Towards a Holistic Approach in Implementing the Water-Energy-Food Nexus

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Abstract

The success or failure of some frameworks and policies put in place by the government, especially, in urban areas, depends on the understanding of the ecology of the Water-Energy-Food (WEF) nexus problem by local actors and the ability to formulate sustainable leverage points. Understanding how urban dwellers' process information and make meaning of the interconnections between the WEF nexus elements and the ecology of the nexus problem is, thus, critical to developing primary leverage points, necessary for transformation. There has been minimum exploration of the underpinning societal values, ethics, beliefs and worldviews interact with social structures to shape the emergent strategies, then used by policy-makers to come up with leverage points for the WEF nexus. Based on the appreciation of the richness of the WEF nexus, there is need for combining several theories and methodologies, partly or wholly, to identify leverage points at all four levels of intervention. These must stem from different paradigms, realising the complexity associated with the nexus challenge. No singular approach effectively identifies leverage points for sustainability, thus, a conceptual framework which can be used for guiding research and policy interventions in the WEF nexus using systems thinking is proposed.

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INTRODUCTION

While the Water-Energy-Food (WEF) nexus has been proposed in both academia and practice as a way forward for managing primary resources in the 21st century, it is imperative for frameworks which enhance sustainable leverage points in applying the model at global, national or community level. Efforts are being made to link the WEF nexus to Sustainable Development Goals (SDGs) to better the lives of people. There remains a question on whether SDG policies and WEF policies will accomplish their goals, as their success are an outcome of the interaction of various factors.

The world urban population is increasing, especially, in Africa, with projections showing a continued trend of exponential growth with a forecast of 9.2 billion people by 2050 (Haseeb *et al.*, 2019). As a result, there has been an increase in pressure on primary resources like water, energy and food (Keairns, Darton and Irabien, 2016). Historically, food shortages, current water and energy crisis, due to increased population demands and increased negative effects of climate change in developing countries, have led to the need for integrating water, energy and food (WEF) policies into the WEF nexus (Artioli, Acuto and Mcarthur, 2017). The WEF nexus debate has its roots in the late 20^{rh} century, with momentum being gained in the early 21st century. The Bonn Meeting of 2011 became a game changer in the WEF nexus debate with much traction in policy-formulation and research being initiated after this meeting (Sohofi *et al.*, 2016). Since then, regions and governments are in the process of contextualising the WEF nexus (Mabhaudhi *et al.*, 2018; Nhamo *et al.*, 2019).

Previous attempts to address challenges associated with the water, energy and food sectors have been sector-focused and have not taken into consideration how decisions in those sectors affect other sectors positively or negatively. This has necessitated an aggregate approach to managing these resources as they all aim of addressing poverty reduction, inequality, access to primary resources and economic growth (*ibid.*).

In recent times, the WEF nexus has been linked to SDGs, particularly Goals 2, 6 and 7, associated with eliminating hunger, reliable clean water provision and clean, accessible and affordable energy respectively (ibid.). While the nexus debate seeks to sustain livelihoods through addressing complementarities and trade-offs between these three sectors for the sustainable management of resources, recent research has also suggested the need for deeper investigation into the nexus approach (Keairns, Darton and Irabien, 2016; Artioli, Acuto and Mcarthur, 2017). Trivedi and Misra (2015) argue that, so far, innovative solutions of addressing social problems have failed to create positive social change as they are only shallow rooted in their interventions and do not address and understand the interaction between social entrepreneurship ventures and context in socio-ecological problems. Without profound research, researchers run the risk of leading policy-makers into development and implementation of policies that will manifest the same inconsistences in resource allocation after some time (Artioli *et al.*, 2017). Trivedi and Misra (2015) suggest that, to effect positive and sustainable change with social problems, there is need to take cognisance of the ecology of the social problem, that is essentially how a social problem relates to local context and other social problems. This enables identification of underlying structures of social problems and hindrances to effective change *(ibid.)*.

In a bid to explore underlying structures, managing and evaluating the WEF nexus, studies by Nhamo *et al.* (2019) have come up with indices that will enable operationalisation and implementation of WEF polices. The indices will enable analysis and management of the connectedness and causal relationships among the three sectors. This was through the development of matrices which then gave feedback in terms of quantitative aspects of the WEF nexus. Furthermore, Sohofi *et al.* (2016) discuss the challenge of unintended consequences, due to lack of analysis into the underlying structure of the WEF nexus by exploring a systems approach as a way of further understanding the hidden constructs of the WEF nexus. Their research unveils accidental adversaries and limits to success as two archetypes that can capture synergies and trade-offs between the WEF nexus. However, this study contends that fundamental factors influencing research and policy on WEF have not been fully explored. Moreover, there have been limited efforts to use a multidisciplinary approach that is holistic in analysing the WEF nexus challenge.

Meadows (1997) posits four levels of intervention that he initially developed and presented as a nested structure by Abson *et al.* (2017) to solve most complex social problems for sustainable interventions in society. These are summarised as intent, design, feedback and parameters.

We assert that unless changes occur at every level of intervention with fundamental solutions coming from the intent level that is the deepest realm of change, there is risk of other systems archetypes, such as fixes that fail or shifting the burden having counterintuitive effects on solutions that would have been effected. This study proposes a conceptual model for developing approaches for intervention that is able to address all the four levels (Abson *et al.*, 2017). Emphasis of selection of the theories and methods were placed on understating the various philosophical dispositions embedding the subject and the need for a holistic approach which could manage both structured and unstructured situations as they form part of the WEF nexus challenge. Selection was also based on the inclination towards implementing fundamental solutions at the intent level that is recognised as the deepest realm of change.

WEF NEXUS: THE NATURE OF THE PROBLEM

Research in recent times has acknowledged the difficulties associated with managing primary resources, such as land, minerals, water, food and energy. This comes at the backdrop of an increase in population and climate change that have further worsened pressure in managing these resources (Mabhaudhi *et al.*, 2016; Kling *et al.*, 2017; Mabhaudhi *et al.*, 2018). Few studies have focused on the WEF nexus in the context of urban areas, yet urban areas are more populated and require more of the three resources. Furthermore, urban areas have numerous social aspects in the form of power, policy, regulation which come into play as they house most governance institutions(Covarrubias, 2019).

Planners of urban structures and services seem to have negated how the materialistic and social factors of the nexus interact in urban areas (*ibid.*). Efforts by researchers has shown that previous energies to manage the resources used silo approaches in the form of a sectorial approach. This is whereby strategies for each of the resources is crafted under the parent

ministry that has the mandate over that resource without consultation of the other related ministry (Mabhaudhi *et al.*, 2016; Mabhaudhi *et al.*, 2018). The sectorial approach has, thus, brought challenges associated with counterintuitive decisions within and between sectors that have hampered meaningful attainment of policy objectives. A shift in approach has then been pursued with a resultant instigation of an integrated approach in managing the WEF nexus (Mabhaudhi *et al.*, 2018).

Most nexus studies and policy frameworks realise the complexity associated with integrating and managing the three sectors. Thus, they have proposed solutions which target both input and outputs in terms of cross sector co-ordination, linkages, strategy and policy. The solutions recommend sparing use of resources, integrating technologies, introducing biological measures and managing trade-offs which ensure a win-win situation for resource management (Sohofi *et al.*, 2016; Albrecht, Crootof and Scott, 2018). An integrated WEF nexus approach, therefore, calls for cross-sector governance, policy-formulation, project implementation of resource management (Kling *et al.*, 2017). From this integrated perspective according to Nhamo *et al.* (2019) the WEF nexus approach can be used for framing the challenges associated with sustainably delivering water, food and energy. An integrated perspective also enables coherent coordination and cross-sector participation in policy-making. However, an in-depth systemic approach which improves analysis of how interactions between all aspects of the sectors influence each other has not been explored. Most research has made attempts to analyse synergies and trade-offs by quantification of inputs or outputs to the WEF nexus (Sohofi *et al.*, 2016; Albrecht, Crootof and Scott, 2018).

Policy-makers have concentrated mostly on intervening at parameter level or feedback level that is considered problematic as it intervenes at shallow levels of societal decision-making as argued by Abson *et al.* (2017). At parameter level there are three levels that exist. Firstly, policy-makers concentrate on the structure of materials, the stocks of these materials that are available and how the materials flow (Abson *et al.*, 2017). For example, when it comes to the

WEF in urban areas and the water sector, these are aspects related to how water can be harnessed (runoff, rainwater, recycled water). The forms can be found (in dams, lakes, rivers and boreholes) and the end-user has ways to get it effectively. When it comes to electricity, these materials and stocks are in the form of electricity that can be generated from renewable and non-renewable energy sources and how the energy can be distributed effectively. In terms of food, this analysis focuses on inputs needed for food production.

Covarrubias (2019) also considers these as materialistic flows and these have been the essence of policy-formulation in urban areas to regulate availability of resources to the ever-increasing urban population. The second level of parameters is the size of buffer stocks in relation to their sustainable use and replenishing. For example, in terms of water analysis, this relates to the amount of fresh water, ground water or recycled water available for agriculture, domestic purposes or electricity generation. At the lowest level of intervention, trade-offs and synergies have also been identified on sources of funding, taxes, policy and legislation which can benefit these three sectors. This level also involves interventions using technologies or infrastructure that have advantages over all three sectors for example treatment of raw sewage in urban centres which then makes recycled water, energy and nutrients for fertilisers available (Walker *et al.*, 2014).

Researchers and policy-makers have also made strides on the second level of intervention in establishing cross-sector linkages, interactions and feedback (Mabhaudhi *et al.*, 2016; Mabhaudhi *et al.*, 2018). The studies have gone further to identify positive and negative feedbacks between these sectors. These feedback loops are important as they determine behaviour of the nexus. In urban areas, for example, research by Brandoni and Bošnjaković (2017), on urban systems focus on feedbacks between sewer treatment plants, renewable energy and water provision. The research established the existence of negative feedback in terms of increased energy demand, due to certain types of sewer treatment plants but this can be offset by the energy that can be generated from the sludge from the plant *ibid.*).

Other researchers in urban areas have also discussed the implications of erecting thermal cooling tower based electric generation plants on demand for water in urban areas and the subsequent effect that has on domestic water requirement and food production (Conway *et al.*, 2015). This feedback also enables identification of underlying structures and recent research by Sohofi *et al.* (2016) suggested two systems archetypes which determine the behaviour of trying to manage the WEF nexus in the context of climate change. Nevertheless, Abson *et al.* (2017) reason that interventions stemming from these two levels create short-term results which seem to solve the problem but, after some time the problem recurs, sometimes, with greater complexity. Meadows (1997) also suggests that there are unintended effects arising from solutions coming from these shallow leverage points and advocates rethinking about the way we think and see things.

Trivedi and Misra (2015) attribute lack of positive sustainable change by interventions to lack of understanding the ecology of a social problem. This is essentially how a social problem relates to local context and other social problems, thus, identifying underlying structures of social problems and hindrances to effective change. Local context, in urban areas, entails understanding institutional and social structure dynamics, how they are crafted and manage feedback (executive, legislature, local government, communities). It also takes cognisance of the underpinning values, beliefs, attitudes and world views (soft factors) of actors (Checkland, 1981). These are all in the form of mental models, which can be defined as a way people make sense of the world as informed by these soft factors (Sterman and Sweeney, 2007). So far, according to Artioli, Acuto and Mcarthur (2017), the WEF nexus approach has a challenge in that it was birthed in a capitalistic global environment and without deep confrontation of the mind-set that is rooted in capitalism, we may run into lack of sustainability of resource allocation using the approach. Abson *et al.* (2017) suggest effecting changes to institutions or social structures and the transcending of paradigms by shifting of mental models as fundamental changes which can see sustainable interventions being implemented. From a systemic point of view this means the intent is altered and so are the social and institutional structures that manage the WEF nexus (see Figure 1).

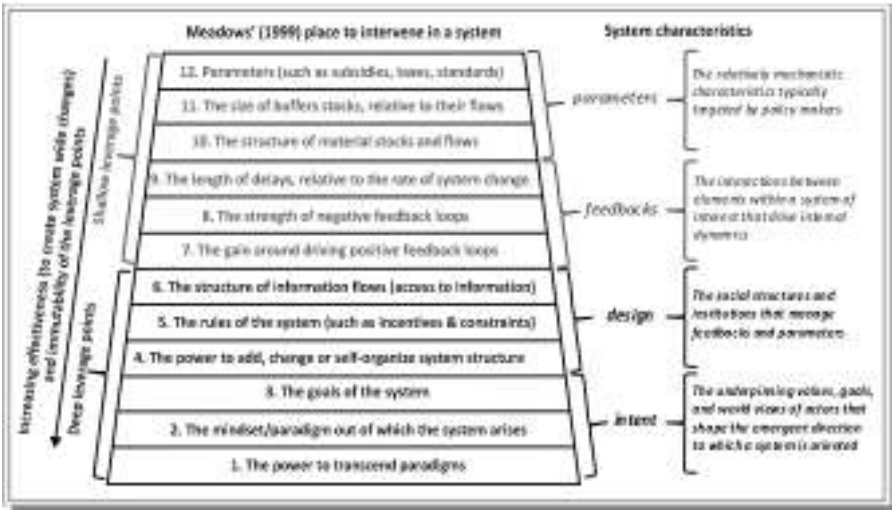

Figure 1: Leverage Points for Sustainability (Abson *et al.*, 2017).

Positive and sustainable social change in urban areas can result from a systemic approach as a more holistic perspective is implemented (Trivedi and Misra, 2015; Sohofi *et al.*, 2016; Albrecht, Crootof and Scott, 2018). Researchers need to apply interdisciplinary approaches which also have the ability to incorporate various paradigms and engage various stakeholders in dialogue (Albrecht, Crootof and Scott, 2018).

There has been use of a disciplinary or disjointed approach to address social problems, of a socio-ecological nature, where everything is inextricably linked (Trivedi and Misra, 2015). Most frameworks and intervention approaches have tried to integrate and link WEF nexus components (Mabhaudhi *et al.*, 2018), but they have done so at the shallowest level of intervention when they are contrasted to the four levels of intervention (Meadows, 1999; Abson *et al.*, 2017). Other aspects to do with system intent and design have not been incorporated into these frameworks. For example, Mabhaudhi *et al.* (2018) analyse five frameworks for the WEF nexus. In all these frameworks, though some mention the importance of qualitative aspects in the WEF nexus, there is no incorporation of these factors tangibly in these frameworks. To a large

extent, this confirms the notion that most frameworks designed by researchers and practitioners do not holistically address social problems (Sterman, 2002).

Furthermore, a framework by Covarrubias (2019) tries to address this deficiency of causality. The research outlines a conceptual framework that shows the different connections between materialistic components and social flows (Covarrubias, 2019). However, there is limited analysis of the relational aspects and how they contribute to the emergent characteristic of WEF resource distribution. There is need to employ short-term measures, such as building or managing sewer treatments and enhancing drainage to improve WEF performance, on one hand. On the other hand, there is need to implement long-run fundamental solutions, such as building dams, revisiting societal values and changing in energy consuming lifestyles. These factors have the ability to shift whole system behaviour. von Wehrden *et al.* (2017) call for the application of a plurality of methodologies for sustainability when managing problems, such as the WEF nexus that require a change in mind-set and are considered as wicked problems. This is because wicked problems are problems that are vague, have causality and result in ambiguity. They are difficult to delineate boundaries and difficult to establish interconnectedness hence, one method cannot tackle the wickedness associated with the problem (Head, 2008; Head and Alford, 2015).

The methods to manage wicked problems can vary in terms of paradigm origin but are able to complement each other with each method addressing certain aspects of the wicked problem (Head, 2008; Head and Alford, 2015). This requires procedural rigour and ability to meaningfully integrate the methodologies with an emphasis on ethical conduct (von Wehrden *et al.*, 2017). Green and Hardman (2013) accent to the use of pluralism in complex problems mainly for three reasons, firstly because most problems in society are complex and are linked to various paradigms. These different paradigms require a degree of focus without ignoring the interconnections with other paradigms. Secondly, designing policy and interventions for a problem, such

as the WEF is not a single linear event but rather an iterative process that has different stages which also require different approaches (von Wehrden *et al.*, 2017). Finally, pluralism considers the different philosophy and theories that emanate in each of these paradigms, thus, bringing richness to frameworks which can combine different methodologies. The purpose of this article is to come up with a conceptual model from a pluralist viewpoint that can guide policy-formulation and intervention of the WEF nexus. There was realisation that the implementation of the WEF nexus in urban areas is complex as the urban areas themselves. The following factors were considered in the development of the framework

i) Most enablers of the WEF nexus as shown in the frameworks reviewed by Mabhaudhi *et al.* (2018) are social problems themselves which can be regarded as wicked.
ii) The WEF nexus itself has been classified as a wicked problem.
iii) There is need to come up with policy and strategy that address all four levels of intervention as elaborated by Abson *et al.* (2017) from a philosophical and pragmatic point of view.

Systems thinking is a scientific approach which realises that anything or problem in nature is made of components. These components or parts make up the whole and the way they relate, determines the emergent characteristic of a system. Systems thinking also acknowledges that the whole is greater than the parts and for one to understand system behaviour, they must carefully study the system components and how they relate to each other. Finding leverage points from such an approach is not easy as it also requires people who are able to think systemically (Meadows, 2002). The model by Abson *et al.* (2017) is a system thinking model that outlines different levels at which leverage points can arise within a system and their effects in sustainably implementing change.

PROPOSED CONCEPTUAL MODEL

Selection of the methods and theories was based on the ability to be integrated into the leverage points for sustainability transformation by Abson *et al.*

(2017). The conceptual model thus, resembles the Abson *et al.* (2017) nested structure for leverage points. System dynamics is the overarching method for the framework as it has abilities to unravel true systemic change. From this model there is appreciation that mental models are the driver for decision-making for individuals and the society at large, thus, mental models determine how people act out certain behaviours (Sterman, 2000). This determines how social structures are formed and out of the institutions, rules and strategies of managing social problems emerge (Meadows, 1999).

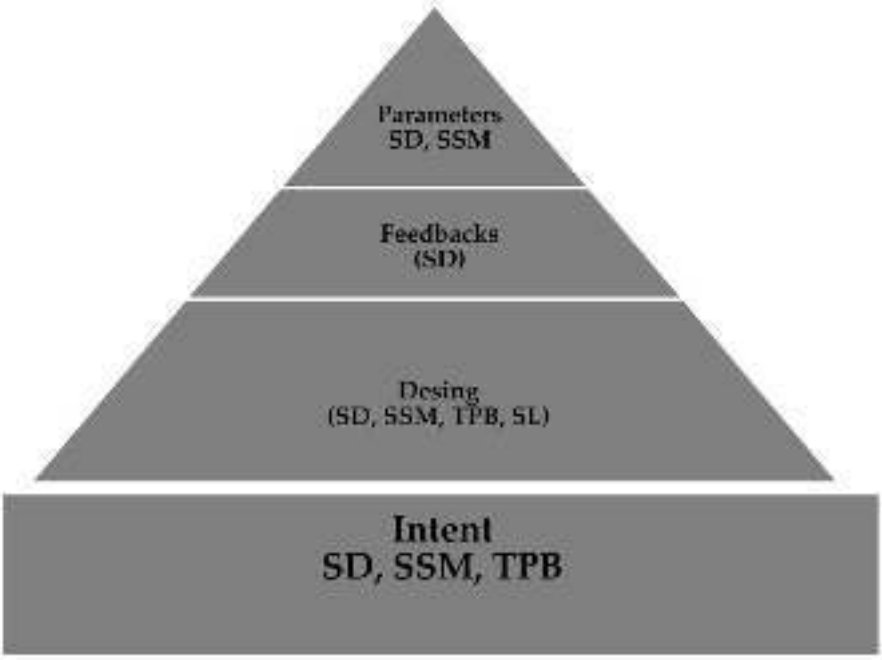

Figure 2: A Conceptual Model for Intervening in WEF Nexus

The following section describes the methodologies chosen and the motivation for their selection.

System dynamics form the bedrock of this conceptual model because of its multifaceted abilities. System dynamics (SD) is a system thinking approach

which uses dynamic hypothesis formulation through systems diagrams, causal loop diagramming and simulation to identifying structure underlying the behaviour of systems (Sterman, 2000). It is used in investigating behaviour and managing complex systems which exhibit feedback (Jackson, 2003). The greatest advantage of system dynamics over most simulation and modelling techniques is its ability to incorporate both quantitative and qualitative aspects of a problem (Wolstenholme, 1999). In this conceptual model, it is able to reveal and change mental models at individual level and assist in the design of transformed institutions and social structures. SD can also expose feedback and able to recommend parameter changes with an understanding of the interactions which exist with other components of a system. The Sterman (2000) Model of SD was chosen for the purpose of this conceptual framework. The reasons for selecting System Dynamics are based on the following:

- SD modelling is holistic in nature and gives the user an appreciation of the forest view.
- Ability to show and explain feedback through causal loop diagramming, thereby improving thinking process.
- SD can reveal and shift mental models of actors as it is a highly participatory.
- SD can also identify generic system behaviours through identification of archetypes.
- Leverage points can be identified at both dynamic hypothesis formulation and simulation and from these strategies for intervention can be adopted.

A picture of the SD process is shown in Figure 3.

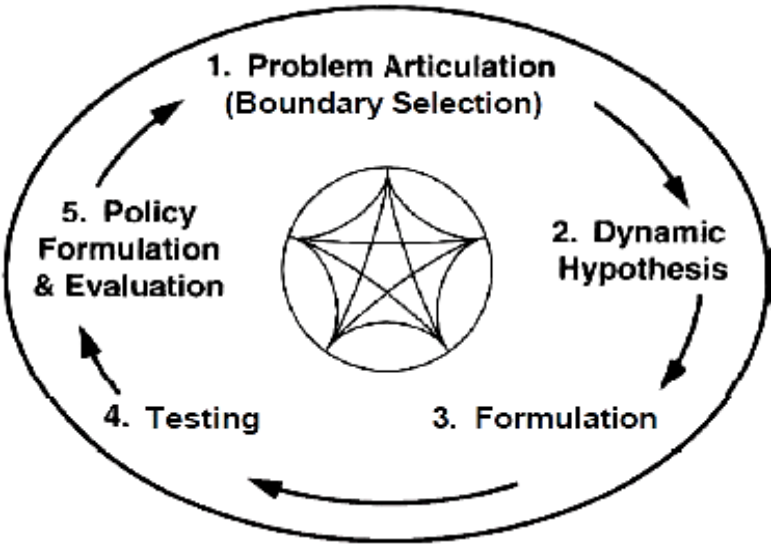

Figure 3: System Dynamics Dodel (Sterman, 2000)

Soft Systems Methodology (SSM) can be used in management of problematic situations where there are multiple conflicting interacting perspectives and the problem is not structured (Checkland, 1999). It has its strengths in elaborating mental models and it possesses the ability to change and shift these mental models (Jacobs, 2004).

The following features of SSM motivated its inclusion in the development of the conceptual framework:

- SSM can be used to resolve problems where ambiguity exists in both identification and definition of the problem.
- SSM acknowledges that in any problem situation, there are people trying to solve the problem, hence it analyses their action in relation to the whole state of the problem.
- SSM can be used to develop an appreciation of the way the actions of the various stakeholders interact to form the outcomes that the situation is currently exhibiting and, where possible, some of the trend patterns that are visible with deeper analysis.

- The SSM process is highly creative through the use of the Rich Picture, CATWOE and Root Definition as these allow boundaries to be expounded, giving participants space to think deeply while facilitating learning and, in the end, allowing for creative thinking.
- SSM is highly participatory in nature involving various stakeholders with each perspective contributing to analysis and the final solution, hence, minimising policy resistance. This is achieved through use of multi-causal diagramming during the SSM process revealing deeper trend patterns and analysis by stakeholders, giving credibility of the interpretation.

The SSM process is shown in Figure 4.

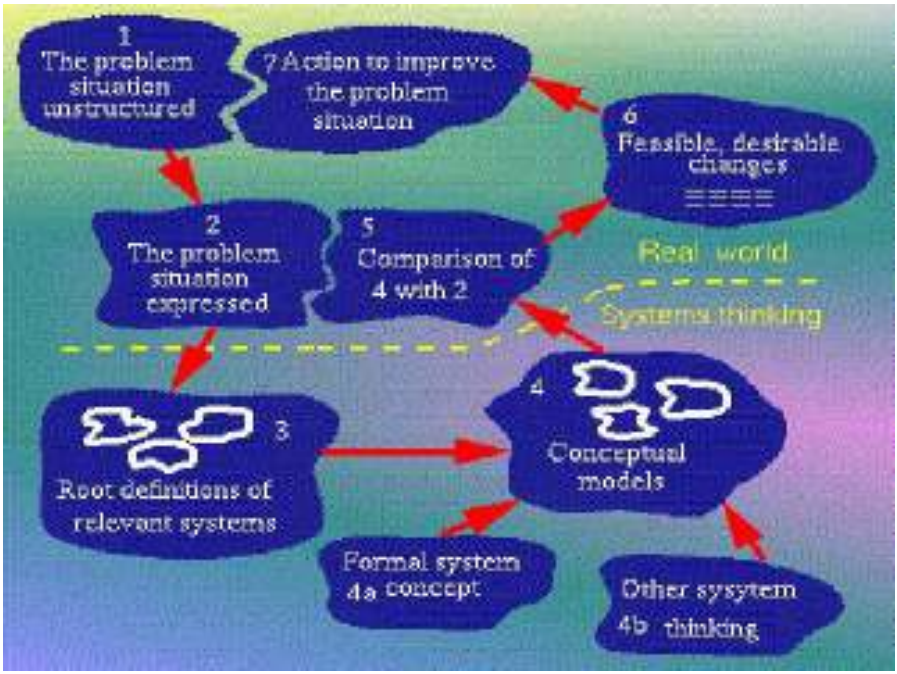

Figure 4: Checkland's Soft Systems Methodology

The WEF nexus is an emerging concept that requires much study and knowledge for all stakeholders. Issues to do with the WEF nexus and its enablers are composed of structured and unstructured components. Economic factors, social, political and biophysical factors are some of the components that affect the WEF nexus and climate change, hence, these require the split ladder of participation which prescribes the kind of learning required in both structured and unstructured problem situation and devises when to promote such kind of learning. The split ladder comes from Arnstein's (1969) Ladder of Participation and proposes different kinds of participation for different problems contexts and relevance (Hurlbert and Gupta, 2015).

The argument for selecting the split ladder is based on the following:

- For unstructured problems, the split ladder brings about triple loop learning as it enables deeper understanding of context through questioning values and norms underlying assumptions. One then learns of context, power dynamics and values influencing a problem.
- Triple loop learning leads to transformation but it requires trust and social trust is key if people are to discard their views and subsequently adopt other people's views in social settings.
- Participation of stakeholders determines level of trust and this is shown by the quality of information which flows between participants.
- Wicked problems like the WEF nexus can be responded to buy cyclical and active engagement with public, with triple loop learning occurring, allowing for deep understanding, shifting of assumptions and changing of mental models to occur.

The split ladder is shown in Figure 5.

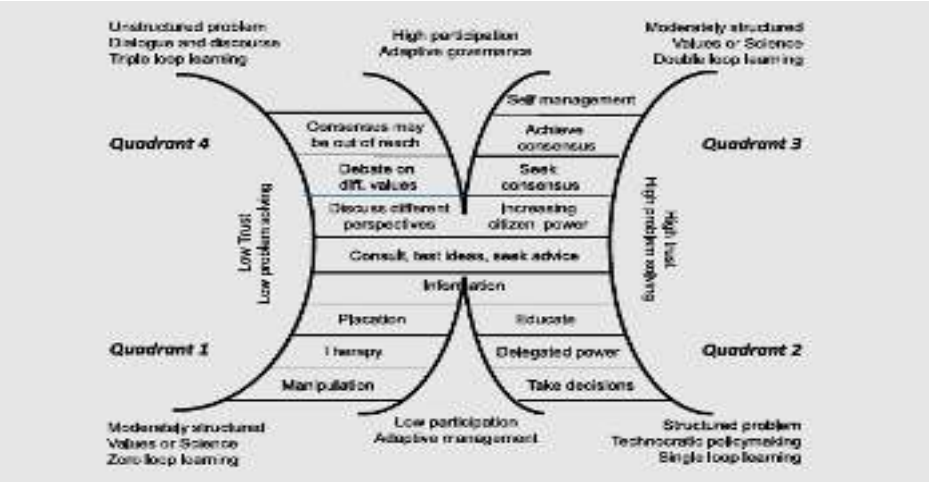

Figure 5: The Split Ladder

The Theory of Planned Behaviour (TPB)

The theory of planned behaviour (TPB) is frequently used in health behavioural domains. It is based on the assumption that people decide on intentions prior to action and intentions are best predictors of behaviour. Judgements that determine intention are listed as attitude regarding the behaviour subjective norm and perceived behavioural control. Self-efficacy is an important component in development of intention. It is based on analysis of the following: complexity of task, effort required and potential barriers. The psycho-social constructs have significant associations with behavioural intention to adapt to a phenomenon by having a proclivity towards the phenomenon (Masud *et al.*, 2016). How an individual sets out boundaries has connotations as to whether they are willing to act towards socio-ecological issues (Mancha and Yoder, 2015). The argument for selecting the theory of planned behaviour is based on the following:

- Consciousness is recognised as an important causal agent in getting individuals, communities and societies to adopt certain behaviours.
- Interventions at mind-set level can help change factors associated with consciousness, thus increasing intentions.

A diagrammatic presentation of TPB is shown in Figure 6.

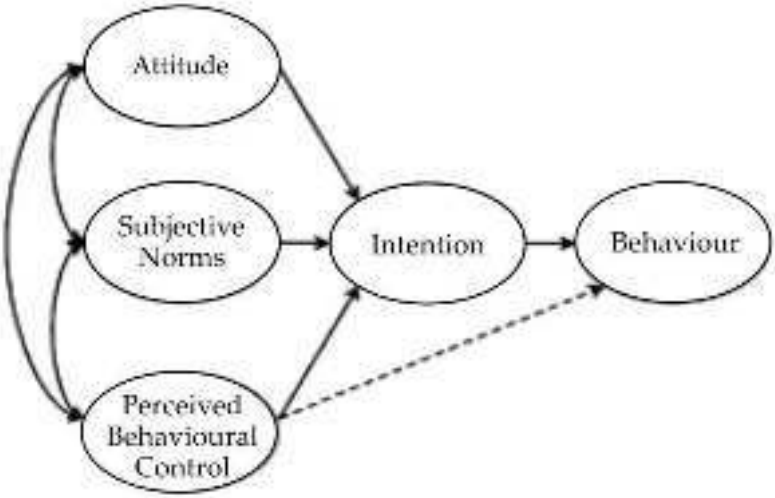

Figure 6: The Theory of Planned Behaviour

The Case of Chitungwiza

Chitungwiza is a municipal area close to Harare. it is the second largest urban area, by population. Its population has risen from below 15 000 when St Marys township was established in the late sixties to above two million, thus, overshooting the initially targeted population (Munzwa and Jonga, 2010). Overtime various complexities have arisen, due to this overpopulation with the provision of essential services (water, electricity and sanitation) deteriorating in Chitungwiza. This has been due to the strain on infrastructure. coupled with lack of maintenance of the overstretched infrastructure, which has led to a decrease in decent living conditions of residents (Dube and January, 2012). Furthermore, land-use in urban areas has changed over time. However, the initial colonial plans have had a bearing on the current outlook. There has been only a few cosmetic changes to the infrastructure that was built with most notable changes being expansion of households (Munzwa and Jonga, 2010).

Urban dwellings have mostly expanded the urban built-up area with a concentration of increased housing settlements for high-density areas as population increased. As these settlements increase, there is less idle space for

agriculture purposes. thus, affecting accessibility of land for food production by urban dwellers (Marondedze and Schütt, 2019). Moreover, urban dynamics, especially, in high-density settlements, like Chitungwiza, cannot be separated from poverty, food security and diseases, such as HIV and Aids (Murambadoro, 2010). These have been linked to the wider socio-economic performance of the country's economy that is agro-based.

The interconnectedness of issues of poverty and food systems has posed a challenge to intervention within these domains in Chitungwiza. Urban households engage in various livelihoods survival strategies for multiple streams of income and to reduce possibilities of hunger (Murambadoro, 2010). Practices, such as *dambo* cultivation, are now common in urban areas and in Seke peri-urban communal lands to augment incomes. Land, that was not previously meant for agriculture purposes has, thus, been increasingly cultivated, due to increasing difficulties in socio-economic conditions (Mabeza and Mawere, 2012).

Lack of employment has also driven people into small to medium enterprises wherein most people are self-employed (Gombarume and Mavhundutse, 2014). This has seen the mushrooming of backyard broiler chicken cultivation to boost income and food for families (Kelly *et al.*, 1994). Others have set up small industries around shopping centres and along roads. All these enterprises have, however, faced challenges associated with funding and lack of essential resources, such as water and electricity, as the design and setting of the town was not meant to accommodate the current population that is way above what was planned for (Gombarume and Mavhundutse, 2014).

Due to this unplanned massive influx of people and the growth of the population unprecedentedly in Chitungwiza, there have been other complexities at household level associated with multi-habitation (Schlyter, 2003). This is whereby three or four families reside on one piece of land ranging from 200m^2 to 1000m^2 and have to share the available resources in terms of water, electricity and land for the garden. This has created further pressure at a sociological level as there are many challenges, associated with this cohabitation (Schlyter, 2003). The inability, by the city authorities to provide essential resources for residents, has forced them to look for other

alternatives to ensure survival. In the case of food production, there is the invasion of idle land for a small space to establish gardens and women are usually at the forefront of this farming. For supply of water, residents have resorted to the digging of wells for watering the gardens and personal use, due to water-rationing (Dube and January, 2012). However, most of the wells are polluted by raw sewage from burst and unrepaired sewer pipes that has affected most of the water found underground near the surface (Dube and January, 2012). For energy supply people have resorted to massive deforestation in the neighbouring communal lands posing challenges associated with deforestation. All these factors have made it difficult for authorities to improve the living conditions of residents in Chitungwiza.

DISCUSSION

The WEF nexus can be regarded as a system which comprises three sub-systems that have been combined. It is also part of the larger socio-ecological system. Approaching the WEF nexus challenge, therefore, should be done in the ecology of the nexus problem. From this point of view, the nexus challenge is viewed holistically with the understanding the available resources, enablers and social aspects that contribute to the behaviour of the whole system. Most social problems are inextricably linked and this can be noted in areas like Chitungwiza hence, they require the capturing of the dynamic behaviour of the problem at a forest view level. From this view, strategy to specific mandates can then be crafted as there will be an understanding of overall system behaviour. Actors will then avoid unintended consequences which may arise from decisions made without an understanding of the holistic cross-sector linkages of the WEF nexus. According to Forrester (1970), creation of urban areas comes with challenges, such as those being faced in Chitungwiza when a systems approach is not applied when planning and designing the urban area. The conceptual model proposed in this study places emphasis on coming up with policies or frameworks which implement fundamental changes as a source of sustainable transformation to the WEF nexus. Other interventions proposed in most studies will also be implemented along with fundamental changes. The resultant change is then an emergent property which cannot be easily predicted through simple input, processing and output approach to policy-formulation.

CONCLUSION

This article sought to discuss holism into adopting a water-energy-food Nexus Framework. The WEF nexus can be used for managing these three primary resources. However, it is a complex process that requires approaching using multiple methodologies from various paradigms. Approaching the WEF nexus from a holistic point of view enables behavioural and social aspects that play a role in nexus characteristics to be incorporated in seeking leverage points to effect positive sustainable change. Thus, there is need for plurality of systemic methods which can effect change when applied to the WEF nexus for the achievement of Sustainable Development Goals. Chitungwiza is an example of an urban area facing critical shortages of these resources where the model can be applied.

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