

KwaZulu-Natal Sandstone Sourveld Research Programme

CLOSE-OUT REPORT

Phase 1: July 2011-June 2014



eThekweni Municipality-University of KwaZulu-Natal
Joint Research Partnership





Close-out Report: Phase 1

July 2011 – June 2014

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Abstract

This report summarises the outcomes of the KwaZulu-Natal Sandstone Sourveld Research Programme for its full three year term (July 2011- June 2014). The report provides an insight into some of the achievements of the programme – both the ‘more tangible’ scientific and collaborative management outcomes, as well as the ‘less tangible’ human capital and social learning outcomes. The scientific outcomes of the programme can be divided into three broad themes, namely biodiversity, ecosystem functioning and land use change. Twenty-one projects, spread across these three main themes, were conducted from 2011-2014. A conceptual research framework and a product-oriented research framework have also been developed. These are important collaborative management outputs of the programme which assist in guiding the research activities across disciplines and identifying synergies between science and policy/management. An evaluation of the scientific outcomes, using the product-oriented research framework, assessed the alignment of current projects with the municipality’s research questions and highlighted some important research gaps. These were mostly in the disciplines of socio-economic, geographic and governance research. Climate change-related research questions would also require more focused attention during the next phase of the research programme, although the programme has started generating crucial baseline biodiversity data which is required for monitoring the long-term effects of climate change on this threatened ecosystem. The human capital and social learning outcomes may actually be greater than the scientific outcomes at this early stage of the research programme. The programme has provided capacity building opportunities for 21 students during its three years. In addition, programme participants have had numerous social learning opportunities to learn more about working in a collaborative project environment across traditional disciplinary and institutional boundaries and improve their own working networks and build alliances. The preliminary results of a process evaluation of the programme which is regularly being conducted indicated that programme participants recognised and valued the social learning and alliance-building opportunities provided by the programme.



Members of the KZN SS research team at Tanglewood Nature Reserve

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EXECUTIVE SUMMARY AND HIGHLIGHTS

The achievements of the KwaZulu-Natal Sandstone Sourveld Research Programme, funded by eThekweni Municipality from 2011 to 2014, are described below in 5 themes:

1. Building a foundation for long-term collaboration

The programme has built a solid foundation for long-term collaboration. Significant gains have been made in capacity building and knowledge investment, and from this foundation even more benefits will be gained in the future.

Developing research relationships and interdisciplinary expertise: Researchers from a wide range of disciplines at the University of KwaZulu-Natal were involved in the research partnership.

18 university researchers were involved.
Researchers represented **7 different disciplines** including Botany, Ecology, Zoology, Geography, Agricultural Economics, Environmental Science and Land Use Planning & Management

Building social capital: People learnt to work collaboratively and to cross traditional institutional boundaries, to communicate with others outside of their normal sphere of work and to think and solve problems in new ways. They built long-term research relationships and students are improving their employability by engaging with practitioners beyond the academic context.

Comments from participants about building social capital:
“It’s an opportunity for **exposure and interaction with non-academics.**”
“it has created **a learning organisation** that has huge potential.”

2. Building capacity

The programme provided an opportunity for training and up-skilling young South Africans in biodiversity and environmental management to be able to contribute to research and management on global issues such as climate change at the local level. These young graduates can now be employed by the Municipality and elsewhere which addresses a severe skills shortage in the environmental and biodiversity sector.

11 post-graduate students completed their studies through the programme.
12 postgraduate students are currently pursuing degrees through the programme.

3. Conducting relevant research

Transdisciplinary research: The programme is ensuring that research conducted at university is relevant and addressing real problems and challenges by conducting inter-disciplinary research which is embedded in a process that goes beyond the gates of the university and has a real impact on Durban’s communities and the ecosystems which underpin their well-being.

Comments from participants about being involved in transdisciplinary research:
“It has a bigger picture approach” “We are **bridging communication** between the needs of policy makers and academic research.” “We are involved in community engagement by working with the municipality to **solve practical societal problems.**”

4. Generating useful knowledge

The programme has successfully generated needs-based knowledge which the EPCPD can use in their planning and management activities. Some examples of such research are given below:

Collecting biodiversity data to contribute to better management of D'MOSS: Important baseline biodiversity data has been collected which will be used to refine and improve Systematic Conservation Planning in Durban and can be used for long-term monitoring of climate change and other impacts.

Floristic surveys were conducted at 6 KwaZulu-Natal Sandstone Sourveld sites by **investigating plant species in 60 plots**. Sophisticated DNA barcoding techniques were used to **identify approximately 2000 invertebrate species** in D'MOSS.

Understanding local community reliance on ecosystems: Studies were conducted on the use of forest products and grazing in and around the KwaZulu-Natal Sandstone Sourveld to determine the utilisation of natural resources by peri-urban communities.

150 households were surveyed in the Inanda mountain area and it was found that **56% of households generate income from forest products**.

Climate change adaptation: Research was conducted to determine how humans and biodiversity respond to climate change and to consider suitable adaptation options.

In a household survey about climate change, two thirds of households would **adapt to climate change by seeking alternative economic activities**. In a grassland experiment, it was found that an increase in temperature **changed the species composition and productivity** of KwaZulu-Natal Sandstone Sourveld and that this could lead to a decrease in biodiversity under climate change.

5. Unexpected Outcomes

Increased awareness about eThekweni Municipality's environmental work: Students and researchers have presented their work both locally to conservancies and local interest groups, as well as nationally and internationally at academic conferences. This raises awareness at all levels of the work done in Durban by the Environmental Planning and Climate Protection department.

The research programme has been presented as a case study of a science-policy-practice partnership at **1 international and 2 local conferences**. Results of the urban crowned eagle ecology study have been presented to **16 local conservancies** and interest groups, as well as **1 local and 1 international conference**. Invertebrate barcoding research has been presented at **2 international conferences**.

Leveraging co-funding to develop new, relevant knowledge and build capacity in Durban: Through the research programme, the university has been able to leverage additional co-funding which has exceeded the core research funding provided by eThekweni Municipality.

Core funding provided by eThekweni Municipality = **R 1 500 000**
Additional co-funding leveraged externally = **R 2 240 000**

1. Introduction

1.1 *General introduction to the KZN SS Research Partnership*

The KwaZulu-Natal Sandstone Sourveld Research Programme is a research partnership between the eThekweni Municipality (EM) and the University of KwaZulu-Natal (UKZN) which was officially initiated in May 2011. The partnership was developed to advance knowledge in biodiversity conservation and management within the context of global environmental change. It is facilitated by the Environmental Planning and Climate Protection Department (EPCPD) in eThekweni Municipality and by Land Use Planning and Management research staff at UKZN, along with researchers from various other disciplines at UKZN. The programme not only aims to generate much-needed knowledge to assist managers in the Municipality in making biodiversity and conservation decisions, but also to build capacity by employing interns and supporting student research activities at the university. Such novel institutional partnerships are important for generating knowledge and learning and to address the gap between scientific research, policy development and management within a local government setting.

The Municipality provides funding to support research by staff and students at the university, and the current phase of the programme focuses research effort within the KwaZulu-Natal Sandstone Sourveld (KZN SS) ecosystem (Figure 1). This ecosystem is found only within KwaZulu-Natal, has very high rates of species diversity and endemism and has been identified provincially as critically endangered. It therefore requires the Municipality to conserve and manage it effectively. The specific objectives of the research programme, which currently focus on the KZN SS (note: the focus was more general at the initiation of the project), are as follows:

- Increase understanding of biodiversity
- Increase understanding of ecosystem functioning and ecosystem services
- Better understanding of past, present and future land use changes
- Assist EM with decision-making for land use planning
- Assist EM with decision-making for management
- Assist EM in communicating the ecological and socio-economic value of KZN SS
- Develop monitoring protocols in the face of climate change
- Address specific climate change challenges
- Address climate change adaptation issues, especially ecosystems-based adaptation
- Increase human capital in the areas listed above

Research on the KZN SS ecosystem is conducted by researchers and students from various disciplines at UKZN, and the core programme co-ordination team aim to integrate results across these disciplines to generate decision-making products for the municipality. The disciplines include: land use planning and management, remote sensing and GIS, agricultural economics, biodiversity and ecology. Research is currently biased towards the environmental and biological sciences, but the programme aims to expand in its second phase (from 2015) to incorporate relevant research expertise in social science, governance and economics.

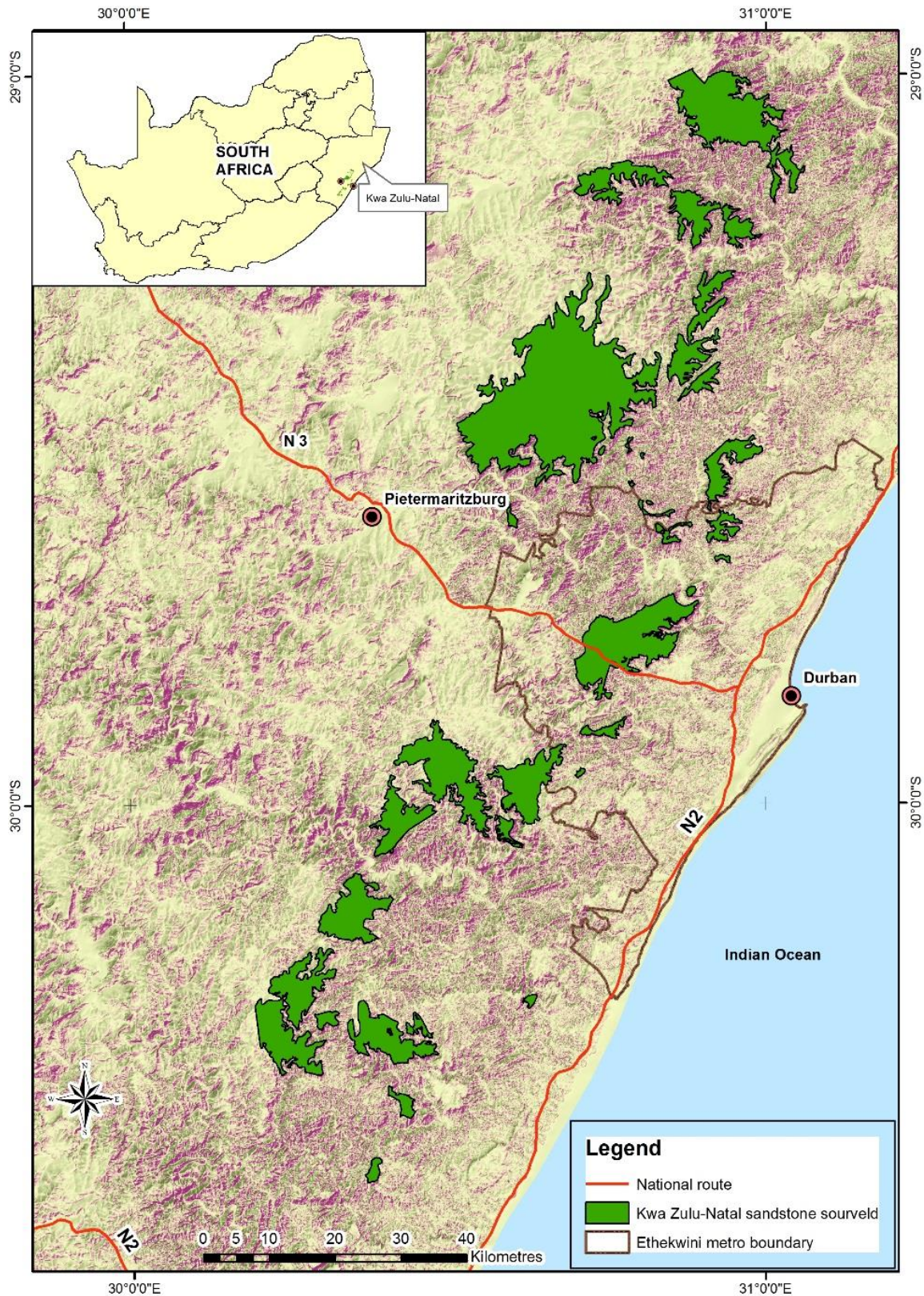


Figure 1: Map showing the full extent of the KZN SS vegetation type (green areas) as well as the EThekweni Municipal boundary (dark brown line).

1.2 History of the partnership between UKZN and EPCPD – The KwaZulu-Natal Sandstone Sourveld Research Programme

In the early 2000s, whilst conducting interviews for new staff in the then Environmental Department of eThekweni Municipality, it became apparent to Dr. Debra Roberts (currently Deputy Head: Environmental Planning and Climate Protection) that there was a shortage of capacity in biodiversity planning and management. As a result it was extremely difficult to fill available municipal posts. This led to discussions with the Council for Scientific and Industrial Research (CSIR) that resulted in the launch of a 2-year internship programme in which graduates were trained in a modular fashion on environmental and biodiversity management. This was to be the first in a sequence of endeavours by the Environmental Department to build capacity. Despite five candidates completing the CSIR programme, the majority were still not suitable for employment within eThekweni Municipality as their skills were still not sufficiently specialised for the needs of the department. This first attempt to build capacity locally costed eThekweni Municipality approximately R1.5 million, and only one of the five candidates was suitable for employment in the Municipality.

Having accepted that the CSIR training programme was not going to fulfil the needs of the Municipality for skilled biodiversity staff, it was decided that the best approach might be to go back to ‘the root of the problem’ – i.e. to approach the local university, the University of KwaZulu-Natal (UKZN), and collaborate with them on an internship programme to train graduates in specific biodiversity skills as required by the Municipality. Two interns were recruited from within the School of Biological and Conservation Sciences (now Life Sciences). The interns were based at the University but spent certain dedicated slots with the Municipality to become familiar with municipal systems. This arrangement allowed the candidates to gain a thorough understanding of the functions of the Municipality’s Environmental Management Department, and to benefit from supervision from university academics and develop specialist biodiversity skills. Both candidates were employed upon completion of their Masters programmes on an initial contract basis, and following the demonstration of suitable performance in the department, they were moved into full time positions where they still work. This second attempt at building capacity was successful, had cost the Municipality substantially less (R380 000), but required a substantial time-commitment from municipal staff to co-supervise and mentor the interns, which was deemed unsustainable in the long-term as staff resources were severely limited.

An attempt to replicate the university-municipality internship programme in 2010 was initially unsuccessful, as there were no students in the life sciences at UKZN interested in participating in such an internship programme. A candidate was eventually identified from the School of Environmental Sciences and despite the Municipality’s need for specialised biodiversity skills, it was agreed that a ‘generalist’ student from the field of environmental science could still be a valuable asset to the Municipality. The cost of this second internship was R160 000, and the outcome was unsuccessful as the intern chose not to join the Municipality. This subsequently led to litigation being initiated by the Municipality to reclaim the funds spent on the internship. The concern regarding the ability of Municipality staff to sustain the levels of input required to co-supervise and invest in up-skilling of the interns remained during the course of this second phase and led to the eventual merging of the internship concept with the new research partnership established between the Municipality and the University of KwaZulu-Natal.

This research partnership was initiated in 2010 when Dr. Roberts approached Professor Rob Slotow at the University with the proposal for a second internship and took the opportunity to raise the possibility of establishing a long-term research partnership (based on similar research partnerships that already existed with the University in the water and waste sectors) between the Environmental Planning and Climate Protection Department and the School of Biological and Conservation Sciences. Professor Slotow was a deputy vice-chancellor at UKZN and had been involved in providing in-service biodiversity conservation training on behalf of UKZN to staff at the Environmental Management Department of eThekweni Municipality to support the on-going capacity building efforts in the department. Having a good understanding of the difficulties in bridging the gap between science, policy and practice, Professor Slotow agreed to provide support for development of such a partnership from the university's side. The partnership was formalised through a memorandum of agreement (MOA) which was signed by the Municipality and the University and began at the commencement of the 2011/12 Municipal financial year. To allow for 'organic' growth of the partnership and promote openness and inclusivity, the overall goals of the partnership were very broad at the beginning. This meant that academics from various disciplines could find a 'niche' within the partnership for participation, depending on their expertise. However, once research projects were underway, the Municipality took a firm hand in influencing the way in which research was conducted to ensure that the money they were spending on the programme would yield results in line with the overall goals of their department. As a result an endangered vegetation type, the KwaZulu-Natal Sandstone Sourveld, was agreed upon as an 'anchor' for the programme which would initially frame the research activities. This resulted in some tension as researchers at the university felt that the Municipality was too engaged with their research. In most externally-funded research researchers are allowed greater academic freedom by funders and this new arrangement was possibly difficult for some to adjust to.

The municipality provided funding of R500 000 per year (R1.5 million overall) for research to be undertaken by students and academics at the university – in this way, much-needed knowledge was generated simultaneously as biodiversity skills and human capacity were built in the context of urban biodiversity management. It was initially agreed that the KwaZulu-Natal Sandstone Sourveld Research Partnership would run for a three-year period after which the terms of the partnership would be re-negotiated. This three-year term came to an end in June 2014 (Phase 1), and planning is underway to extend the partnership for a further three years with an increased budget for research (Phase 2).

In the early stages of the research partnership, the relationship between Municipality and University staff members engaged in the partnership was at times difficult and meetings were often tense. This can be ascribed to the challenges of different institutional cultures, unclear expectations and different modes of working within the two institutions. These early tensions resulted in some of the university research staff pulling out of the partnership, as they found the collaboration across institutions difficult, however others have remained committed to the programme and the programme leaders continued pushing the partnership forward despite these setbacks.

A recent evaluation of the research partnership showed that participants feel that they have built networks and long-term research relationships through the partnership, and 98% of respondents indicated that they would like to continue participating in the programme. Thus it seems that the initial 'teething problems' have mostly been solved and that the research programme is on track.

This can possibly be ascribed to additional human resources allocated to the programme since its inception. Dr. Sean O'Donoghue, who joined the Climate Protection Branch of the Environmental Planning and Climate Protection Department (EPCPD) in 2011 (from UKZN), provided much needed additional support for management of the research partnership. In 2012, Professor Mathieu Rouget was appointed in a South African Research Chair Initiative position in Land Use Planning and Management at UKZN and is now the lead researcher on the KwaZulu-Natal Sandstone Sourveld Research Programme at UKZN. As a result there are now 'more hands on deck' to manage the day-to-day administration and decision-making of the research partnership.

The research partnership is now well established and is producing not only useful biodiversity, ecological and environmental change results, but has also contributed to capacity building of students in these areas of research. Since the start of the research partnership in 2011, four MSc and seven Honours students have completed their studies through the research programme

This innovative research partnership, which cuts across both institutional and disciplinary boundaries, provides valuable learning opportunities for solving complex, environmental problems. Staff and students from both UKZN and EPCPD have benefited, but further work still needs to be done to ensure that the Municipality's knowledge and ability to manage ecosystems in the context of global change is improved. This will be done through increasingly focused and policy relevant research. Appendix 1 provides a detailed overview of this history, and the diagram in Figure 2 illustrates the every-improving trajectory of the partnership between UKZN and EPCPD.

Highlights and key success ingredients of the EM-UKZN Research Partnership History:

- The right people, in the right place, at the right time
- Brave leaders!
- Champions: finding people with a shared vision – i.e. the need to bridge the science-policy-practice divides
- Perseverance and commitment – learning by doing, acknowledging that there will be difficulties and steep learning curves
- Patience: Changing institutional patterns and behaviour takes a long time and a lot of resources

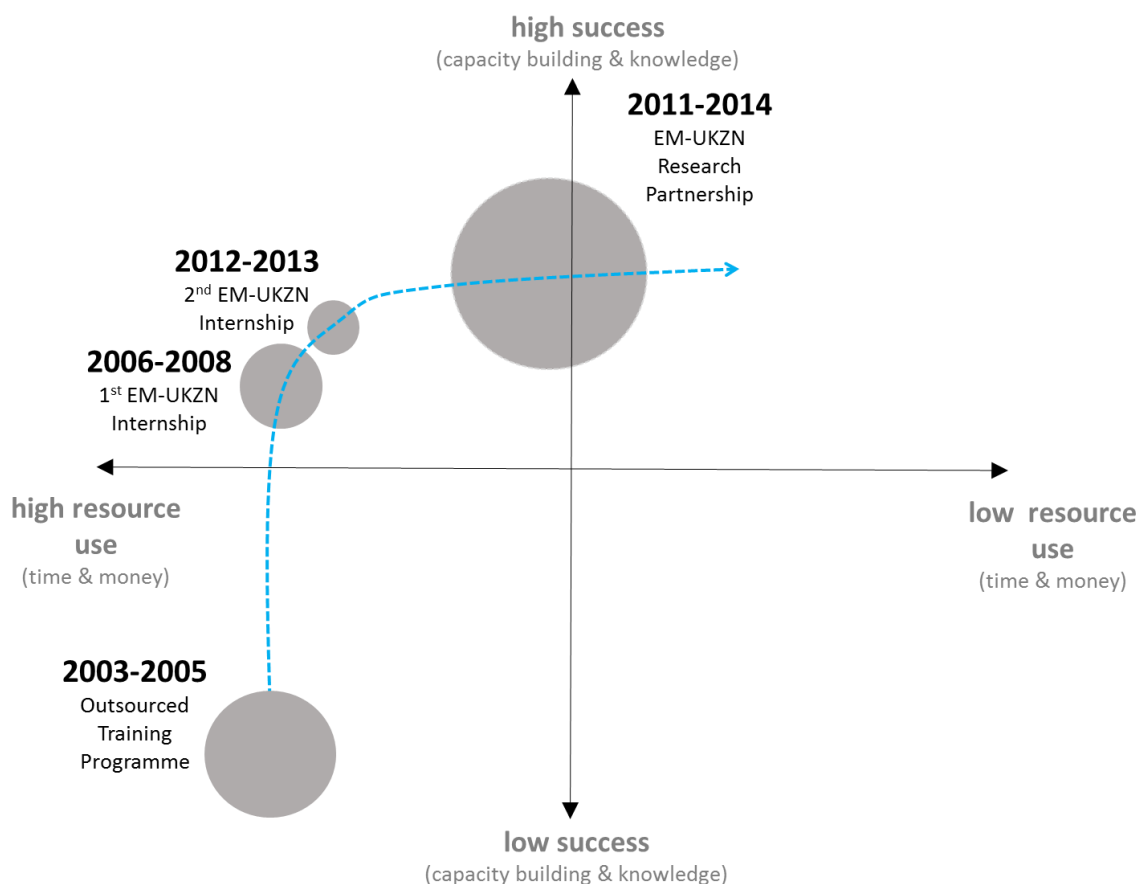


Figure 2: Perceived success of the various interventions leading up to the development of the KwaZulu-Natal Sandstone Sourveld Research partnership between UKZN and eThekweni Municipality in 2011. The size of the bubbles represents the relative number of people who received biodiversity training/up-skilling during that intervention.

2. Programme outputs

2.1 Output 'by the numbers' – an overview

Measuring the outputs and success of a partnership like this by quantitative metrics does not give an accurate representation of the true value of the programme, however it is a useful way of summarising some of the key metrics. Figure 3 provides a visual overview of some of the key metrics of the KZN SS research partnership over the first three years of Phase 1.

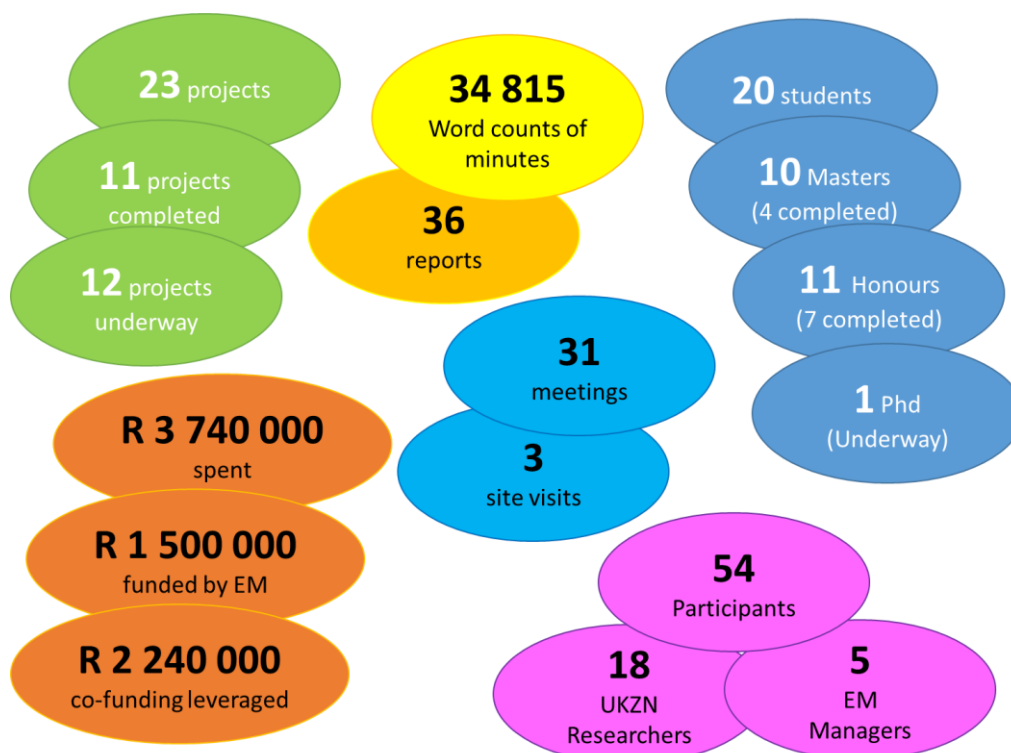


Figure 3: A summary of some of the key outputs from the KZN SS research programme.

2.2 Core funding and financial report

EThekweni Municipality provides the core funding for the KZN SS research programme, with a budget of R500 000 per annum. The expenditure for 2011-2014 is summarised in Table 1.

Table 1: Summary of expenditure for 2011-2014.

Item	Year One	Year Two	Year Three	TOTAL
Student time	R 162 000	R 276 000	R 288 000	R 726 000
Running costs	R 266 908	R 52 190	R 70 489	R 389 587
Research assistants for PIs	R 71 092	R 90 767	R 94 484	R 256 343
Overall co-ordination *	R 0	R 81 043	R 47 027	R 128 070
Total	R 500 000	R 500 000	R 500 000	R 1 500 000

* includes the appointment of two research fellows to assist in coordinating individual research components of the projects

2.3 Partner contributions: Additional funding and in-kind contributions

In addition to core project funding provided by eThekweni Municipality over the three years (R1 500 000), a number of researchers and students at UKZN leveraged additional funding to support KZN SS research projects (Table 2). The total amount of co-funding leveraged was R 2 240 000 for the three years.

The co-funding came from various sources, including the University of KwaZulu-Natal, National Research Foundation (NRF), International Barcode of Life - International Development Research

Centre (IDRC) Canada, African Centre for DNA Barcoding, Eskom, Mazda Wildlife Trust, Victoria Club, Zimbali Coastal Estate, Cotswold Downs, Birdlife KZN Midlands, South African Falconry Association and anonymous private donors.

Table 2: Summary of external co-funding leveraged for 2011-2014.

Item	Year One	Year Two	Year Three	TOTAL
Student bursaries	R 0	R 342 000	R 290 000	R 632 000
Running expenses*	R 211 500	R 600 000	R 275 500	R 1 087 000
Research assistance and co-ordination	R 0	R 270 000	R 251 000	R 521 000
Total	R 211 500	R 1 212 000	R 816 500	R 2 240 000

*Note that approx. R 830 000 of this amount was the cost of DNA bar-coding done through the International Barcode of Life project, funded by the International Development Research Centre Canada (IDRC)

2.4 Collaborative management outputs

Although the focus of the KZN SS Research Programme is to generate knowledge to support the Municipality in biodiversity conservation and management of the KZN SS, the success of the programme can also be evaluated by considering management outputs that go beyond research projects – this is part of a process evaluation, rather than outcome evaluation, which considers actual research outputs.

2.4.1 Meetings and team learning opportunities

During the programme, participants were involved in a total of 31 meetings (Table 3). Despite meetings often being viewed as time-consuming, they are important learning opportunities in a collaborative research partnership such as this one, and are thus useful indicators of programme output.

Table 3: Record of meetings held during 2011-2014

Date	Topic	Venue	Attendance
FULL TEAM MEETING			
<i>All PIs and/or students, EM and UKZN staff</i>			
19 Oct 2011	Programme Workshop #1, Year 1: UKZN Research Meeting	UKZN: Room 639	10
17 Mar 2012	Programme Workshop #2, Year 1: UKZN KZNSS student project presentation and meeting	UKZN: Westville Campus	n/a
17 Oct 2012	Programme Workshop #1, Year 2: Principle Investigator meeting: programme update	UKZN: Westville Campus	n/a
12 Nov 2012	Programme Workshop #2, Year 2: PI Project presentations	UKZN: Westville Campus	21
12 Dec 2012	Programme Workshop #3, Year 2: PI One-on-One meetings	UKZN: Westville Campus	n/a
8 Apr 2013	Programme Workshop #4, Year 2: PI Project Progress Reports	UKZN: Westville Campus	14

Table 3 (cont.): Record of meetings held during 2011-2014

Date	Topic	Venue	Attendance
17 May 2013	Programme Workshop #5, Year 2: UKZN SS Research Programme Workshop Project Presentations	UKZN: Westville Campus	25
02 Dec 2013	Programme Workshop #1, Year 3: KZNSS 2013 Year end Symposium	Paradise Valley Nature Reserve	27
01 Aug 2014	Programme Workshop #2, Year 3: UKZN SS Research Programme Workshop Project Presentations	UKZN: Westville Campus	32
PROGRAMME CO-ORDINATION MEETING EM and UKZN staff			
12 Jan 2012	Co-ordination Meeting #1, Year 1: UKZN Research Project meeting.	UKZN: Westville Campus	3
23 Jan 2012	Co-ordination Meeting # 2 Year 1: eThekweni Municipality Intern- MSc project discussion	UKZN: Westville Campus	5
02 Apr 2012	Co-ordination Meeting # 3 Year 1: UKZNSS Programme Research	UKZN: Westville Campus	3
02 Apr 2012	Co-ordination Meeting # 4, Year 1 : UKZN Research Meeting	UKZN: Westville Campus	3
19 Jun 2012	Co-ordination Meeting # 5, Year 1 : Project Meeting	UKZN: Westville Campus	4
12 Oct 2012	Co-ordination Meeting #1, Year 2: Programme Planning	City Engineers Building	7
12 Dec 2012	Co-ordination Meeting #2, Year 2: Programme Update	UKZN: Westville Campus	n/a
18 Feb 2013	Co-ordination Meeting #3, Year 2: New Projects and Update	UKZN: Westville Campus	10
7 Jun 2013	Co-ordination Meeting #4, Year 2: Research framework and planning meeting	UKZN: PMB Campus	10
12 Jul 2013	Co-ordination Meeting #1, Year 3: Budget Meeting	UKZN: Westville Campus	9
26 Aug 2013	Co-ordination Meeting #2, Year 3: Year 3 Planning Meeting	DVC boardroom – Howard College	7
04 Oct 2013	Co-ordination Meeting #3, Year 3: KZN SS Phase 2 Planning Meeting	UKZN: Westville Campus	18
02 Dec 2013	Co-ordination Meeting #4, Year 3: 2014 Year-end meeting	Paradise Valley Nature Reserve	8
25 Mar 2014	Co-ordination Meeting #5, Year 3: 2014 Planning meeting	UKZN: Westville Campus	8
6 Jun 2014	Co-ordination Meeting #6, Year 3: 2014 Planning meeting	UKZN: Howard College	10
WORKING GROUP MEETING Focus group discussing a specific topic EM and/or UKZN staff			
29 Nov 2012	KZN SS focussed EPCPD meeting (EM staff)	City Engineers Building	6
7 Feb 2013	Update, Budgets and development of conceptual framework (UKZN PIs and staff)	UKZN: PMB Campus	11
07 Feb 2013	KZNSS: Update and Development of conceptual framework (UKZN PIs and staff)	UKZN: PMB Campus	11

Table 3 (cont.): Record of meetings held during 2011-2014

Date	Topic	Venue	Attendance
24 April 2013	KZN SS Research framework and partnership paper prep (UKZN staff)	UKZN: Westville Campus	5
24 May 2013	KZN SS Vegetation paper prep (EM and UKZN staff)	UKZN: Westville (and New Germany)	8
13 June 2013	Evaluation planning (UKZN staff)	UKZN: Westville campus	5
02 Aug 2013	Working Group Meeting: Long-term monitoring and data management for the KZN SS Programme	UKZN: Westville Campus	5
06 Sep 2013	Working Group Meeting: Long-term monitoring and data management for the KZN SS Programme	UKZN: Westville Campus	6
04 Feb 2014	KZNSS Milestones Brainstorming meeting(UKZN Staff)	UKZN: Westville Campus	4
SITE VISITS PIs and/or students, EM and UKZN staff			
8 Mar 2013	KZN SS Site visits to aid with project site selection (with Richard Boon)	Various locations: Cato Ridge, Ntshongweni etc.	10
24 May 2013	KZN SS site visit with David Styles and Richard Boon	New Germany Nature Reserve	8
22 Jan 2014	KZNSS site-visits for new students (with Trafford Petterson)	Cato Ridge and Edgecliff	9

2.4.2 Capacity building outputs

Another important measure of success in a collaborative programme is looking at how many people have benefited from the programme. Table 4 summarises the number of participants from various groups within the programme (further details about participants can be found in Appendix 3). One of the main aims of the KZN SS research partnership is to build human capacity in biodiversity conservation and management within the context of global environmental change. Thus, the participation of researchers, but more importantly students, in the programme is an indicator of human capacity building outputs for the programme. In total, eighteen students from UKZN have been involved in the KZN SS research partnership during the programme period. Fewer Municipal staff have however benefited from the programme and it will be important in phase 2 to find innovative ways to build the capacity of EM staff.

Table 4: Human capacity involved in the KZN SS Programme during the 2012-2013 financial year

Participants	How many?
EThekwini Municipality: Managers	5
EThekwini Municipality: MSc Interns*	1
University of KwaZulu-Natal: Researchers	18
University of KwaZulu-Natal: Project Administrator	1
University of KwaZulu-Natal: Students (MSc)	9
University of KwaZulu-Natal: Students (Honours)	11
University of KwaZulu-Natal: Students (PhD)	1
University of KwaZulu-Natal: Students on Associated Projects (See Table 6)	8
TOTAL NUMBER OF PARTICIPANTS	<u>54</u>

* The eThekwini Municipality intern was an MSc student at UKZN.

2.4.3 Collaborative research outputs

The KZN SS Research programme is currently preparing two academic journal articles for publication. These articles will be direct collaborative research outputs from the research partnership, as they will be co-authored by staff from both eThekwini Municipality and UZKN. Publication of academic journals at a university is important for a number of reasons: for career development of academic staff at the university; for the university to gain access to research subsidies from national government and for the university to measure its research output. For the programme as a whole, publication of academic journal articles is important for attracting research staff, for raising the status of the programme at the university and to raise awareness and create possible further opportunities for collaboration about the programme in the academic community as a whole. The UKZN support team is currently preparing these articles and the intention is to have them submitted for publication before the end of 2014.

The two research articles are described below.

1. *Managing threatened ecosystems in urban environments: Implementation of a science-action partnership.*

This article will be a descriptive case study of the research partnership as a whole.

Aim of the paper: To present a case study on establishing a partnership between an academic institution and local government to plan and manage for a threatened ecosystem. A draft has been completed and is currently being circulated to all co-authors for comment.

2. *What do we know about the threatened KwaZulu-Natal Sandstone Sourveld ecosystem?*

This article will be a brief review of current knowledge of the KZN SS vegetation type.

Aim of the paper: To provide a description of the KZN SS vegetation type along with an analysis of the status of this vegetation type from a land cover change perspective.

In addition to these academic journal publications, a 'conceptual research framework' and a 'decision-oriented research framework' (which will be included in discussion in the above papers),

were also significant collaborative research outcomes of the research partnership during this financial year. Both of these outcomes were developed in ‘Programme co-ordination’ or ‘Working Group’ meetings (Table 3) during which programme participants, from both the municipality and the university, worked together in developing these frameworks (see sections 3 and 4 below).

3. What has been studied?

3.1 Developing a research framework

In order to ensure synergy across individual projects, a research framework was jointly developed.

The research framework identifies three main research themes, including the linkages between each theme (land use change, biodiversity, and ecosystem functions, Figure 4). Linkages between the themes are illustrated by arrows. The research programme therefore aims at identifying and quantifying key land use changes which impact on biodiversity and ecosystem functioning.

Appropriate responses to address these changes were proposed to assist the municipality in decision-making. These are presented in Figure 6 (see section 4).

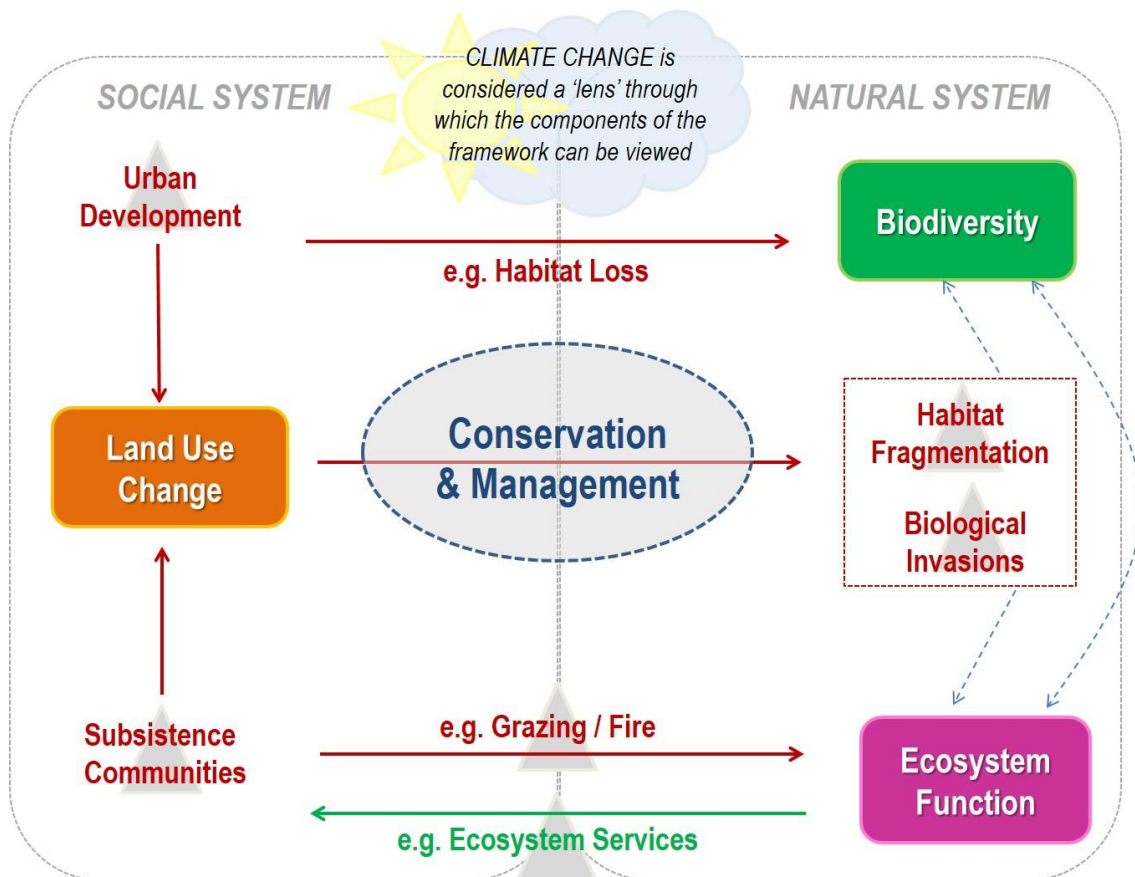


Figure 4: Conceptual research framework developed for the KZN SS research programme. The research framework indicates the interaction between the social system (left) and the natural system (right), and indicates the three main research themes within the programme: Land use change, Biodiversity and Ecosystem function.

3.2 KZN SS projects for Phase 1

During Phase 1 of the partnership, 23 research projects were carried out in the KZN SS research programme (Table 5), eleven have been completed and twelve are currently underway. These projects have involved one PhD student, ten MSc students and twelve honours students and were supervised by eleven principal investigators. The research projects covered a range of scientific disciplines, and were categorised into three broad research themes, as presented in the conceptual research framework i.e. biodiversity, ecosystem function and land-use change (Figure 4).

Table 5: List of projects of the KZN SS Programme for Phase 1.

#	Project title	Short title	Principal Investigator	Student name	Degree	Status*	Period
BIODIVERSITY THEME (10 student projects)							
1a	The plant composition and seed bank in remnant patches of KwaZulu Natal Sandstone Sourveld.	Floristics and seedbanks	Dr. Syd Ramdhani, Dr. Sershen Naidoo	Philani Mbatha	Honours	C	2012
1b	Floristic and seed bank studies within selected patches of remnant KZN SS	Floristics and seedbanks	Dr. Syd Ramdhani, Dr. Sershen Naidoo	Charmaine Drury	Honours	C	2013
1c	Floristic and seed bank studies within selected patches of remnant KZN SS	Floristics and seed banks	Dr. Syd Ramdhani, Dr. Sershen Naidoo	Renira Boodhraj	Honours	C	2013
1d	A Biogeographic Study of the KZN SS patches within the eThekweni Municipal Area	Floristics and seedbanks	Dr. Syd Ramdhani, Dr. Sershen Naidoo	Charmaine Drury	Masters	U	2014 -
2a	Utility of DNA barcoding for the rapid assessment of ants (Formicide) in the eThekweni region.	Invertebrate DNA barcoding	Dr. Sandi Willows-Munro	Sohana Singh	Masters	C	2012-2013
2b	The utility of DNA barcoding in South African spiders	Invertebrate DNA barcoding	Dr. Sandi Willows-Munro	Siphesihle Mthethwa	Honours	C	2013
2c	The utility of DNA Barcoding in Hymenoptera and Dipetra pollinators of eThekweni	Invertebrate DNA barcoding	Dr. Sandi Willows-Munro	Sanelisiwe Duze (Tina)	Masters	U	2013 -
2d	The utility of DNA barcoding in South African spider	Invertebrate DNA barcoding	Dr. Sandi Willows-Munro	Siphesihle Mthethwa	Masters	U	2014 -
2e	The utility of DNA barcoding of South African Hemiptera	Invertebrate DNA barcoding	Dr. Sandi Willows-Munro	Ashrenee Govender	Honours	U	2014
3	The species composition of non-volant soil macro invertebrate taxa within the KZN SS	Soil invertebrate diversity	Dr. Tarombera Mwabvu	Ntobeko Mkhonza	Honours	C	2013

Table 5 (cont.): List of projects of the KZN SS Programme for Phase 1.

#	Project title	Short title	Principal Investigator	Student name	Degree	Status*	Period
ECOSYSTEM FUNCTION THEME (6 student projects)							
4	The impact of grazing on the persistence of the KZN SS and its plant communities	Grazing impacts	Dr. Alfred Odindo	Farai Mazvimbakupa	Honours	C	2012
5	Towards an ex situ plant germplasm conservation strategy for dominant taxa within the KZN SS	Seed conservation	Dr. Sershen Naidoo	Nireshnee Naicker	Masters	U	2013-
6	Urban Ecology of Crowned Eagles in KwaZulu-Natal	Crowned eagles	Prof. Colleen Downs	Shane McPherson	Masters - upgraded to PhD	U	2012-
7a	Effects of simulated elevated temperature on seedling recruitment and productivity	Temperature effects on seedlings	Dr. Sershen Naidoo	Rowan Buhrmann	Honours	C	2012
7b	The seasonal effects of simulated elevated temperature on seedling recruitment and productivity in the KZN SS	Temperature effects on seedlings	Dr. Sershen Naidoo	Rowan Buhrmann	Masters	U	2014 -
8	Is rodent species diversity higher in forest patches than grassland patches within an urban landscape?	Rodents and bush clumps	Dr. Shomen Mukherjee, Prof. Corrie Schoeman	Angelique Lazarus	Honours	U	2014 -
LAND USE CHANGE THEME (7 student projects)							
9	The potential of hyperspectral and multispectral remote sensing in discriminating and mapping the bracken fern (<i>Pteridium aquilinum</i>) within KZN SS	Bracken fern cover	Prof. Oni Mutanga, Dr. John Odindi	Zinhle Ngubane	Masters	C	2012-2013
10a	Recent land cover change and climate policy planning implications for KZN SS management	Woody-herbaceous ratio	Dr. Syd Ramdhani	Nidhi Nepal	Masters	C	2012-2013
10b	Mapping wood density variation and canopy cover percentage in the KZN SS using Worldview-2	Tree density	Prof. Oni Mutanga	Sizwe Hlatshwayo	Honours	U	2014
10c	Leaf Area Index (LAI) variability in the KZN SS	Leaf Area Index	Prof. Oni Mutanga	Keenan Terry	Honours	U	2014
11	Urban biodiversity management in the face of climate change: livelihood impacts and adaptation strategies in eThekweni metropolitan area.	Inanda livelihoods	Dr. Wale Zegeye	Andrias Nkoana	Masters	C	2012-2013

Table 5 (cont.): List of projects of the KZN SS Programme for Phase 1.

#	Project title	Short title	Principal Investigator	Student name	Degree	Status*	Period
12	Assessing land surface temperature and heat island intensity across various land use/land cover using MODIS data: A case study in the eThekweni Municipality.	Heat islands	Prof. Oni Mutanga, Dr. John Odindi	Thembi Ngubane	Masters	U	2014 -
13	Biodiversity utilization and conservation conceptualization in peri-urban areas in eThekweni Municipality: A case study of Inanda Mountain	Biodiversity utilisation	Dr. Suveshnee Munien	Happy Buthelezi	Honours	U	2014 -

Projects in the biodiversity theme (soil invertebrates, invertebrate DNA barcoding and floristics and seed banks) all provide inventories of species and measuring various indices of biodiversity across various KZN SS sites. They are contributing to important baseline knowledge of the biodiversity within the KZN SS in eThekweni Municipality. The ecosystem functioning theme includes projects which ask questions about ecological processes, roles of individual species or biodiversity as a whole, services or the 'functioning' of whole systems, and impacts of climate change. The crowned eagle (*Stephanoaetus coronatus*) project falls into this research theme as it looks at how crowned eagles use habitats in the Durban Metropolitan Open Space System (D'MOSS), including KZN SS. The project on temperature effects on seedlings considers the response of seeds and germination to increases in temperature (simulating climate change conditions) and is thus asking questions about processes. In the land use change theme, one illustrative example is the bracken fern (*Pteridium aquilinum*) project. In this project, remote sensing data was used to quantify the extent of bracken fern invasions in the KZN SS grasslands. Since bracken fern is considered an invasive species, this is a form of land use change from pristine, well-managed to invaded land.

The map shown in Figure 5 indicates the sites at which research through the KZN SS programme is on-going.

There were a number of research projects undertaken by staff and students at UKZN which address questions relevant to conservation and management of KZN SS, but which were not funded by eThekweni Municipality and were thus not formally part of the research programme (Table 6). A number of these projects were initiated specifically to address some of the major research gaps for the KZN SS ecosystem, for example mapping and classifying the remaining fragments of KZN SS which is essential baseline information needed to inform all other KZN SS research activities. Upon completion, the findings of these research projects will be integrated into the overall outputs from the KZN SS research programme.

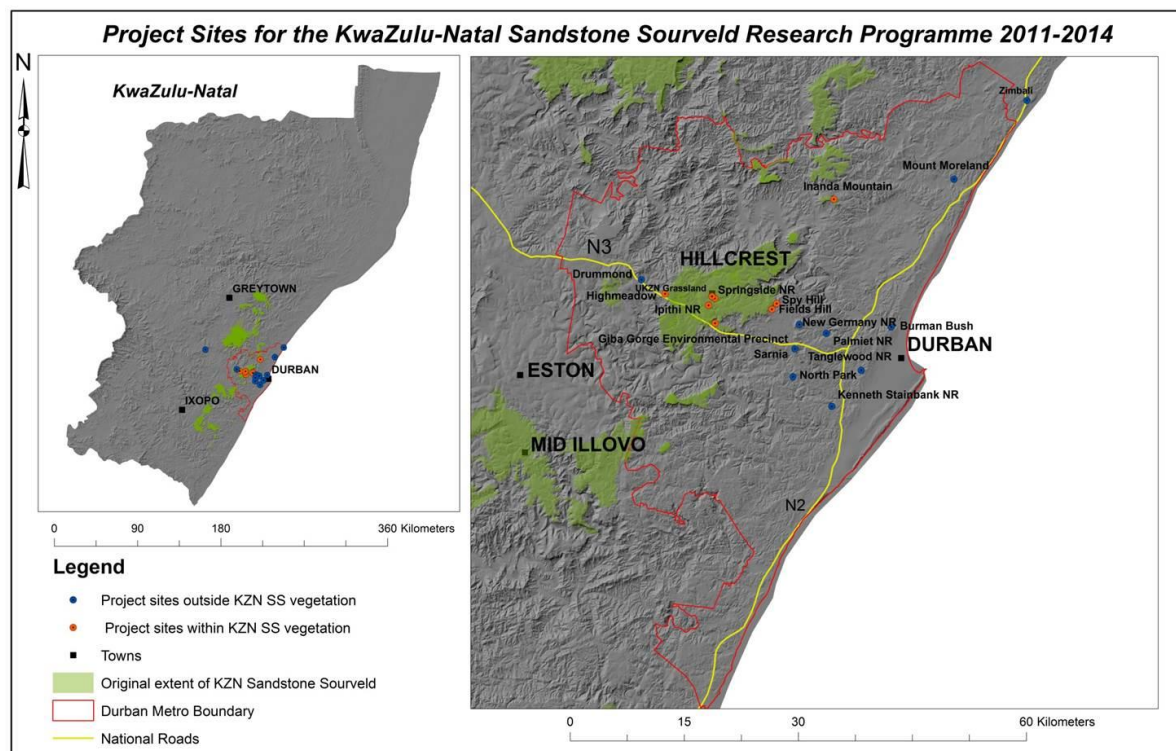


Figure 5: Sites in eThekweni Municipality where research projects are being conducted through the KZN SS research programme.

Table 6: Research projects associated with the KZN SS programme but not receiving funding from eThekweni Municipality

Project topic/title	Student and degree	Supervisor(s)
Assessing habitat fragmentation of the KZN Sandstone Sourveld utilising GIS	Rowan Naicker (MSc)	Mathieu Rouget Onesimo Mutanga
Spatial and temporal fire assessment in different vegetation types using MODIS burnt area products	Nokuphila Buthelezi (MSc)	Onesimo Mutanga Mathieu Rouget
Mapping and classifying the remaining fragments of the KZN SS using remote sensing	Nomcebo Hlanguza (MSc)	Onesimo Mutanga Mathieu Rouget
Challenges in resolving and protecting biodiversity in a developing city: the case of the Cato Ridge and Harrison Flats grasslands, Durban	David Styles (MSc)	Serban Proches
Assessing the variation in sandstone underlain grasslands; investigating bush encroachment in subtropical coastal grasslands	Lyle Ground (MSc)	Rob Slotow Bruce Page
Identifying ecosystem services hotspots for urban conservation planning in eThekweni Municipality	Rashieda Davids (MSc)	Mathieu Rouget
Mapping the variability of aboveground biomass and carbon content in the KZN SS grassland	Mbulisi Sibanda (PhD)	Onesimo Mutanga Mathieu Rouget

3.3 Key findings from Phase 1 projects

Key findings from the eleven completed projects during Phase 1 are summarized in Table 7.

Table 7: Key findings from all completed projects (see Table 5 for details of each project)

Project short title	Objectives	Key findings
Floristics and seedbank (1)	<ul style="list-style-type: none"> Determine the plant taxa present in six KZNSS patches: Inanda mountain, Giba Gorge, Spyhill, Tanglewood Nature Reserve, New Germany Nature Reserve, Springside Nature Reserve. Compare the floristics of the various sites (present and past studies) To compare plant species composition and abundance of natural seed banks at the sites. 	<ul style="list-style-type: none"> 10 quadrats were sampled at each of the 6 sites in autumn and winter (60 quadrats in total). Findings are summarised per pair of sites studied in each student project: <p><u>Inanda and Giba Gorge (P. Mbatha):</u></p> <ul style="list-style-type: none"> A total of 24 plant families were identified at both sites. 58 plant species, 10 were grasses, 48 were non-graminoid plant species in both sites. Eleven non-graminoid species were found at Inanda (including 4 alien species). At Giba Gorge, there were 24 non-graminoid species (including 1 alien species). Giba Gorge has more plants species than Inanda. Giba Gorge also has fewer alien taxa. Only 7 plant species germinated from the soil seed banks sampled at Inanda and Giba Gorge, four of which were common to both sites. <p><u>Spyhill and Tanglewood Nature Reserve (TNR) (C. Drury):</u></p> <ul style="list-style-type: none"> A total of 135 species from 33 angiosperm and one fern family were found at both sites. At Spyhill 104 species (29 families) were collected, while only 86 species (25 families) were found at TNR. Asteraceae (37 species), Poaceae (18 species) and Fabaceae (16 species) were the three most dominant families at both sites. The alien <i>Ageratum houstonium</i> and the invasive <i>Pteridium aquilinum</i> (bracken fern) were found at TNR. The spread of bracken fern is concerning at TNR. 8 species emerged from the Spyhill soil seed bank and 7 from the TNR seedbank. Germinant abundance was higher at TNR (136) than Spyhill (18). Tanglewood Nature Reserve was found to be more stable in species composition as compared to Spyhill, which had a higher turnover. Species turnover and species richness gradients were significantly higher in TNR when compared to Spyhill Nature Reserve. One of the main outcomes of this study was that more efforts are needed to conserve Spyhill as it had a higher diversity of species and is facing several threats as it is an unprotected site. TNR should remain protected.

Table 7 (cont.): Key findings from all completed projects (see Table 5 for details of each project)

Project short title	Objectives	Key findings
Floristics and seedbank (1)		<p><u>Springside (SSNR) and New Germany Nature Reserve (NGNR) (R. Boodhraj):</u></p> <ul style="list-style-type: none"> • A total of 124 species from 30 angiosperm and two fern families were found at both sites. • A total of 86 and 89 species were collected at NGNR and SSNR, respectively. New Germany Nature Reserve had 25 families while SSNR had 28 families. • Asteraceae (30 species), Poaceae (23 species) and Fabaceae (16 species) are the three most dominant families at both sites. • The rare species, <i>Schizoglossom elingue</i> was found at SSNR while <i>Eriosemopsis subanisophylla</i>, classified as a vulnerable was found at NGNR. • <i>Chromolaena odorata</i> was found at NGNR but was not abundant. <i>Pteridium aquilinum</i> (bracken fern) was found in SSNR and its high abundance poses a constant problem at the reserve. • 20 germinants emerged from the seed bank samples from Springside Nature Reserve (SNR), and 13 from New Germany Nature Reserve (NGNR). • The 33 germinants represented 12 different taxa, with ten taxa below-ground. • The KZN-SS indicator species <i>Watsonia densiflora</i> was found in the seed banks of SNR only. • The germinable seed bank values calculated for each species ranged from 0.0036 - 0.015 seeds m⁻² for NGNR and 0.0044 - 0.025 seeds m⁻² for SNR. The results suggest that SNR has a healthier seed bank than NGNR: the germinable seed bank values for certain taxa were much higher at SNR. • The major outcomes of this study were that the species composition between NGNR and SSNR are similar although the dominant taxa do vary. The cluster analysis along with other floristic data as well as the seed bank study preliminarily concluded that NGNR houses KZNSS vegetation. The abundance of bracken fern in SSNR is concerning.
Invertebrate DNA barcoding (2)	<ul style="list-style-type: none"> • To develop a preliminary inventory and DNA reference library of invertebrate taxa in eThekweni urban green spaces. • To identify unique invertebrate fauna associated with specific vegetation types, in particular the KZN SS • To couple DNA data with spatial information such as GPS coordinates to facilitate landscape genetic analysis. 	<ul style="list-style-type: none"> • To date, 8265 specimens have been examined, photographed and submitted to BOLD (Barcode of Life Database). • The mitochondrial gene <i>cytochrome oxidase</i> has been successfully sequenced from 7065 individuals and the reference library is 86% complete. • Analysis of the molecular data indicates significant genetic diversity and differentiation both among and within morphologically diagnosable species. • Preliminary "barcoding gap" analysis was conducted and at least 2221 distinct barcode clusters (BINS, defined as 10 times the mean intraspecific variation for the group under study) were recovered (comparable to morphospecies).

Table 7 (cont.): Key findings from all completed projects (see Table 5 for details of each project)

Project short title	Objectives	Key findings
Soil Invertebrate diversity (3)	<ul style="list-style-type: none"> To identify and determine the relative abundance of soil macro-invertebrates at Inanda and Giba Gorge. 	<ul style="list-style-type: none"> Twenty nine soil macro-invertebrate families (of which eleven are shared) were collected at Inanda (21) and Giba Gorge (19). The most dominant (in terms of abundance) insect families at Inanda and Giba Gorge were the Formicidae and Tenebrionidae, respectively. Although the species composition at the two sites was similar different taxa were dominant. Twenty two of the eighty species that were collected from Giba Gorge and Inanda were shared. More species (56) were collected at Inanda than at Giba Gorge (46). However, greater abundance was observed at Giba Gorge compared to Inanda.
Grazing impact (4)	<ul style="list-style-type: none"> To examine the relationships that exists between veld condition and plant diversity within the KZN SS To identify the key plant species that form an integral part of the KZNSS, and those that are most vulnerable to grazing? To investigate the effect of grazing management variables on plant diversity within the KZNSS? 	<ul style="list-style-type: none"> The main outcome of the study is that the sites that were sampled are disturbed, have generally poor soils that cannot support any meaningful agricultural productivity. The grass species that were observed at these sites at the time of the study are generally associated with poor soils and may have little or no potential for agricultural production. However, it should be noted these results are not conclusive. The sampling was not representative of the entire Ntshongweni area and the data should be validated by repeating the exercise over a wider area and at different temporal scales.
Seed conservation (5)	<ul style="list-style-type: none"> To characterize the post-harvest seed physiology of selected indigenous KZN-SS species To develop <i>ex situ</i> plant germplasm storage protocols for selected indigenous KZN-SS species To develop seedling establishment and re-introduction protocols for selected indigenous KZN-SS species 	<ul style="list-style-type: none"> Seeds of all species are orthodox (desiccation tolerant) Their desiccation tolerance makes them amenable to conventional <i>ex situ</i> seed storage and suggests that they will persist in natural seed banks Seeds of some species exhibit physical dormancy which can be broken Seeds appear to be slow ageing - this does not affect their germination capacity under lab conditions but may compromise germination <i>in situ</i> when reintroduced (e.g. <i>T. macropoda</i>) For <i>T. macropoda</i> reintroduction appears to be most successful when un-aged seeds are used (as opposed to aged material or seedlings)

Table 7 (cont.): Key findings from all completed projects (see Table 5 for details of each project)

Project short title	Objectives	Key findings
Crowned eagle (6)	<ul style="list-style-type: none"> To census Crowned Eagle breeding sites in the study area. To define ecological factors associated with nest site selection and breeding outcomes. To describe the dietary composition as pairs' provision their young. To describe habitat use and range size of adult pairs. To investigate post-fledging dispersal and survival. 	<ul style="list-style-type: none"> 50 crowned eagle nest sites were included in the database in 2012. 35 of these are in urban areas. Five juveniles from the 2011 season were ringed, 2 of which have been shot. Five nest site cameras operated during 2012 which collected 8,500 hours of nest observations. A full complete dataset of the 2012 nest cameras have been obtained including 400,555 images. 363 of the 422 prey items delivered to the nests were identified as belonging to 22 species. Prey majority consists of: 40% Rock Hyrax, 25% Hadedda Ibis, 13% Blue Duiker and other bovidae, 10% Vervet Monkey and 5% domestic fowl. No dogs and just one domestic cat appear to conclusively address the pet-wildlife conflict issue.
Temperature effects on seedlings (7)	<ul style="list-style-type: none"> To assess the degree to which open-top chambers (OTC) chambers alter environmental conditions relative to control plots (not covered by OTCs). To compare seedling recruitment and productivity between OTC and control plots. To compare community structure between OTC and control plots. 	<ul style="list-style-type: none"> The use of open-top chambers (OTCs) to simulate elevated temperatures was successful: temperatures within OTCs were 1-2°C higher than control plots (based on 5 OTC and 5 control plots). The effects of elevated temperatures on the vegetation were particularly evident when the above-ground biomass of the graminoids within the OTC and control plots was compared; biomass of the graminoids was higher in the OTC plots. Significant differences between the abundance of herbs and C4 species within the control and chambers plots was also observed but the number of taxa did not change significantly at elevated temperatures. Herbaceous species may have been displaced by the graminoids at higher temperatures, causing a subsequent decline in plant abundance but not species diversity. The results do suggest that there will be an enhancement in graminoid (above-ground) productivity at elevated temperatures (particularly in C4 grasses) with a concomitant decline in herbaceous species abundance.
Bracken Fern (9)	<ul style="list-style-type: none"> To investigate the required spatial resolution to map bracken fern from satellite imagery To determine whether the additional bands available in WorldView-2 (WV-2) have any value To determine the accuracy of the Random Forest algorithm in identifying the Bracken fern using WV-2. 	<ul style="list-style-type: none"> World-View-2 (WV-2) imagery is key in mapping the bracken fern (IAPs): The additional bands of WV-2 separate bracken better than the traditional bands. Due to the exceptional spectral and spatial combination in WV-2, its classification of the bracken fern surpasses that of SPOT 5 which has medium spatial resolution and broad spectral bands. There is potential for advanced classification algorithms in bracken classification as demonstrated by the Random Forest algorithm in this study These findings on the use of remote sensing for bracken fern could be useful for mapping and monitoring other invasive alien plants as well.

Table 7 (cont.): Key findings from all completed projects (see Table 5 for details of each project)

Project short title	Objectives	Key findings
Woody herbaceous ratio (10)	<ul style="list-style-type: none"> To quantify the woody-herbaceous ratio and determine land cover trends found between 1978 and 2011 at five sites with KZNSS vegetation (within the EMA) To discuss to what extent the above changes are linked to climate variability To discuss changes within the context of current policy and planning To suggest recommendations so as to pre-empt possible negative impacts 	<p><u>Land cover change:</u></p> <ul style="list-style-type: none"> Multi-temporal image analyses showed changes in the woody-herbaceous ratio in all five selected sites. Overall, the change was negative for herbaceous (grassy) vegetation and positive for woody (trees and shrubs) vegetation. Overall a decrease in herbaceous vegetation was noted (298ha), with a corresponding increase in woody vegetation (383ha). <p><u>Fire:</u></p> <ul style="list-style-type: none"> There appears to be a relationship between the lack of fires and woody (forest) expansion. This tentatively suggests that the lack of fires and possible low fire frequency during this period may have influenced the woody-herbaceous ratio in the reserve. <p><u>Climate change:</u></p> <ul style="list-style-type: none"> The climatic variables considered were average monthly rainfall, average minimum monthly temperature and average maximum monthly temperature. No significant trend in climate was observed during the period It was extremely difficult to work with missing and/or poorly documented climatic data that essentially cannot be linked to fire and vegetation changes. <p><u>Policy:</u></p> <ul style="list-style-type: none"> Climate change concerns are present through all levels of planning and management, as is the concept of adaptation (Global, national, local). KwaZulu-Natal Sandstone Sourveld, in some cases owing to its micro-scale, is largely absent or not specifically addressed. Consequently, it could be difficult, in the larger scheme of policy and planning, to determine management progress of KZNSS due to its lack of prominence in municipal plans and monitoring efforts.
Inanda Livelihoods (11)	<ul style="list-style-type: none"> To assess the dependence of rural communities on natural forest resources To examine coping (adaptation) strategies in response to climate change impacts on these resources 	<ul style="list-style-type: none"> 150 households surveyed 56% of households generate income from forest products, which creates an imperative for sustainable use Most households have perceived an increase in temperature and rainfall over the last 30 years Two thirds of households would adapt to climate change by seeking alternative economic activities out of the forest sector

4. What can the research be used for?

The first two years of the programme have focused on building the foundations and developing a better understanding of the KZN SS system. Several key decision-making products have been conceptualised (see Figure 6) which will assist eThekweni Municipality in land use planning and management of the KZN SS ecosystem.

4.1 Decision-making products for the municipality

To ensure that outputs from the research projects would be useful to the Municipality and assist them in decision-making, the conceptual research framework was complemented by the development of a product-oriented research framework which presents key decision-making products. This was drawn up by considering the conservation and management tasks and responsibilities which the municipality has around the KZN SS and drawing up a framework of 'envisaged products to assist decision-making' (blue boxes in Figure 6). The second framework specifically focuses on KZN SS conservation and management and links with the research framework. It consists of four main aspects: forward land use planning, communicating the socio-ecological value of the KZN SS, monitoring land use and ecosystem changes, and management interventions (both practical and governance issues).

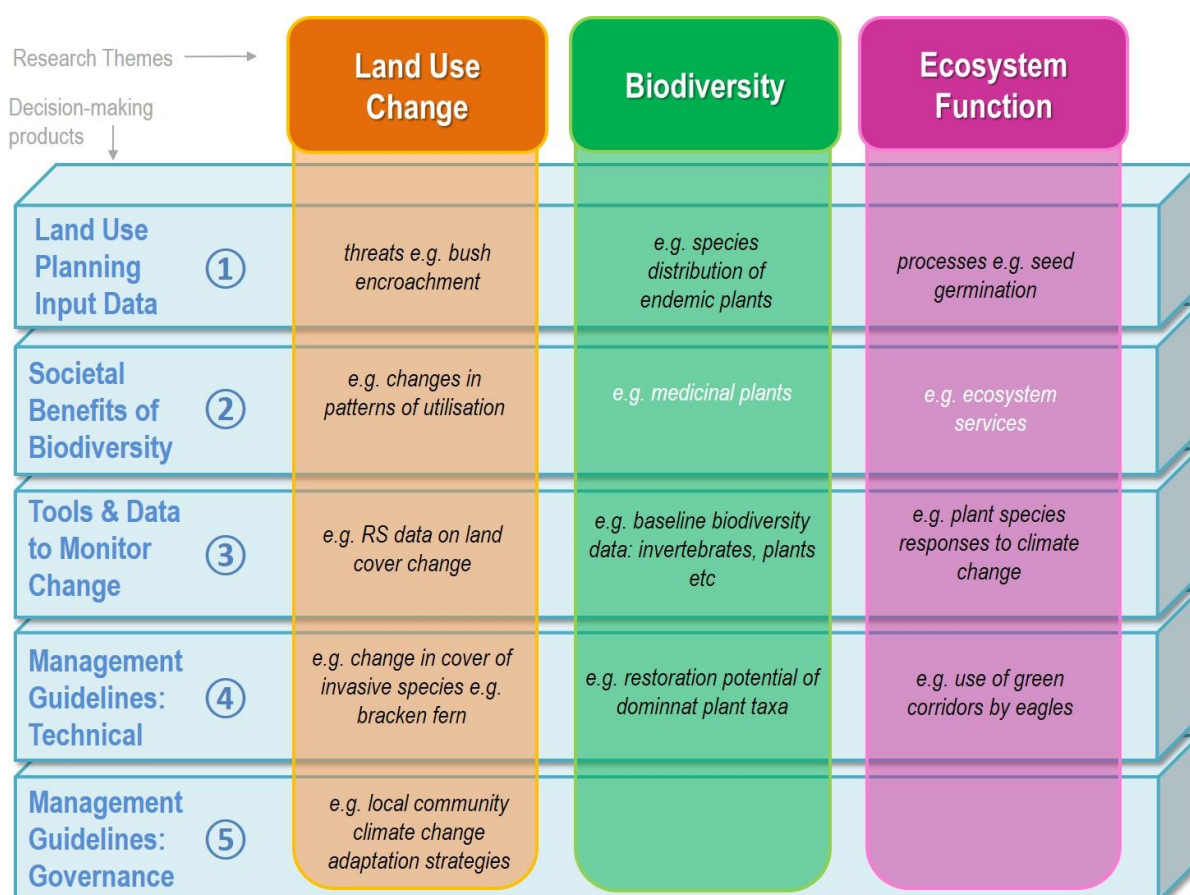


Figure 6: The product-oriented research framework developed for the KZN SS research programme, which shows the envisaged decision-making products.

While some individual projects can contribute directly to improved decision-making, there is a need to integrate and translate key results into decision-making products. This is generally beyond the scope of most Honours and MSc projects and will be a core focus of the Phase 2.

5. How has climate change been addressed?

Climate change research is an important theme within the KZN SS research programme, and three of the main objectives of the programme incorporate this theme:

1. Develop monitoring protocols in the face of climate change
2. Address specific climate change challenges
3. Address climate change adaptation issues, especially ecosystems-based adaptation

The programme has so far focused on generating a baseline biodiversity dataset which will be crucial for monitoring future impacts of climate change. The most significant data outcomes to date were biodiversity inventories across a range of taxonomic groups, i.e. records of species currently found in the KZN SS which were provided by the soil invertebrate project, the invertebrate DNA barcoding project, the floristic survey and seedbank composition projects. Two projects specifically sought to address climate change adaptation issues – but in very different contexts.

The Inanda Livelihoods Project investigated local communities' possible adaptation strategies should climate change affect the natural resources they depend on. This study reported that most households have perceived an increase in rainfall and temperature over the last 30 years which is not directly aligned with observed climatic trends. Respondents also indicated various adaptation strategies by seeking alternative sources of income. Another project investigated the effect of increased temperatures, simulating climate change, on the productivity and biodiversity of KZN SS flora. Open-top chambers were designed to simulate the effects of temperature increases. This study showed that the use of open-top chambers (OTCs) to simulate elevated temperatures can increase temperatures within OTCs by 1 to 2°C. The effects of elevated temperatures on the vegetation were particularly evident and the biomass of the graminoids was higher in the OTC plots.

Scientific outcomes on climate change research questions are currently limited, and this was identified as a research gap through the evaluation of the programme. Some of the projects which have addressed climate change issues, most of which are contributing to collection of baseline data, are shown in Table 8 (see next page).

Table 8: Contribution of KZN SS research projects to climate change issues in Phase 1 of the programme.

Abbreviated project title	Aspect of climate change addressed	How the project addresses this aspect
Soil invertebrates	Baseline data for long-term monitoring	Observing changes in species composition and dominance over time could provide useful data for predictive modelling of future patterns.
Inanda livelihoods	Climate change challenges and adaptation	Investigating how rural communities might adapt to the current and future effects of climate change, focusing on their dependence on the natural resource-base for sustainable livelihoods.
Invertebrate DNA barcoding	Baseline data for long-term monitoring	Data from the project can be used to compile biodiversity inventories for certain 'green areas' within the city. The development and implementation of a DNA-based identification tool will lead to improved monitoring of biodiversity through space and time.
Seedbank health and composition	Baseline data for long-term monitoring	In order to prioritise areas and species for conservation under various climate change scenarios it is necessary to measure the recovery potential and predict the resilience of vegetation types. The study will aid this measurement and prediction by characterising the species composition and health of seed banks within KZN-SS patches.
Temperature effects on seedlings	Climate change adaptation	The project will investigate the potential effects of rising temperatures on abiotic factors and most importantly floral diversity and productivity of KZN SS flora.
Floristics and seedbanks	Baseline data for long-term monitoring	Continuous periodic seasonal sampling and monitoring of sites will be able to detect changes in composition and phenology in the long term.
Woody-herbaceous ratio	Baseline data for long-term monitoring	It is expected that distribution of woody and herbaceous/grass taxa will change with changes in climate. This attempts to determine if there are links between local climate fluctuations and fire regimes, and how this affects the woody-herbaceous ratio in KZNSS.

6. Milestones of the KZN SS partnership

The KZN SS partnership has encountered a number of challenges and also reached various milestones (Table 9, next page).

Table 9: Phases, milestones and challenges of the KZN SS partnership

Phase	Milestones	Challenges
0: Founding	<ul style="list-style-type: none"> • Outsourced CSIR Training Programme • EPCPD-UKZN Internship Programme 	<ul style="list-style-type: none"> • High costs of out-sourcing training and capacity building • Time pressure on EPCPD staff to co-supervise interns
A: Exploring	<ul style="list-style-type: none"> • 'Casting the net wide' • Finding (willing) expertise • Bringing together multiple disciplines 	<ul style="list-style-type: none"> • Clash of institutional cultures • Unclear/vague and objectives • Uncertainty
B: Consolidating	<ul style="list-style-type: none"> • EPCPD Research Questions • Conceptual research framework • Consensus- and team-building • Evaluation: process and outcomes 	<ul style="list-style-type: none"> • Keeping everyone involved i.e. avoiding attrition • Identifying research questions • Developing a mutual understanding
C: Integrating	<ul style="list-style-type: none"> • Tools – external experts e.g. Finnish collaboration • Conceptual integration i.e. decision-making products 	<ul style="list-style-type: none"> • Expertise • Human resources • Filling the gaps • Need for a quantitative model for data integration

7. The way forward

7.1 Logistics constraints and solutions

An evaluation of the KZN SS research programme is currently underway and will be reported in full elsewhere. This will include an outcomes evaluation and a process evaluation. Preliminary results of the process evaluation (based on an anonymous questionnaire completed by programme participants) gave a useful indication of some of the constraints and challenges experienced by participants, as well as some possible solutions. Figure 7 shows participants' perceptions of the most important constraints or challenges in the research programme (each respondent selected their top 3). This result shows that challenges are mostly logistic in nature i.e. time constraints (participants feel they have a lot on their plate and it is difficult to find time for participating in the research programme) and financial and logistical support (there has been minimal admin support for the programme which means researchers have to manage admin and finance themselves which is considered a burden). It must be noted that many of the financial issues may be due to recent structural changes at the university which have resulted in reduced efficiency of financial administration. The results in this graph also highlight that participants' responses about challenges are varied – people experience the same programme in different ways.

Other challenges identified included clashes between the different organisational cultures (i.e. the academic work environment of the university vs. the practice-oriented work environment of the Municipality) and finding suitable programme participants.

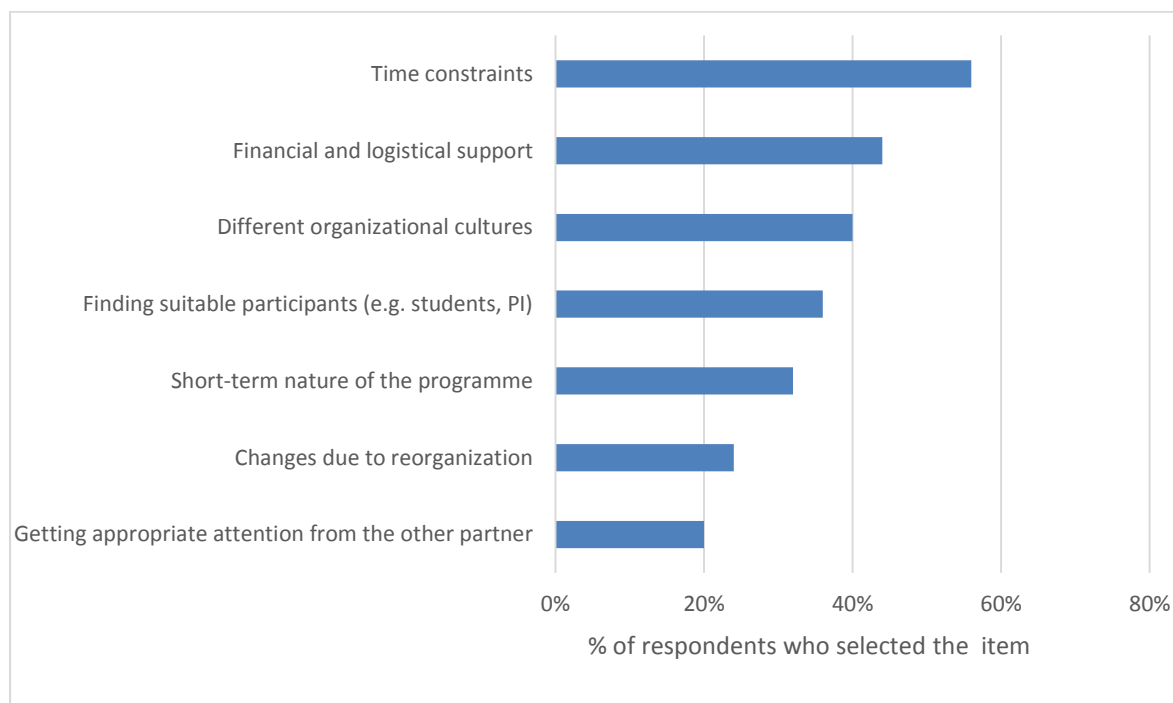


Figure 7: KZN SS programme participants' perceptions of the most significant challenges experienced during the programme.

As part of the evaluation questionnaire, participants were asked to suggest solutions to the challenges faced in the programme. These suggested solutions were summarised into five major themes:

- Reduce administrative load of the PIs by getting additional administrative support for the programme
- Improve meeting planning and timing
- Improve financial mechanisms and management
- Set goal jointly and understand each other's perspectives
- Recruit more high quality students

These are useful suggestions which have been partially addressed in the third year of the KZN SS research programme, and will inform the next phase.

7.2 *Future research projects*

A 'Steering Committee' planning meeting was held on 7 June 2013 to address two aims:

1. To further refine and discuss the conceptual research framework and alignment between current projects and EPCPD research questions
2. To develop a research agenda for the coming years, including a list of future projects.

The outcomes of the first aim were presented above. Research activities that should continue were identified as well as research gaps to be addressed in the next phase of the programme. The discussion followed the research themes (biodiversity, ecosystem functioning and land use changes), and resulted in a list of proposed research projects for the third year of the programme (and possibly also for Phase 2 of the KZN SS research programme. This included proposed projects for the eThekweni Municipality-UKZN Reforestation Research Programme, which will begin in 2014 and will run as a parallel research programme with the KZN SS research programme within the broader eThekweni Municipality – UKZN partnership.

The following provides a brief summary of key discussion points to be considered for planning future research activities within each of the research themes, which were then used to develop the project list (see Appendix 2)

Biodiversity

Currently, projects are focused on developing a biodiversity baseline for KZN SS.

The following activities should continue:

1. Habitat use of KZN SS by various taxa (expand the list of taxa, looking for indicator groups)
2. Floristic assessment of KZN SS fragments (need to expand sites to areas outside reserves and consider the importance of prioritizing surveys and including population structure)
3. Database of existing data collected (across all components)

Ecosystem functioning

The current projects within this theme are very fragmented and do not address key issues of ecosystem functioning. It was suggested that seed bank studies should be conducted within a restoration context and will be better aligned with the Reforestation Programme. There is a need to identify one or two flagship projects to draw the public's attention.

The following gaps were identified:

1. Ecosystem Goods in the KZN SS (MSc)
2. Quantification of ecosystem function and services in KZN SS (MSc)
3. Invasions and bush encroachment (MSc)
4. The ecological use of forest clumps in KZN SS (across diverse taxa) (MSc or possible team project)
5. Regeneration after clearing gums using Working on Fire sites (Hons)
6. Grazing impacts (MSc)
7. Pollination studies (with Steve Johnson's group)

Land use change

The current projects demonstrate various applications of remote sensing with regards to land use changes.

The following gaps have been identified:

1. An assessment of the usefulness of remote sensing to assist in local land use decision making. This will include remote sensing products of various resolutions (PhD)
2. Practical recommendations (a manual / protocol) on the implementation of remote sensing approaches in EM
3. Develop methods, indicators and data for regular monitoring of land use changes using RS (MSc or part of PhD 1)

As was discussed in section 6 above (alignment of research projects with EPCPD research questions), research activities to address social, economic and governance questions are under-represented in this research programme.

In the planning meeting, the following key points were discussed around the issue of governance:

Governance

This component needs to be developed, but currently there is no expertise in the team. The Steering Committee resolved to develop expertise here, and the following suggestions were made:

1. Align with the stewardship work currently being pursued in the Biodiversity Planning Branch.
2. Topics to consider include land use management systems and land use changes in land under the traditional leadership authority of the Ingonyama Trust Board.
3. A review of existing knowledge could be done as well as sourcing additional PIs.
4. Perhaps even consider an open call on this topic

7.3 *Looking forward: the challenge of integration*

The research outcomes resulting from this programme need to be integrated at two levels:

- i. Scientific integration: across academic disciplines i.e. interdisciplinary
- ii. Sectoral integration: integration across science and society: out of the academic (scientific) context, into the policy and practice context i.e. transdisciplinary.

As most of the researchers involved in this partnership are conducting research within specialised disciplines, the findings of the various disciplinary research projects need to be integrated in order for them to become applicable in the policy and practice context, and also to maximise the value of the research by looking for synergies in outcomes across disciplines. Integration of the scientific outcomes into the policy and practice context requires the outcomes to be 're-packaged' into 'decision-making products' which can be integrated into the planning and management processes at the municipality.

Integration at these two levels requires specific tools and the expertise to analyse data and apply such tools (i.e. intellectual research capacity), as well as technical research support to manage data, conduct statistical analysis and co-ordinate these activities. Access to such tools and the relevant

expertise and capacity is a challenge which needs to be recognised and addressed in order for integration to become a reality. However, the integration process should also not be seen as a separate exercise to the research being conducted by the various disciplinary specialists (students or researchers). Mechanisms need to be put in place to incentivise researchers themselves to consider how best to integrate their findings across disciplines and into the policy-practice context. Success in an academic career is still mostly based on publication of peer-reviewed academic journal articles, and the time and effort required for cross-sectoral integration by researchers needs to be recognised somehow.

It is also necessary to recognise that integration of such trans-disciplinary research takes place in both a conceptual and a quantitative manner. A conceptual framework which visually illustrates how specialised research outputs can be integrated into inter-disciplinary and trans-disciplinary research products is needed as an overall guideline for the process. Quantitative, analytical tools (e.g. models, software programmes etc.) are required to process large amounts of data from different sources.

Summary: Challenges for the way forward

To fully realise the potential of the KZN SS programme to bridge the science-policy-practice gap and to integrate research in a meaningful manner, the following constraints need to be addressed:

- i. Data management support
- ii. Integration tools/methods along with sufficient intellectual research capacity
- iii. Scaling up – beyond the KZN SS: how?
- iv. Governance and social research expertise

8. Conclusion

During the first three years of the KZN SS research programme it has grown significantly and undergone a process of maturation. Research projects now address several objectives across three main themes: biodiversity, ecosystem functioning and land use change. A conceptual research framework and a product-oriented research framework have been developed to guide the research activities and identify synergies between projects and across disciplines, and these are important collaborative research outputs of the programme. Projects have started contributing towards the goal of developing decision-making products for the municipality on the following aspects: land use planning, management (both technical and governance issues), monitoring and making the case for biodiversity. An evaluation of the project outcomes has shown that there is considerable support for this programme and has helped identifying research gaps which need to be addressed in the future. These include socio-economic, geographic and governance questions. The climate change aspects of the programme also need some additional attention in future, however current projects are already providing valuable baseline data for long-term monitoring of climate change.

The research programme has also developed valuable local capacity – by training students and thus increasing the local pool of much-needed biodiversity management skills, and also by providing opportunities for students as well as university researchers and municipal employees to learn more about working in a collaborative project across traditional disciplinary and institutional boundaries. Through the process evaluation, participants have identified some important challenges in the programme, the majority of which are logistic in nature (administrative and financial support). The participants' suggestions for solutions will be incorporated into planning and management of the research partnership in the future.



Field trip to Giba George (photo: E. Douwes)

Appendices

Appendix 1: Summary of events leading up to the development of the KwaZulu-Natal Sandstone Sourveld Research Programme

Date	Event	Outcome
2003-2005	<p>Outsourced Training Programme</p> <p>A programme in which university graduates from the environmental and biodiversity sciences were placed into a targeted training programme during which their skills in environmental management and biodiversity science were improved. This programme was contracted by the Environmental Planning and Climate Protection Department (EPCPD) of the eThekweni Municipality (EM) to the Council for Scientific and Industrial Research (CSIR).</p>	<p>Unsuccessful.</p> <p>The programme was expensive, and despite 2 years of training most of the candidates were still not suitable for employment by the EPCPD.</p>
2006-2008	<p>1st EM-UKZN Internship Programme</p> <p>During this internship programme, MSc students from the University of KwaZulu-Natal (UKZN) were co-supervised by staff from the EPCPD and academics from the University of KwaZulu-Natal in research projects which would provide them with the specialist biodiversity skills needed by the EPCPD.</p>	<p>Successful, but resource-expensive.</p> <p>Despite both candidates being suitable for employment by the EPCPD, the time investment required for co-supervision by EPCPD staff was deemed too high and another, more sustainable, model was needed.</p> <p>Key ingredients: Intensive support from EPCPD staff, high calibre of candidates.</p>
2010-2013	<p>2nd EM-UKZN Internship Programme</p> <p>A second phase of the UKZN-EPCPD internship programme was launched in 2011 which was then embedded in the newly formed KwaZulu-Natal Sandstone Sourveld Research Programme.</p>	<p>Successful, but no longer necessary.</p> <p>The research partnership was deemed a better investment of time and financial resources than the internship and was likely to yield a larger number of employable candidates along with much-needed scientific research outputs.</p>
2011-2014	<p>EM-UKZN Research Partnership: KwaZulu-Natal Sandstone Sourveld Research Programme: Phase 1</p> <p>The first phase of the research partnership was initiated in 2011, and was formalised through the signing of a Memorandum of Understanding between UKZN and the EPCPD. The EPCPD would provide research funding, and researchers at UKZN would conduct scientific research based on research questions jointly developed by the EPCPD and UKZN to address the conservation and management of the KwaZulu-Natal Sandstone Sourveld grassland ecosystem in eThekweni Municipality.</p>	<p>Successful.</p> <p>Baseline biodiversity, ecosystem function and land use change knowledge of the KZNSS has been generated, approximately 6 students have graduated with the relevant skills, and a successful collaborative research partnership i.e. a 'boundary organisation', has been established.</p> <p>Key ingredients: Committed champions on both sides, patience and perseverance from participants and strong leadership.</p>
2014-	<p>EM-UKZN Research Partnership: KwaZulu-Natal Sandstone Sourveld Research Programme: Phase 2</p> <p>Based on the successes of the first phase, it is proposed that the research partnership be extended by another 3-year funding phase. Funding allocation by eThekweni Municipality runs in 3-year cycles, and approval for Phase 2 is pending.</p>	<p>To be determined.</p>

Appendix 2 List of proposed research projects for 2013-2014 financial year and Phase 2 of the research programme


Project topic	Degree
Global change (including land use change)	
<ul style="list-style-type: none"> An assessment of the usefulness of remote sensing to assist in local land use decision making 	PhD
<ul style="list-style-type: none"> Develop methods, indicators and data for regular monitoring of land use changes using remote sensing 	MSc
<ul style="list-style-type: none"> Modelling climate change impacts on KZN Sandstone Sourveld ecosystem 	MSc/PhD
<ul style="list-style-type: none"> Assessment of threats to biodiversity for Durban Metro 	PhD
<ul style="list-style-type: none"> How to mitigate and adapt to those threats 	PhD
<ul style="list-style-type: none"> Land use changes within Ingonyama Trust Board 	MSc/PhD
Biodiversity	
<ul style="list-style-type: none"> Habitat use of KZN Sandstone Sourveld by various taxa 	MSc/Hons
<ul style="list-style-type: none"> Floristic assessment of KZN Sandstone Sourveld fragments 	Hons
<ul style="list-style-type: none"> Identifying appropriate biological indicators for monitoring climate change 	MSc
<ul style="list-style-type: none"> Identifying priority fragments for monitoring and collecting baseline data 	Hons
<ul style="list-style-type: none"> The use of broad-scale biodiversity data for local decision making 	MSc/Hons
Ecosystem functioning	
<ul style="list-style-type: none"> Ecosystem Goods in the KZN Sandstone Sourveld 	MSc
<ul style="list-style-type: none"> Quantification of ecosystem function and services in KZN Sandstone Sourveld 	MSc
<ul style="list-style-type: none"> Invasions and bush encroachment 	MSc
<ul style="list-style-type: none"> The ecological use of forest clumps in KZN Sandstone Sourveld (across diverse taxa) 	MSc
<ul style="list-style-type: none"> Regeneration after clearing eucalyptus 	Hons
<ul style="list-style-type: none"> Grazing impacts on KZN Sandstone Sourveld 	MSc
<ul style="list-style-type: none"> Understanding the best practice methods appropriate for rehabilitation and reforestation 	MSc/PhD
<ul style="list-style-type: none"> Monitoring the success of the rehabilitation 	MSc




Appendix 3: KZN SS Research Programme Team Members

STAFF:

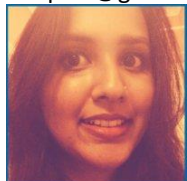


Name and contact details	Position and details	Period
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Jayanti Mukherjee jayanti.rm@gmail.com 	Post-Doctoral fellow (Westville) Programme coordination	Jan 2011 – June 2014

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Name and contact details	Position and details	Period
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<p>John Odindi Odindi@ukzn.ac.za</p> 	<p>UKZN PI (Pietermaritzburg): <i>Remote sensing</i></p>	
<p>Sershen Naidoo Naidoose@ukzn.ac.za</p> 	<p>UKZN PI (Westville): <i>Plant Ecophysiology</i></p>	
<p>Syd Ramdhani Ramdhani@ukzn.ac.za</p> 	<p>UKZN PI (Westville): <i>Botany/Biogeography</i></p>	
<p>Taro Mwabvu Mwabvut@ukzn.ac.za</p> 	<p>UKZN PI (Westville): <i>Soil Invertebrates</i></p>	<p>Joined in June 2013</p>
<p>Onesimo Mutanga MutangaO@ukzn.ac.za</p> 	<p>UKZN PI (Pietermaritzburg): <i>Remote sensing and GIS</i></p>	

Name and contact details	Position and details	Period
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Alfred Odindo 	UKZN PI(Pietermaritzburg) SAESS	Left in December 2012
Corrie Schoeman 	UKZN PI (Westville) School of Life Sciences: Zoology	

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KZN SS RESEARCH PROGRAMME: CLOSE-OUT REPORT

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Rashieda Davids (MSc)	UP Student: MSc	2012	NO
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Nokuphila Buthelezi	UKZN Student: MSc	2013	NO

KZN SS RESEARCH PROGRAMME: CLOSE-OUT REPORT

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Siphesihle Mthethwa	UKZN Student: MSc (PMB)	2014	YES
Keenan Terry	UKZN Student: Honours (PMB)	2014	YES
Ashrenee Govender	UKZN Student: Honours (PMB)	2014	NO
Sizwe Hlatshwayo	UKZN Student: Honours (PMB)	2014	YES
Happy Buthelezi	UKZN Student: Honours (PMB)	2014	YES
Angelique Lazarus	UKZN Student: Honours (Westville)	2014	YES
Mbulisi Sibanda (PhD)	UKZN Student: PhD (PMB)	2014	NO

This report summarises the outcomes of the KwaZulu-Natal Sandstone Sourveld Research Programme for its full three year term (July 2011- June 2014). The report provides an insight into some of the achievements of the programme – both the ‘more tangible’ scientific and collaborative management outcomes, as well as the ‘less tangible’ human capital and social learning outcomes.

The KwaZulu-Natal Sandstone Sourveld Research Programme forms part of a research partnership between the eThekweni Municipality and the University of KwaZulu-Natal which aims to advance knowledge and build capacity in biodiversity conservation and management within the context of global environmental change.



eThekweni Municipality-University of KwaZulu-Natal
Joint Research Partnership

