

A comparative knowledge map of priority environmental issues and Doctoral research in South Africa

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Abstract

Researchers not only respond to strategic direction; their discovery of emerging issues also make them accountable to guide policy reform. The alignment of environmental doctoral research with environmental-related legislation and policy documents in South Africa is unknown. Doctoral research from 1998, the inception date of the National Environmental Management Act, to 2017 were analysed through a systematic literature review strategy and content analysis to determine the alignment of doctoral research topics to the key strategic environmental themes derived from one (1) African policy document and ten (10) South African policy documents and legislation. A comparative knowledge map was developed to graphically represent the extent of alignment, the under-researched themes, gaps and the potential niche areas for future research. The comparative knowledge map assists in discovering where the knowledge is located, and where the gaps exist. It further offers policymakers and researchers a clear way to make decisions on past and current focus areas and points out where potential future research and practitioners' foci should be. The extent to which South African research is responsive to national environmental priorities and goals is

now known and environmental-related research is expected to demonstrate real-world relevance, not only aligning with policy but also guiding policy reform.

Keywords: Comparative knowledge map, systematic literature review, environmental legislation, environmental sustainability agenda, South African Doctoral research, priority environmental issues

Introduction

Evidence-informed policy-making is advisable in any complex environment which implies that policy-makers need scientific input to make informed political decisions (Grimm et al., 2018. p. 6). As a result, researchers and policy-makers need interactive engagement to advance decisions in addressing current challenges. Mouton (2010) suggests that research supervisors have to ask themselves whether students are pursuing research that is in line with a country's plans and goals or whether it is not seen as a priority. Mouton et al., (2019, p. 67) also ask the question "To what extent is South African research responsive to national (and international) societal priorities and goals?"

The South African government further recognises the value of research as a means to enhance the quality of life for their citizens (Jeenah & Pouris, 2008). Governments are signatories to international treaties, subsidising doctoral research and using taxpayers' money to do so. Taxpayers, therefore, need to benefit from the value and contributions of research (Van Schalkwyk et al., 2020). Investment into higher education by governments and the public is done because they believe that it creates social and individual benefits and is a strategy for economic development (Mohee et al., 2020). It, therefore, makes sense that researchers should consult government documents to aid the government in their efforts to inform policy about a

healthy natural environment for humans. Furthermore, in the case of research in the environmental studies field, it can be argued that this field is an applied field that deals with real-world problems and research are, therefore, expected to demonstrate real-world relevance and alignment with societal issues, which should be reflected in policy.

However, the perpetual conundrum between the autonomous role that researchers have to focus on under-researched fields, conduct research to discover new knowledge, provide direction and assist policy development, and the role that researchers have to conduct research in response to strategic government direction is acknowledged. This article argues that there would, and should, be research in response to strategic direction as well as research that guides policy reform as research is not only at the forefront to discover and drive emerging issues, but also has to address and pursue a response to policy development and advancement. Academic freedom should however prevail, and researchers must be able to determine their own research path, free from government interventions. Mouton (2010) stated that a significant percentage of students, in sub-Saharan countries agreed that their work was aligned with the development plans of their country. The percentage of students that agreed with the statement in the field of arts and humanities was 75%, 87% for economics and management, and 83% in the sciences (Mouton, 2010). The number, specifically for environmental studies in South Africa, has not been determined and the alignment between Doctoral research and government goals is not known. The term 'environmental studies' is used in this article as a collective term that includes environmental management, environmental studies and environmental science. Reference to 'environmental studies' were necessitated considering that the identified departments at the different South African universities, award doctoral degrees in all these mentioned sub-disciplines. Doctoral degrees (referred to as PhDs from this point onwards in this article) completed between 1998, the inception date of the National Environmental Management Act

(NEMA), and 2017, the year before which this study was initiated, were included. The year in which NEMA was promulgated was regarded as the year in which environmental consciousness about the prevention of pollution, environmental degradation and the promotion of sustainable development gained traction in South Africa in terms of air quality measures, norms and standards, management and control. Since the promulgation of NEMA, several subsequent environmental legislation and policy-related government documents were published. The PhDs completed in the 20-year study period of this research were included from seventeen South African universities' environmental studies-related academic departments and the relevant environmental-related South African Research Chairs Initiative (SARChi). PhD studies done on South African environmental topics by other international universities were not considered for this research.

The purpose of this research was to extract the critical, priority, environmental studies research topics from selected strategic documents, as key strategic environmental drivers that South Africa ascribes to and to conduct a comparative analysis of environmental-related PhD research completed between 1998 and 2017. The comparison was made to determine the alignment of PhD research and government goals in environmental studies to develop a knowledge map of the knowledge contributions of South African PhDs in environmental studies about key strategic environmental drivers that policy and legislation advocates.

This article will show that there is an alignment between research driven by environmental policy documents. In some cases, research preceded the policy documents, and the assumption needs to be made that the research potentially influenced the policy development. Furthermore, the article will show that there are gaps in environmental studies research that does not yet address important environmental issues highlighted by policy documents.

Environmental Policy documents

The heightened international awareness and promulgated legislation made the protection and management of the environment pertinent in the mind of scholars and government officials and began to feature in local and international development plans and frameworks. The documents included in this research provide a past, present and future view from 1998 to 2017 and beyond to 2063 of the environmental issues that were, are and potentially will be important for the environmental wellbeing of South Africans and the environment.

Section 24 of the South African Constitution of 1996 provides for the protection of the environment and the National Environmental Management Act (NEMA) No. 107 of 1998 gave effect to Section 24 of the Constitution (Strydom & King, 2015, p. v). NEMA encapsulates five Specific Environmental Management Acts (SEMAs) to ensure the proper management of biodiversity, protected areas, air quality, coastal areas, and waste management. These acts provide guidance and contain the themes and aspects that are deemed important for the management of South Africa's environment.

In 1999 the Government undertook a study to determine future long-term research and technology needs in environmental management (Kok & Pietersen 1999). Kok and Pietersen (1999) conducted a two-phase study with participants from the government, Higher Education Institutions, industry, labour, non-government organisations and research councils. The first phase of the Kok and Pietersen (1999) study was to obtain the views of participants regarding opportunities and constraints of environmental management topics. The second phase was aimed at obtaining consensus of the identified topics by the participants. The result of the study suggested and identified specific topics that should be considered for future research and development funding in South Africa.

Three State of the Environment Reports (SOER) in 1999, which received a name change to State of the Environment Outlook (SAEO) in 2006 and again published as SAEO in 2012, shed light on the actual status and challenges the environment faced. The National Development Plan (NDP) – 2030 (published in 2012) and the Agenda 2063 documents (released in 2015) are also included in the study, reflecting on the future direction of environmental matters in South Africa and in the case of 2063, Africa as a whole. The Sustainable Development Goals (SDGs) have not been the focus of this study, it is however an aspect that can be investigated in future, to see how the PhDs are aligned to the SDGs. The intensified focus on the urgent need to care for and raise awareness around environmental destruction has led to the rise of the field of environmental studies.

Research in Environmental Studies

Heightened international awareness and promulgated legislation made the research of environmental issues pertinent in the mind of scholars. The environmental agenda really started with sustainable development issues that can be traced to the 1972 United Nations Conference on the Human Environment held in Stockholm (Department of Environmental Affairs and Tourism (DEAT), 2004). Scholars across a number of disciplines embraced the inclusion of environmental-related studies into curricula (Strydom & King, 2015). In South Africa, the environmental studies discipline was mostly incorporated within the various geography departments of South African universities (Visser et al., 2016).

A PhD study in South Africa requires a student to demonstrate ‘expertise and critical knowledge in an area at the forefront of a field and the ability to conceptualise new research initiatives and create new knowledge or practice’ (South African Qualifications Authority

(SAQA), 2012). The PhD is further considered new or innovative by peers and it needs to make a noteworthy contribution to the discipline (Council of Higher Education (CHE), 2013; Van Schalkwyk et al., 2020). The traditional role of a PhD was to deliver future academics; however, from 1990 onwards, the focus has since shifted, and the PhD is now playing a major role in the knowledge economy (Blankley & Booyens, 2010). PhDs may be an early indicator of the status of a body of knowledge and can create a platform for further research that is relevant to the goals, objectives, and vision of a field of study (Xifra & Castillo, 2006). Thus, PhDs are a significant source of information to study trends in any field as PhDs create, distribute and disseminate scientific information (Bozkurt et al., 2015). It is for these reasons that this study selected PhDs conducted in a number of environmental-related disciplines at Higher Education Institutions in South Africa to determine the level of alignment between research driven by environmental policy documents and the research conducted by PhD graduates. Underlying this alignment of South African environmental-related PhDs to national environmental management policies, plans and goals for South Africa is the theoretical thinking associated with complexity theory.

Complexity theory

The complexity theory is a multi-agent systems theory, where all the elements have the potential and opportunity to be dominant, depending on the conditions and rules as set out at the beginning of the process (Peter & Swilling, 2014). The characteristics of these complex systems are that they are interdependent, interactive, interconnected, nonlinear, adaptive and self-organising (Colchester, 2016).

PhD topics are in itself not centrally coordinated, which also makes PhD topics self-organised and patterns will emerge from the bottom up. The South African legislation, regulations,

environmental reports and development plans are documents that frame the management and mitigation efforts required as a result of the human interactions as a complex system, within the complex system of the environment itself. These documents are developed as a result of the observed and researched effects that human interactions have on the environment. When analysing these documents, niche focus areas can be identified as the priority environmental concerns for the environment by the South African Government. It can be assumed that such identified priority areas should be phenomena that require better understanding to better manage and mitigate the influence of human interactions on the environment. The purpose of research is to investigate phenomena to better understand them.

The process of deciding on a research study can be daunting, chaotic and complex and is driven by context. Contexts wherein students make decisions for their research are personal and professional, organisational, policy, national or theoretical (Plowright, 2011). The professional and personal contexts are driven by work tasks or personal interests. Organisational, policy and national contexts are potentially driven by organisational or national policy. Theoretical context is driven by discipline literature (Plowright, 2011). The different constructs discussed within research are interconnected elements from which order and knowledge emerges.

A feature of a complex system is emergence, which occurs in layers and emerges from the bottom up (Colchester, 2016). The emergence of new patterns or orders from change and adaptation is almost impossible to predict (Colchester, 2016; Nunn, 2007). For this reason, the alignment between PhD studies and national priority environmental issues is investigated in hindsight due to the self-organising nature of the selection of PhD topics. Colchester (2016) further states that systems thinking focuses on the whole system and not the individual parts or elements. The elements in the system include the PhDs and the identified environmental

government documents. It should be noted that, the PhDs were not analysed individually to uncover the quality or theme, but rather for their contribution they made to the entire environmental-related research field. The theoretical framework of systems thinking is not the breaking down of the different elements to understand it better. It is building from the bottom up to better understand the entire system and was the foundational thinking in searching for the connectivity between the elements, rather than investigating the elements themselves.

Research methods

The research design was qualitative and utilised a systematic literature review strategy, to analyse the government documents against the PhD research. Several similar studies, outside of South Africa that used the systematic literature review have been undertaken to determine the focus of various disciplines (Bilotta et al., 2014; Holman & Banning 2012; Chan & Hsu 2016; Erdogan 2015; Bozkurt et al., 2015; Vierula et al 2016; Lin et al., 2018; Kazemia et al., 2018 Lindebaum et al., 2020). In South Africa, systematic reviews had been conducted on the fields of accounting (De Jager & Frick 2016) and tourism (Visser 2016) and at the time of commencing this research, no similar study for environmental-related research was found.

Purposive, intentional sampling was used in identifying the South African PhD research in environmental studies between 1998 and 2017 as well as South African legislation, policies and plans related to environmental issues. South Africa has 26 public tertiary education institutions, which are divided into three categories: nine universities of technology, six comprehensive universities and eleven traditional universities (De Jager & Frick, 2016). The PhDs that were included would only have been done by students at the eleven traditional and six comprehensive South African universities, focused only on South Africa in environment-related research, and supervised within environmental study departments. Seventeen

institutions were therefore included in this study. The research aimed to include all the PhDs done in South Africa, based on South African environmental issues that were found in various departments of environmental study research in Higher Education Institutions (HEIs), between 1998 and 2017. To collect the PhD data, the institutional repositories of the universities were scrutinised. These institutional repositories were found in the online libraries of the respective universities. The sampling was therefore a census, intentional and purposeful (Maree, 2012). This search led to 214 PhDs identified in relation to this study. No PhDs were recorded at the Walter Sisulu University, University of Limpopo, University of Zululand and University of the Western Cape; hence no analysis was done. Other historically disadvantaged institutions also did not have many completed PhDs, but this does not indicate that the PhDs did not align with national environmental policy. Further, thirty PhDs from various universities could not be placed into any theme. This in no way implies that these PhDs did not research important environmental issues. The studies that did not align, was mentioned at the bottom of Table 1. A verification process was done by sending the list of the collected 214 PhDs at each university, to the Heads of Department. The PhDs were then grouped per university, numbered, and manually scrutinised to determine the content, concepts and themes thereof. The Leximancer© text-mining software program was then used to analyse the entire full text of each PhD, to verify and corroborate the findings of the manual search. Leximancer indicates the frequency of words in text, their connection with each other and their spatial proximity. The data was then used to identify concepts and the relationship between the concepts as well as higher-level themes (Thomas, 2014). As the co-occurring concepts are combined into themes, the themes are used to create concept maps that show the scale of connections between the concepts and the proximity of concepts (Hyndman & Pill, 2018). The words, concepts, themes and concept maps allow for the relationship between concepts to be visually read (Finneran, 2018). The main concepts and themes identified by Leximancer were compared with the content and

Table 1: Summary of all PhDs analysed and placed under themes and aspects

Themes	Aspect in government document	Total per university*	Total/aspect	Total/ theme
Protected areas	Protected areas (SEMA)	UCT (1); UKZN (5); NWU (1)	7	10
	Protect and sustain natural environment (Indicators, integrated framework and the number of areas under protection) (NDP)	UKZN (1); UNISA (1); NWU (1)	3	
Biodiversity, Habitat and Resources	Habitat loss, loss of aquatic ecosystems (SOER, 1999; SAEO, 2006; SAEO, 2012)	UFS (2); UKZN (4); NWU (4); UP (1); RU (2); Wits (1); UNISA (1); NMU (1)	16	68
	Biodiversity conservation, Biodiversity, Biological and physical resources (Agenda 2063; SEMA; SOER,1999)	UCT (2); UFS (2); UKZN (9); NWU (13); UP (2); RU (4); Wits (3); UNISA (2); NMU (6); UV (1)	44	
	Sustainable Natural Resource Management (Agenda 2063)	FH (1); UKZN (4); NWU (2); US (1);	8	
Coastal areas	Coastal management (SEMA; Agenda 2063)	NWU (1); US (1); UKZN (1)	3	6
	Thriving mariculture (Kok & Pietersen)	UCT (3)	3	
Waste Management	Waste management (SEMA)	NWU (1); Wits (1)	2	3
	Zero waste, reduction and clean technologies (SOER, 1999; NDP; Kok & Pietersen)		0	
	Waste usage between industries (Kok & Pietersen)		0	
	Bioprocessing of organic waste (Kok & Pietersen)	UNISA (1)	1	
Social-people of SA	Social impact of drought (Kok & Pietersen)		0	60
	Environmental Entrepreneurship training (Kok & Pietersen)		0	
	People of SA and Human vulnerability (AIDS, poverty food security and services) (SOER, 1999; SAEO, 2006)	UCT (8); UKZN (10); NWU (4); UP (5); RU (10); US (2); Wits (5); UJ (5); UNISA (10)	59	
	Use of indigenous pharmacopoeia food and fibre sources (Kok & Pietersen)	UNISA (1)	1	
Water management	Clean-up technology for contaminated water (Kok & Pietersen)	NWU (3)	3	33
	Use of water efficient plants, rainwater harvesting, wastewater recycling (Kok & Pietersen; Agenda 2063)		0	
	Water quality, security and quantity (SAEO, 2006; SAEO, 2012; Agenda 2063)	UCT (3); UFS (4); UKZN (2); NWU (11); UP (1); Wits (1); UJ (1); UV (2)	25	
	Contamination of water by pollutants (SOER, 1999)	FH (1); NWU (4)	5	
Greenhouse Gas, Low Carbon- or Green Economy and Renewable Energy	Greenhouse gas emissions (NDP; SOER, 1999; SAEO, 2012)	UKZN (3); Wits (2); NMU (2)	7	11
	Low carbon economy and carbon pricing (NDP)		0	
	Sustainable packaging (Kok & Pietersen)		0	
	Energy efficient and zero emission buildings and transport (NDP; Agenda 2063)	UNISA (1)	1	
	Sustainable consumption and production patterns (Agenda 2063)	UNISA (1)	1	
	More use of renewable energy (Agenda 2063; NDP)	UCT (1); UKZN (1)	2	
Climate Change and Natural Disaster	Climate change or climate change centre (SAEO, 2006; NDP)	UCT (3); UFS (1); UKZN (2); UP (1); Wits (5); UJ (1); UNISA (2);	15	31
	Climate resilience – impacts on humans and the economy (Agenda 2063; SAEO, 2006)	UCT (3); UP (3); RU (1); US (1); UNISA (2);	10	
	Natural disasters preparedness (Agenda 2063; NDP)	US (1); UFS (1); Wits (2); UJ (1)	5	
	Sea level rise (SAEO, 2006; NDP)	UKZN (1)	1	
Mining	Sustainable mining and minerals (NDP; SAEO, 2012)	NWU (3); Wits (1); UJ (2); UV (1)	7	7
	Non-renewable resources – minerals (SAEO, 2012)		0	
Soil/Agriculture	Contamination of soil by pollutants (SOER, 1999)	FH (1); NWU (2); RU (1)	4	16
	Investment and research into new agricultural technologies (NDP)	UCT (1); NWU (5); UNISA (4)	10	
	Clean up technology for contaminated land (Kok & Pietersen)	NWU (2)	2	
Air Quality	Air quality (SEMA)	UKZN (2); NWU (4); Wits (4); UJ (7)	17	17
No category	PhDs that were not placed in any theme or aspiration found in the government documents.	UCT (8); UKZN (4); NWU (1); UP (1); US (7); Wits (1); UJ (4); Unisa (4)	30	30

*Nelson Mandela University (NMU); North-West University (NWU); Rhodes University (RU); University of Cape Town (UCT); University of Johannesburg (UJ); University of Fort Hare (UF); University of the Free State (UFS); University of KwaZulu-Natal (UKZN); University of South Africa (UNISA); University of Pretoria (UP); University of Stellenbosch (US); University of Venda (UV); University of the Witwatersrand (Wits).

concepts identified by the manual search conducted for each of the PhDs. Further, a PhD could deal with two or more aspects, and with the corresponding identifier number, the PhD can be found in more than one theme.

The environmental policy documents that were included were analysed according to their content, whereafter main, overarching themes were identified, such as protected areas, biodiversity, coastal areas, waste management, water management and climate change. These main themes were refined to include specific aspects from the environmental policy documents and then compared to the PhD topics to determine the alignment of key strategic themes to the PhD topics.

All documents that were used are in the public domain and therefore need not require permission to access. Furthermore, anonymity need not be ensured, and it is common practice to analyse the information, which is in the public domain such as scholarly articles, and research, which is found on databases and open library repositories to be analysed, compared, classified, ranked and rated with the institutions' names attached (Mouton & Valentine 2017; De Jager & Frik, 2016; Sandham and Retief, 2016; Visser, 2016; Bozkurt et al., 2015; Sinha & Macri, 2002; Caffarella, 1999).

Themes and aspects identified from environmental policy documents and PhDs

The content analysis of the environmental policy documents is summarised in Table 1 (Columns 1 and 2). The environmental-related aspects were extracted and grouped together to identify themes that best represented the group of aspects. Each PhD and its identifier number, completed at each respective university, was allocated, based on its topic(s) of research, to one or more of the government documents' themes or aspects (Table 1 Column 3). The total number

of PhDs that addressed a specific aspect is indicated in column 4 and the total number of PhDs that addressed a specific theme is indicated in column 5.

While a theme can appear to be well aligned with PhDs, certain aspects in that theme could be under-represented. An example is that of the ‘social-people of SA’ theme that aligned with 60 PhDs, yet three of the aspects associated to that theme are under-represented. Under-represented themes could best be identified by re-organising the table and presenting it in accordance with the aspects that had no PhDs aligned to them up to the aspects with the most PhDs aligned to them.

From the findings in Table 2 it is evident that aspects and themes that are most under-represented are waste management, energy (greenhouse gases, low carbon, green and renewable energy), coastal areas, mining and protected areas. Themes with partial alignment in some aspects are social aspects associated with people of South Africa, climate change and natural disasters, soil and agriculture, and water management. Biodiversity and air quality are two of the themes with most alignment to all of the identified aspects.

Alignment of PhDs to identified themes and government documents: a knowledge map

A mapping review, or systematic map, is used to categorise and map existing literature pertaining to a specific topic. A mapping review offers policymakers and researchers a clear way of how to narrow down policy or practice review questions, and whether to undertake in-depth reviews or only sub-set reviews (Grant & Booth, 2009). A knowledge map is concrete, tactical and makes implicit knowledge graphical and more visual. Knowledge mapping assists in the comprehension of how knowledge flows, and what the gaps are. The knowledge map assists in discovering where the knowledge is located, as well as the use and value of the

Table 2: Environmental-related aspects ranked from lowest to the highest occurrence

Theme: Aspect in government document	Total per university	Total/aspect
Waste management: Zero waste, reduction and clean technologies (SOER, 1999; NDP; Kok & Pietersen)		0
Waste management: Waste usage between industries (Kok & Pietersen)		0
Social-people of SA: Social impact of drought (Kok & Pietersen)		0
Social-people of SA: Environmental Entrepreneurship training (Kok & Pietersen)		0
Water management: Use of water efficient plants, rainwater harvesting, wastewater recycling (Kok & Pietersen; Agenda 2063)		0
GHG, Low Carbon, Green & Renewable: Low carbon economy and carbon pricing (NDP)		0
GHG, Low Carbon, Green & Renewable: Sustainable packaging (Kok & Pietersen)		0
Mining: Non-renewable resources – minerals (SAEO, 2012)		0
Waste management: Bioprocessing of organic waste (Kok & Pietersen)	UNISA (1)	1
GHG, Low Carbon, Green & Renewable: Energy efficient and zero emission buildings and transport (NDP; Agenda 2063)	UNISA (1)	1
GHG, Low Carbon, Green & Renewable: Sustainable consumption and production patterns (Agenda 2063)	UNISA (1)	1
Climate Change & Natural Disaster: Sea level rise (SAEO, 2006; NDP)	UKZN (1)	1
Social-people of SA: Use of indigenous pharmacopoeia food and fibre sources (Kok & Pietersen)	UNISA (1)	1
Waste management: Waste management (SEMA)	NWU (1); Wits (1)	2
GHG, Low Carbon, Green & Renewable: More use of renewable energy (Agenda 2063; NDP)	UCT (1); UKZN (1)	2
Soil/Agriculture: Clean up technology for contaminated land (Kok & Pietersen)	NWU (2)	2
Protected areas: Protect and sustain natural environment (Indicators, integrated framework and the number of areas under protection) (NDP)	UKZN (1); UNISA (1); NWU (1)	3
Coastal areas: Coastal management (SEMA; Agenda 2063)	NWU (1); US (1); UKZN (1)	3
Coastal areas: Thriving Mari-culture (Kok & Pietersen)	UCT (3)	3
Water management: Clean-up technology for contaminated water (Kok & Pietersen)	NWU (3)	3
Soil/Agriculture: Contamination of soil by pollutants (SOER, 1999)	FH (1); NWU (2); RU (1)	4
Water management: Contamination of ' by pollutants (SOER, 1999)	FH (1); NWU (4)	5
Climate Change & Natural Disaster: Natural disasters preparedness (Agenda 2063; NDP)	US (1); UFS (1); Wits (2); UJ (1)	5
GHG, Low Carbon, Green & Renewable: Greenhouse gas emissions (NDP; SOER, 1999; SAEO, 2012)	UKZN (3); Wits (2); NMU (2)	7
Mining: Sustainable mining and minerals (NDP; SAEO, 2012)	NWU (3); Wits (1); UJ (2); UV (1)	7
Protected areas: Protected areas (SEMA)	UCT (1); UKZN (5); NWU (1)	7
Biodiversity, Habitat and Resources: Sustainable Natural Resource Management (Agenda 2063)	FH (1); UKZN (4); NWU (2); US (1)	8
Climate Change & Natural Disaster: Climate resilience – impacts on humans and the economy (Agenda 2063; SAEO, 2006)	UCT (3); UP (3); RU (1); US (1); UNISA (2);	10
Soil/Agriculture: Investment and research into new agricultural technologies (NDP)	UCT (1); NWU (5); UNISA (4)	10
Climate Change & Natural Disaster: Climate change or climate change centre (SAEO, 2006, NDP)	UCT (3); UFS (1); UKZN (2); UP (1); Wits (5); UJ (1); UNISA (2);	15
Biodiversity, Habitat and Resources: Habitat loss, loss of aquatic ecosystems (SOER, 1999; SAEO, 2006; SAEO, 2012)	UFS (2); UKZN (4); NWU (4); UP (1); RU (2); Wits (1); UNISA (1); NMU (1)	16
Air quality: Air quality (SEMA)	UKZN (2); NWU (4); Wits (4); UJ (7)	17
Water management: Water quality, security and quantity (SAEO, 2006; SAEO 2012; Agenda 2063)	UCT (3); UFS (4); UKZN (2); NWU (11); UP (1); Wits (1); UJ (1); UV (2)	25
Biodiversity, Habitat and Resources: Biodiversity conservation, Biodiversity, Biological and physical resources (Agenda 2063; SEMA; SOER,1999)	UCT (2); UFS (2); UKZN (9); NWU (13); UP (2); RU (4); Wits (3); UNISA (2); NMU (6); UV (1)	44
Social-people of SA: People of SA and Human vulnerability (AIDS, poverty food security and services) (SOER, 1999; SAEO, 2006)	UCT (8); UKZN (10); NWU (4); UP (5); RU (10); US (2); Wits (5); UJ (5); UNISA (10)	59
No category: PhDs that were not placed in any theme or aspiration found in the government documents.	UCT (8); UKZN (4); NWU (1); UP (1); US (7); Wits (1); UJ (4); Unisa (4)	30

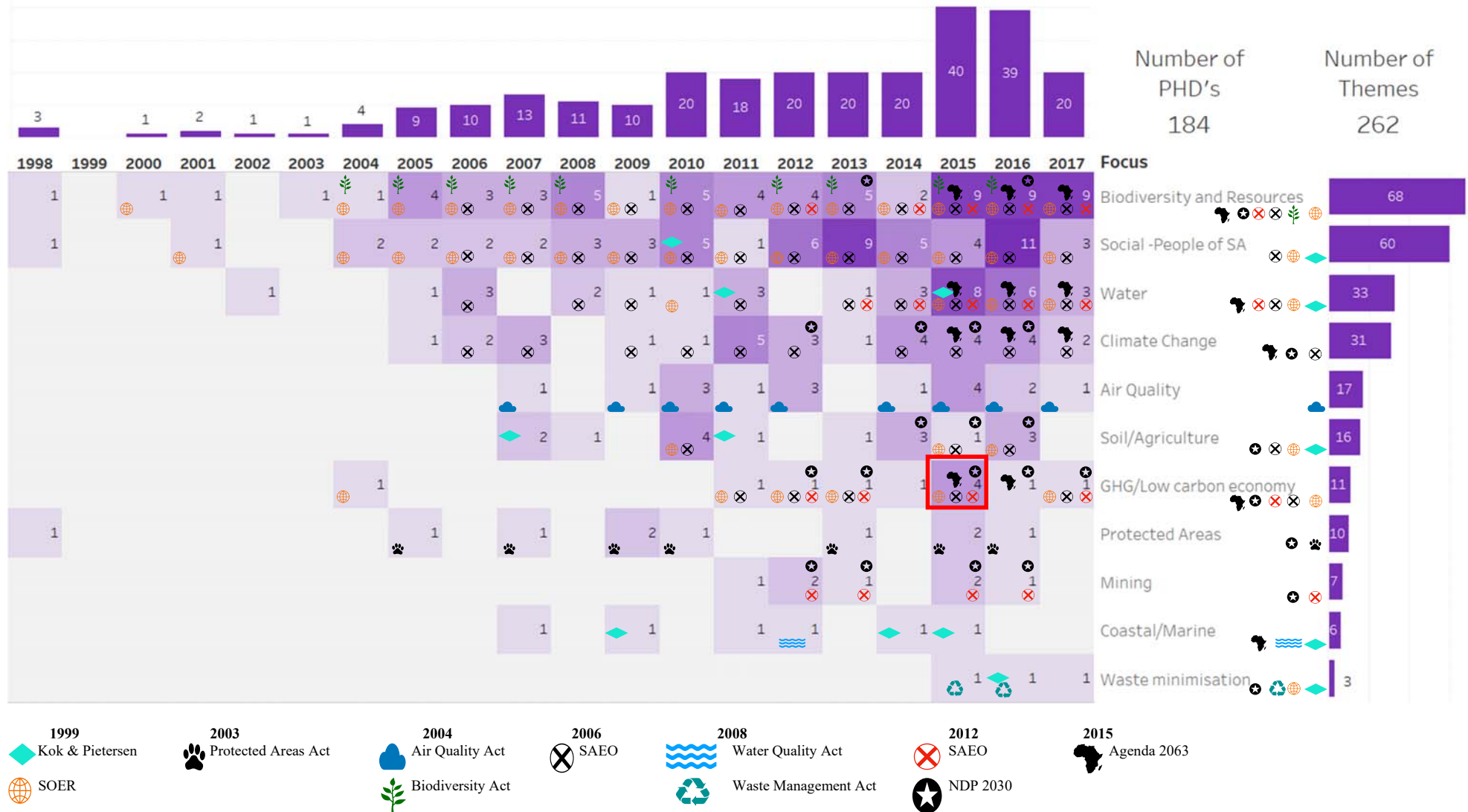
knowledge (Ermine et al., 2006). One definition of knowledge mapping is “an association of items of information, preferably visual, where the association itself creates new, actionable information” (Ebener et al., 2006, p. 636). The style of knowledge map that was used to represent PhD alignment to themes and environment-related policy documents is an annotated heatmap. Figure 1 is a culmination of the analysis of both the PhDs and the chosen strategic documents and the alignment between the two sets of data. The example highlighted in the knowledge map represents 4 PhDs that were completed in 2015 in the greenhouse gas and low carbon economy theme. These PhDs align with SOER (1999), SAEO (2006), SAEO (2012), NDP2030 (2012) and Agenda 2063 (2015)]

Figure 1 displays the PhDs completed per year according to the theme and related to each government document that is placed in order of their publication date relevant to the publication year of the PhD research. This map not only indicates areas of alignment with government documents but also indicates where PhD research on a specific theme precedes the publication of the government documents. Most importantly, the map hints toward the gaps in environmental studies research that can be niche areas that are currently under-researched but have been indicated as important themes for the South African environmental arena.

The knowledge map reads like a matrix, with the top row indicating the total number of PhDs completed per year. The column to the extreme right indicates the frequency of themes covered by the number of PhDs (184) per focus area (second-to-right column). Although the sample of PhDs analysed was reported to be 214, Table 1 indicated that 30 PhDs were unallocated to identified themes. The topics of focus of these PhDs were not associated with environmental matters and covered topics such as census output areas, spatial analysis learning programmes and ethics of urban land use. The icons indicated between these two columns represent the

Figure 1: The comparative knowledge map

PHD's per Year by Focus Areas



government documents aligned with the PhDs conducted over the years indicated as headings in the second row. The bottom row provides an indication of the government documents along with the icon associated with that publication and is ordered according to the year of publication of these documents. The shading of purple in the content area of the matrix is representative of the number of PhDs that align with a specific theme in a specific year. The dark purple blocks indicate where the PhD research was focused on the most, and as the purple colour fades it is an indication of gaps or under-researched areas. In the purple area, above the year row, the number of PhDs completed for each year per focus area is indicated. The icon indicated in each block indicates the government documents to which the PhDs are aligned. The number of themes covered (262) by the PhDs does not add up to a total number equal to the number of PhDs aligned to themes (184), considering that one PhD can be found to cover more than one theme identified by the government documents.

The sixteen blocks with a number in them, without a government document symbol, mean that the PhD did not align with any documents, because the PhD was finalised on the topic before the publication of the corresponding government documents. This is important to note because it is pertinent to see which PhDs are related to which government documents, even before those documents were published. A PhD topic that has an alignment to a government document that was completed prior to the government document's publication still shows alignment to the strategic direction and shows the potential influence on the government documents. One such PhD had a topic regarding protected area outreach programmes. Others focussed on the disaster preparedness aspect later reflected in the NDP 2030; two PhDs on water management, which were completed before the publication of the SAEO 2006, and two PhDs on the Integrated Coastal Management Act, completed before 2008. Since 2008, growth and a steady rise in PhD research was noticeable in themes related to those government documents published thereafter.

The same under-represented themes that were identified in Table 2 are also evident on the comparative knowledge map, namely waste management, energy (greenhouse gases, low carbon, green and renewable energy), coastal areas, mining and protected areas. In addition, the prevalence of some under-represented themes in government documents is also clearly visible. Energy matters in terms of greenhouse gases, low carbon, green and renewable energy appear as a theme in five government documents and only 11 PhDs align with this theme. Waste management as a theme appears in four government documents and only three PhDs are aligned to this theme.

Significance of the comparative knowledge map

This identification of aspects and themes in environmental studies PhDs and strategic government documents and the alignment thereof assisted in creating a comparative knowledge map where the knowledge contributions of South African PhDs in environmental studies were aligned to strategic research themes. The alignment process reveals trends in environmental studies PhD research, which PhD research aligned with the aspects found in strategic government documents and uncovered research gaps similar to what Bozkurt et al. (2015) and Visser (2016) found. Several under-represented themes and aspects were identified along with more prolifically researched areas. The biodiversity, habitat and resources theme and the social-people of SA theme were the two most dominant themes throughout the study period (Table 2 and Figure 1). Greater alignment was found in aspects that are legislated, but exceptions to this were noticed in terms of the Protected Areas Act and the Waste Act.

Strategic research themes with less alignment were coastal areas, mining, waste management, greenhouse gas, green- or low carbon economy and renewable energy themes and as such indicates a research gap and potential niche areas. Waste management specifically is under-

represented in the PhD alignment but is mentioned in four documents. Waste aspects such as zero waste to landfills, reduction of waste, clean technologies and waste usage between industries had zero PhD alignment. Waste management is a priority matter confirmed in the SOER 1999, the Kok and Pietersen Report, the NDP 2030 and legislation – as captured in the Waste Act. The Kok and Pietersen (1999) report focused solely on future research and funding for environmental studies in South Africa but did not align with many PhDs. The NDP 2030, is a key planning document for South Africa. Renewable energy was only represented by two PhDs, completed in 2015 and 2016. However, this theme could be found in both the NDP 2030 and the Agenda 2063. Mouton (2010) states that 83% of students, in sub-Saharan countries claimed that their work was aligned with the development plans of their country. The claim made by students and the actual reality in alignment for environmental studies might differ as seen from these findings. Publication dates of government documents must be noted and the number of PhD research studies aligning to these documents will change as time pass.

Sixteen PhDs aligned with an aspect in the government documents but were done before the date of the publication of the government documents. Because PhDs are supposed to make a new contribution, the PhDs that precede the government documents, based on the themes covered by those documents, are potential influencers on the inclusion of that topic in the strategic direction of the government documents. By including this aspect as part of the knowledge map, the potential for interactive engagement of the creation of knowledge to a strategic decision is demonstrated. It also emerged that thirty PhDs did not relate to any aspect of the government documents. These uncategorised PhDs could very well also be precursors of key research areas that have not yet been identified by policy documents.

The comparative knowledge map further illustrated that, after 2009, an increase in the finalisation of PhDs occurred. Even with the increase in PhDs, certain gaps are visible. The comparative knowledge map indicated that the climate change theme gained momentum, in terms of finalised PhDs since 2011. Research may thus follow new technology and new developments as conveyed by Caffarella (1999). The increased use of renewable energy as a result of the development of new technology and as necessitated by the struggling ability of South Africa's electricity power utility could potentially result in increased research in this theme.

Prospective researchers wanting to align with key strategic themes from policy documents could interrogate the comparative knowledge map for future research ideas to benefit the sustainable development of South Africa. Strategic policy documents are 'living documents' subject to change and amendments and can also be influenced by ground-breaking research and new knowledge generation from PhD studies. This study may identify research gaps that are relevant at a certain point in time but considering the complexity of the environment and the complexity of human systems influencing the environment a shift in priority within these dynamic ecosystems and human systems are inevitable.

Conclusion

The findings have shown that research in environmental-related PhDs do respond to strategic direction guided by policy, yet PhD research by nature should be at the forefront of new discoveries driving emerging issues and development. The 20-year period of investigation of environmental studies research in South Africa has also highlighted the research gaps that are under-representing key strategic themes from environment-related governmental agendas. These research gaps suggest current under-researched areas, but potential future research ideas

that are aligned with the environmental legislation, environmental reports and developmental plans.

In particular, further research should focus on themes in most under-represented themes including waste management, energy (greenhouse gases, low carbon, green and renewable energy), coastal areas, mining and protected areas. This study could also be conducted periodically to continue to measure the alignment of ever-changing self-organising PhD topics and legislation and policy documents as ‘living documents’ that mutually influence each other within a complex system. The research can also be expanded to all research conducted on South African environmental matters from students enrolled at universities other than those based in South Africa that formed part of this study sample. Scholarly journals can also be included in a similar systematic review to identify alignment, gaps and potential niche areas related to the environmental protection and development agenda of the country.

The reasoning and process that researchers undergo to make their research topic selection are still not known and it would be beneficial to determine the extent to which key strategic themes in environmental matters act as drivers for researchers’ topic selection. Similarly, the reliance that policy-makers have on novel and innovative scholarly input to develop policy, developmental plans and legislation for addressing current environmental challenges would also be valuable to investigate.

The consequence of dismissing this interactive engagement between researchers and evidence-informed policy-makers seem to have been pertinent in the observation from the findings where the government of South Africa initiated the Kok and Pietersen (1999) study to specifically identify environmental research areas of importance with associated funding provided, yet very

little alignment with the PhDs could be seen when comparing topics to this source specifically. This certainly has led to missed research opportunities and a loss for, ultimately, the environment.

While academic freedom should prevail, environmental studies research is expected to demonstrate real-world relevance and alignment with societal issues, which should therefore be reflected in policy. It is now possible with this study to answer the question posed by Mouton et al., in 2019 (in the introduction of this article), from an environmental studies perspective, that the extent to which South African research is responsive to national environmental priorities and goals is now known, and there remains more work to be done.

References

Bilotta, G. S., Milner, A. M., & Boyd, I. (2014). On the use of systematic reviews to inform environmental policies. *Environmental Science & Policy*, 42, 67-77. <https://doi.org/10.1016/j.envsci.2014.05.010>

Blankley, W.O., & Booyens, I. (2010). Building a knowledge economy in South Africa. *South African Journal of Science*, 06(11/12), Art. #373, 6 pages. DOI: 10.4102/sajs.v106i11/12.373

Bozkurt, A., Kumtepe, E. G., Kumtepe, A. T., Aydin, I. E., Bozkaya, M., & Aydin, G. H. (2015). Research trends in Turkish distance education: a content analysis of dissertations, 1986 - 2014. *European Journal of Open, Distance and E-learning*, 18(2), 1-21. <https://doi.org/10.1515/eurodl-2015-0010>

Caffarella, E. P. (1999). *The major themes and trends in doctoral dissertation research in educational technology from 1977 through 1998*. Retrieved August 17, 2021, from <https://eric.ed.gov/?id=ED436178>

Chan, E. S. W., & Hsu, C. H. C. (2016). Environmental management research in hospitality. *International Journal of Contemporary Hospitality Management*, 28(5), 886-923. <http://dx.doi.org/10.1108/IJCHM-02-2015-0076>

Colchester, J. J. (2016). *Systems + Complexity. An Overview: An accessible introduction to the new area of complex systems*. CreateSpace Independent Publishing Platform

Council on Higher Education (CHE). (2013). *The Higher Education Qualification Sub-Framework*. Pretoria: Council on Higher Education. Retrieved March 11, 2021, from https://nr-online-1.che.ac.za/html_documents/6.PUB_HEQSF.PDF

De Jager, P., & Frick, B.L. (2016). Accounting doctorates produced in South Africa, 2008 – 2014. *Meditari Accountancy Research*, 24(3), 438 – 457. <http://dx.doi.org/10.1108/MEDAR-06-2015-0033>

Department of Environmental Affairs and Tourism (DEAT). (2004). *Overview of Integrated Environmental Management, Integrated Environmental Management, Information Series 0*. Pretoria: Department of Environmental Affairs and Tourism. Retrieved February 10, 2021, from <https://www.dffe.gov.za/sites/default/files/docs/series0%20overview.pdf>

Ebener, S., Khan, A., Shademani, R., Compernelle, L., Beltran, M., Lasang, M.A. & Lippman, M. (2006). Knowledge mapping as a technique to support knowledge translation. *Bulletin of the World Health Organisation*, 84(8), 636-642. <https://doi.org/10.2471%2Fblt.06.029736>

Erdogan, T. (2015). Research trends in dissertations on PBL: A content analysis study. *Procedia - Social and Behavioural Sciences*, 197, 308-315. <https://doi.org/10.1016/j.sbspro.2015.07.142>

Ermine, J-L., Boughzala, I., & Tounkara, T. (2006). Critical knowledge map as a decision tool for knowledge transfer actions. *The Electronic Journal of Knowledge Management*, 4(2), 129-140. Retrieved May 26, 2022, from <https://hal.archives-ouvertes.fr/hal-00470387/document>.

Finneran, M. (2018). Language and the concept of change: overview of Leximancer analysis. In: K. Freebody, M. Balfour, Finneran, M. and Anderson, M. (eds.) *Applied Theatre: Understanding Change*. Switzerland

Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal*, 26, 91-108. <https://doi.org/10.1111/j.1471-1842.2009.00848.x>

Grimm, S., Gensch, M. M., Hauf, J., Prenzel, J., Rehani, N., Senz, S., & Vogel, O. (2018). *The Interface between Research and Policy-Making in South Africa. Exploring the institutional framework and practice of an uneasy relationship*. German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE). <https://doi.org/10.23661/dp19.2018>

Holman, D. K. & Banning, J. H. (2012). Honours dissertation abstracts: A bounded qualitative meta-study. *Journal of the National Collegiate Honours Council. Summer, 13*(1), 41-61.

<https://digitalcommons.unl.edu/nhcjournal/338>

Hyndman, B., & Pill, S. (2018). What's in a concept? A Leximancer text mining analysis of physical literacy across the international literature. *European Physical Educational Review, 24*(3), 292-313. <https://doi.org/10.1177%2F1356336X17690312>

Jeenah, M., & Pouris, A. (2008). South African research in the context of Africa and globally. *South African Journal of Science, 104* (9-10), 351-354. Retrieved July 18, 2022, from http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0038-23532008000500008&lng=en&tlng=en.

Kazemia, N., Modakb, N. M., & Govindan, K. (2018). A review of reverse logistics and closed loop supply chain management studies. *International Journal of Production Research, 7*(15-16), 4937-4960. <https://doi.org/10.1080/00207543.2018.1471244>

Kok, P., & Pietersen, J. (1999). *Environmental Management*. The British Council: Human Sciences Research Council.

Lin, T., Lin, I., Potvin, P., & Tsai, C. (2018). Research trends in science education from 2013 to 2017: A systematic content analysis of publications in selected journals. *International Journal of Science, 41*(3), 367-387. <https://doi.org/10.1080/09500693.2018.1550274>

Lindebaum D., Brown V. L., & Al-Amoudi I. (2020). 'Murder They Said': A content analysis and further ethical reflection on the application of neuroscience in management. *Organizational Neuroethics* (Martineau J., & Racine, E. Eds.). Springer.

Maree, K. (Ed). (2012). *Complete your theses of dissertation successfully: practical guidelines*. Cape Town: Juta.

Mouton, J. (2010). The state of social science in sub-Saharan Africa. World Social Science Report: Chapter 2, 63-67. <https://unesdoc.unesco.org/ark:/48223/pf0000190659>.

Mouton, J., Basson, I., Blanckenberg, J., Boshoff, N., Prozesky, H., Redelinghuys, H., Treptow, R., Van Lill, M., & Van Niekerk, M. (2019). *The State of the South African research enterprise*. SciSTIP

Mouton, J., & Valentine, A. (2017). The extent of South African authored articles in predatory journals. *South African Journal of Science*, 113, 1-9. <https://doi.org/10.17159/sajs.2017/20170010>

Mohee, R., Mhlanga, E., Wittfoth, A., Vilakati. N., & Makuku, V. (2020). Quality assurance in Higher Education in Africa. Retrieved June 17, 2021, from http://oasis.col.org/bitstream/handle/11599/3600/2020_Mohee_Mhlanga_QA_HE_Africa.pdf?sequence=1&isAllowed=.

Nunn, R. J. (2007). Complexity theory applied to itself. *Emergence: Complexity and Organization*, 9(1-2), 93-106. Retrieved September 17, 2021, from <https://www.proquest.com/docview/214149064>

Peter, C., & Swilling, M. (2014). Linking complexity and sustainability theories: implications for modelling sustainability transitions. *Sustainability*, 6, 1594-1622. <https://doi.org/10.3390/su6031594>

Plowright, D. (2011). *Using mixed methods: frameworks for and integrated methodology*. London: SAGE. <https://dx.doi.org/10.4135/9781526485090>

Sandham, L.A., & Retief, F.P. (2016). The contribution of Geography to Environmental Assessment (EA) practice and research in South Africa. *South African Geographical Journal*, 98(3), 450-460. <https://doi.org/10.1080/03736245.2016.1208585>

Sinha, D., & Macri, J. (2002). Ranking of Australian economic departments, 1988-2000. *The Economic Record*, 78(241), 136-146. <https://doi.org/10.1111/1475-4932.00019>

Thomas, D. A. (2014). Searching for significance in unstructured data. Text mining with Leximancer. *European Educational Research Journal*, 13(2), 235-256. <https://www.doi.org/10.2304/eej.2014.13.2.235>

South African Qualifications Authority. (2012). *Level descriptors for the South African National Qualifications Framework*. SAQA. Retrieved March 17, 2020, from https://www.saqa.org.za/docs/misc/2012/level_descriptors.pdf

Strydom, H. A., & King, N. D. (2015). *Environmental management in South Africa*. (2 ed). Juta.

Van Schalkwyk, S., Mouton, J., Redelinghuys, H., & McKenna, S. (2020). A systematic analysis of doctoral publication trends in South Africa. *South African Journal of Science*, *116*(7/8), 1-9. <https://doi.org/10.17159/sajs.2020/7926>

Vierula, J., Stolt, M., Salminen, L., Leino-Kilpi, H., & Tuomi, J. (2016). Nursing education research in Finland – A review of doctoral dissertations. *Nurse Education Today*, *37*, 145-154. <https://doi.org/10.1016/j.nedt.2015.10.014>

Visser, G. (2016). *The Production of student tourism research in South Africa: Past, present and future*. Stellenbosch University.

Visser, G., Donaldson, R., & Seethal, C. (2016). *The Origin and growth of geography as a discipline at South African universities*. Sun Press.

Xifra, J., & Castillo, A. (2006). Forty years of doctoral public relations research in Spain: A quantitative study of dissertation contribution to theory development. *Public Relations Review*, *32*, 302-308. <https://doi.org/10.1016/j.pubrev.2006.05.004>