Role of Decision Science Modelling and Systems Analysis to Enhance Sector Integration in South Africa

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Abstract

The national development and growth of a country is pertinent in ensuring a sustainable future for generations to come. The various sectors of the South African economy namely: health, education, and the like, are underpinned by the nexus between the social, economic and environmental aspects of the country. Sector integration can be enhanced by applying decision science modelling and systems analysis for sustainable growth. Decision science modelling and systems analysis have independently shown potential in supporting policy maker's decisions and interventions that impact a country. It is proposed to investigate whether a combination of the two approaches could be viable within the current sector arrangements. Sector integration involves the integration of highly complex systems, thus the investigation is approached in stages, with the view of the research being a continually iterative process. The various sectors will be analysed to determine their inter- and intra-dependencies which will be used to assist in the development of a methodology that could support the decision making process. It is envisaged that key factors influencing policy development and decision making in the country will be identified during this investigation. There is an earnest need for sector cohesion in realising a sustainable future for South Africa and decision science modelling and systems analysis presents a promising way to support policy makers in policy development.

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1. Introduction

The nexus between the various sectors of the South African (SA) economy is a typical representation of a highly complex system. Complex systems are identified as systems that display relationships and interconnections with other systems on different levels. The sectors themselves are viewed as systems and can be dissected and analysed further to find intra- and inter-dependencies with other sectors. Sector integration is driven by the goal of achieving social, economic and environmental cohesion for a sustainable future. It may be noted that sector integration refers to multi-sector integration.

The sectors: education, health, logistics, tourism, financial, manufacturing and the like can be typically represented as a 'house' (Figure 1) along with the 'foundation' of the house represented by the social, environmental and economic aspects underpinning the sectors. The analogy of the house symbolises the idealism that all sectors can enhance their function if their interconnections are synchronised. Each sector relies on infrastructure and resources (e.g. water, electricity, transport and the like) in order to function efficiently and therefore cannot function in isolation. Technology is inherently found within the sectors.

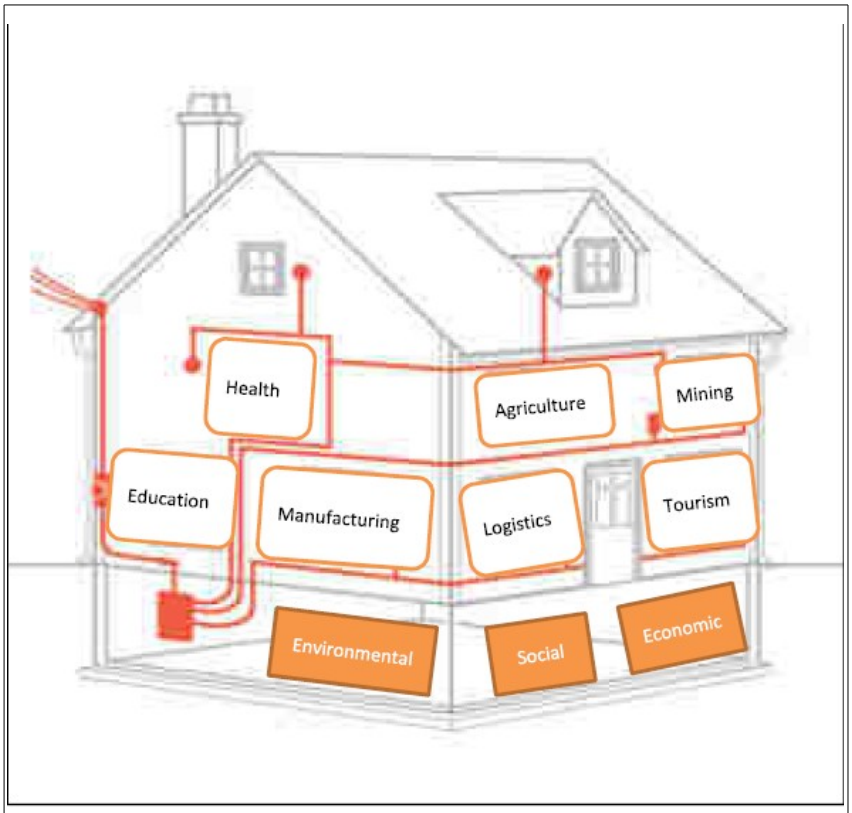

Figure 1: Symbolic illustration of various sectors

The purpose of this paper is to investigate whether systems analysis approach from traditional 'systems engineering' discipline can be employed together with decision science modelling to assist in enhancing sector integration.

There is an earnest need to explore a deeper understanding of the nexus between the sectors of the economy and how systems analysis with decision sciences modelling play a role in enlightening policy makers and decision makers in creating a more sustainable and viable future for all inhabitants.

This investigation forms part of a larger body of investigative work that requires the rallying of experts from respective fields (e.g. scientists, researchers, stakeholders, decision makers, policy developers) to provide input into the development of the work. The merits of systems analysis and decision science modelling are explored and assessed to determine whether sector integration can be enhanced.

Varying definitions of systems analysis have been found in literature, however for this study the following definition is adopted: Systems analysis approach is a problem solving technique that involves the breakdown of the systems, in this instance the sectors, into its' contributing parts which become the component level analysis. The component interactions are further studied to determine the degree to which they achieve their purpose.

Decision science modelling is formulating a mathematical model to fit the system whereby interventions can be applied to the system and the resultant effects evaluated to determine whether the desired goals can be achieved.

Gibson [1] provides a clear explanation of system analysis and it's application in many large complex challenges. He added that systems analysis can be seen as equal to operations research (another name for decision science modelling) and policy analysis.

The sections that follow presents the high level exploration of the combined approach namely, systems analysis together with decision science modelling, to enhance sector integration in the South African economy.

2. Background

Sector integration of the SA economy involves the integration of highly complex systems. During the search very limited literature from the public domain surfaced that alluded to attempts to integrate the various sectors. Certain literature focussed on a single sector and investigated its' integration into the economy based on, for example, the environmental aspect.

Many key words, either directly or indirectly relating to the integration of the sectors of the economy, were used to search for any literature that could indicate

recent works in this field. Very sparse views were found that could help understand whether in fact such a mammoth task is worth pursuing or not.

One has to wonder if there are concerted efforts being made to integrate the various sectors of the economy, but the information is not yet available in the public arena or whether such an undertaking is at all conceivable given the dynamism and complexity of the economy. However so, it is attempted to find the merits of systems analysis and decision science modelling that can help understand the interconnection between the sectors of the economy.

Articles such as [2] [3] [4] have been discussing regional integration of Southern Africa since as early as 1998, and have shown that developing economies benefit from regional trade agreements with larger developed economies. In a similar token, if one where to bring this notion to the sectors, there are opportunities to enhance sector efficiency if a balance is found between the way sectors function and operate. Then greater possibilities of higher economic growth can exist since there will be an increase in efficiency and the integration can stimulate optimal trade-offs needed for investments and policy development. Basically sectors have shown dependencies on each other and by capitalising on these relationships, sector functioning can be enhanced.

The nexus of social, economic and environmental aspects adds to the complexity of the situation but are viewed as underpinning the way trade-offs and balances between sectors are achieved in order to ensure a sustainable future.

Prof Dr Günther Bachmann of the German Council for Sustainable Development, commended the initial work carried out by the Stakeholder Forum on sustainable development integration for Germany [5]. Bachmann also highlighted that:

> “Implementing the SDGs on a national scale will require the National Sustainable Development Strategy to use systematic and integrative mechanisms that would contribute to effective delivering against global goals and to a effectively balance the economic, social and environmental dimensions under each goal.”[5]

It was thus from here the interest to explore systems analysis and decision science modelling to enhance sector integration in SA began.

3. Propositions and Perspectives

Systems analysis approach brings the quantitative dimension to the objective study (or theme) whilst decision science modelling approach looks into the more qualitative dimension to the study in order to reach a desired outcome to the objective study.

An interestingly famous quote from Quade and Miser [6] is often used to describe systems analysis and is given here:

> “the knowledge and methods of modern science and technology, in combination with concepts of social goals and equities, elements of judgment and taste, and appropriate consideration of the larger contexts and uncertainties that inevitably attend such systems.”

[1] describes the attributes of a large-scale system as one that involves complex issues with a policy component. In a way this is very similar to how sector integration can be described, since we have to determine an objective (or theme) and measure its' achievement or performance by also incorporating personal standards and judgement [1]. The policy component attribute of the complex system is usually related to the social aspects rather than only the economic aspect. Another attribute as given in [1] are that the system and sub-systems are challenging to describe analytically and model as a tool.

The following six major phases of systems analysis as described by Gibson [1] can be useful when analysing sector integration: ”(i) Determine goals (ii) Establish criteria for ranking alternative candidates (iii) Develop alternative solutions (iv) Rank alternatives (v) Iterate (vi) Action” [1]. The phases given here can assist the analyst in exploring an objective study and determine alternatives to the goal.

Systems analysis breaks down the systems in this case the sectors into its' functional inter- and intra- dependencies. Functional means it's reliance on other sectors in order to execute its' function. A first attempt would be to investigate if the sector (which is analysed as a system) can function independently, that is, it looks to see if one were to take away a dependency then can the sector still achieve its' function.

There is a need to understand the relationships between sectors, and naturally systems analysis can be employed to achieve this and also can play a role in the integration of the sectors. By breaking down a system into its' functional components one can achieve greater insight into what relationships exists in the system and it will be easier to identify their interactions within their own system and with the other systems.

Generally the objective study or theme being investigated falls within intra- and interdisciplinaries and cannot be left to a single disciplinary to be solved. Decision science modelling can provide direction when trade-offs between the underpinning aspects (namely social, economic and environmental) are required.

Decision science modelling incorporates mathematical techniques and was founded during World War II when scientists and engineers were recruited to assist the military to strategise their efforts with the techniques from decision sciences. Decision science modelling is also commonly known as management science and operations research. Decision sciences modelling approach [7] is used to perform trade-off studies, which may include modelling and simulation, cost analysis, technical risk analysis, effectiveness analysis [7] and feasibility

analysis. The constraints to the objective study are the social, economic and environmental aspects that need to be balanced to ensure sustainability.

When the outcomes of the decision science modelling approach is reported, [7] cautions that it should always be contextually reported, that is reporting on: the tool used; selected assumptions; parameters and data introduced; and variance of the outputs [7].

[9] highlights the minimum assessment criteria as the constraints on cost and time scales which should be acceptable to stakeholders. Trade-off studies are a means for conducting analysis of alternative solutions, which are typically referred to as scenario building. A trade-off study is based on an assessment criteria, which must include the limitations and dependencies between individual criteria. Trade-off studies deal with both objective and subjective criteria and thus sensitivity analysis of the overall study to a particular criterion [7] are also covered.

Another benefit of decision science modelling is that it can also be used to determine a maximum or minimum outcome. For the maximum likelihood it will look at: maximising profit, maximising yield or looking at optimal performance. In the minimum likelihood, it is able to determine for example: risk ranking (project, financial, etc), loss or cost. Basically the approach is used to understand real world objective study or theme and make projections, if needed.

Policy makers and decision makers can benefit from the useful information that systems analysis and decision science modelling can bring to current policies and future policy development. It is noted that certain policies are usually developed in a 'fragmented' fashion and by analysing a system and applying decision science modelling, a more holistic view of the sectors are created. This holistic view can give greater insights to what interventions are necessary to ensure that a more sustainable future can be achieved. A model or tool is by no means the ultimate decider in policy development and should not be totally depended on, but should rather be used to provide policy developers and decision makers guidance when discretion is needed.

The combined approaches can also play a role in assisting decision makers in making more viable investment decisions by supporting their decisions with the analysis and modelling derived from the two approaches. This combination of approaches could also provide a broader context of knowledge that one needs to have in order to make medium and long-term decisions.

One of the earliest examples of the application of systems analysis for policy planning was the work of Quade et al in the applications to defense [8]. The work resulted from a need by the United States Air Force to determine the location of the bases of the Strategic Air Command. This initiative by RAND Corporation set the scene for the earliest studies in which policy-oriented systems studies began.

The water sector example from [9], is one such example that shows how system analysis is applied to gain a deeper understanding of the sector dynamics. The following excerpt is taken from [9]:

> “Water resources systems are complex ones that encompass different interlinked components, including technical, economic, social, cultural, environmental and legal aspects. A river basin system, for example, can include several ecosystems with different hydrological sub-systems, various kinds of water uses supporting different social and economic activities, different types of actors with different interests related to water and numerous types of 'institutions' – sets of rules, regulations and policies – regarding water allocations.”

A similar analysis can be carried out for the other sectors, namely: energy, transport, manufacturing, mining, agriculture and the like.

The use of decision support for sustainable water development [10] can be further extend to include the social and environmental aspects of sustainable development, and then this exploration can be further interconnected with other sectors to obtain an integrated national view.

4. Future Work

In the pursuit to enhance sector integration, it was explored whether the combination of systems analysis approach and decision science modelling can play a role. Even though this was a high level perspective and proposition, it was seen that there could be benefits to decision makers and policy makers from the insights and guidance that the approaches can bring to the table.

Also the combined approaches can help decision makers to look at alternative scenarios through decision gates and formulation of alternative outcomes. These outcomes can be further used to evaluate the most viable option given the assumptions and basis used to create the scenarios.

It is envisaged that this study be further explored by collective discussions amongst stakeholders, researchers, experts, etc in the pursuit to achieving sustainable development for the current and future generations.

The aim of this paper was to put forward for consideration and debate, a combined approach of systems analysis and decision science modelling to objective studies regarding national concerns in order to enhance the decision process and provide insight into policy development.

Given below are suggestive areas to be considered as an initial starting point (note that this list is not exhaustive):

1. Creating awareness and debate on systems analysis and decision science modelling to enhance sector integration (multiple sectors)

2. The framework development to approaching sector integration

3. Human capital development and capacity building that are needed to undertake these kinds of exploratory studies

4. Analyses of sectors to determine their inter- and intra-dependencies can be used to assist in the development of a methodology that could support the decision making process. It is envisaged that key factors influencing policy development and decision making in the country will be identified during this type of investigation.

5. Investigating the availability and reliability of data needed to develop a model that can provide good decision support to stakeholders.

6. Development of suitable guidelines for accepting the model results, that is, looking into the validation and verification of models.

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