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IMPLICATIONS FOR THE AGRICULTURE SECTOR OF A GREEN ECONOMY TRANSITION IN THE WESTERN CAPE PROVINCE OF SOUTH AFRICA: A SYSTEM DYNAMICS MODELLING APPROACH TO FOOD CROP PRODUCTION

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ABSTRACT

The Western Cape Provincial government in South Africa has introduced a green economy framework, ‘Green is Smart’, to create a more sustainable economy. This framework stipulates plans for the Western Cape Province to implement more sustainable farming practices for food crop production. While sustainable farming practices will have benefits for the environment, they will also impact food crop production and will require financial investments from stakeholders. To comprehend fully the problem at hand, and to understand better the implications of a green economy transition for the food crop production system, system dynamics modelling was undertaken. The model’s findings highlight that sustainable farming practices will only be financially and environmentally viable if they match the yields of conventional farming practices.

OPSOMMING

Die Wes-Kaapse Provinsiale regering in Suid-Afrika het ‘n groenekonomie raamwerk, ‘Green is Smart’, bekendgestel met die doel om ‘n meer volhoubare ekonomie te skep. Hierdie raamwerk bepaal planne vir die Wes-Kaapse Provinsie om meer volhoubare voedselproduksie- en boerderypraktyke te implementeer. Terwyl volhoubare boerderypraktyke voordele vir die omgewing het, sal dit ook ‘n impak op voedselproduksie hê, en sal finansiële beleggings van belanghebbendes vereis. Om die probleem ten volle te begryp, en om die implikasies van ‘n groenekonomie oorgang vir die produksie voedselgewasstelsel beter te verstaan, is stelsel dinamika modellering onderneem. Die model se bevindinge beklemtoon dat volhoubare boerderypraktyke net finansieel en omgewingsvriendelik lewensvatbaar sal wees as dit kompeterend is met opbrengste van konvensionele boerderypraktyke.

1 INTRODUCTION

The Western Cape Province is currently South Africa’s leading agricultural export region, and its aquaculture region enjoys an estimated triple-digit growth rate [1]. The Western Cape, however, is projected to be among the South African provinces that will be the most significantly impacted by climate change. This increases concerns about the sustainability of agriculture in this region, since the Western Cape Province is already water-stressed. The agricultural sector is the Western Cape’s largest employer, and faces a particularly challenging future as the sustainability of crop production is threatened by climate change [1].

The concept of a ‘green economy’ is a response to numerous global crises such as climate change and food and economic crises. A green economy provides an alternative to current production methods, and offers the promise of growth while protecting the ecosystem, which in turn results in poverty relief [3]. This approach increases interest in the concept of a green economy, along with support and funding worldwide [3]. The United Nations Economic Commission for Europe (UNECE) and the United Nations Environment Programme (UNEP) define a green economy as “an economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" [4, 2]. The UNECE adds that a green economy can be seen as a way of providing enhanced quality of life through a robust economy that is bound by the ecological constraints of the planet [4]. The transition from current economic policies and methods to a green economy thus offers potential economic, social, and environmental benefits.

The Western Cape Government has realised the potential benefits of a green economy, and so has developed a green economy strategy framework. The initiative is called 'Green is Smart' [1], with the aim of optimising green economic opportunities and enhancing environmental performance in the Western Cape Province. From an agricultural perspective, farming of the future will belong to those areas that adopt water efficiency, energy efficiency, and low-carbon and low-resource intensity input technologies and practices.

In order to transition successfully to a green economy for agriculture, the Western Cape government has proposed an initiative, 'Smart Agri-production', as a solution [1]. It is suggested that farming practices should be more sustainable and focused on soil quality and carbon sequestration. It is further suggested that farming in the Western Cape Province should focus on input efficiencies, including energy, water, and nutrients. Organic and conservation farming practices meet these suggested requirements for sustainable farming, and are therefore considered as possible solutions.

However, issues arise when yield per hectare for food crops is considered. First, some authors argue that organic farming practices have a lower yield per hectare than do conventional farming practices [5, 6, 7]. And second, conservation farming practices (sometimes called 'no-till'), have a slightly higher yield per hectare than conventional farming practices, but are only applicable to grains [8]; while organic farming practices can be applied to all three food crop commodity categories (fruit, grains, and vegetables) that are produced in the Western Cape.

While organic farming may produce lower yields, it is also expected that more agricultural land will be required than with conventional farming. It is not clear, however, whether production would remain constant even if more land were used to produce food crops. There might also be an adjustment in food crop prices if there were fluctuations in food crop production. Another question that arises is whether organic farming would actually decrease greenhouse gas emissions, given that more agricultural land is required due to lower organic yields; and, if so, how significant this decrease would be. The final question that must be addressed concerns the financial investment that would be required for the Western Cape Province to increase the food crop production area under organic and conservation farming practices. The aim of this paper, then, is to address these uncertainties and to improve the understanding of the implications of a green economy transition in the food production system of the Western Cape Province by using a modelling approach.

2 THEORETICAL MODELLING OF AGRICULTURAL PRODUCTION IN GREEN ECONOMY DEVELOPMENTS

Models that are founded on non-linear interactions and relationships are problematic to solve analytically [9]. According to Sonnessa [9], a mathematical computation based on iterative algorithms is the recommended method to address issues arising in complex systems, and simulation is identified as the most appropriate method to analyse and understand complex systems. Simulations with models integrate the effect of 'simple' processes over complex 'spaces'. Simulation also accumulates the effects of these 'simple' processes over time. Wainwright and Mulligan [10] note that simulation allows for a system's behaviour to be predicted outside the time or space domain for which data is available. Four of the most commonly-used modelling and simulation methods, according to Balestrini-Robinson, Zentner & Ender [11], are network models (NMs), discrete event simulation (DES), system dynamic modelling (SDM), and agent-based models (ABMs).

2.1 Evaluation of different modelling methods

A single modelling approach needs to be identified that can be used to understand better the implications of this green economy transition in the Western Cape Province's food crop production sector. Table 1 describes the key attributes of each of the four most commonly-used modelling approaches, as identified by Balestrini-Robinson *et al.* [11]. For this paper, ease of creation and non-linearity are prioritised as the most desired modelling attributes.

Table 1: A summary of the different modelling approaches [11]

Attributes	Modelling approaches			
	NM	DES	SDM	ABM
Ease of creation	Excellent	Very poor	Good	Very poor
Dynamic behaviour	Poor	Very good	Very good	Very good
Non-linearity	Very poor	Very good	Very good	Excellent
Interactions	Very good	Poor	Poor	Excellent
Ease of validation and verification	Very good	Good	Good	Very poor

NMs are found to be an inadequate approach for the intended purposes because they are more suitable for understanding the relationship between system variables and how they associate with each other. It was also noted that NMs are not suitable for capturing space- and time-dependent effects in a system. Table 1 shows that NMs are very poor at incorporating non-linearity in a model, which is a key characteristic of the food crop production system.

DES is also rejected because it is better suited to modelling supply chains and queues, whereas the food crop production system is viewed as a continuous flow of information and material. The DES approach also tends to focus on the details of a system rather than on the system as a whole. This modelling approach is stochastic, and so requires multiple model simulation runs, which is not ideal, since the problem is viewed at a higher level —that is, from a Provincial government perspective. Another shortfall of DES is that model creation is cumbersome, as reflected in Table 1.

SDM and ABM, due to the nature of these modelling techniques, are considered to be the most appropriate modelling techniques to use to understand better the implications of a green economy transition, thanks to their advantageous characteristics (listed in Table 1). SDM and ABM share similar shortcomings, such as difficulty in determining the scope of the system, and the fact that the modeller needs to understand the system, its components, and their different interactions.

For the purposes of this study, however, ABM is rejected because it is constructed at an individual (micro) level. It is difficult to identify the individual entities for the food crop production system of the Western Cape, and then to determine their individual behaviour on a micro- and macro-level. It should be noted from Table 1 that ABM is excellent at incorporating non-linearity in a system, but it is heavily critiqued for its poor ease of creation and poor ease of validation and verification.

SDM is therefore chosen as the preferred modelling approach to understand better the impact that a green economy transition will have on the Western Cape Province's food crop production. Table 1 depicts SDM as being the best all-round modelling approach, with its only weakness being interactions between model entities and variables. The problem at hand will be more effectively modelled from a system dynamics point of view, since the economy consists of a multitude of role-players and entities. Thus a macro-level approach is best suited to understanding the problem at hand when the problem becomes increasingly complex from a micro-level perspective. SDM will also provide a more holistic solution for investment decisions about the food crop production sector in the Western Cape Province.

2.2 Using SDM to model complex systems

SDM was originally developed by Jay Forrester at the Massachusetts Institute of Technology (MIT) to address industrial problems. The application of SDM has recently evolved from industrial problems to social, technological, environmental, and agricultural systems. De Wit and Crookes [12] define SDM as a simulation approach used to understand complex problems and systems better. Pejić-Bach and Čerić [13] define SDM as the process of "analysing the structure and the behaviour of the system as well as for designing efficient policies of managing the system".

Tedeschi, Nicholson & Rich [14] view SDM as a modelling approach that "applies systems thinking to develop models that are used to describe (and simulate) the interactions among variables, by clearly identifying the behaviour of the variable". Tedeschi *et al.* [14] further describe SDM as a conceptual tool that can be used to understand the structure and dynamics of complex systems. Stave [15] argues that SDM is a "problem evaluation approach" based on the understanding that the structure of a system generates its behaviour. He defines the structure of a system as the way in which system components are connected. Angerhofer and Angelides [16] describe SDM as a computer-aided method that can be used to examine and explain complex problems with an emphasis on policy analysis and design.

According to Pejić-Bach and Čerić [13], SDM can help to understand better the structure and behaviour of systems with non-linear links and feedback. Stave [15] notes that SDM can assist managers to communicate with stakeholders, and adds that managers can use the information from the system to illustrate visually the results of different actions, without having to describe the technical details of the system to stakeholders.

The development of a system dynamics model involves five different phases. These five phases are also interrelated, and each consists of a number of steps. The five phases are [17]:

a) problem structuring;
b) causal loop modelling;
c) dynamic modelling;
d) scenario planning and modelling; and
e) implementation and learning lab.

In order to understand better the structure and behaviour of the food crop production system, causal loop diagrams (CLDs) are developed. These aid the process of identifying key role-players in the system and how these entities interact and influence each other. These CLDs provide the foundation for the stock and flow diagrams (SFDs), and role-players can then be identified as stock, flow, auxiliary, or exogenous variables.

Figure 1 illustrates a simple causal loop diagram that shows the systems structure and behaviour of any given population. There are three variables: births, population, and deaths [17]. If there are births, the population size will increase; therefore, the influence on population is positive (+) since births add to population size. The bigger the population, the higher the birth rate, since there are more individuals who can reproduce, and that will in turn bring about more births (+). This same logic applies to population and deaths: if there are deaths, population size will decrease; therefore, the influence on population is negative (-).

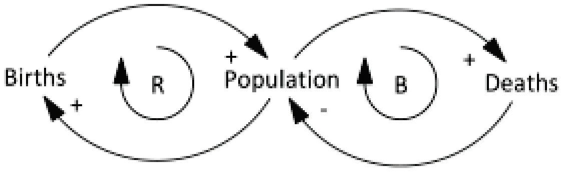

Figure 1: Basic population CLD [17]

Reinforcing loops (R) are positive feedback systems [17]. This indicates that the feedback loop continues in the same direction. This results in either systematic growth or decline. The feedback loop is regarded as 'reinforcing' (or positive) if it contains an even number of negative causal links (-) [18]. Balancing loops (B) are the opposite of reinforcing loops, and are negative feedback systems [17]. This indicates that the feedback loop alters direction. This results in a fluctuation in the system or a move toward equilibrium [19]. A feedback loop is regarded as 'balancing' (or negative) if it contains an uneven number of negative causal links (-) [18].

3 THE GREEN ECONOMY MODEL FOR FOOD CROP PRODUCTION

This research enquiry forms part of a bigger research group that aims to model the whole economy of the Western Cape Province through the development of the Western Cape Green Economy Model (WeCaGEM) [20], and how a transition to a green economy would affect the Province. The WeCaGEM is similar to the South African Green Economy Model (SAGEM) [21], which is a system dynamics-based simulation model whose main focus was to evaluate the effects of investing in technology options for a green economy in South Africa. WeCaGEM focuses on water, road infrastructure, biofuels, and food crop production sectors within the Western Cape Province.

For the food crop production model, the time horizon for the simulation is 2001 to 2040. This is in line with the Western Cape Province's 'Green is Smart' green economy framework. With regard to food crops, only the ten most significant food commodities (in terms of value or volume) are simulated for the Western Cape Province. Table 2 lists the ten farming commodities' productions that are modelled. Data used in the model was obtained from multiple sector-related sources, such as StatsSA, Quantec, the Department of Agriculture, the South African Grain Information Service, Potatoes SA, Hortgro, South African Wine Information and Systems, South African Table Grapes Industry, and the Citrus Growers Association.

SAGEM [21] was used as a guideline to develop the food crop production model. The advantage of using SAGEM as a guideline is that it already incorporates various complex dynamics that cut across the economic, social, and environmental spheres. SAGEM is, however, focused on the whole economy of South Africa. With regard to food crops and the effects of a green economy transition, SAGEM only simulates wheat production that would be affected nationally by this transition. SAGEM nonetheless acted as a sufficient starting point, and was expanded to incorporate the ten different farming commodities listed in Table 2, and confined to the Western Cape Province.

Table 2: Farming commodities used in the food crop production model

Food crop commodities		
Fruit	Grains	Vegetables
• Apples • Pears • Wine and table grapes • Citrus fruit • Stone fruit	• Wheat • Canola • Barley	• Onions • Potatoes

Figure 2 illustrates the conceptualisation of the problem by means of a causal loop diagram (CLD). The diagram consists of multiple variables that affect each other either in a positive (+) or negative (-) manner. These interactions between the different variables create a number of feedback loops that are either balancing or reinforcing, indicated by 'B' or 'R' respectively. This CLD is used as a tool to comprehend the behaviour of the system before the SFD is created.

Some of the key variables (drivers/role-players) in the CLD are population, food demand, food crop price, yield per hectare, food crop production, different farming practices, and environmental factors. The CLD consists of ten balancing and five reinforcing feedback loops. Although not all of the feedback loops are discussed in this paper, some are noteworthy.

Population size affects food demand, and an increase in population will lead to an increase in food demand that would then negatively affect food security. If food security decreases, food crop prices tend to increase; therefore, this relationship is negative. When food crop prices increase, food demand decreases. The behaviour of this feedback loop is balancing, and is illustrated by feedback loop B2.

The effect of current farming practices is indicated in the CLD by balancing feedback loop B5. If planned food crop production increases, there will be an increase in one, or both, of conventional farming and organic / conservation farming. If conventional farming is chosen, then the yield per hectare will increase, and this will result in a rise in food crop production in the Western Cape Province. The rest of loop B5 is similar to that of loop B4.

However, if farmers choose to implement organic farming and conservation practices, then it is assumed that yield per hectare will decrease (as previously mentioned). If this happens, food crop production will also decrease, and this will result in an increase in planned food crop production, if the rest of the feedback loop is followed. This leads to even more organic and conservation farming practices being adopted. Reinforcing feedback loop R3 depicts this described system behaviour when organic and conservation farming practices are implemented.

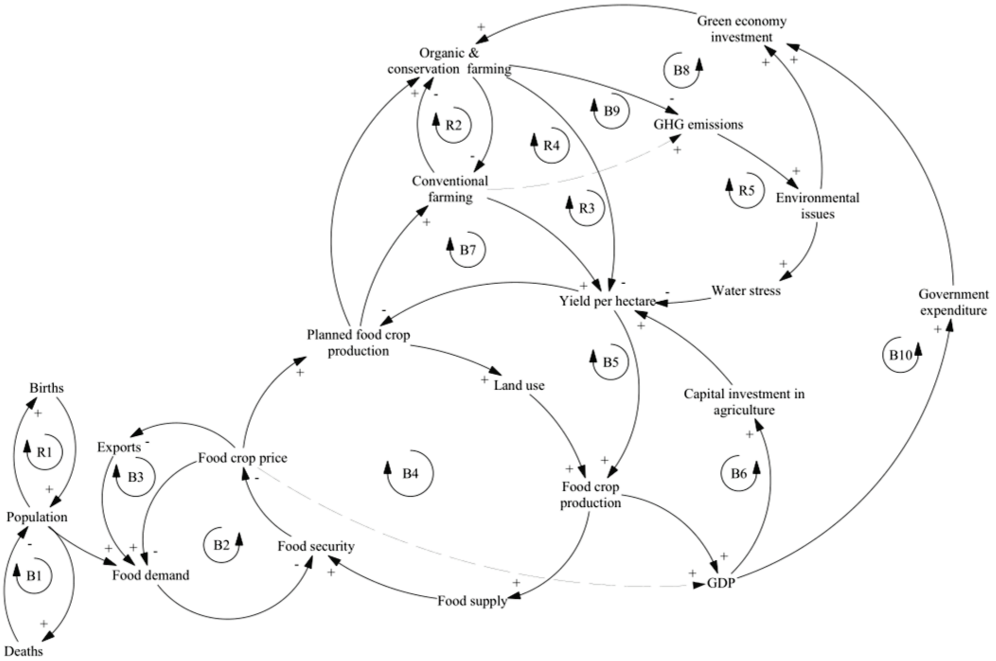

Figure 2: Expanded CLD for food crop production in the Western Cape

Loop R5 is a reinforcing feedback loop, and illustrates how conventional farming practices impact greenhouse gas (GHG) emissions and, ultimately, yield per hectare. If there is an increase in conventional farming, then that will result in increased GHG emissions being generated by food crop production. This increase in GHG emissions would then create further environmental problems and increase water stress in the Western Cape Province. Higher water stress levels in turn will negatively affect yield per hectare, and result in an increase in planned food crop production in order to compensate for diminishing yields. This will, in turn, lead to more food crops being under conventional farming and increase GHG emissions even further.

Organic and conservation farming has an opposite impact on GHG emissions than conventional farming. If there is an increase in the food crop area under organic and conservation farming practices, then GHG emissions decrease – the opposite of conventional farming. This leads to a decrease in environmental issues, lessens water stress, and improves yield per hectare. This balancing feedback loop is represented by loop B9.

The last noteworthy feedback loop in this CLD is the balancing feedback loop B8, which represents how environmental issues would affect the food crop area under organic and conservation farming. An increase in environmental issues would result in an increase in green economy investment. This would then result in more food crops being produced through organic and conservation farming practices. GHG emissions would then decrease, and result in reduced environmental issues.

The system dynamics model for this paper consists of nine SFD sub-modules that simulate the transition to a green economy in the Western Cape Province's food crop production sector. These nine SFDs were created using the CLD to conceptualise system behaviour and to incorporate it into a mathematical model. The SFD sub-modules include the following [22]:

a) Population module;
b) Agricultural yield module;
c) Food crop production module;
d) Food crop price module;
e) Emissions module;
f) Green economy investment module;
g) GDP module;
h) Education module; and
i) Provincial land module.

These nine sub-modules interact with each other to create the dynamic behaviour of the system. The effects that the different scenarios have on the simulated system are further described in the 'results' section of this paper.

4 SCENARIOS

Scenarios for the Western Cape Province's food crop production sector were developed according to the 'Green is Smart' framework [1], which identifies sustainable farming practices as the major goal for agriculture to form part of the green economy. Other initiatives for improvement are energy-efficient cooling, water efficiency technologies, beneficiation of waste, climate-related agricultural research, and food security. Sustainable farming practices, however, remain the major driver moving current agricultural food crop production towards compliance with the green economy framework.

The first scenario is called 'business as usual' (BAU), and represents the system's behaviour if it were to continue with current practices (see Table 3). Here, conventional farming practices are considered the preferred method of producing food crops, with conservation and organic farming practices contributing significantly less. Investments in sustainable farming practices (green economy investment) are also minimal due to the preference for commercial farming using conventional methods. This scenario predicts future system behaviour, and sets the baseline for comparison with the green economy scenarios.

Table 3: Model scenarios and respective input parameters [22]

Input parameters	**Model scenarios**			
	BAU	GEWC	GERC	GEBC
Yield vs conventional				
Organic	75%	65%	75%	100%
Conservation	115%	115%	115%	115%
Production area				
Conventional	80%	45%	45%	45%
Organic	5%	15%	15%	15%
Conservation	15%	40%	40%	40%

The second scenario is called the 'green economy worst case' (GEWC). This modelling scenario simulates system behaviour if organic yields per hectare are significantly less than those of conventional farming. Since this is a green economy-type scenario, organic and conservation farming practices are applied more consistently to food crop production. The aim is to reduce GHG emissions so that green economy investment will increase. Food crop production and land used for production will also be affected as more crops are produced with sustainable farming methods. This scenario adopts a pessimistic view of organic yield per hectare.

The third model scenario is the 'green economy realistic case' (GERC). This scenario is similar to GEWC, in that food crops are produced under the same percentage of organic and conservation farming practices. The third scenario also has the same primary aim of reducing GHG emissions from food crop production. The main difference, however, is in the yield per hectare for organic food crops. The yield per hectare in this scenario is slightly more than with GEWC, but still less than that of conventional farming. This scenario adopts neither a pessimistic nor an optimistic point of view, but rather views organic practices in a conservative way.

The final green economy scenario is an optimistic scenario, and is called the 'green economy best case' (GEBC). It is similar to GEWC and GERC in respect of food crops being produced under the same percentage of organic and conservation farming practices. However, the notable difference between GEBC and the other two green economy scenarios is that the organic yield is expected to be the same as that of conventional farming practices. This scenario depicts what the system behaviour and investment cost would be if organic yield per hectare could improve to equal that of conventional farming. Here, the potential future benefits (if any) of sustainable farming practices are highlighted.

5 RESULTS

The SDM approach has seven important output parameters: population, yield per hectare, food crop production, land required, food price, GHG emissions, and financial investment. For the purpose of this paper, only the three most noteworthy output parameters are discussed in further detail: land required, GHG emissions, and financial investment. (For a detailed discussion of all seven output parameters, refer to the work of Van Niekerk [22].) In general, the population of the Western Cape is likely to show steady growth from 4.52 million people in 2001 to 7.8 million in 2040. Total food crop production is also predicted to grow from 3.7 million tonnes in 2001 to 5.8 million tonnes in 2040 for the ten different commodities combined.

5.1 Land required

All four modelled scenarios follow a general decreasing trend in land required. The reason for this is a change in yield per hectare. Agricultural capital increases over time and results in an increase in yield. This increase in yield, in turn, requires less area (or land) to produce the same volume of food crops, and causes the land used for production to decrease as yield increases.

The BAU and GERC scenarios have the same land usage, according to the simulation outcomes; thus GERC overlaps with BAU (Figure 3). For both of these scenarios, land usage decreases from 637 500 hectares in 2001 to 503 400 hectares in 2040 — a 21 per cent decrease.

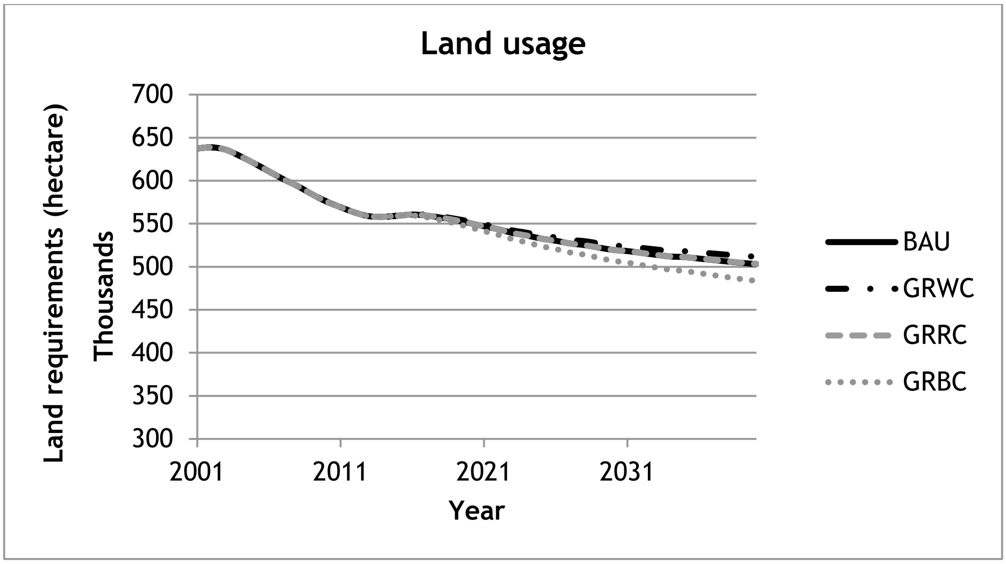

Figure 3: Total land requirements for the Western Cape's food crop production sector

The GEWC scenario requires the most arable land to produce food crops. GEWC has the lowest yields per hectare of all the scenarios; thus it is to be expected that it would require the most land. For this scenario, land usage decreases from 637 500 hectares in 2001 to 511 700 hectares in 2040. However, this is 8 300 hectares more than with either BAU or GERC.

GEBC displayed positive results in that the land required for this scenario was notably less than for any of the other three scenarios. Land usage decreased from 637 500 hectares in 2001 to 483 600 hectares in 2040 — a 24 per cent decrease. This is also four per cent less in 2040 than in the case of BAU and GERC, and five per cent less than GEWC. This could also have significant benefits for GEBC in relation to GHG emissions.

5.2 Emissions

The first remark of note is that the trend of the emissions is similar to that of land used for food crop production (see Figure 3), due to the way the model is built. Emissions from food crop production are calculated by determining the emission per hectare for the different commodities and farming practices; and that is what creates this close resemblance between Figures 3 and 4. In general, for all four scenarios the GHG emissions decrease over the simulated time. As previously mentioned, this is a result of increasing yield, which affects land requirements.

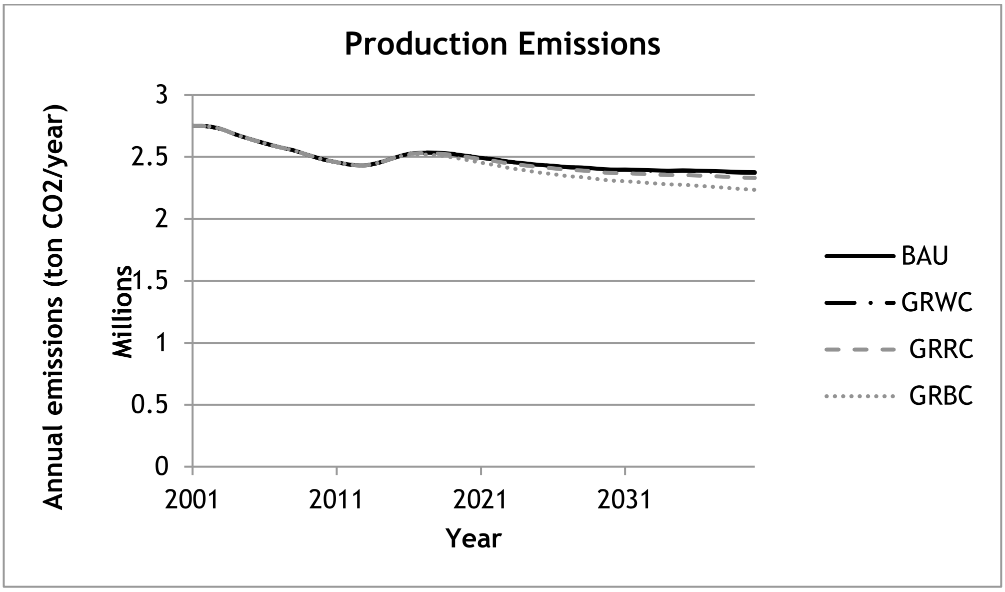

Figure 4: Annual GHG emissions created from total food crop production in the Western Cape

As expected, the GEBC scenario emits the lowest GHG emissions of the four scenarios. The GEBC scenario's emissions start at 2.75 million tonnes of CO_2 in 2001 and decrease to 2.24 million tonnes of CO_2 by 2040. This represents a 19 per cent decrease from initial emissions. The GEBC scenario also emits six per cent less GHG emissions than the BAU scenario by 2040. The GEBC scenario's superior organic yield (100 per cent vs conventional) results in less land being required to produce food crops, and thus it has the lowest GHG emissions. GEBC's emissions start to decrease more rapidly than BAU in 2015, when organic and conservation farming practices are more significantly employed.

GERC is the second-best scenario when GHG emissions are considered. As previously noted, all four scenarios have decreasing emissions, including GERC. GERC's initial emissions are the same as GEBC, and decrease to 2.33 million tonnes CO_2 by 2040. GERC emits less GHG emissions than both GEWC and BAU, and is two per cent less than BAU by 2040.

GEWC and BAU achieve similar results when their GHG emissions are compared (see Figure 4). The difference between the two scenarios is insignificant, and they can be regarded as equal. BAU was expected to be the highest GHG emitter; however, GEWC was not expected to be the same as BAU in GHG emissions. GEWC's unexpected poor results with regard to GHG emissions can, however, be explained if its organic yield is examined. Its organic yield was set at 65 per cent of conventional yield, and so required more agricultural land to produce food crops than did BAU, GERC, and GEBC. The amount of GHG emissions saved per hectare for GEWC, however, is not enough to offset the additional land requirements, and so GEWC has similar GHG emissions to those of BAU.

5.3 Financial investment

The last important model output is the green economy investment expenditure, which is regarded as the additional cost required for the different modelling scenarios when sustainable farming practices are used. Simulated green economy investment results for each of the four scenarios are shown graphically in Figure 5, and represent the accumulated financial investment up to each given time point. All four scenarios only start to require investment from 2015, because sustainable farming practices are assumed to begin only in 2015.

As expected, the BAU scenario requires the least amount of financial investment. This scenario has the least amount of food crops being produced by sustainable farming practices; therefore, its financial requirements are the lowest. By 2040, the total cost of the BAU scenario is projected to be R972.3 million (refer to Figure 5).

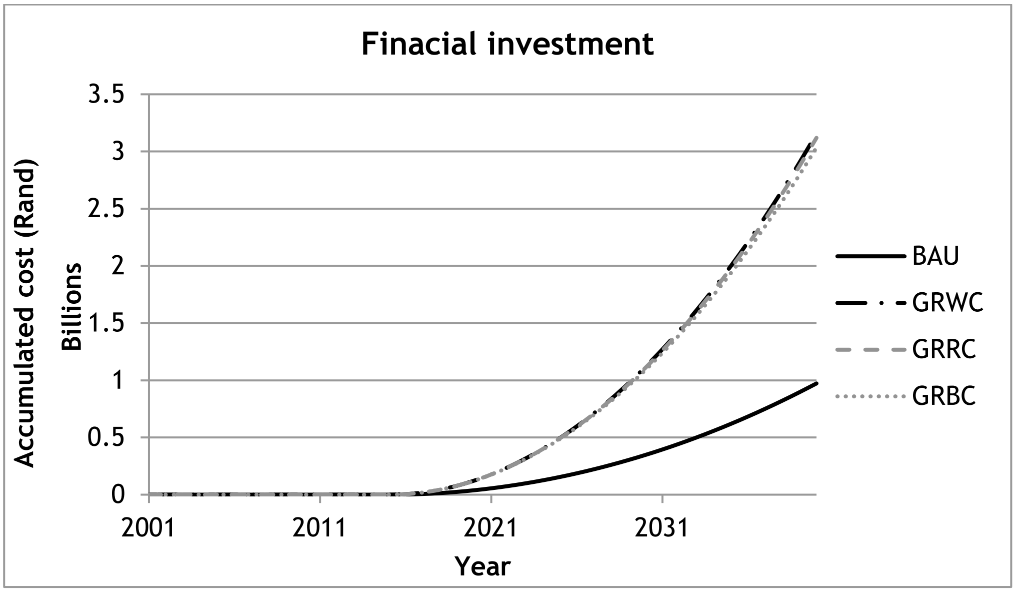

Figure 5: The accumulated financial investment required for each scenario

The three green economy scenarios have similar financial investment requirements, as shown in Figure 5. These three scenarios require significant financial investment when compared with the BAU scenario. This can be attributed to the food crop area increase under sustainable farming practices. The GEWC scenario requires the largest investment of the three green economy scenarios, followed by GERC and GEBC. The difference in investment between these three scenarios can be explained by the difference in land requirements between them. GEWC requires the greatest amount of land, followed by GERC, and then GEBC. GEWC requires a total investment of R3.16 billion by 2040, which represents a 225 per cent increase compared with BAU investment costs. GERC and GEBC require R3.12 billion and R3.03 billion respectively by 2040. The GERC and GEBC scenarios represent an increase of 221 per cent and 212 per cent respectively, compared with BAU investment costs.

6 DISCUSSION AND RECOMMENDATIONS FOR THE WESTERN CAPE AGRICULTURE SECTOR

System dynamics modelling helps to understand better the implications a green economy transition will have on the food crop production sector of the Western Cape Province. Thus recommendations about financial cost, organic yield improvements, and the promotion of conservation farming are offered, given the four scenarios that were developed and then evaluated.

6.1 Recommendation 1: Financial cost

As highlighted, the green economy will require significant financial investment. It is projected to have a total cost in excess of R3 billion in current monetary worth by 2040. This is the first major challenge facing the transition to a green economy in the agricultural food crop production sector of the Western Cape.

An argument could be made that farmers would fund the required financial investment because organic food crops have a higher market value than conventional food crops. The developed system dynamics model assumes, however, that food crops are produced organically to be more sustainable, rather than to cater for a niche market; the majority of the province’s citizens cannot afford organic food crops, owing to their higher prices. This means that farmers would not receive a higher food price that could be used to pay the additional incurred financial cost.

A possible solution is that the Western Cape's government provide subsidies to farmers who implement organic farming practices. This requires the government to fund the projected R3 billion-investment cost. If either GEWC or GERC were the case in terms of organic yield, then this financial investment would not be worthwhile if emissions were the main criterion. GEBC emits six per cent less GHG emissions by 2040 than BAU, and could be viewed as worth the financial cost for government. The GHG emission reduction in the GEBC scenario could be even greater if the organic yields could be improved, resulting in more food crops being produced with organic practices, since the yield would potentially be higher than for conventional practices.

6.2 Recommendation 2: Organic yield improvements

The three green economy scenarios evaluated the uncertainty about organic yields when compared with their conventional equivalent. GEWC and GERC both highlighted that if organic yields are less than conventional yields, the GHG emissions will not decrease significantly enough to justify the financial investment required. Both de Ponti, Rijk & Van Ittersum [5] and Tuomisto, Hodge, Riordan & Macdonald [7] noted that the average yield for organic food crops is 75 per cent in the two independent studies. Both studies were conducted in Europe; there is a lack of research about organic food crop yields in South Africa, and in the Western Cape specifically. To increase the model's accuracy, it is recommended that research be conducted into organic yields in the Province. This will also have the added benefit of convincing farmers to adopt organic farming practices because they will be more likely to consider findings that are more relevant to the area under consideration. GEBC highlighted the advantage of organic farming: it has similar yields to those of conventional farming. It is also recommended, therefore, that more funding be provided for agricultural research to help improve organic yields in the Western Cape Province.

If yields cannot be improved, then consideration could be given for adapting organic regulations to accelerate the transition from conventional farming practices to organic farming practices. If an initial agreement cannot be reached, and organic regulations are not adapted, then genetically modified crops (GMCs) could also be considered for organic farming. Although this recommendation might be highly controversial, it provides a reasonable solution. Organic regulations limit the use of pesticides and other chemicals; so organic yields struggle to compete with conventional yields.

6.3 Recommendation 3: Conservation farming promotion

According to Venter [23], conservation (or no-till) farming refers to farming practices where soil disturbance is reduced to a minimum. Organic matter is left in the production area and accumulates in the soil. Conservation farming has multiple advantages, yet conventional farming practices remain popular in the production of grains in the Western Cape.

Venter [23] highlights six advantages to using no-till farming practices to produce food crops. The first major advantage of no-till is that it helps to reduce soil erosion. The second is that water and moisture is conserved and so helps to reduce drought stress. This is a big advantage, given the uncertainty of the impact of climate change on the Province's water stress levels. Venter [23] also notes that evaporation from the soil is reduced by 75 per cent. Reduction in machinery cost and labour savings are the fourth and fifth advantages of no-till [23]. The last advantage of no-till farming practices is yield improvements of up to 33 per cent.

A study by Lankoski, Ollikainen & Uusitalo [24] that compared conventional farming with no-till farming found that no-till farming cost close to 49 Euros/ha less than conventional farming. This only adds to the growing list of no-till advantages over conventional farming.

In light of the overwhelming advantages for conservation farming practices, it is recommended that the Western Cape's government promote conservation farming among grain farmers in the Province.

7 CONCLUSION

Three areas can be targeted to assist the green economy transition: financial costs, organic yields, and conservation farming. As highlighted previously, financial cost is a key area of concern for the three green economy scenarios, given the significance of the cost and investment required. The three green economy scenarios also evaluated the organic yield impacts on food crop production where organic yield improvements are viewed as an alternative option. Promoting conservation farming is the third proposed target area to assist stakeholders with the green economy transition of food crop production.

Overall, this research paper aimed to address the ‘gap’ in the literature for Western Cape food crop production, and the potential implications of a green economy transition of this sector. Future research studies should aim to apply the model to the eight other provinces of South Africa, and thereby create a more detailed and accurate SAGEM model.

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