range, including both up- and downstream value chain activities (GRI 2018:21). Furthermore, the revised GRI 303 requires organisations to account separately for their water-related impact on water-stressed areas, through the explicit disclosures of water consumption, discharge and withdrawals in those areas (Hewawithana, Hazelton, Walkerden & Tello 2021:2). The revised standard recommends assessing which areas are water-stressed and proposes credible and publicly available tools to use, which include the WRI Aqueduct Water Risk Analysis and the WWF Water Risk Filter (Hewawithana et al 2021:4) (see section 3.8). On the whole, organisations that do report on water predominantly use the performance indicators set out in GRI 303 (Gibassier 2018:58).

Another example of the GRI 300 series is GRI 305 Emissions; as already established, GHG emissions are a major contributor to climate change (GRI 2016:4). Given the significant degree of uncertainty surrounding the timing and scope of water-related risks brought on by climate change, organisations are increasingly concerned about water risk impacts in both their own operations and their value chains (Laporte-Bisquit, Camargo & Morgan 2020:3). This has necessitated various national and international regulations and initiatives aimed at reducing and reporting on GHG emissions (GRI 2016:4), with one such initiative being the Task Force Climate-related Financial Disclosures (TCFDs), discussed below.

3.6 TASK FORCE CLIMATE-RELATED FINANCIAL DISCLOSURES

In 2015, the TCFD was set up by the Financial Stability Board (FSB), with the purpose of developing recommendations for more effective climate-related disclosures (TCFD 2022:6). The final recommendations were released in 2017, to assist organisations in making better investment, insurance underwriting and credit decisions, and to enable stakeholders to better understand their vulnerability to climate-related risks (TCFD 2022:6). TCFD guidelines are

based on four core areas related to how organisations operate, namely governance, strategy, risk management, and metrics and targets (TCFD 2017:iv). These four core areas are assisted by specific disclosures that organisations should incorporate in their reports, according to the TCFD (2022:18). The recommendations mention that organisations should include information on climate-related risks in their value chains (up- and downstream) that could impact their operations, financial planning and strategies (TCFD 2017:20, 64).

The TCFD report (2017:6) explains that the impact of climate change can pose physical risks to water availability and quality, and that organisations should disclose the metrics and targets used to assess and monitor risks such as excessive water consumption and pollution. The TCFD splits the risks resulting from climate change into either acute, driven by events (e.g., floods) or chronic risks (long-term adjustments in climate change, such as constant higher temperatures leading to droughts) (OECD 2018:10). For the TCFD, one way of assessing water-related risks is to undertake scenario analyses (Laporte-Bisquit et al 2020:4). To that end, the WWF Water Risk Filter (discussed in more detail in section 3.7.1.4) – an already prominent online tool for organisations and investors to address water risks – is now expanding to offer future-looking scenarios of water risks based on climate change, in line with TCFD recommendations. Further, a key strategy for managing and reducing the impacts of climate change and its risks is frugal innovation (Ismail et al 2021:693). Examples include carbon sequestration, efficiency improvements by reducing water use in production and closed-cycle manufacturing by recycling (Ismail et al 2021:700). In agriculture, carbon sequestration relies on farmer management practices to increase the quantity of carbon stored in soil, particularly in agricultural and grazing land (Paustian, Larson, Kent, Marx & Swan 2019:1). The demand for TCFD disclosures is significant, given the current upsurge in investment funds being environmentally focused, with both ESG and conventional investors increasingly prioritising organisations' resilience to climate change (Carney 2019:3, 8) and its related impact on water supply.

3.7 ENVIRONMENTAL, SOCIAL AND GOVERNANCE REPORTING

Prospective investors are increasingly using ESG factors to screen organisations for possible investment opportunities (Piu 2020:4). Corporate social responsibility (CSR) is a self-regulating business model whereby entities are seen to be aware of their impact on the wider society (Cook 2021:online) The ESG factors that organisations need to consider pertain to

environmental, social (their relationships with stakeholders) and governance (the organisation's leadership and internal controls) factors (Piu 2020:4). ESG as a concept was first used in a 2004 UN report "Who Cares, Wins", by Kofi Annan, then UN Secretary-General, who invited financial institutions to develop guidelines and recommendations on how to improve the integration of ESG into the business modules of various market actors (UNGC 2004:i). Figure 3.2 depicts those market actors (UNGC 2004:i-ii).

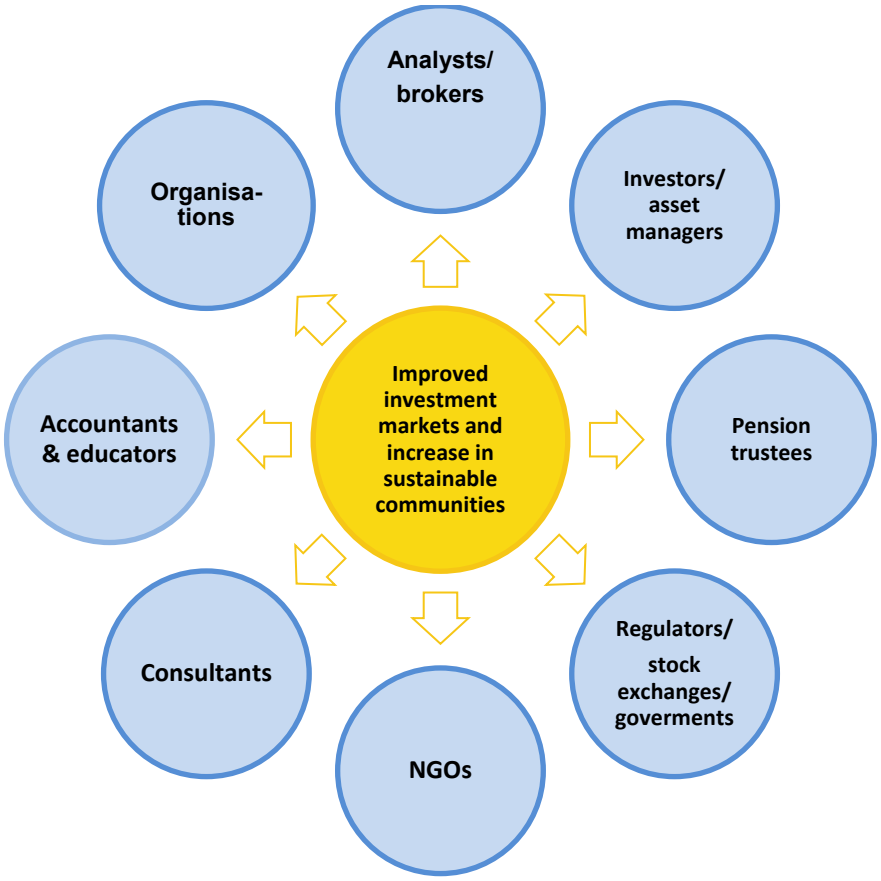


Figure 3.2: Market actors that should enhance the awareness of ESG elements

Source: UNGC (2004:v)

Although ESG factors are strategic in nature, change will only happen if all market actors (see figure 3.2) join in efforts to better understand and integrate ESG into their respective organisations. Importantly, each organisation should choose its own path, based on its structure and culture, as there is no single optimal solution (UNGC 2004:37).

The integration of ESG information into investment decisions has been a major development in financial markets in recent times (Christensen, Serafeim & Sikochi 2022:147). According to the Global Sustainable Investment Alliance (GSIA 2020:5), a key finding for 2020 was that

ESG integration was deemed the most common sustainable investment strategy. The growth in ESG disclosures has been exponential, managing to attract the interest of financial regulators and ratings agencies alike. The latter in particular have assisted investors with their financial decisions by undertaking ESG evaluations (based on an organisation's related disclosures) against ratings and scores they have developed (Ellili 2022:1095). Standard and Poor (S&P), an American credit rating agency, compiled a global ESG Risk Atlas by sector and region, with the risk score based on risk exposure to the environment. Scored on a scale of 1–6, a score closer to 1 represents relatively low exposure (see table 3.1).

Table 3.1: S&P ESG sector scores for 2020

Sector	Environmental Score
Agribusiness and commodity foods	5
Chemicals (e.g., fertilizers)	5
Power generation	5
Metals & mining	6
Oil and gas	6

Source: S&P Global (2020:4)

As shown in table 3.1, the agribusiness and commodity foods sector scored a five for environmental factors due to its water resource risks, loss of biodiversity and contribution to GHG emissions (S&P Global 2019:1). By comparison, the mining, oil and gas and power generation sectors achieved an environmental score of six, despite these sectors and their operations posing an inherent threat to the environment (S&P Global 2019:4). With the intensification of the climate crisis, investors have increasingly requested more reliable data and greater clarity on ESG factors, including water (WWF 2022:5). The WWF report (2022:6) states that water is often portrayed in ESG data as a single measure (e.g., volume), despite being a much more complex and multifaceted commodity, hence the current approach – whether it pertains to reporting or ratings – does not adequately cover water risk exposure or the mitigation thereof.

Morrison, Schulte and Schenck (2009:11) note that while disclosure frameworks such as the GRI provide a fundamental starting point for communicating water-related information to

external stakeholders, they do not offer tools or methodologies through which to measure or analyse water use. For this reason, a number of water tools and decision support frameworks have been designed and implemented to evaluate corporate water practices, and encourage the adoption of water stewardship strategies (Larson, Freedman, Passinsky, Grubb & Adriaens 2012:583; Octavianti & Staddon 2021:1; Vardon et al 2023:1).

3.8 GLOBAL CORPORATE WATER TOOLS AND DECISION SUPPORT FRAMEWORKS

Over the past 20 years, thanks to constant innovation, collaboration and private sector commitments (Morgan et al 2020:5), several regional and international tools have emerged by means of which to account for, assess, and report on, water (Gibassier 2018:57). These water-related tools and decision support frameworks can be grouped based on their respective functions.

3.8.1 Tools for assessing organisational risks and opportunities

As part of the water stewardship process, certain global tools were designed to help organisations evaluate their water-related risks and opportunities. These tools include the Global Environmental Management Initiative (GEMI) Water Sustainability Tool, the Global Water Tool (now the India Water Tool; IWT), the Aqueduct Tool and the Water Risk Filter, of which the latter three are the most commonly used (Gibassier 2018:38).

3.8.1.1 Global Environmental Management Initiative water sustainability tools

GEMI is an international organisation that develops and shares sustainability tools and information (Sachidananda, Webb & Rahimifard 2016:4). Its water-related tools include the Local Water Tool (LWT), and “Collecting the Drops” and “Connecting the Drops” (Forin, Berger & Finkbeiner 2018:6). The LWT is a free tool which enables organisations to assess external impacts, management plans, as well as the risks and opportunities in terms of water use and discharge at a particular site or operation (Weintraub, Tao & Redder 2017:606). GEMI’s “Collecting the Drops” has as its purpose to walk the user through the process of transforming a corporate sustainability strategy and converting it into a site or unit strategy for improved water stewardship (GEMI 2007:i).

GEMI created the “Connecting the Drops” tool and website to assist organisations in developing a water strategy (GEMI 2002:5). Forin et al (2018:9) recognise that this tool offers guidelines on the value chain as part of the model. Its website hosts a database of real-world examples of water management practices gleaned from GEMI members across numerous industries. For example, a case study by the Novartis Corporation highlights the importance of employee education to check for leaking pipes and taps, and how employee awareness could also lead to other initiatives such as the installation of new equipment that uses less water in the manufacturing process, greater recycling of water and the efficient use of wastewater to irrigate crops on a nearby farm (GEMI n.d.). Considering frugal innovation theory, these same innovative solutions were discussed in the semi-structured interviews (see 5.6.1.1). India Water Tool is another online platform which helps organisations manage their water-related risks, as discussed below.

3.8.1.2 World Business Council for Sustainable Development Global Water Tool and India Water Tool

The WBCSD’s GWT was decommissioned as of 1 June 2019 and taken offline due to more advanced geographical information system (GIS) tools becoming readily available (Morgan et al 2020:8). However, in collaboration with WBCSD members and other stakeholders, the WBCSD’s IWT was developed and launched in 2013, because India had been identified as having some of the most insecure water resources in the world (Shiao, Maddocks, Carson & Loizeaux 2015:1). The IWT incorporates several innovative datasets that provide users with maps, graphs and charts enabling them to identify water risks at their locations, for further investigation and action. In addition, it allows users to calculate metrics that can be used to report (as part of disclosure initiatives such as GRI and CDP) on water withdrawal, discharge and recycling, amongst others (WBCSD 2022:4, 5). Examples of datasets included in the IWT are groundwater level and quality, surface water stress, annual rainfall, and details of the ten main crops produced in India and their water-related productivity (WBCSD 2022:5). The IWT helps organisations to understand their risks and design water management interventions in that country, making this tool a unique example of partnerships emerging between key stakeholders on the subcontinent (Morgan et al 2020:8).

3.8.1.3 World Resources Institute's Aqueduct

The WRI developed the Aqueduct Water Risk Atlas, a freely accessible global database and mapping tool, to help assess and disseminate information on global basin water-related risks. (Reig, Shiao & Gassert 2013:2). An updated version of the Atlas (v. 3.0), released in 2019, assesses basin water risks associated with an organisation's geographic location using 13 risk indicators which are grouped into three categories: physical risk quantity, physical risk quality, and regulatory and reputational risk (Hofste, Kuzma, Walker, Sutanudjaja & Bierkens et al 2019:3). It forms part of a collection of Aqueduct tools which provide comprehensive innovative information on the water-related risks posed to agriculture and food security (Aqueduct Food), water risks at the national level (Aqueduct Country Rankings, see figure 3.3) and flood risks and their impacts (Aqueduct Floods) (Morgan et al 2020:23). Notably, according to Morgan et al (2020:11), the WRI's Aqueduct does not gather organisational or operational data, nor does it analyse operational water risk – it does, however, focus on water-risk exposure. For many organisations, particularly food-producing entities, water-based risks are more extensive in the value chain than for other industries. Aqueduct Food provides available water-risk information where crops are grown worldwide, highlighting hotspots and the crops that are most at risk (Walker & Lakshman 2022:3). Table 3.2 gives the risk rankings for South Africa.

Table 3.2: WRI Water Aqueduct 3.0 country and province rankings for South Africa's provinces

Name of Country	Name of Province	Score	Rank score	Category	Label	% Dairy farms per province
South Africa		2.89	48	2	Medium–- High (20-40%)	100%
	Western Cape	4,06	375	4	Extremely High (>80%)	28.3%
	North West	3,89	430	3	High (40-80%)	1.4%
	Limpopo	3,46	573	3	High (40-80%)	0.4%
	Gauteng	2,86	754	2	Medium–High (20-40%)	4.4%
	KwaZulu-Natal	2,22	1060	2	Medium–High (20-40%)	28.3%
	Eastern Cape	2,14	1095	2	Medium–High (20-40%)	29.5%
	Mpumalanga	2,06	1127	2	Medium–High (20-40%)	4.5%
	Northern Cape	1,51	1421	1	Low–Medium (10-20%)	0%
	Free State	1,18	1562	1	Low–Medium (10-20%)	3.2%

Source: Adapted from WRI (2019:online)

Table 3.2 depicts the average water risk exposure of South Africa's provinces, according to the Aqueduct's risk indicators of baseline water stress, riverine flood risk and drought risk. The researcher adapted figure 3.3 by adding the last column using the figures from Chapter 2 figure 2.2, that indicates the number of dairy farmers in South Africa per province. The Western Cape, where the second-highest number of dairy farms are situated, had the highest risk exposure, however the WRI's Water Aqueduct does not mention how many provinces or countries in the world the ranking score of 375 is out of. South Africa's water risk is considered medium to high, scoring 48th of the 189 countries measured, with Qatar at number one as the country with the highest water risk. Against this backdrop, several large South African companies such as Sappi Limited have recognised water as an essential resource that needs to be carefully managed through responsible water stewardship (Sappi 2021:94). This company applies the WRI's Aqueduct Tool, and consults and collaborates with WWF-SA, S&P Global and the Global Change Institute (GCI) at the University of the Witwatersrand (Wits) to identify climate change patterns and manage water-related risks (Sappi 2021:91).

3.8.1.4 Worldwide Fund (WWF) Water Risk Filter (WRF)

The WWF designed the WRF, a practical free online tool, which was launched in 2012 with the aim of assisting organisations and investors to assess water risks in their operations, value chains and investments (Laporte-Bisquit 2021:321). To enable organisations and investors to assess their current water risk exposure, the WRF has the most up-to-date datasets (Laporte-Bisquit et al 2020:6). It assesses three risk types, namely physical, regulatory and reputational (Laporte-Bisquit 2021:322), and allows users to explore, assess, respond to and value water-related risks globally (Morgan et al 2020:25). The elements of the WRF consist of the following:

- The "explore and assess" sections allow river basin risks to be evaluated using 32 global risk indicators and data sets for 12 countries and regions. Operational risks are evaluated using a questionnaire with either ten drop-down questions or a more detailed questionnaire consisting of 45 items, determined by the user's needs.
- The "respond" section allows for risk assessment results to be linked to a mitigation toolbox which guides users on relevant water stewardship actions for their particular water risks.

- The “value” section includes an online resource to find the best tools for valuing water, namely the Valuing Water Database and the Water and ValuE (WAVE) tool (Morgan et al 2020:25).

The Valuing Water Database consists of over 100 tools/approaches, of which only a few are restricted to water – most cover the whole environmental and social risk scope (Morgan & Laporte-Bisquit 2019:7). The Aqueduct Water Risk Atlas, Ceres Aqua Gauge, CDP Water, and the Global Water Tool are included in the Valuing Water Database (WWF 2019:online). The other online resource is the WAVE tool. Developed to be the backbone of the WRF and the CDP water database, it draws data from both these databases and user inputs to transform water risk values into current and future financial impacts for a particular site (Morgan & Laporte-Bisquit 2019:12). In 2018, the WRF extended its focus to include WRF scenarios (figures 3.3 and 3.4) by integrating 2030 and 2050 projections in preparation for water-related risks which arise due to climate change. These cover optimistic, current trend and pessimistic scenarios (Laporte-Bisquit et al 2020:6, 7).

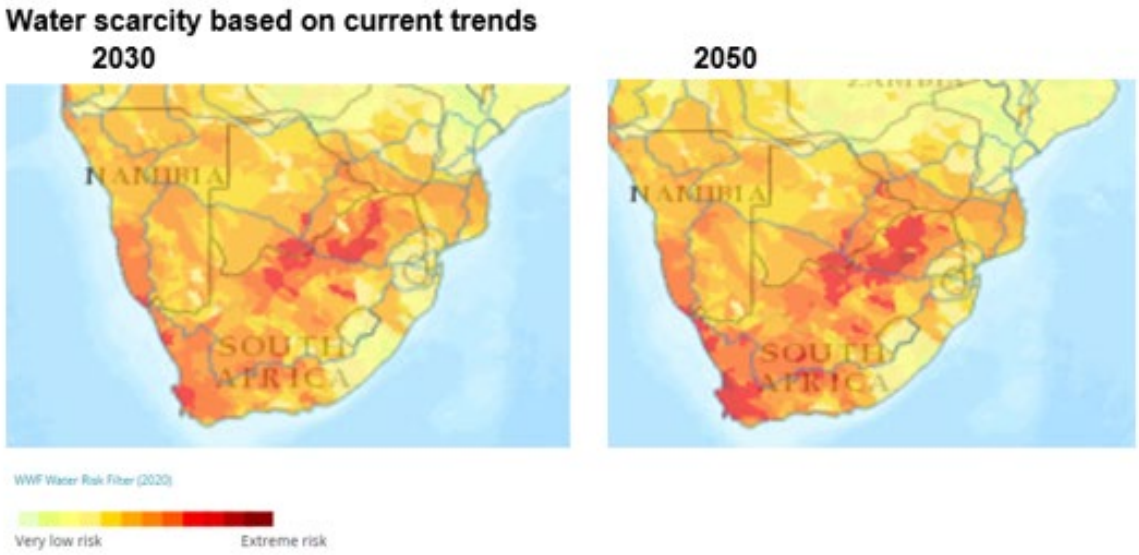


Figure 3.3: WWF WRF scenario analysis for South Africa, water scarcity for major river basins, based on current trends for 2030 and 2050

Source: WWF (2019:online)

Based on current trends, figure 3.3 displays how water scarcity is likely to increase from 2030 to 2050 to more extreme water scarcity affecting larger parts of South Africa. Of particular

concern is the Western Cape, where 28 per cent of dairy farms are situated, in light of the fact that more of this area will be affected by extreme water scarcity by 2050. This forecast highlights the relevance of water reporting in the dairy industry and the significance of this study.

Water quality based on current trends

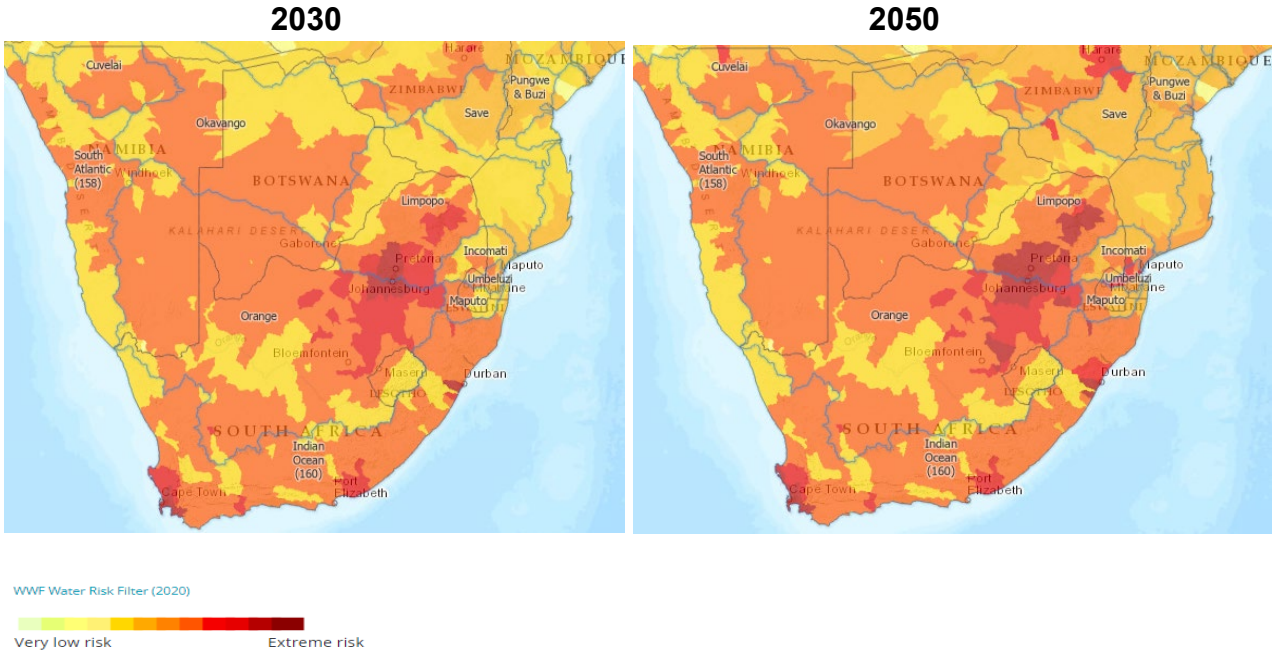


Figure 3.4: WWF WRF scenario analysis for South Africa, water quality for major river basins, based on trends for 2030 and 2050

Source: WWF (2019:online)

Based on trends, figure 3.4 demonstrates the expected worsening in water quality from 2030 to 2050. Gauteng displays the only significant change, with water quality envisaged to decrease to extreme risk levels, in large parts because it is the economic hub of the country and the province with the highest population numbers.

The 2008 Blue Drop Audit, launched by the DWS, is a process which assesses and benchmarks the performance results of water service institutions, causing them to earn rewards or incur penalties based on evidence of their successes or shortcomings in relation to established minimum standards or requirements (DWS 2022a:i, 13). According to the 2023 Blue Drop Audit, the quality of the nation's drinking water is declining (WRC 2024:14). Almost half (46%) of all water supply systems fail to meet microbiological criteria. These non-

compliant systems present serious health hazards, especially where drinking water is tainted by sewage. In addition, the report indicated that over two-thirds (67.6%) of all wastewater treatment facilities are on the verge of failing (WRC 2024:14). In the context of this study, poor drinking water quality can have a negative impact on dairy cattle's health and productivity (Giri, Bharti, Kalia, Arora & Balaje et al 2020:14).

Organisations are motivated by the need to recognise and mitigate business risks associated with water and to seize opportunities to improve the situation, whether it is to enhance their own competitiveness, assure their long-term survival or preserve their social licence to function (Morrison, Schulte, & Schenck 2010:7). Once water risk assessments/identifications have been conducted, Morrison et al (2010:7) recommend that water use and the impacts of products and processes be determined. The tools used to do this, are discussed in the next section.

3.8.2 Water use and impact assessment tools

Initiatives are vital for increasing the understanding of the public, corporates and policymakers when it comes to water consumption, water resource protection and the management of water. Also worth considering are the Water Footprint Assessment (WFA), the Life Cycle Assessment (LCA) and ISO 14046, which is based on the LCA (Tillotson, Liu, Guan, Wu & Zhao et al 2014:1564).

3.8.2.1 Water Footprint Assessment

The term "water footprint", coined in 2002 by Hoekstra and Hung (2002:7), relates to the concept of "virtual water" (Allan 1997:1). A global standard manual for WFA was developed by Hoekstra et al (2011:preface) and the NGO Water Footprint Network (WFN). Hoekstra and Hung (2002:10) explain that the production of almost all goods requires water, therefore if one country exports a product to another, it exports water in a virtual form. To clarify, the water footprint of a product looks at both the direct (internal) and indirect water (value chain) used during all the processing stages of production, considering blue (surface/groundwater), green (rainwater stored in soil/available to plants) and grey water (polluted water) (Hoekstra et al 2011:2). For example, the water footprint of milk produced in South Africa, specifically in the Vaalharts irrigation scheme, requires 1 352 m^3 of water to produce a single tonne of milk that contains an average of four per cent fat and 3.3 per cent protein, of which 107 m^3 (8%) is blue, 1 185 m^3 (88%) is green water and 60 m^3 (4%) is grey water (Owusu-Sekyere

et al 2016:7). The Vaalharts irrigation scheme, located in the Northern Cape province of South Africa between the Vaal and Harts rivers, is located in a summer rainfall area (Scheepers & Jordaan 2016:4). Owusu-Sekyere et al (2016:10) warn that the significant increase in the water scarcity index, which occurs four months a year in this catchment area (see figure 3.5), should be of great concern to water users and policy makers alike.

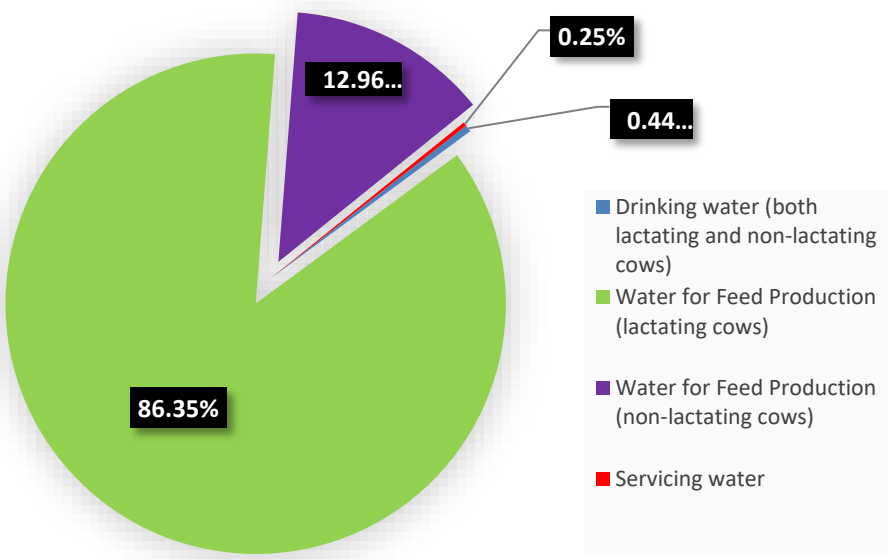


Figure 3.5: Contribution of the various components to the total dairy water footprint

Source: Owusu-Sekyere et al (2016:8)

Figure 3.5 illustrates that water for feed production for lactating cows alone accounts for 86.35 per cent of the total water footprint of milk. The drinking water of lactating and non-lactating animals (dry cows, heifers, bulls and younger cows) accounts for a further 12.96 per cent – therefore, in total 99 per cent of all water resources in the footprint is used on feed production and drinking water (Owusu-Sekyere et al 2016:8). This emphasises the importance of enhancing water reporting in the upstream value chain of the dairy industry, as a significant portion of water resources is consumed at the farm level.

One of the main objectives of both the WFA and LCA is to identify activities (so-called “hot spots”) within the life cycle of a product, process or service, that will make a substantial contribution to the total possible impact of a product. This could involve identifying regions or countries where the footprint is large or water scarcity is high, to pinpoint areas in which water should be better managed (Jefferies, Muñoz, Hodges, King & Aldaya et al 2012:156). As

depicted in figure 3.5, feed production is considered a “hot spot”, where 86 per cent of the total water footprint is reliant on rainwater, thus the risk of droughts in a locale such as the Vaalharts area is a serious concern.

Agarwal, Chung and Brem (2019:142) describe how a forced water cut of 25 per cent, implemented in California due to a period of drought, had a significant impact on water availability for the agriculture sector. The organisation gThrive saw the need to create a low-cost, simple-to-use monitoring (frugal innovation) solution. To that end, a portable monitoring system was designed to evaluate farmers’ water consumption and ensure the efficient use of this scarce resource. The monitor is made up of several wireless portable gStakes that can be placed around the farm, a gLink base station for gathering data from the gStakes, and software that stores data in the cloud. A radio link allows the gStakes to transmit data to the gLink base station about the amount of sunlight, air and soil temperature, soil moisture and electrical conductivity. The data are subsequently gathered and uploaded to the server by gLink via either a cellular phone network or Wi-Fi. Farmers can view the data at any time once it has been uploaded, and can track real-time data using a web browser or mobile app (Agarwal et al 2019:142).

A number of studies suggest using two key means of measuring the water consumption of products/processes in the value chain, namely WFA and LCA (Jefferies et al 2012:155; Pfister, Boulay, Berger, Hadjikakou & Motoshita et al 2017:352; Martínez-Arce, Chargoy, Puerto, Rojas & Suppen 2018:1). These methods are discussed in the next section.

3.8.2.2 Life Cycle Assessment

The LCA is a systems assessment tool developed with the specific purpose of measuring the environmental sustainability of products and services throughout the value chain (Morrison, Schulte & Schenck 2009:21). It was developed to assess impacts across various environmental types, including emissions, habitat destruction and water scarcity, whereas water footprinting is only water specific (Morrison et al 2010:19). The LCA, which has gained popularity as an environmental impact assessment tool for its ability to manage resource use and emissions in connected industrial systems, and for identifying possible problem shifting due to changes in product, management or technology implementation, has been standardised by the ISO (Pelletier, Bamber & Brandão 2019:1582). This type of assessment

involves determining the environmental impacts of a product, process or activity over its lifetime, hence it is often described as a “cradle-to-grave” analysis (Roy, Nei, Orikasa, Xu & Okadome et al 2009:2).

Many LCA-focused research studies have been published over the years, particularly in the agricultural sector, with numerous international conferences devoted to the LCA of foods (Morrison et al 2009:19). As Muralikrishna and Manickam (2017:57) explain, there are four stages to conducting an LCA, as standardised by the ISO:

- Stage 1: Goal and scope definition – the product, process or activity needs to be defined and described.
- Stage 2: Inventory analysis – determine and quantify water, wastewater discharge, energy, material usage and emissions.
- Stage 3: Impact assessment – analyse the possible human, animal and environmental impacts of issues identified during the inventory analysis.
- Stage 4: Interpretation – analyse the results from the inventory analysis and impact assessment.

The ISO is largely based on the LCA (Gibassier 2018:40), particularly ISO 14046: Water Footprint, which is discussed below.

3.8.2.3 International Organisation for Standardisation

Globally, the ISO is one of the most active and oldest standard-setting organisations. The international standards which it creates are voluntary, consensus-based and market-relevant, encourage innovation and address global problems (OECD-ISO 2016:9). As the OECD-ISO (2016:55) report states, the ISO does not provide certification of its standards, but rather encourages organisations seeking to obtain certification, to engage one of the many independent certification bodies. ISO is well known for ISO 9001, an international standard for quality management, ISO 45001 for occupational health and safety, and ISO 14001 for environmental management (ISO 2015:3). ISO 14001 can be used by all manner of organisations, as it prescribes that organisations have due regard for all environmental issues pertinent to its operations, including water, air pollution, climate change, soil contamination and waste management (ISO 2015:3).

The ISO standards for water cover almost every water issue, including water quality, irrigation, water footprinting, infrastructure, drinking water, wastewater, water reuse, hydrometry, piping and valves, and the measurement of fluid flow (ISO 2017:8). The ISO has well over a thousand standards related to water, with a good deal more being developed every year (ISO 2017:9). ISO 14046: Water Footprint, released in 2014, can be applied to products and processes, and is based on LCA principles (Pfister et al 2017:3). However, as various authors point out, ISO 14046 “quantifies the possible environmental impacts related to water use” along the life cycle of a product, process or organisation, and as such does not primarily measure the volume of water used to produce a product (which the WFA does): instead, it shows the possible impacts thereof (Roy et al 2009:1; Pfister et al 2017:353; Bai, Ren, Khanna, Zhou & Hu 2018:370).

Once an organisation has conducted an assessment on its corporate water risks, opportunities, usage and impacts, it is required to disclose and report the findings to its stakeholders and the general public – a requirement which allows entities to be accountable and transparent about their water use (Morrison et al 2010:10).

3.8.3 Water reporting

For many organisations across the globe, sustainable reporting has become institutionalised (Larrinaga & Bebbington 2021:174). GRI 303: Water and Effluents (discussed in section 3.4) and the CEO Water Mandate Disclosure Guidelines (see 3.7.3.1) define which water-related key performance indicators are to be disclosed (Gibassier 2018:41).

3.8.3.1 United Nations Global Compact – CEO Water Mandate

The CEO Water Mandate, launched in 2007, is a voluntary, business-led initiative of the UNGC, that requires the endorsement of participating chief executive officers (CEOs), hence the name (CEO Water Mandate n.d.:2; Sojamo & Rudebeck 2024:296). The CEO Water Mandate (n.d.:2) is a worldwide platform for committing to corporate water stewardship. Organisations that subscribe to the mandate, publicly pledge to foster water stewardship in six commitment areas: direct operations, value chain and watershed management, collective action, public policy, community engagement, and transparency. If organisations endorse the CEO Water Mandate they pledge to perform a number of actions in line with the value chain and watershed management commitment: to encourage their suppliers to improve their water

management practices, to develop competencies to evaluate and manage basin-related risks, to promote and give guidance to suppliers on carrying out water use and impact assessments, to share current and future water conservation approaches with suppliers, and to encourage key suppliers to report frequently on progress made in attaining water-related objectives (CEO Water Mandate n.d.:6; Sojamo & Rudebeck 2024:308). Recognising the role of the value chain as part of water stewardship and reporting, as well as the broad benefits and social responsibility attached to it, is a key driver of enhanced water-reporting practices. With this in mind, the CEO Water Mandate developed a corporate water disclosure framework (see figure 3.6).

<table>
<tr><td rowspan="6">Organisation's water profile</td><td rowspan="6">Defining what to report</td><td colspan="3">Detailed disclosure</td></tr>
<tr><td>Current state</td><td>Implications</td><td>Response</td></tr>
<tr><td>Context</td><td>Business risks</td><td>Policies, governance and targets</td></tr>
<tr><td>Performance</td><td>Business opportunities</td><td>Internal actions</td></tr>
<tr><td>Compliance</td><td>External impacts</td><td>External engagement</td></tr>
<tr><td colspan="3">Linkages across sustainability issues (e.g., food and energy)</td></tr>
<tr><td colspan="4">Connections between sections and subsections</td></tr>
</table>

Figure 3.6: CEO Water Mandate Corporate Water Disclosure Framework

Source: CEO Water Mandate (2014:6)

The CEO Water Mandate (2014:30-33) provides an explanation of the disclosure framework. As depicted in figure 3.6, the framework is split into three pillars of information, namely the organisation's water profile, defining what to report while considering its materiality assessment, and detailed disclosures.

- The organisation's water profile should be a high-level summary of its water-related issues, acknowledging challenges such as the percentage of water withdrawals from water-stressed areas, compliance violations and management's actions (e.g., the number/percentage of facilities implementing wastewater treatment initiatives).
- What to report depends on relevance and materiality, and whether the organisation is particularly exposed to significant water-related risks due to the nature of its business (for example, the agriculture sector).
- The detailed disclosure pillar consists of 11 information areas, which include reporting on both the core organisation and its value chain. It is important for the organisation to make connections between sections and subsections within the framework, as this

adds meaning to the information (for example, responses should address specific risks, opportunities [such as how managing water-related topics could improve profits or an organisation's competitive advantage], and impacts within the organisation and its value chain). It is essential for organisations to disclose connections or links between water and other sustainability areas, for example, climate change, land use, biodiversity, energy use, and food production and security (CEO Water Mandate 2014:30-33).

Another initiative of the CEO Water Mandate, in collaboration with the Pacific Institute, is the Water Action Hub (The Hub), an online water stewardship, information/knowledge-sharing and engagement tool (CEO Water Mandate n.d.:1). According to the CEO Water Mandate (n.d.:1), the objective of The Hub is to raise awareness of water stewardship activities around the globe, thereby sharing innovative ideas and best practice among different organisations to address worldwide water challenges. Hundreds of projects on The Hub can be filtered using several different parameters, for example, country, type/status of projects, type of organisation, and SDG target addressed (CEO Water Mandate n.d.:1) There are numerous examples of case studies on The Hub website. One that is pertinent to this study is a project undertaken by the Strategic Water Partners Network (SWPN), which hired technical experts and involved other partners in efforts to reduce water losses in 27 irrigation schemes across South Africa. This was done by implementing the Water Administration System (WAS) that allows for efficient water release, which leads to water savings, increased scheme productivity and sound financial performance (Benadé & Benadé 2018:4-10). Approximately 55 million m^3 per annum of water savings is being achieved due to this project (SWPN 2021:27). As the organisation prepares for its next reporting and management cycle, it is important to reassess its materiality assessment by considering water challenges, specific basin conditions and stakeholder expectations (including investors' requirements).

3.8.4 Investor-led water stewardship initiatives

Investors, as key stakeholders, have come to realise that water, like carbon, can pose a material risk to organisations (Sarni 2011:131). Sarni (2011:132), who is critical of water performance reporting and disclosure, explains that it was not keeping pace with carbon reporting, thereby hampering rigorous investment analysis. That prompted several investor-led initiatives to be introduced, including the CDP Water Disclosure project, the Ceres Aqua Gauge and the ESG (see section 3.6).

3.8.4.1 Carbon Disclosure Project (CDP) - Water Disclosure Project

The CDP was founded over 20 years ago, and in 2002 its first disclosure cycle was launched with the signing of 35 investors requesting climate information and 245 organisations answering the first questionnaire (CDP 2021:8). That initial questionnaire focused on climate-related issues, and in 2008 the CDP extended its work to include the value chain, which saw member companies nominating their suppliers to receive and complete a questionnaire. In 2011 the CDP asked cities around the world to disclose, via its platform, how they were acting on climate change and making improvements year on year (CDP 2021:8). In 2013, water scarcity and stewardship were introduced, and in 2017 forestry (CDP 2021:8). The organisation continues to grow; it now has offices all around the world, and a head office in London.

The CDP collects information via online questionnaires. Organisations that are invited to participate can opt to make their information public, disclose only to institutional investors, or decline to participate (Zhang, Tang & Huang 2021:2). This water questionnaire is extensive, covering issues such as water governance, efficiency, risk exposure, consumption, value chain engagement, dependence, targets and goals (Zhang et al 2021:5). The yearly CDP global water report results that are available on the organisation's website are grouped by sector, and of the 12 sectors, this study would resort under "Food, beverage and agriculture" (CDP Global Water Report 2020:16). One KPI in the CDP's annual global water reports, which is applicable to this study, would be "value chain engagement": in total, for all the sectors for 2020, 29 per cent of respondents (up from 28% in 2019) "required 50% or more of their suppliers to report on their water use, risks and/or management information" by sector. The "Food, beverage and agriculture" sector was also at 29 per cent for 2020, while the "Apparel" sector scored highest at 67 per cent (CDP Global Water Report 2020:38). The CDP Global Water Report (2020:8) also recommends that organisations support and incentivise suppliers across the value chain to advance water stewardship and collaborate with communities to address shared water-related challenges.

3.8.4.2 Ceres Aqua Gauge™

The Aqua Gauge is an Excel-based framework that allows investors to scorecard an organisation's water management practices, and helps organisations to assess their own water management practices and strategies (Barton, Adrio, Hampton & Lynn 2017:7). The

Aqua Gauge consists of four main categories: measurement, management, stakeholder engagement and disclosure (Barton et al 2017:9). Measurement is split into two subcategories – data gathering and risk assessment, while management is split into governance, policies and standards, and business planning. For each activity an organisation's development can be assessed against four stages: no action, initial steps, advanced progress and leading practice. The Aqua Gauge considers questions relating to the value chain in its measurement activities, asking: Does the organisation collect water-related data on its supplier's water management practices? Does the organisation identify and quantify water-related value chain risks? Under "Management activities", the Aqua Gauge addresses sustainable water management in suppliers' standards and codes, and their procurement practices. Under "Stakeholder engagement activity", it considers whether the organisation engages with its suppliers on water-related issues, to assist them with water management. The Aqua Gauge employs terminology in line with the GRI and CDP water disclosure guidelines (Barton et al 2017:7). This is another tool that advocates for water reporting and stewardship throughout the value chain, with a view to combining frugal innovation efforts aimed at managing water as a scarce resource.

All the abovementioned water tools and decision frameworks can assist with corporate water management, by enabling organisations to identify and mitigate water-related risks and impacts in both their direct operations and their value chains, and by taking advantage of water-related opportunities. Water management and water governance are interrelated issues and, as such, effective water governance systems should make it possible for practical water management tools to be appropriately applied as and when circumstances call for it (Tortajada 2010:299).

3.8.5 Water governance

The Organisation for Economic Co-operation and Development (OECD) argues that the "water crisis is largely a governance crisis", that the management of water is not just about water availability but also a matter of good governance (OECD 2011:1; Weston & Goga 2016:ii). The OECD report (2011:1) advocates that water is a local issue involving a multitude of stakeholders at the international, national, regional, municipal and basin levels. To that end, the OECD's Water Governance Programme was developed.

3.8.5.1 The Water Governance Indicator Framework of the Organisation for Economic Co-operation and Development

The OECD first established its Water Governance Programme in 2009 to help governments bridge serious governance gaps in the development and implementation of their water policies (Akhmouch, Clavreul & Glas 2018:6). In 2015, the OECD developed the principles of water governance by defining the concept as the range of political, institutional and administrative rules, practices and processes (formal and informal) through which decisions are taken and implemented, stakeholders can articulate their interests and have their concerns considered, and decision makers are held responsible for water management. (OECD 2015:5)

The OECD Water Governance Programme has expanded from aiding governments, to now supporting over 170 organisations in 41 countries (Taylor, Longboat & Grafton 2019:3). The 2030 Sustainable Development Agenda recognises improved water governance as critical to achieving the SDGs (Bertule, Glennie, Bjørnsen, Lloyd & Kjellen et al 2018:1). Figure 3.7 depicts the OECD principles on water governance.



Figure 3.7: OECD principles on water governance

Source: OECD (2015:4)

The OECD report (2015:4) (see figure 3.7) recognises 12 must-have principles for effective, efficient, and all-inclusive water governance. These principles should be centred around three dimensions, namely effectiveness, efficiency, and trust and engagement. The OECD Water Governance Indicator Framework was designed with the aim of assisting with the implementation of the OECD Principles on Water Governance, based on a bottom-up, multi-stakeholder approach (OECD 2015:5).

Until water is meaningfully integrated into corporate governance, organisations will not undergo the necessary transformations (CDP Global Water Report 2018:4). Middle management can make incremental improvements to organisational water performance, however, strategic decisions taken by the CEO and board can significantly alter the course they take, and ensure a water-secure future (CDP Global Water Report 2018:16). Creating governance structures that will direct funding and resources towards these goals, making board-level and C-suite executives accountable and incentivising them to achieve these goals, is the best course of action (CDP Global Water Report 2020:8). The CEO and his/her immediate reports with “chief” in their titles, such as the Chief Financial Officer (CFO) and Chief Operating Officer (COO) make up the C-suite (Atwood & Bacon 2011:1). Investors are increasingly trying to hold C-suite executives responsible for their actions regarding water-related issues (CDP Global Water Report 2018:16). In 2020, the CDP Global Water Report (2020:40, 41) stated that of the total reporting organisations, 67 per cent had board oversight of water issues, while the figure for the Food, beverage and agriculture sector was 75 per cent. However, only 23 per cent of total responding organisations currently provide C-suite incentives, compared to the 25 per cent in the Food, beverage and agriculture sectors.

Given its complexity, good governance does not just happen – it requires rigorous planning, and is the result of complex, protracted processes that have to be carefully laid out and maintained (Tortajada 2010:298). Moreover, sustainable value chains require effective governance models based on multi-stakeholder collaboration, supported by innovative technologies (Gurzawska 2020:274-275). The next section provides a summary of all the global water tools and decision frameworks discussed so far.

3.8.6 Summary of corporate water tools and decision support frameworks

One of the main objectives of this chapter was to determine whether the value chain was considered in global water reporting tools and decision frameworks (see section 3.8), and the findings are presented in table 3.3.

Table 3.3: Summary of corporate water tools and decision support frameworks, and value chain inclusion

Initiative's purpose	Tool	Value chain inclusion
Assessing water-related risks and opportunities	GEMI Water Sustainability Tool	Considers the whole value chain when assisting organisations to develop a water strategy. Uses a five-stage value chain to identify and assess water-related uses, opportunities, risks and impacts.
	WBSCD India Water Tool	Provides data to help organisations understand risks and opportunities if their value chain (or part of it) is located in India.
	WRI Aqueduct	Provides a global database and mapping tool on water-related risks that organisations can use to assess risks in their value chain.
	WWF Water Risk Filter	Provides up-to-date datasets which allow organisations to evaluate their risk exposure in their value chain.
Water use and impact assessment tool	WFA	Calculates the amount of water used (blue, green and grey) – both direct (focal organisation) and indirect – (value chain) to produce a product or service.
	LCA	Assesses the environmental impacts of a product throughout its value chain and life cycle ("cradle to grave").
	ISO 14046	Uses the LCA principles and therefore considers the whole value chain.
Water reporting	CEO Water Mandate	One of the six core commitment areas is to consider water stewardship in the organisation's value chain.
	GRI	GRI 303, updated in 2018, recommends that water reporting include the whole value chain.
Investor-led water stewardship initiatives	CDP Water Disclosure	The questionnaire includes questions about engagement activities in the value chain, together with identifying

Initiative's purpose	Tool	Value chain inclusion
		opportunities (e.g., innovation in the value chain to reduce dependency on water), risk exposure, impacts in the value chain, usage, water-related targets/goals, covering the entire value chain, up- and downstream.
	Ceres Aqua Gauge	Expects organisations to understand the impacts and risks in the whole value chain by including questions relating to data gathering, risk assessment, supplier standards and codes, procurement practices and engagement activities with suppliers.
Water governance	OECD Water Governance Programme	A multi-stakeholder approach, but no specific mention is made of the value chain.

Source: Author's own observations from the literature

As shown in table 3.3, while most of the tools and frameworks reviewed do consider the value chain, none are designed specifically for the upstream value chain of the dairy industry. In addition, these frameworks are generic in nature and not tailored to a specific sector. Many are also complex and resource-intensive, making them difficult for dairy farmers to implement given the resource constraints they already face. There is therefore a need for a simpler, more focused framework specifically designed for corporate water reporting in the upstream dairy value chain in South Africa, which is the gap this study seeks to address

The aforementioned water tools and decision frameworks require reporting organisations to consider their value chain, yet they do not take into account the difficulty of how to trace water throughout the value chain and how to enhance related reporting. Morgan et al (2020:4) admit that although these tools have assisted organisations in many ways, they have caused some confusion around specific water-related concepts, as well as the differences and similarities between certain tools. Therefore, in reply to calls from investors and entities for comparable and consistent sustainability information, the International Financial Reporting Standards [IFRS] foundation (Financial Reporting Council [FRC] 2021:1) effected several changes (see section 3.2).

3.8.7 Empirical studies on value chain-oriented water reporting frameworks

Empirical research into value chain-oriented water reporting systems continues to reveal inadequacies in value chain transparency and integration. Botha et al (2022a:391) discovered that organisations in the food, beverage, and tobacco industries generally provided insufficient disclosure of water-related value chain information, despite rising stakeholder expectations. According to CDP data, just 20% of regularly disclosing organisations identified value chain water risks in 2023, up from 16% in 2021, and only 40% of organisations evaluated water risks in their value chains at all (CDP Global Water Report 2023:11-13). Only 7% of organisations in the food, beverage, and agriculture industries set water-related goals for their value chains, which is pertinent to this study (CDP Global Water Report 2023:33). Literature further highlighted that previous corporate water accounting research focused predominantly on direct organisational water use, despite value chain usage often exerting greater impacts (Christ & Burritt 2017a:217). Remarkably, not much seems to have changed since this finding was made. According to CDP data, most organisations still concentrate their water reporting efforts on their direct operations rather than their value chains (CDP Global Water Report 2023:13). These findings indicate that challenges relating to the incorporation of value chain considerations and value chain-related water impacts persist within water reporting frameworks. These findings support the need for a framework for water reporting that is expressly designed to address the upstream value chain, which is the contribution this study aims to make. The next section introduces the initial conceptual framework for this study.

3.9 CONCEPTUAL FRAMEWORK

A research framework is the fundamental arrangement of concepts and ideas that underpin the phenomenon being studied (Lester 2005:458). It provides a theoretical summary of the research, and imposes order in the process (Leshem & Trafford 2007:96). Taking cognisance of the study's theoretical lens, the initial framework (figure 3.8) was prepared after reviewing the literature from chapters 2 and 3.

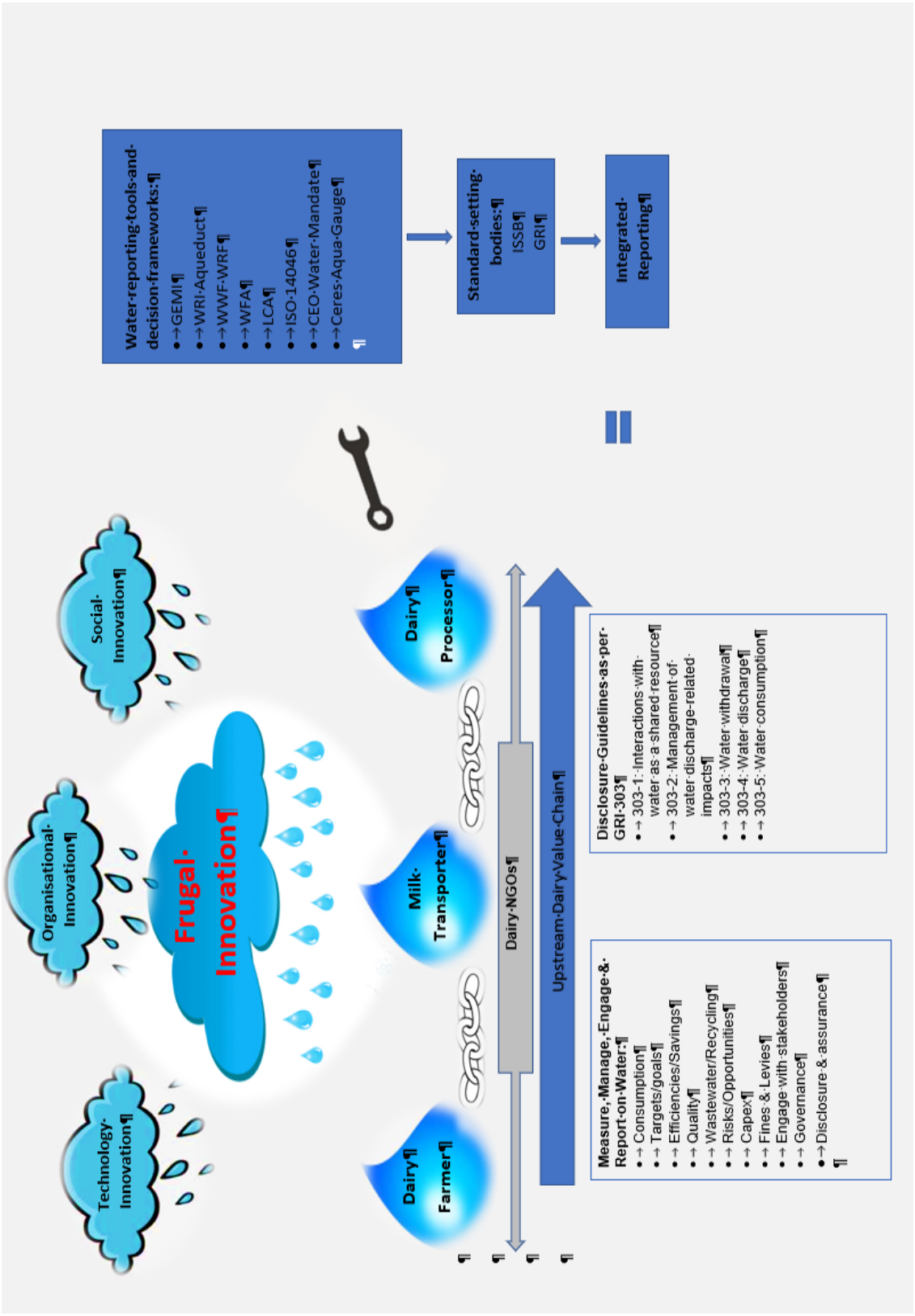


Figure 3.8: Initial framework

Source: Own observations

The top part of the framework in figure 3.8 shows that frugal innovation theory and its accompanying dimensions (social, organisational and technological innovation) may be used to seek ground-breaking solutions to improving water reporting in the upstream value chain, from the dairy farmer to the dairy processor. Each member of the upstream value chain has a range of water data and metrics for measuring and managing water, with the aim of improving water stewardship (refer to the blocks under the value chain participants). Dairy processors need to combine this information with their own water data, to produce an integrated report. To do so, various water tools, and decision and disclosure frameworks are available for use. The need to incorporate water-related issues in water reporting tools and frameworks across the value chain of the dairy industry is self-evident, but these disclosures are frequently secondary to direct operational water measurements and management. This study aims to make a practical contribution by focusing only on the upstream value chain.

3.10 SUMMARY

In this chapter, the researcher undertook an appraisal of several reporting initiatives, paying specific attention to global water tools and decision frameworks, for the purposes of meeting the first secondary objective of this study: that being, to review the water-reporting frameworks and identify any niche areas that accommodate the value chain, which could be used in the dairy industry. It was established that some, not all, initiatives take the value chain into account, to a greater or lesser extent. Of importance is that the IIRF, the King report, ESG factors and the GRI require organisations to disclose or report on water-related matters, without guiding them on how to measure, analyse or account for water-related issues in their direct or indirect operations. This is where global water tools and decision frameworks are essential.

The GEMI Water Sustainability Tool, WBCSD IWT, WRI Aqueduct and WWF WRF can and do assist organisations in assessing water-related risks in both their direct and indirect operations. The WFA, LCA and ISO can measure water use and the impacts of an organisation’s products throughout the value chain. The CEO Water Mandate and GRI 303 provide water-related disclosure guidelines, while the CDP Water Project and Ceres Aqua Gauge offer a platform for reporting on water-related issues to investors and various stakeholders. However, none of these initiatives consider how challenging it is for the main organisation (e.g., dairy processors) to report on water use further down the value chain. The

chapter concluded by presenting the initial framework underpinning this study. This chapter also informed the interview schedules that were applied during the fieldwork phase (for more information, see Chapter 5), so as to develop the final framework for advancing water reporting in the upstream value chain of dairy processors (see Chapter 6).

The next chapter, which deals with the research methodology, discusses the research strategy, design and methods employed to explore the research problem. It also casts a spotlight on the ethical aspects of this study.

CHAPTER 4: RESEARCH METHODOLOGY

"We forget that the water cycle and the life cycle are one." (Cousteau n.d.)

4.1 INTRODUCTION

The preceding chapters focused on the global issue of water scarcity, the current water situation in South Africa, challenges within the dairy industry as they relate to water, and various elements related to the dairy value chain. The discussion progressed by exploring the theoretical framework of the study, focusing on frugal innovation alongside its interrelated dimensions of social, institutional and technological innovation in the context of this academic undertaking. Some of the prominent water-reporting frameworks and tools available in the public domain were analysed to establish whether they incorporated value chain water reporting. Furthermore, an initial framework was presented, since the primary aim of this study is to create a water-reporting framework for the upstream value chain within the South African dairy industry.

The aim here is to provide the reader with straightforward and unambiguous information on the research methods used in the present study, so that it might in some way be repeated, if needed (Biggam 2011:114). The research methodology outlines a methodical approach to problem solving, and explains how data were acquired during the research process (Rajasekar, Philominathan & Chinnathambi 2006:5). In Chapter 1, figure 1.4 gives an adapted version of the research onion (Saunders et al 2023:131) as it applies to the current study. This model will be used as the framework for navigating the present chapter. The research onion created by Saunders et al (2023:131) was adapted to align with the methodologies applied here, as illustrated in the sections marked in green in figure 1.4. Commencing with the outside layer, each layer of the onion is discussed below.

4.2 RESEARCH PHILOSOPHY

A research philosophy describes the beliefs and assumptions a researcher adopts when embarking on an investigation to develop knowledge in a certain field (Saunders et al 2023:131). Research is developed on a set of philosophical assumptions which direct the

process. Those assumptions, in turn, determine the choice of research method (Antwi & Hamza 2015:217).

There are four philosophical assumptions, namely ontology (reality), epistemology (knowledge), axiology (the role of values in research) and methodology (the process of doing research) (Holden & Lynch 2004:398). Ontology, which is the study of the nature of reality, examines what (if any) objects exist, and whether reality is the creation of one's imagination (Burrell & Morgan 1979:326). The second component, epistemology, relates to the study of the nature of knowledge, specifically how it is possible, if it is conceivable, for us to learn about the world (Hughes & Sharrock 1997:5). Axiology investigates the role of ethical considerations, beliefs and values in a research study, including the potential influence of the researcher's own values on aspects such as the research design, data collection, interpretation and dissemination (Saunders et al 2023:135). Ontology and epistemology are expanded into two opposite extremes, namely objectivism and subjectivism (Saunders et al 2023:136).

Objective researchers work to establish universal facts and laws guiding social behaviour, and that social reality is external to them (Johansson & Svensson 2022:43). By contrast, subjective researchers are curious to learn about the many viewpoints and stories that can be used to explain various social realities, and are unable to separate themselves from their own ideals while using the collected data (Saunders et al 2023:138). As mentioned in Chapter 1, for this study the researcher adopted a subjective view. As suggested by Drapeau (2002:3), two methods can be used to ensure that the researcher's subjectivity and bias are limited, such as using a self-reflection journal and a debriefer/third party to assist with coding and/or transcribing the data. The researcher employed an EIC, to promote the transparency and credibility of the findings (Cofie et al 2022:75).

There is a significant body of literature on the design and process of conducting research, from which it may be inferred that there are typically two main philosophical perspectives, namely positivism and interpretivism (McKerchar 2008:6; Kovács, Kiss, Kassai, Pados & Kaló et al 2019:359; Dawadi, Shrestha & Giri 2021:26; Junjie & Yingxin 2022:10). The positivist paradigm adheres to scientific principles, and is intended to produce data and facts that are free from bias or human interpretation; typically quantitative methods are used as they are deductive and highly organised, with large samples (Saunders et al 2023:145). Researchers

who seek objectivity in their explanation of social reality mostly adopt a positivist approach, while those who take a subjective view, tend to adopt interpretivism (McKerchar 2008:7). A key distinction between interpretivism and positivism is that the latter seeks to establish universal principles that can be generalised to all groups without taking contextual factors into account, whereas interpretivists aim to enhance the richness of the data collected (Riyami 2015:412, 413). Other less specific paradigms such as pragmatism, critical realism and postmodernism, lie along a continuum between positivism and interpretivism (McKerchar 2008:7; De Vos, Strydom, Schulze & Patel 2011:5).

Pragmatists begin their research journey with a problem and seek practical solutions that will influence future practice, thus they are more interested in practical results (Saunders et al 2023:152). To best answer the research question, a pragmatic researcher will use a variety of data-collection techniques and sources (Creswell 2013:28). Critical realists address the "how" and "why" questions, finding deeper complexity in the relationships they study – for them, reality is an iceberg of which the largest portion is unseen to the observer (Stutchbury 2022:114). This paradigm aims to criticise and transform society, rather than merely study and understand it (De Vos et al 2011:5). One can recognise critical realism and pragmatic paradigms in mixed-methods research, as those researchers often draw from both ends of the continuum (McKerchar 2008:8). Postmodernism holds the fundamental idea that knowledge claims must be evaluated by taking into account current global situations, as well as diverse viewpoints on class, race, gender and other group affiliations (Creswell & Poth 2018:26). Postmodernists are often dubbed "armchair radicals", since they concentrate their criticism on altering ways of thinking as opposed to urging others to take appropriate action (Thomas 1993:23). They use several levels of data analysis to ensure rigour, employing software to aid in the analysis, and provide qualitative research in the form of scientific reports (Creswell & Poth 2018:26).

Considering the researcher's subjective perspective in this study, interpretivism was adopted as the research philosophy. Instead of positivists' notion of a single reality, interpretivist researchers seek to perceive the world through the eyes of the subjects they are studying, and this gives them access to many perspectives on reality (Greener 2008:17). When the philosophy of interpretivism is adopted, the researcher functions as a mediator in negotiating knowledge about reality (Tracy 2013:40). Myers (2013:39) notes that, according to interpretive academics, language, awareness and shared meaning are examples of social

constructs that are the only ways in which reality can be accessed. The goal of interpretivist research is to provide a fresh, more in-depth understanding and interpretation of social settings and contexts, which requires business researchers to examine organisations by listening to the views of various groups of individuals (Saunders et al 2023:150). This line of inquiry correlates with the frugal innovation theory adopted for this study, which considers the role of social, institutional and potential technological innovations in value creation. At this point it is important to distinguish between diverse research approaches.

4.3 RESEARCH APPROACH

Contributing to the extant body of knowledge in the field, requires a researcher to either generate theory (via inductive research) or examine it (via deductive research) (Trafford & Leshem 2008:49). Saunders et al (2023:149) also propose using an abductive approach where data are collected to modify an existing theory, which is often subsequently tested. In general, qualitative research normally follows an inductive approach, whereas quantitative research typically follows a deductive one (Hyde 2000:82). The deductive approach is useful for creating research hypotheses and putting theories to the test (Leedy & Ormrod 2005:32). The process moves from the broad to the specific, following a pattern that could theoretically or logically be anticipated, to make observations that examine whether the expected pattern manifests (Delport & De Vos 2011:48). In using the inductive approach, the researcher starts by collecting specific data from study participants and then organises those data into categories or themes. The themes are subsequently developed into broad patterns or generalisations, which are then contrasted with individual experiences or existing literature on the subject (Creswell & Creswell 2018:63). Figure 4.1 illustrates the difference between the inductive and deductive approaches.

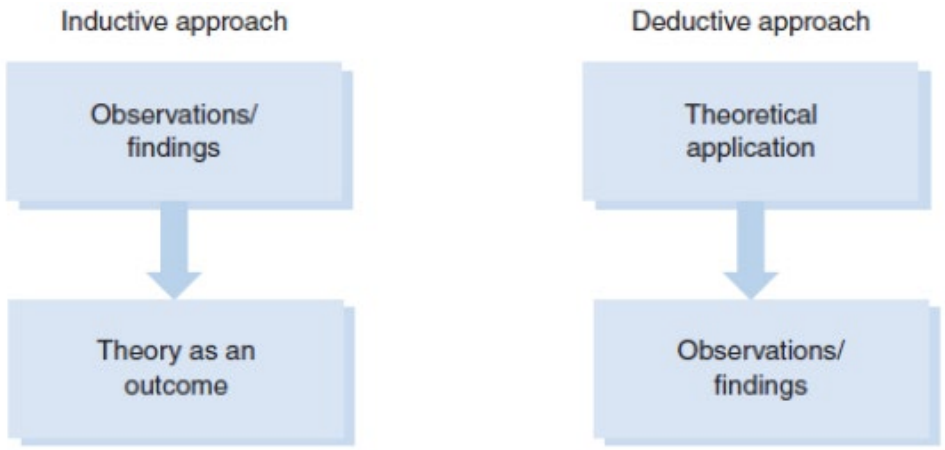


Figure 4.1: How theory fits into research

Source: Wilson (2014:13)

An inductive researcher examines a sample and then comes to conclusions about the population from which it originated (Delport & De Vos 2011:48). Creswell (2013:186) explains that a back-and-forth between different themes and the collected data is necessary for an inductive approach, before a set of themes or a conceptual framework can be developed. Since a researcher who works inductively collects data with the purpose of creating narratives of what is happening, the approach is exploratory in nature (David & Sutton 2004:36). The research approach followed in this study was inductive, because the researcher examined a sample of participants in the upstream value chain within the dairy industry, by collecting data from transect walks and semi-structured interviews – this, with the aim of developing and organising the data into themes, to create a conceptual framework. The research strategy used in this study is explained next.

4.4 RESEARCH STRATEGY

A research strategy is a plan outlining how a researcher plans to respond to his or her stated research question (Saunders et al 2023:191). Creswell and Creswell (2018:10) suggest that three choices are available to the researcher, namely qualitative, quantitative and mixed-methods research. Qualitative research is distinguished by its objectives, which involve comprehending a particular aspect of social life, and by its techniques, which (mainly) generate words, whereas quantitative research generates numbers for data analysis in an effort to measure something (McCusker & Gunaydin 2015:537). Mixed-methods research

involves collecting, analysing and interpreting quantitative and qualitative data in a single study (or succession of studies) of a single phenomenon (Leech & Onwuegbuzie 2009:267).

For this study, a qualitative research strategy was chosen since, in contrast to the information obtained from quantitative methods via surveys, qualitative methods like interviews offer better insights into participants' perspectives and attitudes about a topic (Gill, Stewart, Treasure & Chadwick 2008:292). Furthermore, qualitative research methods have been found to successfully address questions and problems in environmental studies, the management and conservation of natural resources, and the finding of solutions to environmental problems (Roudgarmi 2011:879). Lastly, in many contexts the dynamic and human elements of accounting research, for example, tend to be ignored by quantitative studies, whereas qualitative research reveals the researcher's first-hand knowledge based on his or her descriptive language (Alsharari & Al-Shboul 2019:56).

The researcher undertook a multi-method qualitative study, where multiple forms of data collection, such as semi-structured interviews, transect walks and document analysis, were used. The data were reviewed and interpreted before being organised into themes which cut across all the data sources.

The time horizon of a study can either be cross-sectional, where data are collected at a specific point in time to investigate a particular phenomenon, in other words, it constitutes a "snapshot" (Saunders et al 2023:212) or longitudinal, where the same subjects (individuals, households or other units of analysis) are monitored multiple times over a prolonged period of time (Privitera 2024:278). As Privitera (2024:281) notes, the longitudinal approach is time-consuming, possibly encompassing months to years, and tends to be expensive. For those reasons, the present study adopted the cross-sectional approach, collecting cross-sectional data.

4.5 RESEARCH DESIGN

A research design is a comprehensive framework or plan that serves to direct the researcher through the research process, and increases the possibility that the research objectives will be met (Wilson 2010:102). This study employed Design Science Research (DSR) to assist in achieving the main objective of developing a corporate water-reporting framework for the

upstream dairy industry, informed by frugal innovation principles. DSR is a qualitative research methodology that generates both knowledge and an innovative artefact (Carstensen & Berhard 2019:85) that addresses real-world problems (Vom Brocke, Hevner & Maedche 2020:1). DSR enables academics to go beyond making pure theoretical contributions, by presenting real-world implications and illustrating the relevance of their work (Hevner, March, Park & Ram 2004:85). In addition, it allows researchers to progressively iterate their knowledge, resulting in a continuous improvement in the artefacts and theories generated, thereby ensuring rigour in the research (Venable, Pries-Heje & Baskerville 2016:77; Vom Brocke et al 2020:16). This study was guided by the adapted model developed by Peffers et al (2006:97), which was illustrated in Chapter 1, figure 1.5. The DSR process undertaken in this study is discussed in more detail below.

Identify the problem and motivate: This activity defines the specific problem and the justification of finding a solution (Peffers et al 2006:89). The act of justifying the value of a solution serves two purposes: it acts as a source of motivation for both the researcher and the research audience to actively pursue a solution, while also allowing the latter to recognise and acknowledge the researcher's comprehensive grasp of the problem at hand (Vom Brocke et al 2020:6). The literature reviewed in chapters 2 and 3 served to clarify the state of the problem, namely that corporate water reporting in the value chain is lacking.

Define the objectives of a solution: This activity involves understanding the current problem, possible solutions and the effectiveness thereof. It functions as an essential link between identifying the problem and developing the artefact (Peffers et al 2006:90). The objective of this study was to develop a water reporting framework for the South African dairy industry's upstream value chain.

Design and develop: This activity involves identifying the intended purpose of the artefact and its structure, and is followed by the construction of the actual artefact (Peffers et al 2006:90). To accomplish the main research objective, a qualitative research methodology was applied in this study. Multiple qualitative data-collection methods were used (semi-structured interviews, transect walks), making this a multi-method qualitative investigation (Saunders et al 2023:182).

Demonstration and evaluation: Evaluating the artefact is the core activity in DSR (March & Smith 1995:261; Hevner et al 2004:82). A study by Peffers, Rothenberger, Tuunanen and Vaezi (2012:402) found that a number of evaluation methods are used in DSR studies, one being expert evaluation. In the DSR study by van Pelt, Jansen, Baars and Overbeek (2021:31), eight expert semi-structured interviews were conducted to assess their framework, while Nouri, Cabrero-Daniel, Torner, Hakan and Berger (2024:222) interviewed nine experts to evaluate their artefact. Interviews with experts were used to evaluate the artefact in this study: five experts, two dairy processors, two farmers and one NGO contributed their views, until data saturation was reached.

Communication: Here, all the perspectives of the problem and the developed artefact are communicated to the appropriate stakeholders (Vom Brocke et al 2020:5). In the current instance, the researcher plans to communicate the framework through this thesis, published articles and possibly by presenting papers at conferences.

4.6 DATA-COLLECTION METHODS

Several issues arise during data collection, including anticipating ethical concerns when asking for permissions, implementing a sound qualitative sampling strategy, gaining access to and establishing a rapport with the study participants, developing tools for recording information, addressing problems as they arise in the field, and securely storing the data (Creswell & Poth 2018:148). Individuals who agree to take part in qualitative research are more than mere participants – they are active contributors to the data-collection process (Saunders et al 2023:185). The next section discusses the sampling methods used in this study.

4.6.1 Sampling methods

Purposeful sampling was used, as it allowed the researcher to consciously choose study participants and study locations deemed suitable for helping to understand the research problem and the main phenomenon under study (Creswell 2013:156). This non-random method does not require foundational theories or a specified number of participants, and focuses on individuals with specific traits who can contribute meaningfully to the research (Etikan et al 2016:2, 3). The first few participants were selected through purposeful sampling,

after which snowball sampling was used. This type of sampling is especially helpful in instances where it is difficult to recruit participants, since it takes advantage of social networks (Grove, Burns & Gray 2012:396). With water being a sensitive topic in the agriculture sector, the researcher faced several challenges in recruiting participants to interview, but snowball sampling expanded the pool of participants, enabling the researcher to make use of prior interactions and communications with existing participants, to gain the cooperation and trust of prospective participants so that sufficient data could be obtained to strengthen the research findings (Cohen & Arieli 2011:428). Biernacki and Waldorf (1981:160) point out that due to the possibility of recruiting participants from relatively homogeneous associations, snowball sampling may have limitations that generate bias, and reduce the generalisability and credibility of the findings. To address these limitations, the researcher followed the guidelines proposed by Cohen and Arieli (2011:428), to carefully plan the sampling procedure.

To mitigate bias in this study, diverse groups of individuals from various geographic locations were deliberately selected. No individuals were excluded from the study based on factors such as race, sex or social and financial criteria, thus ensuring the credibility and authenticity of the research findings. The next sections describe the data-collection methods used to achieve the research objectives, as well as the number of participants in each instance.

4.6.2 Transect walks

A transect walk is an interactive method that allows researchers to collect qualitative data. Some equate it to a moving interview, during which the researcher walks with a participant through the identified study area(s), collecting data by means of direct observation (Van Staden, Rogers, Makaudi, Winkler & White et al 2006:9). As Puttkamer (2017:online) indicates, there are many advantages to transect walks, including that they represent one of the most engaging approaches for data gathering, altering the researcher's perspective as s/he might not be fully aware of local practices. Ideally, the walk experience will lead to a mutual exchange of information and knowledge between the researcher and the participant (Puttkamer 2017:online). Furthermore, the strong visual emphasis of the activity allows for a profound understanding of the phenomenon being researched.

Transect walks also assist with the triangulation of data (Rojas, Nomedji & West 2021:18). By triangulating data-collection methods, as in this study with semi-structured interviews and

transect walks, it overcomes inherent biases more effectively than using a single data-collection method would (Noble & Heale 2019:67). For business research, observations has traditionally been neglected, yet it can be rewarding and insightful, while significantly increasing the richness of a study's data (Saunders et al 2023:390). Therefore, to be in line with the innovation lenses used in this study, transect walks were conducted as part of an innovative approach to gather data in business-related studies.

The purpose of the transect walks was to determine the specific areas in which water is used and recycled, and where wastewater is disposed of on dairy farms. Two transect walks were conducted at two different dairy farms. The transect walk was designed more for qualitative observations rather than for gathering quantitative data, hence the sample size can be flexible, with one to three transects per study area being recommended (FAO n.d.:20). At the first dairy farm the dairy farmer walked with the researcher, and at the second, the dairy farmer nominated one of his employees to accompany the researcher. The researcher asked permission to access the various areas where water is used and recycled, and wastewater is disposed of. The researcher also sought permission to record the conversations and take photographs using a mobile phone. Both farmers agreed to this. The researcher transcribed the recorded comments from Farm 1, since the information gathered there was used to inform the interview schedules. The recording made during the transect walk at Farm 2 was transcribed by an external independent transcriber. Engaging an external service provider for transcription can free up significant amounts of time, according to Allsop, Chelladurai, Kimball, Marks and Hendricks (2022:158). The researcher maintained confidentiality standards during the entire research study, and to this end the transcriber also signed a confidentiality agreement (see Annexure I). While taking photographs on the farms, the researcher was cognisant not to photograph workers' faces or the names of the farms, to ensure the anonymity of the participants as per the ethics approval obtained from the university (Gibbs 2018:13).

4.6.3 Semi-structured interviews

Semi-structured interviews were conducted as part of the data-collection process. The interview schedules presented in Annexures D, E and F were developed from themes identified in the literature review and refined through insights obtained during the first transect walk. The interview schedules were reviewed by the supervisors and an independent

qualitative expert prior to use, and ethics approval, which included a review of the research instruments, was granted by Unisa's College of Accounting Sciences Ethics Review Committee (see Annexure C). The first round of interviews focused on three broad areas, namely: water stewardship, the drivers and limitations of corporate water reporting, and the role of frugal innovation in water management within the upstream value chain. The second round of interviews presented participants with the draft framework and invited their feedback on its accuracy, completeness and practical applicability. The schedules were therefore designed to ensure alignment between the study objectives, theoretical framing, contextual observations and participant interviews. Annexure D was the interview schedule developed for the dairy farmers, Annexure E was the interview schedule developed for the dairy processors and Annexure F was the interview schedule developed for OrgiAgri and the NGOs. While the interview schedules addressed the same research objectives, some questions were omitted and additional questions were included to reflect the specific roles and contextual knowledge of each participant group. This ensured that the data collected were relevant and appropriate to each category of respondents.

These interviews were based on a predetermined list of questions, but the participants were also given an opportunity to elaborate on certain areas and mention specific issues or themes, therefore the mix of set questions and the inherent flexibility of the process were attractive to both the researcher and participants (Wilson 2010:147). In qualitative research, particularly with semi-structured interviews, reliability does not imply achieving the same outcomes (as seen in quantitative research), but rather confirming that the results are credible and would be replicable in similar circumstances (Saunders et al 2023:453). Creswell and Creswell (2018:200) recommend the strategy of triangulating data sources to ensure reliability. This study thus made use of literature sources and two empirical data sources, namely transect walks and semi-structured interviews.

The literature consulted and reflected in Chapter 2 offered perspectives on global water challenges, South Africa’s specific water-related issues, the state of water consumption in the dairy industry (worldwide and locally), and engagement with the value chain as regards water. Chapter 3 examined various water-reporting frameworks and tools to determine the level of detail required when reporting on water in the value chain. From these two literature review chapters and the transect walk on Farm 1, the researcher compiled the semi-structured interview schedules. Notably, four different schedules were drawn up for each

group of participants who represented different contributors to the upstream dairy value chain. One interview schedule was compiled for dairy farmers, one for raw milk transporters, one for dairy processors and one for OrgAgri/NGOs, although many of the questions overlapped. While conducting the first few interviews, it came to the researcher's attention that raw milk transporters use the water of the dairy processors to wash their trucks once they have off-loaded their cargo. Therefore, any water measurement or management would be undertaken by the dairy processor and, as a result, milk transporters were not included in this study.

Each interview schedule consisted of four sections, dealing with introductory information; questions on frugal innovation; on measuring, managing and engaging stakeholders and reporting on water; and lastly on new legislation instituted by the South African government which makes the installation of water meters compulsory. The questions were all structured with the main objective in mind, namely to develop a framework for water reporting in the upstream value chain. Table 4.1 shows the number of participants from the different participant groups for both rounds of interviews.

Table 4.1: Semi-structured interviews conducted

Description	**Population**	**Sample size 1st round**	**Face to face**	**Online**	**Sample size 2nd round**	**Online**
Dairy farmers in SA	882	8	6	2	2	2
Dairy processors in SA	125	5	2	3	2	2
Dairy – organised agricultural organisations (OrgiAgri) and an NGO	Fewer than 10	4	-	4	1	1
Grand total		**17**	**8**	**9**	**5**	**5**

Source: Own compilation

The population for this study comprised stakeholders operating within the upstream value chain of the South African dairy industry, including dairy farmers, milk processors, organised agricultural organisations and non-governmental organisations. The sampling frame

consisted of stakeholders identified through industry associations, professional networks and referrals relevant to water management and reporting within the upstream dairy value chain. The sampling unit for interview data collection comprised individual stakeholders selected based on their knowledge and experience relating to water reporting, water stewardship and dairy production activities.

In February 2023, the researcher travelled to the Eastern and Western Cape in South Africa to conduct eight face-to-face interviews. As shown in Figure 2.2, the Eastern and Western Cape were chosen as they account for the majority of South Africa's dairy farming activities. To ensure that the data gathered was pertinent and significant to the study's objectives, participants were explicitly chosen based on their direct involvement in and expertise with water management strategies within the upstream dairy value chain. Nine online interviews were conducted via Microsoft Teams due to the participants being in another region of the country, or preferring to do an online interview. Given the challenge of recruiting participants who were willing to discuss water-related issues, especially amongst the farming community, the researcher established only a few specific criteria when selecting participants: they needed to be experienced dairy farmers, dairy processors and OrgAgri participants who had to be directly involved in the dairy industry, while the NGO participant was recommended by one of the dairy processors as having worked extensively in the sector. It is noted that this may be interpreted as a limitation in terms of objectivity; nonetheless, NGO1 was chosen for their substantial expertise and experience in the dairy industry, which is consistent with the purposive sampling approach used in this study. Furthermore, the danger of selection bias was addressed by triangulating data from three data sources and using an EIC. As discussed under section 1.10.5.1, when interviewing a homogeneous population (as in this study, which involved individuals from the dairy sector), a sample size of four to 12 participants is regarded as the minimum (Saunders et al 2016:297). In total, 17 semi-structured interviews were conducted in the first round, which exceeded the minimum requirement. Participants were recruited via telephone or email. All the interviews were recorded with the written consent of the interviewees. Each interview lasted approximately one hour. Once all the interviews were completed, they were transcribed by an independent external transcriber. The researcher then reviewed all the transcriptions for authenticity. A second round of semi-structured interviews was conducted with five participants selected from the first round, namely processors 1 and 3, farmers 2 and 8, and NGO1, based on the knowledge and expertise they demonstrated. The purpose of the second round was to present the draft framework and to

invite feedback on its accuracy, completeness and practical applicability. All interviews were conducted online, with the draft framework having been sent to participants a day prior to afford them sufficient time to review it beforehand.

The researcher then reviewed all the transcriptions for authenticity. Table 4.2 illustrates how the four sections of the interview schedules align with the specific research objectives of this study.

Table 4.2: Alignment between interview schedule sections and research objectives

Interview section	**Content focus**	**Research objective aligned**
Section 1	Introduction information	All objectives: establish each participant's role and experience in the upstream dairy industry
Section 2	Frugal innovation & water management	Objective 3: identify existing and future elements of frugal innovation in water management and assess how these may support water reporting
Section 3	Measuring, managing, and engaging with stakeholders on water reporting	Objective 1: explore existing corporate water reporting frameworks and identify niche areas and gaps; Objective 2: identify key drivers and limitations of water reporting
Section 4	New water meter legislation	Objective 2: identify drivers of water reporting. Objective 4: informs the triangulation and

Interview section	Content focus	Research objective aligned
		development of the water reporting framework
Second round of interviews	Evaluation of draft framework	Objective 4: to gather expert feedback on the draft framework and assess its practical relevance and applicability within the upstream dairy value chain

Source: Own compilation

4.7 DATA-ANALYSIS TECHNIQUES

Most of the data produced by qualitative research are unstructured text-based data, examples of which include interview transcripts, observational notes and recordings (Wong 2008:14). The aspect of qualitative research that most clearly sets it apart from quantitative research is the analysis of the data (Wong 2008:14). It is more of a creative, dynamic, intuitive and inductive process of thinking and theorising than a technical exercise, as is the case in quantitative approaches (Holloway 2005:5). There are different approaches to qualitative data analysis, but in this instance thematic analysis was used. The primary objective of thematic analysis is to explore and identify themes or patterns emerging across different data sources (Saunders et al 2023:664). Thematic analysis is structured, offering a systematic and coherent approach to examining qualitative data (Saunders et al 2023:664).

Braun and Clarke (2006:87) propose a six-step process of thematic analysis, which was used in this instance (see table 4.2). Their process is an impactful method, as it provides a straightforward and practical framework for conducting thematic analysis (Maguire & Delahunt 2017:3353).

Table 4.3: Data analysis of semi-structured interviews using thematic content analysis

Step 1	**Familiarising yourself with the data**
	All the semi-structured interviews conducted with the dairy farmers, dairy processors, OrgAgri and NGO were recorded with the written consent of the participants. Following that, the recordings were transcribed by an independent external transcriber (IET). The researcher reviewed all the transcriptions – a process which is essential for ensuring data reliability; although it can be quite time-consuming, it allows the researcher to become immersed in the data upon reviewing each transcription (Gibbs 2018:136).
Step 2	**Generating initial codes**
	Atlas.ti was used to code the semi-structured interviews, since it is a quicker and a more efficient method of coding than coding by hand (Creswell & Creswell 2018:192-193). All 17 transcribed interviews were coded in Atlas.ti. An EIC also used Atlas.ti to code the interviews. Engaging with an experienced independent expert is deemed essential for expanding a researcher's perspective and deepening his or her understanding, according to Williamson et al (2020:9). Coding was done inductively – a "learn-as-you-go" approach that generates unique codes during the examination of the data (Saldaña 2021:41). Inductive coding demonstrates that the researcher is receptive to the insights gleaned from the data, instead of trying to fit the data into established codes (Miles et al 2020:74). Descriptive coding was primarily used, and in some instances, in vivo coding was applied when the researcher identified significant statements made by the participants (Miles et al 2020:65; Saldaña 2021:134).
Step 3	**Searching for themes**
	Themes do not emerge from data (Braun & Clarke 2013:225): developing themes is an active process during which the researcher analyses the codes and the coded data, to begin identifying possible patterns rather than merely "discovering" them (Taylor & Ussher 2001:297). Once all the interviews were coded, the codes were critically reviewed to identify duplicates/overlaps and those that had

	significant meanings that could be collated into themes. Cross-checking of codes between researchers is recommended (Gibbs 2018:138). As mentioned in step 2, an EIC assisted with the coding, to establish reliability.
Step 4	**Reviewing themes**
	After identifying a range of possible themes, it is necessary to evaluate and refine them (Riger & Sigurvinsdottir 2016:35). Once the codes were grouped into possible themes, the review process included several rounds of evaluation. Three themes were decided on, that best reflected the data collected.
Step 5	**Defining and naming themes**
	Naming each theme is crucial, as it can indicate both the subject matter and the researcher's analytical perspective on the data (Braun & Clarke 2013:259). The themes were analysed and re-analysed as part of step 5, to ensure that the names represented the content discussed under each theme.
Step 6	**Producing the report**
	After thoroughly identifying themes and their connections, a research report can be developed (Riger & Sigurvinsdottir 2016:35). Chapter 5 presents the findings of the research study, as outlined in this step. The three participant groups (dairy farmers, dairy processors and OrgAgri/NGO perspectives) were discussed under the three themes created.

Source: Adapted from Braun and Clarke (2006:87)

The headings from Braun and Clarke's (2006) six-step process were used in table 4.2, while the content was aligned with this study's data-analysis activities. Once the interviews had been conducted and transcribed, codes were generated and themes identified. The findings emerging from this process are presented in Chapter 5. Having discussed the data analysis of the semi-structured interviews, it is important to examine the ethical aspects that are essential to qualitative research.

4.7.1 Data management within qualitative data analysis

Qualitative data analysis is similar to assembling a jigsaw puzzle, where each piece symbolises data. These data pieces, along with their interconnections, aid researchers in constructing a coherent picture of the insights conveyed by the data (Saunders et al 2023:661). The frequencies with which a phenomenon occurs are not used as evidence when employing qualitative analysis, to explain or make sense of an investigation – rather, meaning is extracted from the data in a methodical, thorough and rigorous manner (Smit 2002:66). It is important to note that, while Braun and Clarke's (2006:87) six-step thematic analysis process was the primary data-analysis method in this study, as outlined in section 4.7 and table 4.3, the data management process — that is, how the data were collected, condensed, displayed, and verified prior to thematic analysis — was guided by Miles et al's (2020:10) interactive flow model. A summary of the data-analysis steps undertaken in this study is presented in figure 4.2.

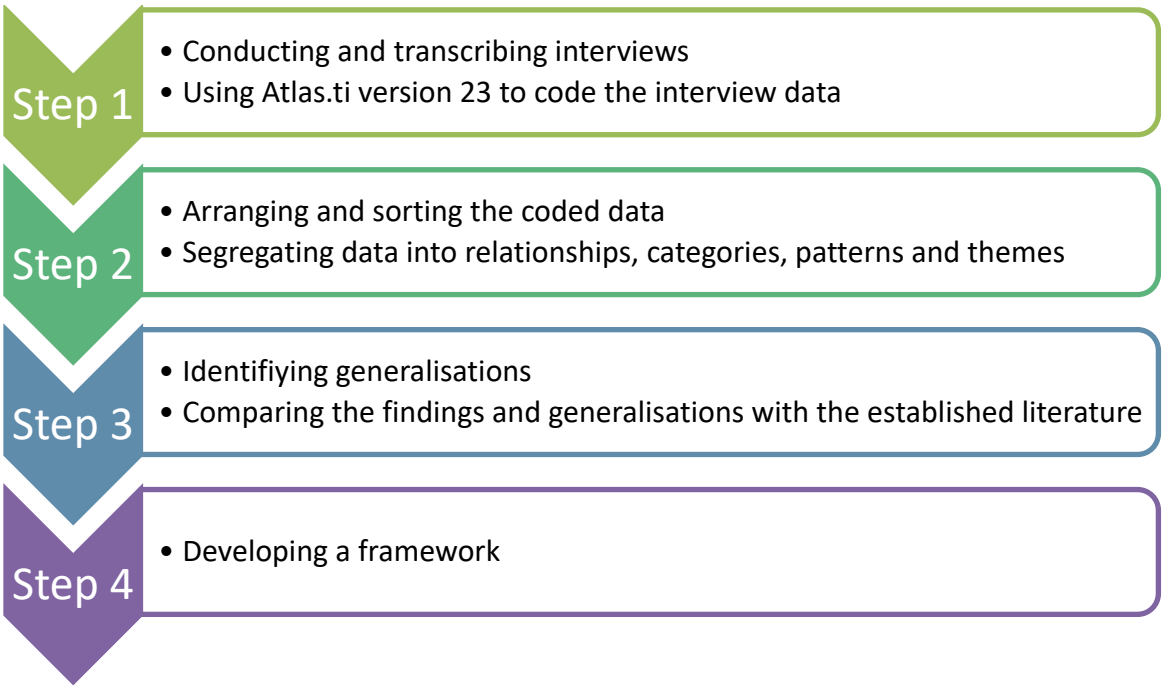


Figure 4.2: Qualitative data-analysis process

Source: Adapted from Miles et al (2020:10)

Following the lead from Miles et al (2020:10), the qualitative data process is an interactive flow of four activities – data collection, condensation and display, as well as the drawing and verifying of conclusions. For this study, as reflected in figure 4.2, step 1 included conducting

interviews and then transcribing them. The transcription phase is the link between the interviews and data analysis (Da Silva Nascimento & Steinbruch 2019:413). As Mondada (2007:1) recommends, the transcriptions were done as soon as possible after the semi-structured interviews had been conducted, to ensure that the conversations were still salient.

Transcribed documents then followed parallel routing. The researcher began the pre-coding, eventually leading to the full coding and analysis. Concurrent to this process, the researcher provided the IEC with e-copies of the transcripts to code independently. This was done at the same time and in parallel with the researcher's coding. The EIC was given 12 of the 17 transcripts to code, and the researcher compared that coding with her own. The EIC's role was limited to coding not to do an in-depth analysis, in line with ethical requirements as reported in Williamson et al (2020:5). The role of the EIC is discussed in more detail below.

The researcher uploaded the transcribed documents into Atlas.ti v.23 for analysis. At the textual level, Atlas.ti relies on the participants' raw data which are refined through encompassing tasks such as text segmentation and coding (Smit 2002:73; Smit & Scherman 2021:2). Attaching keywords to text segments is known as coding (Saldaña 2021:5). These are the initial stages by which the conceptual level is achieved through connecting codes, concepts and categories to the raw data, such that a higher-order analysis may be conducted (Smit 2002:73). The researcher started pre-coding (Saldaña 2021:31) by reading all the transcripts manually, and making notes of possible codes.

The researcher drew her own Atlas.ti reports and worked through them in tandem with the EIC's Atlas.ti reports. Areas of consensus were noted, and these codes were deemed stable for the next stages (see section 4.7.2). Where the EIC and the researcher did not align, interesting insights from the EIC's coding were noted for further analysis. A "concordance" meeting was held, during which the researcher discussed and probed the coding further (Barbour 2001:1116), with software-driven access to the quotations from the raw data, to create a stable code list that would provide the impetus for subsequent analyses. The next step, as depicted in figure 4.2, included arranging the coded data to segregate it into relationships, patterns and themes (Miles et al 2020:10).

4.7.2 Establishing themes to develop a conceptual framework

Step 2 involved grouping together similar codes to generate categories. This process is illustrated in figure 4.2 (see Saldaña 2016:14).

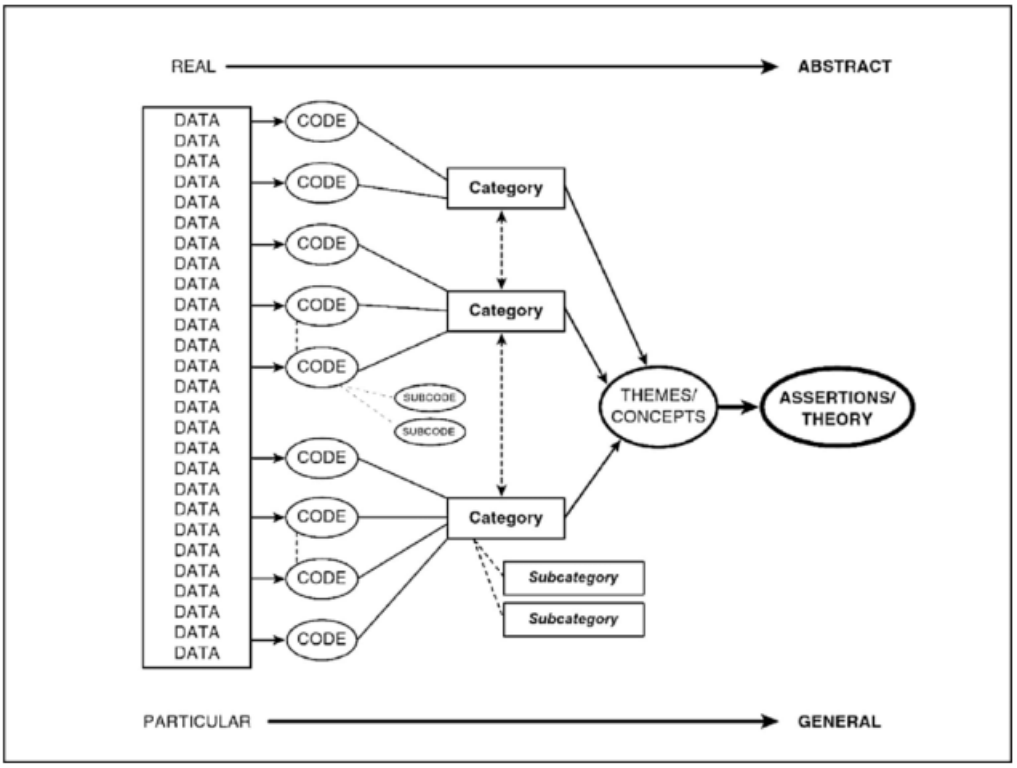


Figure 4.3: A streamlined codes-to-theory model for qualitative inquiry

Source: Saldaña (2016:14)

The streamlined model shows how data move from codes to categories and then to themes/concepts, and eventually into assertions/theory/an artefact, such as a framework. Categorisation is a crucial component of analysis, as it establishes the initial framework on which interpretations give actions significance and serve as the basis for explanations (Smit 2002:67). Both the coding and categorisation were done in Atlas.ti.

The next step in the data-analysis process involved identifying themes. A theme embodies a significant aspect of the data in relation to the research question (Braun & Clarke 2006:82). Saldaña (2021:258) describes a theme as an “extended phrase or sentence” that indicates the meaning of a unit of data. Notably, themes do not "emerge" in a mystical or miraculous way, despite what some authors claim in their reports; themes are the researcher’s interpretations and constructs (Saldaña 2021:259). The identified themes for this study were (i) water stewardship, (ii) the drivers and limitations of water reporting, and (iii) the synergy

between value chain stakeholders. The theme of water stewardship was informed by the literature reviewed in Chapter 2, specifically sections 2.7 and 2.8, which addressed corporate water stewardship and value chain engagement, respectively. The theme of drivers and limitations of water reporting was derived from the literature reviewed in Chapter 3, which examined existing corporate water reporting frameworks and their strengths and weaknesses, as well as from the findings of the semi-structured interviews. The theme of synergy between value chain stakeholders, in turn, emerged from the interview data, as participants consistently highlighted the importance of collaboration between dairy farmers, processors and organised agricultural bodies in advancing water reporting in the upstream value chain. All three themes were further viewed through the lens of frugal innovation theory, as discussed in Chapter 2, section 2.5, with the three dimensions of social, institutional and technological innovation directly informing Section 2 of the interview schedule — exploring stakeholder collaboration and water awareness, governance structures and reporting systems, and technology-enabled water measurement and reporting respectively — and are reflected as distinct components of both the draft framework in figure 5.3 and the final framework in figure 6.1. To provide clarity on how the overarching themes and sub-themes were derived, table 4.4 presents each theme alongside its source, thereby demonstrating the alignment between the literature, transect walks and interview findings that informed the thematic analysis

Table 4.4: Overarching themes, sub-themes and their sources

Overarching theme	**Sub-theme**	**Source**
Water Stewardship	Water conservation	Literature (Chapter 2) and interviews
	Water info & metrics	Literature (Chapter 2) and interviews
	Accuracy of measuring & reporting	Interviews
	Water quality	Interviews
	Wastewater	Transect walks and interviews
	Water-related areas requiring further attention	Interviews
	Value in water reporting	Interviews

Overarching theme	Sub-theme	Source
	Assurance	Literature (Chapter 3) and interviews
	Awareness of water frameworks and tools	Interviews
Drivers & limitations of water reporting	Drivers of water reporting	Literature (Chapter 3) and interviews
	Limitations of water reporting	Literature (Chapter 3) and interviews
Synergy between value chain stakeholders	Identification of risks and opportunities	Interviews
	Engagement between value chain members	Literature (Chapter 2) and interviews
	Innovation in the value chain and through engagement with other stakeholders	Literature (Chapter 2) and interviews
	Sustainable Value Chain Management (SVCM)	Literature (Chapter 2) and interviews
	Government systems and interrelationships	Literature (Chapter 2) and interviews

Source: Own compilation

It is important to note that, while this study primarily used an inductive approach, as discussed in Section 1.10.2, the three overarching themes — water stewardship, the drivers and limitations of water reporting, and the synergy between value chain stakeholders — were initially informed by the literature reviewed in Chapters 2 and 3, indicating a deductive component. Sub-themes and specific results within each topic, evolved from the interview data throughout the analytic process, in line with an inductive methodology. This mix of deductive and inductive reasoning is characteristic of an abductive technique, which is deemed ideal in qualitative research that draw on both existing literature and actual data to produce new information (Saunders et al 2023:147), as is the case in this study.

4.7.3 Triangulation of data sources

Triangulation is a well-known qualitative research strategy that involves combining multiple data sources, methods, or perspectives to gain a more complete and credible understanding of a phenomenon (Noble & Heale 2019:67). Denzin (1978:291) describes four types of triangulation: data triangulation, investigator triangulation, theory triangulation, and methodological triangulation. This study used methodological triangulation, which is the use of many methods to collect data on the same research topic (Saunders et al. 2023:182), which increases the reliability and trustworthiness of the findings.

To develop the draft framework, triangulation was used in three stages. In the first step, the literature examined in Chapters 2 and 3 served as the theoretical and contextual foundation, identifying existing water reporting frameworks, their strengths and shortcomings, and the value chain water reporting gap. In the second stage, the first transect walk on Farm 1 influenced the creation of semi-structured interview schedules, while the second transect walk on Farm 2 provided observational data on how water is utilised, measured, and managed on the farm. It is important to note that the transect walks did not serve as a primary source of analytical data but rather acquainted the researcher with the study environment and the upstream dairy value chain, and provided contextual observations that were used to refine and strengthen the semi-structured interview schedule prior to the first round of interviews. In the third stage, the results of the 17 semi-structured interviews gave empirical insights into the drivers and limitations of water reporting, current and future features of frugal innovation in water management, and value chain stakeholder synergy. The convergence of these three data sources, literature, transect walks, and semi-structured interviews influenced the creation of the draft water reporting framework described in Chapter 5. This process of integration and triangulation addressed research objective 4 by informing the development of the draft framework, which was subsequently evaluated through a second round of interviews with five expert participants to produce the final water-reporting framework presented in Chapter 6.

The three dimensions of social, institutional, and technological innovation provided a framework for organising and interpreting the interview results. Frugal innovation theory also functioned as an analytical lens during the data-analysis process. The three dimensions of frugal innovation were included as a separate and essential part of both the draft and final

water reporting frameworks, as shown in figure 5.3 and the final framework in figure 6.1. This illustrates how the theoretical lens of this study went beyond informing the data analysis to being clearly embedded in the artefact produced.

4.8 ETHICAL CONSIDERATIONS

Ethics relates to the moral principles governing a researcher's conduct in respect of the rights of those who become participants in the study or are impacted by it (Saunders et al 2023:253). The ethical guidelines for qualitative research were followed in this study. The concept of informed consent requires participants to be made fully aware of what they are agreeing to, what they will experience during the research, and how their data will be handled once the research concludes (Gibbs 2018:13). A participation information document was sent to all participants prior to the interviews/transect walks being conducted. This document included details on how the researcher would protect the security of the data obtained, each participant's right to anonymity, and the right to withdraw from the study at any time (see Annexure H). Importantly, the Protection of Personal Information Act (POPIA) 4 of 2013 (RSA 2013:3), which seeks to encourage the safeguarding of personal data, was adhered to in this study. The participants had to sign and return a letter granting the researcher permission to conduct the research (see Annexure G). All participants voluntarily took part in this study, and neither their identities nor the names of the organisations they work for and/or the names of the farms in question, are disclosed in this study.

Throughout this academic undertaking, the researcher adhered to the principles of situational ethics as outlined by Tracy (2010:847), continually evaluating whether the chosen methods aligned with appropriate moral standards to achieve the intended outcomes. In tandem, relational ethics (Tracy 2010:847) were also prioritised, ensuring that all participants were treated with dignity, respect and care throughout the research process. Ethics approval was granted by Unisa's College of Accounting Sciences Ethics Review committee (see annexures A, B and C for the ethics approval certificates for the initial proposal of this study, reference no. 2021_CAS_044, the transect walks, reference number 2022_CAS_028 and the semi-structured interview schedules, reference number 2022_CAS_041).

It is vital to guarantee the trustworthiness of the data gathered for a qualitative study. The elements of Lincoln and Guba's (1985) "parallel criteria", also known as "the Four-Dimensions

Criteria" (FDC) (Forero, Nahidi, De Costa, Mohsin & Fitzgerald et al 2018:2), which include credibility, dependability, confirmability and transferability, are described in table 4.5.

Table 4.5: The four dimensions criteria of trustworthiness

Trustworthiness criteria	Definitions and strategies	Strategies used in this study
Credibility	This refers to the degree to which the research findings can be trusted to be accurate. Credibility determines whether those findings accurately reflect the participants' initial opinions, and are based on information derived from the original data (Korstjens & Moser 2018:121).	The researcher carried out interviews by directly engaging with the participants and posed insightful open-ended questions to gain a deeper understanding of the phenomenon being examined, enabling participants to provide detailed accounts of their experiences (Groenewald 2019:74) The data were transcribed by an external independent transcription service. The researcher and an EIC coded the data separately using the same software package (Leonard 2020:22).
Transferability	Transferability indicates how well the research findings can be generalised or applied to different contexts, populations, groups and settings. The main method for ensuring applicability is through purposive sampling, gathering rich descriptive data, and creating detailed descriptions (Kakar, Rashid, Rasheed & Akhter 2023:169).	This study used purposive sampling to start off with, after which snowball sampling was used. Rich data were gathered through the transect walks and semi-structured interviews. The findings are discussed in detail in Chapter 5, which also reflects the direct quotes of the participants.
Dependability	The research process should be systematic and clear, ensuring that the steps and methods are auditable and verifiable. Data recordings and transcriptions, as well as software to facilitate the coding and storage, management and retrieval of data, can all be used to demonstrate these aspects (Hanson, Ju & Tong 2019:1017).	All interviews and transect walks comments were recorded and then independently transcribed. The researcher and EIC used Atlas.ti to code the data. The interviews were also stored on Atlas.ti, which allows for easy data retrieval and code allocation.

Trustworthiness criteria	Definitions and strategies	Strategies used in this study
Confirmability	Confirmability is “the degree to which findings are determined by the respondents and conditions of inquiry and not by [the] biases, motivations, interests or perspectives of the inquirer” (Lincoln & Guba 1985:290). Qualitative research is fundamentally interpretive, however engaging several researchers (including quotations that back up the results) and allowing participants to review the interpretations can guarantee that the findings encompass the complete depth and breadth of the participants’ experiences and viewpoints (Hanson et al 2019:1016-1017).	An EIC was employed to independently code some transcripts, to reduce bias. As mentioned, direct quotes are included in the chapter detailing the findings. Once the artefact was developed from the data obtained in the first round of interviews and transect walks, a second round of interviews served to evaluate the artefact.

Source: Own compilation

4.9 LIMITATIONS OF THE RESEARCH DESIGN

This study focused exclusively on the upstream dairy industry in South Africa, and may not be applicable to a broader context. Conceivably, the conceptual framework can possibly be used in other agricultural industries and geographical areas. With refinement, it may also be used in other types of industries. Considering the qualitative approach of this study, where sample sizes are smaller, if a quantitative approach had been used, with larger sample sizes, the correlations and relationships among different factors could have been measured. An interpretive, subjective research philosophy was used here, which can create opportunities for biases; this was mitigated by interviewing three groups of participants and consulting an EIC. The data collection methods of transect walks and semi-structured interviews have their own limitations, specifically the researcher's subjective interpretation of observations during the transect walks, as well as the risk of social desirability bias (where participants may respond in a manner they feel is expected of them rather than answering honestly) and

interviewer bias during the interviews (Saunders et al 2023:395, 453), both of which were mitigated through the use of an EIC and data triangulation.

Frugal innovation, with its interrelated dimensions of social, institutional and technological innovation, was employed as the theoretical lens for this study, yet the findings may have differed if the study were approached from a different theoretical perspective. Despite these limitations, the study findings were deemed to yield valuable insights into the subject of water and its reporting. The conceptual framework developed from a combination of literature reviewed (see Chapter 3) and the findings from the transect walks and semi-structured interviews can potentially increase the reporting of water use in the upstream value chain of the dairy industry. The framework will endeavour to streamline and simplify the reporting information that will eventually become a mandatory requirement of various stakeholders.

4.10 DEVELOP A CONCEPTUAL FRAMEWORK

DSR emphasises the need to develop an innovative artefact that can address “real-world” problems (Kotzé, Van der Merwe & Gerber 2015:2). Using the adapted DSR process of Peffers et al (2006:97), the third step in this study involved designing an artefact or conceptual framework that leveraged literature reviewed (see chapters 2 and 3), along with the findings from the semi-structured interviews and transect walks (see Chapter 5), to enhance water reporting within the value chain. In steps 4 and 5, the initial framework was shared with a selected group of participants in a second round of interviews, with the aim of evaluating the framework. The final framework, which is presented in Chapter 6, aims to streamline and simplify the reporting requirements that are currently (or will soon be) a requirement of stakeholders and investors alike.

4.11 SUMMARY

This chapter outlined the research approach and methodological choices which were informed by the researcher's approach to the study, and were based on an interpretive research philosophy. Semi-structured interviews and transect walks were identified as suitable data-collection instruments, while the participants were selected through purposive sampling, followed by snowball sampling. Thematic analysis served as data-analysis

technique, while Atlas.ti software assisted with the coding and analysis of the transcripts. Finally, the ethical guidelines adhered to in this study, were considered.

The next chapter presents the findings of the transect walks, accompanied by photographs taken on farms 1 and 2, which depict the water usage observed. The findings of the semi-structed interviews are discussed under the developed themes, after which a draft framework is presented and explained.

CHAPTER 5: PRESENTATION AND INTERPRETATION OF THE RESEARCH FINDINGS

"Water links us to our neighbour in a way more profound and complex than any other" (Thorson 2013)

5.1 INTRODUCTION

In the preceding chapters, the pertinent body of existing literature was examined to support the research problem and assist in achieving the objectives of this study. Chapter 3 mapped the corporate water-reporting frameworks, with a specific view to identifying which reporting niche areas could be used in the upstream value chain of the dairy industry. Chapter 3 also presented an initial conceptual framework, given that the main objective of this study is to develop a corporate water-reporting framework tailor-made for the South African dairy industry. Chapter 4 was dedicated to discussing the methodology employed in this undertaking, and specifically how the data were collected. The empirical study within this research project set out to identify the drivers and limitations of corporate water reporting, as well as the existing and future elements of frugal innovation in water management within the upstream value chain of the local dairy industry. To that end, transect walks and several semi-structured interviews were conducted with individuals deemed to have direct knowledge of water management in the South African dairy industry.

Transect walks (see Chapter 4, section 4.6.3) are intended to reinforce the underlying theory of a study, inform the interview schedules, and allow for the triangulation of data collection in an effort to increase the credibility and validity of the findings. In choosing frugal innovation, the researcher endeavoured to embody some of the associated principles in elements of the study. Observations or transect walks have traditionally been overlooked in business studies (Saunders et al 2023:390). For that reason, this methodological device was adapted for data collection to create a more vivid picture of the data in relation to context. The insights reported on here thus set the scene prior to sharing the main interview data, especially in relation to the third research objective (identifying existing and future elements of frugal innovation in water management) and, where relevant, cut across the objectives and contribute to the primary objective.

This chapter commences with the findings of the transect walks, before outlining the qualitative data-analysis process. Thereafter, the researcher gives an overview of the demographics of the study participants. The three themes by which the data were analysed are discussed, and the findings of the interviews are communicated. Lastly, the draft framework is reported, presented and discussed.

5.2 TRANSECT WALKS

Transect walks encourage a deep understanding of challenging subjects and foster a knowledge exchange between the researcher and the phenomenon being researched (Okoko & Prempeh 2023:473). The main objective of this study was to develop an evidence-based reporting framework – an area in which the transect walk was deemed to provide useful input, in addition to serving to triangulate the evidence. It was also important to understand first-hand where and how water is used and managed in the upstream value chain (objective 3). The first farm transect walk, conducted at the onset of the fieldwork, was used to inform and shape the interview schedules as contextual evidence. The second farm transect walk, undertaken during the semi-structured interview phase, formed part of efforts to achieve objective 3, specifically through the identification of existing elements of frugal innovation in water management on that farm.

Typically, the researcher first meets in person with those participating in the transect walk, to draw a map of the areas and resources, and decide on the walking route (Kanstrup, Bertelsen & Østergaard Madson 2014:56). During the transect walks undertaken at both farms in this study, the researcher asked the farmer or an employee to walk to wherever water is used, stored, recycled or purified – these locations were then named as observation points (see section 5.2.1). The researcher was cognisant of looking for aspects and examples of frugal innovation during the walks. Therefore, not only is the theoretical lens of frugal innovation being applied to the data of this study, but it has also been mainstreamed into the methodology applied, so that the principles of innovation and frugal innovation are evident in many aspects of it. Additionally, as per the OECD report (2015:4) (see figure 3.7), innovation is one of the 12 essential principles for efficient, effective and comprehensive water governance.

Throughout the walk, the participants talked about anything they saw that might be related to water management, and by asking questions and making observations, the researcher prompted additional discussions. Having obtained permission beforehand, a recording device was used during the walks, photographs were taken with the researcher's cellular phone and fieldnotes were systematically maintained.

5.2.1 Settings and observations from the transect walks

The section below reports on the transect walks, which informed the data collection and findings reported in this study.

5.2.1.1 Farm 1

The first transect walk was conducted on a dairy farm in Mpumalanga, South Africa.



Figure 5.1: Aerial view of a portion of Farm 1

Source: Google Maps

- The farm is situated close to the Gauteng/Mpumalanga border, in South Africa. The transect walk participants were the farmer, the PhD candidate, her main supervisor, and a former farmer with a wealth of knowledge related to farming, particularly dairy farming and the area where the farm is situated.
- Feed is grown (maize) on the farm, the fields are completely rain-fed and no irrigation is used for watering crops. Cow manure is dispersed back onto the fields as fertiliser.
- Approximately 700 cows are milked per day, three times a day. Milk is collected once a day (at 7 am) by the dairy processor via a contracted transport organisation. Up to 19 000 litres of milk is collected per day.

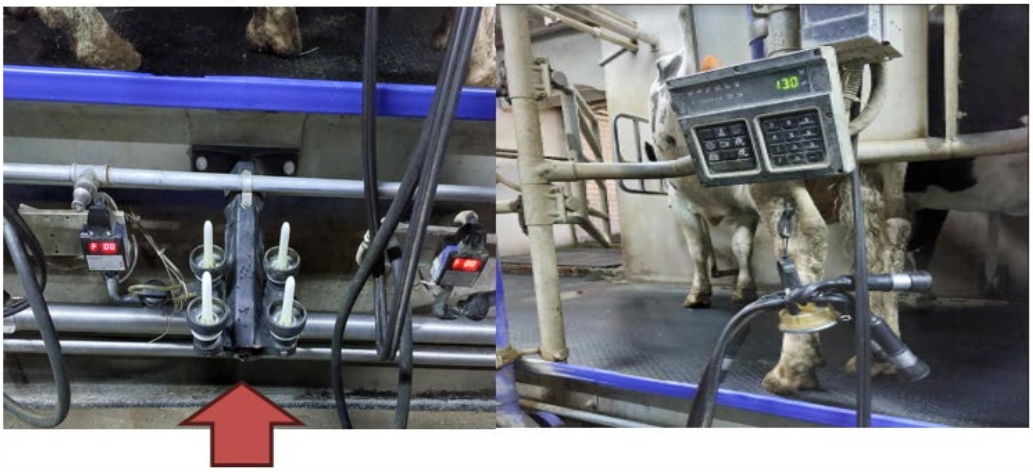
- This farm is not required to report on its water usage to its processor.

Table 5.1 presents the observation points with a description and the photographs the researcher took during the transect walk on Farm 1.

Table 5.1: Transect walk of Farm 1

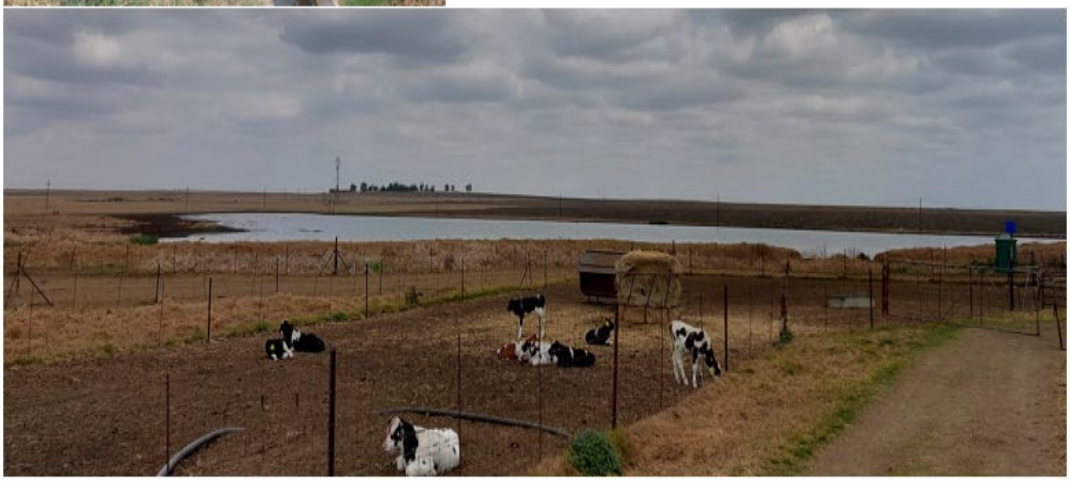
Observation points	Farm 1
Observation point 1.1 – water source	Water for all activities on the farm is supplied by rainwater and four boreholes. In the past when there was a severe drought and the boreholes ran dry on the farm, the farmer had to collect water from a neighbouring farm. Two of the boreholes on the farm are pictured below. The water quality sourced from the boreholes is not tested. The Farmer mentioned that if the water quality from the boreholes were of inferior quality, this would be established in the quality of the milk being supplied to the dairy processor. All milk is tested by the milk transporter before taking delivery on the farm and is tested again at the dairy processor.  
Observation point 1.2 – Tankers and reservoir	The boreholes are switched on twice a day to fill the two green water tanks which flow into the concrete reservoir, pictured below. This reservoir supplies water to the entire farm, all the farming activities, the farmhouse and the farm workers' homes. The green water tanks hold a capacity of 10 000 litres each, 20 000 litres are pumped into the reservoir while 20 000 litres are held in the two tanks. These are filled twice a day (7 am and 4 pm), therefore the farm uses approximately 80 000 litres of water per day. 

Observation point 1.3: Water troughs on the farm.	Several water troughs are located throughout the farm. These are topped up automatically via a water-level ball valve when the water reaches a certain level. All troughs are washed and cleaned once a week. Lactating cows drink vast quantities of water, and this constitutes a very water-intensive part of dairy farming. Lactating cows are kept close to the dairy parlour to conserve their energy levels, especially in the summer months. 
Observation point 1.4: Room where bulk milk cooling tanks are held.	There are three bulk milk cooling tanks on the farm. These maintain the milk at a cold temperature until the milk transporter collects it (once a day). The images below show two of the tanks on the farm.  This image shows a hole in the ground in the room containing the bulk milk tanks. Any runoff of milk or water used to clean the area and the tanks flows into this hole, which then flows by pipes into a dam on the farm. 

	In the next image, a red arrow indicates the drain where all the wastewater is washed into, which then runs into a dam on the farm. The image on the right, shows that a particular cow produced 13 kilos of milk (the machine reads in kilos, not litres). 
Observation point 1.5: Room that houses water tanker, chemicals, and heating tank that contains water and chemicals, used to clean the dairy parlour and milk cooling tanks.	This room is next to the dairy parlour. The green water tank contains water that is pumped into the silver tank to heat the water seen in the right-hand photo to clean the milk cooling tanks (see inspection point 4). Chemicals are added to the water in the silver tank, to wash and clean the dairy parlour next door. 

Observation Point 1.6: The dairy parlour	Everything is washed and cleaned in the dairy parlour after each milking session (three times per day). 40 cows are milked at a time. The cows' udders are cleaned with a chemical before the milking apparatus is attached. Once all 700 cows have been milked at each milking session, the parlour is washed down and thoroughly cleaned. If the cow messes while being milked, the mess is cleaned up straight away.  

Observation Point 1.7: Disinfected baths and cow dip	Once the cows have been milked, they walk through two green plastic containers to clean and disinfect their hooves (left image). The image on the right shows a dip containing chemicals – the cows pass under this, to protect them against pests and disease.  

Observation point 1.8: The dam where all the wastewater from the farming activities is disposed of, which filters back into the groundwater.	 

Source: Own observation

5.2.1.2 Farm 2

The second transect walk took place on a farm in the Western Cape, South Africa.



Figure 5.2: Aerial view of a portion of Farm 2
Source: Google Maps

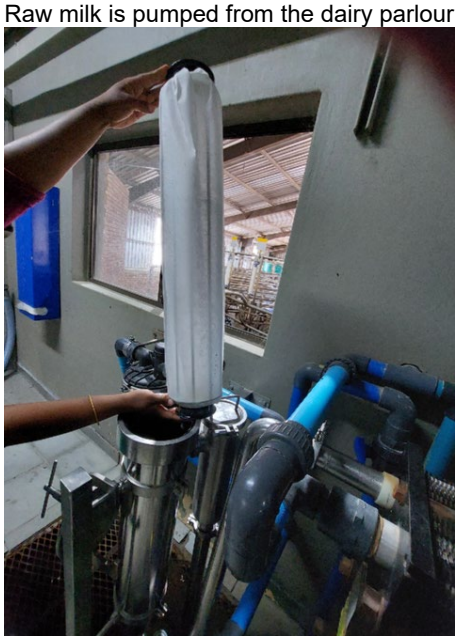
- Farm 2 is situated roughly halfway between Cape Town and Port Elizabeth, now known as Gqeberha.
- The participants on the transect walk were the researcher and one of the dairy parlour employees.
- Feed (maize) is grown on the farm, the crops are under irrigation, and the source of water is either the municipality, recycled water and/or rain. Cow manure is dispersed across the fields as fertiliser. Approximately 1 150 cows are milked per day, twice a day. Milk is collected once a day by the dairy processor.
- This farm reports on its water usage to its processor.

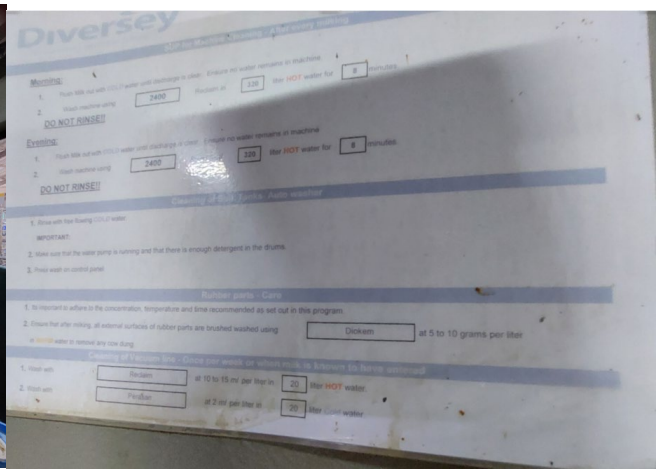
Table 5.2 presents the observation points with a description and the photographs taken by the researcher during the transect walk on Farm 2.

Table 5.2: Transect Walk of Farm 2

Observation points	Farm 2
Observation point 2.1 – water source	Rainwater, municipal water and recycled water (from a water purification plant on the farm) are used. Below is the water purification plant and dam on the farm which is used to store water.   

Observation point 2.2: Water troughs on the farm.	Troughs provide drinking water for cows going into the parlour. Drinking water is provided for them in each area where they roam on the farm.  

Observation point 2.3: Room where bulk milk cooling tanks are held.	Bulk cooling tanks are situated in the room next to the rotary system. Milk is pumped from the dairy parlour into these tanks. Water is used to wash the cooling tanks once the milk transporter has collected the milk. Wastewater flows down into drains, which are covered by green and black plastic covers.  Raw milk is pumped from the dairy parlour through this filtering system into the cooling tanks. 

Observation point 2.4: Area that houses water tanker, chemicals, and heating tank that contains water and chemicals, used to clean the dairy parlour and milk cooling tanks.	Green-water tanks – water is pumped from the water purification plant into the tanks, for use in the dairy parlour.  The silver tank is where hot water is stored for cleaning the dairy parlour. The blue plastic bins contain chemicals that are used for cleaning. The document outlines the standard operating procedures in terms of the quantity of water to be used to clean the dairy parlour – it requires 2 400 litres per day. This process takes approximately eight minutes, using special high-pressure hoses.  
Observation Point 2.5: The dairy parlour	Cows are separated into various teams for milking. 

	Below is the rotary milking parlour. The parlour and the clusters (which are attached to the teats) are washed. An employee walks around checking the cows for any issues during the milking process. Approximately 50 cows are milked at a time, and 1 150 in total. 
Observation Point 2.6: Disinfected baths and cow dip.	Cows are dipped once a week.  

Observation point 2.7: The dam where all the wastewater from the farming activities is disposed of, which filters back into the groundwater.	Wastewater coming from the dairy parlour.     This image shows where the wastewater flows from various areas on the farm. This is where liquids and solids are separated. Solid matter goes back onto the land as fertiliser, while the water irrigates the land.
Observation point 2.8: The tank where the colostrum milk is stored for newborn calves.	This is the tank where the colostrum milk is stored for newborn calves, which are on colostrum milk for their first three days, before being fed milk for 60 days. This area also has to be washed down regularly. 

Observation point 2.9: Drains and hose pipes.	One of many hosepipes used on the farm for cleaning and washing down areas.  Wastewater is washed down various drains and pipes.  
Observation point 2.10: Waste- water management area.	Wastewater from various areas on the farm is pumped here, before liquid and solids are separated. Solid matter goes back onto the land as compost, and wastewater is used to irrigate the land.  

Source: Own observation

The observations from the Farm 1 transect walk, in conjunction with the literature review chapters, were informative in enabling the researcher to develop the semi-structured interview schedules (see annexures D, E & F). The researcher observed how and where water is used on a typical dairy farm. Even though Farm 1 is not required to report on water-related issues to the processor, the farmer is aware of how important water is to the farm, and acknowledges that water is a scarce resource. This is evident from the farmer recycling all the wastewater to irrigate the land for crops (Farm 1 transect walk observation point 1.4, 3rd photo and observation point 1.8).

The second farm transect walk (Farm 2) was done on a farm that works closely with its processor to develop and test many innovative solutions, including a water purification plant. Farm 2 reports on various sustainability issues to its processor, including its water usage.

The transect walks were engaging and informative, and the researcher concedes that she would not have learnt as much from merely conducting an interview in a dairy parlour or a farmer's office. The researcher was able to conduct the semi-structured interviews more effectively, thanks to the background information and newfound knowledge gained during the transect walks. All the information and findings pertaining to the semi-structured interviews are discussed below.

5.3 SEMI-STRUCTURED INTERVIEWS

Seventeen semi-structured interviews were conducted between January and March 2023. The researcher travelled to the Eastern and Western Cape to conduct eight face-to-face interviews with six dairy farmers and two dairy processors. Nine interviews were conducted online via Microsoft Teams with three participants from OrgAgri (Gauteng and Western Cape), one with an NGO (KwaZulu-Natal), three from milk processors (Mpumalanga, KwaZulu-Natal and Eastern Cape) and two farmers (KwaZulu-Natal and Western Cape). Once the researcher had explained the objectives of the study to the participants, and informed them that their identities would remain anonymous, they were willing to sign the consent form and were open and free about sharing information. After the interviews, most of the participants admitted to finding this an interesting study and said they looked forward to seeing the results once the study was completed.

5.3.1 Overview of participants

Initially, it was challenging to get farmers to participate in the study, because some do not trust people doing research studies or projects on their farms. A few of the interviewed farmers mentioned an incident where a government department undertook a project on invasive alien plants and trees. The farmers allowed those employees onto their land, as they assumed the intention was to assist them in removing invader species. However, after some time the farmers were contacted and informed that they had to remove the invasive plants and trees themselves, or receive a fine of up to R1 million. Notably, the individual offering to remove said plants for a considerable sum had their own company that happened to provide this service. This incident was but one example of why the farmers were cautious about allowing researchers or outsiders onto their farms.

Table 5.3 provides the details of the participants in the semi-structured interviews. All participants were anonymised by assigning numbers to them. In total, 17 participants were interviewed, which exceeded the minimum requirement for a homogeneous population, as set out by Saunders et al (2016:297). In addition, data saturation was reached when no new data or themes were identified (Fusch & Ness 2015:1409). As outlined in Section 4.6.3, separate interview schedules were developed for the participant groups and are included in Annexures D, E and F. The findings presented below should therefore be considered in relation to these interview schedules.

Table 5.3: Participant groups from the upstream value chain in the dairy industry

Group	Description – Level 1	Interviewees – Level 2	Pseudonyms
Group 1	Eight dairy farmers	Dairy farmers from the Western Cape, Eastern Cape and KwaZulu-Natal	Farmer1 to Farmer8
Group 2	Five dairy processors	Senior staff members from multinational or national dairy processors in South Africa; one interviewee from a third party that collects sustainability-related information on behalf of dairy processors, from dairy farmers	Processor1 to Processor5
Group 3	Three OrgAgri participants. One participant from an NGO	Senior staff in the organisation	OrgAgri1 to OrgAgri3 NGO1

5.4 DATA ANALYSIS DISCUSSION BY THEME – THEME 1: WATER STEWARDSHIP

As mentioned in section 4.7.2, the central identified themes of this study were (i) water stewardship, (ii) the drivers and limitations of water reporting, and (iii) the synergy between value chain stakeholders. Furthermore, frugal innovation, encompassing its three interlinked dimensions of social, institutional and technological innovation, emerged as a cross-cutting sub-theme across all three themes, as participants consistently referenced innovative practices related to water management and reporting throughout the interviews. The findings of the interviews are discussed under these themes.

The topic of water stewardship was discussed in Chapter 2, section 2.7, where a number of definitions were articulated. Ultimately, water stewardship entails collecting water-related data to understand the risks, opportunities and impacts of shared water resources; establish and implement water management plans and targets; and monitor and report on those issues, as well as on stakeholder engagement (AWS 2019:6). The following aspects are discussed under the theme of water stewardship: water conservation, what is measured and how the metrics are defined, the accuracy of the water information reported, whether water quality is tested, how wastewater is managed, the targets and KPIs which can be implemented, how the data are assessed, the value of water reporting, assurance/audits and the disclosure of water-related information.

5.4.1 Water conservation and the desire to gain knowledge and innovate

The term “water conservation” describes any managerial action or user behaviour intended to protect or conserve a water resource and stop its degradation, including its quality (Pereira, Cordery & Lacovides 2012:40). Chapter 2, figure 2.5, step 3 of the water stewardship steps entails taking internal action by increasing the efficiency of water use. Several frugal innovative examples for conserving water were highlighted during the interviews. Processor1 mentioned, inter alia, that some farmers lower irrigation nozzles so that they are closer to the soil, or research the use of smaller nozzles which release smaller droplets, so that water usage is more effective. This also ensures that only the exact quantity of water is dispersed onto the crops during scheduling, to guarantee maximum water retention in the soil by preventing run-off and evaporation. As Processor2 indicated,

> the healthier the farmer’s soil, the more resilient the soil is to both excessive moisture, to flooding or drying out [due to] droughts.

All participants agreed that water usage and soil health are interlinked, specifically if the carbon water-holding capacity of the soil is improved, which saves a lot of water and prevents farmers from having to irrigate as often. When water availability is limited, farmers also try to irrigate the pastures closest to the dairy parlour, so that the cows have the shortest walking distance to cover, because the further they walk the more drinking water and energy are required. Farmers also harvest rainwater. A few of the participating farmers discussed experimenting with different crops that are more resilient to dry weather conditions.

Farmer1 explained that he receives a lot of rain in the winter months, which is when most of the grazing is produced for silage, adding that he had changed the species of grass planted on the drylands:

> So we’ve gone from an annual rye/oats mix to a lucerne/chicory mix and now we’re looking at perennial grasses that are more resilient than rye grass, like cocksfoot and fescues. A lucerne/chicory grass mix [has] a deeper segment that you utilise just because the roots are going deep […]. Where the river water is salty chicory is planted, as it is more salt tolerant. (Farmer1)

Numerous processes in the production of dairy products employ the use of steam to help keep equipment hygienic and sterile, while also encouraging chemical reactions and physical changes in raw milk to produce pasteurised milk, cheese, and so on. The boiler produces

steam, which a pipework distribution system transports throughout the dairy processing plant (Spirax-Sarco Ltd 2000:2) – steam transmits heat and condenses back into water during each step of the process. Processor2 mentioned that, as the steam cools, this water can be captured in the factory, recycled and reused.

Confirming their quest to conserve water, Processor3 recommended using better sprayable nozzles when washing the inside of the tanks and the factory floor. This participant also mentioned that when they purchase machinery and perform modifications (by installing their own water circulation system) it can reduce water consumption from 30 litres to seven (a 77% saving). Additionally, Processor3 reported funnelling rainwater from their warehouse and factory rooftops into tanks, and from downpipes into a canal system which goes into their water purification plant for reuse. This participant also mentioned that they have a team of maintenance staff who are available 24/7 to take care of water and steam leaks on the various production lines, thus saving water when a leak is repaired within a short period of time. As Processor3 explained, every resource in the factory is aimed at saving on water, electricity, fuel, and so on. Processor5 communicated that their organisation needs to install more meters at various extraction points in the factory, to pinpoint whether and where water is being wasted, and to recycle more water by installing a water purification plant in the future.

Since the dairy industry is water-intensive, everyone in the value chain must be innovative to ensure that they conserve this resource when using equipment. Examples of frugal innovation, as discussed by OrgAgri2, include raising awareness and training farm workers and those on the factory floors regarding water-saving initiatives. Examples pertain to leak detection, the timely fixing of leaking hoses and pipes, reducing the size of spray nozzles and introducing non-flow nozzles. NGO1 criticised the suppliers of irrigation equipment to the dairy industry, lamenting that once the sales representative had sold the product, it was difficult to secure after-sales service. NGO1 also identified a gap in the industry, suggesting that a small start-up company might be based in each local area to go around and do repairs for farmers and/or dairy processors, with a 24-hour turnaround time. This will save water if a leaking pipe or pivot needs to be repaired, and will improve process efficiency and water conservation.

Soil moisture sensors were mentioned by all the participants: these devices measure the moisture content of the soil, indicating to farmers when, where and how much to irrigate.

According to Farmer5, such tools measure the moisture in the soil down to a metre and every 10 cm after that, as well as the temperature of the soil. The participating farmers who make use of these moisture probes mentioned that once the profile of the soil is wet, it is easy to top up and they can also automatically trigger the irrigation system. As Farmer6 explained:

> On the innovation side, I think, soil moisture sensors made a huge difference in our management. It goes a couple of ways on the pastures, but the important thing is we used to irrigate the top section of the source, so we used to irrigate a lot, say 5 ml a day. And we didn't fill up the profile every time, so we gave it little, short bursts of irrigation. Now we are trying to, with the probe, see where the bottom extraction line is and fill the whole profile up once again. And that made a huge saving on water, but it also meant that we have a much higher yield from the pastures, because we are training the roots to go deeper.

There have been several new developments in terms of sprinkler packages aimed at reducing evaporation and water usage. Several of the farmer participants mentioned the benefits of the Low Energy Precision Application (LEPA) system. Developed by William Lyle (Bordovsky 2019:1343), the system applies water with low pressure directly to the soil surface, thereby reducing irrigation and run-off.

Farmer3 shared a recent innovation where a pipeline had been installed from a large irrigation dam shared by several farmers downstream. This participating farmer mentioned that they used to run the water downstream, but now, with the installation of the pipeline, there could be a water saving of up to 30 per cent due to reduced evaporation. Farmer3 added that each "tap-off point" in the shared irrigation system is equipped with an electronic water-flow meter. While water withdrawal measurements are now taken manually, the meter might be linked to farmers' cell phones, to enable more effective monitoring and reporting.

5.4.2 Water information and metrics

It was important to determine whether water reporting was being conducted throughout the upstream value chain, but also to investigate what was being reported and what metrics were being used. The four farmer participants who reported on water, stated that the information required by the processors was basic, including how much water is used for irrigation, wash-down and wastewater respectively. As Farmer1 stated, the processors that use an external organisation to collect data from farmers send those farmers a spreadsheet requesting the

necessary data, and the information from these spreadsheets is then fed into their own water tool(s) for assessment purposes.

Farmer1 mentioned that he can provide information on the water usage of the dairy parlour on a daily basis, without being required to give a split of where in the dairy parlour the water was used (e.g., for washing the holding yard and tanks). Farmer2 explained that, each week, the farm managers measure the pasture length and the cows' movement on the farm using GPS probes, to determine exactly how much to irrigate those pastures, thereby saving water and improving the accuracy of water reporting.

The processors (1, 2, 3 and 4) that require the farmers who supply to them to report on water. do in fact provide guidance of how to measure and manage the water on the farm, and are always available to give advice. Information on the volume of irrigation and other water used (e.g., the quantity of water needed to clean the dairy parlour), is required. Once a year, according to Processor2, they access the information the farmers provide, to calculate the premium payable to the farmers. Processor3 explained that they require water usage data from the various pivots per month, as well as water usage in the dairy parlours. Processor4 also required reports of the water used for irrigation and in the dairy parlours. The quantity of water used in the dairy parlour is not influenced by the weather and is therefore more easily controllable. However, this is not where most water is used – the biggest usage comes from irrigation. Processor2 reported using an assessment tool for capturing and monitoring farmers' sustainability information, which covers cultivation methods, the means of irrigation, and so on. Some processors use an external organisation's assessment tool, which requires that a value be placed on everything that comes onto the farm, for example, where extra feed comes from and what its carbon footprint is. However, processors 2, 3 and 4 mentioned that collecting and reporting on water-related issues in the same detail as the carbon footprint, would be difficult.

During the interview, the researcher asked whether it would be possible to obtain water-related figures on everything that came onto the farm. Processor4 responded:

> No. That is a pie in the sky. We know to produce a litre of milk is x amount of water, to produce a ton of lucerne is x amount of water, but that x can be x plus or x minus to produce a kilogram of wheat or maize… sort of standardised norms, that are not exact. There is no way that someone will give you exact amounts. "I have measured now the

lucerne being used in the Northern Cape at Douglas, and that is the amount of water being used." They have got standardised figures, how much wheat and that is what is in use. Otherwise, there is no use in the further control, I mean you need to look at systems, how you can produce more food with the same amount of water or less water.

5.4.3 Accuracy of water-related measuring and reporting

Another important aspect was to determine the degree of accuracy of the water-related figures being reported. Since many stakeholders use the data in sustainability reports to make critical decisions, it is crucial that those figures be accurate (Gnanaweera & Kunori 2018:6). Processor1 highlighted their key reporting challenge within the upstream value chain, saying that "water is our biggest challenge when it comes to accurate measurement".

Farmers 1 and 3 explained how they measure their water consumption on the farm. Farmer1, who belongs to a water scheme, had this to say:

> According to the hectares that you have got, so there was a fixed cost and then there's a per-hectare cost (variable cost), so that's how we worked it out between the farmers and that system will have flow meters at every outlet and [those] will be monitored electronically. I think it takes a reading every 30 seconds or sends the reading every 30 seconds.

Farmer3 takes monthly readings from all the meters positioned around the farm. There is not a meter on every pivot (that provides irrigation), but there is a meter on the pump feeding the pivots. A borehole which supplies clean water has its own meter that is used in the dairy parlour for cleaning the machinery. Recycled water with a dedicated pump is only used for washing down the dairy, for example, to remove manure. This, too, has a meter and its reading is recorded once a month. Farmer3 was confident that his water-reporting figures were quite accurate, and mentioned that he can even report their water usage by clean and recycled water.

Processor1 stated that while some farmers report accurately, the water reporting by other farmers is questionable:

> Many farmers work with approximate figures that, at the end of the year when they need to report their water usage, they take the number of pivots divided by the average they irrigate each month. There is a spectrum of farmers, some that do not record

water consumption and farmers that record and measure everything accurately, so one should not stereotype farmers. Farmers who obtain their water via a water scheme keep very accurate records as they are charged for the water they use. Importantly, the accuracy of water measurement has improved over the years with new technologies.

Processor5 did not require its dairy farmers to report on water, despite monitoring their own water use in the factory, to ensure water-use efficiency. This processor is currently focusing on sustainability issues at their own factories.

5.4.4 Water quality

It is widely recognised that access to clean and sufficient drinking water is essential for the welfare of dairy cows, but also for their growth and production (Schütz, Huddart & Cox 2019:16). Water stewardship implies that the drinking water made available to dairy cows must be of the best quality. Good-quality water constitutes an important part of a dairy cow's diet, for if there is no water, there is no milk. Farmers and processors are responsible for the quality of milk intended for drinking and further processing, which must be monitored and tested during milk collection on the farm and upon arrival at the processor's factory (DSA 2017:3). Thus, to ensure that the water quality adheres to set standards, all processors test the water used in the production process on a regular basis.

When the participating farmers were asked whether and how frequently they tested the quality of the water being used on the farm, they indicated that they indeed test the water quality, albeit with varying frequency. The water used in the dairy parlours was tested more often. Where water was sourced from the mountains, testing was only done every five years. Farmer5 reported testing the water quality once a year, while Farmer6 claimed to do so every quarter. Farmer6 has a water purification plant on the farm (see transect walk of Farm 2, observation point 2.1); while Farmer7 mentioned that their water is sourced from a borehole, and the quality of the water used in the dairy parlour is tested once a year. Farmer7 also mentioned that, in the past there were problems with the quality of surface water due to agricultural activities upstream from the river. For that reason, they had changed to 100 per cent borehole water.

Farmer3 mentioned that if the quality of the milk is inferior, the quality of the water could well be the problem. In such a scenario, the processor would give a warning and try to assist the farmer, where possible, to rectify the situation. Farmer8 indicated that when their milk buyer does its annual audit, the quality of the water being used in the dairy parlour is tested, but not the water used in the fields. Farmer8 added that it is “through observation, exposure and experience, that one can look, smell and see if the water quality is deteriorating, and it also depends on where the water is sourced from”. As an example, Farmer8 noted that none of their cows were getting pregnant a few years ago, and after an investigation they found that there was too much iron in the water, which was causing infertility.

5.4.5 Wastewater

The poor management of dirty water is a missed opportunity for organisations, not only in terms of managing regulatory, reputational and litigation risks, but also when it comes to managing wastewater, which is a significant and largely untapped resource (CDP Global Water Report 2019:2). Wastewater management is an important component of water stewardship (Singh, Nagabhatla & Kreutzer 2023:133). All the farmers interviewed discussed a similar approach to dealing with their farm's wastewater, since water which has been used for various operations on the farm is often channelled into furrows/drains leading into an effluent dam (see Farm 1 transect walk, observation points 1.4 and 1.8; Farm 2 transect walk, observation points 2.8, 2.10 and 2.11). Solids are separated from liquids, after which the solids (manure) are spread on pastures and the liquid is reused for irrigation.

Processors need to pay for the sewerage and affluent they dispose of in the municipal system. Processors 3 and 4 reported having water recycling plants on their premises, which helped to reduce the cost to the processor and saved water through reuse. All the processors interviewed stated that the milk tankers transporting the milk from the farmers to their production sites are washed out after each delivery. However, only Processor3 mentioned that the wastewater from the washing of the tankers is recycled.

OrgAgri1, 2 & 3 and NGO1 all mentioned that, at the farm level, dairy parlours need to be washed down, following which that water is normally collected, recycled and reused (see Farm 2 transect walk, observation points 2.8, 2.10 and 2.11). The same participants also pointed out that some dairy processors and dairy farmers were implementing state-of-the-art technology at their recycling plants. Processor3 commented that most of their farmers’ dairy

parlours are automated, meaning the wash-down of the parlours and bulk tank machines use a specific quantity of water for each cycle (see Farm 2 transect walk, observation point 2.4, and their standard operating procedure [SOP] of how much water to use to wash down the dairy parlour). Water might be wasted inside the parlour where hand-held devices are used, such as hosepipes and pressure washers.

There are ongoing projects where OrgAgri and NGOs assist farmers with wastewater management. Such projects are financed with the help of the levy the dairy farmers pay to Organised Agri, according to OrgAgri1. One example of what may be considered frugal innovation is riparian buffers – an area of land adjacent to streams, lakes and wetlands – that are carefully maintained with perennial vegetation such as grass, shrubs and/or trees (Dosskey, Schultz & Isenhart 1997:1). This type of management is aimed at improving and safeguarding aquatic resources by mitigating the harmful effects of agricultural practices. From the above it is evident that stakeholders in the dairy industry are collaborating to reduce the negative impacts of wastewater. Admittedly, if related information is not reported and shared with the various value chain members, and especially with the final consumer, they will be unaware of these initiatives.

5.4.6 Water-related areas requiring further attention

One question which was put to the participants, dealt with identified gaps in terms of water-related issues in their upstream value chain. Processor2 expressed concerns that paying attention to water usage on farms is not a priority, specifically if the farm is not in a water-stressed area, that technology is expensive to adopt, that expertise is limited, and water is relatively cheap. If water were to become more expensive, it might be valued more. Processor3 noted that in dairy parlours some farmers could be more diligent about the use of water, remarking that there are many opportunities to save water on irrigation and soil management. Processor4 mentioned that, as for their farmers, water withdrawal figures should be reported at the source level, to comply with government requirements (see figure 5.3, where this reporting gap is included in intermediate and advanced reporting). NGO1 voiced concerns about the water information being reported by processors being too basic, and that “they use the correct jargon and policies, but it is not always translated into practice, however, sustainability is a journey, no one is going to achieve 100 per cent success overnight”. NGO1 continued that another opportunity would be to gather dairy processors to discuss sustainability issues and learn from one another. While some information will

understandably be confidential, not all of it will be, therefore these stakeholders should be urged to share information on tried and tested initiatives in a safe space.

5.4.7 Value in water reporting

Another question posed to participants was whether they saw any value in water reporting. Three of the farmers answered in the affirmative, since they receive feedback on their reported figures from their processors to indicate whether they have reduced their water usage on the farm, which is the ultimate goal. Farmer3 stated that if one only measures for the sake of measuring, without using accurate figures, it becomes just another administrative burden. Farmer8 mentioned that measuring is valuable for their own planning and efforts to develop the farm. Processor2 agreed that such information does add value, but deemed it limited, as it is very difficult to establish correct benchmarks to measure against. What is "enough" water? If a farm is experiencing a drought, farmers might use more water (from the borehole, for instance) since they cannot rely on rainfall. Processors3 and 4 agreed that the water-related information received from farmers influences their decision-making, as do interventions aimed at assisting farmers in improving their water use efficiency.

5.4.8 Assurance/audit of water information

The external assurance offered by sustainability reports instils in stakeholders a degree of trust and confidence in the quality of the information provided, functions as a check on managers, and decreases the ambiguity and asymmetry of information-related concerns (Miralles-Quirós, Miralles-Quirós & Daza-Izquierdo 2021:48). All participating farmers who reported on water-related issues to their processors said that their information is audited by the processor and/or an external consulting organisation. Farmer6 mentioned that their processor can see whether a figure is incorrect, as they have a database on which they compare information with that which the farmer submitted the year before. Some external companies audit information and send out staff to work through the submitted information with the farmer. One specific retailer purchases milk from certain farmers, and conducts audits on the farms on a biennial basis. The agronomists whom Processor4 employs provide monthly feedback on its farmers' irrigation management systems, to assist with more accurate water readings. The auditing of water-related information may thus ensure the reliability and completeness of the data, while providing insights and corrective advice to farmers.

5.4.9 Awareness of water frameworks and tools

When the dairy processors were asked whether they were aware of, or used, any water tools, they admitted to being aware of some such tools or standards, including the WWF Risk Filter, CDPs and ISO standards (as discussed in Chapter 3). ISO is used in their factories, and processors 2 and 3 owned to being members of CDPs. Processors 1, 2, 3 and 4 all used their own water tools to assess carbon, where water forms part of carbon measurements and assessments. The OrgAgri participants had heard of these tools; NGO1 admitted to promoting the use of the WWF water risk filter, but branded it better suited to an organisation than a farm.

The question on water tools was not included in the farmers' questionnaire, as the researcher believed they would not be using such tools for water-reporting purposes – something which was confirmed during the interviews' general discussion. The findings discussed under this theme of water stewardship directly informed the water reporting category of the framework, as reflected in figures 5.3 and 6.1. The sub-themes of water conservation, water metrics, water quality, wastewater management, targets and KPIs, the value of water reporting, and assurance and disclosure are incorporated as reporting requirements in the framework, progressing from basic to advanced reporting levels. Next, under theme 2, the drivers and limitations of water reporting are discussed.

5.5 THEME 2: DRIVERS AND LIMITATIONS OF WATER REPORTING

Consistent reporting and the disclosure of comparable water-related information encourage accountability, strengthen collaboration and drive organisations to take action (CDP Global Water Report 2023:7). This entire study centred around how to enhance water reporting in the upstream value chain. Discussed below are the various elements found to drive and limit water reporting respectively, and the various issues that should be addressed when reporting on water-related issues. Identifying the drivers and limitations of water reporting was objective 2 of this study.

5.5.1 Drivers of water reporting

Of the eight farmers interviewed, four (farmers 1, 2, 3 and 6) were required to report on their water usage and management to their dairy processors. For this information, farmers are paid a premium on their milk price and/or provided with financial assistance when they require

an upgrade to their facilities. For example, they could qualify for assistance to upgrade their irrigation systems, solar energy installations or water recycling systems. Therefore, offering incentives aligns with the recommendations of the CDP Global Water Report (2020:8), which advises that organisations support and incentivise their suppliers to advance water reporting and stewardship (see section 3.8.4.1). Farmer2 said, in essence, that the processor provides enough incentives to make it worth his while to comply. Although the financial incentives act as drivers for farmers to report on water, farmers 1, 2, 3 and 6 stated that even if no premium or funding were provided by their dairy processor, they would continue to measure and keep a record of water usage on their farms. In their view, if they failed to look after the own water usage, farming would become unsustainable for them and for future generations. Even those farmers who were not required to report on their water usage, monitored and were mindful of how they used this resource, some to quite a detailed degree. As Farmer1 stated:

> So you have to look at every single possibility of producing more pasture with less water, and how to recycle your water and how to get the most out of every drop.

Another important factor to consider in South Africa is the impact of loadshedding, which peaked in 2022 and 2023. Loadshedding occurs when an energy utility lowers demand on the energy-producing system, by temporarily stopping the distribution of energy to specific geographical areas (Western Cape Government 2019:2). Electricity is needed to pump water to various areas on a farm. This is expensive, especially during loadshedding, when farmers resort to using costly diesel-operated generators. For that reason, the participating farmers stated that they were very conscious of their water usage, in an effort to limit costs. To highlight, OrgAgri1 mentioned an innovation whereby dairy farmers use the methane in cow dung to generate electricity, thereby reducing their dependence on the municipality. An example of this is a dairy farm in Uilenkraal, in the Western Cape, which had developed a biogas plant using cow dung to generate electricity. In 2020, 72 per cent of the farm's power supply came from its own biogas plant (NIRAS-LTS, E4tech, AIGUASOL & Aston University 2021:13-14).

Manure management and innovation within the dairy industry are important, as such endeavours reduce GHG emissions and water quality impacts (Niles, Horner, Chintala & Tricarico 2019:1). During periods of extensive loadshedding, many farmers turn to solar energy, despite the fact that the batteries needed to store the energy are very expensive. Farmer1 explained that the bulk of their farm’s energy use goes into cooling down the milk

and keeping it cool until the transporter comes to collect it. Farmer8 was in the process of installing solar irrigation, which can be used between five and six hours a day during sunny periods, but Farmer7 felt that solar energy was not viable for their farm, as they only had a solar energy charge of 4.5 hours a day, due to their geographical location. Having electricity readily available can advance efforts towards greater water stewardship.

The researcher asked the four participating farmers who were not required to report on their water usage to their processors at the time, whether – if required to do so in the future – they could provide accurate information. Farmers 4 and 5 said it would depend on what was being asked – if it were unrealistic information they would not, but since they have water meters and are already measuring water usage for irrigation and the dairy parlours, and testing samples, they could provide accurate water reports. Farmer7 replied that he did not have the resources to implement the necessary mechanisms, especially if these did not contribute to his profit, adding: “So, if we are forced to do it by law, we will.”

5.5.1.1 Processors have the power to influence water reporting in the upstream value chain

The majority of the processors interviewed required their dairy farmers to report on water; only Processor5 did not. However, dairy processors 1–4 noted that water reporting is not enforced, and that they continue to purchase milk from farmers who do not report on water usage on their farms. Notably, those farmers do not receive a premium on the milk price. Processors 2 and 3 reported paying an incentive to dairy farmers, who are obliged to become members of a third-party organisation that tracks and monitors their performance on sustainability issues, by filling in data sheets. Those farmers are expected to work with the third-party organisation to improve their performance.

While two of the processors that required farmers to report on water usage paid this premium, the other did not, but provided financial assistance by way of a grant/advance payment to assist the farmers with upgrades to their farms. Importantly, the premium paid is not specific to water reporting but covers other sustainability issues too, such as soil health and climate change. Processor3 reported supplying milk to a specific retailer, which requires farmers to adhere to its strict requirements in order to be certified and supply milk to that retailer, to receive additional payments. Processor2 commented that

> …water is cheap, especially relative to electricity, and when water gets more expensive, the value chain would value it more and start measuring and managing it.

Processor2 explained that if the processor is a multi-national organisation, pressure from its global head office will motivate them to obtain and report water-related measurements throughout their value chain. As NGO1 pointed out, one of the drivers of water reporting would be if there was enforcement by legislation, admitting that it does not help if there is legislation but no monitoring or policing thereof.

5.5.1.2 Water measurement and reporting provides opportunities for benchmarking and innovation

Another driver of water reporting is benchmarking, which is a performance assessment and improvement procedure that has been proven to be effective in encouraging industry-wide behavioural changes in respect of water usage (Ajiero & Campbell 2018:1). Farmer7 mentioned that South African farmers benchmark themselves internationally every year, against Australia, New Zealand, Europe and the United States, thereby ensuring that, in his opinion, they are amongst the most efficient dairy farmers in the world. Where they fall short on efficiency, they strive to attain international best practices. Farmers often want to benchmark their milk production, genetics, running costs, maintenance costs, labour costs and labour per cow. In addition, data per cow, and other metrics per litre and per hectare, are also often of interest. Water quality is also tested and compared against benchmarks.

During the interviews the dairy processors were asked whether they set goals, targets and/or KPIs for the farmers. The four farmers who reported on water stated that they are not given targets, despite processors reviewing their previous year's figures and calling for improvements on those numbers. Farmer6 admitted to setting his own targets for water usage on the farm. According to Processor2, the factory reports on the litres of water used per kilogram of product produced and then sets certain targets, while their actual figures related to water consumption are benchmarked against their different factories around the world. Processors 2 and 3 did not set water-related KPIs for their farmers, but had KPIs for their own water usage. Processor4 revealed that they set water KPIs for their farmers, which motivated the latter to install water meters.

The farmers were asked how measuring and reporting on water could be made easier, since technological innovations may assist them by reducing the administrative burden of reporting and could reveal more accurate figures. Simple, readily obtainable and widely available technologies are among the fundamental principles of frugal innovation (Sharma & Iyer 2012:601). Farmer7 mentioned that if they could get electronic water meters installed and the readings sent through to a central database, it would assist them with the reporting process. Farmers 1 and 3 stated that an application (app) where all aspects around water measurement could be punched in and collected, would be useful. As Farmer7 remarked:

> We farmers do not shy away from technology, it is a misnomer. And the reason that we implement all this technology is not because we like it, it is because we see the efficiency gains we get and it is a way of us staying in business.

Processor1 revealed that there is an app that they are working on, to enable farmers to keep a record of the quantity of water each irrigation pivot uses. Farmers can enter data in their phones onto a database. This provides invaluable information to the farmer on a monthly basis, making it much easier to record details and obtain feedback. During the interview, Processor2 mentioned using a scorecard with various criteria that farmers need to complete. This scorecard is accessed once a year, and that is how they determine the premium payable to each farmer. The external consulting organisation then goes through the scorecard with each farmer and gives expert advice on a range of issues. Therefore, farmers who report to their processors receive feedback with important insights into water savings, soil management and other aspects on their farms.

Farmer1 made reference to an innovative type of technology:

> …an ultrasound water meter that you clamp around the pipe, and it uses technology to determine how much water flows through, and that sends that reading wirelessly to a control room, which obviously makes the whole measuring [process] much more accurate and easier.

All the farmers interviewed stressed that there must be a return on investment for them to buy into new innovations, which must also simplify their lives. Farmer2 stated that they use a payback period to decide whether an investment is viable: for example, for a new irrigation system the payback period is four years, as it reduces water requirements. The payback method of investment appraisal calculates the annual return from the project's inception until

the total returns equal the investment cost (Lefley 1996:207). None of the participants mentioned the Net Present Value (NPV) method, which has been found to be the most common and extensively used capital budget investment technique (Shou 2022:829). With the objective of improving corporate water reporting, it was essential to investigate the limitations to water reporting in the upstream value chain, and that matter is addressed below.

5.5.2 Limitations of water reporting

To improve corporate water reporting, the researcher needed to understand the possible limitations or stumbling blocks. The farmers mentioned that it takes time to report on water, and that the administrative burden of reporting on various sustainability issues can take a toll. All the farmers interviewed claimed to have reporting fatigue, lamenting that they had to keep recording/reporting endlessly. They all understood that they had administrative commitments, but noted that their job is to farm. Currently, there is no legal compulsion for farmers to measure and report on their water consumption to the government, but if (or when) this regulation comes into force they might be penalised for efficient water use, as in their view the less water they use, the less water will be allocated to them. Farmer7 mentioned that he would only do extra reporting if there were a benefit for his farm, adding:

> I think it is the cost and then it is like, will I change my practice on the farm by measuring water? Unlikely. Another thing is, I mean dairy farmers work a 76-hour week already.

The processors had some sympathy for the fact that farmers find all the sustainability reporting onerous. In this regard, Processor1 stated:

> Milk buying is a relatively competitive space. If processors became so strict with their reporting requirements, then the farmers start saying, “Well, we will sell it to someone else who is not so strict.”

Processor2 disclosed that at present water is not their main focus in efforts to advance sustainability, but rather climate change, even though water does form part of climate change. OrgAgri2 mentioned that, given the competitive nature of the dairy industry, sharing water usage and efficiencies in the public domain could be a sensitive issue for some value chain members. NGO1 found that the term “water reporting” has different connotations for different farmers, who are quite sensitive about submitting any figures to the government. NGO1 recommended the following:

> So if you [spoke of] water measuring or monitoring of water usage or measuring for water efficiency, that I think would be more appealing to farmers, and might be a little bit less threatening […]. I think that there are almost sometimes neighbour[ly] disputes that come into it. Someone who is upstream or downstream [might have] grumbles with each other because they turn on their pivots when the river is already low, and then, as a result, the offended party gets virtually nothing.

All the interviewed farmers reported endeavouring to practise frugal innovation, which included scheduling irrigation at night when evaporation is at its lowest, and irrigating when there is no wind. They also alluded to planting different plant species that are more drought resistant.

Some of the participating farmers (2, 3, 6 & 7) were very negative and despondent when discussing loadshedding, which they saw as just another issue to contend with. The government does not exclude farmers from loadshedding as they are not categorised as essential services. Farmer5 mentioned that by having to irrigate on hot days, when there is electricity, he loses up to 40–50 per cent of the water used. When there is no loadshedding farmers look at the weather forecasts for predictions of rain, wind and humidity, and measure the soil moisture in order to schedule optimal irrigation so that they use water optimally. Such forecasting is done on a weekly or daily basis. Building trust and fostering a deeper sense of understanding among value chain participants is achieved through the exchange of information and knowledge. Next, the focus falls on theme 3, being the synergy between value chain stakeholders.

5.6 THEME 3: SYNERGY BETWEEN VALUE CHAIN STAKEHOLDERS

A value chain progressively develops into an operating mechanism for risk and resource sharing (Gu & Yu 2022:4): as a result of shared knowledge, the whole agricultural value chain becomes more productive and generates synergistic benefits. Under this theme, the following issues are discussed below: the identification of risks and opportunities in the value chain; how dairy farmers and milk processors engage with their suppliers on water-related issues; sustainable value chain management, government systems and interrelationships; and support for dairy farmers as key value chain members.

5.6.1 Identification of risks and opportunities in the value chain

The success and long-term viability of a value chain is largely influenced by synergies between participants in terms of managing shared risks and opportunities (Gray & Boehlje 2005:281). Several of the processors interviewed were multinational organisations, which make use of some of the tools discussed (see section 3.8.1) to assess risks and opportunities in their global value chains. All participants were asked whether they identified risks and opportunities related to water, and how they managed those risks. In response, they admitted to identifying risks, for example, the possibility of droughts, which they mitigate by storing water; and adjusting the grazing regime by feeding more with baled feed, rather than pasture-based grazing. Farmer6 explained the risk inherent in managing water more efficiently:

> I had an allocation for X amount of water and now the government is lessening my allocation because we are using water more efficiently. Now when the bank comes and does a valuation on my farm, they say, “No, you only got water for X amount of water per hectare. Your water has been reduced, so we are going to devalue your land.”

All the processors conceded that water-related risks and opportunities are discussed within their organisations. As Processor2 mentioned, some of their milk comes from the Gauteng region where water quantity is not an issue as the mines in the area discharge their water into the catchment; however quality is an issue, with the potential of high salt, bacteria and e-coli. OrgAgri4 commented:

> There are many dairy farms situated in the coastal regions, even before the Covid pandemic many people had semi-grated from the inland regions to the coastal regions where better-run municipalities are situated. The Covid pandemic [exacerbated] this as people could work from home, which has and will have an impact on the amount of water in the coastal regions.

As shown in Chapter 2, figure 2.2, 86 per cent of South Africa’s dairy farms are situated in coastal regions, and that may in the future have an impact on water supply for farmers in these areas. NGO1 recommended:

> Water-related risks are a shared risk throughout the value chain. It is not just the farmer's risk, there needs to be a common understanding that will lead to shared action.

Figure 2.1 depicts how water-related risks stretch across the value chain, emphasising that individual actions can affect others, and thus demand a collaborative and coordinated response. Discussed below is the engagement between upstream value chain members, where the close relationship between processors and farmers encompasses the sharing of water-related risks in the industry.

5.6.2 Engagement between value chain members

In this section, engagement between the farmer participants and their suppliers is discussed, as is the question of whether the processors liaise with all their upstream suppliers. The farmers were asked whether they engaged with their suppliers on water-related issues, and whether they needed to report on water usage beyond the borders of their farms. The farmer participants admitted to engaging with the suppliers of machinery and equipment on irrigation, waste management, and any other matters related to water and saving water. Notably, the suppliers of fertiliser, concentrates and seeds are normally sales representatives, not technical advisers, but if the farmers wished to discuss water with these companies, they could arrange to meet with their technical advisors.

During the interviews, the farmers were asked whether they would be able to report on their suppliers' water-related issues if their dairy processor required them to do so. All the farmer participants replied in the negative. As processors 3 and 4 explained, reporting is "ring-fenced" (restricted) to just the farm, but if the farmer buys extra feed and fertilisers these are calculated against established figures on feeds, concentrates and fertilisers that provide an environmental footprint, which is when this aspect is considered. However, this was not specifically calculated in respect of water.

Although this study was delineated to only include the upstream value chain, Farmer3 made important points during the discussion on engagement between members of the value chain, downstream from the dairy processors:

> [We] never get an opportunity to engage with retailers, the one time they did have a meeting organised by the dairy processor to voice their concerns and problems with the retailers. One retailer stood up and said: "By the strike of my finger, I can put you out of business". […] processors are in the middle, trying to keep the farmer and retailer happy. Retailers don't think long-term – they import cheap milk and in the process bully the whole industry's milk prices down in South Africa.

Farmer6 remarked that retailers have no respect for farmers, identifying as one of the biggest issues the fact that there is a total disconnect between the dairy industry and the consumer: the latter does not know what is involved in producing dairy products, and what it costs to produce milk at the farm level versus what they are paying for dairy products. This participant felt there needs to be stronger engagement with consumers, to inform them that the dairy industry is doing a good job of reducing its carbon emissions and water footprint, compared to other industries. NGO1 supported this by saying that consumers need to be educated on what it takes to produce a litre of milk.

When asked whether they know all the members of their upstream value chain, the farmers and processors who participated in this study reported having a close relationship with one another, speaking weekly or even daily. The exception was Processor2, who explained that they purchase 90 per cent of their milk directly from farmers and the other ten per cent from a milk trader, hence they had no direct relationship with those farmers. Processor5 remarked:

> We work hand in hand, that's why we always communicate on a weekly basis. If we've got a problem on our side, then we communicate with them, and so forth.

To substantiate this, Processor5 explained that in 2022 their factory had water availability issues, but nearby farmers helped to supply them with water. Processor5 also highlighted that when farmers struggle with loadshedding to keep their milk cooling tanks working, the processors assist by collecting the milk from the farmer directly after milking. Processor4 revealed that they even donate tanks which are no longer in use to their farmers, for water harvesting when it rains.

5.6.3 Innovation in the value chain and through engagement with other stakeholders

One of the objectives of this study was to identify future elements of frugal innovation in water management. The social innovation dimension was included in this study, as water scarcity is considered a social problem (Cerutti 2017:156). Social innovation encompasses the development of new social partnerships, all while addressing social needs (Murray et al 2010:3). During the semi-structured interviews examples of this emerged, particularly as regards the engagement of value chain members.

A few of the farmers interviewed mentioned that belonging to study groups, where farmers share innovative ideas on resource management (pertaining to water, soil and plant species),

is beneficial to all. However, as Farmer2 noted, the dairy industry is competitive and there is intellectual property on every farm, hence it is vital not to go into details, despite sharing information. Farmer6 gave another example of social partnerships, referring to a few local river trusts, and OrgAgris which assists farmers in need. Trusts are formed to manage, conserve and protect natural resources; they promote cooperation and assist decision-makers in balancing the interests of the numerous stakeholders who are reliant on a particular national resource (Sharp, Thwaites, Curtis & Millar 2013:1246). Farmer6 commented thus on the local river trusts and OrgAgris:

> They're very accessible and they're very willing to help. If you go to them and say "Look, I've got an area that's fully grown with black wattle", they'll come and give you a cost-effective way of fixing it and the benefits that you can expect. And if you want to replant it to natural vegetation they will say to you, "Well, use this or use that, or do not do that, that's going to cause a problem." But yes, it's mostly been from within the farmer and the local agriculture union that we get new ideas and new plans.

Processor4 mentioned that there is a government-owned research farm in George, in the Western Cape, that focuses on several aspects such as water usage, drought-resistant plants, soil management and carbon emission reduction not only for the dairy industry, but for all agricultural products. The processor added that they consult universities for theoretical research, while practical aspects are tested at the research farm. If an innovation is successful, it can be rolled out to the dairy industry. Processor4 disclosed that it was working with various NGOs in different catchment areas to clear IAPs and re-establish riparian areas close to rivers. This is an example of value chain engagement aimed at protecting water sources.

OrgAgri 1 and 2 mentioned that they share information, provide best practice guidelines, and offer training and development opportunities for the dairy industry. They also bring together industry players by organising conferences. Research and development information covering a range of issues, including global warming and irrigation efficiency, is shared in monthly newsletters, on their websites, on Facebook and in regular articles, all of which is indicative of how they promote social innovation in the dairy industry.

5.6.4 Sustainable Value Chain Management (SVCM)

SVCM was also discussed during the interviews. In Chapter 2, section 2.9, this topic was discussed and in figure 2.6, the process steps of SVCM were presented. The interviews featured questions on some of these steps. Step 5 requires that supplier criteria be established and made binding. The question asked of the participants, was whether water-related criteria were included in supplier contracts. The four farmers who reported on water said there was no specific mention of water-related issues in their contracts with their processors, and that reporting on water was not a prerequisite. All the processors interviewed concurred that their supplier contracts did not include anything specifically on water-related issues.

Step 4 of the process steps in SVCM required that modifications be made to internal structures and processes. Processor3 mentioned that they now have a sustainability department, while Processor2 remarked that their organisation has created new structures and responsibilities, formulated targets and strategies, and created various tools. Processor2 also mentioned that one of the biggest changes was the introduction of dairy farmers being paid a premium on milk prices, to encourage them to report on sustainability issues, including water.

In the Org Agri/NGO interview schedule (see Annexure F) one question pertained to how participants think a sustainable value chain could be developed. OrgAgri1 described how their organisation interacts with the International Dairy Federation (IDF), which provides directives and guidelines on various issues in the dairy industry, placing sustainability at the forefront for the past couple of years, for example, how to calculate a carbon footprint. OrgAgri1 has developed a code of best practice, which is an extensive document, and an audit programme that is communicated to all members, including dairy farmers and dairy processors. OrgAgri1 added that these cannot be made compulsory for farmers, but in the past five years, considerable progress has been made especially as regards water sustainability. OrgAgri1 explained that there are ongoing projects to inform consumers of the nutritional value and benefits of dairy, to ensure the long-term future of dairy products. Notably, consumers can purchase a variety of different dairy substitutes and products, including plant-based drinks (oat, almond and soy), water, fruit juices and fizzy drinks. However, it is important to note that a literature review of 21 peer-reviewed articles undertaken by Carlsson Kanyama, Hedin and Katzeff (2021:8), on the environmental impacts

of plant-based alternatives versus dairy products, revealed that producing almond drinks requires a lot more water than producing dairy milk.

OrgAgri2 also communicated information about sustainability, noting that the South African dairy industry is extremely serious about this topic, and more and more farmers are realising that being environmentally aware and informed can deliver economic benefits. NGO1 explained that, to establish a sustainable value chain, each member of the value chain must understand how sustainability affects them. It is not just the farmer's problem, “understanding shared risk and having a common understanding of what leads to shared action” (NGO1) or synergy in the value chain: this participant agreed that there has been a lot of discourse on the topic over the past few years, and highlighted that good leadership and more sustainability champions are needed in individual companies, to share stories at conferences and inspire people. NGO1 mentioned that transparency and traceability are needed. To create a sustainable value chain, these requirements must be stipulated in supplier contracts. OrgAgri4 concluded that, in order to invest in sustainable initiatives, one must receive something in return. This confirms that identifying drivers of corporate water reporting, as per objective 2 of this study, is essential.

5.6.5 Government systems and interrelationships

Government is considered a key stakeholder in the dairy industry value chain (Felix & Sibongiseni 2019:3). Amongst other things, government sets out, and ensures compliance with, applicable laws and regulations as well as tax-collection efforts (CIMA 2022:44). In South Africa, the National Water Act (NWA) 36 of 1998 (RSA 1998:37) was promulgated with the fundamental principle that the national government is ultimately in charge of managing the country’s water resources, as well as of the responsible use of water in the public interest and its equitable distribution. This Act states that water use must be licensed, and stipulates that water use includes, inter alia, taking water from a water source, storing water, diverting its flow and discharging waste into a water resource (RSA 1998:37). Therefore, all farms and processors should obtain a water use licence from the DWS. Processor1 addressed the important point that farmers do not always realise that water is a national resource, which does not belong to any one person. Questions included in the farmers’ interview schedule asked whether they had ever received fines from the national government for water-related transgressions, and whether they needed to report this to their processors, to which all eight farmers interviewed responded in the negative.

As mentioned in Chapter 2, section 2.4.2, to protect South Africa's scarce water resources the South African government, by way of the DWS, announced in Government Notice no. 131 of 2017 that "all farmers that are not members of an irrigation board or water users association" need to take responsibility for water conservation by installing water meters at their own cost (DWS 2020:173). Questions arose about this new water meter law (see Annexure D, Qs 54–57, Annexure E, Qs 59–62 and Annexure F, Qs 29–32). All of the interviewees were aware of the new water meter legislation. One of the functions of OrgAgris is to inform stakeholders in the dairy industry of such changes, or the introduction of new legislation. The general perception of the farmer participants was that it is merely another way of taxing farmers. As Farmer7 stated:

> You know, most of the regulation stuff that comes from government, we just ignore [it] now because usually there is no consultation with farmers, there is no structure put in place as to how they are going to implement it. It is just an absolute mess.

There were mixed feelings among the participants, when asked whether the installation of water meters is an expensive exercise. Some responded that it is not expensive to install such meters, while others said it is all relative: for example, for a small dairy farmer it would be expensive, but not for a multinational dairy processor. A water meter would need to be installed at every extraction point (see transect walk Farm 1, observation points 1.1, 1.2, 1.8; Farm 2, observation point 1.1). Regardless of the number of meters installed on a small farm, they all need to be serviced annually. It is not just the cost of the water meter, there are also piping and installation costs (NGO1). Phadu, Avidon, Phohlo and Galloway (2022:12) report that a project was initiated in 2021, where the WWF and Trace and Save offered participating dairy farmers a 50 per cent rebate on the cost of water meters, of a brand of their choice, and ranging between R8 000 and R10 000 each. The farmers bore the costs associated with the installation of the water meters, the data logger, and any pipework modifications required. During the project, it emerged that the installation and adjustment costs averaged between R25 000 and R40 000 per water meter, exceeding initial expectations and significantly surpassing the costs of the meters alone. In addition, each farm acquired its own individual weather station, priced at R8 598 each. As Processor1 pointed out:

> I definitely do not get the sense that farmers are sitting there saying, "Oh, what a stupid law. That's terrible." No, they understand it. It makes sense. It is not a stupid law. It is logical. It is just about when would they prioritise putting in the water meter, relative to how much it costs and relative to other costs that they have to address.

If dairy farmers join an irrigation scheme they are monitored, and their water withdrawal is measured. From the interviews it became clear that those farmers who extract water from rivers, dams and boreholes on their farms do not have water meters at all extraction points. It was further established that all the participants agreed that the use of water meters is the most accurate way of measuring water consumption, but made it clear that no system is 100 per cent accurate. Water meters need to be calibrated correctly, and the calibration verified on a regular basis. If meter readings are not taken regularly, debris might enter the meter or the meter may have broken since the last reading, meaning the readings will be inaccurate (Farmer1).

During the interviews, none of the interviewed processors reported forcing their farmers to install such water meters (see Annexure D, Q 56). They did, however, communicate that if a farmer needs financial assistance to purchase or install water meters, they assist them (Annexure E, Q 60). Many interviewees from all three groups mentioned that government officials lacked the skills to manage, understand or enforce the new water meter legislation. Not only farmers were installing water meters, but according to the processor participants, their processing plants were doing so as well. Processor3 confirmed that they had installed several meters throughout their factory. These are electronically programmed, so that the readings are captured at a central location. NGO1 mentioned that since the new law came into effect there has been an increase in the number of farmers installing water meters, but there is still “huge room for improvement on the metering side of things”. A common theme to emerge throughout the interviews was the South African government’s lack of support for the agriculture industry.

Processor1 shared a clear example of frugal innovation for measuring water consumption in the absence of water meters. This process involves measuring a pump's rated flow capacity against the duration time of a pump. The results are then compared against the water captured in rain gauges, which are placed below the irrigation pivot points. These combined methods assist farmers in determining their water consumption. Processor1 believed properly monitoring water use, is imperative. This processor branded irrigation systems and the management thereof as amongst the major innovations affecting farmers.

All the interviewees lamented that the government does not support farmers, specifically regarding subsidies. This belief is confirmed by MilkSA (2022:3). An example given by one

of the participants referred to France, where farmers were paid not to cultivate their lands when the government realised that the wheat crop was going to be too large (AgriOrg3). If there is an overproduction of milk overseas, it is dumped in South Africa with no regard for the local dairy industry, according to AgriOrg3. Government and retailers are duty bound to protect South Africa's dairy industry, but this is not happening at the moment (Manako 2023:online).

Adding to the dairy farmer's expenses, some mentioned having to repair roads belonging to the government, in order to conduct their business. Farmer7 reported having spent over R200 000 in 2021, repairing roads. As Farmer3 stated:

> If the government was pro-farmers, I think we would have seen a lot more successful Black farmers already, as commercial farmers. We are sitting in a country where we, as farmers, actually do not get that recognition even. And we kind of feel that we do not belong. That is the kind of vibe that you get.

Without the help of the government, dairy farmers have had to become more independent, to the point where they no longer need the government (Farmer7). Many smaller farmers cannot compete due to economies of scale and have had to exit the industry, with bigger farmers buying up their cows and land. This substantiates the point made in Chapter 1, where it was stated that the number of South African dairy farmers had declined by 59 per cent, from 2011–2020.

Farmer7 described farmers as "mom-and-pop businesses", which government treats as mini-corporations. For example, a government official would call a farmer and ask to speak to the human resource manager or accountant, when the farmer is in fact responsible for everything on the farm. The impression created was that there is a total disconnect between government and farmers. The farmer participants stated that Organised Agri is seen as the voice of farmers, sending out questionaries and petitions, lobbying for farmers' rights, and informing farmers and industry of changes to legislation, which allows farmers to continue their day-to-day activities on their land.

Notably, Farmer8 mentioned that on smaller farms, the farmer is involved in all aspects of the normal day-to-day running of the enterprise, leaving him or her with little time to implement innovative ideas and plans. With this in mind, Farmer7 emphasised that if farmers cannot see

a return on investment they will not adopt a new innovation. This is where frugal innovation can play an important role.

Figures 5.3 and 6.1 show how the findings on the theme of “synergy between value chain stakeholders” influenced the framework's water reporting progression and frugal innovation dimensions. Specifically, the sub-themes of engagement among value chain members and innovation in the value chain contributed to the framework's frugal, social, institutional, and technological innovation components, while the identification of risks and opportunities, sustainable value chain management, and government systems and interrelationships informed the progression from basic to advanced water reporting requirements.

5.7 DRAFT FRAMEWORK

Developing a corporate water-reporting framework was the primary objective of this study. The initial conceptual framework (presented in Chapter 3, figure 3.8) was based on the contextual foundation presented in Chapter 2 and the review of the frameworks discussed in Chapter 3. Chapter 3 sought to achieve objective 1, of mapping the various corporate water-reporting frameworks, water-reporting tools and decision frameworks. However, during the interviews it transpired that many of these water-reporting frameworks/tools are not applicable to the farmers but rather to large corporates, or are tailored by processors to become bespoke frameworks. The findings provided insights into what farmers are reporting on by way of water-related issues. Such reporting was found to occur on a basic level.

The framework depicted in figure 5.3 is an attempt to take the farmers’ water reporting from the current basic level to a more advanced level.

Figure 5.3: Framework for advancing water reporting

Source: Own observations

The above framework, underpinned by frugal innovation theory, was developed by triangulating the three data-collection methods used in this study, namely a comprehensive literature review, the two transect walks, and semi-structured interviews. The components of the draft framework are interconnected: the drivers and limitations of water reporting (section 5.9.1) influence the progression from basic to advanced water reporting (section 5.9.2), as the drivers motivate farmers to progress to higher reporting levels while the limitations present obstacles to that progression. The three dimensions of frugal innovation, social, institutional and technological innovation (section 5.9.3), underpin this progression by providing the means through which farmers and processors can overcome the limitations and respond to the drivers, ultimately advancing water reporting in the upstream dairy value chain. The framework was developed in response to the serious water scarcity issues confronting South Africa, as outlined in Chapter 2. The empirical findings indicated that dairy farmers are highly aware of water scarcity and are already taking every precaution to minimise their water usage, as evidenced by the countless examples of frugal innovation reported during the interviews and transect walks. The framework therefore addresses water use and management, water scarcity, water-related risks and wastewater management as its foundational pillars, all of which are incorporated as reporting requirements within the basic, intermediate and advanced levels of the framework. This framework is discussed in detail below.

5.7.1 Drivers and limitations of water reporting

The drivers and limitations of the findings were discussed under Theme 2. Based on the findings, processors paying farmers an incentive to report on sustainability issues on their farms, was found to be the biggest driver. Other drivers included receiving feedback on how to better run their farms and reduce costs. As regards law enforcement, if government were to enforce and monitor the recording of water usage, farmers would be forced to report on that issue. Growing water scarcity might also encourage farmers to report on water. Setting benchmarks, goals/targets/KPIs would also drive farmers to improve their water reporting and the accuracy thereof. Good leadership and champions in the dairy industry, such as certain farmers, need to set an example for others to follow. Stakeholder engagement and collaboration are essential, as water-related impacts are shared across catchment areas and value chains. Pressure from the dairy processors' head offices, in conjunction with shareholder expectations, and including water reporting as a requirement in supplier contacts can drive more farmers to report on water.

Time constraints, coupled with the concomitant administrative burden, reporting fatigue and costs to purchase water meters and data-logging telemetry, were found to act as significant deterrents when it came to reporting on water at the farm level. Based on the interviews, climate change reporting is the participants' main focus, and even though some water reporting is required when reporting climate change-related information, it is not the primary concern. How much water is being used on a farm can be a sensitive topic, because farmers might be fined for overuse or penalised for using less water, by being allocated less water. Dairy processors can evaluate the various drivers and limitations noted here, and use this information to encourage farmers who are not yet reporting on water to do so. Farmers who are already reporting on water can learn how to alleviate their administrative burden. The way in which farmers can progress from basic to advanced water reporting, is discussed below.

5.7.2 Water reporting progression

An evaluation of the various water-reporting frameworks was undertaken and reported on in Chapter 3. The GRI reporting standards – specifically GRI 303: Water and Effluents – was mainly used in this study's draft framework to help farmers progress from their current basic water reporting to more advanced water reporting. This was decided upon because, according to a global survey of sustainability reporting undertaken by Klynveld Peat Marwick Goerdeler (KPMG 2022:10), the GRI remains the prevalent standard in use world-wide. In 2022, the International Financial Reporting Standards (IFRS) Foundation and the GRI signed a memorandum of understanding aimed at strengthening their working relationship (IFRS Foundation 2024:online). This enhanced cooperation will conceivably maximise the potential of the GRI and the new International Sustainability Standards Board (ISSB) to support reporting on the impacts, risks and opportunities confronting an organisation (IFRS Foundation 2024:online).

5.7.2.1 Basic/current level water reporting

Based on the semi-structured interviews and transect walks, the four farmers who reported on water to their processors, gave details of water usage in the dairy parlour and for irrigation purposes. The water consumption of dairy cows is calculated based on various criteria, for example, herd size, milk production levels, ambient temperature, feed mix, animal physiological state, management techniques, water quality and seasonality (Golher, Patel, Bhoite, Syed & Panchbhai et al 2021:617). Assurance of the accuracy of the information is

important, as it affects the veracity and completeness of the data submitted. Those farmers who are not as yet reporting on water could start off with basic activities, before moving on to intermediate-level reporting, which is discussed below.

5.7.2.2 Intermediate-level water reporting

Water quality and wastewater management reporting is required for farmers to move from the basic to the intermediate level. Giri et al (2020:78) point out that good-quality water is vital for improved or sustained dairy cattle health, and for the production of high-quality milk and milk products. While the dairy industry's wastewater contains high levels of dangerous chemicals, and the sector contributes significantly to water pollution (Al-Tayawi, Sisay, Beszédes & Kertész 2023:1), wastewater is a major water resource that remains largely untapped (CDP Global Water Report 2019:2). For that reason, it is important for farmers and processors to report on how they manage their wastewater, specifically the quantity of water discharged, and into which receiving bodies of water it is discharged. All the farmers interviewed were already managing their wastewater, despite not all reporting on it.

As mentioned, a driver of water reporting is to set goals and targets; a goal being a desired result, while a target is a precise milestone that assists an organisation in reaching its goals (Drury 2004:590, 661). Various water-related goals and targets need to be set not only by the farmers themselves, but also by the dairy processors, and these, together with the actual figures and their variances, need to be reported on with an explanation for any variance(s). Reporting on water withdrawal by source is important: the GRI 303-3 disclosure on water withdrawal requires this, as water being withdrawn from water-stressed areas might harm local communities (GRI 2021:11). Wastewater reuse and recycling were discussed in section 5.6.5, in terms of limiting the impact on local communities, for example, through the development of riparian buffers.

In Chapter 3, a number of tools for assessing water-related risks, opportunities and impacts were discussed, including the GEMI Water Sustainability Tool, the Global/India Water Tool, the Aqueduct Tool and the Water Risk Filter. The availability of these options indicates that reporting on water-related risks, opportunities and impacts is important, and would be beneficial to farmers. Moreover, if processors were made aware of such risks, opportunities

and impacts, they could assist farmers either with funding or by sharing their expertise. Next, the progression from intermediate to advanced water reporting is discussed.

5.7.2.3 Advanced-level water reporting

The advanced level requires reporting not only on the quality of the water used on dairy farms and at production sites, but also on the quality of the effluent discharge. Dairy wastewater has a high pollutant load, therefore releasing partially or untreated effluent can have detrimental effects on the ecosystem (Shete & Shinkar 2013:1615). The quality of wastewater discharge often has to meet stringent government regulations (United Nations Water 2017:64), hence this added measurement of effluent discharge quality is deemed vital.

The GRI 303-3 Water Withdrawal Framework requires a breakdown of all water withdrawal sources, including surface, ground, sea and recycled water (GRI 2018:11). The GRI (2018:11) recommends this level of reporting, since it can reveal the effects a farm or processing plant has on water-stressed areas, and give stakeholders greater confidence in an organisation’s water stewardship efforts.

The setting of goals and targets was discussed for the intermediate level, but at the advanced level KPIs need to be set (i.e., a metric that measures the organisation's success or progress towards achieving a set goal) (Drury 2004:1002). When KPIs are used in corporate reporting they should enhance the transparency and comparability of disclosures (Zarzycka & Krasodomska 2021:653). Processors could set some of these KPIs, so that there is a single, uniform measure for all farmers. Comparing business processes and performance indicators to industry-leading practices and other organisations’ best practices is known as benchmarking (Chartered Institute of Management Accountants (CIMA) 2022:352). In section 5.7.1.2, Farmer7 mentioned using benchmarking, and noted that where thoughts on best practices are exchanged between farmers, it can be used to improve on their water reporting.

As discussed, wastewater remains an untapped resource. Water resources globally are facing considerable and increasing pressures, which have intensified the focus on water recycling (Nkhoma, Alsharif, Ananga, Eduful & Acheampong 2021:278). The recycling of water and reporting on associated efforts have a number of benefits, such as improved brand image and water use efficiency. If done correctly, there will be no need to pay for the

discharge of wastewater into local water bodies, or to apply and pay for discharge permits (CDP Global Water Report 2017:103). Reporting on the quantity of water recycled will therefore be beneficial to both farmers and processors. Following the insights gained from the transect walks and interviews, the researcher was mindful of a farmer's administrative burden and wanted to make the progression from basic to advanced water reporting as easy as possible. Frugal innovation, combined with technological, social and institutional innovation, is discussed below.

5.7.3 Frugal, social, institutional and technological innovation

During the semi-structured interviews and transect walks, participants shared various examples of how frugal innovation influences water reporting in the upstream dairy value chain. In terms of social innovation, participants agreed that exchanging water-related knowledge and information between farmers and processors raises water awareness and encourages reporting. Institutional innovation, irrigation schemes, processor incentive programmes and the government's water meter regulations were highlighted as critical accelerators of more structured water reporting. Technological innovation was evident in participant’s references to water meters, irrigation technologies, apps, AI and satellite technology as practical instruments that aid farmers in measuring and reporting their water consumption, as discussed in section 2.5.3. Together, these three dimensions of frugal innovation can support farmers and processors improve their water stewardship and water management, and are reflected as distinct components of the draft framework in figure 5.3. Reporting on stakeholder collaboration and knowledge sharing, water meter installation and irrigation scheme membership, and the use of digital tools for water measurement and management, are recommended as reporting requirements under the social, institutional and technological innovation dimensions of the framework respectively. Consistent with the literature, a number of interviewees remarked that dairy processors could benefit from collaborative projects with government and NGO focused social innovation (Orlitzky et al 2017:36). Institutional innovation is where departments are restructured or new departments are formed to focus on water management and sustainability issues. Another example is irrigation schemes, where farmers who belong to such schemes are able to measure their water withdrawal accurately. Lastly, new incentive schemes were also noted under institutional innovation, processors can develop such schemes to motivate farmers to report and manage water consumption and use on their farms.

The initial framework, illustrated in Chapter 3, figure 3.8, was based on the literature review conducted in chapters 2 and 3, which included a discussion of the theoretical lens, and frugal innovation (with its three interrelated dimensions). This framework was enhanced so as to accommodate practical issues identified during the transect walks and semi-structured interviews.

5.8 SUMMARY

This chapter presented and described the findings of the two dairy farm transect walks, as well as the research findings from the semi-structured interviews, which informed the development of the draft water-reporting framework. The semi-structured interviews were discussed under the three themes of water stewardship, the drivers and limitations of water reporting, and synergy between value chain stakeholders. This chapter highlighted how innovative farmers and the larger dairy industry are. Although one of the main drivers of water reporting is processors paying farmers an incentive, the beneficiary farmers highlighted that they would continue to report on their water usage even if the incentives were withdrawn, as they recognised the value in doing so.

The main objective of this study was to produce a water-reporting framework for the upstream dairy industry, informed by the principles of frugal innovation. To this end, the findings from the literature review, transect walks and semi-structured interviews were integrated through triangulation to develop the draft framework presented in Figure 5.3. In the chapter which follows, the researcher presents the findings from the second round of semi-structured interviews conducted to validate the draft framework and guide the construction of the final framework. (section 6.3 and figure 6.1). The implications for future research, the limitations of the study, and the contribution which this thesis makes to the body of knowledge in the field, are also discussed.

CHAPTER 6: CONCLUSION, IMPLICATIONS AND OPPORTUNITIES FOR FUTURE RESEARCH

"Water is the driving force of nature" (Da Vinci n.d.)

6.1 INTRODUCTION

The main aim of this study was to develop a corporate water reporting framework for the upstream value chain of the South African dairy industry, capable of enhancing accountability, transparency and stewardship. In pursuit of this aim, global and South African water challenges and how climate change is affecting water availability and quality, were explored. The study focused on the dairy industry as a significant consumer of water, particularly in the upstream value chain where approximately 90 per cent of water usage occurs at the farm level. The theoretical frameworks underpinning this study were frugal innovation and its interlinked dimensions of social, institutional and technological innovation. The literature review included a chapter that evaluated various water-reporting tools and frameworks to, inter alia, determine whether the value chain was included in their reporting requirements.

To achieve the objectives of this study, a qualitative approach with an interpretive philosophy was used. DSR served as the research design, where the development of an artefact is required. Semi-structured interviews served as the primary data-collection method, while transect walks provided a secondary source of data to support contextual understanding and the triangulation of findings. The data were analysed using thematic analysis. Atlas.ti was used to code the empirical data. The preceding chapter discussed, in some detail, the research findings of this study, and presented a draft water-reporting framework. The concluding chapter is considered the final piece of the larger thesis "jigsaw puzzle" (Biggam 2011:185). Concluding a doctoral thesis is a task with multiple dimensions, and requires the researcher to "tie up the ends from where they started" (Trafford & Leshem 2008:128). Saunders et al (2023:734) recommend that the focus of the final chapter be on whether the research objectives were indeed met.

This chapter summarises the literature and empirical research, in addition to detailing how the study's objectives were met. The results from the second round of interviews (held to

assess the draft framework) are explored, and the finalised framework is illustrated in figure 6.1. The study concludes with its contributions to the existing body of knowledge, an examination of implications for future research, an acknowledgement of the limitations of this undertaking, and a concluding summary.

6.2 OVERVIEW OF THE LITERATURE AND EMPIRICAL STUDY

Globally, water has become a fundamental issue in the environmental crisis, driven by rising demand, escalating pollution, and the inadequate management of water resources by both government and private entities. The agriculture sector, as one of the biggest consumers of water, has a crucial responsibility to ensure the efficient management of water resources. Among various agricultural practices, dairy farming is particularly demanding in terms of water usage, as it requires water for both drinking and cleaning, in addition to water being embedded in the production of animal feed. In the context of water management and stewardship, many organisations only concentrate on their own direct operations. However, a considerable portion of their water footprint is contained in their value chains.

The aim of this study was to transform research insights into a framework for enhancing water reporting in the upstream value chain of the South African dairy industry. To accomplish this aim and address the stated research problem, table 6.1 indicates the alignment between the research objectives and the corresponding sections of the thesis in which they were addressed.

Table 6.1: Mapping the research objectives to the relevant thesis chapters

Main objective	Relevant chapters
To develop and evaluate a water reporting framework for the upstream dairy industry, informed by frugal innovation principles and constructed through the triangulation of literature, transect walks and semi-structured interviews.	Chapter 1 introduced the theories used in this study. Chapter 2 delved deeper into frugal innovation and its accompanying dimensions of social, institutional and technological innovations, which were incorporated as the overarching elements from the draft framework through to the final version. Chapter 3 reviewed several of the water-

	reporting frameworks that are currently discussed in the literature. From this review, an initial framework was developed (see figure 3.8). Chapter 5 provided the findings of the transect walks and the first round of semi-structured interviews. From these empirical findings, a draft framework was produced (see figure 5.3). A second round of semi-structured interviews was conducted to evaluate the draft framework. The suggestions and recommendations received from the participants were used to improve the draft, to create the final framework for this study (see figure 6.1).
Secondary objectives	**How were the objectives achieved?**
To explore existing corporate water reporting frameworks, with a specific view to identifying niche areas and gaps for water reporting within the upstream dairy value chain.	As mentioned, Chapter 3 evaluated the various water-reporting frameworks that are available in the public domain. The chapter focused on water-reporting tools and decision-making frameworks, to determine whether they incorporate the value chain in their nexus.
To identify the key drivers and limitations of corporate water reporting in the upstream dairy value chain through the literature review, transect walks and semi-structured interviews.	The semi-structured interviews contained questions relating to drivers and limitations (see annexures D: Q22 & Q23, E: Q20 & Q53, and F: Q23 & Q24). In Chapter 5 (the findings chapter), section 5.7 focused on the drivers and limitations of water reporting in the upstream value chain. These were incorporated into both the draft and final frameworks (see figure 6.1).
To identify existing and future elements of frugal innovation in water	Chapters 1 and 2 provided more insights into frugal innovation, while the findings in

management within the upstream dairy value chain in South Africa and assess how these elements may support water reporting.	Chapter 5 gave real-life examples from the empirical data collected during the transect walks and interviews.
To integrate and triangulate findings from the literature, transect walks and semi-structured interviews to develop and evaluate the relevance and applicability of a water-reporting framework for the upstream dairy industry.	Chapter 3 reviewed existing corporate water reporting frameworks. Chapter 5 integrated the findings from the literature review, transect walks and the first round of semi-structured interviews to develop the draft framework (see figure 5.3). Chapter 6 evaluated the draft framework through a second round of semi-structured interviews, from which the final framework was developed (see figure 6.1)

Source: Author

A qualitative approach was adopted, with semi-structured interviews and transect walks as data-collection methods. Purposeful snowball sampling was undertaken, and DSR was used as the research design method: in particular, the process steps of Peffers et al (2006:97) were followed (see figure 1.5). Once ethics approval had been obtained, the first transect walk was conducted on Farm 1 (table 5.1), which informed the interview schedules. Three such schedules were developed, one each for farmers, processors and Organised Agri/NGOs (see annexures D, E & F). Seventeen semi-structured interviews were conducted and a second farm transect walk was done. The data were analysed using thematic analysis, to identify themes. Once a draft framework had been developed from the findings, a second round of semi-structured interviews was conducted with five participants, as part of the DSR process, to evaluate that framework. The research findings from the second round of interviews are reported below.

6.3 EVALUATION AND RECOMMENDATIONS ON THE FRAMEWORK

As discussed in Chapter 1 (section 1.10.5.1), a second round of interviews was held to obtain feedback and evaluate the draft framework presented in Chapter 5 (section 5.3). As depicted in table 4.1 and in accordance with the suggestions of Saunders et al (2016:297), a minimum sample size for semi-structured interviews is between five and 25 participants, and, if considering a homogeneous population (such as expert interviewees within the upstream dairy industry), a reasonable sample would be between four and 12 participants. The second round of interviews included five participants, which is in line with the above minimum participant criterion. The five participants, who were also included in the first round of interviews, were processors 1 and 3, farmers 2 and 8, and NGO1, who were selected for the second round of interviews based on the knowledge and expertise they demonstrated during the first round of interviews. In addition, processors 1 and 3 and NGO1 represented and collaborated with numerous farmers, hence their views were sought. Data saturation was reached after the five interviews as nothing new came to light or, as Sandelowski (2008:875) refers to it, “informational redundancy” had been reached. All the interviews were conducted online, the draft framework and a short summary of the framework having been sent to the participants a day before the interviews, to allow them time to review those.

The second round of semi-structured interviews contained six questions (see Annexure K), all relating to the draft framework. The participants were asked to analyse the drivers of water reporting listed in the draft framework and to recommend any additional drivers. All the participants stated that the list of drivers was sufficiently comprehensive. Notably, NGO1 mentioned that law enforcement is impossible without legislation being in place, and Farmer8 indicated that a driver to report on water would be to achieve cost efficiencies. Reporting on water would highlight excessive water usage, while using less water was also linked to savings on electricity, since farmers rely on a stable electricity supply to pump water from the source. Legislation and cost efficiencies were therefore added to the list of drivers.

When asked whether most of the relevant limitations were included in the framework, processors 1 and 3 and Farmer2 deemed the list of limitations to be all-inclusive. However, the researcher found that some of the limitations had to be reworded, as they were not clear to the participants: “Precedence of climate change reporting” was reworded to “Focus is on carbon footprint reporting”; “Water reporting connotations” was amended to “Term – water

reporting negative connotations" and "Info – sensitive nature" was amended to include water, therefore it became "Water info – sensitive nature". NGO1 stated the following about water reporting:

> I think that it must be linked to water pricing. Currently, water is too cheap, for example, the agricultural water rates compared to industrial rates. So, the higher the water rates, the more incentive there is to use it sparingly and to monitor, measure and try and be as efficient as possible.

NGO1 also mentioned that there are costs involved in reporting on water, such as water meters, telemetry and data loggers, which should be included as a limitation. Farmer8 pointed out that, on smaller farms there might not be the necessary skills to report on water. These observations were added to the list of limitations.

With reference to the arrows in the framework that demonstrate the water-reporting progression from basic to intermediate to advanced, NGO1 suggested that the researcher change the colour when introducing new reporting requirements from basic to advanced, so as to assist the reader in clearly identifying the new reporting requirements in the next step. This advice was taken on board, and these now appear in blue. Processor1 suggested to the researcher that water usage for irrigation per pivot was not a basic level reporting activity, and should move to the intermediate level, in addition to changing the phrasing to "by irrigation methods" as there are other forms of irrigation. Also, Processor1 stated that since many farmers do not report even at the basic level, the first arrow's name cannot be labelled "current level" and should be changed to "basic level" only, with "current level" removed. NGO1 suggested that the researcher include water extraction/withdrawal from the main source in the basic level arrow, in order to represent the initial action that the majority of farmers could take, to begin their water-reporting journey.

NGO1 stated that the progression from basic to advanced water reporting is possible, yet it would have to be enforced by the milk processor, government or local water management institutions, such as water user associations (WUAs), water boards, and catchment management agencies (CMAs). These water management institutions wield a great deal of power, according to NGO1. According to the DWS (2023b:76–77), the WUAs, CMAs and water boards can do the following: WUAs manage and maintain local irrigation systems, while ensuring that members comply with local regulations and by-laws (e.g., following abstraction

limits and fulfilling maintenance responsibilities). CMAs develop strategies for managing catchment areas and may establish rules to control water usage. Water boards are state-owned bulk water service providers which function under the Water Services Act (DWS (2023b:76–77); they deliver water to municipalities and, in certain instances, to industries; and they manage dams and large-scale infrastructure. Their tariffs are regulated by the DWS/minister.

Processor1 and NGO1 could not see the progression from basic to advanced reporting happening, unless there were incentives for farmers to improve their water reporting. As NGO1 cautioned,

> there are dynamics at play, where the milk processors do not want to upset the farmer in the event the farmer moves over to another milk processor, to whom they would rather sell their milk. Therefore, the processor would not want to put too much pressure on the farmers to report on water.

Processor3 and Farmer8 mentioned that the smaller farms would not be able to progress unless there were assistance and training provided by, for example, milk processors and MilkSA/AgriSA. Farmer2 believed farmers could progress to the intermediate level, but that it would require a lot of effort and money. Processor1 stated:

> We've seen progress and I think we've got a couple of people sitting at that intermediate reporting stage, and then maybe like one or two farmers that I know of at the advanced reporting stage. The bulk of people are still lagging at the basic reporting [stage]. And it's because there's no incentive for them.

When asked whether farmers and the dairy industry as a whole would benefit from the water-reporting progression, all the participants concurred that this would be the case. They stated that by reporting on water-related issues, farmers would enhance their water-related efficiencies. Processor3 warned that the DWS is already working in the Eastern Cape to investigate whether farmers are using water more efficiently, and have begun monitoring water usage. “If you can’t prove that you are measuring and monitoring your water use, the farmer could lose some of their water rights” (Processor3).

Farmer8 stated that water reporting can assist with long-term planning, for instance, where more irrigation is necessary. This participant also noted that while many farmers are paying

for all their water use licences, others are not. If water reporting were to become mandatory, it would compel those farmers who currently do not pay for water to start doing so. Processor1 advocated for the farmers, stating that it is not that they lack any concern for water, but rather that measuring and reporting have not been prioritised, and there are no incentives to encourage them to take action. In fact, the management and stewardship of water is among the easier tasks to be carried out on a farm, so it should not be difficult for farmers to measure and report on water (Processor1).

The issues discussed above did not necessitate any amendments to the framework per se, but provided valuable insights into whether the farmers could move from basic to advanced water reporting, and whether the progression would benefit the upstream value chain at all. The theoretical framework for this study of frugal, social, institutional and technological innovation, is depicted in the final framework. When asked in what way innovation assists the upstream value chain in enhancing water reporting, most of the participants' recommendations echoed those made during the first/initial round of interviews, which included using integrated water meters and irrigation systems that can automate the reporting of water through apps and sensors. NGO1 mentioned Green Water Credits (GWCs), a market-based investment mechanism that aids upstream farmers in investing in enhanced green water management practices for downstream water users (International Soil Reference and Information Centre [ISRIC] 2016:2). As ISRIC (2016:8) avers, green water credits are financial incentives that reward land users (such as farmers) for using land and water management methods that promote natural water retention, infiltration and ecosystem health.

Upon being asked to suggest ways to improve the draft, apart from the refinements discussed above, Processor1 complemented the researcher on the framework, commenting that it "makes sense and it is pretty good"; Processor3 commented "that it is a very nice system, especially at a farm level"; Farmer2 approved of the framework as it is straightforward, and believed it would encourage participation. Lastly, Farmer2 invited the researcher to attend one of their river catchment meetings to explain the framework and how easy it is to begin reporting on water-related issues, since none of the farmers in that catchment currently report on water. The comments, suggestions and insights gathered from the second round of interviews were incorporated into the framework, leading to the final version illustrated in figure 6.1.

Figure 6.1: Framework for advancing water reporting in the upstream value chain

Source: Own observations and input from interview participants

6.4 CONTRIBUTION TO KNOWLEDGE

As demonstrated in Chapter 3, several frameworks and water tools are available in the public domain, although many are complex and mostly targeted at corporate organisations, which include corporate farming entities. In contrast, the framework created in this study (as shown in figure 6.1) is more straightforward and arguably more achievable, particularly at the individual farm level, where it can contribute to water stewardship initiatives. Therefore, it would be less intimidating for farmers or organisations which have not yet begun reporting on their water-related issues, or those wanting to advance their water-reporting initiatives. It is particularly useful that the framework accommodates various levels (basic, intermediate and advanced) of water reporting in the upstream value chain of dairy farmers. While the GRI 303 includes value chain reporting requirements, it is primarily designed for large corporate organisations and requires a level of technical expertise and resources that most individual dairy farmers do not have access to. Similarly, tools such as the WWF Water Risk Filter and the CDP water questionnaire are valuable for assessing water-related risks at a corporate level, but do not provide a step-by-step reporting progression from basic to advanced levels, nor are they designed specifically for the upstream dairy industry in a water-scarce developing country context such as South Africa. The framework developed in this study therefore, addresses these gaps by offering a practical, accessible and context-specific reporting tool for the upstream dairy value chain informed by experts in the field. This study also builds on earlier applications of frugal innovation in sustainability reporting by advancing its use in corporate water reporting within the dairy industry. Furthermore, the study moves beyond some other generic and conventional water reporting frameworks by proposing frugal innovation as a new normative principle in the field of corporate water reporting in the South African dairy industry.

As the figure demonstrates, water reporting needs to shift to a more strategic and forward-looking approach, which is consistent with the principles of the IIRC (now consolidated into the IFRS foundation) (see Chapter 3). Additionally, the framework provides clear drivers (e.g., financial incentives and cost efficiencies) and shows limitations (including the cost implications and the significant administrative burden attached to water reporting), and what measures value chain members can institute or attempt, to promote water reporting throughout the value chain. To illustrate the potential practical contribution of this study, the researcher reviewed the water-reporting initiatives of several companies. Tiger Brands, one

of the largest publicly traded producers of fast-moving consumer goods (FMCG) as reported in Africa's 2024 Integrated Report (Tiger Brands 2024:1), did not include any water-related information pertaining to its value chain. In similar vein, RCL Foods, which is listed on the JSE, is a prominent food producer in South Africa, offering a diverse selection of both branded and private label food items (RCL Foods Ltd 2025:4). Although it adequately reported on the water-related issues of its direct operations, it did not include any value chain water information in its 2025 integrated report. Nestlé, listed on the Swiss Stock Exchange, is the largest food and beverage corporation in the world, based on revenue (Nestlé 2024:3). Upon reviewing Nestlé's non-financial statement for 2024, extensive qualitative information was supplied on water and value chains, yet the quantitative information on water resources can be assumed to relate only to direct operations – no mention is made of their value chains, nor are value chain figures shown separately.

The final framework put forward here, could guide water reporting in practice for both small organisations and large multinational listed companies, by enabling the integration of value chain data. Water reporting can also support key steps in water stewardship, including internal action, collective action and influence governance (see figure 2.5).

As regards a methodological contribution, as mentioned in section 4.6.2 and alluded to by Saunders et al (2023:390), observation has traditionally been overlooked in business research. This researcher undertook two transect walks, which may be regarded as an innovative data-collection method, as they revealed important insights that would not otherwise have been gained. Hopefully, other business and accounting studies candidates can be inspired to conduct transect walks as part of their data-collection methods, especially in instances where immersion in the research context is essential for meaningful engagement with the study participants.

Provin, Vieira Cubas, de Aguiar Dutra, Mussi and Junges et al (2024:14) concluded in their study that there is a need for more research on frugal innovation in qualitative research, as it permits participants to express their feelings on, opinions about, and motivations for, doing more with fewer resources. Considering that this study employed frugal innovation as the theoretical lens and adopted a qualitative approach, it has added fresh insights and offered new perspectives on advancing water reporting in the dairy industry. Furthermore, although Hossain (2021:6) indicates that India is at the forefront of frugal innovation research, the

current study focused on the South African setting, thereby setting an example for the use of frugal innovation in other geographical areas and contexts.

From a theoretical contribution, this study adds to the field of corporate water reporting in agricultural value chains by expanding the application of frugal innovation theory beyond its conventional context of product redesign and financial resource constraints in low-income markets. In particular, the study shows that Bhatti et al.'s (2018:109) three-dimensional frugal innovation construct, which includes social, institutional, and technological innovation, offers a fresh and suitable perspective for comprehending how resource-scarce solutions can be created to address reporting issues related to water. This application advances the theoretical application of frugal innovation beyond its traditional bounds, especially in the South African context where water shortage is a natural resource constraint rather than just a financial one (Hossain 2017:199-205).

6.5 RECOMMENDATIONS

Dairy farmers are increasingly expected to report on a wide range of environmental and sustainability issues, including greenhouse gas emissions, climate change, soil health and water usage, amongst others. This places a significant administrative burden on farmers, particularly those operating as smaller enterprises with limited resources and capacity. It is therefore recommended that dairy processors take an active role in supporting and incentivising their supplier farmers to commence water reporting, as the findings of this study suggest that farmers are more likely to report when encouraged and supported by their processors. The framework developed in this study attempts to alleviate the reporting burden by presenting water reporting requirements in a basic, intermediate and advanced progression, demonstrating to farmers that initiating water reporting need not be an overwhelming undertaking, even alongside their other reporting obligations. The South African government should consider implementing subsidy schemes, shared funding mechanisms, and incentive programs to encourage dairy farmers to gradually adopt water-reporting technologies and practices, thereby avoiding additional financial burdens on farmers and strengthening water stewardship across the upstream dairy value chain. Investors and ESG market actors are encouraged to include upstream value chain water reporting as a requirement in their investment decisions, as this would create a further

incentive for processors and farmers to adopt the framework. Additionally, by encouraging water reporting and stewardship in the upstream dairy value chain, the framework contributes to the achievement of SDG 6 (clean water and sanitation), as discussed in Chapters 2 and 3.

6.6 IMPLICATIONS FOR FUTURE RESEARCH

Future studies could prioritise the water-reporting drivers and limitations outlined in the framework, ranking them from most to least significant. This approach would ensure that the most pressing issues are addressed first, thus facilitating the launch and advancement of water reporting in the upstream value chain of the dairy industry. Although this study focused on the dairy industry in South Africa, it could be replicated in other agricultural settings and industries, and even in other countries, to investigate how the upstream value chain might enhance water reporting and curtail any factors that limit such advancement. Additionally, the study adopted frugal innovation as its theoretical framework. Future researchers may consider carrying out a comparable study using different theoretical frameworks, such as the Water Footprint Assessment framework or the Value Chain Assessment framework, as both could offer complementary insights into water reporting in the upstream dairy value chain.

6.7 THE LIMITATIONS OF THIS STUDY

This study was limited to the upstream value chain, which included dairy farmers and milk processors, as most of the water consumed is at the farm level. The study centred around the South African dairy industry, but the prospect exists to discover whether the findings would be the same (or similar) in other countries or agricultural sectors. The research cannot be generalised, since the study employed a qualitative approach where smaller samples sizes were used. However, a range of expert interviewees were consulted to enhance the credibility of the study. The researcher interviewed 17 participants during the first round of interviews, and five in the second round. Data saturation was nevertheless reached in both rounds. While the sample size of 17 participants exceeded the minimum requirement for a qualitative study of this nature, the findings may not fully represent the views of all dairy farmers and processors across South Africa, and caution should therefore be exercised when applying the framework beyond the upstream dairy value chain.

The framework remains a voluntary tool and was developed specifically for the South African dairy industry, which means it may require adaptation before it can be applied in other countries or agricultural sectors. Furthermore, the framework focuses exclusively on the upstream value chain and does not extend to downstream activities. Future studies could therefore explore how the framework could be mandated or incentivised, adapted for other countries and sectors, and expanded to incorporate downstream value chain activities as water reporting practices mature.

Subjectivity and bias are inherent in qualitative research, yet measures were taken to guarantee the reliability of this undertaking. For example, in this study an EIC was contracted to assist in coding the semi-structured interviews. Moreover, qualitative interviews were deemed an ideal method for collecting data, since they allowed for the gathering of in-depth, valid, and reliable information and insights. Frugal innovation, underpinned by institutional, social and technological innovation, provided the theoretical lens for this study, whereas other theories may provide different insights.

6.8 CONCLUSION

The core aim of this study was to develop a framework, guided by frugal innovation, to enhance water reporting in the upstream value chain of the South African dairy industry. This undertaking included a detailed literature review to establish, among other things, the importance of water to life and industry, and investigate and evaluate the water-reporting tools and frameworks available in the public domain. This chapter confirmed how the objectives were achieved. While no new theoretical constructs were proposed, the study employed frugal innovation in an innovative way. The development of a water-reporting framework specifically for the dairy industry made a novel, practical contribution. In addition, the implications for future research and the limitations of the study were highlighted. This research may benefit dairy farmers, dairy processors and NGOs aiming to enhance water efficiency and accuracy in water reporting. Furthermore, the findings could be of interest to a number of ESG market actors (as per figure 3.2), including investors/asset managers, regulators/government officials, accountants and educators, since ESG information influences investment decisions.

The framework created in this study directly addresses the problem identified in the problem statement. By guiding dairy farmers and dairy processors through a progression from basic to advanced water reporting, the framework enables reporting organisations to assess their water management practices, identify water-related risks and opportunities at the source, and identify gaps and issues in the upstream value chain, aspects that existing frameworks have largely treated as supplementary rather than essential reporting activities.

Lastly, the researcher's passion for the environment, nature and all living things, and the value of water served as the driving force behind this academic investigation. If water embodies the planet’s magic, and climate change reveals its force, then our future rests on how wisely we safeguard what is arguably our most vital natural resource. Therefore, if this research can inspire more people to appreciate the true value of water by measuring, managing, collaborating/engaging and reporting, then it has made an invaluable contribution to the field.

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ANNEXURE A: RESEARCH ETHICS APPROVAL CERTIFICATE FOR PROPOSAL

UNISA university of south africa

UNISA COLLEGE OF ACCOUNTING SCIENCES RESEARCH ETHICS REVIEW COMMITTEE

Date: 10 November 2021

ERC Reference # : 2021_CAS_044
Name : T Askham
Student no: 50870130

Dear Ms T Askham,

Decision: Ethics Approval from 9 November 2021 to 8 November 2024

Researchers: Ms Theresa Askham (askhat@unisa.ac.za)
Supervisor: Prof Bienkie Shuttleworth (shuttcc@unisa.ac.za)
Dr Jaco Moolman (moolmj@unisa.ac.za)

Working title of research:
Enhanced Corporate Water Reporting in the Value Chain of the South African Dairy Industry

Qualification: PhD and Non-degree

Thank you for the application for research ethics clearance by the Unisa College of Accounting Sciences Research Ethics Review Committee for the above-mentioned research. **Ethics approval is granted for this conceptual research ethics application for the purpose of R&D leave.** The certificate is valid for the period **9 November 2021 to 8 November 2024.**

*The **negligible risk application** was **approved** by the CAS RERC on **9 November 2021** in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the CAS RERC.

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3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
7. No fieldwork activities may continue after the expiry date **(8 November 2024)**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **2021_CAS_044** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Signature : **Prof Lourens Erasmus**

Chair of CAS RERC

E-mail: erasmlj1@unisa.ac.za
Tel: (012) 429-8844

Signature : **Dr Chisinga Chikutuma**

Digitally signed by Dr CN Chikutuma
DN: cn=Dr CN Chikutuma, o=Unisa College of Accounting Sciences, ou=Head: Office for Graduate Studies and Research, email=chikucn@unisa.ac.za, c=ZA
Date: 2021.11.10 10:26:02 +02'00'

Head : Office for Graduate Studies and Research
By delegation from the Executive Dean: College of Accounting Sciences

E-mail: chikucn@unisa.ac.za
Tel: (012) 429-3401

URERC 25.04.17 - Decision template (V2) - Approve

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ANNEXURE B: RESEARCH ETHICS APPROVAL CERTIFICATE TO CONDUCT

TRANSECT WALKS

UNISA university of south africa

UNISA COLLEGE OF ACCOUNTING SCIENCES RESEARCH ETHICS REVIEW COMMITTEE

Date: 6 September 2022

ERC Reference # : 2022_CAS_028
Name : T Askham
Student no: 50870130

Dear Ms T Askham,

Decision: Ethics Approval from 6 September 2022 to 5 September 2025

Researcher: Ms Theresa Askham (askhat@unisa.ac.za)
Supervisors: Prof. Christina C Shuttleworth (shuttcc@unisa.ac.za)
Dr Jaco Moolman (moolmj@unisa.ac.za)

Working title of research:
ENHANCED CORPORATE WATER REPORTING IN THE VALUE CHAIN OF THE SOUTH AFRICAN DAIRY INDUSTRY

Qualification: PhD and non-degree

Thank you for the application for research ethics clearance by the Unisa College of Accounting Sciences Research Ethics Review Committee for the abovementioned research. **Ethics approval is granted for data collection by means of observation.** The certificate is valid for the period **6 September 2022 to 5 September 2025.**

*The **low-risk application** was **approved** on **6 September 2022** in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the CAS RERC.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.

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4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
7. No fieldwork activities may continue after the expiry date **(5 September 2025)**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **2022_CAS_028** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Signature : **Prof Lourens Erasmus**



Chair of CAS RERC

E-mail: erasmlj1@unisa.ac.za
Tel: (012) 429-8844

Signature : **Dr Chisinga Chikutuma**



Head : Office for Graduate Studies and Research
By delegation from the Executive Dean: College of Accounting Sciences

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ANNEXURE C: RESEARCH ETHICS APPROVAL CERTIFICATE TO CONDUCT SEMI-STRUCTURED INTERVIEWS

UNISA university of south africa

UNISA COLLEGE OF ACCOUNTING SCIENCES RESEARCH ETHICS REVIEW COMMITTEE

Date: 7 December 2022

ERC Reference # : 2022_CAS_041
Name : T Askham
Student no: 50870130

Dear Ms T Askham,

Decision: Ethics Approval from 6 December 2022 to 5 December 2025

Researchers: Ms Theresa Askham (askhat@unisa.ac.za)
Supervisors: Prof CC Shuttleworth (shuttcc@unisa.ac.za)
Dr Jaco Moolman (moolmj@unisa.ac.za)

Working title of research:

ENHANCED CORPORATE WATER REPORTING IN THE VALUE CHAIN OF THE SOUTH AFRICAN DAIRY INDUSTRY

Qualification: PhD and non-degree

Thank you for the application for research ethics clearance by the Unisa College of Accounting Sciences Research Ethics Review Committee for the abovementioned research. **Ethics approval is granted for data collection by means of interviews.** The certificate is valid for the period **6 December 2022 to 5 December 2025.**

*The **low-risk application** was **approved** on **6 December 2022** in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the CAS RERC.

Open Rubric

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3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
7. No fieldwork activities may continue after the expiry date **(5 November 2025).** Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **2022_CAS_041** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Signature : **Prof Lourens Erasmus**



Chair of CAS RERC

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Signature : **Dr Chisinga Chikutuma**



Head : Office for Graduate Studies and Research

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ANNEXURE D: INTERVIEW SCHEDULE FOR DAIRY FARMERS

UNISA university of south africa

INTERVIEW SCHEDULE FOR DAIRY FARMERS

Interview schedule towards the completion of a Doctor of Philosophy degree at the University of South Africa

Participant ☐

This research is within a qualitative approach, with the researcher's objective being to enhance corporate water reporting in the value chain of the South African dairy industry. This study uses semi-structured interviews as one of its data collection methods. The questions below will refer to the upstream value chain. The upstream value chain deals with the buying side from its suppliers – materials entering the organisation (Chaffey 2002: 335) the organisation being the Milk Processors. Therefore, the upstream value chain refers to Dairy Farmers, Milk Transporters and Milk Processors.

Ethical considerations:

Ethics approval has been obtained from UNISA to conduct the research. A permission letter has been sent to you, to request you to participate in the research interview. Participants are required to sign a consent form to acknowledge the context and nature of the research and their participation therein. All participants' identifiers will be kept private and all personal identifiers will be removed from research-related information.

PART 1: Introductory Information

1. Please indicate how long you have been dairy farming for?

a. 0 – 5 years
b. 6 –10 years
c. 11 –15 years
d. 16 –20 years
e. 20 + years

2. How many lactating dairy cows are on the farm currently?

3. How many times do you milk per day?

4. Do you operate in a water-stressed area (where water availability, quality and accessibility) is an issue?

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5. From where do you source your water?

6. Do you produce most of your own feed?

Yes	No

7. How is your crop irrigated?

a. Irrigation
b. Rain-fed
c. Combination

8. Does your dairy processor require you to report on water-related information?

Yes	No

PART 2: Frugal Innovation
Innovation "involves identifying, developing and exploiting new ideas to generate value" (Prabhu 2017:4).

Frugal innovation means "the art of overcoming harsh constraints (for example water) by creating an effective solution using limited resources" (Prabhu & Jain 2015:847).

9. How could innovation assist you with measuring and therefore reporting on water information to your dairy processor? Prompt: technology, organisational and social.

10. Have you in the past or are you planning to install/implement innovative technologies that can assist with water-related issues on your farm?

11. What is your view on the ability of farmers to innovate regarding water in South Africa at the moment?

12. For innovation, would you prefer to create your own innovations and why?

13. Or, for the government/other relevant role-players (milk processor/NGO) to provide innovative options for you and why?

PART 3: Measure, manage, engage on and report on water (Answer if you answered no to question 8 above) (if you answered yes to question 8, continue to Part 4)

14. Even though you are not required to report on water to your dairy processor, do you measure water usage on your farm?

Yes	No

15. Are these measurements done for every source?

Yes	No

16. Do you test the water quality on the farm and how often?

17. If Yes is the water quality compared to any standards or benchmarks?

18. If No is answered, what is preventing you from testing the water quality?

19. How would you know if the water quality has deteriorated?

20. What do you do with your wastewater? Prompt: If the answer is "recycle it," ask how and do you measure the recycled water to obtain net withdrawals?

21. If you were required in the future to measure water consumption and report on other water-related issues on the farm, would you be able to accurately do this? Explain how this will be done.

22. What would drive you to start measuring, managing, and reporting on water on your farm?

23. What would hinder you to start measuring, managing, and reporting on water on your farm?

24. Do you identify risks and opportunities related to water and how do you mitigate these?

25. Can you see the value of measuring, managing and reporting on water?

Continue to Part 5

PART 4: Measure, manage, engage and report on water (If you answered yes to question 7 above)

26. How do you measure water usage on the farm?

27. Do you know how much water is used for every activity on the farm?

28. Do you test the water quality on the farm?

Yes	No

29. What water-related information does your dairy processor require from you? Prompt: wastewater, recycling, impacts, risks/opportunities, fines/levies, capex/investment.

30. How is water information collected by your dairy processor, Prompt: do they provide you with predetermined fields in spreadsheets?

31. How often do they require this information?

32. Does your processor establish supplier criteria in their supplier contract with you, that relates to water that you as the farmer must comply with?

33. What happens if you don't adhere to these criteria?

34. Is this water information audited?

Yes	No

35. How often are these audits conducted?

36. Does the dairy processor provide guidance on how to measure and manage water-related information?

37. Does the dairy processor provide feedback on the water-related information you provided to them, for example how to decrease water usage? If so, give some examples.

38. Can you see the value in providing this information to them? Prompt: Or is it just another administrative burden?

39. Does the dairy processor give you targets/goals to achieve these water-related issues? Give examples.

40. Do you set your own water targets/goals. Give examples.

41. What drives you to report on water-related issues to your processor?

42. What hinders you to report on water-related issues to your processor?

43. Does the dairy processor give incentives for achieving their supplier criteria regarding water targets, give examples?

44. Does your dairy processor provide financial assistance to assist you with, for example water saving initiatives?

45. Do you engage with any NGOs on water-related issues in the value chain? If so, can you give some examples.

46. Do you engage with other farmers on water-related issues in the value chain? If so, can you give some examples.

47. Do you engage with your suppliers on water-related issues? If so, can you provide some examples.

48. Does government engage/assist you and other dairy farmers on water-related matters? If so, can you provide some examples.

49. How can independent divisions (silos) be broken down between members of the upstream dairy value chain regarding sharing information on water-related issues?

50. Have you received fines/levies from the government for water-related issues? If so, can you provide some examples.

51. Do you have to report these fines/levies to your processor as part of your water reporting data?

52. If your dairy processor expected you to report on water-related issues from your suppliers, would you be able to do so?

PART 5: New Legislation

With the aim of protecting South Africa's scarce water resources the South African government by way of the National Water and Sanitation Master Plan made it law that the agricultural sector needs to take responsibility for water conservation by installing water meters at the farmer's own cost by March 2021 (Milk Producer's Organisation [MPO] 2021:1).

53. Do you have water meters on the farm?

Yes	No

54. Is it an expensive and difficult undertaking to install water meters? Please explain.

55. What is the feeling amongst the dairy farmers about this new legislation?

56. Is your processor pushing for the installation of water meters on your farm?

57. Will the water meters help you to accurately measure water use on the farm?

Yes	No

ANNEXURE E: INTERVIEW SCHEDULE FOR DAIRY PROCESSORS

UNISA university of south africa

INTERVIEW SCHEDULE FOR DAIRY PROCESSORS

Interview schedule towards the completion of a Doctor of Philosophy degree at the University of South Africa

Participant ☐

This research is within a qualitative approach, with the researcher's objective being to enhance corporate water reporting in the value chain of the South African dairy industry. This study uses semi-structured interviews as one of its data collection methods. The questions below will refer to the upstream value chain. The upstream value chain deals with the buying side from its suppliers – materials entering the organisation (Chaffey 2002: 335) the organisation being the Milk Processors. Therefore, the upstream value chain refers to Dairy Farmers, Milk Transporters and Milk Processors.

Ethical considerations:

Ethics approval has been obtained from UNISA to conduct the research. A permission letter has been sent to you, to request you to participate in the research interview. Participants are required to sign a consent form to acknowledge the context and nature of the research and their participation therein. All participants' identifiers will be kept private and all personal identifiers will be removed from research-related information.

PART 1: Introductory information

1. Which department do you work in?
2. What manufacturing process is done to the raw milk at this plant?
3. Where is your water sourced from?
4. Do you operate in a water-stressed area (where water availability, quality and accessibility) is an issue?
5. Do you test the water quality before using it in the production process?

Yes	No

6. If Yes is answered, is the water quality compared to any standards or benchmarks?

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7. If No is answered, what is preventing you from testing the water quality?

8. Does your organisation measure, manage and report on its own water use?

Yes	No

PART 2: Frugal Innovation

Innovation "involves identifying, developing and exploiting new ideas to generate value" (Prabhu 2017:4).

Frugal innovation means "the art of overcoming harsh constraints (for example water) by creating an effective solution using limited resources" (Prabhu & Jain 2015:847).

9. How could innovation assist you with measuring and therefore reporting on water information? Prompt, technology, organisational and social.

10. What innovative technologies is your organisation using or planning to use to reduce water consumption in your organisation?

11. Is your organisation assisting its upstream value chain members with reducing water consumption through frugal innovation, if so, please give some examples.

12. For innovation, would you prefer to create your own innovations and why?

13. Or for the government/other relevant role-players (NGOs) to provide innovative options for you and why?

Part 3 Process steps of a sustainable value chain management

14. Does your organisation know all the members in its upstream value chain?

Yes	No

15. What are the water-related impacts that have been experienced in your upstream value chain, please give examples.

16. What water-related risks have been identified in your upstream value chain, please give examples.

17. What water-related opportunities have been identified in your upstream value chain, please give examples.

18. To have a sustainable value chain how would/or has your organisation's internal structures and processes need/ed to evolve?

PART 4: Measure, Manage, Engage and Report on Water
If you answered No to question 5 (if you answered yes, continue to Part 5)
It is assumed that if the organisation does not measure, manage and report on its own water-related issues it will not require its upstream value chain to do so.

19. What are your reasons for not measuring, managing, and reporting on your own water-related issues?

20. What would drive you to start measuring, managing, engaging and reporting on water?

21. If you had to start measuring, managing, engaging and reporting on water in your own organisation would you be able to accurately do this? Explain how.

22. Why is water not measured, managed and reported on in your upstream value chain?

23. What would drive you to start measuring, managing and reporting on water in your upstream value chain.

24. If you were to start requesting water information from your upstream value chain, how would your organisation initiate and make it mandatory?

25. Are you engaging with your upstream value chain members on any water-related matters?

Continue to Part 6

PART 5: Measure, Manage, Engage and Report on Water.
If you answered yes to question 5 above

26. Does your organisation measure, manage and report on water in your upstream value chain?

Yes	No

If the answer is No, ask questions 19 to 22

If answer is Yes continue below:

27. What type of water information do you receive from your upstream value chain?

28. How far down the upstream value chain are you collecting water data?

29. Why does your organisation report on water in the upstream value chain?

30. How is water information communicated and collected through the upstream value chain?
31. How accurate is the water information received from your upstream value chain?

32. Are there plans in place to improve water use efficiency in the upstream value chain? Explain what you have done or plan to do.

33. What are the gaps identified regarding water-related issues in your upstream value chain?

34. Does your organisation set water-related KPI's for your upstream value chain, can you give some examples?

35. Does your organisation offer incentives to your upstream value chain members to assist with water-related issues, for example water savings, recycling and quality improvement schemes, give examples.

36. Does your organisation offer financial assistance to your upstream value chain members to assist with water-related issues for example water savings, wastewater treatment, recycling and quality improvement schemes, give examples.

37. How does your organisation build/improve on water-related issues (water savings, wastewater recycling) in your upstream value chain?

38. How does your organisation evaluate water-related performance in your upstream value chain?

39. Does your organisation provide education to dairy farmers and milk transporters on water-related issues? If so, please give examples.

40. Does your organisation have water-related criteria in your supplier contracts, if yes please explain.

41. How are these supplier water-related criteria monitored and enforced?

42. Is your organisation using established water tools to assist with water data collection, reporting and disclosure, for example, CDP, CEO Water Mandate, ISO, Water Footprint, Water Risk Filter and so on? If so which ones

43. If your organisation is not using any of these tools, what is being used

44. Why is the organisation not using the established water tools?

45. What disclosure guidelines is your organisation using to prepare its integrated report? For example, GRI

46. Do you audit water information received from your upstream value chain?

Yes	No

47. If yes, does this include your Dairy Farmers and Dairy Transporters?

48. If so, how often?

49. Is it done by your organisation or a third party?

50. The water information that is collected from your upstream value chain does it create value for your organisation?

51. Does it influence internal management decisions, if so, how, please give examples.

52. How can independent divisions (silos) be broken down between members of the upstream dairy value chain regarding sharing information on water-related issues?

53. What factors drive value chain water reporting?

54. What factors hinder value chain water reporting?

55. Does your organisation collaborate with any NGOs on issues such as water data along the upstream value chain. If so, can you discuss some projects?

56. How does/has this collaboration assisted your organisation?

57. Does your organisation engage with any government departments on water-related issues along the upstream value chain?

58. Does your organisation have any public/private partnerships with the government to address water matters in the upstream value chain? If so, please provide examples.

PART 6: New Legislation

With the aim of protecting South Africa's scarce water resources the South African government by way of the National Water and Sanitation Master Plan made it law that the agricultural sector needs to take responsibility for water conservation by installing water meters at the farmer's own cost by March 2021 (Milk Producer's Organisation [MPO] 2021:1).

59. To your knowledge are dairy farmers installing these water meters?

Yes	No

60. Is your organisation assisting dairy farmers with the rollout of these water meters? If so, please explain how.

61. What is the feeling amongst the dairy farmers about this new legislation?

62. What is your organisation's opinion on this new legislation?

ANNEXURE F: INTERVIEW SCHEDULE FOR ORG AGRI & NGO IN THE SOUTH AFRICAN DAIRY INDUSTRY

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INTERVIEW SCHEDULE FOR ORG AGRI & NGO IN THE SOUTH AFRICAN DAIRY INDUSTRY

Interview schedule towards the completion of a Doctor of Philosophy degree at the University of South Africa

Participant ☐

This research is within a qualitative approach, with the researcher's objective being to enhance corporate water reporting in the value chain of the South African dairy industry. This study uses semi-structured interviews as one of its data collection methods. The questions below will refer to the upstream value chain. The upstream value chain deals with the buying side from its suppliers – materials entering the organisation (Chaffey 2002: 335) the organisation being the Milk Processors. Therefore, the upstream value chain refers to Dairy Farmers, Milk Transporters and Milk Processors.

Ethical considerations:

Ethics approval has been obtained from UNISA to conduct the research. A permission letter has been sent to you, to request you to participate in the research interview. Participants are required to sign a consent form to acknowledge the context and nature of the research and their participation therein. All participants' identifiers will be kept private and all personal identifiers will be removed from research-related information.

PART 1: Introductory information

1. Please indicate what is your position at the organisation.
2. How long have you worked at the organisation?
3. What is your background regarding sustainability, water and the environment?
4. What is your organisation's main function/purpose in the South African Dairy Industry?

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PART 2: Frugal Innovation
Innovation "involves identifying, developing and exploiting new ideas to generate value" (Prabhu 2017:4).

Frugal innovation means "the art of overcoming harsh constraints (for example water) by creating an effective solution using limited resources" (Prabhu & Jain 2015:847).

5. How could innovation assist the upstream value chain in the dairy industry with measuring, managing and therefore reporting on water information?

6. What is your organisation's involvement with assisting the upstream value chain with innovation or innovative technologies regarding water?

7. Is your organisation assisting its upstream value chain members with reducing water consumption through innovation, if so, please give some examples.

8. What specific value does your organisation bring, regarding innovation in the dairy industry?

9. Do you know of any best practice examples regarding innovation and water in the upstream dairy industry? Please discuss these

10. Do you know of any new innovations in the pipeline that may assist with water-related issues in the upstream dairy industry? Please discuss these?

11. Regarding water-related risks, do you have any ideas on how to mitigate these risks using frugal innovation?

PART 3: Measure, Manage, Engage and Report on Water

12. To your knowledge are dairy farmers measuring their water usage, can you quantify the number of dairy farmers doing this?

13. To your knowledge are dairy farmers reporting their water data to their milk processors can you quantify the number of dairy farmers doing this?

14. To your knowledge are milk transporters measuring their water consumption, can you quantify the number of milk transporters doing this?

15. To your knowledge are milk transporters reporting water data to their milk processors, can you quantify the number of milk transporters doing this?

16. Why do you think it is important for value chain members, such as dairy farmers, milk transporters and dairy processors to measure, manage and report on water?

17. Do you and your organisation view water reporting in the upstream value chain as a benefit to the industry, explain these benefits.

18. Does your organisation offer any education on water issues in the upstream value chain? Please give examples

19. Is your organisation working with any of the upstream value chain members on water-related issues? Can you give me some examples of these projects?

20. Does your organisation engage with any government departments or other stakeholders on water-related issues along the upstream value chain?

21. Is your organisation involved in any public/private partnerships to address water-related issues in the upstream value chain? Please give some examples.

22. How can independent divisions (silos) be broken down between members of the upstream dairy value chain regarding sharing information on water-related issues?

23. What factors drive value chain water reporting?

24. What factors hinder value chain water reporting?

25. How do you think a sustainable value chain can be developed? Prompt: What steps/processes need to be undertaken?

26. How does/would your organisation assist/facilitate with this?

27. Is your organisation aware of the established water tools to assist with water data collection, reporting and disclosure, for example, CDP, CEO Water Mandate, ISO, Water Footprint, Water Risk Filter and so on? If so which ones.

28. Does your organisation promote these water tools throughout the upstream value chain, please explain how.

PART 4: New Legislation

With the aim of protecting South Africa's scarce water resources the South African government by way of the National Water and Sanitation Master Plan made it law that the agricultural sector needs to take responsibility for water conservation by installing water meters at the farmer's own cost by March 2021 (Milk Producer's Organisation [MPO] 2021:1).

29. To your knowledge are dairy farmers installing these water meters?

30. Is your organisation helping dairy farmers with the rollout of these water meters? Please explain how.

31. What is the feeling amongst the dairy farmers about this new legislation?

32. What is your organisation's opinion on this new legislation?

ANNEXURE G: PERMISSION LETTER TO CONDUCT RESEARCH

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PERMISSION LETTER

Request for permission to conduct research at <insert name of organisation or institution>

Enhanced Corporate Water Reporting in The Value Chain of the South African Dairy Industry

<insert date>

<insert contact person's name>
<insert contact person's building no. or room no.>
<insert contact person's Department>
<insert contact person's telephone number and email address>

Dear <insert contact person's title and name>,
My name is Theresa Askham, a senior lecturer in the Department of Management Accounting at Unisa. I am doing research with Professor Bienkie Shuttleworth, a Professor in the Department of Management Accounting and Dr Jaco Moolman a senior lecturer in the Department of Management Accounting towards a Doctor of Philosophy in Accounting Sciences at the University of South Africa. We are inviting you, or representatives of your organisation, to participate in a study entitled: **Enhanced Corporate Water Reporting in the Value Chain of the South African Dairy Industry**

This research study aims to develop a conceptual framework that could be used by the upstream value chain members (Dairy Farmers, Milk Transporters, and Dairy Processors) of the South African Dairy Industry to enhance or even initiated corporate water reporting, which in turn will improve water management in the industry.

Participants have been selected as they are members of the upstream value chain of the South African dairy industry and therefore have the experience and knowledge to answer the semi-structured interview schedules.

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The study will entail semi-structured interviews with selected participants from the South African dairy industry, namely Dairy Farmers, Milk Transporters, Dairy Processors and Dairy NGO's.
The benefits of this research study are to design a framework to assist in enhanced corporate water reporting, which will allow for improved management of water in the upstream value chain of the dairy industry in South Africa. It will be of interest to Dairy Farmers, Milk Transporters Dairy Processors and Dairy NGOs.

It is anticipated that there will be no negative consequences associated with participating in this research study. The only inconvenience and/or discomfort in participating in this study is your time to answer the interview schedule which the researcher is very grateful for.

If you would like to be informed of the final research findings, please contact Mrs Theresa Askham telephonically on 012 429-2622 or via email at askhat@unisa.ac.za. The findings are accessible for five years. Should you require any further information or want to contact the researcher about any aspect of this study, please contact Mrs Theresa Askham telephonically on 012 429-2622 or via email at askhat@unisa.ac.za.

Yours sincerely



Mrs Theresa Askham
Senior Lecturer, Department of Management Accounting
Tel: 012 429- 2622
Email: askhat@unisa.ac.za

I hereby give Mrs Theresa Askham permission to conduct semi-structured interviews with staff members at XXX

Contact person: Name & Surname..... (please print)

Contact person: Signature.....Date

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ANNEXURE H: PARTICIPANT INFORMATION SHEET

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PARTICIPANT INFORMATION SHEET

Ethics approval reference number: 2022_CAS_041

January – February 2023

Working Title: Enhanced Corporate Water Reporting in The Value Chain of the South African Dairy Industry

Dear Prospective Participant

My name is Theresa Askham, a senior lecturer in the Department of Management Accounting at Unisa. I am doing research with Professor Bienkie Shuttleworth, a Professor in the Department of Management Accounting and Dr Jaco Moolman a senior lecturer in the Department of Management Accounting towards a Doctor of Philosophy in Accounting Sciences at the University of South Africa. We are inviting you to participate in a study entitled: **Enhanced Corporate Water Reporting in the Value Chain of the South African Dairy Industry**

WHAT IS THE PURPOSE OF THE STUDY?

This research study aims to develop a conceptual framework that could be used by the upstream value chain members (Dairy Farmers, Milk Transporters, and Dairy Processors) of the South African Dairy Industry to enhance or even initiated corporate water reporting, which in turn will improve water management in the industry.

WHY AM I BEING INVITED TO PARTICIPATE?

Dairy Processors were selected due to brand names in South Africa. Dairy Farmers' and Milk Transporters' contact details were given by their Dairy Processors and the Dairy NGOs' contact details are in the public domain. Participants have been selected as they are members of the upstream value chain of the South African dairy industry and therefore have the experience and knowledge to answer the semi-structured interview questions.

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WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The study involves semi-structured interviews with selected participants from the South African dairy industry, namely Dairy Farmers, Milk Transporters, Dairy Processors and Dairy NGOs. The semi-structured interviews with be audio recorded if done in person and if done via an online meeting platform such as Microsoft Teams or Zoom with be recorded with the video on. The semi-structured interviews could last approximately one hour.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

The benefit of this study is to design a framework to assist in enhanced corporate water reporting, which will allow for improved management of water in the upstream value chain of the dairy industry in South Africa. It will be of particular interest to Dairy Farmers, Milk Transporters Dairy Processors and Dairy NGOs.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

It is anticipated that there will be no negative consequences associated with participating in this research study. The only inconvenience and/or discomfort in participating in this study is your time to answer the interview schedule, which the researcher is very grateful for.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Confidentiality of information will be protected at all times. Only the informed consent document, which you will sign prior to partaking in the interview will contain personal identifiable information. Your name and your organisation's name will not be recorded anywhere, and no

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one will be able to connect you to the answers you give. Your answers will be given a code number or a pseudonym and you and/or your organisation's name will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

The external independent coder and transcriber of the interviews will only have access to anonymised data, they will also sign confidentiality agreements as an additional safeguard. Your answers may be reviewed by people responsible for making sure that research is done properly, such as members of the Research Ethics Review Committee, however, your interview schedules will already be anonymised.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of ten years in a locked cupboard/filing cabinet in the researcher's office for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. Hard copies will be shredded and/or electronic copies will be permanently deleted from the hard drive of the computer through the use of a relevant software programme.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

Participation in this research study is voluntary, therefore no payments or incentives will be paid. Additionally, it is anticipated that no costs will be incurred in participating in this research study.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study has received written approval from the Research Ethics Review Committee of the College of Accounting Sciences, Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Mrs Theresa Askham telephonically on 012 429-2622 or via email at askhat@unisa.ac.za. The findings are accessible for five years. Should you require any further information or want to contact the

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researcher about any aspect of this study, please contact Mrs Theresa Askham telephonically on 012 429-2622 or via email at askhat@unisa.ac.za.

Should you have concerns about the way in which the research has been conducted, you may contact Dr Jaco Moolman on 012 429-2194 or via email at moolmj@unisa.ac.za. Contact the research ethics chairperson of the Research Ethics Review Committee of the College of Accounting Sciences, Professor Lourens Erasmus, on 012 429-8844 or via email at erasmlj1@unisa.ac.za, if you have any ethical concerns.

Thank you for taking the time to read this information sheet and for participating in this study.

Your participation is greatly appreciated.



Mrs Theresa Askham
Senior Lecturer, Department of Management Accounting
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Cell: 083 701 0807
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ANNEXURE I: CONFIDENTIALITY AGREEMENT – TRANSCRIPTIONIST

CONFIDENTIALITY AGREEMENT - TRANSCRIPTIONIST

I, Samantha Geldenhuys on behalf of Top Transcriptions Transcribers, transcriptionist, agree to maintain full confidentiality in regards to any and all audiotapes and documentations received from related to the research study on: Enhanced Corporate Water Reporting In The Value Chain Of The South African Dairy Industry. Furthermore, I agree:

1. To hold in strictest confidence the identification of any individual that may be inadvertently revealed during the transcription of recorded interviews, or in any associated documents.

2. To not make copies of any recordings or computerised titles of the transcribed interviews texts, unless specifically requested to do so by the researcher, Mrs Theresa Askham.

3. To store all study-related electronic recordings and materials in a safe, secure password-protected location as long as they are in my possession.

4. To delete all electronic files containing study-related documents and recordings from my computer hard drive and any back-up devices.

I am aware that I can be held legally responsible for any breach of this confidentiality agreement, and for any harm incurred to individuals if I disclose identifiable information contained in the files to which I will have access.

Transcriber's name (printed)

Samantha Geldenhuys on behalf of Top Transcriptions Transcribers.



Transcriber's signature

Date 07.03.2023

ANNEXURE J: CONFIDENTIALITY AGREEMENT – EXTERNAL INDEPENDENT CODER

CONFIDENTIALITY AGREEMENT – EXTERNAL INDEPENDENT CODER

I, Charmaine Williamson independent coder, agree to maintain full confidentiality in regards to any and all audiotapes and documentations received in relation to the research study on: Enhanced Corporate Water Reporting In The Value Chain Of The South African Dairy Industry. Furthermore, I agree:

1. To hold in strictest confidence the identification of any individual that may be inadvertently revealed during the transcription of recorded interviews, or in any associated documents.

2. To not make copies of any recordings or computerised titles of the transcribed interviews texts, unless specifically requested to do so by the researcher, Mrs Theresa Askham.

3. To store all study-related electronic recordings and materials in a safe, secure password-protected location as long as they are in my possession.

4. To delete all electronic files containing study-related documents and recordings from my computer hard drive and any back-up devices.

I am aware that I can be held legally responsible for any breach of this confidentiality agreement, and for any harm incurred to individuals if I disclose identifiable information contained in the files to which I will have access.

Independent Coder's name (printed) Dr CM Williamson



Co-coder's signature

Date 2022-11-24

ANNEXURE K: INTERVIEW SCHEDULE TO VALIDATE FRAMEWORK

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INTERVIEW SCHEDULE TO VALIDATE PHD FRAMEWORK

Interview schedule towards the completion of a Doctor of Philosophy degree at the University of South Africa

Participant ☐

The researcher's objective in this qualitative study is to enhance corporate water reporting in the upstream value chain of the South African dairy industry. This study uses semi-structured interviews as one of its data collection methods. This interview schedule is to evaluate the proposed Water Reporting Framework depicted in Appendix A.

Ethical considerations:

Ethics approval (Ref 2022_CAS_041) has been obtained from UNISA to conduct the research. A permission letter has been sent to request your participation in the research interview. Participants are required to sign a consent form to acknowledge the context and nature of the research. All participants' identities will be kept private, and all personal identifiers will be removed from research-related information.

1. In your opinion are the most relevant **drivers** of water reporting included in the framework? Are there any that you could add?
2. In your opinion are the most relevant **limitations** of water reporting included in the framework? Are there any that you could add?
3. How do you think Farmers would, in the future, be able to progress from basic, to intermediate, to advanced water reporting?
4. In your opinion, how do you think the progression would benefit the farmers and the dairy industry as a whole?
5. Overall, could you please suggest ways to improve the framework?
6. In what way do you think innovation could assist farmers with water reporting?

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ANNEXURE L: LANGUAGE EDITING CERTIFICATE

GET IT EDITED

Elsa Crous • Copy editor • 072 6111 737

10 February 2026

To whom it may concern

This letter serves to confirm that I edited the doctoral thesis entitled "A water reporting framework for the South African dairy industry's upstream value chain" by T. Askham.

In keeping with the demands of editing texts of an academic nature, I correct errors in grammar and spelling, and put forward stylistic and formatting recommendations in addition to highlighting gaps in terms of content and referencing. I also adhere to the style guide preferred by the institution, department or journal in question.

For nine years I was employed as a copy editor, proofreader, translator and project manager in the Journals Division of Unisa Press, the publishing arm of the University of South Africa, prior to accepting my current position as language practitioner with Unisa's Language Services directorate. Having held this position for the past ten years, I am responsible for editing scholarly articles, tutorial letters, study guides and other ad hoc materials for publication by lecturers or entities affiliated to the University of South Africa. As a freelance language practitioner, I edit dissertations and theses, in multiple disciplines, for students from across the country.

During my career I worked as a schoolbook editor (and later publisher) at Kagiso/Haum-De Jager, prior to that I was a script checker for the soapie *Generations* and at the start of my career I was employed as an English teacher at Hoërskool Waterkloof in Pretoria. My qualifications include a BA (English, Afrikaans and Psychology majors), a higher education diploma, an Honours in Afrikaans (University of Pretoria) and a Master's degree in French literature (University of Johannesburg).

I trust you will find the above in order. Should you require any further information, please do not hesitate to contact me.

