ACCESS

Applied Center for Climate & Earth Systems Science

ACCESS IMPLEMENTATION PROSPECTUS

2011 - 2018

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EXECUTIVE SUMMARY

- ## Who and what is ACCESS?

ACCESS is a consortium of several agencies, researcher councils, research programmes, universities and research groups who have combined efforts to deliver a range of outputs aligned to the Department of Science and Technology's (DST) Global Change Grand Challenge (GCGC). It is a platform for an **integrated and end-to-end research and education, services and training outputs and outcomes related to the opportunities and challenges emanating from a varying and changing environment**, collectively referred to as Earth Systems Science. ACCESS provides an opportunity for unprecedented co-operation across a range of disciplines which reflects the inter-connected nature of the southern African Earth System (SAES). Thus our (expanding set of) partners represent an equally broad range of expertise and education and training institutions who have committed themselves to delivering **a new scale of intervention in Earth System's science** which will do justice to the **globally unique opportunity that the southern African Earth System** provides us with.

The DST's Global Change is an important programme in the DST's Innovation Strategy to contribute to the transformation of ours into a "Knowledge Based" economy. **The main limitation to achieve the goals of this strategy is the shortage of skills in South Africa.** In order to fulfil the goals of this strategy, a concerted and game changing effort needs to be implemented that will create an unprecedented opportunity **for training a new generation of technically and analytically skilled people to service the country's science and technology needs.** The DST strategy has recognised five Grand Challenges that present both threats to, and opportunities for growth in Science and Technology as a means of unblocking the path to knowledge based economic development. Among these, **Global Change** is one grand challenge that presents **both opportunities and challenges to the development of the country's and the region's economy.**

The opportunity to be gained by addressing these Global Change challenges span several areas, from studies of the SAES which will contribute new knowledge and a better global understanding of ES processes, to innovation and new technologies; all focussed on **a substantial change in the way science is practiced** and the preparation of a **new, expanded and transformed cohort of technically trained people** across the region. To this end, ACCESS is one of several instruments created by DST to deliver these outcomes. As a key player in the GCGC architecture, **ACCESS has been mandated to develop and implement a programme on a nation and regional (and eventually continental)** scale that will provide us with the means to address challenges and harness opportunities at this scale as a means of producing a **new generation of technically trained people** for deployment in the knowledge economy.

To achieve this it is necessary that the long-standing and inherited weaknesses in the academic system enjoy robust intervention in order that we effectively access the skilled people we need. **We recognize four obstacles to transforming the Education and Training footprint in the country: interest and attraction to science, funding, preparedness of students and post-graduate supervisory capacity. ACCESS will address each of these challenges.**

For instance, in terms of the lack of supervisory capacity for research students in the region, is a problem of both **quantity and quality** and there have not been any signs of significant growth in this area for decades. Current approaches of rewarding academic excellence have clear merit, and the country and region should be proud (and continue to support) of the excellence and international recognition achieved by our scientific community. However, without careful management this system including the creation of self-organizing discipline specific specialist entities (e.g. SARCHI chairs) will not, in isolation, address the fundamental structural challenges in the heterogeneous academic system, and has the potential to perpetuate inequity. While there has been a gradual shift in the demography of post-graduate students, **the quantum leap sought has not been achieved and in particular, the supply of black South African candidates for post-graduate science studies remains unacceptably low.** These factors conspire with the result that there are limited opportunities for potentially successful young researchers and traps students in historically disadvantaged institutions in limited academic environments.

Bold and creative initiatives at all educational and academic levels are required to address all of these obstacles in concert, in order that the pool of untapped potential can be accessed and that opportunity for meaningful participation in and access to meaningful and relevant careers is facilitated. Given the shortage of skills in the country and region, particularly in science and mathematical fields, it is **ACCESS's aim to make a significant contribution to changing the status quo** and producing the people needed to tackle the Global Change Grand Challenges and exploit opportunities it offers in transforming our economy. This will take time, commitment and funding.

- **What is ACCESS' value proposition?**

  - ACCESS creates a national **framework of unprecedented scale** for inter-intuitional cooperation, including established research institutions/groups, and national research agencies and science councils and HBUs that will provide the material for a meaningful national effort to address and harness Global Change challenges and opportunities and to train a new breed of technically competent and broadly educated South Africans. **There is no comparable framework for achieving this outcome.**
  - The ACCESS Education and Training portfolio is ready to **transform the way ES science has been conducted** in the country and the region will implement an end-to-end programme of activities which will maximise the opportunities at hand. This will provide **a beacon of hope and attraction** to previously un-accessed students and facilitate the development of **modern careers** in the knowledge economy.
  - ACCESS will provide southern Africa with a globally enviable scientific programme focussed on **basic to applied research** which will produce outcomes that address not just regional, but indeed globally relevant questions. This will serve as a beacon for international collaboration and form the basis of a sustained source of inspiration for young scientists.
  - ACCESS outputs will provide new knowledge assets of global significance along with a range of applications directed at governance systems and decision makers.

- **What will ACCESS achieve? (Changing the game in ES Science)**

Earth Systems Science is a concept that is derived out of an integration of a range of disciplines that have to date been **fragmented and disparate**. Practitioners and experts in the various Earth System subcomponents have focussed on their respective fields, resulting is pockets of excellence and a fragmented picture of the Global Change challenges and opportunities that have emerged. In addition, the model of funding and resources deployed have not achieved the scale of operation in SAES Science that is required for the attainment of the **Grand Challenge scale of strategy**. The current system of fragmented research efforts is thus counter-productive and has not seen unified national "team-SA" approach emerging, but rather silo'ed and narrow foci of activities prevailing. Furthermore, inter-institutional collaboration has also been limited and inherited areas of weakness in the academic system remain. Agencies, tasked with several ES stewardship have several capacity and budgetary challenges. This is an unsuitable state of affairs if the GCGC is to be achieved.

To address these challenges, the DST's GCGC has produced a Research Plan and a Human Capital Development plan which aims to address this fragmentation. ACCESS is mandate to implement particular aspects of these plans.

With this mandate, **ACCESS has developed the partnerships, the plan and the governance structures** designed specifically to deliver on the GCGC vision. **ACCESS aims to change the way science and education and training in ESS is done** and to deliver not just **the technical products for application in the economy, but the people to manage it.**

The major value in ACCESS' approach is in the partnerships that have been established. By achieving this, each player has an identified position and role in the team, either in terms of the expertise they offer, the education and training role that they can play, or in terms of their mandate in providing ES products and services. Thus, ACCESS has created **a whole, which is larger than the sum of its parts.** Through the governance systems in place, a truly integrated and **national effort** can now be delivered with the support of the DST.

Within this initial phase, ACCESS aims to produce a cohort of **300 M Sc graduates (3 cohorts of 100 Msc Students in 7 years, thereby doubling the number of Earth Systems MSc graduates currently produced) and 200 PhD graduates (2 cohorts of 100 PhD students in 7 years or which 50% will be trained internationally, thereby doubling the number of Earth Systems PhD graduates currently produced)**, to reach a new and previously un-accessed pool of undergraduates and put support in place for the **development of young and emerging researchers**. This target will be the key means by which **research and applications of ES knowledge will be generated and delivered** and **skilled and broadly trained people developed**. The outcome of this will be new knowledge (of global importance) and skilled people to be deployed both in the research domain and in the public or private sector. By robust and active engagement of partners at Historically Black and rural Universities, and by augmenting existing programmes, ACCESS will make a significant impact on the capacity to train earth stewards across the region.

- **Globally Positioning South African Science**

We have at our disposal an **ideal (and unique) natural laboratory** for the study of Earth Systems. Southern Africa's unique and globally recognised earth system is a bequest that has been **underutilised to date**. Given the fact that the human species evolved here, and that our varied and dynamic climatic zones have changed over time (and are set to change in the future), resulting in unparalleled biodiversity, and that we are located in close proximity to one of the most important and unexplored climatic drivers (the southern Oceans) we have the opportunity to build an **internationally enviable platform for research, education and training.**

This aligns well with the social and economic dynamics which require significant intervention in order to provide redress so as to provide new opportunity for **a legacy justifying our position as a leading nation in international affairs** (exemplified by the Soccer World Cup, Square Kilometre Array and UNFCCC COP17) is fulfilled. We recognise this as an exceptional opportunity for positive change. ACCESS is a vehicle to achieve this by becoming a **beacon of hope and attraction** to a new generation of earth systems scientists who will deliver **outcomes of global significance and provide skills to drive the knowledge economy.**

- **What has ACCESS Achieved?**

ACCESS has had a significant gestation focussed mainly on developing our partnerships. This has been a complex task of building the vision of a national effort which will involve collaboration beyond established domains and comfort zones. To date, 14 institutions and agencies have signed up for ACCESS and others are preparing to join. Attached in a progress report for the previous financial year but in summary, ACCESS has in the last two years:

- Implemented a preliminary research programme with several major sub-programmes (e.g. Southern Oceans and Climate Variability and Prediction)
- Funded around 30 students
- Implemented a career development programme at school level
- Run several symposia and technical workshops
- Implemented the Habitable Planet Programme (focussed on undergraduates)
- Implemented the "Early Career workshops"
- Implemented two international programmes and planning additional ones
- Represented the Earth Systems Science community in several national and international forums and meetings
- Produced several new publications
- Formalised a governance systems and collaboration among several partners
- Developed relationships with entities in the region and continent
- Developed the ACCESS Brand

- **What is ACCESS doing now and what will ACCESS do?**

The DST's GCGC Research Plan was developed through a process that resulted in the identification of the major scientific aspects of the Grand Challenge. Using this as the basis for further planning, ACCESS has sampled the ES community, through a tightly directed process, with regard to the key scientific and educational foci for the ACCESS programme. This has resulted in a plan that comprises two portfolios.

The Education and Training portfolio comprises a series of activities (of which some are already implemented) designed to utilise the advantages that ACCESS has at its disposal (see above) to deliver an innovative, bold and creative programme targeting all levels of education and training. The products of this portfolio **are confident, knowledgeable and skilled individuals** ready for deployment in research careers or as leaders in the knowledge economy.

In summary the programme comprises the following elements:

- A pipeline development and outreach sub-programme (mostly school based)
- An Undergraduate sub-programme including the successful extra-curricular course entitled "How to Build a Habitable Planet"
- A Post Graduate programme where the two key interventions are a research project linked bursary programme and the delivery of the National Masters Framework for Global Change (inter-institutional national programme).
- Early Career programme with workshops and courses for young and emerging researchers
- A series of other interventions including a post-doc fellowship programme, inter-institutional / agency co-supervision of post-graduates and technical workshops and symposia

The Research and Services Portfolio comprises seven Thematic Sub-programmes which present an interacting set of research programmes aimed at addressing the key SAES questions, delivering **new knowledge of relevance to governance processes and of international value** and serving as a platform for the Education and Training Portfolio. These seven themes have been developed into a workplan for phased implementation. The implementation will be carefully managed so that the outcomes serve the dual goals of transformation and expansion of the research capacity footprint in the region, while delivering science outputs of the highest standard. The set of Thematic Sub-programmes consist of the following:

- Earth Systems Modelling & Biochemical Cycles
- Seasonal / Inter-annual Climate Predictability
- Water Resources Dynamics
- Urban & Rural Landcover & Landuse
- Ecosystem Services & Livelihoods
- Long Term Climate & Impacts
- Marine & Coastal, Estuarine Systems

This will be implemented by means of a series of national or regional (and international) projects of appropriate scale, combined with **regional and localized "living laboratories**" based at rural universities with national collaboration.

- ## What does ACCESS need?

To date ACCESS has been moderately funded and has developed incrementally to this stage. The establishment of ACCESS as a Center of Excellence has been a useful means of developing the concept and establishing the systems now in place. However, the time has now arrived that ACCESS should graduate into a **new phase of implementation** whereby significant resources are invested into its potential. In order that the scale of ACCESS' ambitions (and those of its principals in government) are achieved, an **investment of World Cup proportions** is required. If this is not achievable, then the investment in both the ACCESS and GCGC processes to date will be threatened and we will fail to transform our potential into a new paradigm for science in South Africa

ACCESS requires funding to the value of R100M per year, of which at least 50% will be dedicated to student training (including M.Sc and PhD research bursaries) which will be the main means of new knowledge generation. In addition funding for the ACCESS Education and Training Portfolio will extend beyond bursaries and into a range of other programme activities to provide the "scaffolding" for emerging scientists.

The burden for achieving his **cannot be laid at the door of South African government alone**; however, strong financial and political support from DST (and other relevant ministries) is required. Given that several international partnerships have been established and are in the process of being established, the prospects for substantial international partnerships are excellent. With DST's help, the "A" in ACCESS should be restored to "Africa", and in collaboration with regional and continental bodies, bilateral, multi-lateral and international agency collaboration should be urgently sought.

ACCESS is ready and is seeking substantial investment so that it can achieve its goals and that of the DST's Innovation Strategy. With both the financial and political support that has been forthcoming, ACCESS will grow into a proud African Earth Systems Institution by leveraging the resources (human and financial) that will make us all proud.

1. INTRODUCTION

ACCESS is building on the firm foundation that has been laid in its formative years and is embarking on a new phase of growth and implementation aligned with its mandate from the Department of Science and Technology's Global Change Grand Challenge programme. The marching orders are very clear, and these are to:

- Develop, expand and transform earth systems science and scientists while,
- Addressing the challenges and opportunities posed by global change environmental drivers,
- Produce outputs that contribute the goal of changing South Africa to a more "Knowledge Based" economy.

To this end, in the first half of 2011, ACCESS embarked on a process to sample the Earth System Science Community (ES) in South Africa (and beyond) with calls for participation and targeted solicitation of input to an augmented suite of 'concept notes" which have been distilled into this document. Out of this process, we aim to convince our principals in the DST and NRF that ACCESS will indeed deliver on the imperatives that have been well articulated in the Global Change Grand Challenge (GCGC) Research Plan and the HCD plan and that ACCESS is the appropriate vehicle for its implementation.

1.1 ACCESS Vision

The South African National Planning Commission's first report which is entitled a "Diagnostic Overview", states that

"Our implicit conclusion is that a business-as-usual approach will result in South Africa failing to meet a great many of its objectives, and the diagnostic document highlights the main reasons why this is so. We acknowledge that our growth so far has been insufficiently inclusive. Too many people remain poor and marginalised. We are optimistic that South Africa has the capability to tackle these challenges, but it will require leadership and the support and determination of all South Africans and sectors of society"

It is precisely the identification of this issues that the ACCESS programme aims to address. The ACCESS Board has considered it necessary that a clear ACCESS vision statement should be developed. This vision should make it clear that ACCESS is more than just a science programme or an HCD Programme but is indeed something quite novel and innovative in its approach to science and education. This novelty and innovation is necessary as it is recognized that with regard to the traditional academic and research process, "business-as-usual" will not necessarily ensure that the goals of the GCGC are reached and a creative and tightly managed programme is required if the results sought are to be realized. The vision should take cognizance of the fact that here in Southern Africa, we live in "a special place in a special time" and that this should refer both to the natural environment and its geological trajectory, as well as to the society and its historical and current political trajectory.

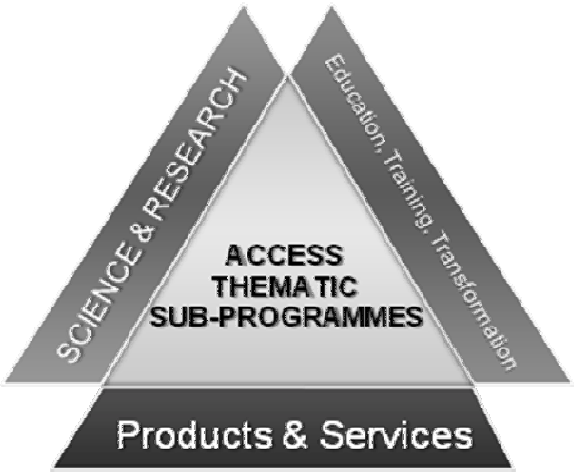
Thus the proposed vision statement for ACCESS read as follows:

ACCESS is a "development through science" programme, maximizing the advantage of our unique social and natural assets and history, to enthuse and attract proud young scientists into technical and research careers in order to effectively address regional, continental and global needs and environmental challenges"

1.2 Process to this stage

The recent process undertaken by ACCESS has resulted in the selection of Thematic Area Sub-Programmes (TASs) for the design of the technical and scientific aspects of the ACCESS programme. The process was initiated by a call for "concept notes" which were designed on the multiple criteria of reflecting the thinking contained in the GCGC Research Plan and HCD plan and which would take cognizance of the transformation goals, the need to provide opportunity for the rural universities and regional collaboration. Some forty-five concept notes were received and these were evaluated on the criteria in the call. Some of these were rejected as they were deemed unsuitable for the ACCESS scope or did not meet the criteria. The balance was evaluated by a team of specialists appointed by the ACCESS director and grouped into seven thematic areas. Drafting teams were assembled for each of the themes which comprised some of the senior authors of the Concept Notes as well as some selected authors for balance and equity. The drafting teams were issued with a Terms of Reference which clearly defined the desired format and content required for the Thematic Sub-programmes. From these plans the training and education aspects would be extracted and augmented with a series of activities and intervention. This would result in ACCESS delivering two major but inter-related portfolios: The Science and Services Portfolio and the Education and Training Portfolio each managed full time with a senior manager. The process also resulted in a scoping of the resources that would be required for the delivery of a large and far reaching initiative to revolutionize the scale of impact of Earth Systems science in the country and region.

The major outcome is a plan for the Thematic Sub-Programmes and Education and Training programme designed to achieve a balance among the three drivers or three imperatives, as depicted in the figure below:



1.3 Partners and partnerships

A critical element of the success of the ACCESS programme is the partnerships that it creates and maintains. Adjunct to this is not just WHO the partners are, but HOW the partnerships work. This principle is the basis by which the impact of the Education and Training Programme can be affected.

The process undertaken thus far has sought to ensure the inclusion of both the traditional and established institutions, along with those whose research record is not as successful as the former. A focus on collaboration with staff and students from HBUs is a key aspect of intervention, along with recognising that the student population of the established institutions of higher learning are much more representative of the population than they have been in the past. It is also recognised that research agencies and science councils is an equally important set of partners in achieving these goals and these are fertile ground for improving the capacity of existing staff and future technically trained employees. Nevertheless, the departure point is that the status quo in earth system science is far from adequately transformed and it incumbent upon us to ensure that the programmes implemented get the balance among the three imperatives adequately represented. Thus, the management of the ACCESS implementation plan will have a critical role in ensuring that the activities of both portfolios is robust, creative and active in achieving this outcome.

In addition to this, it is important that the partners have a sense of ownership of the ACCESS Programme and to this end; the governance structure of ACCESS should accommodate all the partners where their influence can be assured. The ACCESS Collaborative Agreement is the key vehicle to achieve this as it ensures that the signed-up partners have a seat on the Steering Committee which will be the operational decision making body of the programme answerable only to the ACCESS board.

To date the following institutions/agencies have signed the ACCESS Collaborative Agreement and negotiations are continuing with others:

Universities:	Science Councils:	Agencies:
WITS	CSIR (Hosts)	ARC
UWC	GSC	SAWS
UP		SANBI
UCT		ORI
UKZN		
Rhodes		
US		

Target entities:
SAEON, UFH, WSU, U Venda, UZul, U Limpopo, NWU.
Note that while researchers and students from these targeted institutions have been part of ACCESS processes, the administration of the formal signing of the ACCESS Collaborative Agreement is more complex and will take some additional time.

2. EDUCATION AND TRAINING PORTFOLIO

2.1 Background and context

The National Planning Commissions report identifies a number of historical drivers of the challenges and problems being faced by South Africa Society. One of these is the legacy of apartheid education. The report laments the state of the education system in the country and recognises the legacy of the apartheid system continues to have an impact in access to quality education for black school pupils (in particular). In an extensive analysis, the report shows that addressing education and training of our youth is a key element of our development path. It states:

"Skills acquisition is out of line with the needs of a modernising economy. Higher education institutions are not producing the number of skilled personnel that the economy requires" and *"In-depth studies on factors that contribute to poor school outcomes for learners in South Africa* [conclude that] *learners possess inadequate subject knowledge and lack basic pedagogical ability, especially in subjects such as languages, science and mathematics.*

The ACCESS programme seeks to address this directly and has recognized that there are four major obstacles to the development of skilled people. These are:

- interest and attraction to science
- preparedness of students
- lack of funding
- post-graduate supervisory capacity

The Global Change Grand Challenge (GCGC) Human Capital Development Strategy (HCDS) highlights critical challenges and gaps on research skills and capacity, technical skills and knowledge necessary for South Africa and the region to respond appropriately to global change challenges. The HCDS clearly points out that a key area of concern in South Africa's human capital development 'pipeline' is the lost capacity of youth who graduate at Grade 12 level from school with Mathematics, Science and Geography, but who are lost to higher education and various global change occupational opportunities due to various social and historical factors. Some of these young scholars who make it to higher education are just not adequately exposed to the career opportunities and possibilities that the GCGC presents; and potential capacity is lost at first degree, honours and masters levels, particularly amongst black graduates. The HCDS also acknowledges that the environment/global change education and training system is currently 'on the backfoot' and largely *reactive*, and points to a need for added impetus to strengthen national capacity to adopt a more proactive, futures oriented approach to global change skills development. The South African Global Change Grand Challenge National Research Plan highlights the growing importance of developing skills for risk prediction and risk management; sustainability innovation; complex systems analysis; building system resilience; and adaptive management.

In addition to this, it is recognized that limitations also exist in terms of the supervisory capacity for research students in the region. This is a problem of both quantity and quality and there have not been any signs of significant growth in this area for decades.

Current approaches of rewarding academic excellence has clear merit, and the country and region should be proud (and continue to support) of the excellence and international recognition achieved by our scientific community. However, without careful management this system including the creation of self-organizing discipline specific specialist entities (e.g. SARCHI chairs) will not, in isolation, address the fundamental structural challenges in the heterogeneous academic system, and has the potential to perpetuate inequity. While there has been a gradual shift in the demography of post-graduate students, the quantum leap sought has not been achieved and in particular, the supply of black South African candidates for post-graduate science studies remains unacceptably low. These factors conspire with the result that there are limited opportunities for potentially successful young researchers and traps students in historically disadvantaged institutions in limited academic environments.

Bold and creative initiatives at all educational and academic levels are required to address several of these challenges in concert, in order that the pool of untapped potential can be accessed and that opportunity for meaningful participation in and access to meaningful and relevant careers is facilitated. Given the shortage of skills in the country and region, particularly in science and mathematical fields, it is this incumbent upon us to ensure that ACCESS can make a significant contribution to changing the status quo.

2.2 Design and Implementation

The ACCESS Education and Training Portfolio has been designed to respond to the GCGC HCDS goal to have in existence by 2018 a sustainable human capital development system for global change research and knowledge development as part of the National System of Innovation. This goal is to be achieved through the following objectives:

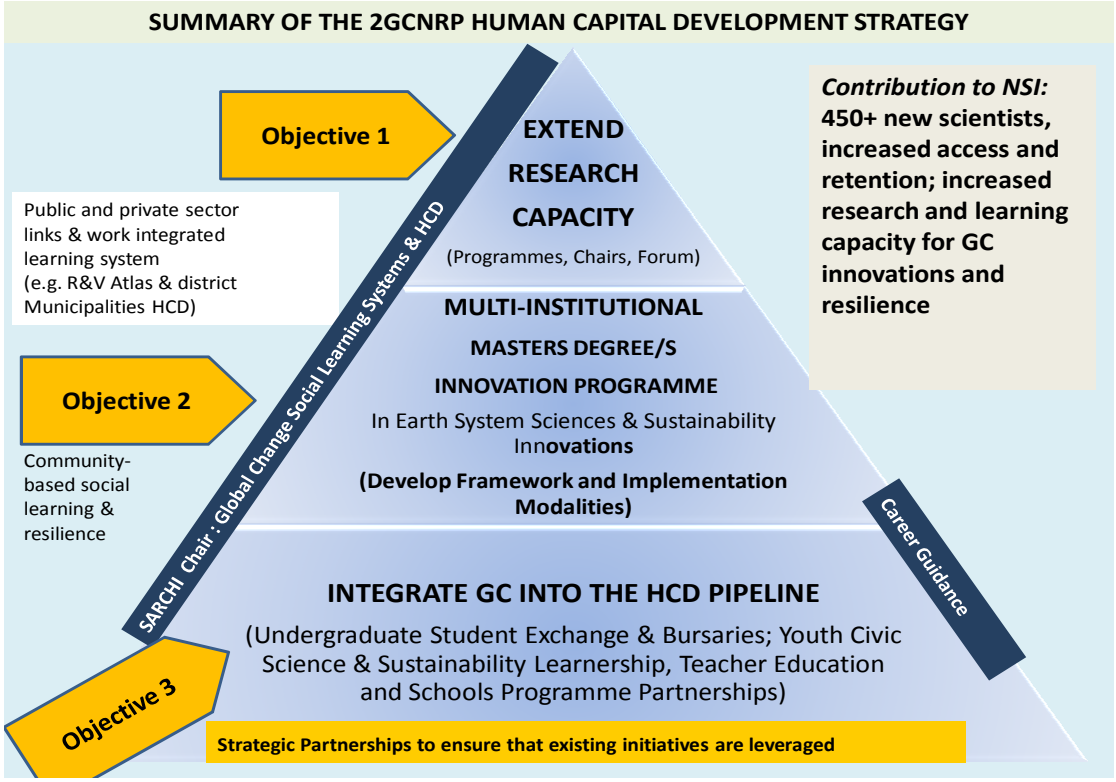
- Expand **research and research supervision capacity** for the Global Change National Research Plan Knowledge Challenges and ACCESS Research Themes
- Increase **access to, and graduation levels** in Global Change study fields particularly at **Masters and PhD level** in the areas of Earth System Sciences and Sustainability.
- Strengthen Global Change **knowledge, capacity and social learning in the Human Capital Development pipeline**.

This ACCESS Portfolio is designed specifically to address the HCD aspects of the Earth System's Science aspects of the GCGC. However it is understood that this emphasis is not decoupled with the other aspects of the GCGC and thus, the activities planned are able to engage across the entire conceptual space of the GCGC in collaboration with other GCGC supported structures and programmes and beyond.

As a basic approach, it seeks to use the exceptional Earth System phenomena which form the focus of the Research and Services Portfolio (section 3), as a means of leveraging new and enhanced Education and Training opportunities at all levels of the academic system, from school level to professional graduate researchers. The goal is to leverage the opportunities that the GCGC has conferred on ACCESS and deliver a vibrant, attractive

and exciting set of activities that will change the perception of Earth System Science as a career option. The Portfolio seeks to produce fully capacitated, confident and knowledgeable new entrants into successful research careers and suitable employment at academic institutions, research agencies and public sector posts.

An illustrated summary of the Strategy is provided in the diagram below:



The ACCESS Education and Training portfolio has therefore been strategically established to play a central role in developing programmes through a network of partnerships and pooling of resources that will to a greater extent ensure the implementation of the HCDS objectives/plans. Whilst fully recognising and appreciating some of the systemic and socio-historical challenges/shortcomings within the education and training system; however, ACCESS does not seek to provide a 'silver bullet' for all such challenges. The ACCESS mandate requires collaboration among key partners at all levels of the Education and Training system in providing the "scaffolding" required to support develop ACCESS students into productive researchers and job-ready and proficient citizens. The approach is to implement an end-to-end set of sub-programmes which will develop and support a pipeline of education programmes that will secure and prepare learners and students for the country's Global Grand Challenge National Research Plan and beyond. This will be done by strengthening existing programmes and collaboratively helping to develop new ones.

The ACCESS education plan will pay substantive attention to transformational issues in providing Earth Systems Science and Climate Change research capacity and learning opportunities. In order to achieve this, it will be critical to pursue strategic alliances and partnerships with Historically Disadvantaged Universities (HDUs) and Historically

Disadvantaged Individuals/students (HDIs). The establishment of Risk and Vulnerability centres in HDUs will further provide opportunities for ACCESS develop and support local context relevant research and curriculum programmes. This will be done in close collaboration with relevant research chairs such as the proposed Global Change Social Learning Systems Chair in order to provide a reflexive and practice based research support mechanism for such University based centres, local Government authorities and community structures.

In collaborating with Higher Education Institutions greater care will be taken not to undermine their independence and individual strengths of their programmes; but to find ways in which these can be supported to enable a greater reach of students locally and across the African continent. ACCESS further intends to facilitate a cross-institutional sharing of resources and programmes by developing and providing both a platform and framework for such programmes. Such initiatives as proposed in the HCDS will open currently non-existing pathways for students from various backgrounds and location.

2.3 The suite of Education and Training sub-programmes

As described above the ACCESS Education and Training Sub-programme will be spread across all levels of the education and training system comprising a school based pipeline programme (**with emphasis on global change knowledge and teacher capacity to teach global change knowledge in key global change relevant subjects**), under-graduate programme (**with emphasis on career guidance and global change student leadership development**), post-graduate programme (**with emphasis on scholarships and research-based work experience opportunities**) and an early career scientist programme (**young scientists leadership development**). The approach that ACCESS to education and training is an *innovation centred approach* that will address the following areas:

- Student attraction and retention programmes (e.g. career orientation; science communication; winter schools (e.g. Habitable Planet Programme); bursary and work placements);
- Transformative approaches to teaching and learning (e.g. e-learning; new science teaching methodologies (e.g. modelling); values-based and integrated approaches; work integrated strategies; mix of social learning and 'formal' curriculum approaches)
- Curriculum design and innovation (e.g. Curriculum design to support new global change courses at Honours and/or Masters level; curriculum design for reflexive competence and positive, integrated capacity for dealing with global change issues)
- Collaborative thinking and links across the education system (e.g. Links to Eco-Schools, SAEON education network etc.)
- Post-graduate Student and Post-doc teaching and exchange programme.
- Integrated research / curriculum development activities.

The Education and Training programmes are further elaborated in brief as follows:

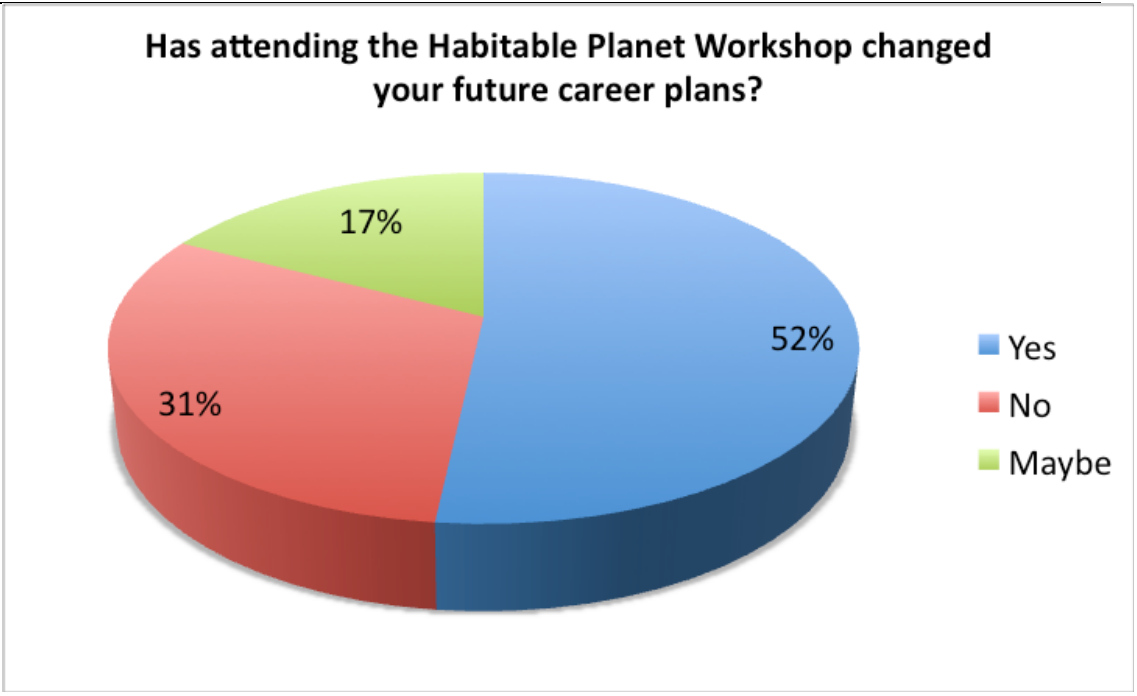
2.3.1 School Based Education Programme

The GCGC presents great opportunities for innovation in teaching and learning at school level. It further offers new dimensions in exploring and understands the world in terms of its origins, its contemporary state and issues and associated future possibilities depending on the decisions and associated actions. ACCESS also recognised that a number of Environmental Education and science related activities already exist in a variety of forms; our intention therefore is not start parallel programmes and activities or compete with such initiatives. A collaborative and supportive approach is therefore needed in order to further the HDCS objectives. The following activities will be implemented as part of the schools based education programme:

- **School based curriculum development**: as a point of departure focus will be given to supporting existing initiatives and entities (e.g. Eco-Schools, SAEON, SANParks, Delta, WESSA etc) in developing learner and educator support materials. Other activities will also including providing opportunities for learners to visit local science centres or environmental education centres as well as opportunities to meet and interact with practising scientist at various research sites or science centres. Focus on science schools like LEAP?
- **Career Education**: this will be done through participating in e.g. science expos, coordinating some of the university based ACCESS partners to conduct school visits and presentations etc.
- **Teacher education and professional development:** it will be critical for ACCESS to participate in forums that are aimed at providing support and input into curriculum policy development for pre-service and in service teachers. The HCDS has already identified challenges with teachers' lack of capacity to find or handle new content related to environmental science teaching and learning.

2.3.2 Undergraduate Programme

- **Habitable Planet Winter Schoo**l **Programme:** These workshops have since inception proved to be a great success and have increased in popularity amongst students. Although they started at one location they are now spreading across the country including HDUs. The Workshops are currently aimed 3rd, 4th and honours students from various disciplines. The programme also includes a career exposure opportunity in the earth systems sciences. This novel earth science curriculum activity which happens over two weeks can serve as a platform for recruitment and access of students into the earth sciences. These programme has much potential to be developed into a 'nodal system' or bridging mechanism at different universities and can be linked up with scholarships at Honours and Masters level, and research Chairs and programmes. Find below feedback from student participants at one of the workshops on career impact/influence:



- **Student Participation or mobility programme**: students studying in the various disciplines associated with the earth systems science are offered opportunities to attend relevant conferences, seminars or exhibitions. This may also involve inter-international exchanges between local and international institutions. Opportunities like these provide students with exposure to various career and research opportunities and further allow them to see things from various perspectives other than just what their discipline or institution presents.

2.3.3 Postgraduate Programme

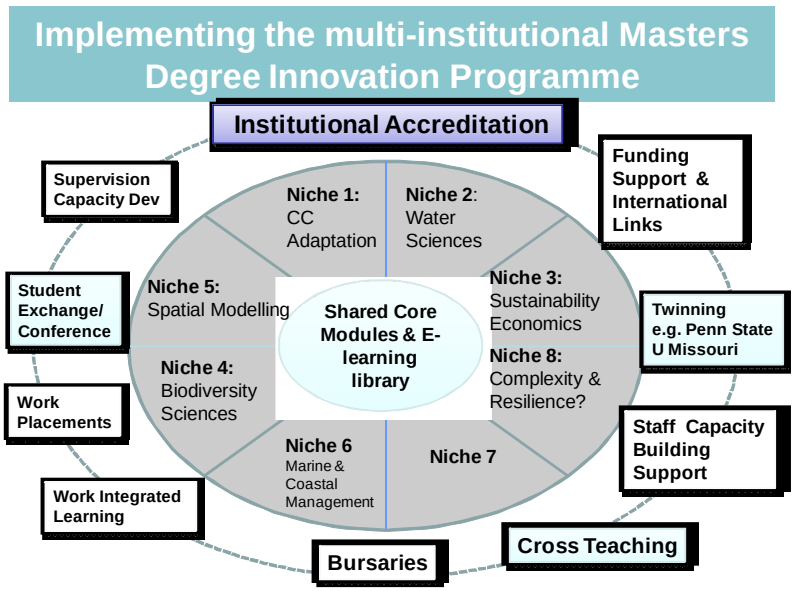
- **Scholarship and Research Programme support:** Career orientation and support for applying to, and obtaining scholarships for Global Change Sciences – link to a range of participating universities and key 'niche' areas for Earth System Sciences. Here we must describe the bursaries from the TASs. Say that they will be project specific and not open calls for bursaries.

- **Implementation of Masters Degree Innovations Programme for Earth System Sciences and Sustainability:** The HCDS involved consultation with universities where it was agreed that a collaborative effort to improve the quality and outputs of Masters Degrees in Earth System Sciences and Sustainability is needed to increase graduate numbers in Global Change sciences. To this end, ACCESS will play a key role in developing and implementing a National Masters Degree Framework which will be a key instrument of delivery of ACCESS' outputs.

- ACCESS will support development of core modules that can be used in key Masters Degree programmes in co-operating universities; and will particularly support HDUs to develop new Masters Degree Programmes in Global Change niche areas; while also supporting the sharing of knowledge through an e-learning library and teaching exchanges within the Global Change Science Community. This programme will also be linked up to NRF scholarships, research chairs and the Risk and Vulnerability Assessment Centres.

  Due to the lack of a policy framework that allows for cross-disciplinary teaching; a proposal that seeks to enable a multi-institutional approach has been developed. At a recent meeting with Universities there was general agreement to proceed with the National Masters Innovation Programme. The following suggestions have been made as part of the proposal:

- **Co-development of modules and integration of them into existing accredited programmes** (provided changes are not more than 50%) – it is possible to develop core modules together
- **Co-teaching is possible** – institutions can make arrangements for such co-teaching possibilities. Examples exist with highly positive conclusions. This further opens space for engaging in technical experts from research agencies and international partnerships and international expertise to be brought in.
- **Shared course design approaches:** this may include teaching methods, assessment, teaching and learning materials, e-learning library, student support etc.
- **Co-supervision arrangements** across universities – collaborative supervision capacity development programme
- **Development of new courses and academic and training offerings at partner institutions.**



Schematic of planned National Global Change Masters Degree Framework

- **Student Participation or mobility programme**:

Students studying and conducting research in the various disciplines associated with the earth systems science are offered opportunities to attend relevant conferences, seminars or exhibitions. This may also involve inter-international exchanges between local and international institutions. Other activities will involve providing opportunities for students to attend extra research skills development workshops arranged or hosted by any of the partner institutions or research chairs.

2.3.4 Early Career and Emerging Scientist Programme

- **Early Career Workshops**: these will provide early careers scientists and academic a forum for interaction and engagement with peers and also with senior scientists. Activities may include supervision workshops, research skills workshops and field trips with more experienced researchers, mentoring and collaborative research projects and academic publications including co-authoring. Other activities will also include coordinated participation in major international gatherings involving joint presentation, side or pre-conference workshop, seminars etc.
- **Post-doc Teaching Opportunities**: this will include opportunities for Post-Doctoral scholars/researchers to be placed in other institutions for short term based teaching. This programme will also provide capacity and exchange of skills and knowledge through exchange programmes with international Universities. Other teaching opportunities may also include special workshops for undergraduate and postgraduate students on research skills/methods and other areas within the Global change discourse.

3. SCIENCE AND SERVICES PORTFOLIO

This portfolio is focussed on the scientific research and outputs of the programme. Its relationship with the Education and Training Portfolio is inter-dependent and there is close co-ordination designed into the operations. The Science and Services Portfolio is aimed at two fundamental outcomes:

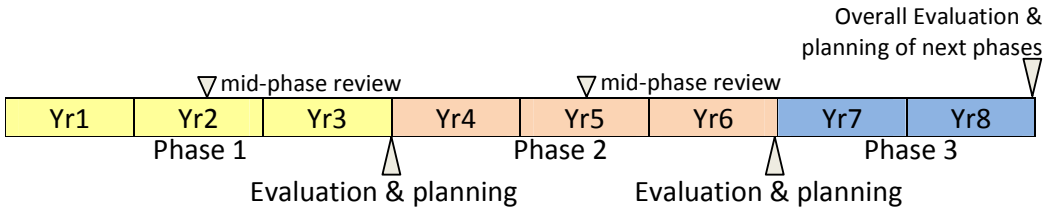
- Delivering a platform of a new and unprecedented scale for scientists and students to produce work of the highest standard and of relevance to the development of southern African society, and of international importance,

- To produce a range of products and services that are applicable to agencies of government, and civil society that will contribute to the sustainable development of the region.

3.1 Structure and function of the implementation plan

This portfolio focuses mainly on the outcomes as planned in the Global Change Grand Challenge Research Plan. The proposed implementation of this portfolio is designed in a

series of Thematic Areas which to some extent divide up the foci into manageable Sub-Programmes. Each of these themes will be executed in three stages (see figure below).



The goal is to proceed to implementation as speedily as possible without compromising on the inclusivity of additional partners currently being targeted. The plan is to split up the sub-programmes into three phases of implementation with a tight-loose-tight formula to ensure that the programmes are being executed according to specification. In planning the TASs we have solicited two-part documents which describe the long term (8 year) plans and a first phase (3 year) detailed plan. A workshop with all theme participants (as described in the long-term plan) will be held at the inception in order than inter-theme engagement and common cause is established. Annual symposia will also be held ensure that he respective researchers report adequately. Review and evaluation (as depicted in the figure above) will be conducted with the Evaluation & Planning serving as opportunities for the expansion and further broadening (in scope and partnership) of the sub-programmes. When adequately resourced, the idea is to contract out these TASs to the multi-institutional ACCESS partners involved in each of the sub-programmes respectively. Governance of these sub-programmes will be designed appropriately and as the scope and scale develops, a variety of management options, including the possibility of formal sub-programme management will be considered.

3.2 Overall thematic concept

3.2.1 Alignment with the Global Change Grand Challenge Research Plan & focus of the ACCESS plan.

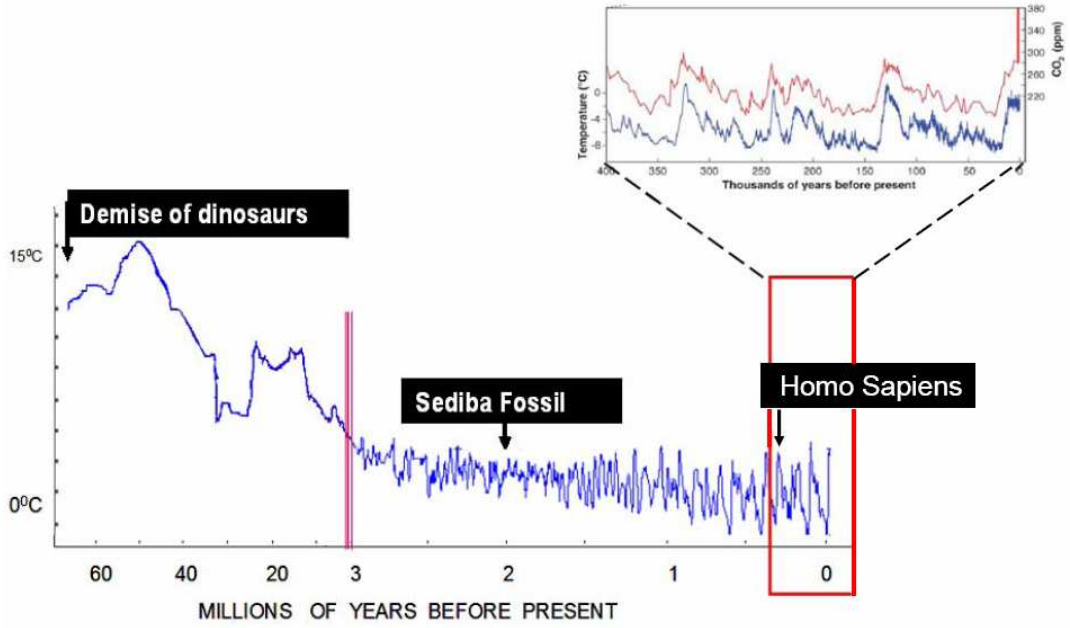
The design of the ACCESS Implementation plan is purposefully aligned with the Global Change Grand Challenge Research Plan as this represents the most up-to-date assessment and statement provided by the Global Change Community. The planning was directed so that the process drew heavily on the GCGC Research Plan. ACCESS is mandated to focus on the Earth System aspects of this research plan, but it is recognised that these are not decoupled from the Adaptation and Innovation aspects of the GCGC programme. While the centre of gravity of the work to be undertaken by ACCESS is around the “Understanding a changing planet” and “Reducing the Human Footprint” aspects of the plan, many of the items, actions and activities identified in the ACCESS Concept notes and TASs go well beyond these limitations (see illustration below). This is an advantage in that it provides opportunities for fuller integration of the GCGC outcomes.

ACCESS Center of gravity in relation to other aspects of the GCGC Research Plan

Understanding a changing planet	Reducing the Human Footprint	Adapting the way we live	Innovation for Sustainability
1. Observation, monitoring & adaptive management. 2. Dynamics of the oceans around southern Africa. 3. Dynamics of the complex internal earth system. 4. Linking the land, the air, and the sea. 5. Improving model predictions at different scales.	6. Waste minimization methods and technologies 7. Conserving biodiversity and ecosystems services 8. Institutional integration to manage ecosystems and the services they offer 9. Doing more with less	10. Preparing for rapid change and extreme events 11. Planning for sustainable urban development in a South African context 12. Water security for South Africa 13. Food and fibre security for South Africa	14. Dynamics of transition at different scales - mechanisms of innovation and learning 15. Resilience and capability 16. Options for greening the developmental state 17. Technological innovation for sustainable social-ecological systems. 18. Social Learning for sustainability, adaptation, innovation and resilience.

3.2.2 A Special Place in a Special Time

The main concept behind the implementation of this portfolio is encapsulated in the statement "*a special place in a special time*." The hominid fossil of a boy (whom we name Bafana), recently discovered near Johannesburg, is the latest in a series of important hominid fossil finds in the region and the continent. The Sediba fossil is an internationally recognized, emotionally powerful reminder that, originally, we were all Africans. Our ancestors made an amazing journey, through constantly changing climates and environments, from the strange world of the fossil a few million years ago, to the familiar world of today. The story of that journey culminates in the revelation that we, today, are in a special place, at a special time. We are on the only planet known to be habitable, at a time of an exceptionally temperate climate (a special time). Our species, *Homo sapiens*, arrived recently and in the (geological) blink of an eye took full advantage of the favourable conditions to progress spectacularly from the invention of farming to technological marvels. We now have the power to interfere with the processes that make this a habitable planet and hence are its stewards. Familiarity with our story, which interests everyone, can help us be wise and responsible stewards of planet Earth, while introducing us to fascinating scientific concepts and methods. Our story, implicit in figure below, is known only in its barest outlines.



Variations in $\delta^{18}O$ over the past 65 million years, obtained from sea-floor cores, and converted to approximate surface temperatures in Polar Regions. Note that the time-scale changes at 3 million years. The inset shows fluctuations in temperature (blue) and in the atmospheric concentration of carbon dioxide (red) over the past 400,000 years as inferred from Antarctic ice-core records. The vertical red bar in the inset is the increase in atmospheric carbon dioxide levels over the past century.

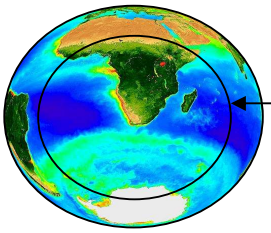
Southern Africa is the ideal base (a special place) for a research and education programme to reconstruct the botanical, zoological, geological, oceanic, atmospheric and climatological conditions in the past, leading to the status quo at the present thus giving early hominid fossils a context, contributing to an understanding of why the present is a special time, and hence leading to an improved ability to anticipate future climate changes. South Africa is the natural international leader of such an ambitious and important project.

This concept then provides a overall framework for executing a science and education programme. The fundamental scientific question then is to understand the structure and function of the coupled and dynamic earth system, its variability on seasonal scales, inter-annual, decadal and geological time scales. This will equip us with the information we need to more confidently predict the trajectory of these earth system dynamics while at the same time, providing a vital and exciting opportunity to generate a new generation of proud young South African researchers.

3.3 A model of the Earth System

In order for us to understand the impacts of global change on our earth system and the range of goods and services that we obtain from the environment and the products we can offer for better management of these goods and services (or resources), it is important that a means of understanding the interactions and feedbacks among the notionally independent elements of the system. In its simplest iteration, land, ocean and atmosphere (and their subsidiary systems) all interact and a mutually inter-dependent way in different scales of space and time. Thus conceptually we can envisage an regional earth systems model which is

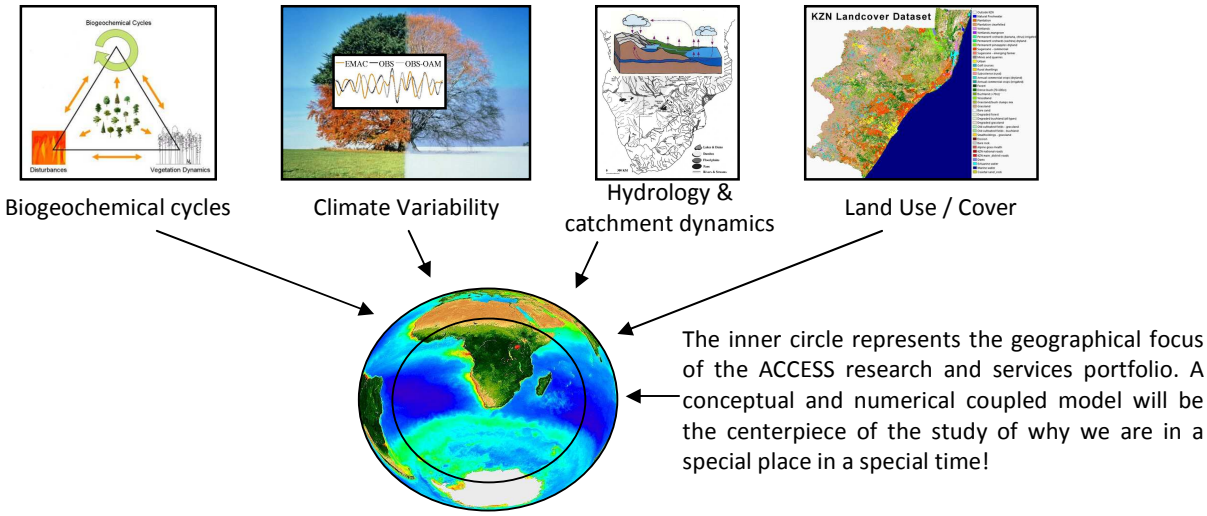
a centre piece that comprises our best understanding of these dynamics and can be used both conceptually and numerically to describe the regional earth system and its global context (see figure below):



The inner circle represents the geographical focus of the ACCESS research and services portfolio. A conceptual and numerical coupled model will be the centerpiece of the study of why we are in a special place in a special time!

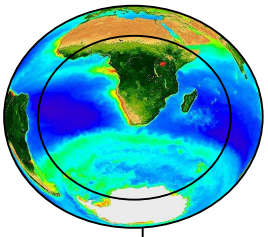
3.4 Model inputs

In order for this model to be conceptualised and function, it requires certain fundamental building blocks. This requires a better understanding of the dynamics (seasonal and other) and the drivers of the elements of the model. These complex subsystems require dedicated effort in themselves which are by their very nature, inter-disciplinary. The data and information emanating from the study of these subsystems become inputs for the model.

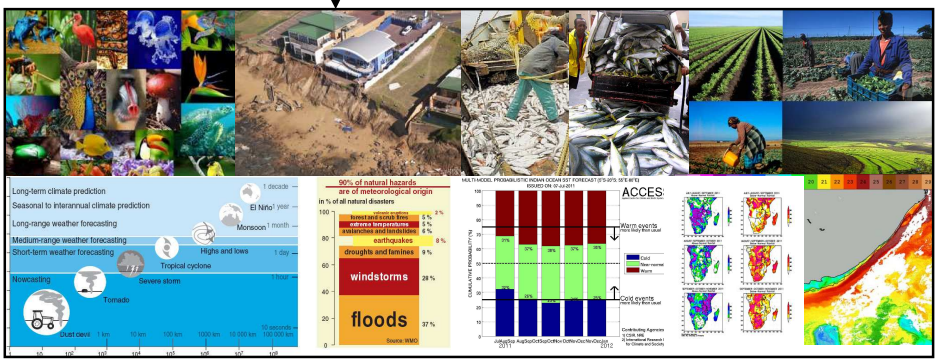


3.5 Model outputs

The true value of such an effort described above will be to use the model to explain phenomena and understand the trajectory of the southern African earth system from its past, through the present and hopefully, produce robust scenarios and predictions of it future. The outputs would be generated from applications of the knowledge in information products which can be used in a variety of disciplines. Among these outputs are a variety of information systems and operational products including new and improved seasonal climate predictions, early warning systems, operational oceanography products and information related a range of ecosystem goods and services including water provision, coastal management applications, fisheries management applications, agro-meteorological products and biodiversity management information.



The inner circle represents the geographical focus of the ACCESS research and services portfolio. A conceptual and numerical coupled model will be the centerpiece of the study of why we are in a special place in a special time!



In essence, the suite of sub-programmes is then designed as an end-to-end system of studies and applications which serves the dual purpose as a platform for training and education, and for scientific research of the highest standard with applicable outputs and an integrated approach to global change challenges. The TASs span the design described above from inputs to output, and by virtue of the multi-institutional and multi-disciplinary nature of this, the programme provides a meaningful, exciting and attractive set of opportunities for young researchers in the region (and indeed, the world).

3.6 ACCESS Thematic Area Programme

3.6.1 Thematic Areas

The following is a list of which have been assembled by the ACCESS programme panel of experts. Below that follows a description of each of the Thematic Area.

- BIOGEOCHEMISTRY & ES MODELLING
- SEASONAL / INTER-ANNUAL CLIMATE PREDICTABILITY
- LONG TERM CLIMATE & IMPACTS
- WATER RESOURCES
- MARINE & COASTAL, ESTUARINE SYSTEMS
- URBAN & RURAL LANDCOVER & LANDUSE
- ECOSYSTEM SERVICES & LIVELIHOODS

3.6.2 Biogeochemistry & ES Modelling

This TAS will occupy center stage in the suite of Thematic Areas using common currency of elements and media (as in chemical media) as a means of integration of information from them and among them. What this TAS will do is unpack the ES model in terms of the respective ES sub-system questions. It is increasingly clear that the Earth System – the coupled atmosphere, oceans, land, freshwater and ice components, with human systems embedded in them – operates as a whole, and needs to be studied as such. At the same time, key Earth-System processes often have a regional origin and the outcomes of global processes are regionally differentiated. This TAS sets out to address a small set of globally critical questions for which South Africa is well positioned to provide answers, and in the process to develop our capacity to understand and respond to the large-scale, human-induced changes that are taking place in the coupled elemental, energy and climate systems of the world. Carbon has been selected – as constrained by the water, nitrogen, Iron and other elemental cycles – as a unifying theme in the research programme. Carbon is a shared currency of both life and the human economy. The work will both inform negotiations on a safe future pathway for society globally and underpin more local and immediate concerns such as land and ocean productivity, regional climate change, water resources and the avoidance of pollution. This TAS has interdependent observational, experimental and modelling elements and aims to:

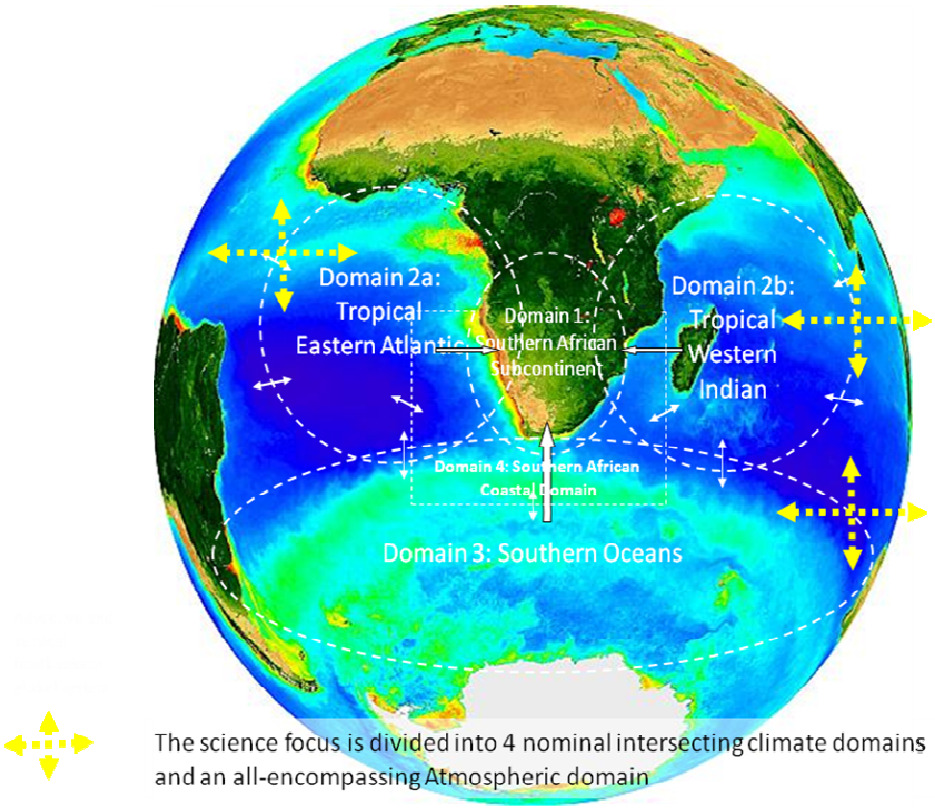
- Develop an understanding of Earth-System processes relevant to southern Africa, contributing knowledge of key regional processes to the global picture, and enriching projections of global trends with regional detail;
- Develop an African-based Earth System Model (fully coupled climate model), with in depth description of the physical and dynamic processes relevant to the coupled SARES; and
- Establish an integrated, long-term observation system for key indicators of the functioning of the Earth System in a regional context; SARES – Observatory to support the ES Modelling and generate societal-relevant indices of change.
- Train a new generation of researchers and practitioners, with world-class domain knowledge, having an integrated view as well as systems modelling and analysis skills.

This TAS is to build new capacity in South Africa within the field of developing, improving and applying Earth System Models to improve our understanding of the southern African Earth System. In particular, through the research tasks of developing coupled land-surface atmosphere modelling capacity, ocean C-cycle parameterizations, atmospheric chemistry and cumulus convection parameterizations, the development of an African-based Earth System Model is foreseen. This model will have flexible regional climate modelling capability, and will be respected by international peers, especially for its world-leading skill in describing climate system phenomena in southern Africa and the southern hemisphere

This research will contribute to reducing uncertainties surrounding changes in carbon fluxes, climate, ecosystem services, and the water balance. The new knowledge

generated here will inform policy and management decisions about large-scale, long-term societal and environmental issues such as climate change and biodiversity. Moreover, a new generation of world-class global climate system modellers living and working in Africa will be achieved through the SARES HCD programme. This outcome will rely strongly on DST funded infrastructure of the Centre for High Performance Computing (CHPC).

It is through the integrated nature that the TAS will deliver its analysis and assessment of Ecosystem Services that are of value to South Africans, as well as the Earth System Services that are of value to the Planet. This TAS will be a key vehicle for the delivery of large (regional) scale outcomes and a context for the ACCESS TASs and Education and Training Programme, as a whole. From an HCD point of view, the opportunities for training and education are vast given the scale of work envisaged and furthermore, its broad geographic and multidisciplinary nature.



The science focus is divided into 4 nominal intersecting climate domains and an all-encompassing Atmospheric domain

3.6.3 Seasonal / Inter-Annual Climate Predictability

This TAS is an end-to-end programme focused on the structure, function, predictability and applications of short to medium term climate. A fundamental distinction must be made on the time scale of this TAS which focused in the inter-annual to decadal time scale (notionally: climate variability) as opposed to the multi-decadal climate change time scale. While both of these time scales are important (see below), this climate variability time scale is more operational in that current drivers of drought, floods, extreme weather phenomena and their impacts are of immediate concern in the Global Change big picture. The interface between these timescales is where the trends in climate variability become important.

Climate is the key agent of environmental change and most livelihoods and ecosystem goods and services provision depends on the variability of key climate parameters such as temperature and precipitation. Also, climate extremes have a direct bearing on natural, industrial and agricultural productivity. Over the last century, Southern Africa has suffered from dramatic inter-annual changes in climate leading to severe droughts, increased occurrence of floods or disturbance in the marine or terrestrial ecosystems, stronger wind leading to increased occurrence of fire. Such variability of climate affects the agricultural industry, water reserves, fisheries and thus the Gross National Product. It has a particularly detrimental effect on rural subsistence farmers and fishermen, the health of people in rural areas and the management of a sustainable natural environment. Such natural hardship hamper the accomplishment of the Millennium Development Goals defined at the Johannesburg Millennium Summit in September 2000. During the last decades much has been gained on how the oceans can influence the climate of Southern Africa at the interannual and also decadal scale scales. This offers predictability at the seasonal scale. This also indicates that the future climate of Southern Africa will be influenced by the future state of the oceans under natural and anthropogenic forcing.

The TAS is conceived in three parts: *climate fundamentals*, *climate predictability* and *applications of climate information*. The overall goal is to coordinate relative fragmented efforts in this field and to ensure that graduate students produced through this TAS from the range of institutions and agencies involved, have a comprehensive understanding of all aspects of climate and weather dynamics, the limitations and applications.

- The goal of the *climate fundamentals* aspect of the TAS is to ensure that the appropriate systems are in place to monitor and study climate variability.
- The goal of the *climate predictability* aspects of this TAS is to further develop operational forecasting systems for southern Africa by enhancing current multi-model forecasting systems, and by establishing the use of

existing and the development of new fully coupled ocean-atmosphere models as research and operational forecasting tools. This aspect of the work is focussed on operational outputs.

- The goal of the *applications of climate information* aspects of this TAS is to enable the appropriate use of climate variability information for application across a wide range of sectors, comprising to elements: translating forecast climate information (e.g. rainfall, temperature, likelihood of particular health risks) into targeted user-specific information that can be used for decision making and climate risk management and disseminating the forecast information (via different media) to the targeted users, and packaging that information in a manner that is understandable to the end user as well as clearly outlining the skill and uncertainty of the forecast

This TAS will change the way that short- to medium-term climate information is collected, used and disseminated in the southern African sub-region. It will provide a new scale of effort for this critically important aspect of global change drivers and create a robust and sustainable system for managing climate information. It will also produce a new cohort of broadly trained climate practitioner and specialists who will be better equipped to understand and engage with information about climate trends. The TAS will also leave behind a new and sustainable climate data and information infrastructure which will stand the region in good stead for the longer term future.

3.6.4 Long Term Climate & Impacts

Africa is particularly vulnerable to regional changes and variability of the climate system, and there are key gaps in knowledge and understanding of projected impacts, adaptation options and mitigation. These knowledge shortcomings severely limit effective decision making and the implementation of value response actions by society.

This proposal seeks to address this problem, and divides this TAS into four Work-packages:

- Addressing regional climate projections (focusing on projected climate change for the subcontinent) - A central foundation of responding to climate change is relevant information on and understanding of baseline attributes and physical changes of the regional climate system; without this knowledge all one can do is enhance resilience in anticipation of an unknown. This work package thus forms a core component on which much of the broader foci of this thematic area are dependent. Recognizing the current state of research within South Africa on the subcontinent's climate system, the following research topics represent priority knowledge gaps that constrain the development of relevant policy and adaptation, and which undermine the decision making process in responding to climate change.
- Climate change impacts (projected/modelled impacts for key sectors) - Sectors selected for impact modelling comprise those sectors indicated as

priority sectors of concern under climate change in the National Communications of a number of African countries (see, for example, South Africa, Namibia, Mozambique, Kenya and Tanzania).

- Mitigation and sequestration - Climate change mitigation requires the implementation of policies to reduce emissions of greenhouse gases and the enhancement of carbon sinks through processes such as sequestration. The identification, quantification and reporting of those pollutants and sinks that play a role in climate change provide a foundation to understand the potential for climate change mitigation and allow for the development of appropriate policy responses. In light of growing international pressure for developing countries to reduce greenhouse gas emissions, an improved understanding of the opportunities and challenges for regional mitigation and sequestration is required.

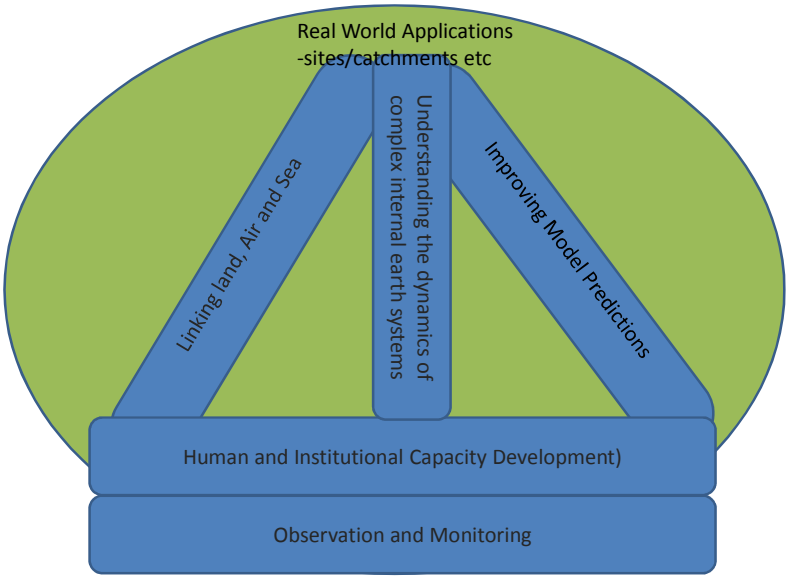
- Options for supporting adaptation, including communication, education and improved awareness (as well as strategy development) - All the research is of limited value if the knowledge products, and the increased understanding of the regional climate change impacts is not effectively communicated to those responsible for policy and decision making, and critically also to the wider population. Two deliverable products are necessary; data products with quantified uncertainty and probability measures on time and space scales of relevance, and qualitative storyline understanding of regional change and impacts.

3.6.5 Water Resources

This TAS intends to improve the understanding of the impact of global change on water resources and the capacity of society to respond accordingly. It does so through a programme that is built on a foundation of earth observation and monitoring coupled with human and institutional capacity development on which three key overarching research sub-programmes/themes are based, as illustrated in Figure below. The three research themes are drawn from the national Global Change Research Plan (GCRP) but are expanded upon substantially in the programme document and below.

In order to respond to global change drivers and impacts (on water resources and other aspects), we need to understand it better. This includes understanding the drivers and responses and the feedbacks within the earth system. Long term monitoring is an important foundation for building this understanding. Through detailed and long term monitoring we are able to identify trends over time, identify drivers of this change, improve our understanding of the processes that are affected by change and the dynamics and feedbacks of these, which in turn can be used to improve and test our models, and if necessary, develop new ones. Thus, the Programme will establish detailed and long-term monitoring and study at a suite of research catchments representative of the country's climatic regions (and expanded to Africa in future) which are established as long term "living laboratories" used to monitor and understand hydrological/water resources related aspects of global change and provide foci for capacity building from undergraduate through

postgraduate and moving through to early career (including, but not restricted to Post Doctoral support) development.



Overview of research programme of water resources under global change

Projects and partners in the programme will be clustered both geographically and thematically – a model which aids collaboration. New partners will be brought on board through extension of the network of monitored catchments (for example, Univs of Zululand, Limpopo and Venda through extension to monitoring of catchments nearby). The programme provides for strong linkages between science councils, state institutes (such as SAEON) and universities to aid supervisory and training capacity and will seek funding to cover fractional appointments of staff from non-research based institutes. In collaboration with other ACCESS partners, cross cutting research themes to "lift" issues/impact of broader relevance from the research catchments and to allow for linkages with participants in other ACCESS research themes will be sought. This provides for research and training with both depth (e.g. detailed hydrological process studies) and breadth (e.g. application of understanding of hydrological process studies to ecological problems). The living laboratories also provide for shared projects, workshops and field schools in common research sites/catchments with other scientists in other themes (e.g. Land Use/Land Cover change etc), particularly when research catchments are considered in a nested way, which allows scaling up of research findings to operational areas. Thus, the study sites provide opportunities for transdisciplinary studies based on issues related to global change that can be studied through the network of shared catchment based study sites with other themes in ACCESS. Ultimately, this provides for the development of a climate change monitoring network for SA.

The ultimate goal is to establish a network of monitoring sites (catchments) to produce the data and information critical for understanding variability and trends in hydrological processes in the region. This will herald a long term and sustained programme through which information and tools can be developed to enable

scientists and students to analyze these trends and produce both the capacitated people and outputs for application in water governance strategies.

The approach to this TAS will be implemented in a three-pronged set of project comprising: Dynamics (understanding patterns of water supply (from precipitation to reticulation), hydrological processes and runoff / evaporation) ; Improving Model Predictions (one of the key utilities that this TAS will produce is improved information regarding water supply and management) and Linking Land Sea and Atmosphere (water is a key earth systems medium and thus, its supply and dynamics is critical element of all earth systems dynamics). Thus, the work produced in this TAS will require inputs from other themes and be designed to supply the appropriate scale of information for "downstream" studies of other earth systems processes. Attention to interoperability of the inputs and outputs form this theme are thus a critical aspect of the work.

Given the critical nature of water in Southern Africa, this TAS aims to produce outcomes of direct application to the management of this key natural resource. Our ability to improve the predictability of water supply and appropriate time and space scales (through both monitoring and modelling) addresses the core technical goals of the Global Change Grand Challenge. In addition, given the need for managers at all levels of administration and the shortage of skills in this critical sector, in close collaboration with the ACCESS Education and Training Portfolio, this TAS has the potential to have a significant impact on the required skills development quotient.

3.6.6 Marine & Coastal, Estuarine Systems

The lack of scientific and technical expertise is a major bottleneck in the South African, and indeed African, economy and this applies particularly in the marine and ocean sciences. This TAS aims to implement an end-to-end earth observing system for South Africa's marine, coastal and estuarine ecosystems with a focus on marine climate variability and change, and in the process build infrastructure and train scientists and technologists to sustainably deliver products and services for society. The first three years will build an understanding of ecosystem resilience on a national scale with a focus on pilot studies driven by regional scientific question at select sites or "living laboratories", to be expanded more widely in a second phase. The ocean environmental variability is a fundamental driver of climate, weather and rainfall patterns on the coast and on land, through its storage and transmission of heat to the atmosphere, generating wind, storms and rain and through more complex biogeochemical processes. These in turn feed back to the ocean and food chains leading to fish and fisheries and all the other ecosystem services provided by the sea as a source of food, transport, mineral extraction and recreation. This TAS sets out a plan to enhance the observations of the seasonal cycle and trends in that cycle from year to year on short time scales up to the decadal scale, compared to the long timescale of Theme 1 above. It is also designed to slot into the earth systems modelling approach with an element focused on the links between the ocean component of the earth system and the terrestrial and atmospheric components. South Africa is uniquely situated for

marine and estuarine studies because our coastline spans both the cool Atlantic and warm Indian Oceans, with the Southern Ocean on our doorstep. Our advanced technology base, situated in a developing economic environment, provides a unique opportunity for new marine technology to drive economic development. The specific aims of this TAS are to:

- Develop a sustainable marine, coastal and estuarine observing system, with state of the art infrastructure to deliver products and decision support useful for society.
- Develop an ocean forecasting system that provides regular estimates of the ocean state and its evolution into the future that are better than climatology for, inter alia, maritime, fishing, and tourist industries.
- Develop an understanding of how marine, coastal and estuarine ecosystems in southern Africa are influenced by climate variability and change, and the feedbacks and interactions with the larger global earth system and global change pressures.
- Train a new generation of scientists and technologists to sustainably operate a new observing system, its instruments, databases, computers, models, forecasts and graphics.
- Develop indicators and analytical skills to inform policy makers and management agencies of the state of living and non-living resources in South Africa and Africa.

3.6.7 Urban & Rural Landcover & Landuse

The role of the land surface in climate dynamics is well established and it is clear (despite shifting base lines) that the land-cover of southern Africa has been completely transformed by global change drivers over the past 300 years. Despite this land cover and its dynamics at all space and time scales is one of the most poorly researched and understood drivers of earth systems variability. At local to regional scales, land cover determines biodiversity and ecosystem processes (such as fire regime) and services (such as water yield and quality), and thus links directly to socio-economic outcomes including the quality of peoples' lives and their livelihoods. At regional to global scales, changes in land cover provide feedback to climate through alterations in albedo and biogeochemical fluxes. Socio-economic activity alters land cover directly, which in turn has impacts on human quality of life from rural to urban settings, and has vital implications for food, water and energy security at local to regional scales. There are big gaps in the scientific understanding of these fundamental roles of land cover, especially in the southern Hemisphere. These gaps cut across traditionally demarcated scientific disciplines, further limiting our capacity to deal with them. Our consequent poor ability to predict the impact of human decisions about and activities on the land represents a large risk to decision makers at all scales. Land cover is most obviously subject to change via intensive human impacts such as clearing land for crops, roads and cities, but there is now increasing recognition of extensive anthropogenic impacts on land cover other than by complete transformation that are much less well understood. What is critically important in an urbanising world is to understand the drivers and implications of change in all these settings, and how they interact. This is especially important in South Africa,

where poverty and quality of life are closely linked to local environmental conditions.

This TAS plans to implement a cross-disciplinary programme to explore the causes and consequences of land cover changes in southern Africa at local, regional, continental and global scales. Our focus here is on change along a conceptual gradient of land transformation by human activities, from relatively unmanaged landscapes through to urban and intensive agricultural landscapes. Land cover in southern Africa is very interesting in a global sense because it can and does change rapidly over vast areas due to its sensitivity to a range of anthropogenic drivers. Understanding this unique sensitivity provides an excellent opportunity to develop South African scientific capacity that will have an immediate presence on a global stage, and will be relevant for policy makers at national level.

It is the contention of this TAS therefore that the South African research community is particularly well placed to explore questions relating to these drivers of land cover change through the potential for biome switches and compositional shifts, and their consequences at diverse scales, including through building a better understanding of implications at the global scale by improving the tools currently being used. Research on this question would place South African (and African) researchers in a competitive position in the hotly contested global change research community. This TAS will:

- Significantly advance understanding of the causes and consequences of land cover change in southern African ecosystems, with a strong focus on productive ecosystems prone to rapid change, and of national, regional and global interest.
- Build a productive network of experimental, observation and modelling-based projects that enhance multi-disciplinary and cross-disciplinary work, using an integrated gradient-based approach. This network of sites and projects will aim to leverage ACCESS funding to attract strong participation and co-funding by international groups.
- Develop strong predictive tools, including through developing mechanistic models of vegetation change and toolkits relevant for decision makers, and through pursuing strong linkages with related ACCESS themes.
- Enhance inter-Institution collaboration in the field of land cover change and rural/urban linkages.
- Accelerate the training of young scientists skilled both in specialist areas, and who have been exposed to cross- and multi-disciplinary thinking and practice, and to the science/policy interface.

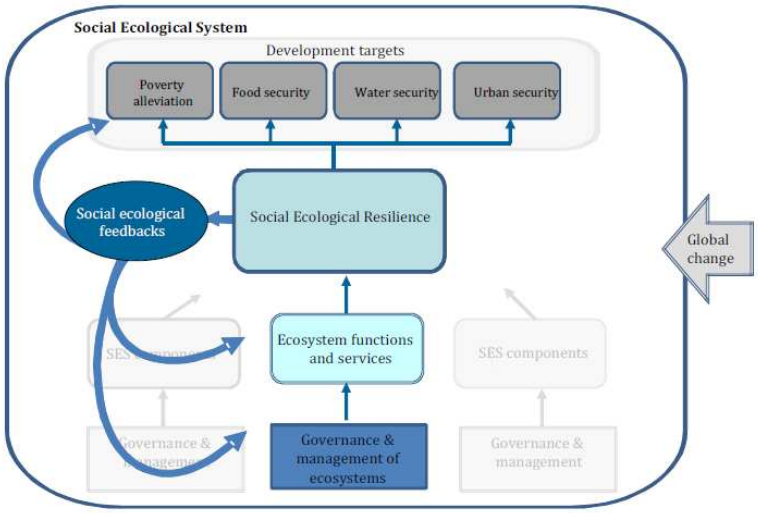
3.6.8 Ecosystem Services & Livelihoods

This TAS is focussed on the interface between Earth Systems dynamics and Human social systems. Ecosystems provide a range of essential goods and services which underpin human well-being and are the very basis of the existence of society. Ecosystem services are dynamic and change over time in response to global drivers like climate as well as regional and local factors including human impact. Further, predicting change in ecosystem services is complicated by

uncertainty, feedbacks between social and ecological systems, as well as rapid change that can occur when resilience is exceeded and thresholds are crossed. Rsearch gaps exist in the understanding of the interrelationships between ecosystem services, biodiversity, social systems and human welfare in South Africa. In particular the lack of understanding of the impacts of land use, land degradation and biodiversity loss on ecosystem service provision especially on vulnerable members of society such as the rural poor require special attention. This has enormous implications for the development of South African society and for redress in relation to the past political injustices. Given that south Africa retains a dependence on ecosystem goods and services for the maintenance of livelihoods (industrial, commercial and subsistence) changes and trends in the provision of these ecosystem goods and services, on a range of time and space scales, is a critical area for the ACCESS programme to address as part of the earth systems model.

Global environmental change (GEC) is recognized as being responsible for significant, global-wide declines in ecosystem function and human-wellbeing, along with increases in biodiversity loss. The primary drivers of GEC include habitat change, climate change, invasive alien species, pollution, rapid urbanisation, disease and over-harvesting of natural resources. Predictions for southern Africa's climate show variability in temperature, precipitation and atmospheric carbon dioxide that exceed natural variation. A myriad drivers influence variability in vegetation dynamics, biodiversity, productivity of domestic livestock production, agriculture, carbon storage and hydrology making prediction of the trends prevision of these services and thereby presenting a challenge to the management and sustaining of livelihoods – again, particularly in poorer rural communities.

This TAS will bring together and develop the expertise across the region in order to collect, integrate and interpret key socioeconomic, demographic, health, livelihoods, and environmental data longitudinally in an existing health demographic surveillance site (or "living laboratory") in rural South Africa as well as comparable in other parts of Africa thereby integrating across human- and earth systems. This research will yield valuable information on the ecological underpinnings of human well-being, including health, food and nutrition security, and livelihood resilience, in poor rural communities faced with global change. This information will have value in informing policy, planning and interventions for rural development.



Conceptual framework of the links between ecosystem management and the supply of ecosystem services essential to building social-ecological resilience required to meet development targets in a turbulent world. The circle represents our focus and area of competitive advantage.

4. RESOURCING ACCESS

ACCESS is a programme designed as one the core platforms of the DST Global Change Grand Challenge to address the knowledge gaps in the interdisciplinary field of global change and the challenges posed by the need to transform science training and education in the country and the region. In addition to this, it presents the opportunity for creating a new flagship programme which will serve not just the utility, but also serve as a symbol of African achievement in global change science at a national, regional and continental scale.

Recent efforts by the South African government to promote the region and continent as a global destination (c.f hosting of the World Summit for Sustainable Development the FIFA Soccer World Cup, the Square Kilometre Array, the hosting of the UNFCCC COP17 among others) and given the investment in scientific infrastructure in the country (CHPC, new Polar Research Vessel, the SANREN network), the opportunity to achieve an unprecedented effort in science and technology have not been better. Furthermore, given South Africa's role in global and continental affairs, this programme offers South Africa an opportunity for a leading role in both continental and global scientific endeavour.

4.1 Leveraging funds

It is recognised that the principal stakeholder in ACCESS (the DST Global Change Grand Challenge) is limited in the level of resourcing that it is able to commit to the programme. Developing the resource base for ACCESS is a process which depends as much on ACCESS' performance as it does on investment in its potential. Therefore, the strategy for resourcing ACCESS should be multi-facetted with the DST playing a key role in that strategy.

4.1.1 DST investment

It is envisaged that aside from direct funding from DST (via the NRF) – see below – a more important contribution from DST will be political leadership. This will involve elevating the ACCESS programme and actively promoting it in government, in the regional and continental political structures and in the country in general. To this end we envisage the following engagements to be facilitated:

- Briefing of relevant DST departments on ACCESS' role (e.g. International) with a view towards leveraging of funding from various departments to address mutually beneficial targets/goals.
- Presentation of ACCESS to Directors General Council with a goal to reach Cabinet Level
- Direct discussions facilitated by DST with the Ministries of Higher Education, Water Affairs and Environment (and others as appropriate)
- Presentation of ACCESS in regional (e.g. SADC) and Continental processes (e.g NEPAD, AU forums) and global processes (e.g. UN programmes, GEF).
- Promotion of the ACCESS programme as a vehicle of engagement in bilateral / multilateral (regional) and international programmes.

4.1.2 ACCESS programme's role

The ACCESS programme and its structures will actively seek opportunities for leveraging DST investment for additional funding both locally and internationally. We acknowledge that we will have to do this in partnership with the NRF and DST departments. However, it is crucial that the interests and plans of these entities are well aligned in order that these opportunities can be effectively realised. Among these are:

- Bilateral scientific relationships – e.g. BCCR, SATREPS
- EU programmes and calls
- Multi-lateral research programmes and opportunities – e.g., SASSCAL
- Private sector

4.2 Education and Training

The bulk of resources required for the ACCESS programme's successful implementation will be directed to the Training and Education Portfolio of activities. Funding will be required to implement the four sub-programmes as well as the Multi-institutional Global Change Masters Degree Framework as defined in the GCGC HCD Strategy. ACCESS aims to produce 300 MSc graduates (3 cohorts of 100 MSc Students in 7 years, thereby doubling the number of Earth Systems MSc graduates currently produced) and 200 PhD graduates (2 cohorts of 100 PhD students in 7 years or which 50% will be trained internationally, thereby doubling the number of Earth Systems PhD graduates currently produced).

The table below sets out the cost estimates for achieving these targets):

Degree	**Annual Cost**	**# Cohorts**	**Total Cost**
MSc	180k	3 * 100	54 000 000
PhD	360K	1*100 (local) 1* 100 (intl)	72 000 000 150 000 000
		Total	**240 000 000**

In addition to this, funding will be required to implement the sub-programmes of the Education and Training Programme according to the table below (7 years):

Sub-programme	**Funding**
School based curriculum development	7 000 000

Career Education	7 000 000
Teacher education and professional development:	7 000 000
Habitable Planet Winter School Programme	7 000 000
Student Participation or mobility programme	6 000 000
Scholarship and Research Programme support (from above)	250 000 000
Implementation of Masters Degree Innovations Programme for Earth System Sciences and Sustainability	7 000 000
Early Career Workshops	2 000 000
Post-doc Programme	7 000 000
Total	**300 000 000**

4.3 Research and Services Portfolio

The bulk of the resources required for ACCESS's Research and Services Portfolio will be borne by the funding for students. In addition to this, the Research and Services programme will require the funding of scientists and research staff (for supervision of students and execution of Thematic Area Sub-programmes) from Universities, Science Councils and Research Agencies, some of which will be working in cost-recovery financial systems or will be of "soft-money". In addition to this, the acquisition of equipment for the execution of the work and mobility costs to support the partnerships will also be required. It is estimated that around R10M per year per TAS will be required to cover these costs making a **total of R490M.**

4.4 Operational Costs

The ACCESS programme will require rigorous management and the ACCESS governance system will be a critical tool in its success. To this end, funding for the operational aspects programme will need to be secured. This funding will be utilised for necessary salaries and running costs and also to ensure that the ACCESS programme expands its partnerships and develops beyond the life of the Global change Grand Challenge. The table below scopes out these costs (kilorands, 7 years).

Function	**Funding**
Salaries	20 000 000
Board and Committees	3 500 000
Running Costs	30 000 000
	53 000 000

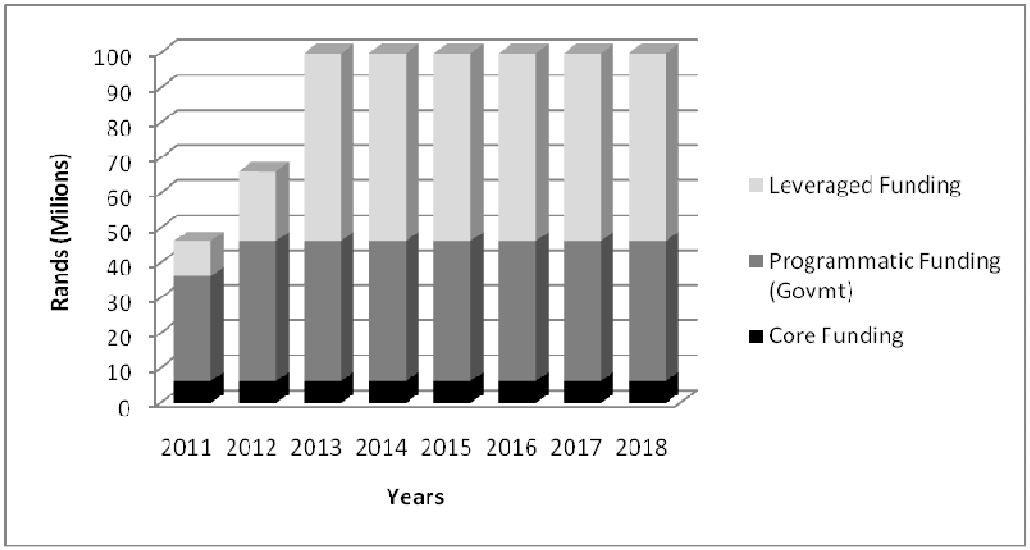
4.5 Achieving the appropriate level of funding

Below is a summary of the funding required for the successful implementation of ACCESS and the realisation of its outcomes. This is a large new or incremental investment relative to the level of funding hitherto invested in earth systems science but small relative to the investment in other major national projects (~100M / year).\

Education and Training	300 000 000
Research & Services	490 000 000

Operational	53 500 000
Grand Total	**843 000 000**

It is envisaged that in order to reach this level of funding a process of reaching this target will need to be implemented (see 4.1 above). The funding model envisaged is illustrated in the graphic below.



In this model, core funding already allocated to ACCESS via the DST is retained. In addition, funding from DST and other government programmes is sought to reach a level of R40M per year. ACCESS commits to leveraging these funds to reach the target of ~ R100M/year by 2013.

5. CONCLUDING STATEMENT

ACCESS has completed its development phase and now requires substantial investment so that it can achieve its goals and that of the DST's Innovation Strategy and so that it can contribute the vision being developed by the National Planning Commission as articulated in the Diagnostic Analysis and indeed the Presidential Outcomes for the development of the country. With both the financial and political support that has been forthcoming, ACCESS will deliver on the vision of establishing an African Earth Systems Institution. This presents an opportunity for South Africa to take the lead in transforming our region into a global destination for both the learning and education and the science and technology pertaining to our unique and globally important southern African earth system.