Seed politics: An exploration of power narratives in the South African seed industry

by
Stefanie Swanepoel

Thesis presented in partial fulfilment of the requirements for the degree of Master of Philosophy in Sustainable Development in the Faculty of Economic and Management Sciences at Stellenbosch University

Supervisor: Mr. Luke Metelerkamp
Co-Supervisor: Dr. Milla McLachlan

April 2014

Declaration

By submitting this thesis/dissertation electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

DATE: April 2014

INTEGRATED ABSTRACT

This study (*Seed politics: An exploration of power narratives in the South African seed industry*) attempts to unravel the contradictory power relations shaping South Africa's seed system and to explore spaces of system intervention that could allow alternate seed systems to emerge. As a base for the agricultural sector, the seed system plays an important role in determining the type, quality and cost of seed supplied to the country's farmers. By extension then, it also partly determines the type, quality and, to some extent, the cost of food sold to the country's citizens. Ownership of seed germplasm, protected through plant breeders' and intellectual property rights, is a contentious, current issue. Debate on international and national levels focuses on possible health issues related to consumption of genetically modified food, ethical considerations around ownership of plant life, monopolisation of seed markets, and the implications of biodiversity loss for food security and climate change adaptation. The first article (*Contesting the credibility of consolidation of the South African seed industry*) examines how historic and current power relations (on a global and local level) have shaped the 'modernistic' direction of South Africa's seed system, which is now dominated by two US-based multinational companies. The contradictions between this direction and state policy are highlighted, focusing particularly on issues of food security, biodiversity and climate change. Article 2 (*Imagining a sustainable South Africa seed system*) unpacks the assumptions on which the current system is based, in order to provide space for a new 'narrative' around seeds to emerge, motivating for a collaborative 'imagining' of a sustainable seed industry, based on a social learning approach. Points of system intervention are suggested and expanded on. In both articles, the complexity of seed systems is outlined providing a framework for understanding the interconnectedness of system elements, intervention points and potential for non-linearity. The study weaves together theory drawn from a diversity of themes to expose how the 'hidden' faces of power (entrenched in economic hierarchies and institutions) predetermine the path of the system and whom it benefits and whom it excludes. These themes include economics of consolidation, innovation theories, patenting issues, South African policy documents, international treaties and agreements, systems theory and complexity thinking, social learning, industrial and agro-ecological farming methods, agricultural productivity, and climate change. The study promotes social learning as a tool that could unlock the potential of the seed system to contribute to the urgent issues South Africa faces around biodiversity loss, food insecurity and climate change.

Keywords: seed system, genetically modified and hybrid seed, seed patents, seed innovation, social learning, systems theory, complexity thinking, consolidation of seed industry.

GEÏNTEGREERDE OPSOMMING

Hierdie studie (*Saadpolitiek: ʼn ondersoek van magsnarratiewe in die Suid-Afrikaanse saadbedryf*) poog om die teenstrydige magsverhoudinge wat vorm aan die Suid-Afrikaanse saadstelsel gee, uit te pluis en ruimtes van stelsel-intervensie wat die opkoms van afwisselende saadstelsels moontlik kan maak, te ondersoek. As grondslag van die landbousektor speel die saadstelsel ʼn belangrike rol in die bepaling van die soort, gehalte en koste van die saad wat aan die land se boere verskaf word. Dus bepaal dit ook deels die soort, gehalte en, in ʼn sekere mate, die koste van die voedsel wat aan die land se burgers verkoop word. Eienaarskap van saadkiemplasma, wat deur planttelersregte en regte op intellektuele eiendom beskerm word, is ʼn omstrede en aktuele kwessie. Debatvoering op sowel internasionale as nasionale vlak fokus op moontlike gesondheidskwessies wat verband hou met die inname van geneties gemodifiseerde voedsel, etiese oorwegings ten opsigte van eienaarskap van plantlewe, monopolisering van saadmarkte, en die implikasies van die verlies aan biodiversiteit op voedselsekerheid en aanpassing by klimaatsverandering. Die eerste artikel (*Betwisting van die geloofwaardigheid van die konsolidering van die Suid-Afrikaanse saadbedryf*) ondersoek hoe historiese en huidige magsverhoudinge (op sowel globale as plaaslike vlak) die ‘modernistiese’ rigting van die Suid-Afrikaanse saadstelsel, wat nou deur twee multinasionale maatskappye in VSA-besit oorheers word, gevorm het. Die teenstrydighede tussen hierdie rigting en regeringsbeleid word uitgelig, en daar word in die besonder gefokus op die potensiële invloed op voedselsekerheid, biodiversiteit en die kapasiteit om by klimaatsverandering aan te pas. Artikel 2 (*‘ʼn Veronderstelling van ʼn volhoubare Suid-Afrikaanse saadstelsel*) ondersoek die aannames waarop die huidige stelsel gegrond is, ten einde plek te maak vir ʼn nuwe ‘narratief’ oor saad, motivering vir ʼn medewerkende ‘veronderstelling’ van ʼn volhoubare saadbedryf, gegrond op ʼn benadering van sosiale leer. Punte van stelsel-intervensie word voorgestel en op uitgebrei. In albei artikels word die kompleksiteit van saadstelsels uitgestippel ten einde ʼn raamwerk te bied waarvolgens die onderlinge verband van stelselelemente, intervensiepunte en die potensiaal vir nie-lineariteit begryp kan word. Die studie verweef teorie vanuit diverse temas ten einde bloot te lê hoe die roete van die stelsel, asook wie daaruit voordeel trek en wie daardeur uitgesluit word, vooraf deur die ‘versteekte’ aangesigte van mag (verskans in ‘stelselgeheue’ en bekragtig deur instansies) bepaal word. Hierdie temas sluit in die ekonomie van konsolidasie, innoveringsteorieë, patentkwessies, Suid-Afrikaanse beleidsdokumente, internasionale verdragte en ooreenkomste, stelselteorie en kompleksiteitsdenke, sosiale leer, industriële en agro-ekologiese boerderymetodes, landbouproduktiwiteit en klimaatsverandering. Die studie bevorder sosiale leer as ʼn hulpmiddel wat die potensiaal vir die saadstelsel om tot die dringende uitdagings vir Suid-Afrika ten opsigte van die verlies aan biodiversiteit, voedselonsekerheid en klimaatsverandering by te dra, kan ontsluit.

Sleutelwoorde: saadstelsel, geneties gemodifiseerde saad, hibriede saad, saadpatente, saad-innovering, sosiale leer, stelselteorie, kompleksiteitsdenke, konsolidasie van saadbedryf.

ACKNOWLEDGEMENTS

This thesis would never have been completed without the help of my family and friends. The following people have my heartfelt thanks.

- My sister, Dr. Natalie Swanepoel, for her willingness to read and respond to all of my drafts, for her patient words of encouragement and advice, as well as cash flow support during the year!
- Tobi, for the millions of cups of coffee, delicious meals, listening to my thesis 'moans and groans', and the much-needed laughs in the last few months!
- My housemates, Andrew and Craig for bearing with me during this crazy and emotional experience. And, a special thank you to Kim for her patience, courage, creativity and humour this year.
- Sasha and Matt, for being an incredible source of inspiration and for kindly making the effort to read and comment on the final draft, even when out in the wild!
- Trish, Pat, Ruth, Anne, Haidee, Martine, Mary, and Francis for the constant support and encouragement that helped to keep me on the path towards completion.

I was privileged to be part of two learning groups during the process, one at the Sustainability Institute and the other at the Southern African Food Lab, and to all who took part in these processes, I thank you for your contribution to my thinking on this topic.

Thank you to Eve Annecke and Mark Swilling of the Sustainability Institute for offering the programme that they do, allowing people like me to believe in the power of change again. And, a special thanks to my supervisor, Luke Metelerkamp, for his patience and feedback, during a very busy year for him.

I thank Candice Kelly for her faith in me and hope that it has been justified. Finally, it is with much appreciation that I acknowledge the Southern African Food Lab for granting me the opportunity to discover social learning and I hope that I have been able to contribute through this study towards the fantastic work that they do.

This work is based upon research supported by the National Research Foundation (NRF).

Any opinion, findings and conclusions or recommendations expressed in this material are those of the author and therefore the NRF do not accept any liability in regard thereto.

Contents

LIST OF FIGURES

LIST OF TABLES

ACRONYMS & ABBREVIATIONS

CBD	Convention on Biological Diversity
GM	Genetically modified
GMO	Genetically modified organism
ITPGRFA	International Treaty for Plant Genetic Resources for Food and Agriculture
OPV	Open-pollinated varieties
SANSOR	South African National Seed Organisation
TRIPs	The Agreement on Trade Related Aspects of Intellectual Property
US	United States
WTO	World Trade Organisation

GLOSSARY

Agrobiodiversity: “The variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture ... It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals.” (FAO 1999).

Agroecological farming methods: Focus on efficient food production that does not damage natural resources. Practices include integrated pest and nutrient management, conservation tillage, agroforestry, aquaculture, water harvesting and livestock integration (Pretty 2006).

Biodiversity: “... the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems” (CBD 1993).

Climate change: In this context, it refers to long-term change in the earth’s weather patterns, primarily due to an increase in average atmospheric temperature.

Farmers’ Rights: The customary rights of farmers, recognised as the ‘guardians of agrobiodiversity, to save, replant and exchange seed. The International Treaty for Plant Genetic Resources for Food and Agriculture emphasises that governments have the responsibility for implementing and protecting these rights through protecting traditional knowledge, ensuring equitable participation in benefit sharing and decision making at a national level on issues related to the conservation and sustainable use of plant genetic resources for agriculture and food (ITPGRFA 2004).

Food Security: “Food security exists, at the individual, household, national, regional, and global levels when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for a healthy and active life” (1996 World Food Summit).

Food Sovereignty: “... the right of peoples, communities, and countries to define their own agricultural, pastoral, labour, fishing, food and land policies which are ecologically, socially, economically and culturally appropriate to their unique circumstances. It includes the true right to food and to produce food, which means that all people have the right to safe, nutritious and culturally appropriate food and to food-producing resources and the ability to sustain themselves and their societies” (NGO/CSO Forum for Food Sovereignty 2002).

Genetic modification: “Genetically modified (GM) foods are foods derived from organisms whose genetic material (DNA) has been modified in a way that does not occur naturally, e.g. through the introduction of a gene from a different organism” (World Health Organisation 2014).

Germplasm: The collection of genes within a plant species.

Hybridisation: The deliberate crossing of two genetically different individuals to create a new variety with the preferred traits of both parent lines.

Landraces: "A landrace of a seed-propagated crop is a variable population, which is identifiable and usually has a local name. It lacks 'formal' crop improvement, is characterized by a specific adaptation to the environmental conditions of the area of cultivation ... and is closely associated with the uses, knowledge, habits, dialects, and celebrations of the people who developed and continue to grow it" (Vetelainen & Negri 2009).

Introduction

"Seed is the self urge of life to express itself, to renew itself, to multiply, to evolve in perpetuity in freedom"

(Seed Freedom 2012: 324)

This study, titled *Seed politics: An exploration of power narratives in the South African seed industry*, and submitted in the format of two journal articles, attempts to unravel the contradictory forces shaping the current direction of the country's seed industry (Article 1: *Contesting consolidation of the South African seed industry*) and to explore spaces for system intervention that could allow alternate seed systems to emerge (Article 2*: Imagining a sustainable South African seed industry*). I propose to submit the articles to the Development Southern Africa journal, which focuses on publishing articles the generate debate around key development challenges and policy issues facing southern African countries. The Journal publishes peer-reviewed articles of up to 7 000 words, follows the Harvard referencing method and uses UK English spelling.

Article 1 examines how unequal, historic national and global power relations, entrenched in the country's legislative framework, institutions and international commitments around seed, inhibit policy attempts to create an inclusive, productive and sustainable agricultural industry. Power is understood as an unequal relationship based on institutional positioning and economic power and/or status, as defined and enacted within historical and cultural contexts (Roscigno 2011). Article 2 examines the assumptions on which the current system is based, in order to provide space for a new 'narrative' around seeds to emerge, motivating for a collaborative 'imagining' of a sustainable seed industry, based on a social learning approach. Areas of focus include dismantling and distributing power, re-imagining the farmer, co-creation of knowledge, innovation, and role of the state. In both articles, the complexity of seed systems is outlined providing a framework for understanding the interconnectedness of system elements, intervention points and potential for non-linearity. In the second article, points of possible intervention are identified and expanded on.

Seed is a contentious issue, on local and international platforms, and it is increasingly in the media spotlight due to concerns around the patenting of plant genes. Concerns range from the health implications of consumption of genetically modified food to the ethical considerations around ownership of living matter, and the implications for biodiversity loss and food security, particularly given the need for climate change adaptation. My personal interest in this topic stems from a fascination with seed, as a living organism that is capable of producing the food, fibre and fuel needed for human existence, while simultaneously possessing the means of its own reproduction. The recent merger of Pannar (South Africa's largest seed company) and Pioneer Hi-Bred (a fully-owned subsidiary of Du Pont) has resulted in two US-based companies (Pioneer and Monsanto) monopolising South Africa's commercial seed market with almost total ownership of the germplasm for the country's staple food crops, white maize and wheat. It is argued that this duopoly of germplasm ownership has negative implications for biodiversity and for food security, and limits the country's ability to adapt to or mitigate the effects of climate change.

Methodology

I have chosen to use a qualitative research design that relies on an extensive review of relevant literature and acknowledge that my approach is interpretive (Slotnick 2009), has a social justice focus and may be subjective (Traynor 2007), as it reflects my ideological stance (Chamberlain 2000). My ideological stance echoes my desire to be a transformative intellectual (Traynor 2007), by using what I have learnt through my studies to effect change through my work as a freelance writer, researcher and editor. In an attempt to counteract subjectivity, I have followed a disciplined and rigorous approach to documenting and reviewing the data collected throughout the literature review (Traynor 2007) and have ensured that literature has been drawn from a wide variety of sources (Mouton 2001). This has allowed me, using a 'pile-sort' technique, to explore the interconnection (Chamberlain 2000; Hayden 2006) and capture the complexities (Traynor 2007) of the political, social and economic paradigms that ground this particular topic. Using the thread of power to explore the many platforms on which the issue plays out, sources of literature cover a diversity of themes: economics of consolidation; patenting and alternative systems; national legislative and policy documents; innovation theories; international treaties and agreements; power relations; systems and complexity thinking; social learning approaches; industrial and agro-ecological farming methods; trends in the global and South African agricultural sector; biodiversity; climate change; agricultural extension; agricultural productivity; etc. The seed system is understood to be a complex system and the work of Paul Cilliers (1998, 2000) and Clayton and Radcliffe (1996) has been instrumental in my understanding and visualisation of seed systems.

South Africa is an outlier on the African continent in terms of its development path. The region was initially colonised as a settler community as opposed to an enclave community meaning that food production was of primary importance for the settled community. During the Apartheid era (1948-1994), the country was largely isolated from global trade, which influenced policy decisions around agriculture, among other industries. Following the implementation of democratic rule in 1994, the country's economy was suddenly exposed to international trends and influences, the most pertinent being globalised trade. As a result, South Africa has a distinctively different approach to seed and agriculture than other African countries. Most literature focusing on African seed systems, therefore, is not applicable to the South African situation. It was necessary to weave together 'grey literature' with information and statistics drawn from the annual reports and publications of organisations and institutions (such as Grain SA, Biowatch, Fertiliser SA, Statistics SA, African Centre for Biosafety, United Nations Food and Agricultural Organisation, AGRA, etc.) with the theoretical sources to uncover the linkages between power, consolidation and patenting, and the potential implications for biodiversity, food security and capacity to counteract climate change.

In addition to the literature review, six semi-structured interviews and email interviews were conducted to provide a sense of 'real-world' balance to the theory uncovered. The interviews focused on both direct and exploratory questions (Mouton 2001) that were clearly stated to elicit accurate responses (Hayden 2006), ones that provided in-depth reflections (Slotnick 2009). Choice of sources was delineated by the information uncovered during the literature review: the dualistic system of agriculture in South Africa and the vast differences between commercial and smallholder experiences, along with the entrenched power hierarchies that dominate the seed system. I therefore opted to interview representatives of power, those that spoke for the marginalised, and representatives of consumer interests and farmer organisations to gain a broad sense of power relations in the industry, as opposed to the individual experience of farmers. It is acknowledged that the limited amount of interviews (due to time constraints and distance) only give a 'flavour' to the theoretical base and this study is limited in its on-the-ground testing of the theories advanced.

<u>List of regional interviews</u>

Haidee Swanby	African Centre for Biosafety	Cape Town
Zayaan Kahn	Surplus Peoples' Project	Cape Town
Julian Jaftha	Chief Director: Plant Production & Health, Department of Agriculture	Pretoria
Johan de Lange	Chief Director: Products, KaapAgri	Malmesbury
Liesl Haasbroek	National Coordinator: Biodynamic Agricultural Association of Southern Africa	Stellenbosch
Rob Small	Director: Abalimi	Cape Town

I also attended a parliamentary briefing by the Department of Agriculture, Forestry and Fisheries, Trade and Industry Health, Rural Development and Land Reform and the Department of Science and Technology on the status of genetically modified food in South Africa on the 13 September 2013. Representatives of the above-mentioned departments presented on their involvement with genetically modified products and processes and were subsequently questioned by members of parliament. This meeting was a precursor to the public hearings on genetically modified organisms to be held later this year.

Limitations of the study include the lack of on-the-ground sources, which would have provided a real-life balance to the literature review. I also elected not to frame the research question in terms of seed security or seed sovereignty, which feeds into frameworks of food sovereignty or to confront the ethical and health issues surrounding genetic modification of plant germplasm. This was deliberate in that these terms and issues are emotionally laden and I wanted to explore power relations, and how individuals, communities and the South African state are all bound within complex systems, with sometimes limited space to manoeuvre. Challenges faced during the process include the multidisciplinary nature of the research question, as the theme of power crosses economic, environmental and social issues, and an in-depth knowledge of politics, economics and agriculture is needed for a full understanding of the topic. Despite these challenges, this study aimed to tease out some further lines of enquiry: the contradictions between legislative and policy direction; the need for up-to-date demographics on South Africa's farmers, including their reasons for farming; and the need for close examination of the ideological assumptions underpinning laws and regulations around seed in South Africa.

The personal journey undertaken during the write up of this study has followed a social learning approach, in that I have been fundamentally affected by those I have interviewed and the two 'study' groups I was part of at the Sustainability Institute and the Southern African Food Lab. I have had my assumptions and worldview challenged and transformed during the process. On completion of this study, I hope to return the gift I was given by contributing something of worth to those who fight against corporate ownership of the 'commons'. This study, while not neglecting the role of information and financial support and capacity building for successful sustainable agriculture, looks behind the scenes to explore the hidden faces of power, entrenched in historical and current hierarchies and institutions, which present a serious obstacle in this endeavour. It attempts to illuminate points of intervention in the seed system, which, using a social learning approach, could unlock the potential of the seed industry to contribute to issues of national import, such as biodiversity, food security and climate change.

Contesting consolidation of the South African seed system

INTRODUCTION

This paper contests the credibility of corporate consolidation of the South African seed system on the basis that it is inappropriate given the country's challenges around biodiversity loss, climate change adaptation and food insecurity. Not only is it an inappropriate response, but it runs contrary to the progressive ideals of resilience, inclusivity, increased productivity and sustainable agricultural practices, which are outlined in the relevant South African government policy (DoA 2002; DEAT 2008; NPC 2011; DAFF 2012). Seed, in combination with fertiliser and irrigation water, plays a primary role in agricultural viability (FAO 2010; Baxter 2012) and, as such, the system through which it is bred, multiplied and distributed deserves critical analysis.

South Africa faces particular developmental challenges. These include:

- High levels of food insecurity, roughly 13 million people in 2013 (Shisana et al. 2013) with high malnutrition rates in one of five children, resulting in lowered adult productivity (NPC 2011).
- Predictions that changes in climate could result in a 30% decrease in production of the country's staple maize crop, among other crops, by 2050 (IFPRI 2012; Sasson 2012).
- Increasing biodiversity loss leading to ecosystem degradation (DAFF 2012), with the resultant implications for water generation and soil degradation (DEAT 2005).

The credibility of a seed system, one that serves South African citizens, can be judged on the following criteria: it provides good quality, appropriate (context- and cultural-specific) seed to farmers (at all scales of farming) (Venkatasen 1994; Almekinders 2000; Monyo et al. 2004), at the right time, in the right place and in the right quantities (Venkatasen 1994; Monyo et al. 2004). This paper argues that the South African seed system also needs to address issues of agrobiodiversity, nutrition, food security and climate change.

South Africa's corporate-dominated seed system, using patented seed technologies, cannot do this; a corporation's only mandate is to ensure a return on investment for its shareholders (Rusike 1995; Wield et al. 2010; Afari-Sefa et al. 2012). The 2012 acquisition of Pannar (South Africa's largest locally-owned seed company) by Pioneer Hi-Bred (a fully-owned subsidiary multinational Du Pont), resulted in the dominance of the South African commercial seed market by just two US-based multinational corporations: Monsanto and Pioneer (Bernstein 2012). This seed duopoly controls about 90% of the commercial seed market (Stoddard 2011) giving them power to a large degree to determine seed access, type and cost in the country.

The structure of any seed system is not determined by a neutral process, but rather reflects a dominant political, economic and social narrative (Vanloqueren & Baret 2009; Scoones & Thompson 2011; Van Zwanenberg et al. 2011). The narrative of South Africa's seed system has been shaped by particular historical forces (colonisation, Apartheid, democracy) (Tansey 2011; Mayet 2012; SSA 2012; O'Laughlin et al. 2013), is influenced heavily by globalisation and international regulations and institutions, and benefits a particular group of stakeholders (Tansey 2011).

In this paper, seed's importance is highlighted, the complexity of the seed system unpacked and a description of seed system elements given to provide a context for the South African seed system. This system, with its historical and current drivers, is expanded on before the inherent contradictions between corporate dominance of the seed system and government's stated desire, in policy documents, for an inclusive, sustainable and productive agricultural system are unravelled.

THE IMPORTANCE OF SEEDS

Seeds' expression in plant life, located in healthy ecosystems, provides provisioning, regulating, cultural and supporting services (Fazey et al. 2007; Hozman 2012; Tengberg et al. 2012). The cultivation of food falls within provisioning services, while degradation of regulating and supporting services undermines food production services (Raudsepp-Hearne et al. 2010). The interdependence of differing ecosystems contributes to the efficient functioning of 'meta'-ecosystems at a landscape level (Quijas et al. 2012) determining regional biodiversity levels (Perfecto & Vandermeer 2010). South Africa's 2005 National Biodiversity and Strategy Plan emphasises that scientific research and understanding should encompass this landscape level of diversity to manage better the impact of human activities on the environment (DEAT 2005).

Seed, as a primary input into agriculture (FAO 2010; Baxter 2012), plays a pivotal, linked role in assuring both agrobiodiversity and food security. These are explored further below.

SEED, BIODIVERSITY CONSERVATION & FOOD SECURITY

Biodiversity, the entirety of plant varieties and animal genetic life found on earth (DEAT 2005; Driver et al. 2005) sustains the health of humans (Kerssen 2010; Kloppenburg 2012). Domesticated food crops have been carefully bred from wild species (Altieri 1999) with their continued existence "underpinned by a reservoir of genes present in a much larger number of related wild species" (Murray 1995:22). Sustainable development is not possible without effective management of biodiversity (Driver et al. 2005), as it underpins the South African economy and human wellbeing (DEAT 2005). In the context of this paper, reference made to agrobiodiversity refers specifically to food plants, as expressions of seed, both cultivated and wild, while germplasm refers to the collection of genes within a plant species.

South Africa is food secure at a national level (SSA 2012), sometimes at a community level, but not at a household level (Du Toit 2011; SSA 2012; Drimie & McLachlan 2013; Shisana et al. 2013), with a quarter of the population (roughly 13 million people) hungry on a daily basis (Shisana et al. 2013). Food insecurity in South Africa is increasingly understood as a poverty problem opposed to a productivity problem (SSA 2012; Shisana et al. 2013). Price increases arising from volatile commodity speculation, climate change, deepening levels of poverty (Foley et al. 2011; Drimie & McLachlan 2013), rising input costs (SSA 2012), and constrained production environments (soil degradation) (DEAT 2005) threaten the country's food security.

Climate change & agriculture

Global climate shifts are likely to be the biggest external driver of ecosystem change over the next century (De Schutter 2011; Hozman 2012). South Africa is predicted to experience a shift in rainfall intensity, duration and location, along with a 1°C increase in temperature along the coast and 3°C increase in the interior of the country (DEA 2011; IFPRI 2012). This has negative implications for farmers' ability to maintain agrobiodiversity levels (DEA 2011; De Schutter 2011) and maintain or increase food production (De Schutter 2011; Maponya & Mpandeli 2012; Sasson 2012), particularly in rainfed production areas, with medium-to-high yield areas particularly under threat (DEA 2011; IFPRI 2012).

Developing the robustness and resilience of the agricultural sector to climate change is important for food security purposes (FAO 2010; DEA 2011; De Schutter 2011; Foley et al. 2011; Kopainsky et al. 2012; Maponya & Mpandeli 2012). Resilience in this sense is understood to be "...the ability to absorb disturbance, to be changed, then to re-organize and still have the same identity" (Wahl 2011:42). Maintaining species diversity builds resilience in mitigating risk from extreme weather events as well as new pest, weed and disease vectors (UN 2009; Goldblatt 2010; DEA 2011; De Schutter 2011; Maponya & Mpandeli 2012; Shiva 2012; Barthel et al. 2013; Srang-iam 2013).

Thus, agrobiodiversity, dependent on healthy regulation and supporting ecosystem services, including at the 'meta'-ecosystem level, as well as availability of and access to diverse seed types, of both wild and cultivated plants, plays a role in building the resilience of the agricultural sector to climate change, which is seen as a threat to food security.

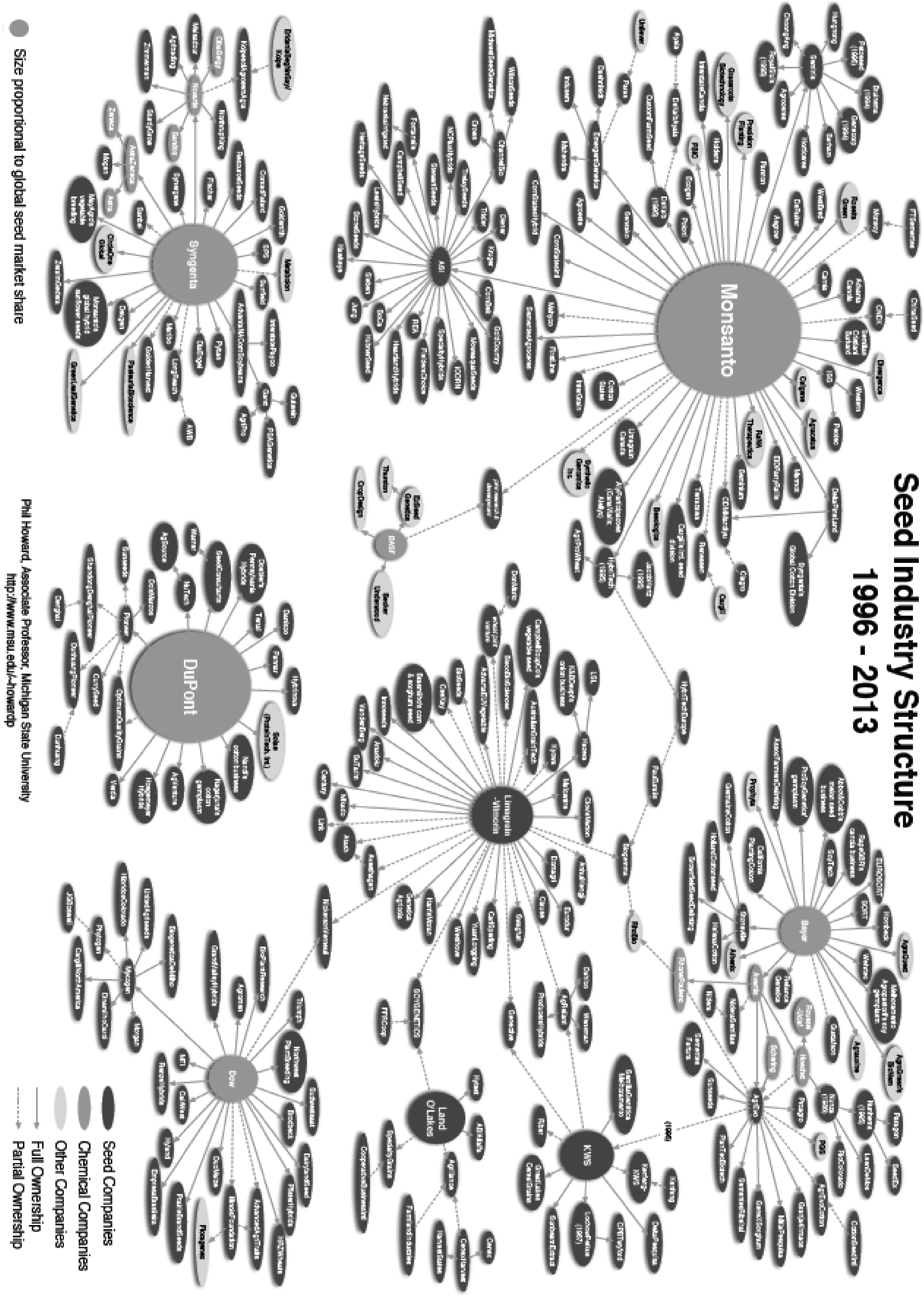
Seed, the farmer & the corporation

Seed, occupying a unique position as the 'platform for techno-economic transformation' of agriculture (Rangnekar 2001; Howard 2009), is perceived as the ideal vehicle for selling proprietary genetic traits (Brahy 2009; Wield et al. 2010; Moss 2011; Fulton & Giannakas 2012), as it has a captive market (the world's farmers) and an established distribution network (Moss 2011). The embedded intellectual property in each seed can be charged for repeatedly, without re-investment in initial research, development and regulatory costs (Fulton & Giannakas 2011). These can range up to $100 million for transgenic traits (Eicher et al. 2006; Moss 2011; Galushko 2012), and US$4 million for regulatory approval of a single event (Eicher et al. 2006). In contrast, it costs about US$1 million to develop conventionally bred hybrids (Shand 2012). Beyond this, seed offers corporations opportunity to capture revenue deriving from complementary sales of chemical products (Wield et al. 2010). An obstacle to recouping and making a return on this type of investment is seed's ability to self-reproduce and farmers' ability to save and exchange seed. These are overcome with biological means, as hybrids do not breed true, and intellectual property rights protection (Howard 2009).

Farmers need quality, affordable, appropriate seed (Venkatasen 1994; Almekinders 2000; Monyo et al. 2004; FAO 2010; Baxter 2012; Kopainsky et al. 2012), at the right time (Venkatasen 1994; Okry et al. 2010) and in particular quantities (Venkatasen 1994). A number of attributes contribute towards a farmer's decision to buy seed: input costs and yield potential as well as intangible attributes, such as trust in the seller before committing to buying seed (Kopainsky et al. 2012). For this reason, farmers prefer to see the seed perform in local environments, under local management practices and input restrictions (Thiele 1999; Almekinders 2000; Jones et al. 2001; Monyo 2004; Setimela 2004; Lwoga et al. 2011).

By end-2012, the global commercial seed market was estimated to be worth US$45 billion with South Africa's market share at US$428 million of that (ISF 2012). On a global level, the top 10 commercial seed companies control close to 75% of the market (Mooney 2012; Hubbard 2013), in contrast to 50% in 2005 (Barker 2007). The top six's relative global market share is depicted in the following figure.

Figure 1: Seed industry structure 1996-2013



Source: Howard, P. (2013). Seed industry structure

In the 1990s, South Africa's formal seed industry consolidated around six companies (Pannar, Sensako, Asgrow, Ciba Geigy, Saffola and Cargill) who went onto to merge or acquire each other

(ACB 2011). Pannar (acquired in 2012 by US-based Pioneer Hi-bred, a DuPont subsidiary) is the largest in the country and Monsanto is the second (through acquiring Sensako in 1999 and Carnia in 2000) (Bernstein 2012).

The needs of corporate seed companies and farmers do not align. The deliberate attempt on an international level to shape the regulatory and legislative environment surrounding seed breeding, saving, propagating, multiplication and breeding to the benefit of private business constrains the informal market and does not serve the needs of farmers.

SEED SYSTEM DESCRIPTION

The seed system is an open system, which is influenced by other systems (such as ecological, economic, social and political systems). These systems operate at a variety of scales interacting dynamically making policymaking and governance challenging (Hammond & Dube 2012). There is a need for a systems-thinking approach based on an understanding of complexity that takes into account this dynamic interaction, feedback loops and 'counterintuitive' system behaviour (Hammond & Dube 2012).

THE COMPLEXITY OF SEED SYSTEMS

Complex systems share several primary common characteristics, regardless of their operating environment or physical, social or economic context. These are:

- Many dynamically interacting elements operating in an open system (Cilliers 1998).
- Asymmetrical relationships that can be regulated determining system trajectory (Cilliers 1998).
- Non-linear effects emerging from element interaction (Cilliers 1998).
- System at stability but not equilibrium (Cilliers 1998).
- Thresholds, that if manipulated can change the behaviour of the system (Cilliers 2011).
- The starting condition of a system determines future paths and possibilities through the history that the system retains as memory (Clayton & Radcliffe 1996; Cilliers 2000).

It is clear, using these characteristics as a guideline, that seed systems are complex systems. There are a large number of dynamic elements at play, as the seed system comprises both organisational and institutional components; their interaction determines breeding, multiplication, supply and use of seed as well as distribution (Thiele 1999), and the system includes formal and informal elements (Scoones & Thompson 2011). Seed systems differ according to country and cultural contexts (Thiele 1999; Almekinders 2000).

Asymmetrical relationships, entrenched in legislation and policy, affect the robustness of the system (Venkatesan 1994) and can determine seed security levels (based on the pillars of availability, access and quality) (Scoones & Thompson 2011). As complex systems, seed systems have thresholds; once resource limits have been breached within ecosystems, there is a risk of sudden declines in food production (Perfecto & Vandermeer 2010; Raudsepp-Hearne et al. 2010; Hozman 2012; Tengberg et al. 2012), increased disease transmission and the proliferation of new pests (De Schutter 2011; Hozman 2012). These comprise some of the negative non-linear effects that can occur from isolated interventions into complex systems (Weston 2012). Non-linearity can also lead to increased system resilience.

FORMAL AND INFORMAL SEED SYSTEM ELEMENTS

Formal and informal elements within the seed system display markedly different characteristics, serve different purposes (Okry et al. 2010), and are themselves sub-systems.

THE FORMAL SYSTEM

A formal seed system comprises intensive research, development, and regulated seed production and distribution (Thiele 1999; Almekinders 2000; Mayet 2012). Elements include formal breeding stations, commercial seed growers, gene banks, and agro-dealers and distributors (Scoones & Thompson 2011), as well as seed certification and quality control organisations (Venkatesan 1994). In South Africa, examples of these include companies such as Monsanto, its subsidiary Sensako, as well as private companies, such as KaapAgri, and the state-subsidised Agricultural Research Council, which is also funded by private sector work. An example of the formal system at work in the Western Cape wheat industry is given below.

> *KaapAgri procures from Sensako foundation seed under licence. Sensako breeds spring cultivars specifically for the Western Cape. Selected farmers are contracted* [by KaapAgri] *to grow out and multiply the* [hybrid] *seed following strict quality and operational standards, including which and how much pesticides and fertilisers to use. Once production quotas are filled, the seed is delivered to a seed plant where it is cleaned, treated and bagged. The in-house* [KaapAgri] *seed inspector is qualified to certify the seed for sale. Payments to contractor farmers are linked to the SAFEX wheat index so when the wheat price is down, farmers are paid less. Other costs to KaapAgri include the cleaning and treatment of seed, royalty payments to Sensako and capital costs of machinery and so on.*
> (Johan de Lange, Production Manager, KaapAgri, 2013)

THE INFORMAL/FARMER SYSTEM

The informal system is driven by on-farm seed saving and unregulated production and distribution (Thiele 1999; Scoones & Thompson 2011; Mayet 2012) with farmers often doing their own research and development (Venkatesan 1994; Almekinders 2000). This locally organised and integrated system (Mayet 2012) disseminates into the broader system (Scoones & Thompson 2011; Mayet 2012), including household and farm seed saving, farmer networks of gift, exchange and local markets (Almekinders 2000; Scoones & Thompson 2011; Mayet 2012).

> *In South Africa there is little heritage seed and people access seed in a variety of ways – they buy it, they save it, they get some from granny. In Venda, there are seed blessing ceremonies. People go to the chief's house to bless the seeds and plant a big garden at the chief's house – the ceremony serves for community cohesiveness, in-situ seed bank, a safety net of food and it has spiritual connotations.*
>
> (Haidee Swanby, African Centre for Biosafety, 2013)

Both the formal and informal can co-exist across all scales of farming. In South Africa, many commercial farmers are saving and replanting seed, purchased every few years from the formal sector. The South African Seed Organisation (SANSOR) estimates that close to 85% of soya beans (genetically modified (GM)) are planted with farmer-saved seed (SANSOR 2013) and Johan de Lange of KaapAgri (De Lange 2013) estimates that nearly three quarters of wheat farmers in the Western Cape save and replant their hybrid wheat seed. Cost is often a barrier to purchasing seed from the formal sector, but the trade-off in cost may result in a trade-off in quality (Nordhagen & Pascual 2013).

COMPLEMENTARY SYSTEMS

These systems should be supported and managed as complementary systems (Almekinders 2000; De Schutter 2011). There is a perception that the informal sector is disorganised and low tech (Venkatesan 1994) and generally unable to contribute towards food security through the provision of good quality seeds (Thiele 1999; Scoones & Thompson 2011), as distributed seed is often unmodified seed from previous harvests (Martens & Scheibe 2012), with limited opportunity for the generation of new germplasm (Thiele 1999). Seed supply from this market can also suffer due to inadequate knowledge around seed production and storage techniques (Afari-Sefa et al. 2012). For this reason, intervention efforts by international organisations and states often focus on the formal system (Thiele 1999; Scoones & Thompson 2001).

The formal sector specialises in the provision of quality seed (Almekinders 2000; Jones et al. 2001). However, it struggles in terms of diffusion, particularly to poorer farmers who cannot afford the input cost (Almekinders 2000); those reluctant to take the chance on unproven seed (Almekinders 2000; Jones et al. 2001; Kopainsky et al. 2012); and those in more remote areas (Almekinders 2000; Martens & Scheibe 2012). The formal market typically focuses on seed that offers a commercial incentive (cash and food crops) (Rusike 1995; Almekinders 2000), neglecting crops (such as millet, cowpeas and groundnuts (Rusike 1995)) that might play an important role in community food security (De Schutter 2011).

In most cases, the informal seed system is a resilient one that contributes to maintaining agrobiodiversity (Almekinders 2000; Scoones & Thompson 2011) providing a buffer against crop failure and drought through the rapid diffusion of seed (Thiele 1999; Jones et al. 2001), as breeding and diffusion are integrated functions carried out simultaneously in the informal sector (Thiele 1999). It is also often a more affordable option for farmers to access seed from this system (Nordhagen & Pascual 2013).

The formal and informal should be supported in tandem with the informal recognised as an important supplier of seed, allowing the formal system to concentrate on national seed supply (Almekinders 2000), while the informal (holding a diversity of varieties) contributes to agrobiodiversity and influences what is planted at farm level (Norhagen & Pascual 2013). If linked, they can create a ‘seed security blanket’ that is both responsive to farmer needs and contributes to building climate change resilience (Nordhagen & Pascual 2013).

AN OVERVIEW OF SOUTH AFRICA’S SEED SYSTEM HISTORY

Rusike (1995) outlines four stages of seed system development; South Africa’s system is in the mature stage with a highly developed legislative and regulatory seed framework. The four stages are outlined in the table below along with relevant descriptions of events during each period.

Table 1: The four stages of seed system development in South Africa

Introductory stage **Up to 1900s**	• Up to the early 1900s, the primary system for seed acquisition was farmer seed exchange (Venkatesan 1994; Rusike 1995; Kloppenburg 2012). • Colonial settler opposed to enclave economy led to the establishment of a domestic market and a focus on commercial food production (Zapiain 2008; Mayet 2012). • The seed industry was geared to serve this market's needs (Rusike 1995; Mayet 2012). • Stage characteristics: basic science base, rudimentary innovations, research and testing, organised selection, breeding and multiplication of seed (Rusike 1995).
Emergent stage **1900s-1930s**	• State-run experimental and research institutions were set up in early 20th century (Venkatesan 1994; Rusike 1995; Mayet 2012) to generate a diversity of food seed for farmers (Dillon 2005; Kloppenburg 2012). • State certification and quality assurance increased numbers of farmers buying from the formal system (Schenkelaars 2011). • Fertiliser, Seeds and Agricultural Remedies Act passed 907; Maize Breeders Association formed 1917. • Stage characteristics: public plant-breeding research, testing, varietal development and release of seed to farmers for multiplication (Rusike 1995).
Growth stage 1930s - 1980s	• During the 1940s, a Maize Control Board, official seed-testing laboratories, and Seedsmen Association were established (Zapaian 2008). • The Apartheid state structured and supported a dominant, large-scale commercial farming sector (white-owned) using 'green revolution' farming methods (Zapiain 2008; Satgar 2011). • The first private hybrid seed programme was established in South Africa in 1959 by Sensako (Rusike 1995). • Further regulatory measures were introduced with the Seeds Act (1961), Foundations Seeds Act (1961) (Rusike 1995) and Plant Breeders Act (1976). • Multinationals entered the country in 1963 with first strategic alliance between Pioneer and Pannar in 1968 (Rusike 1995). • Stage characteristics: private investment in seed breeding, research and development, growing, processing and marketing; use of genetic technologies; increased regulatory controls, including mandatory testing and certification schemes (Rusike 1995).
Maturity stage 1980s onwards	• International breakthroughs in genetics science allowed identification of specific plant inheritance traits and in vitro technologies laid the groundwork for GM organisms and seeds (Schenkelaars 2011). • Introduction of phytosanitary regulations (Venkatesan 1994). • By 1980, the entire commercial maize crop in South Africa (94% of total maize production) was planted to hybrids (Rusike 1995). • Functions of seed certification, laboratory seed testing and management of national cultivar trials had been transferred to private companies (Rusike 1995). • SANSOR was formed in 1989, the Agricultural Research Council in 1992. • Stage characteristics: appearance of new technologies and the institutions to protect investments in them (Rusike 1995).

Source: Adapted from Rusike's (1995) characterisation of seed system stages.

The interaction between farmers, state and private companies has shifted during each stage, as have power relations between the three groups. The relationship between farmers and state has moved from a synergistic one to one in which farmers have a more scientific, abstracted relationship with seed, as production becomes increasingly specialised (Brahy 2009; UN 2009).

Farmers were further distanced from seed with hybridisation, as the reproduction process was removed from their control (Kloppenburg 2012). The notion that farmers did not have the requisite levels of technical skills to adequately save, preserve and describe seed introduced a technical barrier to participation in the sector (Kokopelli 2012).

The South African state adopted the ‘green revolution’ philosophy of farming from the 1950s onwards and aggressively pursued this approach, which advocated the use of high-yielding hybrid seed varieties that responded well to irrigation, the heavy application of synthetic fertilisers and pesticides, and crops that could be densely planted and easily harvested by machine (Zapiain 2008). Agricultural marketing boards, state parastatals that operated from the 1940s up until 1990, provided essential farm inputs, along with information and marketing advice (Van Tilburg & Van Schalkwyk 2012). The focus on intensive farming, to secure food security for the nation during the years of economic sanctions, has resulted in a dualistic farming system in the country with a well-supported commercial farming sector servicing national food requirements and a relatively underdeveloped, unsupported smallholder and subsistence sector (DEA 2011; Satgar 2007; IFPRI 2012; O’Laughlin et al. 2013). This sector contributes 20% towards overall production (Hachigonto et al. 2013). Effects of South Africa’s ‘green revolution’, spread out over much of the country’s arable land, include increased soil salinisation and resistance to chemicals among pest populations (Zapiain 2008). Traditional crops were also sidelined, as ‘green revolution’ crops were those with commercial potential (Dillon 2005; Schubert 2005).

In contrast to the ‘green revolution’, which was primarily state-led, the ‘gene revolution’ is driven by multinational corporations (Zapiain 2008). A turning point for the global seed industry was the 1980 US Supreme Court ruling allowing patenting of plant genes (Barlett & Steele 2008). Field trials for GM food were initiated in 1992 in South Africa prior to the establishment of a legislative framework for these technologies – the GM Organisms Act was only passed in 1997, and the first lot of GM white maize (South Africa’s staple food) was released onto the market in 1998 (Zapiain 2008). In the period leading up to approval of the Act, more than 160 applications for field trials were approved with 45 trials having already taken place (Zapiain 2008). By 2013, 80% of white maize, 80% of soya bean and 90% of yellow maize was GM (SANSOR 2013), making the country the eighth largest in the world in terms of commercially grown biotech crops (Eicher et al. 2006; SANSOR 2013). It is estimated that 75% of all GM maize in the country originates from Monsanto (Mooney 2012), which is also responsible for 82% of field trials (Wield et al. 2010). Field trials for GM potato, cassava and sugarcane were approved between 2006 and 2011 (Daff 2013); these have not yet been approved for general release. South Africa is the first country in the world whose staple food supply - white maize – is predominantly GM (Eisher et al. 2006).

POST-1994 TO CURRENT

White commercial farmers controlled 86% of the country's arable land (Van Schalkwyk et al. 2012) while Apartheid policies confining black farmers to 'bantustans' with limited access to markets, let alone arable land, had devastated the African farming base and stripped households from agricultural and rural capital (DOA 2002; DEAT 2005; SSA 2012). This changed livelihood systems forever as households increasingly relied on non-agricultural sources of income to purchase food and a wealth of farming acumen was lost (SSA 2012).

> *Apartheid wiped out the intrinsic knowledge that one gets through living on the land. South Africa has a lot of existing agrobiodiversity, but lacks the knowledge on how to maintain it, use it, and multiply it.*
> (Zayaan Khan, Surplus People's Project, 2013)

The agricultural industry in South Africa was restructured just prior to the first democratic elections in 1994 (Venkatesan 1994; Van Schalkwyk et al. 2012) based on the assumption of the superiority of a free market system. Local agricultural marketing boards were dismantled with the implementation of the Marketing of Agricultural Products Act of 1996 (Satgar 2007; Van Tilburg & Van Schalkwyk 2012). The liberalisation of trade (Satgar 2007) and the removal of what had been an indirect subsidy to farmers had serious consequences for smallholder and emerging farmers (Van Tilburg & Van Schalkwyk 2012). By 2008, South Africa had become a net importer of food (Satgar 2007). Though support for large-scale commercial farmers was discontinued, this group continued to benefit from the entrenched benefits of years of state subsidisation, including access to quality infrastructure and accumulated commercial knowledge (Van Schalkwyk et al. 2012; O'Laughlin et al. 2013). It is argued that although policy documents speak to the need to assist the farming sector, in particular smallholder farmers, the unquestioned and unexamined assumptions underlying policy choices and regulation determine who benefits and who is excluded from the system (Van Schalkwyk et al. 2012).

REGULATORY AND LEGISLATIVE FRAMEWORKS INTRODUCED

The country's seed system does not operate in isolation; it is bound within a complex web of political, social and economic dynamics (Vanloqueren & Baret 2009; Scoones & Thompson 2011) and a broader framework of international agreements. Many of these agreements have a binding effect on signatories and increasingly limit state autonomy to make independent decisions (Phillips 2005).

Relevant treaties, to which South Africa is a signatory, include:

- Convention on Biological Diversity (1993).
- International Union for the Protection of New Varieties (1961).
- Agreement on Trade Related Aspects of Intellectual Property Rights (1995).

- The Draft Protocol for the Protection of New Varieties of Plants in the Southern African Development Community Region 2012 (if accepted).

On a local level, the Plant Breeders' Act of 1976 regulates the protection of new species, while policy documents that speak to food security and agrobiodiversity include:

- The Department of Agriculture, Forestry and Fisheries Strategic Plan (2012).
- The Integrated Food Security Strategy for South Africa (2002).
- The Department of Environment & Tourism's National Biodiversity Strategy and Action Plan (2005).

Plant Breeders' Act 1976 (Act no. 15 of 1976)

Passed in 1976 in South Africa, the Act provides a legal framework ensuring that private investment in plant breeding is protected and ensured of a financial return (DAFF 2011). It intended to provide stimulus to the industry by opening up access to high-quality new varieties (essential for increased productivity) and to export markets in which these modern varieties were in demand (DAFF 2011). Relevant elements include:

- Farm-saved seed from protected varieties could be used (related to Farmers' Rights).
- New varieties could be propagated from protected variety seed.
- Exchange of protected seed was forbidden.

Government has claimed that the lack of definition in the Act around the size and scale of farming enterprises as well as plant variety scope has led to 'abuse of the system' resulting in diminished investment in plant breeding of some varietals (DAFF 2011). An amended draft was circulated in 2011, proposing (DAFF 2011):

- The prohibition of propagation of vegetatively propagated crops.
- The prohibition of exchange of harvest material from such protected species.
- That post-harvest seed may no longer be used for saving, propagation or exchange.

Implementation of these amendments and enforced compliance would mean that farmers would no longer be able to save seed of protected varieties for replanting, even on their own lands. In other words, it would become illegal to save and replant seed. This is in direct contradiction to the traditional understanding that farmers, as the customary guardians of agrobiodiversity, have unrestricted rights to save, exchange and develop seeds (Wynberg et al. 2012), commonly referred to as Farmers' Rights or Farmers' Privilege. It must be noted that the Plant Breeder's Rights system is not in accord with the National Environmental Management Biodiversity Act of 2004 and the Conservation of Agricultural Resources Act of 1983 (DAFF 2011). The Department of Agriculture, Forestry and Fisheries acknowledges that the Act has had some unforeseen consequences, including increasing corporate ownership of genetic material, widening the potential for large-scale genetic erosion and weakening food security through biodiversity loss (DAFF 2011).

In South Africa, 60% of plant breeder's rights holders are European or American companies, presenting an asymmetrical power relationship (DAFF 2011), with the remaining 40% owned by local companies.

Grain SA, a voluntary organisation representing the interests of grain farmers in the country, has fought hard to protect the right of farmers to save seed, despite industry role players attempt to abolish this right (Grain 2013). One organisation trying to abolish these rights is the South African National Seed Organisation (SANSOR).

> *Brown bagging' and farmer retained seed remained a serious threat to ongoing research and investment in new variety development of open-pollinated crops such as soya beans, sugar beans and wheat as* ***companies were unable to recoup development expenses from sales*** [emphasis added]. *Sadly, compromised food security and increased imports would be the long-term consequence if no solution is found soon.*
> (John Odendaal, Chairman Agronomy Division, SANSOR Annual Report, 2013)

Private seed companies need to recoup the cost of and return on their investment. This puts them at odds with farmers, trying to reduce their increasing input costs and declining farm profits.

> *75-80% of wheat farmers in the Western Cape are still using farm-saved* [hybrid] *seed. They hold back 1-2% of their crop and either clean it themselves or bring it to KaapAgri for cleaning, treatment and bagging. The* ***cost of wheat seed would have to be substantially lower to get farmers to buy certified seed*** [emphasis added].
> (Johan de Lange, Product Manager, KaapAgri, 2013)

South Africa currently sits in a regulatory vacuum between the Plant Breeders' Act (1975), UPOV 1978 (both of which allow farmers their traditional rights to save and replant protected seed), and The Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs), which demands a plant breeders protection regime be put in place (it allows for a *sui generis* (of its own kind) regime) and the proposed harmonisation of SADC's plant variety protection laws, which automatically enforce UPOV 1991. These are outlined below.

International Union for the Protection of Variety Plants 1961

Initiated by six European countries, the International Union for the Protection of Variety Plants (UPOV) was established in 1961 to protect the interests of plant breeders (Galushko 2012). This system provides a *sui generis* form of intellectual property protection based on unique particularities arising from breeding and cultivation; varieties should be distinct, uniform, stable and novel (DAFF 2011). UPOV was updated in 1972 and 1978 and South Africa ratified UPOV 1978 in 1981 (WIPO 1981). This legislation introduced (DAFF 2011; Van Zwanenberg et al. 2011):

- Owner monopoly rights on commercial propagation and sale of registered varieties.

- Limited control for plant breeders over other uses of the plant:
  - Farmers could still multiply seed for their own use
  - Breeders could develop new varieties from the protected variety as long as repeated use was not made of the protected variety.

UPOV was further amended in 1991; South Africa has signed but not ratified the 1991 version. The 1991 version further entrenches protection of plant breeders' rights by (Anderson 2005; UN 2009; De Schutter 2011; Van Zwanenberg 2011):

- Extended protection of rights to exporting, importing and stocking of protected varietals, increasing the number of acts for which prior authorisation is required.
- Prohibiting breeding of new varietals from a protected variety.
- Entrenching the plant breeders' rights to royalty payments on the use of saved seed.
- Extending monopoly rights over protected varieties to 20 years for plants (from 15) and 25 years for vines (from 20).

UPOV 1991 restricts farmers' rights by removing the possibility for states to determine if farmers can exchange or sell seeds saved from the harvest of protected varieties (UN 2009; De Schutter 2011). It is also an exclusionary system, in that many landraces do not qualify for protection, as they do not meet the requirement for uniformity and stability (UN 2009; De Schutter 2011), thus depriving plant breeders of potential benefits (Brahy 2009). Opponents to this version attest that farmers' continued access to plant genetic resources is vital for maintaining agrobiodiversity levels and contributing to food security (Maathai 1998; Wynberg et al. 2012).

World Trade Organisation (WTO) members do not have to adhere to UPOV 1991, but they do need to put in place their own *sui generis* system that protects plant breeders' rights (De Schutter 2011). In many cases, developing countries do not have the resources (technical or financial) to draw up a customised system or are pressurised through trade and investment agreements to adopt UPOV 1991 (UN 2009; De Schutter 2011). In South Africa, the Department of Agriculture, Forestry and Fisheries openly acknowledges that they lack the capacity to deal with new breeding techniques, research and development, or follow amendments to legislation and international treaties (DAFF 2011). Yet, when it comes to the South African government's support for GM seed technology, the state and the GM industry claims one of the most stringent regulatory environments in the world (Parliamentary Hearings on GMO 2013). This despite contention from organisations such as Biowatch that there is a lack of transparency in the application process (Wynberg & Fig 2013) and the African Centre for Biosafety, who voices concerns around food safety testing protocols (ACB 2012).

DRAFT PROTOCOL FOR THE PROTECTION OF NEW VARIETIES OF PLANTS IN THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY REGION

In 2012, a draft protocol aiming to harmonise plant breeders' rights in the Southern African Development Community region was released. The protocol, applicable to all genera and species, would effectively supersede member state's national laws (SADC 2012). It entrenches the UPOV 1991 stipulations, and in some cases goes further, with mandated conditions (SADC 2012):

- Protected varieties may not be used for the production of another variety if production requires repeated use of the protected variety.
- Only subsistence (not smallholder) farmers may re-use protected seeds on their own holdings.
- The expiration date for protection is extended to 20 years for seeds and 25 years for vines (in line with UPOV 1991).
- Authorisation is required for production and reproduction, conditioning for purposes of propagation, offering for sale, selling or other marketing, exporting, importing and stocking for these purposes.

This protocol would effectively harmonise regional laws in line with UPOV 1991 and perceived benefits include sharing of resources and information, overcoming variations in standards around certification and quality control, as well as combined testing facilities (SADC 2012).

> [Private plant breeders] *will be able to register varieties at significant lower cost and within a shorter period on the regional level and can market seed in all participating countries.* [The South African state will benefit by] *participating in regional activities*. [South African farmers] *will have access to varieties registered on the regional list that are not on the South African varietal list.*
> (Joan Sadie, Registrar: Plant Improvement Act, Directorate: Genetic Resources, 2013)

However, critics of the protocol (a large coalition of 150 African non-governmental and farmer organisations) point out several issues, indicated below.

> *Civil society was not welcome to attend the discussions around this; however, industry was there presenting and in the negotiations, helping to write the law. Harmonisation is a nice way of undermining national processes. Countries should have the flexibility to craft their own seed systems and this protocol effectively disallows SADC member states the autonomy to choose a system best suited to their particular developmental context.*
> (Haidee Swanby, African Centre for Biosafety, 2013)

> *It is felt* [by farmers] *that the laws further support the understanding that this newer industrial method of agriculture is about making money and not about the wellbeing of the*

people or the environment as it severely limits the culture of seed saving, exchange and sharing and promotes the limitation of available agricultural crop varieties.
(Surplus People's Project 2013)

The issue at stake is not the intended collaboration, as South Africa, in conjunction with other African countries, should be thinking in terms of 'shifting seed landscapes' for climate change adaptation (Nordhagen & Pascual 2013). The diversity of environments in Africa, with its abundance of acclimatised crops, translates into a diversity of seed options as weather patterns change across the continent. The South African state stresses the need for cooperative partnerships with neighbouring countries for capacity building, research and training and information sharing (DEAT 2005) and this implies the need for robust mechanisms for exchanging genetic material at this level (Nordhagen & Pascual 2013). These partnerships must be based on cooperation and trust, not competition (FAO, Biodiversity International & Earthscan 2011) and transactions taking place on this transboundary level require management and policies that are aligned with relevant political and administrative capacity (DEAT 2005). What is at issue is the lack of participation by elements of the system that this harmonisation would affect – farmers at all scales and civil society. The protocol moves the conversation away from protection of Farmers' Rights, away from protection of indigenous knowledge and agrobiodiversity, and away from the need for localised seed systems to the exclusive focus on extended protection of intellectual property rights embedded in patented seed technologies, owned almost entirely by a very small handful of multinationals companies, which are headquartered in the US and European Union.

South African strategic plans, strategies and policies

South African citizens enjoy the constitutional right to sufficient food and water and a healthy environment that is protected for the benefit of present and future generations (RSA 1996). This is in conjunction with a policy emphasis on ensuring that all South Africans "attain universal physical, social and economic access to sufficient, safe and nutritious food ... at all times to meet their dietary and food preferences for an active and healthy life" (DoA 2002:6). Relevant policies, strategic plans and strategies present a background of interrelated external and internal factors threatening the country's levels of food security, agrobiodiversity and livelihoods. These factors include:

- Rising global food and crude oil prices (DAFF 2012; Goldblatt 2010; IFPRI 2013b).
- The global recession and deteriorating exchange rate (DAFF 2012; Goldblatt 2010).
- Potential climate change-induced natural disasters (DAFF 2012; IFPRI 2012).
- High levels of species extinction (Raimondo 2011; DAFF 2012).
- Ecosystem degradation (DEAT 2005).

Convention on Biological Diversity (1993)

The Convention on Biological Diversity (CBD) recognises the sovereign rights of states to protect their biodiversity and indigenous knowledge through regulating access to genetic resources and enforcing equitable benefit sharing as regards those resources (UN 2009; De Schutter 2011); however, there is an onus placed on creating conditions to facilitate such access on mutually agreeable terms subject to prior informed consent (DAFF 2011). The CBD has not generated sufficient benefits to fund biodiversity conservation, as per its original premise (Brahy 2009; De Schutter 2011) and does not take into account the unequal power relations that determine access or terms (Marchant 2007; De Schutter 2011).

> *Access to benefit sharing is complex, as it could be a national find, a communal resource. It would be better if payment towards benefit sharing went directly to a fund for development of heritage seed and towards research into indigenous and localised seed varieties.*
> (Haidee Swanby, African Centre for Biosafety, 2013)

A far more innovative system is outlined in the *International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)*, which grants national governments the role of realising farmers' rights (UN 2009; DAFF 2011), including the right to take part in national decisionmaking about the sector (FAO, Biodiversity International and Earthscan 2011). This follows a growing movement to recognise plant genetic resources as a common pool rather than property and the treaty offers a multilateral system facilitating access to plant genetic resources (Anderson 2005; UN 2009; De Schutter 2011; FAO, Biodiversity International and Earthscan 2011), while ensuring equitable benefit sharing (Anderson 2005; De Schutter 2011; FAO, Biodiversity International and Earthscan 2011). South Africa has not yet ratified this treaty (along with the US (Marchant 2007)). It has however drafted legislation with respect to access and benefit sharing through other legislation (DEAT 2005), such as the Biodiversity Act (2004); however these remain silent on the issues of farmers' rights and the ITPGRFA.

Agreement on Trade Related aspects of Intellectual Property Rights

TRIPs presents as an enabling, international framework to encourage and enhance investment, knowledge transfer and innovation (UN 2009; De Schutter 2011; Galushko 2012; Van Zwanenberg et al. 2011; Plomer 2013). Intellectual property rights, the capturing of the financial gains of innovation (Kolady et al. 2012), are perceived to provide incentives for innovation (UN 2009; Galushko 2012). TRIPs enforces minimum international intellectual property rights standards, irrespective of the state of country development, and is enforceable through the WTO dispute settlement system, backed up by the threat of retaliatory sanctions (Plomer 2013). It must be noted that the WTO presents asymmetrical power relations between industrialised and developing countries and its decisions in terms of trade negotiations and differential trade rules are often driven by corporate interests (Zapiain 2008).

TRIPs requires all WTO members to apply a minimum 20-year patent protection on all inventions (UN 2009). Hybrids, created through cross-pollination or genetic engineering of two varieties to produce a new one with specific traits such as hardiness for shipping, long-lasting etc, are considered a patentable ‘invention’ (NWFF 2010). Although protection is optional for plants and animals, WTO members must provide for the protection of plant varieties by patents or an effective *sui generis* system or combination thereof (Anderson 2005; UN 2009; Galushko 2012). South Africa signed the TRIPs agreement in 1995 and amended the country’s Patent Act (1978) in 2002 to bring it in line with TRIPs requirements (Graff 2007) for protection of GM seed. As TRIPs gives some leeway to member states to determine their own system, there is pressure on developing countries involved in bilateral or regional agreements to sign TRIPs-plus agreements; these agreements force (Rangnekar 2001; Galushko 2012):

- Implementation of UPOV 1991.
- Signing of the Budapest Treaty (allows the physical deposit of a microorganism sample as proof of invention for patent protection).
- Mandatory patent protection for biotechnological inventions.
- Compliance with the highest international phyto-sanitary standards.

South Africa, as part of the Southern African Customs Union, is part of a TRIPs-plus agreement (Galushko 2012). There are concerns that these agreements will primarily benefit rich countries, due to the imbalance in relationships between those who retain the knowledge and technologies and those who need to use them (Brahy 2009; De Schutter 2011; Plomer 2013). In addition, there are concerns that they might infringe on fundamental human rights to health, food and education in these countries (Cullet 2007; De Schutter 2011; Plomer 2013). As regards seed, Kloppenburg (2012) argues that the development of increasingly restrictive intellectual property rights legislation is a purposeful move to expropriate farmers’ access to seed reproduction. It must be remembered that the WTO does not have a mandate to consider the human right implications of the legal regimes they promote (Cullet 2007).

A credible seed system for South Africa

The complexity of international and national political, social and economic dynamics of a seed system must be taken into account when determining regulations (Vanloqueren & Baret 2009; Scoones & Thompson 2011; Van Zwanenberg et al. 2011) aiming to establish social justice and environmental stability (Van Zwanenberg et al. 2011). The future of the seed system depends largely on who is ‘writing’ the dominant economic narrative, as this shapes research and development direction (Vanloqueren & Baret 2009; Scoones & Thompson 2011; Van Zwanenberg et al. 2011); the lens through which the seed system is perceived (Vanloqueren & Baret 2009); and determines who benefits and who is excluded from it (Venkatesan 1994).

The state, according to national policy documents, wants an inclusive, sustainable and productive agricultural sector (DoA 2002; DEAT 2008; NPC 2011; DAFF 2012). It then needs to ask what kind of scientific progress should be promoted to bring about inclusivity, sustainability and productivity? What kinds of knowledge and technologies should be promoted? In other words, it is the kind of agriculture chosen that matters (UN 2009; Perfecto & Vandermeer 2010; De Schutter 2011).

This section examines the notions of inclusivity, sustainability and productivity. Inclusive speaks to farmer support; sustainable speaks to environmental, social and economic farming viability; and productive speaks to yield, continued innovation, research and development.

An inclusive seed industry

A credible seed system for South Africa needs to cater to a diversity of farmers operating at different scales, in vastly different microclimates, and under varying operating conditions.

Who are our farmers

There are just over 200 000 smallholders in South Africa (Du Toit 2011; DAFF 2012b; SSA 2012) and an additional 2.7 million households practicing subsistence agriculture (SSA 2012; O'Laughlin et al. 2013). These 200 000-odd smallholders support over a million family members and provide employment for a further 500 000 people (Du Toit 2011). This in contrast to just under 40 000 commercial farms (this sector has registered a marked decline from 60 938 in 1996 (Goldblatt 2010; Bernstein 2012; DAFF 2012b) to 45 818 farms registered in 2002 to 39 982 farms registered in 2007 (Agriseta 2010; Goldblatt 2010)). Already by 2002, just 673 farms were responsible for a third of total gross commercial farm income; most operated on more than one non-contiguous farm, they were owned by corporations, hired specialised labour (Bernstein 2012) and had increased their usage of irrigation, fertilisers, mechanisation and GM seed (Goldblatt 2010). The decline in farm numbers highlights a trend towards consolidation of commercial farming in South Africa (Goldblatt 2010; NPC 2011). Stressors for South African farmers include declining farm profitability, limited capital access, environmental degradation, variable rainfall, widespread poverty, uncertainties around land transformation (IFPRI 2012) and rising input costs (Goldblatt 2010).

South Africa's seed system operates from a dominant 'memory' of colonisation, Apartheid and neo-liberal globalisation economics (Tansey 2011; Mayet 2012). The emphasis as regards the seed system has been on providing support (economic, infrastructural, legislative, and research) for a 'modernistic' take on farming in terms of provision of hybrid and now increasingly GM crops, to be used in a system reliant largely on high use of external inputs (Tansey 2011).

Unlike other African countries, where the majority of seed (80%) is still held, grown and traded on the marginal periphery by smallholder and subsistence farmers (Barker 2007; FAO 2010; Scoones & Thompson 2011; Afari-Sefa et al. 2012; Mayet 2012), South African farmers (both commercial and smallholders) predominantly access seed from the formal market, even those commercial farmers who are saving and replanting seed. By implication then, private corporations control the type and quality of seed available to farmers.

SEED TYPE

The corporate seed system focuses on seed that will provide the best return on investment (Rusike 1995; Wield et al. 2010; Afari-Sefa et al. 2012). These are necessarily seeds that have embedded, proprietary knowledge that can demand a higher premium (hybrids or GM seed) (Wield et al. 2010; Afari-Sefa et al. 2012), seed purposely designed for once-off use (De Schutter 2011). This has several implications for South African farmers.

The commercial farming sector, facing rising input costs (Goldblatt 2010; SSA 2012), will need to reconsider the intensive farming practices aligned with the use of hybrid and GM seed, in order to remain profitable. Just as certain sectors are already starting to reconsider the high usage of other external inputs such as fossil fuels, fertilisers and pesticides (Metelerkamp 2011). However, as choice of seed diminishes on the commercial scale, this group of farmers might find themselves locked into a technological treadmill unable to transition to more sustainable farming methods (Sassenrath et al. 2008). Farmers may, of course, choose not to partake in the formal seed market, however any increase in production overall (through use of high-yielding seeds) lowers prices for all farmers as when supply exceeds demand, prices fall (Howard 2009). There is thus pressure to increase production to maintain farm income and to reap the benefits of economies of scale (Howard 2009; Barthel et al. 2013). In addition, those in this high-yield farming system may find themselves on other treadmills – increased pesticide use to counteract resistance in pest populations and increased synthetic fertiliser use to maintain soil integrity, degraded by previous applications (Howard 2009; Barthel et al. 2013). Commercial seed presents a further treadmill, as hybrid seed loses vigour the following season and GM seed is legally protected from replanting (Howard 2009), locking farmers in to buying seed each season (De Schutter 2011).

Farmers wanting to access the increasing premium organic and biodynamic markets struggle to find affordable bulk certified organic seed in South Africa (Haasbroek 2013). This seed needs to contain high levels of mineral efficiencies and display tolerance to stress and weed suppression traits, as well as being produced in line with organic farming principles (Phillips 2008).

> *Biodynamic and organic farmers cannot use GM seeds if they want certification... there are local suppliers* [of organic seed]*, but they are few... the cost of organic seeds compared to hybrid and GM seed is almost double.*
>
> (Liesl Haasbroek, Biodynamic Agricultural Association of Southern Africa)

The smallholder and subsistence farming sector would be better served by improved open-pollinated varieties (OPVs) (FAO 2010). OPVs do not require high levels of external inputs; are able to adapt over time to changing conditions (De Schutter 2011); are stable in low-yielding and stressed environments; and can be saved and replanted with limited loss in yields. For these reasons, the Food and Agriculture Organisation stresses the need for more research to be done around improving the quality of OPVs (2010). However, there is no money to be made from improving open-pollinated varieties, as there is limited investment return on the seed itself (Afari-Sefa et al. 2012), unless it can be hybridised (such as sunflowers and sorghum) or GM (such as soya bean, cotton and maize). South Africa's official variety list displays a shift from 16 hybrid maize varieties and 39 OPVs in 1964 to 284 hybrid varieties and 19 OPVs in 1993 (Rusike 1995) indicating a decreasing interest from the commercial market in these seeds.

> *Competitive open pollinated varieties are rapidly disappearing from view, since zero funds are invested into open pollinated longitudinal breeding improvements.* [The reason that some are] *available via mainstream seed merchants* [is that] *some African countries (who are more sensible than SA) do not want anything else.*
> (Rob Small, Abalimi, 2013)

If private breeding, protected by rigid regulations and intellectual property rights regimes, is encouraged at the expense of state support for a public sector seed industry, all scales of farmers will be left with less choice of seed and be forced to rely on commercial varieties (Schubert 2005; DAFF 2011). Decreasing choice of seed also affects South African farmers in terms of their market access. This is highlighted in a letter from Basil Kransdorff of Econocom Foods - producer of e'Pap, a maize and soya product fortified with 28 nutrients – to the Biodynamic Agricultural Association of Southern Africa. Kransdorff writes (BAASS 2013):

> *... new large opportunities are opening up to export across the world... We are now being asked for certificates for non-GMO of our product and have recently gone out looking for sources of non-GMO raw materials of maize and soya. We are now told that our whole food chain based on both maize and soya has been converted to GMO... the only way we can export... is to import non-GMO raw materials, which makes our product completely uncompetitive.*

Seed quality

Seed quality can be judged on its yield, taste, nutritional value, resistance to pests and diseases, and financial return from the crop. Quality seed can play a critical role in increasing productivity and food security as well as farmers income (Kopainsky et al. 2012), and the corporate system is undoubtedly capable of consistently providing quality seed (Almekinders 2000; Jones et al. 2001).

However, quality is multi-factored, it is not just a matter of yield or increased resistance to pests and diseases (NPC 2011; Shiva 2012); issues, such as food quality, nutritional benefit, distribution and environmental impact, also need to be considered (Royal Society 2009). The corporate system, with a primary focus on these points, does not adequately cater to these issues.

- Seed is often grown in standardised conditions very different to the environmental contexts in which many farmers operate (Almekinders 2000; NWFF 2010; DAFF 2011; De Schutter 2011).
- Nutritional content of seed is not a deciding factor for corporations on which seeds to breed (Phillips 2008), although malnutrition in children is a priority in South Africa (NPC 2011; Shisana et al. 2013). Indigenous vegetables reputedly have high nutritional content with increased levels of vitamins and minerals (Wynberg et al. 2012; Afari-Sefa et al. 2012; Tengberg et al. 2012; Drimie & McLachlan 2013).
- These indigenous vegetables and traditional crops, significant food sources in South Africa (Venkatesan 1994; Mayet 2012; Tengberg et al. 2012; Drimie & McLachlan 2013), are sidelined in the commercial seed sector, as they provide limited profit potential.
- Seed and culture are intertwined in many communities (Venkatesan 1994; DEAT 2005) and particular seeds have significance beyond their ability to produce plants for food (Phillips 2008; Shiva 2012). This intangible element of quality is not recognised in corporate breeding decisions.
- Taking all of the above into account, farmers, particularly smallholders and subsistence farmers, often cannot access quality seed of the varieties they desire (FAO 2010).

In conjunction with this, the increasingly consolidated supermarket system demands uniform products with particular traits, such as long shelf life, causing commercial farmers to produce according to these requirements, thus contributing further to the lack of incentive of breeders to focus on taste and nutrition (Weatherspoon & Reardon 2003). In contrast, an emerging interest in nutrition by consumers and at a global level by organisations such as the United Nations Food and Agricultural Organisation could shift the marketing strategies of companies. An example of such a shift is Nestle’s commitment to consumer education around nutrition and its reduction of public health-sensitive nutrients and inclusion of ingredients in its products with higher nutritional profiles (Nestle 2013). It is important therefore that seeds of this type – able to produce plants with high nutritional content - and the structures that support their proliferation are safeguarded.

Increasing seed industry consolidation has resulted in the closure of many local and viable seed supply systems (FAO 2010). Small-scale seed producers are adversely affected by consolidation, as they need to make investments and adopt new practices to ‘stay in the game’, including increased scale of procurement and compliance with prohibitive quality and safety standards (Weatherspoon & Reardon 2003). The greater the regulatory requirements are in an industry, the more concentrated it is expected to be, as costs become less prohibitive when spread out over increased product output (Fulton & Giannakas 2011).

The development of new, quality crop varieties with climate-ready traits will be important (DEA 2012; Kopainsky et al. 2012) and increasing monopolisation of ownership of quality seeds from the formal system places access to the required germplasm at risk, due to restrictive patenting regimes (Maathai 1998; Krattiger & Mahoney 2007).

A SUSTAINABLE SEED INDUSTRY

A credible South African seed industry needs to feed into a sustainable farming culture. It must support maintenance of agrobiodiversity, must ensure that cost of seed does not adversely affect farmers' ability to produce, and it must speak to the need for climate-ready seed.

IMPORTANCE OF AGROBIODIVERSITY

South Africa has a wealth of plant species (nearly 10% of the world's plant species (DEA 2011; Hachigonto et al. 2013) offering the potential for new crops and medicines (DEAT 2005). In 2010, the conservation status of all 20 456 taxa (including 13 265 endemic species) of indigenous plants was assessed by the South African National Botanical Institute (Raimondo 2011). Findings showed a 254% increase in threatened plant taxa from 1997 to 2009, with 13% facing extinction (Raimondo 2011). Besides the loss of genetic information that could be useful for plant breeding for climate adaptation, this has consequences for ecosystem functioning, in terms of clean water generation and soil health, as well as rural livelihoods (DEAT 2005). Subsistence harvesting, not necessarily a sustainable practice in itself, plays an essential part in livelihood strategies and health of the rural poor (DEAT 2005). Drimie and McLachlan (2013) contend that nutrient contribution of wild vegetables is underestimated as a food source in rural South Africa.

South Africa's agricultural sector is acknowledged as a prime driver of biodiversity loss negatively affecting all biomes and resident species when vegetation is cleared for crop production, (DEAT 2005; Raimondo 2011).

Genetically uniform seeds perform best under certain conditions (De Schutter 2011). These include monoculture-farming methods, which result in the number of margins being reduced and this, in turn, reduces the number of resident plant and animal species (Ericksen 2007; CGRFA 2010; Berhan et al. 2012; Ceccarelli 2012; Srang-aim 2013). The necessary synthetic fertiliser and pesticide inputs to realise high yields (Ericksen 2007; De Schutter 2011; Shiva 2012) contribute towards the creation of uniform soils and allow the dominance of genetically uniform species (Ceccarelli 2012; Barthel et al. 2013), as well as increasing pollution levels and contributing to soil loss (Ericksen 2007). This has negative implications for food security (FAO 2010), as it will lead to a loss of traditional varieties (DAFF 2011).

Seed biodiversity is relevant to farmers as it provides information value (resistance to pests, disease and drought) (Rangnekar 2001; Brahy 2009; Gonzalez 2012) and insurance value in that there are a variety of productive assets available during times of climatic stress (Brahy 2009; Gonzalez 2012). These are relevant factors for breeding plant varieties with desired characteristics (such as drought, heat and salinity tolerance) (Gonzalez 2012). It is also very much in the interests of corporate seed companies to keep this genetic diversity available, as they require these plants as genetic raw material (Brahy 2009; UN 2009; CGRFA 2010) - the system requires an annual injection of 7% new genetic material (Brahy 2009).

Reliance on external inputs and risk

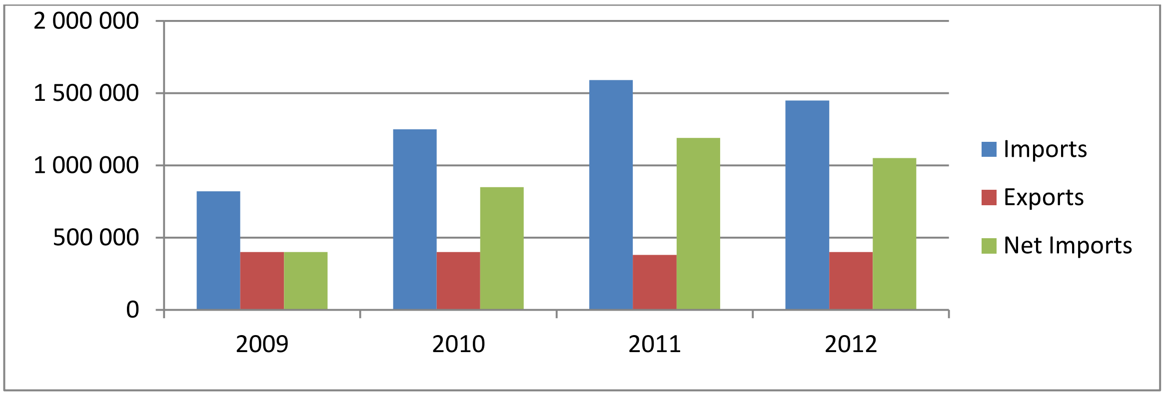
Farmers do need fertilisers, as South Africa's diverse soil types are thin (DEA 2011), lacking in nitrogen and phosphorous and susceptible to degradation (DEA 2011; Gilbert 2012; Sasson 2012). Synthetic fertilisers are one solution to maintaining yields under these conditions; half of the gains in crop yields since the 1940s have been through increased fertiliser use in conjunction with mechanisation, irrigation and use of proprietary seed (Goldblatt 2010), but these create challenges, placing farmers at risk. Promoting corporate-owned proprietary seed creates a dependency on the external inputs (Barker 2007; UN 2009; De Schutter 2011; Wynberg et al. 2012) required to unlock full yield potential (De Schutter 2011). Seed is increasingly bound to agricultural practices that promote topsoil depletion, monocultures, high fossil fuel and water consumption, and contamination of ecosystems (Howard 2009). This has implications for all scales of farmer, as any dependency on external inputs adds to the risks (Goldblatt 2010) and costs of farming (UN 2009; De Schutter 2011).

Fertilisers

Following deregulation of the agricultural industry in the 1990s, local fertiliser production slowed down and by 2000, South Africa was importing 70% of its fertilisers and pesticides (Agriseta 2010; Bernstein 2012). The radical 200% increase in cost of fertiliser between 2006 and 2008 (global demand for fertiliser outstripped supply in 2008 driving up prices (Goldblatt 2010)) highlighted the risk of being dependent on the volatile agrochemical industry (Agriseta 2010; Scoones & Thompson 2011; Bernstein 2012) and subject to fluctuating exchange rates (Agriseta 2010; Goldblatt 2010). And in South Africa, despite a 6.1% dip in imports in 2012, the cost of fertiliser increased by 8.5% from R5.4 billion in 2011 to R5.8 billion, with buyers paying R3 875 per ton in 2012 (Mostert 2013).

The figure below shows the marked increase in fertiliser imports from 2009 to date.

Figure 2: Fertiliser volumes imported and exported 2009 – 2012 (tons per year)



Source: Adapted from Fertilizer Society of South Africa www.fssa.org.za

This has direct consequences for all farmers reliant on use of synthetic fertilisers as rising input costs versus stable crop prices reduce margins for profitability (Grain 2013).

PESTICIDES

Corporate seed companies claim that GM crops will require less pesticide use, thus lowering costs for smallholder producers and reducing the risk to health (IFPRI 2013). However, there is often a need for additional pesticide use, as crops with pesticide or herbicide tolerance can encourage indiscriminate spraying (Goldblatt 2010), and resistance to particular products can encourage the emergence of superweeds (Goldblatt 2010). In South Africa, emerging farmers are being encouraged to adopt or increase their pesticide use in order to enter commercial agricultural production (Rother et al. 2008). Atrazine, a pesticide and herbicide residue affecting prenatal and early childhood growth and rendering amphibians sterile, has been found in surface and groundwater samples in South Africa's maize production areas (Goldblatt 2010).

WATER

South Africa is a water-scarce country and, given climate change scenarios, is likely to become more so (Agriseta 2010; DEA 2011; Goldblatt 2010; NPC 2011; IFPRI 2012; Hachigonto et al. 2013). Already over 60% of water in South Africa is used for farming (Bernstein 2012). In the 12% of the country that supports production of rainfed crops, changes in rainfall patterns will directly affect farming viability (Goldblatt 2010; Hajkowicz et al. 2012; IFPRI 2012; Hachigonto et al. 2013). Currently there are 1.3 million hectares under irrigation (Goldblatt 2010; Kirsten et al. 2010; Hachigonto et al. 2013) with limited potential for expansion as irrigation in unsuitable areas leads to soil salinisation restricting crop choice to salt-tolerant varieties (Goldblatt 2010). The proposed changes to South Africa's water legislation published for public comment in August 2013, indicate that farmers will need to justify water allocations and will no longer be able to keep or trade water not used in the prescribed period (NWA 2013).

Reliance on seed that is in turn reliant on regular and high amounts of a scarce resource has negative implications for yield productivity and farming financial viability (Foley et al. 2011;

Scoones & Thompson 2011). Farmers will need a diversity of seeds that have drought tolerant traits (Kerssen 2010) and that can adapt over a few planting seasons to a changing microclimate. OPVs fulfil these requirements and contribute towards building resilience against climate change impacts, including new pest and disease vectors (UN 2009; De Schutter 2011).

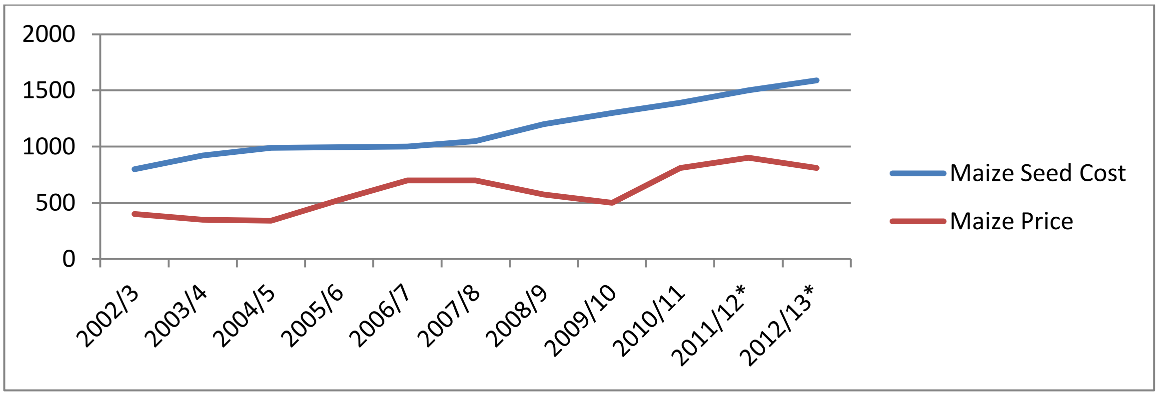
The current corporate dominated structure of the seed industry with its focus on proprietary seeds that require complementary inputs to produce promised yields does not encourage the emergence of desired agro-ecological farming system, as outlined in the 2009 International Assessment of Agricultural Knowledge, Science and Technology for Development report (IAASTD 2009).

SEED COST

The cost of seed as a necessary input for agricultural viability has different implications across the varying scales of farming. Seed makes up a substantial portion of input costs (up to 50% in some cases) for smallholders and subsistence farmers (Mayet 2012), increases in price could negatively affect food production or farming viability. For these farmers, use of formal seed only provides a good economic return when it can be multiplied, saved and distributed on farm (Thiele 1999; Almekinder 2000). As hybrid seed and GM seed is designed for single use, dependence on this system places these farmers at financial risk along with the additional costs of required external inputs (De Schutter 2011).

In the commercial farming sector, seed as an input cost has risen by 12% between 2011 and 2012 to make up 3.5% of the total cost of farming (SSA 2012). Seed prices have been rising at an average of almost 18% a year for the last decade; this is close to triple the average consumer inflation rate for the period (Stoddard 2011). Stoddard (2011) credits this to the increasingly consolidated nature of production and distribution channels. Any increase in cost, for example, due to the desire of the seed company to recoup its sunk costs (Fulton & Giannakas), has a dramatic effect on the viability of these types of farming operations. This in combination with a 12.9% increase for fuel, 29.2% increase in water cost and 43.8% increase for electricity cost from 2011 to 2012 (SSA 2012) makes it increasingly difficult for commercial farmers to remain viable. Increased costs for farming contribute to higher food costs with dire implications for the most vulnerable and food insecure (Raudsepp-Hearne et al. 2010; Stoddard 2011). Grain SA has raised concerns about the increasing price of seed within this sector (Grain 2013). The figure below indicates the increasing margin between the price of maize seed and the producer price and maize is not the only crop in which seed has shown a marked increase. In 2012/13, seed costs for soybean rose by 9.6% and sorghum by 8.4% (Grain SA 2013).

Figure 3: Indices of the price of maize seed and the producer price of maize (2002/3-2012/13) (R per ton)



*Preliminary figures
Source: Adapted from Grain SA: http://www.grainsa.co.za/upload/GSA_JV_Insetnavorsing_en_ontwikkeling.pdf

When concentration reaches a certain level, multinational corporations stop competing on price (Howard 2009). The cost difference for GM maize seeds for sale in South Africa and US, as depicted in the table below, is explained by seed producers as due to (Grain 2013):

- Higher costs in South Africa for research and development.
- Lack of competition from other GM seed companies.
- Lack of economies of scale in terms of markets.
- Multiplication takes place under irrigation and is a distance away from markets, driving up costs.

Table 2: Seed cost comparison between South African and United States maize producers 2012

	United States	**South Africa**
Popular Cultivar	Seed Costs (3 GMO genes)	Seed costs (two GMO genes)
Per 80 000 kernels	R1 824.00	R2 580.00
Per 1 000 kernels	R22.80	R32.20

Source: Grain SA

It is unlikely that this technology will become more accessible in terms of cost to South African farmers and we need to question the wisdom behind supporting its large-scale entry into the seed system.

A PRODUCTIVE SEED SYSTEM

A credible seed system should boost the productivity of the South African agricultural sector, which lags behind the industrialised world due to diminished investment into research and development (AU-NEPAD 2010; Ramaila et al. 2011), differences in capital and land access (Ramaila et al.

2011), the cost of innovation, and market domination by established business (AU-NEPAD 2010). Productivity can be defined as “the ratio of agricultural outputs to agricultural inputs” (Ramaila et al. 2011:12) and calculated using a multifactor or total approach, which takes into account a subset of inputs or, as is often the case, using a partial approach focusing primarily on yield (Ramaila et al. 2011). Sustainable productivity speaks to yield, continued innovation, research and development.

The yield benefit and risk factor

When yield is regarded as the only measure of farm productivity, factors such as energy efficiency, varied production and maintenance of biodiversity are ignored (Perfecto & Vandermeer 2010), as is nutritional content (Afari-Sefa et al. 2012; Sasson 2012; Shiva 2012). Biofortification of GM crops with micronutrients is proposed to counter the nutrition criticism, however this does not address the issue of biodiversity loss or the monopolisation of genetic plant material in the hands of multinational corporations. Even though there is a need to increase yields in Africa (Venkatesan 1994), in terms of long-term sustainability of agriculture, the manner in which they are increased is as important. Some argue that building this long-term stability and resilience is even more important than maximising yields (IAASTD 2009; Berhan et al. 2012).

The push behind hybrid and GM seed use is the promised potential for higher yields (Galushko 2012). However, the benefits of yield increase can easily be offset by increased prices of required inputs (De Schutter 2011; Wynberg et al. 2012) and yield loss from hybrid seed can be substantial (Jones et al. 2001). There is also higher financial risk associated with farming for yields as the cost of the required inputs often needs to be borrowed at the beginning of the growing season and crop failure, can seriously affect the financial viability of farming. There is increased risk of mass crop failure from pests and diseases as crop uniformity increases (De Schutter 2011).

In South Africa, the failure of three of Monsanto’s GM maize varieties to produce seed in 2009 affected close on 3% of the country’s 9 000 commercial maize farmers (Stuijt 2009; Goldblatt 2010). Although Monsanto launched an immediate investigation into the cause, identifying underfertilisation in the laboratory as the cause, and compensated farmers for their losses (Stuijt 2009; ACB 2011), the threat to food security was highlighted.

The importance of innovation

Innovation is understood to be the creation of a new or significantly improved product (goods or services) or process, a new marketing method or a new organisational method in business practices, workplace organisation or external relations (AU-NEPAD 2010). South Africa’s National Development Plan (2011:71) emphasises that “Innovation is the primary driver of technological growth and drives higher living standards”. Hybrid and GM seed, because of the proprietary knowledge embedded in them, are considered innovations.

Does corporate consolidation of the seed industry foster innovation in plant breeding practices? In a consolidated South African seed market with two dominant players supplying proprietary, patented seed, it is more likely that innovation will diminish (Moss 2011; Schenkelaars 2011), with decreased access to useful germplasm blocking development of alternative options (Maathai 1998).

FREE FLOW OF GERMPLASM

The formal and informal have borrowed from one another throughout agricultural history, although this hybridisation of knowledge has often been obscured (Srang-aim 2013). The maintenance of agrobiodiversity is reliant on the free flow of germplasm and the seed system needs to accommodate this flow between the formal and informal allowing for innovation at both ends of the spectrum (Venkatesan 1994; Royal Society 2009; Mayet 2012). Scoones and Thompson (2011) describe this flow as including the movement of modern seed varieties from the formal to the informal, where it is used, saved, sold and transformed by farmers. This is not a one-way system as local varieties and landraces can be brought into the formal sector for testing, certification, multiplication and distribution through conventional channels (Scoones & Thompson 2011). Venkatesan (1994) points out though that it is rare that modern varieties, bred at private research stations, ever pass onto the informal sector for multiplication and sale. This is due in part to price setting and regulation policies (Venkatesan 1994) as well as enforcement of intellectual property rights (De Schutter 2011).

Seed exchange is also important for continued innovation (Brahy 2009; Schenkelaars 2011). Although farmers may still be saving and resowing proprietary hybrid seed, it loses vigour after a season (Brahy 2009; Jones et al. 2011; Schenkelaars 2011) and so continually needs to be replaced, distancing farmers from contributing towards innovative plant breeding (Brahy 2009). Commercial seed is homogenous seed that is created in a particular environment (DAFF 2011), which is rarely replicable in the real world. While natural seed can adapt over a few planting seasons to a different microclimate (Ceccarelli 2012; Shumei International 2012) due to stronger immune systems, stronger root systems (Venkatesan 1994; Barker 2007; Shumei International 2012), increased resilience and resistance to infestation and climate fluctuations (Venkatesan 1994; Barker 2007; Shumei International 2012), hybrid and GM seed cannot. These seeds' ability to adapt is hampered by the fact that hybrid seeds are stagnant, stopped at a particular point of their evolution, and GM seed needs to be purchased anew each year. Innovation is more likely to happen if local systems are linked with science and technology in an equitable and respectful way (De Schutter 2011; Scoones & Thompson 2011).

FREE FLOW OF TECHNOLOGY

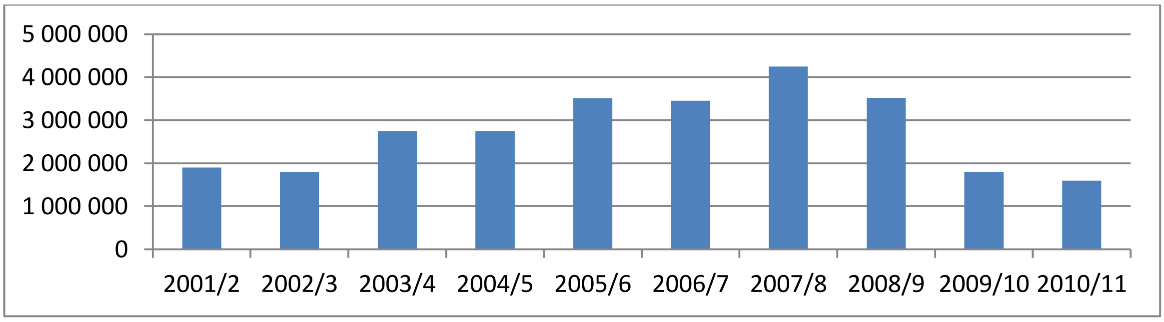
Critics argue that a consolidated industry with near monopoly power has little competition and so can set prices (De Schutter 2011; Galushko 2012) and any increase in price could have a negative effect on technology adoption and diffusion (Royal Society 2009), such as access to high-yielding hybrid varieties (De Schutter 2011; Moss 2011; Galushko 2012). Patent protection also allows corporations with control over key technologies a gatekeeper function (Moss 2011). The cost of accessing technologies is affected by licensing prohibitions on stacking traits (Moss 2011), as each incremental improvement involving new technology is constrained by intellectual property protection (Brewster et al. 2007; Clift 2007; De Schutter 2009b). In South Africa, 72% of the maize planted in 2011 was GM, of this 45.2% had single insect resistant genes, 14.4% herbicide tolerant genes and 40.4% with the stacked insect resistant and herbicide tolerant genes (SANSOR 2013).

RESEARCH AND DEVELOPMENT

The Department of Agriculture, Forestry and Fisheries notes that research has become increasingly centralised towards commercial sector interests (DAFF 2011). This is in line with the worldwide trend of public good research tending to be skewed towards research leading to the creation of commercialised products (Vanloqueren & Baret 2009). It implies that farmers will be increasingly faced with less choice of seed type (Schubert 2005; DAFF 2011). In contrast to the US where (2007 figures) 61% of funding comes from the state and 9% from industry, in South Africa, only 28% of funding originates from the state and 58% from industry (Heher 2007). The state Agricultural Research Council's 2011/12 financial report indicates that the organisation faces a cash shortage of R107 million from years of underfunding, is using aging, in some cases, obsolete equipment, and faces a backlog of work (ARC 2012).

Indications of innovation include the number of peer-reviewed publications produced on an annual basis; this indicator has remained static for the last decade (DEA 2011), as well as royalty payment arising from public research innovation. The table below indicates the rapidly decreasing royalties from patented innovations arising from the Agricultural Research Council in the last decade.

Table 3: Plant Breeders' Rights royalties for the Agricultural Research Council collected by the South African National Seed Organisation (2001/2-2010/11)



Source: Adapted from www.sansor.org.

The long-term investments in research needed to develop high-yielding crop varieties and improved smallholder crop practices will need to come from governments and not the private sector (Eicher et al. 2006).

CONCLUSION

A credible seed system for South Africa would be inclusive (providing quality, affordable and relevant seed to both the formal and informal sub-systems); sustainable (providing a diverse array of seeds able to perform under agro-ecological farming systems); and productive (fostering innovation, increasing yield, nutritional value and income potential). A consolidated corporate seed system cannot contribute towards these criteria and takes the South African agricultural industry even further away from the stated policy ideals of inclusivity, sustainability and productivity, within an agro-ecological farming system framework.

Corporations are mandated to provide a return on investment to their shareholders (Rusike 1995; Wield et al. 2010; Afari-Sefa et al. 2012) and for this reason focus their efforts on areas in which they will make the most commercial gain. Proprietary seed technology provides a vehicle to repeatedly regain research and development costs and, if designed in such a way that mandatory complementary products have to be used to unlock the full yield potential of the seed, these technologies promise an even more lucrative return (Brahy 2009; Wield et al. 2010; Moss 2011; Fulton & Giannakas 2012). Besides this, use of these proprietary seed technologies locks the agricultural system into a particular farming model – monocultures, external input-biased and irrigated – with a particular focus on yield to the detriment of nutrition.

The proliferation of hybrid and GM seed has a negative effect on biodiversity (CGRFA 2010), which is increasingly recognised as important for future genetic contributions to food, medicine and adaptation to climate change. As seed becomes further locked into the stranglehold of corporation ownership, access to it will become even more restricted, and so food insecurity exacerbated. It is likely that innovation in this market will diminish due to the increased costs of access to germplasm (Maathai 1998; Schenkelaars 2011). Seed cost (and necessary accompanying or mandated input cost) is a factor in farming viability and any increase in cost (due to the need or 'greed' to provide an increasing return on investment (Rusike 1995; Wield et al. 2010; Afari-Sefa et al. 2012) will, in particular, affect South Africa's smallholders. Given that food insecurity in South Africa revolves around problems of access (poverty) as opposed to production, a focus on yields seems counterintuitive.

The 'modernistic' take on farming, embodied in legislature and embraced by multinational seed companies, is in contradiction to stated policy aims for the sector. It constrains, rather than supports, the country's farmers, has negative implications for biodiversity and food security and limits South Africa's options in terms of adapting to or mitigating the effects of climate change.

Imagining a sustainable South African seed industry

INTRODUCTION

The use of the verb 'imagining' in this journal article's title implies the deliberate forming of a mental construct of a sustainable seed system. It draws on the published work of many who have studied this sector; government and international policy documents and treaties; as well as selected personal and email interviews, those that speak for the marginalised, and those that speak for farmers and consumers. This makes it, in a very limited sense, a collective imagining. The complex process of imagining is available to all people to varying degrees (Klein et al. 1983) and is a useful tool for transformative work (Sarbin & Juhasz 1970; Klein et al. 1983; Burd 2003). It enables the release of the 'past' (experience and memory) (Klein et al. 1983) through a process of conceptual and innovative creation (Sarbin & Juhasz 1970; Powell 1972) allowing alternative 'futures' to emerge (Klein et al. 1983).

This article outlines the motivation for a new imagining of a sustainable seed system before generating a benchmark of desired outcomes for such a system. The complexity of the system, along with its inherited 'memory', is described before the power relations shaping the system are unpacked. Selected system elements - the farmer and the state agricultural extension service - are re-imagined before the potential outcomes of a fresh farmer-scientist-state, linked by state agricultural extension services, paradigm are described. Imagining ties in with a social learning approach that encourages a 're-framing' of ideology and assumption to bring about empowerment, transformation and innovation. This social learning approach is highlighted in the section: 'A new kind of thinking'.

MOTIVATION FOR A NEW IMAGINING

As seed is a primary agricultural input, along with water and fertiliser (FAO 2010; Baxter 2012), the seed system to a large degree determines the availability, cost and type of seed available to South African farmers and this then influences the type and quality of the food grown in the country. South Africa faces several developmental challenges, some of which could be ameliorated by a well-functioning and credible seed system. These challenges include biodiversity loss, food insecurity and climate change.

Biodiversity loss & food insecurity

Agriculture is a driving force behind biodiversity loss in South Africa as natural vegetation is cleared for crop production, adversely affecting biomes and the species that inhabit them (DEAT 2005; DEAT 2008; Raimondo 2011). A 2010 South African National Botanical Institute survey of the country's 20 456 indigenous plant taxa indicates a 254% increase over the last decade in threatened taxa (Raimondo 2011). Biodiversity refers to the "... variability among living organisms from all sources ... and the ecological complexes of which they are part (CBD 1993), while agrobiodiversity "comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals" (FAO 1999).

Changes in land-use patterns along with expansion of industrial farming techniques directly correlate to biodiversity (including agrobiodiversity) loss (Brahy 2009; DEAT 2005; Foley et al. 2011) and resultant ecosystem degradation reduces availability of ecosystem services (such as … there are many others clean water generation, healthy soils important for food production) (DEAT 2005; Barthel et al. 2013). In South Africa, the condition and management of ecosystem services is seen as a dominant factor in influencing prospects for poverty reduction (DEAT 2005). The proliferation of hybrid seed, which does not breed true the following season, and genetically modified (GM) seed, which cannot be legally saved for replanting, further contribute to agrobiodiversity loss (Brahy 2009; Foley et al. 2011; Ceccarelli 2012; Kerssen 2010; Pagioloa et al. 1998; Srang-iam 2013). This is of concern as wild and indigenous plant species provide the genetic potential for new crops and medicines (Van Wyk & Gericke 2000; DEAT 2005; Tengberg et al. 2012); are a significant source of nutrient-rich food (Wynberg et al. 2011; Afari-Sefa et al. 2012) for South Africa's rural poor (DEAT 2005; Drimie & McLachlan 2013); and potentially hold the traits needed for adaptation to climate change, such as longer, sturdier root systems, which require less water (Venkatesan 2004; DEAT 2005; Barker 2007; DEA 2011; Shumei International 2012

The 2013 South African National Health and Nutrition Examination Survey estimates the number of people going hungry each day at roughly 25% of the population (about 13 million) (Shisana et al. 2013). One in five South African children suffer from malnutrition stunting their learning abilities and hence future productivity (NPC 2011), and quality of life (Raudsepp-Hearne et al. 2010). In South Africa, it is recognised that food insecurity results primarily from poverty (lack of financial access) as opposed to productivity (NPC 2011; Gonzalez 2012) and any increase in food cost negatively affects the ability of the poorest to access food. The price of the basic food basket rose 6.4% between January 2012 and January 2013 (NAMC 2013). South Africa's National Development Plan (2011) recommends that linkages between agriculture and nutrition be strengthened.

Climate change

Predicted changes in rainfall intensity, location and duration will affect food production levels negatively (DEAT 2005; DEAT 2008; Hajkowicz et al. 2012; De Schutter 2011; Nordhagen & Pascual 2013; Sasson 2012), and as most of South Africa's arable land is rainfed, any change in rainfall patterns will have dramatic consequences (Hachigonto et al. 2013; IFPRI 2012). Increases in the number and scale of extreme weather events (De Schutter 2011; Srang-iam 2013), changes in average temperatures (expected to rise an average of 2°C across South Africa (DEAT 2008; IFPRI 2012; Hachigonto et al. 2013), and the resultant emergence of new pest, weed and disease vectors (De Schutter 2011; Hachigonto et al. 2013; Srang-iam 2013) will affect the yield productivity of South Africa's staple maize crop, among others, negatively (IFPRI 2012; Hachigonto et al. 2013). Climate change adaptation requires several measures, including the planting of hardier indigenous species, breeding of plants with climate-ready traits (DEAT 2005; DEAT 2011), and diversification of on-farm species (DEA 2011).

Setting a benchmark

The systems that we create or intervene in now, particularly those responsible for food production, must be learning systems that can, as Schon (2010) puts it, continually bring about their own 'transformation'. Institutions governing social and natural relations and governance processes will need to be adaptable and capable of quick responses to changing circumstances (Schon 2010). This requires a 'new' form of holistic thinking that focuses on systems with an understanding of complex system properties and potential (DEAT 2008). This type of thinking should be actively encouraged at all levels of society to enable individuals, communities, companies and states to engage with both broad and localised system dilemmas, which emerge due to the deeper structural problems within the dominant political, economic and scientific institutions of modern society (Woodhill 2010).

South Africa's seed system, as a base for agricultural viability, must therefore play its role in:

- Supplying commercial, smallholder and subsistence farmers with quality, appropriate seed (Almekinders 2000; Monyo et al. 2004; Venkatasen 1994; Baxter 2012; FAO 2010; Kopainsky et al. 2012), when they need it (Venkatasen 1994; Okry et al. 2010) and in the required quantity (Venkatasen 1994), in order to contribute to food security (De Schutter 2011; FAO 2010; Kopainsky et al. 2012). Seed should produce plants with high nutritional content (Monyo et al. 2004; NPC 2011; Afari-Sefa et al. 2012; Shiva 2012).
- Maintaining agrobiodiversity (DEAT 2005; NPC 2011; Nordhagen & Pascual 2013).
- Developing seeds with climate-ready and drought tolerant traits (Monyo et al. 2004; Venkatesan 2004; Barker 2007; Kerssen 2010; De Schutter 2011; Kopainsky et al. 2012; Shumei International 2012; Nordhagen & Pascual 2013; Srang-iam 2013), that are affordable

to all scales of farmers, suitable for a variety of purposes and a variety of farming scales, and able to adapt in situ to changing conditions.

- Maintaining quality control; for example through training and regulatory systems (Monyo et al. 2004).

The country's current seed system cannot effectively address these challenges. Shaped by particular historical forces, it is constrained by current global forces, and is based on a narrative around 'modern' farming that runs counter to these roles.

Acknowledging complexity and system memory

Complexity of seed systems

South Africa's seed system, with its formal and informal sub-elements (Scoones & Thompson 2011), is a complex one. Cilliers' work (1998; 1999; 2000; 2011) and that of Clayton and Radcliffe (1996) on complex systems is useful for understanding seed system dynamics.

Complex systems comprise a large number of elements that interact dynamically (Cilliers 1998). In a seed system, these include farmers, private seed breeders, public and private research and development organisations, distribution and retail agents, the state and nature, as the primary context in which seed is reproduced. The interaction of all these elements determines the kind of seed that is bred, multiplied, supplied, used and distributed (Thiele 1999). Complex systems are open systems, which often present with asymmetrical power relationships (Cilliers 1999). The structure of a country's seed system is determined through national and international laws and treaties (Scoones & Thompson 2011; Tansey 2011; Van Zwanenberg et al. 2011; Venkatesan 1994). Interventions in complex systems can have non-linear effects (Cilliers 1998). As regards seed systems, any increase in seed prices or changes in regulations around seed saving, etc., may have a disproportionate effect on farmers (Mayet 2012). Breaching of boundaries or thresholds can cause complex systems to collapse or radically change behaviour (Cilliers 2011). It is recognised that passing ecosystem limits risks sudden declines in food production (Perfecto & Vandermeer 2010; Raudsepp-Hearne et al. 2010; Hozman 2012; Tengberg et al. 2012); increased disease transmission (Hozman 2012); and the proliferation of new pest vectors (De Schutter 2011; Hozman 2012).

It is important that the complexity of the seed system be acknowledged, as interventions into complex systems that do not take into account the interconnections and interdependencies of elements within the system and its sub-systems (interlinked social, ecological and economic) result in non-linear effects (Blackmore 2010). The emergence of unpredictable properties at different levels, through feedback loops, can lead to whole system collapse (Bawden 2010). Any intervention into a seed system needs to understand this potential for unpredictability, which can lead to non-linearity in that the cause and the effect are not relative in size..

The starting point of a complex system and its subsequent ‘dominant’ path, retained as memory, affects the future behaviour and potential of the system (Clayton & Radcliffe 1996; Cilliers 2000). Memory refers to “the persistence of certain states of the system, of carrying something from the past over into the future” (Cilliers 2007:57). In other words, a system, through its experiences, builds up a particular memory and organises itself to react to change based on this experience – or collective memory. Seed systems, which develop in unique ways to each location and culture (Thiele 1999; Almekinders 2000), have such a history or retained memory (Tansey 2011). In order to shape a more equitable, productive and sustainable system, the ‘memory’ on which the system operates needs to be examined and realigned with these goals.

South Africa’s seed system’s ‘memory’

A timeline of relevant events and legislation affecting and shaping South Africa’s seed system is given in the following table.

Table 4: Timeline of events and legislation adopted by South Africa related to the seed system

1600s-1900s	Primarily seed swapping and exchange between farmers (Rusike 1995; Kloppenburg 2012, Zapiain 2008). This practice still continues today.	
1900s	Commercial food production, state research and testing stations set up (Venkatesan 1994; Rusike 1995; Mayet 2012).	State directed seed system aimed at serving the interests of white commercial farmers.
1907	Fertiliser, Seeds and Agricultural Remedies Act.	
1913	Land Act. Black African farmers dispossessed of land (Zapiain 2008; Satgar 2007).	
1944	Maize Control Board established (Rusike 1995).	
1959	First hybrid seed programme (Rusike 1995).	
1961	Seeds Act & Foundations Seeds Act.	
1963	First international seed companies entered the market.	
1976	Plant Breeders’ Rights Act passed (Act 15 of 1976).	
1995	The Agreement on Trade Related Aspects of Intellectual Property Rights adopted.	
1995	Convention on Biological Diversity (1992) adopted by South Africa.	
1996	Marketing of Agricultural Products Act. Dismantling of local agricultural marketing boards. Economic liberalisation. (Satgar 2007; Van Tilburg & Van Schalkwyk 2012)	
1997	Genetically Modified Organisms Act.	
1981	Adopted the International Union for the Protection of Variety Plants (1978)	
2002	Amended Patents Act in accordance with The Agreement on Trade Related Aspects of Intellectual Property Rights.	
2003	Signed Cartagena Protocol on Biosafety, introduced under Convention on Biological Diversity.	
2012	Draft Protocol for the Protection of New Varieties of Plants in the SADC region.	
2012	Competition Commission allows the merger between Pannar and Pioneer Hi-Bred, resulting in 90% corporate control over South Africa’s staple food supply, maize.	

Dismantling and distributing power

In the context of this paper, power is understood as an unequal relationship based on institutional positioning, economic power and/or status, as defined and enacted within historical or cultural contexts (Roscigno 2011). It is a reciprocal relationship (Roscigno 2011), in which the relative power of each element can shift in different contexts (Brydon-Miller 2004). The asymmetrical nature of power relations emerges in different spaces – in international, national and local arenas.

There is a dynamic interplay among different actors and interests in the food system centring around who has what power to control particular parts of the system in ways that minimise risks and optimise benefits for themselves (Scoones et al. 2005). These actors include local and multinational seed companies, commercial and smallholder farmers, farmer organisations, the state, and public and private research organisations. International and national legislation and regulation effectively shape the ‘playing field’, defining the boundaries in which these dynamic relations occur. Those who have the power to ‘write’ the legislation and regulation, or ‘rules of the game’ then determine who benefits and who is excluded from the system (Vanloqueren & Baret 2009; Scoones & Thompson 2011; Van Zwanenberg et al. 2011). These actors also frame debate or dissension within a particular paradigm or narrative (Van Loqueren & Baret 2009). In a globalised world, in which the dominant economic model is one of liberalised trade, the ‘rules of the game’ and the ‘metanarrative’ are largely determined by the industrialised countries of the ‘North’, through organisations such as the World Trade Organisation (WTO). This controversial body is the only international organisation with de facto power through its mandatory resolution mechanism, which can enforce economic sanctions (Gonzalez 2012). Although it is meant to be a representative body of all member states, it presents with extreme power imbalances between industrialised and developing nations, and has been criticised for advancing particular economic interests (Zapiain 2008).

The individual state’s ability to respond to modern political, economic and environmental issues is no longer totally within its control (Phillips 2005), as it is enmeshed in complex and often institutionalised political, economic and social power relations (Scoones et al. 2005; Scoones & Thompson 2011; Vanloqueren & Baret 2009; Van Zwanenberg et al. 2011). This has relevance for South Africa, faced with particular developmental challenges and resultant policy, implementation of which is constrained by international agreements.

The ‘metanarrative’ of farming

On a global level

On the highest global levels, an overarching narrative has been created around the need to feed an increasing world population (Maathai 1998; FAO 2009; Mellon 2013). The Food and Agriculture Organisation projects that overall food production will need to increase by about 70% to feed a global population of about 9.1 billion people by 2050 (FAO 2009). The drive to increase yields in order to ‘feed the world’, a “rallying cry for export-orientated agricultural policy” in the United States in the 1970s, conflates the issues of food security and food production (Mellon 2013:1). The dominant agricultural narrative from the 1900s onwards has centred on modernisation, including use of hybrid technologies and external inputs (Satgar 2007). The narrative runs along the lines that if poor farmers could only access and use these modern technologies, they would enjoy higher yields, which would translate into higher incomes, higher levels of food security and higher standards of living for farmers (Maathai 1998; Amanor 2012). It is a nice story. Yet in South Africa, food insecurity results primarily from lack of access (ability to purchase food) as opposed to lack of production (Tansey 2011; DoA 2002). This ‘amplification’ of a large-scale emotional appeal can mask underlying motivations (Roscigno 2011), such as the desire to open up new markets for hybrid and GM seed, inorganic fertilisers, herbicides and pesticides. It also blocks out alternative pathways and narratives that emerge from less powerful actors (Kranakis 2007) in the seed system. The ‘forgotten’ or neglected memory of the system residing in the South African informal seed system, slowly constrained during the colonial period (Tansey 2011) and decimated during the Apartheid era, (Satgar 2007), is disintegrating under the current neo-liberal era of globalisation (Mayet 2012).

Metanarratives present a one-dimensional viewpoint (Max-Neef 2004) and denote a simplistic understanding of social, economic and ecological systems and how they interact and this narrow understanding is not adequate for dealing with the interconnected complexities of current challenges (Bawden 2010; Gonzalez 2012), such as food insecurity, biodiversity loss and climate change. In South Africa, issues such as unequal access to land, credit and education compound the problem. The validity of the modern farming model (along with the underlying ideologies and assumptions on which it is based (Scoones et al. 2005; Van Schalkwyk et al. 2012)) is rarely questioned. The African Union proposes that an underlying cause for the lack of human development in Africa is the ‘Babel of paradigms’ within policymaking based on unexamined assumptions (AU-NEPAD 2010), while the framing of future agricultural systems is often based on the most probable instead of the most desirable outcome (Vanloqueren & Baret 2009).

Modern farming methods have resulted in yield increases over the past five decades (Schenkelaars 2011; Barthel et al. 2013; Mellon 2013); however, increased yields do not automatically translate into increased access to food, increased income or increased nutrition (Barthel et al. 2013; Mellon 2013). A narrative around yield increase does not take into account the broader, interlocking factors and constraints that affect production ability (Sassenrath et al. 2008), such as access to land, capital, information, markets and water. It also does not take into account the negative environmental and social effects of high-yield farming (Shiva 2012). The promotion of uniformity (in terms of crops and farming practices) across a broad spatial scale has resulted in high use of synthetic agrichemical inputs and reliance on non-renewable resources (Barthel et al.

2013); increased greenhouse gas emissions, which contribute to climate change (Gonzalez 2012; NPC 2011), and a radical decrease in biodiversity (Gonzalez 2012; NPC 2011). Both climate change and biodiversity have a direct bearing on the ability of households, communities and countries to remain food secure (DEAT 2005; Kerssen 2010; De Schutter 2011; Kloppenburg 2012; Maponya & Mpandeli 2012; Sasson 2012.).

The focus on increased yields has also led to the commoditisation of seed, creating a narrative in which it is predominantly viewed only as an input into the farming system (Sassenrath et al. 2008; Amanor 2012; Shiva 2012), thus ignoring its role in complex relations on ecological, economic and social levels (Phillips 2008).

ON A NATIONAL LEVEL

South Africa is one of the most unequal countries in the world, with a Gini co-efficient between 0.66 and 0.69 (DEA 2011) and development is beset by a legacy of systems that perpetuate economic marginalisation and environmental degradation (DEAT 2008). Colonisation and Apartheid have left their mark on the economic, environmental and social landscape of the country, seen in the fragmented allocation of benefits and burdens to different race groups, genders and geographical areas in the country (NSS 2009), in terms of access to land (particularly arable land), water, credit and education. South Africa’s seed system then operates from a dominant ‘memory’ of colonisation, Apartheid and neo-liberal globalisation economics (Tansey 2011), with historical inequalities embedded in legislation, bureaucracy and practice (Roscigno 2011).

South Africa’s current frameworks for dealing with seed are based on the dominant hegemonic narrative of seed as object, which can then be appropriated and commoditised (Amanor 2012). This is demonstrated through the implementation of formal seed regulation (Plant Breeders’ Act of 1976); adoption of the International Union for the Protection of Variety Plants (UPOV) 1978 in 1981; membership of the WTO and adoption of The Agreement on Trade Related Aspects of Intellectual Property (TRIPs) (1995); and its significant role in promoting the harmonisation of plant breeders rights at the regional level with the Draft Protocol for the Protection of New Varieties of Plants in the SADC region 2012. The beginning of field trials for GM maize in 1992 prior to relevant legislation governing the use of GMOs in the country, passed in 1997 (Zapiain 2008), also signalled the state’s intention to follow a modern, technology-led approach to seed and agriculture.

Roscigno (2011) argues that policy is often an attempt to demonstrate compliance as opposed to real-life implementation of intent. South Africa’s legislative frameworks around seed protect a power hierarchy residing in private, commercial interests, which is in direct contradiction to the progressive ideals outlines in the country’s agricultural policy.

<u>South Africa at a crossroads</u>

South Africa sits at a crossroads in terms of its international obligations and the obligations it has undertaken to its people through policy. The state is a signatory to the WTO's TRIPs, it is a member of the Southern African Customs Union and so a signatory to TRIPs-plus, it is a party to UPOV 1978, a signatory to UPOV 1991 and, if it is passed, will be a signatory to the Protocol for the Protection of New Varieties of Plants in the Southern African Development Community, which enforces alignment with UPOV 1991. All of these agreements focus on protecting and enforcing intellectual property protection rights; they take the country further towards private ownership of the genetic commons. In contrast, agricultural policy documents stress the importance of maintaining and protecting biodiversity, the importance of local innovation, the need to support smallholder and subsistence farmers in becoming more food secure, and devolving authority to local levels of government for climate change adaptation strategies (DoA 2002; DEAT 2008; NPC 2011; DAFF 2012). In addition, it is argued here that although policy documents speak to the need to assist the farming sector, in particular, smallholders, benefits instead accrue to the increasingly consolidated commercial farming sector with its decades-long history of state subsidisation, including access to quality infrastructure and accumulated commercial knowledge (Van Schalkwyk et al. 2012).

On the other hand, the state is a signatory to the Convention on Biological Diversity, is a member of the Organisation of African Unity, which produced an African Model Law as a guide to state policy around plant genetics, and has put legislation in place around equitable access to and benefit sharing of genetic resource use (although they have not yet adopted the International Treaty for Plant Genetic Resources for Food and Agriculture). All of these promote equitable access to plant genetic resources, benefit sharing and uphold Farmers' Rights. In addition to this, the Draft National Policy on Intellectual Property, released for public comment in September 2013, recommends that exceptions in patent law must include the right for farmers to save and re-use seed; that plant breeders' rights should not be at the expense of traditional agricultural systems, natural seeds or plants; and that the country's Competition Act must be amended to deal with the high level of concentration in the sector (DTI 2013).

According to the country's constitution, the national, provincial and local spheres of government are not regarded as hierarchical tiers, but rather as distinctive, interdependent and interrelated spheres of government (RSA 1994; DEAT 2005). In which case, the state's role should be to provide information and guidelines through policy that would act as start-off points for local implementation as opposed to a centralised one-size-fits-all framework (Schon 2010). Particularly given that the country's farmers operate in diverse settings, at diverse scales and many of them use agriculture as just one of their livelihood strands (Scoones et al. 2005; Zapiain 2008). Standardised policies do not reflect this diversity and they assume a concept of equity that fails to take into account race, gender and geographical discrimination into account (Schon 2010) and the resultant ability of stakeholders to participate in the system in any meaningful way. For example, policy might be orientated in favour of smallholders, but they compete on an unlevel playing field against the already well-developed commercial sector (Van Schalkwyk et al. 2012).

Institutions and governance processes need to be adaptable and capable of quick responses (Schon 2010) and this requires a 'new' way of thinking that focuses on systems (DEAT 2008) at their landscape levels. Therefore, the state, as initiator and facilitator (Schon 2010), must encourage lower level innovation and action, as "The opportunity for learning is primarily in discovered systems at the periphery, not in the nexus of official policies at the centre (Schon 2010:16). Complex systems operate to their full potential in terms of knowledge generation when there is relatively shallow control structure and open boundaries that do not limit the emergence of new properties (Cilliers 2000).

Serious consideration of power requires a fundamental reconsideration of assumptions about inequality, agency and constraint, and the interplay of human actors, social and culture (Roscigno 2011). Assumptions that underlie the worldviews and value systems that shape society and culture need to be carefully questioned if there is any hope for sustainable development (Whal 2009), while hierarchies of power can only be 'dismantled' or 'rearranged' if acknowledged (Amanor 2012; Pahl-Wostl et al. 2008) and the capacity of weaker actors strengthened (Roscigno 2011).

As regards seed, the state has an obligation to support both the formal and informal seed systems; and even to enhance the informal, and often non-commercial, system to ensure people's right to food (FAO 2004). The formal and informal should be supported and managed as complementary systems (Almekinders 2000; De Schutter 2011). In addition to this, the importance of access to a diverse variety of seed germplasm (of both wild and cultivated plants) for adaptation to climate change cannot be underestimated (DEAT 2005; DEA 2011).

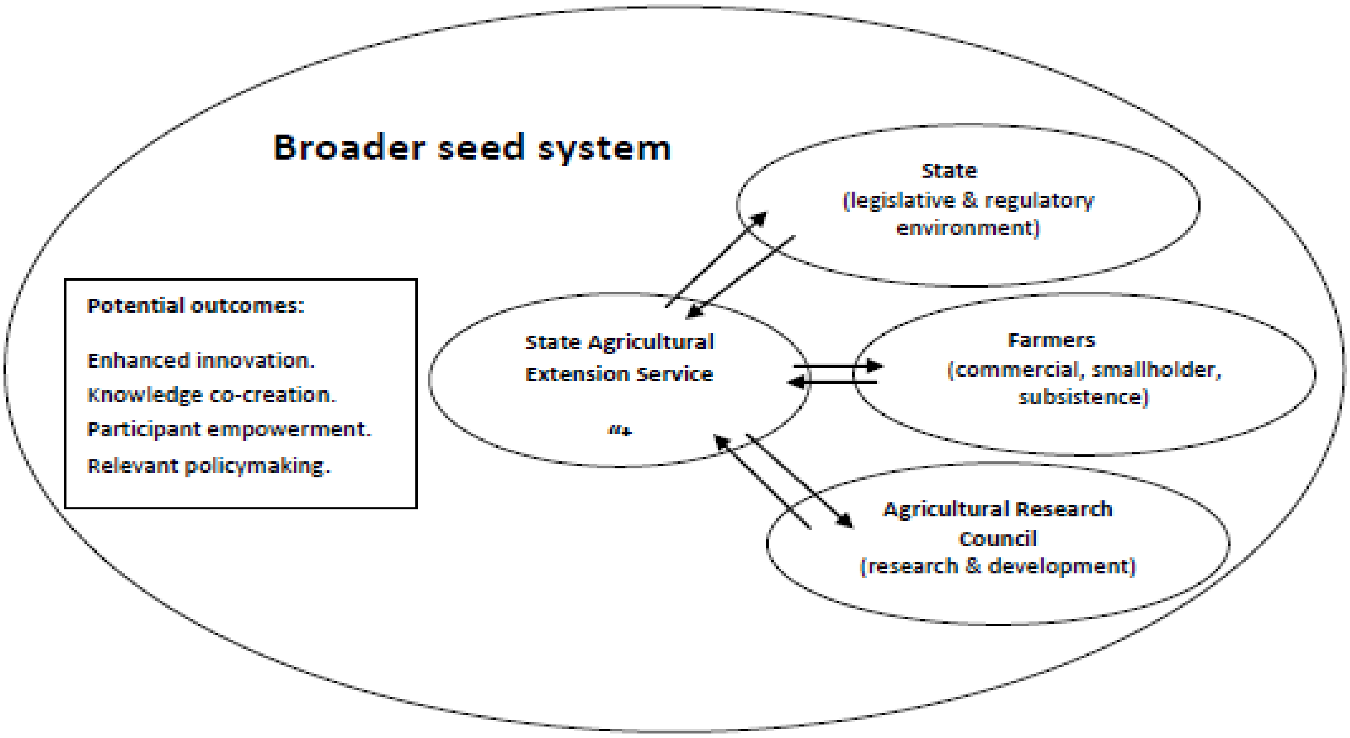
Therefore, South Africa needs to imagine a new narrative around seed, one that is inclusive, productive and sustainable, and that contributes to creating a resilient and robust agricultural system, able to adapt to a changing climate and contribute towards enhancing food security levels. The challenge is how to generate this new kind of thinking or new narrative, rooted in a South African context that benefits both the formal and informal seed and agricultural systems.

A 'NEW' KIND OF THINKING

It is clear that a new narrative is needed; however, any process that does not take into account structural characteristics and constraints will not enjoy a sustainable success. Some of these constraints include hierarchical and institutionalised power relations, limited capacity, and lack of financial, human and social capital. In addition, the complexity of the system needs to be considered and the potential for negative non-linear results arising from interventions. For this reason, existing intersections in the system should be expanded, adapted or redirected, rather than focusing on whole system change, as incremental change, or in-situ change, lessens the risk of unforeseen negative consequences, is less resource intensive and allows for periods of experimentation in smaller parts of the system prior to implementation on larger scales.

A point at which farmers, state and science intersect is the state agricultural extension service (Okry et al. 2010), which is in the process of being overhauled providing an excellent opportunity to create ‘spaces’ and institutions (sets of practices) that will encourage co-creation of knowledge, innovation and empowerment of participants. This linkage is illustrated in the following diagram and the intersections and potential benefits explored further on in this article.

Table 5: Linked state-science-farmer through extension services paradigm



Complexity thinking allows space for a diversity of narratives, emerging from localised levels and finding their own ‘space’ in the system through competition and/or collaboration (Cilliers 1998). It is argued here that the state’s role is not just to support existing elements, but also to purposefully create space for other elements to emerge. Creating ‘space’ requires the empowering of participants, increasing access to relevant knowledge and ensuring that institutions are capable of quick responses. This requires a certain philosophy of change implemented through an approach based on the principles of equity, sustainability and transformation.

Social learning, as process and outcome, is a useful tool for transformational work, both on a personal and group level. The concept of social learning is briefly explained below, including the limitations of this approach, and unpacked further in the sections dealing with the state's agricultural extension services and the potential outcomes of a linked state-science-farmer through extension services paradigm.

INTRODUCING SOCIAL LEARNING

There are many interpretations of social learning, all revolving around the notion that people learn through social interaction and in social contexts (Cundill et al. 2011). For the purposes of this study, social learning is understood as both a process and outcome in which individuals, and the group to which they belong, learn from each other through observation and facilitated deep dialogue while searching for commonality of ideas, actions and purposes (Bouwen & Taillieu 2004). Deep dialogue is fundamentally different in nature from a discussion or debate (Bohm et al. 1991; Isaacs 1999; Dessel et al. 2006); it is a structured and facilitated exploration of the individual group member's unconscious values and assumptions (Bohm et al. 1991). It affords a space for collective learning (Bohm et al. 1991; Isaacs 1999) and the generation of new knowledge (Chen et al. 2013). Importantly, it is a grounded practice (Cundill et al. 2011). It is based on the notion that values and resultant behaviour are learnt in context (Bouwen & Taillieu 2004), and through the understanding of one's own underlying assumptions, as well as those of other members of the group, values and behaviour might shift. For the purposes of this article, social learning is seen as extending further than Bandura's notion of individual learning through observation of and participation in social groups and the understanding of differentiated consequences (1971), it is too narrow to embrace the diverse learning required for sustainable, interlinked economic, ecological and social systems (Bandura's). These processes engage directly with the diversity of actors in the system (Bouwen & Taillieu 2008; Woodhill 2010); can be used at a variety of scales; and be deliberately structured to bring out the underlying value assumptions behind resource management decisions (Pahl-Wostl et al. 2008; Bouwen & Taillieu 2004). Social learning approaches acknowledge and manage power, rank and role differentials between stakeholders (Bouwen & Taillieu 2004; Woodhill 2010).

POTENTIAL OUTCOMES OF THIS APPROACH

Outcomes include transformational and critical thinking (Woodhill 2010), increased capacity within individuals and groups (Pahl-Wostl et al. 2008), joint decisionmaking and a sense of co-ownership in action plans and outcomes (Bouwen & Taillieu 2004; Pahl-Wostl et al. 2008). A successful outcome would rest on the enhanced capacity of individuals and the group to understand itself and its relation to the external environment, adapt their assumptions and belief systems to influence the direction of social change (Woodhill 2010). The ability to think critically, even about the learning process itself, is vital (Bawden 2010).

LIMITATIONS AND FACTORS TO CONSIDER WITH THIS APPROACH

Social learning processes can take considerable time (Bouwen & Taillieu 2004; Pahl-Wostl et al. 2008; Chen et al. 2013) as asymmetrical power relations need to be unpacked as do cultural misunderstandings and gender relations (Brydon-Miller 2004); trust needs to be built (Shackleton et al. 2009; Chen et al. 2013) and a common 'language' created (Chen et al. 2013). The purpose of the social learning process must be clearly understood by all involved, in particular the facilitators (Bojer et al. 2008; Dessel et al. 2006). It must be carefully planned (Anderson & Bryson 2000) with clearly defined outcomes (Bojer et al. 2008) and it must offer sufficient motivation for participation (gain new perspectives, develop new skill sets, gain access to broader knowledge base, and learn about new technologies) (Chen et al. 2013). It must be structured in such a way that it is accessible (in terms of location, cost and timing) to those participants that need to be there (Anderson & Bryson 2000; Freeth 2011). In addition, participants must be open and willing to take part in a process designed to challenge their assumptions and value systems (Anderson & Bryson 2000). It is a lengthy process (Bouwen & Taillieu 2004; Pahl-Wostl et al. 2008; Chen et al. 2013); however, it can result in systems capable of quick response and adaptation.

WHY IS IT AN APPROPRIATE APPROACH?

South African agricultural policy documents reflect concerns around agrobiodiversity loss, climate change, and the lack of inclusivity and equity in the current agricultural system (DoA 2002; DEAT 2008; NPC 2011; DAFF 2012). The seed system – breeding, supply and distribution – as a vital determinant of crop success or failure (Tansey 2011) - needs to address these concerns. It needs to deliver a diverse set of services, which are matched to individual and community food security and livelihood needs. The system involves a diverse set of actors operating at different levels and scales within the system, each set with their own cultural norms, values and expectations. Stakeholders operate in a highly unequal society; power, income and gender all play a part in determining system influence. Social learning processes speak directly to these aspects and can accommodate complexity through careful process design including the building of self-referential or critical learning systems (Bawden 2010). Equity, participation, mutual understanding and co-ownership of outcomes are primary characteristics of social learning processes (Pahl-Wostl et al. 2008). It is a particularly appropriate mechanism for engineering interventions in complex systems (Anderson & Bryson 2000; Bojer et al. 2008; Pahl-Wostl et al. 2008; Bawden 2010), such as a seed system. Social learning, with the above-mentioned potential outcomes of empowerment, innovation, transformational thinking, and co-ownership of initiatives can take place through a linked state-science-farmer through extension services paradigm (Bouwen & Taillieu 2004).

Two of the elements in the linked state-science-farmer through extension service paradigm are explored below - the farmer and the state agricultural extension service. Knowledge of system elements is important, as dynamics within sub-systems can contribute to overall system failure. For example, not enough is known about South Africa's farmers. As a result, policy often rests on assumption, opposed to real-life data. It is proposed then that the notion of 'farmer' in South Africa has also to be re-imagined.

RE-IMAGINING THE FARMER

It is important to ascertain who our farmers are, as well as their varied roles and interests in agriculture (Scoones et al. 2005) and seed. South Africa has about 40 000 commercial farms (Goldblatt 2010; DAFF 2012b; Bernstein 2012), these are increasingly owned by corporate interests (NPC 2011; Bernstein 2012), roughly 200 000 smallholders (Du Toit 2011; DAFF 2012b; SSA 2012) and approximately 2.7 million households practicing subsistence agriculture (SSA 2012). This is a very diverse group of stakeholders (in terms of culture, income, gender, geographical location and capacity) and they operate in radically diverse microclimates with varied agricultural techniques (for example, rainfed versus irrigated agriculture). It is also becoming increasingly clear that many farmers use agriculture as just one of their livelihood strands (Scoones et al. 2005; Zapiain 2008; SSA 2012), with intensity and scale of cultivation varying according to needs.

Farmers then can be divided into remote rural, rural, peri-urban and urban geographies, with the corresponding microclimates and access to infrastructure, such as markets. They can be further divided into subsistence, smallholder, and commercial farmers – although the boundaries of these divisions can sometimes be blurred. They can be divided by gender, culture, education, literacy levels and class; each of these distinctions shaping the kind of agricultural capacity they hold and the farm-level constraints that they face (Okry et al. 2010). A more recent distinction, but one with a growing consumer market and offering the greatest potential contribution towards sustainable agriculture, is organic and agroecological farming methods. This sector requires a seed system that follows breeding methods in line with the philosophy of organic farming producing seed with high mineral efficiencies, tolerance to stress and weed suppression (Phillips 2008).

It is clear that farmers are not a standardised group and therefore standardised policies may not have the intended effect on the diversity of groups within this sector (Scoones et al. 2005). Understanding the context of each group, including analysis of farm-level constraints and livelihood strategies, is vital to increasing the sector's productivity (Scoones et al. 2005).

Seed plays different ecological, economic and social roles, beyond that of input, to farmers across the spectrum (Sassenrath et al. 2008; Amanor 2012; Shiva 2012). It has strong cultural and spiritual significance for many communities (Venkatesan 1994; DEAT 2005) and seed saving – planting, nurturing, harvesting, storing, eating and replanting – has been part of a communal exchange of knowledge and experiential learning since the beginning of agriculture (Phillips 2008; Shiva 2012). This is an important point as differing cultural understandings of seed can create barriers to the adoption of new technologies or strategies (Pahl-Wostl et al. 2008). This has implications for strategies around maintenance of agrobiodiversity levels as well as food security, as traditional crops are often significant food sources (Mayet 2012; Venkatesan 1994; Drimie & McLachlan 2013).

The South African state's recently launched Extension Recovery Plan sets out an ambitious strategy to improve the quality and reach of agricultural services in the country. It is argued that for long-term beneficial outcomes, this approach must be a multidisciplinary one (ARC 2011b), must take into account the complexities of the system, must aim to support the country's farmers in maintaining and enhancing agrobiodiversity levels, in adapting to climate change, and in contributing to food security through the production of safe, healthy and nutritious food.

AGRICULTURAL EXTENSION SERVICE

State agricultural extension services in South Africa are currently in a dire state and negatively affect policy implementation (ARC 2011b). The majority of commercial farmers (predominantly white) enjoy quality extension services from private organisations (chemical, fertiliser and seed companies; privatised cooperatives) as well as research organisations, while smallholder and subsistence farmers predominantly rely on the public sector service (ARC 2011b), although some private companies have exploited this gap in the market. The national agricultural extension service is understaffed by about 5 500 personnel, 90% of existing staff do not have the requisite technical skill or education to properly assist their constituents and each extension officer has to service 873 farmers (ARC 2011b). In addition, in line with the 'silo' mentality that besets the modern world, extension officers operate out of the Department of Agriculture, with limited linkages to other relevant departments, such as Land Affairs, Health, Education, Trade and Industry, etc. In a study done with smallholder farmers in Limpopo Province, it was found that up to 75% of farmers receive no information or support around adaptation to climate change (Maponya & Mpandeli 2012). Extension officers claim that they themselves are not adequately trained on issues of climate change (Maponya & Mpandeli 2012).

The Agricultural Research Council, as one of the public institutions charged with the mandate to pursue economic and social outcomes through the deployment of science, has announced its intention to take a more interventionist role in agricultural extension services in conjunction with the Extension Recovery Plan (ARC 2011b). The council emphasises the importance of a multidisciplinary approach that is inclusive of a wide range of stakeholders that meet regularly to foster innovative thinking (ARC 2011b), as solutions to current agricultural challenges will not only be technological in nature, but will have to take into account the complexities posed by environmental, social and economic issues (Royal Society 2009). What is desired is a collective innovation system that is inclusive of all relevant stakeholders and that can cooperatively find solutions to challenges. The draft of the extension policy document is still under discussion in the Department of Agriculture, Forestry and Fisheries.

Ideally, the extension officer should fulfil the following roles, among others:

- Act as information exchange between farmers, scientists and state (Warner 2005; Okry et al. 2010; Maponya & Mpandeli 2012).
- Facilitate dialogue (ARC 2011b).
- Provide access to markets and new technologies (ARC 2011b).
- Prepare farmers for climate change (Maponya & Mpandeli 2012).

The state-science-farmer through extension service paradigm provides an ideal space for social learning, with the capacity to empower farmers, strengthen innovation, direct research where it is needed most and build collaborative platforms for co-creation of knowledge. Extension officers would need to be trained in multidisciplinary thinking, be innovative thinkers themselves, able to facilitate dialogue among a group of diverse stakeholders and overcome the 'silo' mentality in creating linkages with all relevant departments.

EXAMPLES OF SUCCESSFUL SOCIAL LEARNING IN EXTENSION PRACTICES

There are several local, regional and international projects offering a framework for successful social learning at this level. Social learning is increasingly understood as an approach with much potential for successful natural resource management (Shackleton et al. 2009), as it becomes clearer that people, their value systems, aspirations and relationships are the ultimate determinants of long-term implementation and success (Cundill et al. 2001; Garnett et al. 2009; Shackleton et al. 2009). This requires investment in human capital at all levels, as the adaptive capacity of individuals feeds into adaptive societal capacity (Fazey et al. 2007). It also embraces complexity as a framework for understanding the interrelation between people and planet (Cundill et al. 2001).

All of the projects discussed below were chosen on the basis that they delivered successful social, economic and environmental outcomes, displayed the potential therefore or highlighted important lessons learnt around constraints to successful implementation. The body of research on social learning processes is in its infancy, as we struggle to understand how learning at this level can bring about social change. The article attempts to identify the potential shifts that occur or could occur during projects that follow a participatory and inclusive approach.

A project run in Welverdiend Village in South Africa's North West Province aimed to assess the potential of abundant tree resources to generate local income possibilities (Shackleton et al. 2009). Facilitated discussions were held with the local community (holding low levels of formal skills), researchers and the initiator of the project, a non-governmental organisation as to the results of the assessment (Shackleton et al. 2009). A process of dialogue was started with several community workshops taking place on the way forward and the needs around longer-term financial support and monitoring (Shackleton et al. 2009). The project came to a standstill when the facilitator left and the funding dried up (Shackleton et al. 2009). The importance of long-term interaction cannot be underestimated. The process of change is not easy and requires commitment to the process (Fazey et al. 2007) by all stakeholders, including facilitators. Learning is an on-going process leading to the emergence of new questions, which need to be unpacked, digested and discussed, and the emergence of new power relations (Fazey et al. 2007), given that power shifts in different contexts (Brydon-Miller 2004). This can be unsettling to group members, who require support through this process. Assumptions around which people are important to the process also need to be checked (Garnett et al. 2009; Dyer et al. 2013), as some people, holding unique and relevant knowledge, may not have the financial or time resources to participate (Cundill et al. 2001; Garnett et al. 2009) and key individuals need to be maintained to ensure continuity of the process (Schackleton et al. 2009). Shackleton et al. (2009) recommend that as many people as possible should be engaged initially to provide a buffer for those that fall out, while Garnet et al. (2009) advocate the hiring of community members as co-researchers to ensure their ongoing participation. There are pitfalls with payment to community members for ‘research work’ in that if funding is removed, so is the motivation for participation; payment might not result in desired behaviour change based on attitude change; and it retains a power hierarchy between the payer and payee (Garnett et al. 2009).

The Machubeni Catchment Area in the Eastern cape includes 14 affected villages, home to about 7 000 people, it is one of the poorest communities in the country and earmarked for funding under the Sustainable Land Based Livelihoods Programme (Shackleton et al. 2009). A three-year capacity building process was initiated through the establishment of a community-based natural resources management role for the community (Shackleton et al. 2009). Communities (individuals and institutions) were empowered to take the project forward, while a collaboration of local and scientific knowledge was used to understand the dynamics of local resources (Shackleton et al. 2009). This project fits in with the South African state’s understanding that ecosystems need to be conserved at the landscape level (DEAT 2005), while a shift to more sustainable practices is more likely to occur if inhabitants of the landscape are empowered to shift their personal viewpoints and behaviour (Fazey et al. 2007), given that they have the most direct influence over the environment (Tengberg et al. 2012). A way of empowering community members could have been the awarding of certificates of competency to those community members who learnt new skills; this has been successful in projects involving Chivi farmers in Zimbabwe increasing the social status of the local co-researchers as well as the status of tacit knowledge in the community (Garnet et al. 2009).

The Kansanshi Foundation Conservation Farming initiative in Zambia illustrates well how power relations and perceived power relations can affect the outcome of a project negatively. Established in 2010, one of the components of the project was smallholder training in conservation farming techniques combined with a loan scheme for fertiliser and maize seed (Dyer et al. 2013). The project aimed to meet farmers need for seed, as seed from the Food Reserve Agency habitually arrived after the start of the growing season, and to assist farmers in diversifying their crop selection (Dyer et al. 2013). Tension between farmers and project officers led to miscommunications and farmers rejecting the advice they were given by the officers as well dissension in the community around the labour intensity required with conservation farming (Dyer et al. 2013). This highlights the need for democratic participation and full community consultation in participatory partnerships.

Social learning that has led to on-going collaboration and community ownership of action and outcome is a project run in the Makana Municipality, also in the Eastern Cape Province, home to about 100 000 people, with little formal education (Schackleton et al. 2009). This project showcases a collaboration of non-governmental organisations, community members, learners and academics in developing a local environmental action plan (Shackleton et al. 2009). The resultant environmental forum formed meets on a regular basis and has drawn up a strategic vision and plan for the future (Shackleton et al. 2009).

In California, public and private extension officers, farmers, farmer organisations and scientists have collaborated in long-term several partnerships to extend both the philosophy and methodology of agroecological farming in the state. Warner (2005), in documenting these case studies, notes the importance of extension services moving past the ‘transfer of technology’ paradigm to embrace a ‘transfer of knowledge’ paradigm. Research and extension services are conducted within a social learning framework, as it not just new agroecological techniques that need to be promoted but an alternative understanding of farming systems (Warner 2005). A shift in thinking is required – farmers move from being passive receivers of knowledge and extension officers move from being expert suppliers of knowledge – to a participatory, co-created knowledge space (Warner 2005). Determinants of success in these projects have been the localised nature of projects (farm-scale joint research); flexibility in terms of timing of implementation and allowing different goals to be pursued within partnerships; and the space given for bottom-up change (Warner 2005). Farmers have been empowered through this process to use farmer organisations to lobby for changes to state policy and to negotiate with commodity organisations (Warner 2005). This is important as farmers need to contribute towards the enabling institutional context they require (Van Tilburg & Van Schalkwyk 2012). The farmer is central to this process with on-the-ground knowledge and the ability to implement on-the-ground change (Warner 2005). Points of interaction occur on team levels between farmers, scientists and extension officers and generated knowledge is diffused into the wider community through farmer-to-farmer exchange at demonstrations (Warner 2005).

An example of a farmer-led extension service is the National Smallholder Farmers' Association in Malawi (NASFAM). An independent, democratic, member-owned organisation with over 100 000 members, organised into 'clubs' of ten to fifteen members, NASFAM arose in response to the lack of adequate state extension services in the country. The organisation supplies farmers with technical and market information; enables collective bargaining and buying power; runs community development and capacity-building programmes (including literacy and HIV/Aids awareness campaigns); promotes agroecological farming methods with an emphasis on quality production to increase yields; and links farmers to the state through collective lobbying for policy change and budget allocations, as well as linking farmers to science through building relationships with research organisations; programmes are monitored and evaluated on a regular basis (NASFAM 2013).The organisation provides training on seed saving, pre- and post harvesting techniques, storing, multiplication and distribution (NASFAM 2013). Social learning is enabled through linkages with research organisations and regular farmer-to-farmer meetings in which knowledge is exchanged and farmers are further connected through a twice-weekly radio programme, quarterly newsletters and crop bulletins (NASFAM 2013).

Lack of funds is a major obstacle to longevity of the process and funding should be adaptable to changing circumstances, allowing for 'surprises', both negative and positive opportunities (Shackleton et al. 2009). In addition, it is important to note that when private funds are used, the agenda of change is often set by those with a vested interest in the outcome (Dyer et al 2013). Social learning approaches acknowledge and manage power, rank and role differentials between stakeholders (Bouwen & Taillieu 2004; Woodhill 2010). An important part of social learning is the notion of deep dialogue (Bouwen & Tallieu 2004), which takes time but allows trust to be built and a 'common' framework of understanding established (Chen et al. 2013). Power relations need to be openly acknowledged (Amanor 2012; Pahl-Wostl et al. 2008) and assigning leadership roles to community members can strengthen the capacity of 'weaker' partners (Roscigno 2011).

There are numerous benefits that accrue from successful social learning approaches, besides empowerment of individual members of the group (Pahl-Wostl et al. 2008), a sense of co-ownership of process and outcome (Bouwen & Taillieu 2004); higher levels of understanding and critical thinking (Woodhill 2010), increased collaboration, and increased appreciation for the knowledge and diversity of others (Shackleton et al. 2009). Due to the multidisciplinarity of this type of work, funding can be sourced from a variety of stakeholders as generated knowledge speaks to the complexity of resource management (Shackleton et al. 2009); it enables co-production of context-specific, relevant and usable knowledge; and is likely to increase innovation at a on-the-ground level.

POTENTIAL OUTCOMES OF A STATE-SCIENCE-FARMER THROUGH EXTENSION SERVICE PARADIGM

CO-CREATED KNOWLEDGE

Traditionally farmers have been co-creators in agricultural innovation (Schenkelaars 2011) as opposed to 'passive recipients' and end-users of seed emanating from the formal system (Amanor 2010; Brahy 2009; Sassenrath et al. 2008; Tansey 2011). Farmers have direct knowledge of their local growing conditions, are actively involved in seed multiplication (Amanor 2012) and their knowledge of locally adapted varieties will play a key role in mitigating and adapting to climate change (DEA 2011; Nordhagen & Pascual 2013).

Opening up spaces for co-creation of knowledge has the potential to provide several benefits to the state, to the research community and to the country's farmers. The relatively new practices of participatory and localised science, based on principles of equity, diverse knowledge integration and efficiency (Pahl-Wostl et al. 2008) are gaining ground in genetic resource management (Garnet et al. 2009; Schakleton et al. 2009; Srang-iam 2013) as they offer more opportunity for effective sustainable development. Dialogue, as a key element of social learning process, is central to knowledge co-creation allowing for shared meaning to emerge as well as shared action (Chen et al. 2013). It is not only the biological elements of ecosystems that must be protected, but also the knowledge of management practices related to ecosystems (Barthel et al. 2013). Barthel et al. (2013) refer to bio-cultural refugia indicating places that shelter plant and animal species as well as the knowledge and practical experiences in management of those places. These 'living laboratories' offer space for innovation (Barthel et al. 2013) if 'stewardship' memory is supported; this is not only cultural memory, but the way it is interpreted and lived by contemporary society (Tengberg et al. 2012). This requires the involvement of the community in any research process (as participant and co-designer), both to access local knowledge and to ensure the relevance of the question (Garnett et al. 2009).

The Thicket Forum is a good example of local knowledge co-creation. In the eastern part of the Maputaland-Pondoland-Albany region (a biodiversity 'hotspot' of global importance), a project, funded by the Global Environment Facility, was initiated to raise awareness of the importance of the biome and develop a conservation plan for the region (Shackleton et al. 2009). What was initially an informal network of conservation planners has shifted into a 'social learning institution', the Thicket Forum, which connects researchers, state officials and land managers together (Shackleton et al. 2009). The aim of the group was collaborative knowledge sharing to improve land-management practices (Shackleton et al. 2009).

INCREASED INNOVATION

Knowledge sharing and participatory research is more likely to lead to increased innovation (Venkatesen 1994, Mayet 2012) as local systems are linked with science and technology in new ways (Scoones & Thompson 2011). Social learning offers a different way of looking at information exchange and knowledge creation, in this model, information supports communication as opposed to information being supplied by experts, with no on-the-ground knowledge of local context, to end-users (Pahl-Wostl et al. 2008). Feedback loops between farmers and formal system stakeholders are lacking and scientists have much to gain by considering farmers as equal partners with valuable knowledge (Okry et al. 2010) as opposed to clients of modern agrifood systems when they purchase seeds as inputs (Phillips 2008).

- New seeds can be fine-tuned in different locations (Amanor 2012).
- Farmers can experiment with improved varietals and distribute them quickly (Venkatasen 1994; Okry et al. 2010; Lwoga et al. 2011; Amanor 2012).
- Research can be strategic in nature, given localised settings and knowledge sets (Byerlee 1998).
- Improved technical solutions along with behavioural change (Bouwen & Taillieu 2004).

It is likely to encourage the emergence of a more creative, resilient and adaptive response system to upcoming agricultural challenges (Sassenrath et al. 2008). The exchange of knowledge and explanations of different knowledge paradigms to construct new understandings is vital (Bouwen & Taillieu 2004). Once seen as co-creators, farmers, scientists and plant breeders will benefit from improved knowledge sets (Lwoga et al. 2011), which can be tailored to specific local contexts (Lwoga et al. 2011; Sassenrath et al. 2008). These knowledge sets draw on local, traditional and scientific knowledge and vary according to location, gender, developmental needs, agricultural activities and agro-ecological conditions (Lwoga et al. 2011). Underlying assumptions need to be unpacked so that individuals and other stakeholders understand their starting points for knowledge and expertise (Bouwen & Taillieu 2004). In the formal seed system, useful knowledge is seen as formal and systematic following codified procedures and universal principles (Bouwen & Taillieu 2004). However, implicit or tacit knowledge that is embedded in social interactions and actualised through common practice needs to be acknowledged (Bouwen & Taillieu 2004), as in a globalised world, it is tacit knowledge that affords nations a competitive advantage in terms of innovation (AU-NEPAD 2010). Understanding and appreciating tacit knowledge and practices and how they are carried in social memory requires recognition of the deep practical experience, values and concerns engrained in various agric-cultures (Barthel et al. 2013).

Empowerment of participants

An expected outcome of effective social learning is the empowerment of participants through the internalisation of new knowledge in a context of equality, which leads to a sense of co-ownership of projects accompanied by joint responsibility for outcomes (Bouwen & Taillieu 2004). Using a localised science approach, through farmer field schools, for example, encourages local communities and farmers to generate their own knowledge with access to information from the scientific community, leading to a sense of empowerment (Srang-iam 2013). Enabling neglected system 'memory' to recover and reclaim its space in the system through a series of institutional changes would allow the seed system to 'reboot' in that power relations would shift encouraging the system to serve a wider group of beneficiaries; given that power can shift in different contexts (Brydon-Miller 2004. Smallholder farmers do not only need technical assistance (information, inputs and markets), they need a voice in decisionmaking structures and policy discussions to overcome historically weak social and financial capital (Van Schalkwyk et al. 2012). They need, in other words, a power base of their own (Beyerlee 1998; Van Schalkwyk et al. 2012) in order to grapple with the complexities of the system in order to realise benefits for themselves (Van Tilburg & Van Schalkwyk 2012. Policy must be a negotiated outcome that involves all stakeholders affected by its implementation (Scoones et al. 2005) if it is to reflect the diversity of microclimates, cultures, agricultural systems and indigenous seeds found in South Africa.

Cape Action for People and Environment, the National Grassland Biodiversity Programme, Working for Water, LandCare and the Succulent Karoo Ecosystem Programme, are examples of crosscutting programmes that mainstream biodiversity considerations, display the potential to empower communities and build capacities (DEAT 2005). An example of a state-led initiative that addresses issues of nutrition, climate change and food security, while promoting smallholder agriculture can be found in Kenya. Following a report from the Department of Environmental Earth System Science and Programme on Food Security and the Environment looking at the negative effect of drought and heat stress on maize yields in Africa, the Kenyan government has taken steps to change dietary patterns of its citizens (Lukhele-Olorunju 2011). There have been efforts to promote the consumption of traditional crops in the country through the distribution of seeds and vegetative cuttings of orphan crops (sweet potato, cassava, cowpeas, chick peas, sorghum, and millet) and supermarkets are beginning to stock traditional vegetables and specially milled and blended flours (Lukhele-Olorunju 2011).

CONCLUSION

As seed is a critical determinant of crop success and farming viability, the system through which it is bred, multiplied and distributed must align with the stated policy goals of the agricultural sector – those of inclusivity, productivity and sustainability. Currently, the South Africa system does not do this. A highly formalised system, controlled predominantly by multinational companies protected by strict intellectual property rights, institutionalised privilege and international regulatory frameworks, contributes to declining biodiversity levels, lowers opportunities for local innovation, and contributes to tighter margins on farming viability and may lead to higher food costs. The state has perpetuated a set of technology decisions (support for hybrid and GM seed technology within an industrial farming system) that do not serve the farmers or the citizens of South Africa. This choice determines the direction of the industry, closing off alternative options or pathways (Kranakis 2007).

However, South Africa, at a crossroads in terms of plant variety protection laws, existing and proposed changes to intellectual property laws and facing challenges of food security, biodiversity and climate change, has an opportunity to 'liberate' the forgotten memory of the seed system and provide balance to the dominant metanarrative of the system. The co-existence of TRIPs and ITPGRFA on an international level and the contradictions between the South African state's international obligations and national policy, as well as within national policy, point to existing fault lines that could open space for a new imagining of a sustainable seed system for the country.

Social change does not happen in a vacuum, it often needs to be deliberately orchestrated, planned for and nurtured. Social learning is a particularly apt process for this as it encourages personal and group empowerment, in-depth understanding of complex issues, and realignment of values with desired direction and is useful for acknowledging and overcoming or sidestepping embedded power relations. Interventions in complex systems can bring about non-linear and negative change; recommended interventions therefore focus on existing elements and feedback loops, such as the state agricultural extension service, which is already in the process of being overhauled.

According to policy documents (DoA 2002; DEAT 2008; NPC 2011; DAFF 2012), the South African state desires an inclusive, sustainable and productive agricultural sector. As opposed to being led by technology and the interests of corporate companies, "we should look at what system we want and then use science to get there" (Swanby 2013).

Conclusion

I finish writing this study at a particularly potent time in world history, as consumer groups around the world exercise their combined power to force retailers and governments to change their stance on genetically modified seed and foodstuffs. India has issued a moratorium on field trials for genetically modified crops and prohibited cultivation release from existing crops (IFPRI 2013). Russia, which does not allow the planting of genetically modified seed, is considering import bans on anything containing genetically modified organisms (Sustainable Pulse 2013). In Mexico, all activities involving genetically modified corn, including experimental and pilot planting, have been banned pending the outcome of collective action lawsuits filed by citizens, farmers and civil society organisations in the country (Food Democracy Now 2013). In August 2013, Italy became the ninth European Union member to ban the cultivation of genetically modified crops, joining Poland, France, Austria, Germany, Hungary, Luxembourg, Greece and Bulgaria (Longo 2013). Reasons for banning cultivation of crops or importation of foodstuffs containing genetically modified organisms range from health and ethical to environmental concerns.

South Africa is at a crossroads in terms of its international obligations and its stated policy direction for the agricultural industry. The country's constitution guarantees South African people the right to food and the right to a healthy environment (RSA 1995) and policy calls for an inclusive, productive and sustainable industry (DoA 2002; DEAT 2008; NPC 2011; DAFF 2012). Farmers' rights to save and replant seed are still allowed. These policies aim to benefit people. TRIPs, UPOV 1961 and the proposed protocol for harmonisation of plant breeders' rights in the Southern African Development Community, which will automatically implement UPOV 1991, call for stronger protection of intellectual property rights, allow for the patenting of plant germplasm and disallow Farmers' Rights. This research has argued that these treaties predominantly benefit corporate business. Even internal policy in the country is contradictory with the proposed amendments to South Africa's National Policy on Intellectual Property, released for public comment in September 2013, recommending that patent law must enshrine Farmers' traditional rights to save seed, even patented seed (DTI 2013). However, if the draft SADC harmonisation protocol is accepted, this right would automatically be negated (SADC 2012).

The history of the seed system in South Africa has since the mid-1600s been commercial in nature serving a particular group of participants – colonists, white farmers during the Apartheid era, and private businesses (predominantly multinational companies) in the period post-1994 when the country entered a globalised agricultural market. As a result, the dominant 'memory' of the system, which has left its mark in legislature, institutions (both real world and sets of practice) and infrastructure, rests on a set of power relations, which need to be acknowledged, and a set of assumptions about the benefits of a corporate-led, technology-driven sector. The metanarrative revolving around how high yields will 'feed the world' masks the attempt by multinational seed companies, who are often also chemical companies, to broaden their market for seed containing proprietary knowledge, synthetic fertilisers and pesticides. This metanarrative neglects issues of nutrition, environmental degradation (Shiva 2012) and broader constraints affecting production ability, such as unequal access to land, water and credit (Sassenrath et al. 2008).

It is argued in this paper that the current corporate consolidation of the seed industry, with majority germplasm ownership of the country's staple food supply of maize residing in the hands of two US-based multinational companies, the state places the food security of South African citizens at risk, increases the risk of agrobiodiversity loss, and limits its options in terms of climate change adaptation. Climate change adaptation relies heavily on affordable access to seed with climate-ready traits, which will produce plants able to adapt in-situ to changing rainfall patterns and temperature increases (CGRFA 2010).

Corporations have a mandate to provide a return on investment (Rusike 1995; Wield et al. 2010; Afari-Sefa et al. 2012) and seed provides the perfect vehicle for the repeated sale of proprietary technology. Particularly as the often mandated use of complementary fertilisers, pesticides and herbicides offers opportunity for additional revenue (Brahy 2009; Wield et al. 2010; Moss 2011; Fulton & Giannakas 2012.

Besides the debatable wisdom of handing ownership of the country's staple food over to corporate control, the use of these types of seeds (hybrids and genetically modified seed) locks the country into a particular farming model – that of monocultures and a high external input system, as fertilisers, pesticides, herbicides and irrigation water are necessary to unlock the full yield potential of the seed (De Schutter 2011). This is not taking the country in the direction of agroecological farming methods, outlined in the 2009 International Assessment of Agricultural Knowledge, Science and Technology for Development report (IAASTD 2009) as necessary for food security and adaptation to climate change.

The study outlines the possibility for power to shift in different contexts and proposes the state agricultural extension service as the most efficient point of intervention into the seed system, given that it is in the process of being overhauled. The state agricultural extension service is a powerful link between state, science and farmer and as an 'information exchange' in the seed system could play a transformational role in empowering farmers, opening up space for co-creation of knowledge and increased on-the-ground innovation. Both the potential and limitations for this linked state-science-farmer through extension services paradigm are outlined and the discussion is framed with a social learning approach, based Bouwen and Taillieu's (2004) understanding of social learning.

In a heavily consolidated system, with a dominant 'memory' supported by vested economic and political interests, it is important to find spaces that will encourage the neglected system memory to emerge (this encompasses indigenous knowledge, seed saving and exchanging) and claim its space in the system. In a sense, the system requires fracturing in order to shake up entrenched power hierarchies and create space for alternative narratives to emerge. Complexity thinking is useful in this regard, as it allows and encourages a diversity of narratives to co-exist, all claiming their own space through competition and/or collaboration (Cilliers 1998). The study uses complexity to highlight the interconnectedness of system elements and the asymmetrical nature of their relationships.

It was not possible to explore the many, many threads that emerged during the research in this study. Some of the areas requiring further research include:

- The extent of the practice of seed saving and exchange on the commercial level in South Africa, and what knowledge systems exist within that practice.
- The extent to which indigenous vegetables and grains are still consumed in urban areas, and where and by whom these are being produced.
- The cost of labelling genetically modified foods is given as rationale for resistance by companies to provide accurate and full traceability on their products; however, no cost analysis has been done on this.
- An updated survey of South Africa's farmers – scale, type and reason for farming.
- Documenting the increasing encroachment of corporate power over the agricultural industry.
- Power relations between multinational corporations and the South African state.

References

ACB (2011). *Heavy Hands: Monsanto's control in South Africa*. Johannesburg: African Centre for Biosafety.

ACB (2012). *Pesticides and GM Crop Series: How much glyphosate is on your dinner plate? SA's food safety compromised by lack of testing*. Johannesburg: The African Centre for Biosafety.

Afari-Sefa, V., Tenkouano, A., Ojiewo, C.O., Keatinge, J.D.H. & Hughes, J. (2012). Vegetable breeding in Africa: constraints, complexity and contributions toward achieving food and nutritional security. *Food Security* 4:115-127.

Agriseta (2012). *Sector Analysis Agriculture Report for submission to the Department of Higher Education and Training*. Pretoria: Agriseta.

Almekinders, C. (2000). *The importance of informal seed sector and its relation with the legislative framework*. Paper presented at GTZ-Exchborn, July 4-5, 2000.

Altieri, M.A. (1999). The ecological role of biodiversity in agroecological systems. *Agriculture, Ecosystems and Environment* 74:19-31.

Amanor. K.S. (2012). *From Farmer Participation to Pro-poor Seed Markets: The Political Economy of Commercial Cereal Seed Networks in Ghana*. Policy Brief 047: Future Agricultures Briefings. [Online]. Available at: www.future-agricultures.org. Accessed 15 July 2013.

Anderson, R. (2005). *The interaction between international agreements pertaining to the management of plant genetic resources for food and agriculture and the response of developing countries.* Paper delivered at the 46th Annual ISA Convention, Honolulu, Hawaii, March 1-5, 2005.

Anderson, S.R. & Bryson, J.M. (2000). Apply Large-Group Interaction Methods in the Planning and Implementation of Major Change Efforts. *Public Administration Review* 60(2).

ARC (2009). *Agricultural Research Council Annual Report /2008-2009*. Pretoria: Agricultural Research Council.

ARC (2010). *Agricultural Research Council Annual Report /2009-2010*. Pretoria: Agricultural Research Council.

ARC (2011). *Agricultural Research Council Annual Report /2010-2011*. Pretoria: Agricultural Research Council.

ARC (2011b). *ARC concept towards sustainable agricultural development: A New Role for the Agricultural Research Council in human & social development*. [Online]. Available at: http://www.extensionpolicy.za.net/oid/downloads/1/33_1_9_21_04_AM_ARC_Extension_Concept_version_11_january_2011.pdf. Accessed at 20 September 2013.

ARC (2012). *Agricultural Research Council Annual Report /2011-2012*. Pretoria: Agricultural Research Council.

AU-NEPAD (2010) *African Innovation Outlook 2010*. Pretoria: African-Union-New Partnership for Africa's Development .

BAASS (2013). Personal correspondence to the Biodynamic Agricultural Association of Southern Africa by Basil Kransdorff of Econocom Foods. Supplied by the Biodynamic Agricultural Association of Southern Africa.

Bandura, A. (1971). *Social Learning Theory*. USA: General Learning Corporation.

Barker, D. (2007). *The Rise and Predictable Fall of Globalised Industrial Agriculture*. San Francisco: Columbia Foundation.

Barlett, L.D. & Steele, J.B. (2008). *Monsanto's Harvest of Fear* [Online]. Available at: http://www.vanityfair.com/politics/features/2008/05/monsanto200805. Accessed on 4 August 2012.

Barthel, S., Crumley, C. & Svedin, U. (2013). Bio-cultural refugia - Safeguarding diversity of practices for food security and biodiversity. *Global Environmental Change*. [Online]. Available at: http://www.sciencedirect.com/science/article/pii/S0959378013000757. Accessed 14 August 2013.

Bawden, R. (2004). Chp 3: The Community Challenge: The Learning Response in Multi-party Collaboration as Social Learning for Interdependence: Developing Relational Knowing for Sustainable Natural Resource Management. *Journal of Community & Applied Social Psychology* 14:137-153.

Baxter, K (2012). *Food Security and Seed Saving.* [Online]. Available at: http://permaculturenews.org/2012/01/23/food-security-and-seed-saving. Accessed on 4 August 2012.

Berhan, T., Egziabher, G. & Edwards, S. (2012) The loss of crop genetic diversity in the changing world. In *Seed Freedom: A Global Citizen's Report*. New Delhi: Navdanya.

Bernstein, H. (2012) Commercial Agriculture in South Africa since 1994: 'Natural, Simply Capitalism'. *Journal of Agrarian Change* 13(1): 23-46.

BIOS (2013). *Biological Innovation for Open Society*. [Online]. Available at: http://www.patentlens.net/daisy/bios/home.html. Accessed on 19 September 2013.

Blackmore, C. (Ed) (2010). *Social Learning Systems and Communities of Practice*. London: Springer.

Bohm, D., Factor, D. & Garret, P. (1991). *Dialogue: A Proposal*. [Online]. Available at: www.dialogos.com/resources. Accessed 23 April 2013.

Bouwen, R. & Taillieu, T. (2004). Multi-party Collaboration as Social Learning for Interdependence: Developing Relational Knowing for Sustainable Natural Resource Management. *Journal of Community & Applied Social Psychology* 14: 137-153.

Brahy, N. (2009). *Intellectual Property of Agricultural Resources and Biodiversity*. Expert Submission to the United Nations Special Rapporteur on the Right to Food, Olivier de Schutter. [Online]. Available at: http://www.unamur.be/droit/crid/propriete/rapport-olivier-de-schutter. Accessed on 3 March 2013.

Brewster, A., Hansen, S. & Chapman, A. (2007). Chp 2.2. Facilitating Humanitarian Access to pharmaceutical and agricultural innovation. In A. Krattiger, R. Mahoney, L. Nelson, J.A. Thomson, A.B. Bennet, K. Satyanarayana, G.D. Graff, C. Fernandez, & S.P. Kowalksi (Eds). *Intellectual* *property management in health and agricultural innovation: A handbook of best practices*. Oxford: MIHR & David, California: PIPRA.

Brydon-Miller, M. (2004). The terrifying truth: Interrogating systems of power and privilege and choosing to act. In: M. Brydon-Miller, P. Maguire, & A. McIntrye (Eds): Traveling companions: feminism, teaching, and action research. Westport, CT: Greenwood Press.

Burch, D. & Lawrence, G. (2005). Supermarket Own Brands, Supply chains and the transformation of the agri-food system. *International Journal of Sociology of Agriculture and Food* 13(1).

Burd, A. (2003). *Ruskin's Quest for a Theory of the Imagination*. Massachusetts: EBSCO Publishing.

Byerlee, D. (1998). The Search for a New Paradigm for the Development of National Agricultural Research Systems. *World Development* 26(6): 1049-1055.

CBD (1993). *Convention on Biological Diversity.* [Online]. Available at: http://www.cbd.int/intro/default.shtml. Accessed on 21 January 2014.

Ceccarelli, S. (2012). Living Seed - Breeding as Co-evolution. In *Seed Freedom: A Global Citizen's Report*. New Delhi: Navdanya.

CFS (2012). Center for Food Safety: Corporate Control and Seed Monopolies [Online]. Available at: http://www.centerforfoodsafety.org/campaign/save-our-seeds/corporate-control-and-seed-monopolies/. Accessed on 4 August 2012.

CGRFA (2010). *The Second Report on The State of the World's Plant Genetic Resources for Food and Agriculture*. Rome: Food and Agriculture Organisation Commission on Genetic Resources for Food and Agriculture.

Chamberlain, K. (2000). Methodolatry and Qualitative Health Research. *Journal of Health Psychology* 5(285). London: Sage.

Chen, C., Wu, Y.J. & Wu, W. (2013). A sustainable collaborative research dialogue between practitioners and academics. *Management Decision* 51(3):566-593.

Cilliers, P. (1998). *Complexity & Postmodernism*. New York: Routledge.

Cilliers, P. (2000). What can we learn from a theory of complexity? *Emergence* 2(1):23-33.

Cilliers, P. (2007). On the importance of a certain slowness: Stability, memory and hysteresis in complex systems. In Gershenson, C., D. Aerts & B. Edmonds (Eds.) Worldview, Science and Us: Philosophy and Complexity. Liverpool: University of Liverpool.

Clayton, A.M.H. & Radcliffe, N.J. (1996). *Sustainability: A systems approach*. Edinburgh: The Institute for Policy Analysis and Development.

Clift, C. (2007). Chp 2.4. Patenting and licensing research tools. In A. Krattiger, R. Mahoney, L. Nelson, J.A. Thomson, A.B. Bennet, K. Satyanarayana, G.D. Graff, C. Fernandez, & S.P. Kowalksi (Eds). *Intellectual property management in health and agricultural innovation: A handbook of best practices*. Oxford: MIHR & David, California: PIPRA.

Cullet, P. (2007). Human Rights and Intellectual Property Protection in the TRIPS Era. *Human Rights Quarterly* 29: 403-430

Cundill, G., Cumming, G., Biggs, D. & Fabricius, D. (2011). Soft Systems Thinking and Social Learning for Adaptive Management. *Conservation Biology*, 26(1):13-20.

DAFF (2011) *Plant Breeders' Rights Policy*. Pretoria: Department of Agriculture, Forestry and Fisheries.

DAFF (2012). *Strategic Plan 2012/13-2016/17 for the Department of Agriculture, Forestry and Fisheries.* Pretoria: Department of Agriculture, Forestry and Fisheries.

DAFF (2012b) Department of Agriculture Forestry and Fisheries Pretoria.

DAFF (2013). *Biosafety: Permits Issued*. [Online]. http://www.daff.gov.za/. Accessed 15 October 2013.

De Lange, J. (2013). Personal interview conducted with Johan de Lange, Chief Director: Products, KaapAgri. Conducted 12 October 2013.

De Schutter (2009b). *Seed Policies and the right to food: enhancing agrobiodiversity and encouraging innovation* [UN General Assembly Document a/64/170]. Rome: United Nations General Assembly.

De Schutter, O. (2009a). The right to food: fighting for adequate food in a global crisis. *Harvard International Review* XXXI(2).

De Schutter, O. (2011) The Right of Everyone to Enjoy the Benefits of Scientific Progress and the Right to Food: From Conflict to Complementarity. *Human Rights Quarterly* 33: 304-350.

DEA (2011). *South Africa's Second National Communication under the United Nations Framework Convention on Climate Change*. Pretoria: Department of Environmental Affairs.

DEAT (2005). *South Africa's National Biodiversity Strategy and Action Plan*. Pretoria: Department of Environment & Tourism.

DEAT (2008). *A National Framework for Sustainable Development in South Africa*. Pretoria: Department: Environmental Affairs and Tourism.

Dessel, A. Garlington, S.B. & Rogge, M.E. (2006). Using intergroup dialogue to promote social justice and change. *Social Work* 51(4).

Dillon, M (2005). A Brief History of the Development of the Seed Industry – The Shift from Public to Private Seed Systems [Online]. Available at: http://www.seedalliance.org/index.php?page=SeminisMonsanto. Accessed on4 August 2012.

DoA (2002.) *The Integrated Food Security Strategy for South Africa*. Pretoria: Department of Agriculture.

Drimie, S. & McLachlan, M. (2013). Food Security in South Africa – first steps towards a transdiscplinary approach. *Food Security.* 5: 217-226.

Driver, M., Smith, T. & Maze, K. (2005). *Specialist Review Paper on Biodiversity for the National Strategy for Sustainable Development.* Pretoria: South African National Biodiversity Institute.

DTI (2013). *Draft National Policy on Intellectual Property, released for public comment in September 2013.* Pretoria: Government Gazette, 13 September 2013.

Du Toit, D.C. (2011) *Food Security*. Pretoria: Directorate Economic Services Production Economics Unit, Department of Agriculture, Forestry and Fisheries.

DuPont (2012). *Pioneer-Pannar Merger*. [Online]. Available at http://www2.dupont.com/South_Africa_Country_Site/en_ZA/Media_Center/Press_Releases/2012/Pioneer_Pannar_Merger.html. Accessed on 14 September 2013.

DWA (2013). *National Water Policy Review: Updated Policy Positions to Overcome the water challenges of our developmental state to provide for improved access to water, equity and sustainability*. Pretoria: Government Gazette.

Dyer, J., Leventon, J., Stringer, L., Dougill, A., Syampungani, S., Nshimbi, M., Chama, F. & Kafwifwi, A. (2013) Partnership Models for Climate Compatible Development: Experiences from Zambia. Resources 2:1-25.

Eicher, C., Maredia, K. Sithole-Niang. (2006). Crop biotechnology and the African farmer. *Food Policy* 31: 504-527 2006.

Ericksen, P. J. (2007.) *Conceptualizing food systems for global environmental change research*. Oxford: Environmental Change Institute.

FAO (2002). *The State of Food Insecurity in the World 2001.* Rome: Food and Agriculture Organization of the United Nations.

FAO (2004). *Towards effective and sustainable seed relief activities*. Report of the Workshop on Effective and Sustainable Seed Relief Activities Rome 26-28 May 2003. Rome: Food and Agriculture Organisation of the United Nations.

FAO (2009). Global Agriculture towards 2050. High-level expert forum, Rome 12013 October 2009. [Online]. Available at: ttp://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf Accessed on 12 September 2013.

FAO (2010). *Promoting the Growth and Development of Smallholder Seed Enterprises for Food Security Crops.* Case studies from Brazil, Cote d'Ivoire and India. FAO Plant Production and Protection Paper 201. Rome: Food and Agriculture Organization of the United Nations.

FAO, Biodiversity International and Earthscan (2011). *Plant Genetic Resources and Food Security: Stakeholder Perspectives on the International Treaty on Plant Genetic Resources for Food and Agriculture.* London: Earthscan.

FAO. 1999a. Agricultural Biodiversity, Multifunctional Character of Agriculture and Land Conference, Background Paper 1. Maastricht, Netherlands. September 1999.

Fazey, I., Fazey, J., Fischer, J., Sherren, K., Warren, J., Noss, R.F. & Dovers, S.R. (2007). Adaptive Capacity and Learning to Learn as Leverage for Social-Ecological Resilience. *Frontiers in Ecology and the Environment* 5(7):375-380.

Foley, J., Ramankutty, N., Brauman, K., Cassidy, E. (2011). Solutions for a cultivated planet. *Nature* 478: 337-342.

Food Democracy Now! (2013). *Mexico Judge Rules that GMOS are imminent Threat: Bans Monsanto's GMO Corn*. [Online]. Available at:

http://fooddemocracynow.org/blog/2013/oct/11/breaking_mexico_judge_rules_that_GMOs_are_threat/. Accessed on 14 October 2013.

Freeth, R (2011). *Just Facilitation: Facilitating Sustainable Social Change in Contexts of Injustice.* Thesis presented in fulfilment of the requirements for the degree Master of Philosophy in Sustainable Development Planning and Management in the faculty of Economic and Management Sciences at the University of Stellenbosch.

Fulton, M. & Giannakas, K. (2001). Agricultural Biotechnology and Industry Structure. *AgBioForum* 4(2): pg 137-151.

Galushko, V (2012). Do stronger intellectual property rights promote seed exchange: evidence from U.S. seed exports? *Agricultural Economics* 43: 59-71.

Garnett, S.T., Crowley, G.M., Hunter-Xenie, H., Kozanayi, W., Sithole, B., Palmer, C., Southgate, R. & Zander, K. (2009). Tranformative Knowledge Transfer through Empowering and Paying Community Researchers. *Biotropica* 41(5)571-577.

Gilbert, N. (2012) Dirt Poor. *Nature* 483: 525-527.

Goldblatt, A. (2010). *Agriculture: Facts & Trends South Africa*. [Online]. Available at: http://awsassets.wwf.org.za/downloads/facts_brochure_mockup_04_b.pdf. Accessed on 2 September 2013.

Gonzalez, C. (2012). The global food system, environmental protection, and human rights. *Natural Resources & Environment* 26(3):7.

Graff, G.D. (2007). Chp 3.3. Echoes of Bayh-Dole? A survey of IP and technology transfer policies in emerging and developing economies. In A. Krattiger, R. Mahoney, L. Nelson, J.A. Thomson, A.B. Bennet, K. Satyanarayana, G.D. Graff, C. Fernandez, & S.P. Kowalksi (Eds). *Intellectual property management in health and agricultural innovation: A handbook of best practices*. Oxford: MIHR & David, California: PIPRA.

Grain (2013). *Grain SA*. [Online]. Available at: http://www.grainsa.co.za/. Accessed on 22 September 2013.

Greenberg, S. (2010) *Contesting the food system in South Africa: Issues and opportunities*. Research Report 42. Bellville: Institute for Poverty, Land and Agrarian Studies.

Groenwalk, J., Klopper, J. & Van Schalkwyk, H. (2012). Chapter 2: Strategies to improve smallholders' market access. In: H. Van Schalkwyk, J. Groenewald, G. Fraser, A. Obi, & A. Van Tilburg (Eds): *Unlocking markets to smallholders: Lessons from South Africa.* The Netherlands: Wageningen Academic Publishers.

Haasbroek, L. (2013). Email interview with Liesl Haasbroek: National Coordinator Southern African Biodynamics Association.Conducted 10 October 2013.

Hachigonto, S., Nelson, G.C., Thomas, T.S. & Sibanda, L.M. (2013) *Southern African Agriculture and Climate Change: A Comprehensive Analysis*. Washington DC: International Food Policy Research Institute.

Hajkowicz, S., Negra, C., Barnett, P., Clark, M., Harch, B. & Keating, B. (2012). Food price volatility and hunger alleviation - can Cannes work? *Agriculture & Food Security* [Online]. Available at: www.agricultureandfoodsecurity.com/ontent/1/1/8. Accessed on 29 August 2013.

Hammond, R. & Dube. L. (2012). A systems science perspective and transdiciplinary models for food and nutrition security. *Proceedings of the National Academy of the Sciences in the United States of America* (PNAS), 109(31):12356-63.

Heher, A.D. (2007). Chp 3.5. Benchmarking of technology transfer offices and what it means for developing countries. In A. Krattiger, R. Mahoney, L. Nelson, J.A. Thomson, A.B. Bennet, K. Satyanarayana, G.D. Graff, C. Fernandez, & S.P. Kowalksi (Eds). *Intellectual property management in health and agricultural innovation: A handbook of best practices*. Oxford: MIHR & David, California: PIPRA.

Howard, P. (2009). Visualizing Consolidation in the Global Seed Industry: 1996-2008. *Sustainability* 1:1266-1287.

Howard, P. (2013). *Seed industry structure*. [Online]. Available at: www.msu.edu/~howardp/seedindustry.html. Accessed 1 October 2013.

Hubbard, K. (2013). *Seed Industry Consolidation is still 'out of hand'*. [Online]. Available at: http://blog.seedalliance.org/2013/09/17/seed-industry-consolidation-is-still-out-of-hand/. Accessed on 1 October 2013.

IAASTD (2009). *International Assessment of Agricultural Knowledge, Science and Technology for Development Synthesis Report*. Washington: IAASTD.

IFPRI (2012). *Southern African Agriculture and Climate Change: A Comprehensive Analysis - South Africa.* Washington DC: International Food Policy Research Institute,

IFPRI (2013). *2012 Global Food Policy Report: Policy Choices on the Ground*. Washington DC: International Food Policy Research Institute.

IFPRI (2013b). *2012 Global Food Policy Report: Scenarios for the Future of Food*. Washington DC: International Food Policy Research Institute.

Isaacs, W.N. (1999). *Dialogic Leadership. In: The Systems Thinker* 10(1). Pegasus Communications. [Online]. Available at: www.dialogos.com/resources. Accessed 20 April 2013.

ISF (2012). *Report ISF World Seed Report*. Congress Rio de Janeiro 2012. International Seed Federation.

Jaftha, J. (2013). Email interview conducted with Julian Jaftha, Chief Director, Plant Production & Health, Department of Agriculture. Conducted 10 October 2013.

Jones, R.B., Audi, P.A. & Tripp, R. (2001). The role of informal seed systems in disseminating modern varieties. The example of pigeonpea from a semi-arid area of Kenya. *Experimental Agriculture* 37:539-548.

Kahn, Z. (2013). Personal interview conducted with Zayaan Kahn, Surplus People's Project. Conducted 23 September 2013.

Kerssen, T (2010). *Saving Africa's Seeds: Farmers fighting for diversity* [Online]. Available at: http://www.foodfirst.org/en/node/3224. Accessed on 4 August 2012.

Kirsten, J., Stander, R. & Haankuku, C. (2010). *Measuring Private Research & Innovation in South Asia & Sub-Saharan Africa: A South Africa Country Report.* Washington DC: International Food Policy Research Institute.

Klein, J., Damm, V. & Gibeler, A. (1983). An Outline of a Theory of Imagination. *Journal for General Science* 14(1):15-23.

Kloppenburg, J. (2012). Occupying the Seed: Applying Open Source Biology in Service of Seed Sovereignty. In *Seed Freedom: A Global Citizen's Report*. New Delhi: Navdanya.

Kokopelli, D.G. (2012). How Seed Laws Criminalize Diversity & Farmers' Freedoms. In *Seed Freedom: A Global Citizen's Report*. New Delhi: Navdanya

Kolady, D., Spielman, D. & Cavalieri, A. (2012). The impact of seed policy reforms and intellectual property rights on crop productivity in India. *Journal of Agricultural Economics* 62:2: 361-384.

Kopainsky, B., Troger, K., Derwisch, S., & Ulli-Beer, S. (2012). Designing Sustainable Food Security Policies in Sub-Saharan African Countries: How Social Dynamics Over-Ride Utility Evaluations for Good and Bad. *Systems Research* 29:575-589.

Kranakis, E. (2007). Patents and Power: European Patent-System Integration in the Context of Globalization. *Technology and Culture* 48(4):689-728.

Krattiger, A. & Mahoney, R. (2007). Chp 1.1. The role of IP management in health and agricultural innovation. In A. Krattiger, R. Mahoney, L. Nelson, J.A. Thomson, A.B. Bennet, K. Satyanarayana, G.D. Graff, C. Fernandez, & S.P. Kowalksi (Eds). *Intellectual property management in health and agricultural innovation: A handbook of best practices*. Oxford: MIHR & David, California: PIPRA.

Longo, N. (2013). *Italy becomes the 9th EU Nation to Ban Monsanto's GMO Corn*. [Online]. Available at: http://www.trueactivist.com/italy-becomes-the-9th-eu-nation-to-ban-monsantos-gmo-corn/. Accessed 15 August 2013.

Lukhele-Olorunju, P. (2011). *International Treaty on Plant Genetic Resources for food and agriculture: where does South Africa stand?* Johannesburg: Africa Institute of South Africa.

Lwoga, E., Stilwell, C. & Ngulube, P. (2011). Access and use of agricultural information and knowledge in Tanzania. *Library Review* 60(5): 383-395.

Maathai, W. (1998). The link between patenting of life forms, genetic engineering & food insecurity. *Review of African Political Economy* 25(77):526-528.

Maponya, P. & Mpandeli, S. (2012). Climate change and agricultural production in South Africa: Impacts and Adaptation options. *Journal of Agricultural Science* 4(10).

Marchant, G. (2007). Chp 1.5. Genomics, Ethics and Intellectual Property. In A. Krattiger, R. Mahoney, L. Nelson, J.A. Thomson, A.B. Bennet, K. Satyanarayana, G.D. Graff, C. Fernandez, & S.P. Kowalksi (Eds). *Intellectual property management in health and agricultural innovation: A handbook of best practices*. Oxford: MIHR & David, California: PIPRA.

Martens, B. & Scheibe, K. (2012). Supply Chains in Sub-Saharan Africa: A Decision Support System for Small-Scale Seed Entrepreneurs. *Decision Sciences* 43(5).

Max-Neef, M.A. (2004). Foundations of Transdisciplinarity, prepared for publication in a forthcoming edition of *Ecological Economics*.

Mayet, M. (2012). Seed Systems and Seed Sovereignty in Africa: Key issues and challenges. In *Seed Freedom: A Global Citizen's Report*. New Delhi: Navdanya.

Metelerkamp, L. (2011). Commercial agriculture in the Swartland: Investigating emerging trends towards more sustainable food. Thesis presented in partial fulfilment of requirements for MPhil degree at the University of Stellenbsoch.

Mellon, M (2013). *Let's Drop "Feed the World": A plea to move beyond an unhelpful phrase*. Union of Concerned Scientists. [Online]. http://blog.ucsusa.org/lets-drop-feed-the-world-a-plea-to-move-beyond-an-unhelpful-phrase-229. Accessed on 10 October 2013.

Monyo, E.S., Mgonja, M.A. & Rohrback, D.D. (2004). Analysis of Seed Systems Development, with Special Reference to Smallholder Farmers in Southern Africa: Issues and Challenges. In: P. Sentimela, E, Monyo, & M. Banzinger (Eds) *Successful Community-Based Seed Production Strategies.* Mexico, DF: CIMMYT.

Mooney, P. (2012). Concentration of the seed industry. In In *Seed Freedom: A Global Citizen's Report*. New Delhi: Navdanya.

Moss, D.L. (2011) Competition and transgenic seed systems. *The Antitrust Bulletin* 56(1): 81.

Mostert, A (2013). *South African Fertilizer Imports and Exports*. [Online]. Available at: www.fssa.org.net. Accessed on 13 August 2013.

Murray, M. (1995). The Value of Biodiversity. In: J. Kirby, P. O'Keefe, & L. Timberlake (Eds) *The Earthscan Reader in Sustainable Development*. London: Earthscan Publications Limited.

NAMC (2013). *Executive Summary: Food Price Monitor: February 2013*. Pretoria: National Agricultural Marketing Council.

NASFAM (2013). *National Smallholder Farmers' Association of Malawi*. [Online]. Available at: www.nasfam.org. Accessed on 18 October 2013.

Nestle (2013). *Nestle launches education campaign to help US consumers achieve a balanced diet.* [Online]. Available at: http://www.nestle.com/media/newsandfeatures/nusa-balance-your-plate. Accessed on 23 January 2014.

NGO/CSO Forum for Food Sovereignty (2002). *Food Sovereignty: A Right For All*. Political Statement of the NGO/CSO Forum for Food Sovereignty. Rome, June 2002

Nordhagen, S. & Pascual, U. (2013). The Impact of Climate Shocks on Seed Purchase Decisions in Malawi: Implications for Climate Change Adaptation. World Development 43:238-251.

NPC (2011). *National Development Plan: Vision for 2030*. Pretoria: National Planning Commission Republic of South Africa.

NPC (2012). *South Africa National Development Plan 2030 – Our future: make it work.* [Online]. Available at: http://www.info.gov.za/view/DynamicAction?pageid=623&myID=348761. Accessed on 26 October 2012.

NSS (2009). Statistical Reform in South Africa. [Online]. Available at: http://www.statssa.gov.za/nss/index.asp?link=about.asp. Access on 15 September 2013.

NWFF (2010). *NW Farms and Food: Saving Seeds, Sowing Food Security Gardeners Reclaim their Seed Heritage* [Online]. Available: http://nwfarmsandfood.com/index.php/saving-seeds. Accessed on 4 August 2012.

Okry, F., Van Mele, P., Nuijten, E., Struik, P. & Mongbo, R. (2010). Organizational Analysis of the Seed Sector of Rice in Guinea: Stakeholders, Perception and Institutional Linkages. *Exploratory Agriculture* 47(1): 137-157.

O'Laughlin, B., Bernstein, H., Cousins, B. & Peters, P. (2013). Introduction: Agrarian change, rural poverty and land reform in South Africa since 1994. *Journal of Agrarian Change* 13(1):1-15.

Pagioloa, S., Kellenberg, J., Vidaeus, L. & Srivastava, J. (1998). Mainstreaming Biodiversity in Agriculture Development. *Finance & Development* March 1998:38.

Pahl-Wostl, C., Tabara, D., Bouwen, R., Craps, M., Dewulf, A., Mostert, E., Ridder, D. & Taillieu, T. (2008). The importance of social learning and culture for sustainable water management. *Ecological Economics* 64:484-495.

Parliamentary Hearing (2013). *Briefing by the Department of Agriculture, Forestry and Fisheries, Trade and Industry Health, Rural Development and Land Reform and the Department of Science and Technology on the status of genetically modified (GM) food in South Africa*. Attended 13 September 2013. Cape Town: South African Parliament.

Perfecto, I. & Vandermeer, J. (2010). The agroecological matrix as alternative to the land-sparing/agriculture intensification model. *PNAS* 107(13) 5786-5791.

Phillips, C. (2005). Cultivating Practices: Saving Seed as Green Citizenship? *Environments Journal* 33(3).

Phillips, C. (2008). Canada's Evolving Seed Regime: Relations of Industry, State, and Seed Savers. *Environments Journal* 36(1).

Plomer, A. (2013). The Human Rights Paradox: Intellectual Property Rights and Rights of Access to Science. *Human Rights Quarterly* 35: 143-175.

Powell, G. (1972). Coleridge's "Imagination" and the Infinite Regress of Consciousness. *ELH* 39(2):266-278.

Pretty, J. (2006). *Agroecological approaches to agricultural development*. Background paper for the World Development Report 2008. Santiago: Rimisp-Latin American Center for Rural Development.

Raimondo, D. (2011). *The Red List of South African Plants - A global first*. [Online]. Available at: www.botanicalsociety.org.za. Accessed on 19 September 2013.

Ramaila, M., Mahlangu, S. & Du Toit, D. (2011). *Agricultural Productivity in South Africa: Literature Review*. Pretoria: Directorate: Economic Services Production Economics Unit

Ramaprasad, V. (2012) Seed Quest. In: In *Seed Freedom: A Global Citizen's Report*. New Delhi: Navdanya.

Rangnekar, D. (2001). *Access to Genetic Resources, Gene-based inventions and Agriculture*. [Online]. Available at: http://www.planttreaty.org/content/access-genetic-resources-gene-based-inventions-and-agriculture. Accessed on 3 September 2013.

Raudsepp-Hearne, C., Peterson, G.D., Tengo, M., Bennett, E.M., Holland, T., Benessaiah, K., MacDonald, G.K. & Pfeifer, L. (2010). Untangling the Environmentalist's Paradox: Why is Human Well-being Increasing as Ecosystem Services Degrade? *Bioscience* 60: 576-589.

Roscigno, V. (2011). Power, Revisited. *Social Forces* 90(2):349-374.

Royal Society (2009). *Reaping the benefits: Science and the sustainable intensification of global agriculture.* London: Royal Society

RSA (1996). *Constitution of the Republic of South Africa 1996*. Pretoria: Republic of South Africa.

Rusike, J. (1995). *The Development of Maize Seed Markets in Sub-Saharan Africa*. Washington DC: International Food Policy Research Institute.

SADC (2012). *Draft Protocol for the protection of new varieties of plants (Plant Breeders' Rights) in the Southern African Development Community region*. Pretoria: Southern African Development Community.

Sadie, J. (2013). Contribution to email interview with Dr Julian Jaftha, Director: Genetic Resources in the Directorate Genetic Resources, Government of South Africa.

SANSOR (2013). *South African National Seed Organisation*. [Online]. Available at www.sansor.org. Accessed on 5 June 2013.

Sarbin, T. & Juhasz, J. (1970). Toward a theory of imagination. *Journal of Personality* 38(1): 52-76.

Sassenrath, G.F., Heilman, P., Luschei, E., Bennett, G.L., et al. (2008). Technology, complexity and change in agricultural production systems. *Renewable Agriculture and Food Systems* 23(4): 285-295.

Sasson, A. (2012). Food security for Africa: an urgent global challenge. *Agriculture & Food Security* 1:2-16.

Satgar, V. (2007). The state of the South African cooperative sector. [Online]. Available at: http://www.copac.org.za/files/State%20of%20Coop%20Sector.pdf. Accessed on 12 October 2013.

Satgar, V. (2011). Challenging the globalized agro-food complex: Farming cooperatives and the emerging solidarity economy alternative in South Africa. *WorkingUSA: The Journal of Labor and Society* 14:177-190.

Schenkelaars, P. (2011). Drivers of Consolidation in the Seed Industry and its Consequences for Innovation. Amsterdam: Commission on Genetic Modification (COGEM).

Schon, D. (2004). Chp 1. Government as a learning system in multi-party collaboration as social learning for interdependence: Developing Relational Knowing for Sustainable Natural Resource Management. *Journal of Community & Applied Social Psychology* 14:137-153.

Schubert, R. (2005). *Farming's New Feudalism: Percy Schmeiser and Other Casualties of Industrial Agriculture's Drive to Own It All.* World Watch Magazine, May/June 2005, Volume 18, No. 3. Available at: http://www.worldwatch.org/node/574. Accessed on 4 August 2012.

Scoones, I. & Thompson, J. (2011). The Politics of Seed in Africa's Green Revolution: Alternative Narratives and Competing Pathways. *IDS Bulletin* 42(4).

Scoones, I., Devereux, S. & Haddad, L. (2005). Introduction: New Direction for Agricultural Agriculture. *IDS Bulletin* 36(2).

Setimela, P.S., Banziger, M. & Mwala, M. (2004). Choosing the Right Crop and Variety. In: P. Sentimela, E, Monyo, & M. Banzinger (Eds) *Successful Community-Based Seed Production Strategies.* Mexico, DF: CIMMYT.

Shackleton, C., Cundill, G. & Knight, A. (2009). Beyond Just Research: Experiences from Southern Africa in Developing Social Learning Partnerships for Resource Conservation Initiatives. *Biotropica 41*(5):563-570.

Shand, H. (2012). The Big Six: A Profile of Corporate Power in Seeds, Agrochemicals & Biotech. In: *The Heritage Farm Companion* (Summer 2012). Decorah, Iowa: Seed Savers Exchange.

Shisana, O., Labadarios, D., Rehle, T., Simbayi, L., Zuma, K., Dhansay, A., Reddy, P., Parker, W., Woosain, E., Naidoo, P., Hongoro, C., Mchiza, Z., Steyn, N.P., Dwane, N., Makoae, M., Maluleke, T., Ramlagan, S., Zungu, N., Evans, M.G., Jacobs, L., Faber, M. & SANHANES-1 Team. (2013). *South African National Health and Nutrition Examination Survey (SANHANES-1)*. Cape Town: HSRC Press.

Shiva, V. (2012). Seed Freedom – What is at Stake. In *Seed Freedom: A Global Citizen's Report*. New Delhi: Navdanya.

Shumei International (2012.) The Forgotten Message in a Seed. In *Seed Freedom: A Global Citizen's Report*. New Delhi: Navdanya.

Slotnick, R. (2009). *The Power of Hearing Data: Introduction to Qualitative Research Methods*. [Online]. Available:
http://www.sa.usf.edu/committees/SAPAC/content/Qualitative%20Research%20Methods.pdf [17 November 2012].

Small, R. (2013). Email interview with Rob Small, Director of Abalimi. Conducted on 10 October 2013.

SPP (2013). *Comments on the Plant Breeders' Rights Bill*. [Online]. Available at: http://www.spp.org.za/spp-comments-on-the-plant-breeders-rights-bill/#more-658. Accessed on 23 August 2013.

Srang-iam, W (2013). Decontextualized Knowledge, Situated Politics: The New Scientific-Local Politics of Rice Genetic Resources in Thailand. *Development and Change* 44 (1): 1-27.

SSA (2012). *Agricultural Survey 2011*. Pretoria: Statistics South Africa.

SSA (2012). *GHS Series Volume IV: Food security and agriculture 2002-2011 - In-depth analysis of the General Household Survey data*. Pretoria: Statistics South Africa.

Stoddard, E. (2011). *The Debating Chamber – The seeds of food inflation in southern Africa*. [Online]. Available at: http://www.trust.org/alertnet/blogs/the-debating-chamber/the-seeds-of-food-inflation-in-southern-africa. Accessed 26 February 2013.

Stuijt, A. (2009). *Monsanto GM-corn harvest fails massively in South Africa*. [Online]. Available at: http://digitaljournal.com/article/270101. Accessed 3 March 2013.

Sustainable Pulse (2013). *Russia considers total ban on all GMO products*. [Online]. Available at: http://www.gmwatch.org/index.php/news/archive/2013/15081-russia-considers-total-ban-on-all-gmo-products. Accessed on 19 October 2013.

Swanby, H. (2013). Personal interview conducted with Haidee Swanby, African Centre for Biosafety. Conducted 22 September 2013.

Tansey, G. (2011). Whose Power to Control? Some Reflections on Seed Systems and Food Security in a Changing World. *IDS Bulletin* 42(4).

Tengberg, A., Fredholm, S., Eliasson, I., Knez, I., Saltzman, K. & Wetterberg, O. (2012). Cultural ecosystem services provided by landscapes: Assessment of heritage values and d identity. Ecosystem Services 2:14-26.

Thiele, G. (1999). Informal Potato Seed Systems in the Andes: Why Are They Important and What Should We do With Them? *World Development* 27(1): 83-99.

Traynor, V. (2007). Qualitative Methods: An introduction to key concepts. [Online]. Available: http://notes.med.unsw.edu.au/cphceweb.nsf/resources/WorkshopResources1to5/$file/Introduction+to+qualitative+methods_WEB.pdf [17 November 2012].

UN (2009). *Seed Policies and the right to food: enhancing agrobiodiversity and encouraging innovation*. United Nations General Assembly Document A/64/170. Rome: United Nations.

Van Schalkwyk, H., Groenewald, J., Fraser, G., Obi, A. & Van Tilburg, A. (2012). *Unlocking markets to smallholders: Lessons from South Africa.* The Netherlands: Wageningen Academic Publishers.

Van Tilburg, A. & Van Schalkwyk, H. (2012). Chapter 2: Strategies to improve smallholders' market access. In: H. Van Schalkwyk. J, Groenewald, G. Fraser, A. Obi, & A. Van Tilburg (Eds): *Unlocking markets to smallholders: Lessons from South Africa***.** The Netherlands: Wageningen Academic Publishers.

Van Wyk, B.E. & Gericke, N. (2000) *People's plants: a guide to useful plant of Southern Africa.* Pretoria: Briza Publications.

Van Wyk, B.E. & Gericke, N. (2000). People's plants: a guide to useful plants of Southern Africa. Pretoria: Briza Publications.

Van Zwanenberg, P., Ely, A., Smith, A., Chuanbo, C., Shijun, D., Fazio, M. & Goldberg, L. (2011). Regulatory harmonization and agricultural biotechnology in Argentina and China: Critical assessment of state-centred and decentred approaches. *Regulation & Governance* 5: 166-186.

Vanloqueren, G. & Baret, P. (2009). How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations. *Research Policy* 38: 971-983.

Venkatesan, V. (1994). *Seed Systems in Sub-Saharan Africa*. Washington: The World Bank.

Veteläinen, M. & Negri, V. (2009). *European landraces: on-farm conservation, management and use.* Rome: Biodiversity International

Warner, K.D. (2005). Extending agroecology: Grower participation in partnerships is key to social learning. *Renewable Agriculture and Food Systems* 21(2):84-94.

Weatherspoon, D. & Reardon, T. (2003). The rise of supermarkets in Africa: Implications for Agrifood Systems and the Rural Poor. *Development and Policy Review* 21(3).

Weston, B.H. (2012). The Theoretical Foundations of Intergenerational Ecological Justice: An Overview. *Human Rights Quarterly* 34(1): 251-266.

Whal, D. (2009). *Beyond sustainability: Natural design and resilience*. Paper presented at the 8th European Academy of Design Conference 1, 2, 3rd April, 2009, The Robert Gordon University, Aberdeen, Scotland.

Wield, D., Chataway, J. & Bolo, M. (2010). Issues in the political economy of agricultural biotechnology. *Journal of Agrarian Change* 10(3): 342-366.

WIPO (1981) UPOV *Notification No. 20: International Convention for the Protection of New Varieites of Plants of December 2, 1961, as revised at Geneva on November 10, 1972, and on 1978.* [Online]. Available at: http://www.wipo.int/treaties/en/notifications/upov/treaty_upov_20.html. Accessed 23 January 2014.

Woodhill, J. (2010). Chp 4 Sustainability, Social Learning and the Democratic Imperative: Lessons from the Australian Landcare Movements. In: J. Woodhill. *Social Learning Systems and Communities of Practice.*

World Health Organisation (2014). Food, Genetically modified. [Online]. Available at http://www.who.int/topics/food_genetically_modified/en/. Accessed 21 January 2014.

Wynberg, R., van Niekerk, J., Williams, R., & Mkhaliphi, L. (2012). *Policy Brief. Securing Farmers' Rights and Seed Sovereignty in South Africa.* Cape Town: Biowatch South Africa and the Environmental Evaluation Unit, University of Cape Town.

Wynberg, R. & Fig, D. (2013). A landmark victory for justice: Biowatch's Battle with the South African State and Monsanto. Durban: Biowatch South Africa.

Zapiain, A.O. (2008). *Intellectual property rights, genetically modified seeds and farmers' food sovereignty: The case study of South Africa.* Submitted in partial fulfilment of the requirements for the degree of Masters of Development Studies, Faculty of Humanities, Development and Social Sciences, University of KwaZulu-Natal.