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THE SUSTAINABLE AGRICULTURE IMPERATIVE: IMPLICATIONS FOR SOUTH AFRICAN AGRICULTURAL EXTENSION

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ABSTRACT

This paper draw on relevant published (review) papers to argue that extension is well positioned to promote sustainable agriculture through five pillars of sustainability. Agriculture is not only greatly influenced by the environment in which it operates, but in recent decades it has become increasingly apparent that some modern farming practices may harm the natural environment. In fact in most countries of the Southern Africa, severe environmental problems are direct results of modern farming practices. As a result of the ever growing human population in South Africa, farmers are forced to resort to farming practices that will increase productivity, but compromising the natural environment, in order to ensure food security. Thus the need for establishing frameworks, methods and processes that support viable and attractive sustainable agriculture is imperative. This is particularly true in South Africa's context with its primacy on transforming the agricultural sector where, in the efforts to redress issues of the past, it runs the danger of replicating the inefficient, unsustainable practices of that same past. Ultimately, this has significant implications for South African agricultural extension, which need to be able to help the nation balance the increasing and often conflicting demand for more efficient production, greater inclusion of marginalised smallholder farmers, and creating wealth in impoverished rural communities. The paper concludes by presenting some philosophical recommendations that agricultural extension can utilize in promoting sustainable agriculture.

Keywords: Environment**,** food security**,** farming practices**,** Sustainable agriculture, agricultural extension.

1. INTRODUCTION

The protection of our resources is vital for the continued viability and productivity of agriculture in South Africa. This paper explores the definition of sustainable agriculture and discusses in detail why it has become imperative, during the last decade, to focus on the sustainable agricultural practices. Existing literature on sustainability mostly emphasizes three pillars of sustainable agriculture namely; environment, social and economic aspects. This paper put emphasis on five pillars of sustainable agriculture and how extension can help farmers in promoting the pillars. For agricultural production systems to be sustainable, such systems should meet requirements of biological productivity, economic viability, protection of all natural resources, reduced levels of risk and be social acceptable. The specific examples of change in the agricultural environment and why it is now imperative to scrutinise

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agricultural production practices for their sustainability are also discussed. Agricultural extension should have a deeper understanding of how natural ecosystems function will help us plan more efficient and sustainable cropping systems (Francis, 1990). Most practical examples are based on cropping system because of availability of literature and also that the principal author is a crop scientist. Finally, the paper discuses the application of sustainable agriculture to South Africa's agricultural development agenda.

2. BACKGROUND

2.1. Focus towards sustainable agriculture

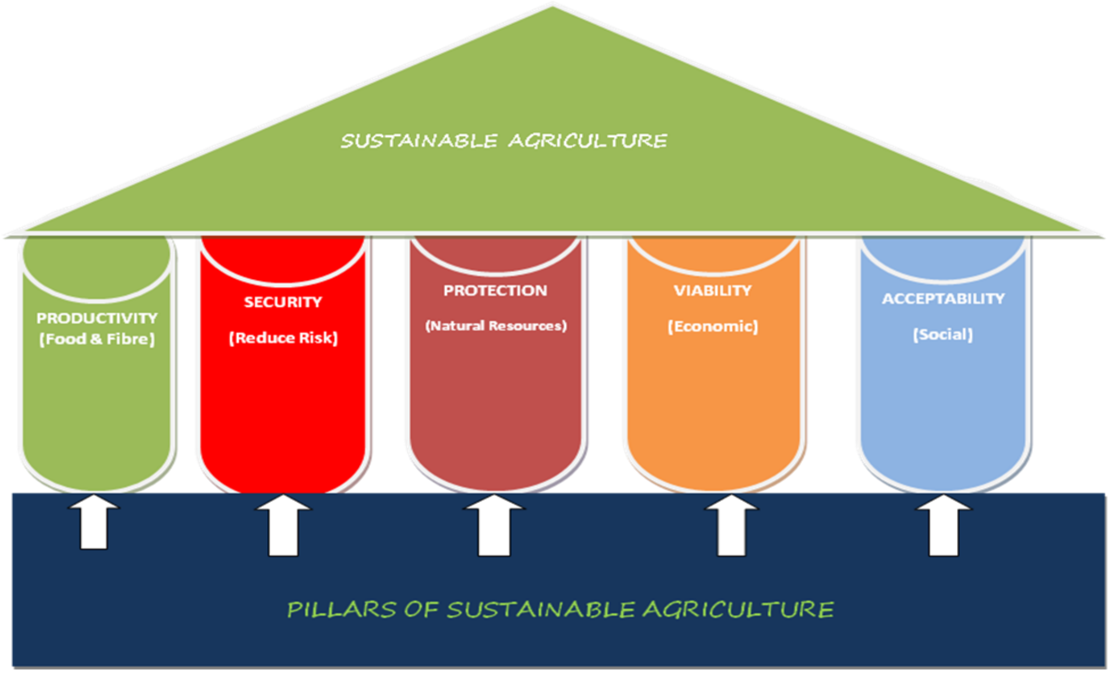

Figure 1: Five pillars of sustainable agriculture (adapted from Khwidzhili, 2012)

Figure 1 graphically depicts the elements of sustainable agriculture. These elements frame the space in which farmers and extension must operate if farmers are to be successful at genuinely engaging in sustainable agriculture and if extension services are to be successful in supporting them. The five pillars are:

- Maintaining and increasing biological productivity;
- Decreasing the level of risk to ensure larger security;
- Protecting the quality of natural resources;
- Ensuring agricultural production is economically viable; and
- Ensuring agricultural production is socially acceptable and acceptance.

The discussion of pillars presents the relevant principles for each pillar and gives a few, perhaps obvious, examples of their practical application to illustrate the point in each case the challenge is in engaging farmers in honest conversations about the respective pillar as it applies to their farming operation and assist them to develop appropriate responses that meet the conditions of sustainable agriculture (as defined by these pillars) and fits their unique circumstances. As will also be discussed, these pillars are meant to be addressed in an integrated fashion, not as individual aspect to be addressed in isolation. And the second challenge will be in resolving the inevitable tension that attempt to correct farming operations relative to one pillar will create on the ability to address the requirements of others. At the ecological level, land scarcity is causing food scarcity for the ever-increasing population. Brown, Abramovitz & Starke (2000) pointed that resources are becoming scarce, natural species and forests are destroyed which also leads to destruction of wildlife and fisheries. Extension should play a pivotal role in discouraging further exploitation of the natural environment.

3. OBJECTIVES

The main objectives of this study are;

- To investigate existing literature on pillars of sustainable agriculture and how public agricultural extension can facilitate the realization of sustainable farm production practices.
- To analyze why it became imperative in the last decade to focus on pillars of sustainable agriculture (implications for agricultural extension).
- To determine some of the challenges faced by farmers and how agricultural extension could help to mitigate them.
- To highlight the importance of preventing further degradation of the natural resources.

4. RESEARCH METHOD

This paper was published as a result of thorough process of reading some background information that already exist and appear relevant to the topic (Bless & Higson-Smith, 1995). A number of documents were used as a major source of evidence to support this study. Merriam & Associates (2002) also support this kind of study. These authors emphasizes that the strength of documents as a data source is that information already exist and do not intrude upon or alter the settings in a way that the presence of the of the investigator might be influenced. Literature on sustainable agriculture mostly provides emphasis on three pillars of sustainable agriculture which are; economic, social and environment sustainability. This paper further explores extra two pillars of sustainability which are production and risk. This is a case study which was aimed at reviewing already existing literature. This paper draws its theoretical framework from Dumanski, Tery, Byerlee & Pieri (1998) in their publication, performance indicators for sustainable agriculture. This framework can be used nationally and internationally to evaluate sustainability. A Framework for Evaluation of Sustainable Land Management (FESLM) was developed through collaboration among international and national institutions as a practical approach to assess whether farming systems are trending towards or away from sustainability (Dumanski *et al*, 1998). Nieuwenhuis (2007) suggested that case study research is a systematic inquiry into an event or a set of related events which aims to explain the phenomenon of interest in social setting so as the researcher understand how it operate or function. As supported by Yin (2003) a blend of data gathering techniques were used to compile this study and these included literature review, document analysis, and some already analysed data information.

5. DISCUSSION

5.1. The definition of sustainable agriculture

According to Francis (1990), sustainable agriculture is a philosophy based on human goals and understanding the long-term impact of human activities on the environment and, consequently, on other species. Use of this philosophy guides our application of prior experience and the latest scientific advances to create integrated, resource-conserving, equitable systems. Sustainable agriculture is not a return to pre-industrial methods, and the rejection of modern techniques. Sustainable agriculture must necessary transcend this dichotomous view and operate solely from the entrenched principles of sustainability. It may well be that the resulting technologies reflect a combination of traditional and modern techniques. Issues central to sustainable agriculture are the necessity of taking a long-term view, thereby ensuring the supply of products to future generations, the necessity to maintain and enhancing soil fertility, veld condition, water supply, water quality, and generic resource on which agriculture depend. Sustainable agriculture delivers on these critical elements through a variety of technology options.

Sustainability is a direction rather than destination (Dumanski, 2007). First we must agree on what is to be sustained, for whom, and for how long? If we degrade our natural resources and poison our natural environment, we will degrade the productivity of agriculture and ultimately destroy human life on earth. Thus sustainable agriculture must be ecological sound, economically viable and social responsible (Botha & Ikerd, 1995). Dumanski (1997) in the context of, planning for sustainability in agricultural development projects, reinforced the generally accepted definition of sustainability put forward by the 1987 Bruntland Commission that "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their needs".

Dumanski (1997), further insisted that the aim of sustainability is to leave future generations as many, if not more, opportunities as we had ourselves. He further stressed that sustainable land management combines technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to simultaneously:

- Maintain or enhance production/services;
- Reduce the level of production risk;
- Protect the potential of natural resources and prevent degradation of soil and water quality;
- Be economically viable; and
- Be socially acceptable.
- The meaning of sustainability was further highlighted by Pearson (2003) who defined a sustainable system as one in which: resources are kept in balance with their use through conservation, recycling and renewal; practices preserve agricultural resources and prevent environmental damage to the farm and off-site land, water and air; and production, profit and incentives retain their importance, because not only agriculture needs to be sustained, but so do farmers and society. These definitions of sustainability pose challenges to farmers (both established and new) and for the South African government, in particular its agricultural extension policies, agencies and operations. They need to be translated into practical measures for agriculture. However, as domestic and international economic pressures and competition cuts profit margins, farmers will need clear guidelines and support if they are to build the capacity to engage in sustainable agriculture.

5.1.1. Maintaining and increasing biological productivity

The first pillar of sustainable agriculture is the requirement that the biological productivity of the soil is maintained and, if possible, increased. Biological productivity refers to the ability of soil to promote microbial activities. Farmers will need to explore ways to achieve this. A key element is to the percentage of organic matter in the soil. For example, extensive open cast mining completely removes biological communities and presents conditions which are extremely hostile for invertebrates. According to Carry & Good (1992), features of newly restored mining and industrial waste sites are likely to inhibit faunal establishment include, lack of suitable food and adverse physicochemical conditions, particularly unfavourable moisture conditions and excessive fluctuations in surface temperature.

Many soil micro-organisms cannot function in acidic soil. The most common way of correcting the pH level of acidic soil is by applying agricultural lime to the soil (Barrett, Pieterse, & Strydom, 2008). Farmers need first to understand the productivity status of the soil and take appropriate actions. These actions, however, must be implemented in concert with responses to the other pillars- that is the essence of 'sustainability'- which as stated earlier is more a direction than a destination.

5.1.2. Decreasing the level of risk to ensure larger security

The second pillar of sustainable agriculture is that the level of production risk must be minimised (it can never be totally eliminated). Risk is endemic to all human endeavours, be they social or economic, it is also clearly true to agriculture. On a simple production level, planting of crops that are not suitable for a particular area increases the chances of production risk. Matching climate and cultivar will eliminate production risk.

Water erosion is another example of risk in agriculture. Rainfall deficiencies limit crop production in dry-land regions; many soils in dry-land regions are highly susceptible to water erosion. Susceptibility will result in, low crop yield, low soil organic matter content, high intensity rainstorm and poor soil-water management (Unger, 1990). Sustainable agriculture will demand that the farmer take command of the risk of water erosion through appropriate crop production operation such as tillage and the use of seedlings which can decrease the impact of rain drops on the soil; maintain favourable water infiltration; decrease run-off velocity; and decrease soil detachability.

5.1.3. Protecting the quality of natural resources

This third pillar of sustainability is directly linked to the biological productivity (first pillar). Sustainable agriculture will have to work within the bounds of nature not against them. This means matching land uses to the constraints of local environment, planning for production not to exceed biological potentials, and carefully limiting fertilisers, pesticides and other inputs to ensure that they do not exceed the capacity of the environment to absorb and filter any excess (Dumanski, 1997) or in considering alternative less measures. Deeper understanding of how natural ecosystems function will help farmers plan more efficient and sustainable cropping system (Francis, 1990).
Land degradation is driven by a combination of forces, such as poverty, excessive population, low productivity, lack of knowledge, ability and desire, or disincentives to adopt technology , and poorly defined or inadequate land tenure systems (Miller & Wali, 1995).

In their conclusion Miller & Wali (1995), highlighted some of the premises of sustainability and indicated that:

- Traditional agricultural systems; some which are sustainable, are disappearing.
- They are being replaced by farming systems that are more intensive and (or) dependent on finite fossil fuel and off-farm resources etc.

5.1.4. Ensuring agricultural production is economically viable

One of the challenges facing South African agriculture is the shift from production of food primarily for home consumption to farm businesses aimed at generating sustained income via profits attained through marketing of agricultural products. Economic viability is vital. The income from selling products must at least equal or, preferably exceed the cost of producing them. However, such economically viability must be sustained without compromising the natural environment.

Technological and scientific advances will be instrumental in the transition to sustainable agriculture, but political, economic and institutional structures will also have to be part of the solution. According to Dumanski (1997), the procedures being developed to assess and monitor farm-level, agricultural sector and even national wealth, and the concept of 'sustainability as opportunity' need to be further developed to balance the bias towards economic efficiency as a primary criterion for sustainability.

5.1.5. Ensuring agricultural production is socially acceptable and accountable

The principle of this pillar is that agricultural production and post-harvest activities must fit the society in which they occur. This covers substantial territory from the choice of products themselves, to the raw (genetic) material used, to the inputs used, and to the production, processing and marketing used. All of these are subjected to the social acceptability and accountability.

A case in point is the use of genetically modified organisms (GMO); to increase agricultural production which has received negative reception by the society. The negative perception towards GMO products is linked to sustainable health of end- users as well as to the impact they have on traditional farming methods, seed storage, and economic viability, among others. Many other such examples are extant.

The economic and social sciences are fundamentally different from physical and agricultural sciences and the natural science of ecology. Agriculture involves self-conscious attempts by human to change or manage natural ecosystem. Human are unique among species in that we make purposeful, deliberate decisions that can either enhance or degrade the health of the environment (Botha and Ikerd, 1995). While these two branches of science have different agendas, both of which must be addressed. A key to addressing these different agendas is to avoid dichotomous thinking, but to view them as a coherent whole. Again, farmers, who live in both these worlds, will need assistance in addressing these fundamental challenges.

5.2. Challenges to sustainable agriculture in South Africa

5.2.1. Overgrazing

Masiteng, Van der Westhuizen, & Matli (2003), recommended that a detailed survey and evaluation of the extension services available to farmers grazing on commonage land needs be done. He further insisted that extension services from the Department of Agriculture are insufficient and ineffective due to lack of capacity. There are very few extension officers with proper knowledge of pasture management. Pasture management research and extension education, training and practice in general to have take in consideration and also reflect the leaning towards more participatory approaches to extension. Training should basically focus on helping farmers towards self-reliance, and environmentally sound practices (NDA, undated). Poor management has led to overgrazing through overstocking and limited grazing rotations, leaving the large tracts of land severely denuded and under threat of desertification. Extension officers should also work with traditional leaders in communal land to encourage villagers on proper grazing management.

Studies conducted by Buttel (2001), predicts that environmental degradation will continue unabated until more preventive measures are taken to alter the behaviour of producers and the trajectory of farming and grazing industries throughout the world. Preventive measures as suggested by Pietikainen & Lehtila (2006) include amongst others minimum number of live stock to avoid exceeding the carrying capacity of local grazing. Some measure includes putting a price on grazing on control areas. Communities should decide on which areas will be used for farmland, grazing land or forest. Extension practitioners should also advice farmers to sell their stock and invest in cultivation (this advice could only be done when necessary). Finally Oba & Kaitira (2006) highlighted that rotational grazing and management of multiple livestock are traditional methods that can be recognised as Traditional Economic Knowledge. Traditional Economic knowledge emphasizes that villagers should not work in isolation, instead they should be govern by the same rules and procedures.Extension officers should assist farmers to determine the caring capacity and appropriate stocking rate in a particular season (Walker & Hodgkinson, 2000). Emphasis should be to keep minimum stock in winter unless there is provision of adequate supplementary feeding.

5.2.2. Pollution by chemical fertilizers

Inorganic fertilisers are often environmental costly. They can leach from the soil and contaminate ground water and streams. Other consequences of injudicious use of fertilisers can reflect in the built-up of toxicity, acidification and salinisation (NDA undated, pp 8). According to the report by OECD (1999) excessive use of nutrients in the soil contribute to eutrophication problem and pollution of drinking water. Excessive levels of nutrients in soils may also result in soil acidification.For example; excessive use of nitrogenous fertilizers concentrates nitrates in the soil and water. Nitrate rich water is carried off into surface water bodies such as ponds, rivers and lakes where it accelerates the growth of algae. These algae consume dissolved oxygen from water and thus deplete the water of its oxygen content leading to the death of useful aquatic life such as fish.

Excessive use of fertilizers over a long period may affect the acidity of the soil and may adversely affect the crop production. They contain ingredients that are toxic to the skin or respiratory system. Incorrect measure of fertilizers can also burn crops. Chemical fertilizers can build up in the soil, causing long-term imbalances in soil pH and fertility. Apart from the essential nutrients required by plants, chemical fertilizers contain certain compounds and salts which a plant is unable to absorb, which are left behind in the soil. With time, these compounds build up in the soil and can even change its structure.Pearson (2003) emphasized that a sustainable system should be kept in balance with their use through conservation, recycling and renewal. He further argued that practices should preserve agricultural resources and prevent environmental damage. It is therefore apparent that extension should assist to educate farmers on the use of both organic and inorganic fertilizers.

5.2.3. Pollution by pesticides, herbicides and fungicides

Pesticides are known to also kill non-target and often beneficial organisms in the immediate area of application. Others chemicals are not biodegradable and may accumulate in the soil and water with hazardous consequences to both animal and human life (NDA undated, pp 8). Pesticides have contributed greatly to increased agricultural productivity and crop quality, but once in the environment can accumulate in soil and water, and damage flora and fauna as concentrations in food-chains become high enough to harm wildlife (OECD, 1999). Pesticide residues also impair drinking water quality, contaminate food for human consumption, cause adverse health effects from direct exposure to farm workers, while some pesticides contain bromide compounds which, when volatised, convert into stratospheric ozone-depleting gases.

A difficulty with establishing indicators that address the issue of agricultural pesticide use is that pesticides vary strongly in their degree of toxicity, persistence and mobility, depending on the type and concentration of their active ingredients, and hence vary in the environmental risk they impose. Also an increase in pesticide use could coincide with a reduction of environmental damage, when more but less harmful pesticides are used, and vice versa, which emphasises the need to undertake pesticide use risk assessment(OECD, 1999). Furthermore, the quantity of pesticides that leach into soil and water depend on, for example, soil properties and temperature, drainage, type of crop, weather, and application method, time and frequency. Moreover, where pesticides are used in combination with certain pest management practices, such as integrated pest management, it may have little or no harmful impact on the environment, pesticide users, or food consumers.

5.2.4. Soil crusting

Regular and/or incorrect tillage changes the structure of the soil causing soil compaction resulting in slower water infiltration, increased run-off and greater risk of erosion. Intensive cultivation and loss of organic materials, together with excessive overhead irrigation, can aggravate the problem. An examination of South Africa’s rural areas reveals the extent to which the country’s ecology has been damaged. Political, economic and social factors impact on the sustainability of agriculture and livelihood of people living in rural areas (NDA, undated). According to a review by Miller & Wali (1995), the world’s soil resources have been pressured not only by food production of indigenous populations but also by advent of modern transportation and storage systems, which brings many of the world’s unique and, heretofore, unused resources to market worldwide.

Agricultural extension practitioners should work to assist farmers in minimising or even avoiding soil crusting. These amongst others should include practices that protect or increase soil structure and organic matter and provide protective vegetation on the soil surface. Practices such as no-till or reduced tillage of cropland reduce or eliminates crust formation. Extension practitioners should promote the use of organic matter and plant residues on the soil to avoid the physical impact of rain drop.

5.2.5. Water

Water scarcity is receiving more attention as an increasingly land-related problem. A recent report from Population Action International predicts that by the year 2025, the number of people living in water deficient countries will approach three billion up from 335 million in

1990 (Miller & Wali, 1995). The implications of water shortage for agriculture are obvious. Studies conducted by Angadi, Cutforth, Mcconkry, & Gan (2003) reveals that growing plants in area with low rainfall patterns will require planned irrigation to avoid plant water stress. Water quality is an important aspect in the bid to achieve sustainable management of irrigated land. The quality of irrigation water affects soil salinity and cation exchange, soil acidity and alkalinity, nutrient availability and soil structure. Sustainable water usage should aim to prevent degradation of ground and surface water (Hillel, 2000).

Water shortage is a major obstacle to agricultural production and also damage aquatic habitats and wildlife. The need to maintain and restore the ‘‘natural’’ state of water resources is an integral part of water management and sustainable agriculture practices. The intensification of agricultural practices in many countries has increased the abstraction rates of limited surface and groundwater resources (OECD, 1999). With the higher demand for water from industrial and public consumers, in addition to agriculture, the growing competition for water resources within the economy is of great concern to policy makers in many countries. Extension officers should assist farmers in measurement of agricultural water use in terms of developing water balances for both the use of surface and groundwater resources by agriculture, together with exploring possible linkages with indicators related to farm management, especially aspects of irrigation management. As part of sustainable water use, agricultural extension should endeavour to encourage farmers on various water use efficiency equations, monitoring stream and river flows (surface water) and also groundwater levels. This can be achieved by making it a point that farmers record or measure the amount of water used for both domestic and agricultural purpose. Farmers should be made aware of the water requirements for crops during different growth stages.

6. CONCLUSION AND RECOMMENDATIONS

The foregoing discussion highlights two things. First, in defining sustainable agriculture, it is seen that elements of it are technical, but that its underpinning is essentially philosophical in which farmers will operate at a level of principle while exploring specific options to specific issues related to production. Second is the essential aspect that these pillars must be viewed in their totality and to avoid dichotomous thinking, but recognising that it is a matter of ‘considered choice’ within recognised limits. Agricultural extension can play a considerable role both in raising farmers’ awareness of the individual pillars and their application to their respective farms and in integrating their application.

The concept of sustainability will remain uncertain and imperfect until better procedures for assessment and evaluation are available. However, the concept can be usefully employed in development projects even with the current imperfections in the definition. It is important that people, farmers and the community at large should engage themselves in practices that will not degrade their natural environment. The probability and capacity for a sustainable future rest largely on our ability to tap the earth’s natural resource with sustainable management strategies.

Sustainable land management in developing countries requires long-term, sustained support and investment in the prudent management and conservation of natural resources to achieve the combined goal of increased production and environmental maintenance. The government, private sectors, non- government organisations, including the international communities should join together in developing policies and guidelines that promote sustainable agricultural practices. Extension officers should continue to give a necessary advice to the farming community on practices that will not degrade our natural environment. In conclusion the big challenge is to ask what will happen in the future if farmers continue to use unsustainable farming practices that continue to harm the natural environment. Finally a follow up question should be what agricultural extension will do to assist the farmers in producing food that will meet the needs of the ever growing world's population without compromising the natural environment.

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