Natuurboerdery®:

Restoring Soil Biological Fertility, Enhancing Productivity and Reducing Ecosystem Impact in South Africa

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I. Introduction

ZZ2 is a multi-system farming conglomerate in the Limpopo Province of South Africa. The company manages 60,000 hectares of land in Mooketsi, Politsi, Polokwane and Musina in the Northern Limpopo Province; Ceres and Riebeek-Wes in the Western Cape; and Langkloof in the Eastern Cape of South Africa. ZZ2 grows food on 10,000 hectares of land, including tomatoes, onions, avocados, mangoes, apples, pears and beef. As Africa's largest tomato producer ZZ2 sells 98% of tomato production domestically and supplies the export market with fruits and some vegetables throughout the year. The remainder of ZZ2's land is used for other purposes, including conservation through private game reserves, water management, and fallowing (resting) the productive lands between crops.

ZZ2 began producing tomatoes for domestic sale in 1953. In the early 1990's, ZZ2 began to experience declining yields despite increased fertilizer and pesticide inputs and a seven-year rotation between tomato crops. They consulted experts who helped them understand that the fundamental problem was degraded soil. Consequently, in 2002, the firm embarked on an adaptive management strategy and pioneered a new agricultural approach: Natuurboerdery® or 'Nature Farming', a method wherein more organic inputs and fewer agrichemicals are used to maintain soil fertility. Since 2002, ZZ2 has made headway in departing from industrial agricultural practices that depend on the heavy use of chemical inputs and is moving toward the use of compost, compost teas, fermented plant extracts, and 'effective microorganisms' (EM) as alternative fertilizers and/or pesticides.

ZZ2's experience with declining productivity is not an isolated case. Global trends indicate a loss of biological diversity that correlates with declining productivity, increasing fragility of systems and growing exposure of farming families to uncertainty, poverty and hunger (Ecosystem Management in Agriculture, 2003). Acknowledging this challenge, the Convention on Biological Diversity, in 2002 outlined an integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. The strategy, termed the *Ecosystem Approach*, is intended to address the Convention's three primary objectives of conservation, sustainable use, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources (Biodiversity and the Ecosystem Approach, 2003). The ecosystems approach serves as a tool for better understanding the complex interactions between the biological, physical and human systems in agro-ecosystems and stands to be one of the most promising strategies for "effectively contributing to food security and the well-being of rural populations"(ibid).

The following case study applies the 12 guiding principles of the ecosystems approach to ZZ2's Natuurboerdery with the aim of understanding to what degree Natuurboerdery may serve ZZ2 as a

long-term strategy for integrating conservation, sustainable use and equitable sharing of natural resources within the gates of ZZ2 and in the greater community.

II. Background and Historical Timeline

ZZ2 started as a small family farm that was displaced several times before finally settling in the small town of Mooketsi in the Limpopo province. Over time, they switched from growing potatoes to tomatoes and expanded throughout the province and country. Initially, ZZ2 farmed with very few inputs. However, as production intensified ZZ2 increased fertilizer use to maintain yields.

	SOUTH AFRICA	ZZ2	NATUURBOERDERY	
1900	• End of the second Anglo-Boer War	• ZZ2 brand certified		**1900**
1910	• Union of South Africa created			**1910**
1920				**1920**
1930		• Cattle branding iron used to market potatoes		**1930**
1940		• Bertie takes over farm – 10% share		**1940**
1950	• Apartheid adopted, National Party (NP) takes power • Agents and coops introduced to National Fresh Produce Market (NFPM), Durban	• Begin growing tomatoes • Bertie rents farm, instigates year round farming and employment • Housing provided for workers		**1950**
1960	• South Africa declared a republic • Mandela sentenced to life	• Overhead irrigation introduced • Bertie Van Zyl Privatized • Pinzgauer breeding begins		**1960**
1970	• NFPM cease sale by auction, agents take commission	• ZZ2 Beherende Beleggings Pty takes over ZZ2 name		**1970**
1980	• First AIDS death recorded in SA • Soil Conservation Act passed	• Board of directors established • Black staff appointed to management positions • Switch to drip irrigation • Bertie establishes trust		**1980**
1990	• ANC Un-banned, Mandela released • Apartheid lifted • ANC wins election, Mandela becomes president • Truth and reconciliation commission begins hearings • New constitution adopted • Deregulation of agricultural markets	• Professor Frederik Engelbrecht introduces open system concepts, placed on board of directors • Berties helps found the Fresh Produce Market Association • Land devoted to Munnik Conservancy wildlife area	• Begin increasing inputs to maintain yields •Decreasing yields despite increasing inputs	**1990**
2000	• Thabo Mbeki becomes president • Governmental HIV/AIDS program instigated • Mbeki reelected in ANC landslide • Public-sector worker strike • Wave of xenophobic riots	• Computer farming initiated • Grootboon Elephant Conservancy receives first elephant • Farm labourer's union organized boycott at ZZ2	• 1st EM trials • Farm-wide application of EM, 1st trial of FPEs and compost • Wide-scale application of compost and FPEs, 1st compost tea trials • Wide-scale application of teas	**2000**
2009	• Jacob Zuma elected president		• Lysimeter readings begin	**2009**

Figure 1: Timeline of the history of ZZ2 and Natuurboerdery in the context of the macro

In the late 1990s, ZZ2 recognized that increasing inputs no longer sustained yields, nor was economically feasible to continue applying chemical inputs. ZZ2 began to experiment with ecologically friendly approaches such as Effective Microorganisms (EM) and compost to restore fauna and nutrients to the soil. The results were overwhelming: their yields began to increase to previous levels and they were able to reduce the fallow period between crop rotations. A brief picture of South African history helps to place ZZ2 within their broader context, and to better understand ZZ2's ambition to engage in conservation efforts, manage their resource base sustainably and promote social and cultural values within and beyond the workplace. Figure 1 is a visual timeline that parallel's ZZ2's emergence as a successful agricultural industry with key historical events within South Africa.

II. METHODS

In January 2010 eight Cornell University students traveled with Dr. Janice Theis[1] to the Limpopo Province in South Africa to conduct on-site research at ZZ2. During the three-week research trip students worked in cross-disciplinary teams to gather data about Natuurboerdery, learn about ZZ2 as an enterprise and make observations about the long-term sustainability of Natuurboerdery as a promising strategy for upholding social, environmental, and economic values. During post-research data analyses, students utilized the ecosystems approach as a methodological framework.

The Convention for Biological Diversity (CBD) outlines three primary objectives: 1) conservation 2) sustainable use and 3) the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. CBD defines agro-ecological systems as complex in nature, and as comprised by a web of interactions between biological, physical and human interactions. CBD places special emphases on soil health and quality as a strategy for maintaining and promoting sustainable agroecological systems, and identifies the study of soil microorganisms as a research gap that, if addressed, has the potential to greatly inform management practices that enhance ecosystem services, effectively contribute to food security, and improve the livelihood of rural populations.

CBD defines "ecosystem" as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" (ibid). As a strategy, the ecosystems approach is based on scientific methodologies focused on biological organization—the essential structure, processes, functions and interactions among organisms and their environment"(ibid). CBD cautions that the ecosystem approach requires adaptive management in the absence of complete knowledge and understanding of ecosystem functioning, and that the ecosystems approach does not preclude other types of management and conservation approaches. The ecosystems framework is comprised of 12 principles that are to be considered holistically and each weighted appropriately and according to local circumstances. The approach incorporates three important considerations:

(i) Management of living components is considered alongside economic and social considerations at the ecosystem level of organisation, not simply a focus on managing species and habitats;

[1] Professor, Crop and Soil Sciences, Cornell University

(ii) If management of land, water, and living resources in equitable ways is to be sustainable, it must be integrated and work within the natural limits and utilize the natural functioning of ecosystems;

(iii) Ecosystem management is a social process. There are many interested communities, which must be involved through the development of efficient and effective structures and processes for decision-making and management (ibid)

The concept of Natuurboerdery as defined by ZZ2, relies on a systems approach that gives due credence to social, political and economic considerations ensuring that the benefits of less resource intensive agriculture creates a ripple effect reaching across the community and the industry. Given ZZ2's stated commitment of long-term viability, improving soil health, conserving natural resources and facilitating just and equitable social and cultural opportunities within the workplace and the greater community, the ecosystems approach serves as an appropriate tool of analysis.

IV. ANALYSIS

In the following analyses we view Natuurboerdery as a management strategy and ZZ2 as a company through the lens of the 12 principles of the ecosystems approach. Under each principle we highlight exemplary demonstrations of the principle in action, and underscore areas on the farm and within the enterprise that may benefit from a deeper or broader application of the principle.

Principle 1: The objectives of management of land, water, and living resources are a matter of societal choice.

Rationale: Different sectors of society view ecosystems in terms of their own economic, cultural and societal needs. Indigenous peoples and other local communities living on the land are important stakeholders and their rights and interests should be recognized. Both cultural and biological diversity are central components of the ecosystem approach, and management should take this into account. Societal choices should be expressed as clearly as possible. Ecosystems should be managed for their intrinsic values and for the tangible or intangible benefits for humans, in a fair and equitable way.

Natuurboerdery includes many activities that are in line with the interests of society. For example, the stabilization of soil carbon though the addition of organic inputs in the form of compost and compost teas is a long-term investment in soil health. This type of management is socially responsible and will help sustain agricultural practices indefinitely into the future. ZZ2 is also making strides to reduce dependency on non-renewable resources by utilizing technologies like drip irrigation and water table monitoring.

In addition to increasing environmental stewardship practices, ZZ2 is making an effort to be a responsible corporation. ZZ2 is both GLOBALGAP and Fair Trade certified, which ensures that core labor standards set by the International Labor Organization are maintained at the company. Recognizing the diversity of its workforce, ZZ2 releases a quarterly newsletter that is produced in three different languages allowing a greater portion of the community to be informed of changes at the company. ZZ2 is also heralding a project to remove invasive plant species from the reserves it maintains. Local people come to the reserves and cut invasive trees for firewood therefore both increasing ecosystem health (and therefore indirectly providing benefits to society through ecosystem

functions) and providing fuel for communities. This multiplier effect on local economies will strengthen ZZ2's bond with surrounding communities, while sharing the responsibility of land stewardship.

ZZ2 does face some difficulties finding employment in the local communities. South Africa's many tribes originated as pastoral cultures and therefore lack indigenous agricultural histories. As a result, they are largely untrained in and not attracted to agricultural work. This presents many obstacles to hiring locally. Additionally, post-apartheid government policies, including the controversial Social Grants program, provide guaranteed social benefits to black residents that may provide a more attractive alternative to work. As a result of this and the current conflict in Zimbabwe, 70% of ZZ2's workforce comes from neighboring Zimbabwe and Mozambique, threatening the stability of the company. Zimbabwean workers tend to have a better education and as a result of their country's turmoil are often will to work for less making them an attractive labor supply. This has resulted in widespread xenophobia, rioting, and violence furthering the instability of the situation.

ZZ2 is a private corporation and needs to turn a profit to be viable, so there is a limit to its ability to focus solely on environmental stewardship, and the extent to which practices, including Natuurboerdery, will agree with the welfare of society. However, there are still many opportunities for ZZ2 to increase both its positive social impacts and community involvement. From a management prospective, ZZ2 can expand its current Natuurboerdery practices to include a pilot biochar program. Biochar (produced from combusting wood in the presence of limited oxygen) has a liming effect on soil, improves soil chemistry, long term carbon build up and stimulates microbial colonization and activity (Magdoff et. al, 2009). ZZ2 can produce biochar using the wood from invasive species in the area starting with those found on the game reserves. ZZ2 can also facilitate use of biochar stoves in the community that can produce biochar for small farmers to apply to their fields. These stoves are also much more efficient than traditional wood burning stoves, and the energy generated can be used for household cooking.

ZZ2 could also enhance their outreach and mentor programs to attract and train local labor, to educate and empower the small vendors who buy produce at the informal markets, and to spread use of Natuurboerdery techniques to small farmers. By utilizing a local labor source, ZZ2 would reduce their vulnerability to external shocks like changes in immigration or foreign policies affecting employment. If ZZ2 began to educate the entrepreneurs who purchase their produce for resale, they could expand recognition of the positive impacts Natuurboerdery and ZZ2 have on the public, provide a forum for feedback from buyers, and potentially increase sales. Finally, the informal mentorship that ZZ2 already has established with some farmers could be expanded to a formal outreach program where small farmers could learn about the techniques and benefits of Natuurboerdery practices through workshops, written materials, and their website.

Principle 2*: Management should be decentralized to the lowest appropriate level*

Rationale: Decentralized systems may lead to greater efficiency, effectiveness and equity. Management should involve all stakeholders and balance local interests with the wider public interest. The closer management is to the ecosystem, the greater the responsibility, ownership, accountability, participation, and use of local knowledge.

Natuurboerdery is much more than a set of agricultural practices: on their website, ZZ2 defines Natuurboerdery as "the convergence of a vertical relationship that starts from the ground and looks upwards" and seeks "a horizontal shared responsibility" where sustainability extends in both directions[2]. The firm views Natuurboerdery as a means to create a mutually beneficial relationship with its stakeholders both inside and outside of the company.

Bertie Van Zyl created a company that departed from the traditional hierarchical anagram management model relying instead on a flat upper management structure that consists of a system of interconnected committees and teams. Division and Project Managers are empowered to make decisions, operate cross-departmentally and, introduce new concepts and initiatives.

Individual farm managers are encouraged to drive any and all processes they believe will improve production, while reducing resource use. This gives them a sense of autonomy over their farm, while being supported by upper management. However, farmers could be further empowered through involvement in the experimentation, data analysis, and decision-making processes. This will ensure that all potential new technologies are identified and tested, that every farmer understands why new techniques are being implemented, and that new knowledge can be applied.

ZZ2 acknowledges the existing tribal administrative set up in the region and has strived to build an active partnership with the local power structures manifest in the tribal councils and the Rain Queen. Bertie van Zyl instituted a system of holding annual meetings between the tribal councils and the management at ZZ2. The company also employs people from the local area who act as liaisons with the tribal councils. These strategies helped foster a relationship based on trust and understanding between the company and local leaders.

While ZZ2 incorporates the knowledge, skills, and interests of many internal and external stakeholders, the firm could realize its full human resources potential and bring greater job satisfaction to entry-level employees by conducting a skills assessment prior to formal employment. New staff could have hidden talents and backgrounds that could be filtered into a position that is appropriate to their skills, knowledge and disposition. We learned anecdotally that a worker employed as a gardener was an engineer in his native country of Zimbabwe. Upon learning this, management promoted him to a position that better utilized his skills and education. There may be other undiscovered talents in ZZ2's entry-level labor pool.

Principle 3: ***Ecosystem managers should consider the effects of their activities on adjacent and other ecosystems.***

Rationale: Management interventions in ecosystems often have unknown or unpredictable effects on other ecosystems; therefore, possible impacts need careful consideration and analysis. This may require new arrangements or ways of organization for institutions involved in decision-making to make, if necessary, appropriate compromises.

Hydrological and leaching assessments have provided ZZ2 with a panorama of their impact on adjacent systems. Water security, both for downstream inhabitants and production, is a limiting factor that in time will emerge as a conflict boundary between ZZ2 and its neighbors. ZZ2 is working to

[2] http://zz2.typepad.com/

maintain a consistent water supply by purchasing headwater lands and constructing dams, and implementing rain-water collection strategies. With in-line irrigation and organic soil amendments, water efficiency has dampened excessive use of water that once caused salinity problems, nutrient loss, soil crusting, and rapid decomposition of organic matter. Evidence of acidity and leaching as a result of high inputs of synthetic fertilizers shifted the agroecological equilibrium and motivated ZZ2 to improve some of their negative externalities.

Though reductions in tillage have been employed, ZZ2 still tills to prepare land and build windrows for crops. With a semi-arid climate, the loss of silt and organic matter from tillage causes watershed sedimentation, CO_2 emissions, and a complete disruption of ecological services. The American Dust Bowl is perfect example of grave mismanagement and provides an omen if current practices are continued.

The spatial scale of South African geography presents a serious threat beyond adjacent systems. Forty heavy lorries, a fleet of small pickup trucks, and energy intensive production methods demand non-renewable resources. Pollution and carbon emissions have not been addressed by ZZ2, and their negligence of this will have dire consequences with increasing fuel costs and global awareness. Careful analysis of ZZ2's management practices will allow for the identification of detrimental effects and can motivate better decision making to avoid negative impacts on the environment.

Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:

- ***a. Reduce those market distortions that adversely affect biological diversity;***
- ***b. Align incentives to promote biodiversity conservation and sustainable use;***
- ***c. Internalize costs and benefits in the given ecosystem to the extent feasible.***

Rationale: The greatest threat to biological diversity lies in its replacement by alternative systems of land use. This often arises through market distortions, which undervalue natural systems and populations and provide perverse incentives and subsidies to favor the conversion of land to less diverse systems. Often those who benefit from conservation do not pay the costs associated with conservation and, similarly, those who generate environmental costs (e.g. pollution) escape responsibility. Alignment of incentives allows those who control the resource to benefit and ensures that those who generate environmental costs will pay.

Natuurboerdery enables ZZ2 to apply an economic approach to ecosystem management. The company is conscious of the threat to biological diversity posed by market distortions that favor agricultural systems based on overexploitation of resources. As a member of the NFPM board, the company has helped draft policies that neutralize such distortions. For instance the policy of fixing the amount of transactions made to big market players like supermarkets protects the interests of all buyers and ensures supply consistency in the long term.

The company is also cognizant of the environmental costs that it creates and makes an effort to compensate for its externalities. For instance, health records of employees who are at higher risk of exposure to toxic chemicals or job stress are regularly collected and maintained in a database. Follow

up action through preventive measures, task replacements and compensation is taken to ensure that externalities are redressed where feasible. ZZ2's ability to invest in extensive research enables them to internalize costs and benefits in the ecosystem by exploring biological alternatives to reduce threats while rejuvenating once degraded soils. Through Natuurboerdery, ZZ2 has initiated integrated pest management by investing in botanical extracts (for pest control) and microbial cultures to improve nutrient mineralization and soil aggregate stability.

In keeping with its objectives of sustainable growth and conservation, ZZ2 can consider the area of carbon trading to benefit from available incentives that promote biodiversity conservation and sustainable use. The resources that the company has at its disposal including the game reserves and plantations give it adequate leverage to avail the benefits of carbon trading. For example, if petroleum-based input use on avocado plantations were reduced, the agriculture operation could be changed so that net carbon is sequestered. This could be used to offset some of the carbon ZZ2 produces in other aspects of its business, such as shipping which is powered by petroleum. Biochar is also a very effective carbon sequestration mechanism providing another potential avenue to the carbon trading market. While there is currently no market for carbon credits in South Africa, ZZ2 could begin converting various systems to carbon negative now and therefore be poised to make transactions in carbon trading once the market develops in the region.

Principle 5: ***Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.***

Rationale: Ecosystem functioning and resilience depends on a dynamic relationship within species, among species and between species and their abiotic environment, as well as the physical and chemical interactions within the environment. The conservation and where appropriate, restoration of these interactions and processes is of greater significance for the long-term maintenance of biological diversity than simply protection of species.

ZZ2's position as one of South Africa's leading agricultural producers relies on the resilience of Natuurboerdery. As an adaptive management system, Natuurboerdery closely observes the ecological impact of interactions on functional relationships, and restores vital ecological services to reduce degradation. Since their conversion from a high input, conventional farming system, ZZ2's production is less dependent on agrochemicals. By assessing an array of biological indicators ZZ2 utilizes scientific decision-making that promotes biodiversity while minimizing excessive resource use.

Starting in 2000, management practices have recognized the importance of soil health in localized contexts. From experimenting with organic compounds to concocting their own fermented plant extracts, ZZ2 has made laudable strides towards better land stewardship by having the ability to manage their impact at different levels. Restoring ecosystem services has resulted in the buildup of healthy soil organic matter and the development of labeling of botanical pesticides to selectively target pests. Biological indicators like trap crops and insect traps provide recommendations for integrative pest management directives. Likewise, technological advances in monitoring climate and leaching have permitted ZZ2 to measure their impact on adjacent systems. These steps have improved soil organic matter content and nutrient cycles, minimized erosion, and lowered costs of inputs as less are used.

Soil fertility is the most important element of Principle 5 for ZZ2. With utilization of soil health tests and local-specific assessments, management has learned and acknowledged the importance of

biodiversity in both above and below soil profiles. Building suppressive soils by encouraging beneficial microorganisms has reduced applications of toxic chemicals and mimicked natural interactions of soil biota. Products like EM and fermented plant extract have proven to reduce unwanted pathogens yet do not sterilize ecological communities. Longer fallows have rejuvenated natural cycles and nutrient flows leading to less pathogenic resistance and crop diseases. Furthermore, conversion of agricultural land to conservations provides a buffer for biodiversity and creates refuge for ecological services. In attenuating low organic matter readings ZZ2 has invested heavily in in-house compost production that recycles biomass and ameliorates the need of short term plant fertilizers. As a result, ZZ2 has streamlined their approach and reduced their footprint in local ecosystems.

Yet, ZZ2 has not fully embraced Natuurboerdery in all their activities. Though they have reduced their water usage by 50%, erosion still poses a problem as the lack of cover crops expose soil to the elements. With excessive erosion, a collapse of ecosystem structure and function are imminent. Moreover, improvements in fertigation practices can evolve into less rudimentary applications, and given sufficient research and development, local-specific applications can be tailor-made for a particular target at the appropriate time. ZZ2 still practices continuous monocropping, which can have negative consequences for production: pathogen pressure and resistance build over time along with exorbitant nutrient mining from fragile ecosystems.

If ZZ2 can adopt intercropping, cover crops, and further develop their knowledge of biological controls, ecosystem structures and their functions will be less taxed, and thus, more resilient.

Principle 6: Ecosystems must be managed within the limits of their functioning.

Rationale: In considering the likelihood or ease of attaining the management objectives, attention should be given to the environmental conditions that limit natural productivity, ecosystem structure, functioning and diversity. The limits to ecosystem functioning may be affected to different degrees by temporary, unpredictable or artificially maintained conditions and, accordingly, management should be appropriately cautious.

Natuurboerdery identifies the limits of natural productivity, ecosystem structure, and functioning and diversity. As practiced at present, Natuurboerdery enables the ZZ2 system to manage ecosystem resources within the limits of their functioning. As ZZ2 experienced in the past during the era of industrial agriculture, one cannot create a sustainable system solely with the application of chemical inputs and fertilizers (Magdoff et. al, 2009). An approach that recognizes the diversity of the system helps further understanding of the limits of ecosystem functionality.

Agricultural systems are, by design, artificial. Humans attempt to manipulate the intricate relationships between different system components to optimize product yield. In and of itself Natuurboerdery is not a natural system. Instead, the crop management practices of Natuurboerdery attempt to mimic the relationships that exist in nature. For example, the application of fungi- or bacteria-dominant compost to tomato and avocado fields respectively helps to improve nutrient cycling in soil while improving the soil quality. Additionally, ZZ2 identifies the importance of evaluating the impact of different management practices on soil quality in the long run. They analyze product quality (e.g. shape, color and nutritive value of tomatoes) and soil quality periodically and also invest in experiments for new management tools that can be incorporated into Natuurboerdery.

Another example of ZZ2's attempt to understand the system limitations is micro monitoring of climate at each farm location. ZZ2 has weather stations at each farm location to keep track of microclimate in the area and the climate information is taken into account during the decision-making of where and when to plant, as well as numerous other decisions that follow after establishing a crop.

ZZ2 is experimenting on greenhouse tomato production. They plan to scale up greenhouse tomato production to compensate for the limitations of natural environmental conditions. However, ZZ2 needs to conduct an environmental impact assessment prior to expanding their greenhouses. Special attention should be given to potential competition for scarce resources (water, electricity and petroleum based fuel) with surrounding communities and other commercial scale activities in the area.

Principle 7*: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.*

Rationale: The approach should be bounded by spatial and temporal scales that are appropriate to the objectives. Boundaries for management will be defined operationally by users, managers, scientists and indigenous and local peoples. Connectivity between areas should be promoted where necessary. The ecosystem approach is based upon the hierarchical nature of biological diversity characterized by the interaction and integration of genes, species and ecosystems.

In order to qualify as an ecosystem approach for farming, Natuurboerdery must be practiced within spatial and temporal boundaries. Boundaries for the management of environmentally sound farming methods include a human component from scientists who explore new avenues for sustainable crop production, farm labor who benefit from healthy management operations in the field (e.g. reduced pesticide use), the surrounding community that benefited from improved economy in the area and reduced environmental damage due to commercial scale farming, and consumers who enjoy a flavorful healthy fruits. Therefore, the impact of different management practices on the farm on the well being of each group has to be assessed carefully.

ZZ2 needs to improve their understanding of the different groups of human components and their interactions, as well as communication within management divisions. When making an important decision that influences the system performance like scaling up the greenhouse production, how the shifting of tomato production method might receive by consumers, surrounding community, and labor has to be assessed in detail prior to initiating the change. In addition to the human component, it is vital to consider the diversity of other biological components in the system such as soil biota, plant species, and insects and other animals within the system boundary. Game reserves adjacent to farmlands improve the regional diversity benefit ZZ2 by diversifying the interactions within different biotic components. Crop rotations as practiced in Natuurboerdery at present also help to improve spatial and temporal diversity in the system. To understand the special patterns of pest and disease incidents, climate change, and invasive weed spreads and associated threats to farming in an area, ZZ2 must communicate effectively with surrounding farms. This level of communication will help to improve the connectivity of different areas within Natuurboerdery.

Principle 8: *Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.*

Rationale: Ecosystem processes are characterized by varying temporal scales and lag-effects. This inherently conflicts with the tendency of humans to favor short-term gains and immediate benefits over future ones.

By design, agricultural systems are a long-term investment of time and resources. However, in many agricultural enterprises, short-term payouts are traded for long-term benefits. CBD acknowledges that people find long-term trends more difficult to detect than short-term trends, but highlight that adaptive agricultural strategies should include the development of long-term visions, plans and goals. In short, when managing for sustainability short-term payouts must sometimes be traded for long-term benefits.

Intergenerational equity and family values have long been at the center of ZZ2's core values, and a desire to preserve the land and resource base for future ZZ2 generations has always been high on the priority list. Still, high-input agriculture lured farm management into strategizing for short-term benefits rather than long-term improvements in soil health and quality. The transition to Natuurboerdery marks an important and laudable step in recognizing the importance of adhering to a longer-term time scale, and the need to take into account the lag time between management actions and their outcomes. With the transition to Natuurboerdery, ZZ2 recognized that the associated adverse environmental impacts of high input agriculture were in direct conflict with maintaining a healthy ecosystem for future generations. ZZ2's decision to first pilot and then implement Natuurboerdery as an agricultural innovation system demonstrates a long-term commitment to ecosystem management.

With the goal of managing their land base for long-term productivity and soil health, ZZ2 faces new spatial and temporal challenges. For example, many of the non-renewable resources ZZ2 depends on for production (land base, water, gas, etc) are community resources and should be allocated as such. Water rights in the Limpopo province remain a valuable asset, and one that ZZ2 has worked hard to control with the construction of dams and monitoring systems. Collective management of natural resources is an important long-term goal; whether ZZ2 will be willing to trade immediate gains from increased natural inputs for long-term sustainability and collective management of these resources is yet to be seen.

CBD reminds practitioners that the lag between management actions and outcomes make it difficult to make reasoned management decisions for the long-term. They suggest devising monitoring systems that are specially designed for accommodating the time scale for change in the ecosystem variables that have been selected for monitoring. Although researchers at ZZ2 employ excellent monitoring capabilities it is not clear that their monitoring systems are in fact measuring on an appropriate time scale. ZZ2's climate monitoring stands to benefit from improving the capacity to monitor and detect long-term, low frequency changes in ecosystem structure and functioning.

Finally, a planning, monitoring and evaluation system is only as strong as its architecture: ZZ2's ability to prepare, strategize, monitor, and, ultimately prioritize long-term benefits over of short-term gains will depend on their commitment to creating a management system that actively supports long-term vision. Stability in this realm is linked to successful collaborations and partnerships with a variety of stakeholders, including government officials, agencies, non- profit organizations and the private sector. While ZZ2 remains clearly committed to cultivating cross-sectoral ties, the company

may benefit from re-assessing these relationships and priorities through the lens of long-term, shared-vision outcomes.

Principle 9: ***Management must recognize that change is inevitable.***

Rationale: Ecosystems change, including species composition and population abundance. Hence, management should adapt to the changes. Apart from their inherent dynamics of change, ecosystems are beset by a complex of uncertainties and potential "surprises" in the human, biological and environmental realms. Traditional disturbance regimes may be important for ecosystem structure and functioning, and may need to be maintained or restored. The ecosystem approach must utilize adaptive management in order to anticipate and cater for such changes and events and should be cautious in making any decision that may foreclose options, but, at the same time, consider mitigating actions to cope with long-term changes such as climate change.

ZZ2 is a highly adaptable company that both embraces change and innovation, while seeking to mitigate factors that may negatively affect production. Indeed, the case study was motivated in part by a fundamental shift in the firms' agricultural practices. ZZ2 recognized that decades of conventional farming had degraded the soil quality to the point of decreasing yields. Natuurboerdery® moved ZZ2's farming practices away from heavy reliance on chemical inputs towards the use of more organic inputs. The firm began a series of trial and error experiments with compost, compost teas, fermented plant extracts, and 'effective microorganisms' (EM) in an attempt to rebuild and improve soil quality and decrease fertilizer use, whilst maintaining or increasing yields.

ZZ2's adaptability is also evident at the farm-level. Regular meetings are organized between lower, middle and upper management staff to encourage an environment of open communication and sharing. These interdepartmental meetings provide platforms for staff to assess, analyze and plan agricultural inputs and pest management strategies.

While ZZ2 is quite forward thinking in many of its management practices, the firm has failed to develop long-term plans that address natural resource scarcity and climate change, the uncertainty of its labor pool, management succession, and diversity.

Adaptive management of nutrients and pests has weaned ZZ2 off of its' complete reliance on nonrenewable resources and has begun to restore previously degraded lands. A drier climate is expected in the Mooketsi region in the future, which will surely lead to increased competition for water resources.3 Indeed, water may be the most limiting factor for the success of ZZ2 as the thousands of rural inhabitants compete with agricultural enterprises like ZZ2 and with a proposed new mining exploration likely to begin in 2010. Involving the local community will be critical for the long-term survival of ZZ2.

As it currently stands, ZZ2 lacks a long-term plan that addresses threats posed by climate change. The scientific community concludes that human activity has altered atmospheric characteristics like temperature, rainfall, levels of carbon dioxide (CO2), and ground level ozone. The agricultural sector is particularly vulnerable to the climate variability and weather extremes

[3] Tourism, 2004.

associated with global warming, including droughts, increased rainfall, and floods.[4] According to the Center for Global Development and the Peterson Institute, the world agriculture will face a serious decline in production due to global warming, particularly in developing high temperature countries like South Africa. Assuming greenhouse gas emissions continue to rise, developing countries with average temperatures that are already near or above crop tolerance levels, will suffer a 10 to 25 percent decline in agricultural productivity by the 2080s.[5] The potential impact of global climate change is unknown; yet, finding appropriate systematic changes will be paramount for fortifying the buffering capacity of this new farming system.

If climate change continues along its current path, it is inevitable that carbon-based fuel products will experience drastic increases in price. While timelines may vary, many scientists and observers from the petroleum industry believe that global petroleum extraction has or will reach peak extraction rates by 2020. When peak oil production is reached, the rate of production will decline, forcing gas prices to escalate. ZZ2s heavy dependence on fossil fuels for many of its processes, most notably the transportation of its goods, may cause serious profit losses in the future. ZZ2 should strive to begin converting to alternative sources of energy in preparation for escalating fuel costs. Some potential options include solar energy, wind energy, hybrid truck engines, and biofuels.

ZZ2 should also develop long term plans to increase social capital through promoting within the company and hiring locally. With one exception, the entirety of ZZ2's management is white, male, and above the age of 35. While homogeneity in social capital may appear beneficial in the short run, ZZ2's external socio-political environment is highly dynamic and diverse. The company's profile as a white-owned enterprise with a racially skewed management profile may make it a vulnerable to external criticism and attack.[6] As an Afrikaans-owned farm with black, migrant labor, ZZ2 faces challenges recruiting and retaining qualified upper management, and is perceived as a "white" presence in the greater community. ZZ2 has struggled to attract competent people of color into upper management. Since the inception of the BEE laws, it has been doubly hard to recruit and retain qualified black managers. Additionally, its homogenous nature may create friction when next there is an intergenerational transition within the company, which may challenge the future growth of the company. Finally, linguistic homogeneity in cooperate management groups was found to result group-specific speech norms, which creates conflicts with management norms.[7] Therefore, homogeneity in ZZ2s upper management is a major weakness.

The managerial staff would benefit greatly from increased diversity. When positions open, ZZ2 would benefit from actively seeking out qualified black, colored, and female candidates to replace them. In order to help overcome any hesitancy that minorities may have when considering working in the agriculture sector in the Limpopo Province as a result of South Africa's culture and history of apartheid, ZZ2 should help fund the education of diverse young scholars in return for them coming to work at ZZ2 after they finish school.

ZZ2 is dependent upon an unstable labor pool, which is a weakness that directly threatens the company's longevity. Approximately 70% of ZZ2's workforce comes from neighboring Zimbabwe and

[4] EPA, IPCC, 2007.
[5] Cline, 2007
[6] Murray 1989, 125-141; Smith et al. 1994; Tihanyi et al. 2000, 1157.
[7] Berrey 1988, 23-26

Mozambique. Although these labor pools are currently abundant, any changes in the availability of workers would be detrimental to ZZ2, since the duties performed by laborers must be completed each day to yield a product. The Zimbabwean labor force is available primarily as a result of conflict in Zimbabwe. The company's reliance on this uncertain labor pool threatens the stability of the company and may increase the system's vulnerability to external forces (such as South African immigration and foreign labor policies and additional political unrest in neighboring countries). South African workers lack an indigenous agricultural history. As a result, they are largely untrained in and not attracted to agricultural work. This presents many obstacles to hiring locally. Developing a community outreach program to attract and train local South African workers may help to mitigate future labor pool uncertainties.

Principle 10: ***The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.***

Rationale: Biological diversity is critical both for its intrinsic value and because of the key role it plays in providing the ecosystem and other services upon which we all ultimately depend. There has been a tendency in the past to manage components of biological diversity either as protected or non-protected. There is a need for a shift to more flexible situations, where conservation and use are seen in context and the full range of measures is applied in a continuum from strictly protected to human-made ecosystems.

In accordance with an ecosystem approach to farming, ZZ2 realizes the importance of integrating land use and conservation incorporating the region's natural biodiversity into its farming and business practices. Principle 10 is especially apparent in ZZ2's preservation of the existing ecosystems in its conservancies. These game conservancies serve as a buffer zone for ZZ2 farmland, and function as an indicator of soil health. ZZ2 also promotes biodiversity in its lands by collaborating with the local community in the removal of non-native plant species. This contributes jobs and firewood to the community while eliminating species that can be detrimental to native species.

Within Natuurboerdery ZZ2 seeks to manipulate the intricate relationships between the various system components to optimize its yield while maintaining the fertility of the land for generations to come. ZZ2 strives to enhance soil biodiversity, reduce impact on local ecosystems and stabilize yields through the use of fermented plant extracts, and integrated pest and nutrient management strategies (Rasmussen, 1998).

Although ZZ2 realizes the intrinsic value of biological diversity, several areas still exist where improvements could be achieved. In particular, ZZ2 can focus on biodiversity beyond the soil level. This can be done through the use of cover-cropping systems, utilization of formal experimental designs, sharing production knowledge, and lobbying for sustainable agricultural policies.

While ZZ2's Natuurboerdery program has addressed the diversity of organisms within the soil, the fields still support crop monocultures, many of which lack cover crops. Leguminous cover-crop species in the tomato fields, for example, would not only increase the diversity of the system, but also help stabilize the soil by preventing erosion. Cover crops go hand-in-hand with reducing the amount of tillage of the land, the end goal being a no-till system. By combining these two techniques, ZZ2 could drastically reduce the erosion of its soils ensuring it can be farmed into the future.

Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.

Rationale: Information from all sources is critical to arriving at effective ecosystem management strategies. A much better knowledge of ecosystem functions and the impact of human use is desirable. All relevant information from any concerned area should be shared with all stakeholders and actors, taking into account, inter alia, any decision to be taken under Article 8(j) of the Convention on Biological Diversity. Assumptions behind proposed management decisions should be made explicit and checked against available knowledge and views of stakeholders.

The concept of Natuurboerdery as defined by ZZ2 relies on knowledge assets derived from various sources and having diverse applications. The information flows provide support to the scientific and technological research initiatives and the value system base of the company. For instance, ZZ2's awareness of local cultural values and its receptivity to different ideas and thoughts is exhibited in its creative management strategies. The company adopted the prevailing tribal system of dealing with social disputes, called *Kgoro*, to address the issue of on farm worker disputes. Furthermore, communication between labor and management is mediated through a representative council referred to as the *Kgoroja z,* which brings presents specific concerns related to working conditions and labor issues before the management board. Furthermore, the company applies a consensus-based approach to decision-making, based on the traditional tribal system where all concerned stakeholders are encouraged to participate and all opinions expressed are given equal weight.

On the scientific front, the company maintains an impressive record keeping system where data on various aspects of farming operations ranging from soil quality to plant heath is collected. Information processed from such data supports decision-making along the value chain including the production of compost and compost teas. However, though ZZ2 implements comprehensive data collection, their data analysis lacks scientific enquiry, and a shared central location.

Consequently, the analyses can be misleading. The inefficiency in analyzing data is due, in part, to the lack of a qualified biometrician on the ZZ2 staff. The company also lacks a common data collection platform needed for monitoring an agricultural enterprise of their size. This can cause failure in identifying important environmental and yield trend patterns and developing appropriate management responses[8]. Accurate, standardized, centralized record keeping is absolutely vital for understanding the mechanisms behind observations in the fields. Coupling agricultural, climate and economic data will help clarify what practices are effective and profitable

Over the years, ZZ2 has collected a massive amount of data on population sizes of different soil organisms without corresponding background information such as a recent history of sampled site (rain, fertilizer application events, etc) that can be associated with the organism numbers. Principles of

[8] For instance, when we sought to evaluate whether Natuurboerdery improved the tomato yield, we experienced significant delays in getting the data files we requested. The data was not kept in a central place: production data was provided by the marketing department, and climate data (rainfall and temperature) was provided by the agronomists. Ultimately, we sat with the senior agronomists to develop a historical timeline of transition to new farming techniques and each farms' transition from conventional farming to Natuurboerdery. We then had to request data on farming inputs for each location to identify when new types of inputs entered a particular system and when old techniques ceased. In the end, no complete data set for any of the farms could be compiled.

soil biology assert that data of this nature hold little value without adequate background information since soil organisms are highly sensitive to environmental factors and their populations can change in a matter of hours. Additionally, there must be good controls in place for use as reference sites to say whether having 109 cells of bacteria in a soil is good or bad, for example. The proper technique would be to first identify the issue that needs to be addressed then select the appropriate methodology.

The data available with ZZ2 is inadequate in its ability to enable the company to view the big picture of its journey up to now, including the history of transition from chemical to Natuurboerdery, severe environmental events (storm, hail, flood, pest outbreaks, etc), and land use history. This information could help ZZ2 to interpret the yield trends and to isolate the effects of changes in management practices on yield, and most importantly to make sure that organizational history is recorded for the next generation of company directors. ZZ2 needs to know where it has been, before it can understand where it needs to go to remain sustainable and competitive into the future. It is impossible to evaluate the success of using a new technique by simply plotting the yield over years; there are many other variables to be considered.

Recognizing the importance of nurturing scientific innovation and practices, ZZ2 has built linkages with educational institutions and universities to both serve their own research interests and cultivate new talent to bring to the company. ZZ2 funds a laboratory at the University of Limpopo for the purpose of plant and soil research and testing. They also offer internships to the students at the University of Limpopo and University of Pretoria and bursaries for doctoral and post-doctoral research. The company can use such linkages with academic institutions in order to address its lacunae in the area of data analysis.

ZZ2 is proactively involved in a number of decision- and policy-making bodies, such as the Tomato Growers' Association, Avocado Growers' Association, and various Wildlife Associations. ZZ2 is also an important member of the Provincial Limpopo Economic Advisory Committee and the NFPM Board. The company's presence in a number of these bodies speaks of a mutually beneficial relationship. ZZ2's presence in the local community gives the company leverage at the local, regional and national levels while simultaneously allowing the company to expand its expertise and knowledge base.

Principle 12: ***The ecosystem approach should involve all relevant sectors of society and scientific disciplines.***

Rationale: Most problems of biological-diversity management are complex, with many interactions, side-effects and implications, and therefore should involve the necessary expertise and stakeholders at the local, national, regional and international level, as appropriate.

The nature of ecosystem management is complex for any individual or community, but particularly so for farmers who depend on the productivity of their natural resource base for their livelihood. Since all resource management decisions and practices have both direct and indirect consequences on a variety of stakeholders, decision-making and ecosystem management should be a participatory, collaborative and inclusive process, on a multitude of levels, involving laborers, government agencies, the private sector, and the local community to name a few. It may be challenging to figure out who should be at the table—

identifying stakeholders is a primary task that must be completed before dialogues begin, and it should be the priority of the decision-making body to continually bring in those voices that are not represented.

ZZ2's propensity to experiment and collaborate has been beneficial for moving the company forward in terms of innovation and organizational development. The constant interaction between the research team, the compost team and the compost extract team is an example of on-farm collaboration and communication. Additionally, ZZ2's willingness to seek outside perspectives from universities, other enterprises and the private sector demonstrates their desire to remain inclusive, and make informed decisions.

A complex organization like ZZ2 requires internal communication and collaboration as well as external relationship and capacity building, both of which come with their own separate challenges. For example, ZZ2 is an organization with upwards of 8000 laborers during peak seasons. Communication between individuals on the property is challenging due to the sheer scope of the labor force, and is further complicated by language and cultural barriers. For instance, farmers may be incentivized through quota requirements, which may in fact be in direct conflict with the proper management of that particular ecosystem. Although there appears to be good communication between upper management regarding decision-making practices, the ultimate success of future initiatives will rely on buy-in from participants at all levels, from the research department to the farm managers to the day-laborers.

The relationship between scientists, researchers and farmers is of particular importance and demands special attention. ZZ2's connection to South African universities domestically and Cornell University abroad provides an excellent resource. However, it will take additional focus to clarify the role of each stakeholder and to identify the ways in which he or she will participate in the long-term visioning process for an ecosystem management approach. Finally, maintaining and cultivating relationships with government officials, policy makers, local businesses and the general community will benefit ZZ2 in their quest to sustainably manage shared community resources while increasing the productivity of their land and resource base.

Contemporary events and developments from the past in the economic and socio-political arena should inform ZZ2's efforts for incorporating responsible and sustainable practices in its agriculture and management operations. In this context we review certain challenges that we believe are relevant to ZZ2's growth and that did not voluntarily appear in our analysis of Natuurboerdery in the Ecosystem framework.

V. CHALLENGES

In the following section we discuss some critical challenges that ZZ2 may encounter in its adaptive management strategies for coping with developments in its environment and its initiatives for innovation and growth. These challenges are by no means exhaustive, and have been reviewed in terms of their implications for the agribusiness industry in general from the perspective of an established firm like ZZ2.

Racial Divide

South Africa is a country with a history of racial segregation and this is especially reiterated in the agriculture industry. At the end of apartheid in 1994, whites owned 87% of the total agricultural land, while blacks owned only 12% (Kargbo, 2006). Such a skewed land distribution was achieved through systematic discriminatory policies[9]. An analysis of the farm ownership patterns by Stats SA&NDA (2000) reveals that while whites have traditionally dominated the commercial farming sector, blacks are largely limited to the subsistence farming sector[10]. Such skewed patterns of ownership and distribution create an extremely uneven economic landscape that builds ground for political instability and social unrest.

Land Reforms

The new government that came to power in 1994 identified land reform to be one of its major objectives, together with the policy for BEE. The government set a target of redistributing 30% of all agricultural land to the black majority by 2014("Hurry Up Land Reform," 2009). A three-pronged approach of land restitution, land redistribution and land tenure reform was adopted to achieve this end (Driver, 2007)[11].

While land restitution has achieved significant success, with 90% of claims being settled, progress in redistribution reform has been much slower ("Why Land Reform is so Tricky," 2007). According to estimates, only 5% of agricultural land has been handed over so far[12]. The reform initiatives have also been criticized for applying a piecemeal approach to redistribution and not addressing the root causes of continuing inequality. Most of the transferred farms have failed ("South Africa's Disputed Land," 2008). According to an article published in the Economist on December 5 2009, the reason for this can be attributed to lack of money and skill. Many of the communities in the region herded cattle and did not traditionally cultivate crops; they therefore lack the experience and technical know-how to practice agriculture. Furthermore, the farms available for sale are usually large and require huge capital investments to repair and maintain, placing them out of reach to new and inexperienced farmers who find it difficult to survive on their lands without a lot of state support. The issue of land reforms is extremely urgent. As noted in a BBC article on November 4 2009, the government is now talking about land expropriation and reviewing its "willing buyer-willing seller" policy. This forewarns a potentially volatile situation urging the need to take lessons from the land appropriation measures undertaken in Zimbabwe.

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[9] For example, the Native Land Act of 1913 restricted the land available for occupation by natives and dispossessed native share croppers and cash tenants thereby replacing sharecropping and rent-tenant agreements with labor tenancy (Thwala 2003).

[10] The average land holding for white-owned farms rose from 979 hectare in 1970 to 1355 hectare during 1988–96. The average farm size in the subsistence sector was found to be less than 2 hectare (SA &NDA, 2000).

[11] Through the restitution process, people or descendants of people who were evicted from land through racially discriminatory policies, such as the Native Land Act of 1913, could reclaim their land holdings or receive cash compensation against the claim. Land tenure reform sought to secure and protect tenure for tenant laborers. Land redistribution initiatives were based on negotiated land reform, where the government provided financial assistance to blacks to enable them to purchase land from existing owners on a "willing buyer-willing seller" basis.

[12] As noted in a BBC article on November 4, 2009, the government has admitted its inability to achieve the target set initially for redistribution and now plans to postpone the deadline from 2014 to 2025.

Political Instability

The skewed distribution in agriculture and agribusinesses has often led to volatile conflicts between blacks and whites and is largely responsible for potential instability in the industry. As Pumza Filhani noted in a BBC news article in April, 2010, over 3000 white farmers have been killed since the end of apartheid in 1994. While many of these incidents have been attributed to the general crime situation in the country, some of the deaths have also been linked to the process of land reclamation. Another BBC news report published in July 2008, claims that between 1994-2008, about 15,000 white farmers sold their land and many among these have left the country.

Xenophobia

As a result of the economic collapse in Zimbabwe due to mismanagement by the government, 94% of the population is currently unemployed and seeking work elsewhere. In South Africa, there are at least one million Zimbabweans, most of which reside in Gauteng, Limpopo, Mpumalanga, and North West. Since many of ZZ2's farms are located in the Limpopo region, a large portion of its wage labor force is Zimbabwean. As a result, xenophobic violence or violence against non-South Africans is an issue that might be of importance, especially as competition for jobs increases. In May 2008, the country witnessed large scale conflict that resulted in the death, injury and displacement.[13]

HIV-AIDS

South Africa has one of the highest rates of HIV prevalence in the world[14]. While acknowledging the magnitude of the humanitarian crisis, implications for labor supply and economic productivity need to be addressed to assess the impact on the agribusiness sector in terms of the implications for firms, households, and the macro-economy (Arndt and Lewis, 2000). For firms, AIDS directly impacts labor productivity through work disruption, absenteeism, and high labor attrition rates. Furthermore, the skill specific incidence of HIV has serious implications for agribusiness firms that absorb large pool of unskilled labor[15]. At the household level, AIDS not only reduces life expectancy and the rate of population growth, but also increases the burdens placed on working age people. High prevalence also translates into changed expenditure patterns and reduced savings for families as medical costs rise. This indirectly impacts human development through lower investment in human capital. As firms are required to provide for worker insurance and benefits, it also increases the cost of production. The increased costs imply eroding of competitiveness and decreased investment for the economy as a whole[16].

Inflation

The competitiveness of the agribusiness sector is affected by the prevailing interest and inflation rates. In 2001, the South African rand depreciated suddenly and steeply against the dollar and

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[14]According to the UNICEF Country Report on South Africa Health Statistics, 5.7 million people, or 11.5% of the population, estimated to be living with the virus in 2007

[15] Various studies (Abt/Metropolitan, June 2000; Dorrington, 2001; ING Barings, 2000) focused on the AIDS epidemic in South Africa, show that HIV prevalence differed according to the level of skills. Lower-skilled people tend to have higher prevalence rates than higher-skilled people.

[16] Since AIDS is seen to affect the most productive segment of the population, in the age group 25-45 (ING, Barings, 2000), the associated mortality and morbidity can have serious consequences for economic growth

the euro. This triggered inflation as the prices of imported products pushed upward. For the industry, this translated into increased production costs for agribusinesses as the cost of inputs ranging from fertilizers to fuel shot up. On the whole, the high level of inflation in the economy reduced the overall competitiveness of the agribusiness sector. The effect of increased food prices on food security also became a matter of prime concern in a country that already has a high incidence of poverty. To offset imminent inflation and attract foreign investment, the Central Bank raised interest rates, resulting in slower domestic growth for the economy in general and agribusinesses in particular.

Public sector inefficiencies

The Strategic Agriculture Plan for South Africa, prepared jointly by industry and the government, identifies key failings in public support and delivery systems, which hinder agricultural growth and competitiveness. Inadequate resources, weak governance, poor accountability, bureaucratic delays in decision-making and poor executive decisions are identified as the main shortcomings in the agriculture sector. Lack of synchronization between state and markets due to red tape and incompetence is held responsible for the slow progress of land reforms in the country. Corruption in public administration and private businesses further exacerbates the prevailing conditions. According to the Corruption Perception Index instituted by Transparency International, SA ranks 55th in a survey conducted across 180 countries, with a score of 4.7. There has been an increase in administrative corruption since 1994 (Lodge 1998, 157-187), which continues to pose a challenge to competitiveness of the agribusiness industry.

Production Systems and Resource Use

As ZZ2 grows, it uses more resources and demands more from the environment. Inefficient resource use has driven competition for water with local inhabitants and accelerated leaching of nutrients from valley soils. The region is highly susceptible to erosion of the sandy loam soils and is a recipe for a South African equivalent of the Dust Bowl. Well-drained soils and high fertilizer use in the past lead to movement of fertilizers and pesticides to surface waters, raises the question of drinking water quality downstream.

The game reserves held by ZZ2 have underappreciated value as biological refugia for their highly vulnerable monocropping cultivation practices. Monocropping, along with exposed soil (lack of a cover crop), have the potential of lowering the resilience of Natuurboerdery® as climate and pathogen resistance to control agents again pose the most serious threats to production.

Competition and Marketing Channels

Global tomato production has increased by nearly three-fold since 1961, reaching 108 million metric tons in 2002. In Mooketsi alone, 337,890 tons of tomatoes were produced in 2000, 47% of the total tomato production in South Africa (NDA, 2000). Because of the low value to mass ratio of tomatoes, opportunities in the export of fresh tomatoes are limited. However, demand for tomato paste and sun-dried tomatoes is on the rise and represents a potential market for ZZ2.

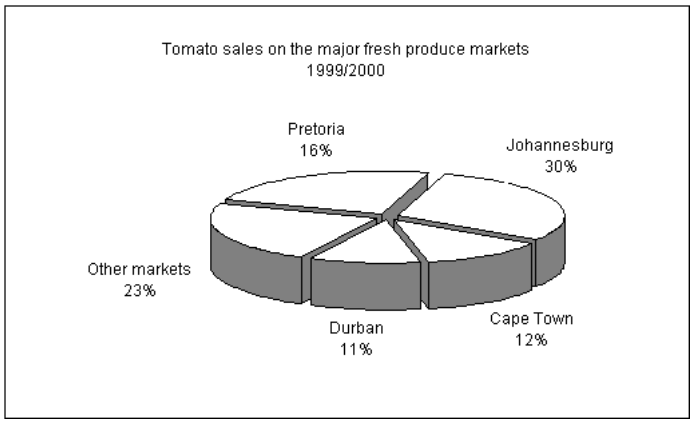


Figure 2: Tomato Sales in South Africa's Fresh Produce Markets, 1999/2000

Given the perishable nature of fresh produce, the market channels used by agribusinesses are of extreme importance. Producers of agricultural commodities must choose between participating in the 18 current NFPMs, selling their produce directly to larger market intermediaries outside of the NFPMs (such as chain stores or large wholesalers) or selling their produce at the local level (retail outlets, road stalls, hawkers, and local farmers' markets).[17] The majority of tomatoes produced in South Africa are sold in fresh produce markets, the largest of which are in Johannesburg (with 30% market share), Pretoria (with 16% market share) and Cape Town (with 12% market share).[18]

V. CONCLUSION

Since their transition from high levels of industrial inputs to the Natuurboerdery system, ZZ2 has made significant strides towards reducing their negative impact on biodiversity. Our analysis of Natuurboerdery through the lens of the 12 ecosystem principles has revealed that the development and use of the various organic soil amendments, the progressive management practices, and intergenerational values have led ZZ2 to fulfill principles 1-8 and 10 relatively well. They can improve their standing with these and the remaining principles primarily by continuing to develop Natuurboerdery with programs like a biochar and carbon sequestration program, creating stronger links with external factors in society, and developing a plan in response to climate change.

Despite ZZ2s areas for improvement, the company still makes an excellent example for other large farming companies to use as a model for reducing detrimental impacts on surrounding ecosystems. ZZ2 identified the areas where changes in their practices were mutually beneficial to the company, the environment, and society. As a result, they are now in a position where their level of sustainability is more advanced than most companies of a similar size, but there are still areas in which ZZ2 can expand the application of the 12 ecosystem principles to further reduce impacts on ecosystems and the surrounding communities. ZZ2 has the flexibility to determine whether scaling up Natuurboerdery makes sense for their current agricultural operation. ZZ2 is also in an excellent position to initiate the formation of a national, and eventually, global standard for responsible, accountable agribusiness behavior.

[17]http://www.namc.co.za/assets/pdf/published/FreshProduceStudy1.pdf

Today, ZZ2 realizes that to become truly sustainable they must scale up Natuurboerdery. One recommended approach is to expand it in accordance with the Convention of Biological Diversity framework in an effort to manage to CBD's three primary objectives of conservation; sustainable use; and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Using the CBD's 12 principles, ZZ2 can benchmark and evaluate its current level of success in achieving the three objectives, and create a set of indicators that can be measured to track any interventions necessary to reach the goals of conservation, integrated sustainable production, and rural livelihoods.

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