Journal of Digital Food, Energy & Water Systems [JD-FEWS]

JDFEWS 5 (1): 146 - 158, 2024
ISSN 2709-4529

Breaking Silo Thinking within the South African Water-Energy-Food Nexus via Systems Thinking and Simulation Workshops

Steven MATHETSA
University of the Witwatersrand, Johannesburg, South Africa
steviemathetsa@gmail.com

Corne DU PLOOY
KU Leuven, Leuven, Belgium

Khabeer TAYOB
Eskom Research, Testing and Development, Johannesburg, South Africa

Received: 28 February 2024
Review: 27 May 2024
Accepted: 27 June 2024
Published: 30 June 2024

Abstract-The current disconnect in policy development and management of the water, energy, and food resources threatens their security of supply despite their inextricable interlinkage, commonly known as Water-Energy-Food nexus. The security of these basic human needs is aggravated by climate change's cross-cutting role, which impacts their availability. These apprehensions suggest that contemporary methods are required to improve and enhance the management of the food, water, and energy resources within the climate change discourse. This study applies Systems Thinking methodologies to foster collaboration amongst key stakeholders within Eskom, the electricity generating sector in South Africa. This was done through several simulation workshops held amongst employees within the generation, transmission, distribution, and corporate employees. The workshops demonstrated the ability of the systems thinking approach to enable stakeholders to apply the “nexus thinking” in managing the WEF sectors within the climate change discourse. The study concludes by recommending the application of this simulation within policy development and other key sectors to enable a broader application of nexus thinking, thus assisting in addressing the silo approach within these resource management.

Keywords—*Systems Thinking, Water-Energy-Food Nexus, Collaboration, Climate Change*

Journal of Digital Food, Energy & Water Systems [JD-FEWS]

JDFEWS 5 (1): 146 - 158, 2024
ISSN 2709-4529

1 Introduction

The concept of Water-Energy-Food (WEF) nexus was introduced within the sustainable development goals to enhance the holistic and coordinated management towards the efficiency of these resources [1][2]. The discussions around these resources and their relationships gained momentum in the last decade as concerns around their security are prompted by global communities' growing needs to attain sustainable development endeavours. The deliberations on the dependencies and competition among these resources have given rise to synergies and trade-offs that can be addressed through advanced technologies and enhanced management approaches [3]. The execution of these synergies and trade-offs is, however, hindered by persistent "silo thinking" in policy development and management of these resources, a factor that is pragmatic across many global communities [2][3][4][5][6][7]. The situation is further worsened by natural and anthropogenically induced climate change, a phenomenon playing an overarching role in the availability of these resources. The impact of climate change, which further aggravates fossil-fuel energy generation processes, results in unreliable water and food supplies due to extreme weather conditions such as floods and prolonged droughts. Therefore, global communities must resort to a more integrated and collaborative approach to efficiently manage these WEF resources. Against these observations, many global communities have developed systems and strategies to collectively address risks and opportunities emanating from these interrelations.

In South Africa, competition for nexus resources such as water, energy, and food, as well as the effects of climate change, is at an all-time high. This situation is aggravated by the country's rapid growth of socio-economic and environmental demands. This results in a Water-Energy-Food-Climate (WEF-C) nexus, a phenomenon highlighting the effect of climate change on the availability of these other resources. These interlinkages and key processes under each sector are highlighted in Figure 1. [4][5]and [8] have observed that, just like it is in many global communities, South Africa's WEF-C nexus landscape is also dominated by a "siloed" approach to policy-making and resource management. This situation is mainly worsened by rain-dependent agricultural activities, over-dependence on the climate change-inducing energy generation sector, and the country's limited water availability, a cross-cutting resource within many economy sub-sectors. [9] suggested that improved water resource management rapidly enhances integrated management of its linkage with resources such as energy and food. Therefore, South Africa must urgently seek alternative solutions to complex resource issues, such as those linking water to energy and food under current and predicted climate changes.

Figure 1: The Water-Energy-Food-Climate Change nexus in South Africa (Source: Authors)

JDFEWS 5 (1): 146 - 158, 2024
ISSN 2709-4529

One way of reflecting on the WEF-C nexus to break the "silo" mentality is the application of Systems Thinking (ST) tools. [4][10] and [11] have suggested that system dynamics, a subset of systems thinking and control engineering, is an effective tool to simulate the complex interactions within the WEF-C nexus, thus enabling effective management of these resources. The systems thinking has been used globally to break the silos of complex processes. The existing connection between human behavior and the consumption of these resources prompts the application of this approach within the nexus. This seems to suggest that a change in mentality can promote the effective management of these competing natural resources. As argued by [12], systems thinking is focused on investigating complex systems with multiple tools to create understanding and formulate better decisions. This highlights the importance of the tool in breaking down disseminations currently experienced in the interlinked WEF-C nexus sectors.

Systems thinking often involves moving from observing events or data to identifying behavior patterns over time, and analyzing the underlying structures that drive those events and patterns [13] [39]. By extending the thinking and assisting in expressing challenges in novel and creative ways, systems thinking increases the variety of options accessible for solving a problem. The ideas of systems thinking also help communities realize that there are no perfect answers and that their decisions will influence the system. This approach can lessen the impact of each trade-off or even take advantage of it by foreseeing it. Thus, it enables wise decision-making. Systems thinking is also useful for creating engrossing narratives explaining a system's operation. For instance, creating causal loop diagrams requires a team to create shared narratives or images of a situation. The tools are useful for locating, outlining, and expressing the understanding of systems, especially in groups. Anecdotal evidence shows that the techniques applied in systems thinking are seen as an ideal tool to be used in the Water, Energy and Food Nexus workshops and planning. By understanding and challenging structures that are not serving well (including our mental models and perceptions), the choices available can be expanded to create more satisfying, long-term solutions to prevalent problems in the WEF-C Nexus [13].

System dynamics is the mathematical simulation of the structures within a complex system to understand dynamic behavior and find leverage points for systemic change [39]. This approach allows stakeholders to better comprehend the interdependence between these sectors, resulting in the development of new paths and policies for successful collaboration and integrated WEF management under climate change considerations. This study uses a system dynamics simulation tool (i.e., the water-nexus game) and system thinking techniques such as the iceberg model to assess the nexus interaction within the electricity generation and supply value chain with the goal of fostering collaborations and an integrated approach amongst key stakeholders. Application of this system thinking tool is, in this study, done within Eskom Holdings State-Owned Company (SOC). The SOC utility is mandated to generate, transmit, and distribute electricity in the country. However, the organisation heavily relies on coal-burning electricity generation technology, producing approximately 60% of the country's Greenhouse Gas (GHGs') [5]. In addition, this electricity-producing technology heavily relies on freshwater supply while contributing significantly towards the country's polluted water. For example, while 2% of the freshwater available in the country is supplied to the sector with high assurance, [9] has noted the significant amount of water pollutants in the Highveld Region, which houses most Eskom's coal-fired power plants and associated coal mines. On the other hand, the competition over land use between coal mining and agriculture significantly impacts the country's food security.

The silo problem, seen globally, has been addressed in Europe through the development of a physical, social simulation board game called the Nexus Game [14]. This social simulation focuses on embodying the experience of preserving the environment while maintaining the economy of two independent countries that share a common river. The benefits include engaging important stakeholders, revealing the bigger picture, and fostering effective collaboration. The Nexus Game was experienced first-hand at the 2018 South African System Dynamics Conference and inspired the development of a system dynamics simulation. Other Nexus simulations exist with different purposes. For example, the System Dynamics simulation of basins in Iran [15] and household water consumption in Israel impacting the Water-Food-Energy (WFE) Nexus [16] were conducted in these respective countries to address their various dynamics. Additionally, projects like Sim4Nexus use serious games to promote integration and collaboration among policymakers [17]. While the environmental sustainability games have been increasing

JDFEWS 5 (1): 146 - 158, 2024
ISSN 2709-4529

over the past decade, as cultural relevance and interest reinforce environmental awareness, using system dynamics simulation as the basis of such serious online virtual games is unique [41] [35].

This paper further outlines the outcome of workshops conducted to promote interactions between these sectors within the organisation. The interactions were conducted through several workshops, termed Water-Nexus, attended by key personnel within different divisions of the organisation. Using the Nexus game, the workshops were mainly aimed at planting the seeds of systemic thinking essential to developing an integrated water, energy, food, and climate policy framework. Furthermore, the interactions also focused on investigating and comprehending mental models and constraints to the establishment of an integrated policy framework within the organisation's energy, food, water, and climate change usage while emphasizing the significance of collaborative work rather than operating in silos.

1.1 Systems Thinking and Nexus

Throughout the history of systems analysis, games have served as a natural complement to model-based analyses, providing much-needed human and social insights into decision and policymaking in a complex world. A simulation game is considered the application of game thinking to solve problems and encourage learning [18]. Because all games, like models, are simplifications of reality, the reality of nexus issues is undoubtedly much more complex than what is depicted in the games. Playing a game scarcely replaces the demands of formal analysis and sincere stakeholder engagement [2]. However, just as well-designed quantitative models can provide useful insights on the important interactions between various variables, it is argued that well-designed simulation games can provide insightful information on the various elements that influence governance and policy development. Games can reveal critical cognitive and behavioral traits and underlying worldviews frequently absent from traditional integrated evaluation [40]. Players can express these fundamentally human aspects of complexity with the help of games. They also teach the soft skills necessary for successful negotiation and problem-solving in the real world. These observations suggest that games could assist in understanding how nexus issues arise and what can be done to address them in theory and practicality [37].

2 Methods

The study used the theoretical Systems Thinking Iceberg model to delve deeper into the WEF-C Nexus's systemic challenges. Furthermore, the study used system dynamics simulation to create an interactive, multiplier environment for engagement online. Finally, the literature on the nexus was combined with both model and game simulation used within four (4) virtual workshops held at different times and with different participants as outlined in Table 1. The forty-two (42) participants involved in the workshops consisted of engineers, managers, strategists, specialists, and scientists from Eskom SOC. Snowball and purposive sampling techniques were used in the selection of the workshop participants. A random-purposeful approach was used to select the participants. As observed by [36], these participants' role and knowledge of various sectors were key to their selection for participation in the workshops. The selection of these participants allowed for diversified and multiple options and observations on the developments around these sectors. Each of the workshops involved eight (8) and sixteen (16) participants.

Table 1: Details of the workshops

Workshop label	Date	Number of participants
Workshop 1	21 June 2021	16
Workshop 2	12 August 2021	8
Workshop 3	7 December 2021	9
Workshop 4	15 February 2022	9

JDFEWS 5 (1): 146 - 158, 2024
ISSN 2709-4529

Three key aspects allowed the ease of virtual integration. The first is that the organisation has adopted Microsoft Teams and has breakout rooms feature, where people can be grouped together. Secondly, the simulation environment connects participants in real-time, meaning each person can immediately see the changes from other players. Finally, the roles for each simulation can scale from one (1) to four (4), and multiple instances of the simulation can be run – meaning that the simulation can easily adapt to the present group size.

Some of the areas the participants function included the divisions of Distribution, Transmission, Generation, Risk and Sustainability, Land use, Research and Development, and the general supply chain. The research results outlined in this paper are based on the four workshops conducted.

Since the workshops were developed and implemented during the COVID-19 pandemic, they were created for virtual participation. Due to the busy schedule of the participants, the workshop was formulated to be done in three (3) hours. The workshop opening establishes intent, preparing participants for productivity and creativity by promoting trust and agency [19]. The workshop thus began with a warm welcome and introduction. Following that, an icebreaker was used to make all participants feel at ease while also demonstrating how the world is seen differently due to neurological pathways formed in the brain. This introduction style was used to help participants be open to other points of view, interpretations, and mental models, which allowed them to break free from self-reinforcing mental patterns. [20] view the main intent of the workshop approach of this nature as important to provide methods that encourage deep creative thought, enabling participants to explore ideas and express concerns, often in cycles of generating ideas followed by evaluating concepts.

The theory surrounding the water, energy, food, and climate nexus was presented, allowing all participants to comprehend the synergies and bottlenecks associated with these factors. The Water Nexus Game (interactive simulation), which is the workshop's core component, was then conducted. This simulation game allowed participants to partake in the workshop and remain engaged while also emphasizing the value of collaborative effort. Participation was not directly measured, but engagement was essential for the group's function. For example, if participant A were absent, the whole group's progress would be slowed, and since the group's scores were tracked, the importance of participation was amplified for both individual and group benefit.

Yet, in some cases, there were challenges with connectivity, and in these cases, often two people would take one role. There were no participants who were online yet not present in engagements. The workshop continued with participants learning and applying system thinking methods they could employ outside the workshop.

The iceberg model looks at the various layers of problems covering the events and patterns and the structural problems causing these events and patterns to occur. It then went a level deeper and analysed the mental models that cause or allow the structural issues to form.

The closing concluded the workshop, validating the time and energy that participants invested in the workshop, supporting continued creative collaboration [21]. The final part of the workshop reflected on what were the key takeaways of the workshops and how to apply the learnings out of the workshop.

The data was analysed through an abbreviated context analysis where the specific words and phrases used by participants were noted. Participants expressed ideas, thoughts, and reflections in the three different aspects of the workshop. Most ideas were verbalised and then noted by the facilitator for future reference. Some ideas were written in the chat space of Microsoft Teams, and some were captured on the Iceberg presentation. The word codes that appear frequently are noted in the Results section 3.2 and Reflection section 4.

Journal of Digital Food, Energy & Water Systems [JD-FEWS]

JDFEWS 5 (1): 146 - 158, 2024
ISSN 2709-4529

3 Results and discussions

3.1 Simulation development

System dynamics is one field that can create simulations of the nexus due to the field's ability to simulate holistic and qualitative [22]. iSee Stella Architect is a dominant software for developing and distributing system dynamics simulations [23]. More importantly, iSee Stella had recently acquired the ability for multiple simultaneous participation (multiplayer) and hosting simulations in the online public domain at no cost. Thus, iSee Stella Architect was chosen as the desired software for developing the Water-Nexus simulation used in the workshop. The user interface for the Prime Minister Player, one of four, can be seen in Figure 2.

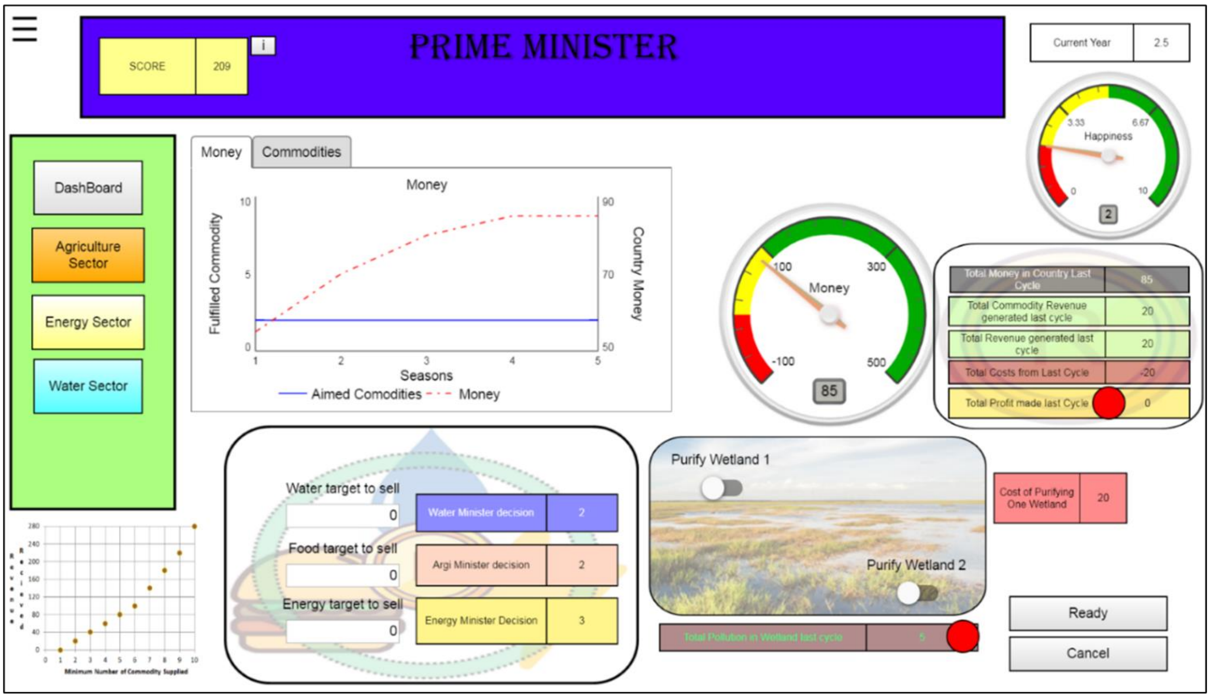

Figure 2: User Interface of the Prime Minister Role (Source: Authors)

The scenario included five (5) cycles, where each cycle was six (6) months. The cycles alternated between high and low rainfalls. Additionally, without the participants knowledge, as the cycles progress, the highest rainfall increases and the lowest rainfall decreases, making it more difficult to manage the Nexus. The scenario aimed to provide the experience of the consequences of climate change, where the frequency of droughts and floods increases.

Only one person is allocated to the role of prime minister. In this specific role, they need to make the following two decisions:

- Define Set the target number of water, food, and energy to sell. It is important to note here that the country will receive money based on the minimum number of these three commodities sold. For example, if three food, three energy, and zero water is sold, they will receive zero income, yet if there were also three waters, they would receive the income of three commodities (not zero). The prime minister also needs to balance this number based on what the country is able to do. They can consult the rest of the ministers for guidance (Water, Energy, and Agriculture) and their team for input, but the prime minister

remains responsible for this decision. Once the targets are defined, the other ministers are responsible for how they will reach them.
- The prime minister also needs to decide how many wetlands to purify. Wetlands, when managed well, can produce passive income and help deal with pollution, but once they are polluted, they need a large monetary investment to clean.

Although the prime minister only needs to make these two decisions, they directly impact each of the other sectors and the country's future prosperity. A good prime minister thus establishes two-way communication and encourages feedback, while a struggling prime minister tries to control the other ministers and deters feedback. Both these types of teams were visible.

The other roles, not visualized in this paper, is for the agriculture minister, energy minister, and water minister. These roles often have only one person allocated, yet when needed, two people (pairs) can take on these roles, enhancing discussion and thinking. In rare cases where roles are unfulfilled, the prime minister can navigate and fulfill the role of the missing minister(s). Thus, in total, four roles can be fulfilled in each team, which four participants ideally fill, but it could also be done with one (1) to seven (7) participants, based on the needs of the group.

Thereafter, some of the results of the simulation are discussed. Most of the styles are intuitive.

3.2 Outcomes of Simulation using Nexus game

Before the simulation started, the majority of participants echoed the lack of collaboration and identified “siloed” thinking as one of the factors hindering societal progression in South Africa, as studied by [6] and [24]. In particular, the siloed-policy development is observed as one of the key factors hindering good governance across many communities, including South Africa. Participants observed this as the biggest threat to attaining resource security and efficiency within the nexus space. In one case, one of the participants mentioned that “lack of collaboration among policy developers seems to be at the highest level as contradicting policies are observed across the sectors of water, energy, land-use and climate change.”. Land use naturally evolved from the discussions on the number of food production fields in the Nexus simulation since it indicated the power of having land. Combine the simulation experience with the history of South Africa’s apartheid legacy, land use might be a pertinent concept for most South Africans. One participant further elaborated on the “development of the environmental policies which, in many cases, do not consider the growing socio-economic and ecological demands confronting the country.” The participant’s experience is a clear demonstration of lack of collaborative efforts amongst key stakeholders, a particular concern the workshop intended to reduce. According to most participants, siloed thinking occurs even at operational levels of the electricity value-chain (within their business). This is due to minimal understanding and acknowledgment of the interdependency of these water, energy, and food systems under developing climate change consequences. For instance, several participants argued that the current environmental challenges across most of the energy generation fleet are aggravated by lack of “working together” between different sectors such as engineering, operations, environmental compliance, and management. Based on this observation, the current simulation is implemented to break silo-thinking within the water, energy, food, and climate change segments. Thus, after participating in the simulation game, participants can identify the silo-thinking as a problem in their immediate working environments and the need and value of breaking them through collaboration.

As the simulation progressed, the participants demonstrated efforts to collaborate to attain resource efficiency. Their efforts were observed in the processes where consideration of other sectors’ needs, and conditions took place prior to decision-making. For instance, consultation with the water minister to confirm the status of water resources by the energy minister before deciding on which electricity-generating technology to use. Furthermore, the collaboration also considered the financial implications of every decision within South Africa’s policy development space [6]. This endorses the ability of the simulation, developed using the system dynamic’s approach, to enable the stakeholders/participants to engage and work towards attaining a mutual understanding of the problem, as highlighted by [2] and [25]. The participants further demonstrated effective communication, another key element of fostering stakeholder collaboration. In most cases, for instance, the team leaders would engage their members before making a decision. Furthermore, they would also consult with team members of the other sectors

JDFEWS 5 (1): 146 - 158, 2024
ISSN 2709-4529

before making a decision. Finally, teams would take agency and self-organize the communication structure from a top-down approach to a more feedback-central focus.

The simulation has assisted the participants in understanding the complex interaction between the systems of water, energy, food, and climate change, a factor that is key and, in most cases, missing across many global societies, including South Africa [4] [5]. The feedback recorded by most of the participants shows the ability of this simulation to provide insights of the inextricable linkage between these sectors, one of the aims of the "nexus" approach. Understanding this interaction is also key to informed decision-making that includes these and other sub-sectors of the socio-economy and environment. One participant believes that "the exposure is also key towards the centralised decision-making and technological advancement aimed at promoting resource efficiencies with the utility's operational plants".

And finally, the simulation was key in determining the relational challenges to promote resource efficiency. In one of the workshops, a prime minister took over the agricultural minister's role from a position of power due to some perceived incompetence. This action led to a break in relational trust, as the strict top-down approach was enforced. Interestingly, the group's final score was lower than most groups' average final score. This type of behavior, where trust is broken, is often experienced in corporate real-world decision-making, yet the consequences are not seen as quickly as in this 'serious game simulation' environment. [26] studied 148 members of 28 teams across four organisations and showed a strong positive correlation between trust and performance within teams although trust is not the only factor. This can provide an extremely useful insight that can reshape informed policy decisions and operational inefficiencies. Several participants were of the view that understanding "the resource efficiency challenges confronting the country should assist in breaking the mental silos, thus developing a common understanding in addressing issues, from an operational level and above".

3.3 Outcomes of the Iceberg Model

The iceberg model is a system thinking tool that can be used to help people understand the relationship between noticeable problems or events and underlying factors. Just as how only 10% of an iceberg's mass is visible above water, the model is based on the idea that there are usually more factors involved in a problem than what is initially apparent. The model can be used to assist people in identifying and addressing hidden causes of problems [27].

The assessment of the Iceberg Model was presented using a newspaper article titled "Eskom ordered to rectify pollution issues at three plants" [28]. It is the view of coordinators that the topic is very much aligned to the nexus as it crosses the systems of pollution within the energy sector. The majority of the participants' deeper mental models and experiences point to the following:

- The event level is thought of as the top of the iceberg that is visible above the water, an observation similar to the one made by [27]. The event level is what people see and experience daily [27]. The event or incident presented in this case was a pollution occurrence that grabbed the attention of the regulators. The majority of the participants agreed that, in the case of this article, pollution emanating from Eskom's power plants was an event that needed a reaction from the regulators. This also highlight the similarities in the participants thinking, thus enabling deeper thinking towards the problem identification. As argued by [27], the event level is important because it is where people's everyday experiences and observations take place. But it's also crucial to keep in mind that the event level is just the tip of the iceberg, and there are frequently a lot of underlying causes that lead to issues or incidents at this level [27].

- Taking the iceberg a step further, the second evaluation examined whether the participants were aware of historical occurrences related to or like the event that had occurred. Most of the participants, whom some work at an operational level, identified a series of events that took place prior to the article. For instance, events at some power stations not mentioned in the article were revealed as a cause for the article of this nature. Most participants agreed that similar pollution is a concern for the country, especially in areas where Eskom operates. The pattern level is essential because it enables individuals to see the bigger picture, comprehend how various occurrences are related, identify trends and patterns that may aid in problem-solving [27].

- Another level deeper on the iceberg model looks at the structures of a system. The term “structures” describes the forces at play contributing to these patterns. Based on their operational experiences, the participants’ thinking aligned on the structural causes of these patterns. For instance, the participants working in the generation division have similarly identified factors contributing to power plants' pollution issues. Furthermore, their thinking towards plant breakdowns, aging, and lack of proper maintenance were identified as key structural drivers behind the patterns, and the article describes just one event that had occurred.

- The deepest level of the iceberg model, mental models, describes the beliefs that either create or maintain the structures. The participants suggested that events of this nature are partly due to the way decisions are made at managerial level and the beliefs experienced by participants. For instance, some participants revealed that they have either seen or experienced the belief that, ‘Things are not going to change so why make an effort’ and that some may believe that there is ‘no consequences or accountability’ which are creating and sustaining the destructive drivers above. The mental model level enables individuals to comprehend why they think and act as they do and how their personal experiences and worldviews influence how they perceive and interact with the world [27].

- Once the iceberg model is completed, the last step is to ask participants to notice how the mental models (above) create the structures that produce patterns of destructive events. They are then invited to imagine distinct types of mental models and how that might alter the system. In the mental model above, some participants suggested that cultivating a sense of responsibility and consequence awareness could create powerful waves of change.

In the end, the participants identified the article's core root causes. It is observed that, in many cases, society focuses on the event of air pollution in this regard. As indicated in the article, this leads to short-term fixes to the problem while the deeper challenges are rooted within and not thoroughly assessed or rectified. This affects critical decision-making processes within the power sector and eventually affects socio-economic and environmental elements. The alternative mental models identified by participants empowered them to embrace a sense of agency and hope since each of us can take ownership of our own thinking.

4 Reflections

Participants were encouraged to share their experiences at the end of the workshop. This practice has many benefits, and it is especially valuable to evaluate if workshop goals were met, identify any changes in perspective, and allow groups to wind down before leaving. Reflection in learning has shown to increase the depth of knowledge, contextualise knowledge, and increase social connections among learners [38]. Some of those reflections will be shared and discussed in the next few paragraphs.

During Workshop 1, one of the participants shared the following three reflections on what the workshop afforded them:

- Increased our cognitive understanding of the system.
- Increase our sense of agency and understanding of connectedness.
- Understand why it matters and why it is meaningful to act on the challenge.

The first point speaks directly to the lack of systemic thinking seen within the Nexus and successfully enhances that understanding. The second point is that the participants experienced increased agency, action/influence, and connectedness. This point speaks directly to the ability to break the silo mentality which keeps people disconnected. The last point speaks to the workshop's ability to foster purpose and action in participants. The three points above speak directly to the intent of Systems Thinking as detailed by [29] in the Fifth Discipline, especially on reigniting learning-driven people and bridging teamwork. In Workshop 2, one of the participants made the following remarks:

‘*My light bulb moment was when the Iceberg was explained, and the example thereof brought home. Also, the demonstration of interdependence of the different parts of our business was very good.*’

The participants expressed appreciation for how the Iceberg Technique was able to connect to their own working environments. They also appreciated the systemic connectedness of complex systems. This comment points towards the workshop's ability to use systems thinking that connects participants to the real-world problems they are facing through a practical yet virtual environment. The participant experience fits well with the role of systems thinking in practice by [30], where they constructed a system thinking learning laboratory to explore SDG 17, focused on means of implementation.

One of the core problem mental models identified by the group in workshop 3 was ‘I only have to achieve my own section/team goals; other things are not important’. The participants responses demonstrated how this mental model reinforces a blame culture, which leads to a lack of capacity, maintenance, information, and shortages of resources. Ref [37] also revealed through a study of 70 companies that the companies with strong blame cultures tend to score poorly on attributes of importance to stakeholders/investors. Furthermore, [37] shows the linkage between blame culture and employee loyalty, employee defensiveness, client service, and relative performance. The group acknowledged that collaboration between teams/sections is essential to start addressing the wickedness of the silo mental model. In the next three paragraphs, general reflections from the facilitators are captured.

Time requirement: According to [31], workshops should be kept between three (3) and eight (8) hours to provide enough participation but not require too much. The workshop needs to maintain awareness of participants' time. Initially, the workshop was scheduled for about 8 hours (a whole day workshop). However, many participants could not stay for the entire day and often had to leave to address their immediate working environment problems. Thus, the workshop structure was revisited and reiterated multiple times to be a morning workshop (half-day). The lesser time afforded more participation as it respected participant's time, which they returned in being present.

Lived experience is sacred: People share their lived experiences throughout the workshop, which needs to be respected. [32] discussed the ethical considerations necessary for any qualitative research. The article discusses the importance of respecting the differences in the researcher and participator’s world views. For collaboration and integration to occur, a safe space must be created where people can freely share their experiences, even in the face of contradictory or negative opinions. Throughout the 8 workshops so far, the facilitators had to learn how to embrace duality and tension within the group while maintaining an atmosphere of respect for each person's lived experience.

Process of Transformation: [33] studied how personal positive transformation occurs in nature through phenomenological accounts of 15 participants between 28 and 70 years old. The transformation consisted of recognition of formerly unknown aspects of self, projected unto nature and experience in an embodied way, evoking an insight into a meaningful personal issue. Transformation seems to start with the recognition of formerly unknown aspect of self. The Iceberg framework triggers the same process, where participants are confronted with their beliefs about reality, often formerly unknown. It is a privilege to see the participants reach a point of surfacing their assumptions (mental models) about the lack of systemic thinking and its root problems. First, participants express the negative mental models (paradigms) underlying structural issues, and then they start to envision new mental models that induce a sense of hope, agency, and connectedness [34]. The participants learned that negative emotions and ideas are critical for the transformation process and should not be avoided.

JDFEWS 5 (1): 146 - 158, 2024
ISSN 2709-4529

5 Conclusion

In conducting this study, several WEF-C workshops have been held within Eskom. During the sessions, attendees discussed the issue of a siloed approach, frequently citing their personal experiences. The encounters revealed that many in the energy sector have yet to accept the relationship between water, energy, climate change, and food. In some instances, it was observed that several participants have yet to recognize the impact of climate change on these sectors. This finding demonstrates the significance of collaboration inside the Nexus and the existing lack of integration. These were mainly observed as collaborative efforts were undertaken during the workshop where the nexus game was played.

The research identified a silo mentality amongst important role players at various organisational levels. However, the ability of systems thinking tools to recognize the existing connections between the competing resources of water, energy, and food under the current climate circumstances is highlighted as crucial to breaking down silos in the organisation and beyond. The sessions produced a safe environment in which participants reported increased cognitive knowledge, a greater sense of urgency, and an appreciation for why meaningful action is required to address the silo-breaking dilemma.

6 Acknowledgment

This work was supported financially and logistically by Eskom through the Eskom Holdings SOC – Research, Testing, and Development under the Grand Water Challenge.

7 References

[1] A. Flammini, M. Puri, L. Pluschke, and O. Dubois, “Walking the nexus talk: Assessing the Water-Energy-Food Nexus in the context of the sustainable energy for all initiative”, Climate, Energy and Tenure Division (NRC), *Food and Agriculture Organization of the United Nations (FAO)*, 2022. Rome, Italy. Available at http://www.fao.org/3/a-i3959e.pdf. Accessed on 26 February 2022.

[2] J. Mochizuki, P. Magnuszewski, J. Linnerooth-Bayer, “Games for Aiding Stakeholder Deliberation on Nexus Policy Issues” (2018). *In: Hülsmann, S., Ardakanian, R. (eds) Managing Water, Soil and Waste Resources to Achieve Sustainable Development Goals, Springer, Cham.* doi.org/10.1007/978-3-319-75163-4_5.

[3] C. Pahl-Wostl, C. Knieper, E. Lukat, F. Meergans, M. Schoderer, N. Schütze, D. Schweigatz, I. Dombrowsky, A. Lenschow, U. Stein, A. Thiel, J. Tröltzsch, and R. Vidaurre, “Enhancing the capacity of water governance to deal with complex management challenges: A framework of analysis”, *Environmental Science and Policy*, Vol. 207, 2020, 23-35. doi.org/10.1016/j.envsci.2020.02.011.

[4] T. Mabhaudhi, S. Mpandeli, A. Madhlopa, A.T. Modi, G. Backeberg, and L. Nhamo, “Southern Africa’s Water-Energy Nexus: Towards Regional Integration and Development”, *Water,* Vol. 8, no. 6, 2016, 1-21. doi.org/10.3390/w8060235.

[5] S.M. Mathetsa, M.D. Simatele, I.T. Rampedi, and G. Gericke, “Perspectives on integrated water resource management and its relevance in understanding the water-energy-climate change nexus in South Africa”, *Journal of Energy in Southern Africa*, Vol. 30. No. 3, 2019, 11-21. doi.org/10.17159/2413-3051/2019/v30i3a5654.

[6] S. Mathetsa, M.D. Simatele, I.T. Rampedi, “Applying the participatory approach to assess the Water-Energy-Climate Change nexus in South Africa”, *Development Southern Africa*, 2022. doi: 10.1080/0376835X.2022.2090898.

[7] C. Pahl-Wostl, A. Bhaduri, and A. Brun, “The nexus of water, energy and food-an environmental governance perspective”, *Environmental Science and Policy*, Vol. 90, 2018, 161-163. doi.org/10.1016/j.envsci.2018.06.021.

[8] G.B. Simpson, and G.P.W. Jewitt, “The development of the water-energy-food nexus as a framework for achieving resource security: A review”, *Frontiers of Environmental Science*, Vol. 7, No. 8, 2019. doi.org/10.3389/fenvs.2019.00008.

[9] T.S. McCarthy and J.P. Pretorius, “Coal Mining on the Highveld and its implications for future water quality in the Vaal River system”, *University of Witwatersrand*, 2019, Accessed on: 2023/01/06. Available at: http://www.foresightfordevelopment.org/sobipro/54/1305-coal-mining-on-the-highveld-and-its-implications-for-future-water-quality-in-the-vaal-river-system. Date accessed: 26 March 2022.

[10] K. Maani, “Decision-making for climate change adaptation: a systems thinking approach” *National Climate Change Adaptation Research Facility*, 2013, pp. 67. Available at https://apo.org.au/sites/default/files/resource-files/2013-06/apo-nid34598.pdf. Accessed: 26 January 2021.

JDFEWS 5 (1): 146 - 158, 2024
ISSN 2709-4529

[11] J. Alcamo, "Systems thinking for advancing a nexus approach to water, soil and wastes" *Center for Environmental Systems Research*, 2015, Keynote presented at the International Conference on Global Change, Sustainable Development Goals and the Nexus Approach. UN University – FLORES; Dresden, Germany; 25-27 March 2015. Available at: https://www2.cesr.de/download/documents/alcamo.keynote.systems-thinking.dresden-nexus-08-05-14-1.pdf. Accessed: 26 June 2021.

[12] C du Plooy, "Exploring Inherent Structural Knowledge in Mental Models through a Qualitative System Dynamics Approach", *Incose International symposium*, 2020. virtual event held on the 20-22 July 2020.

[13] Goodman M. "Systems Thinking: What, Why, When, Where, and How?", 2020. Available at: https://thesystemsthinker.com/systems-thinking-what-why-when-where-and-how/. Accessed on 04 August 2022.

[14] Centre for System Solutions, "The Nexus Game", *International Institute for Applied Systems Analysis*, 2019. Available at: http://systemssolutions.org/social-simulations-old/nexus-game/. accessed on: 18 February 2022.

[15] H. Gozini, B. Zahraie, and Z. Ravar, "System Dynamics Modelling of Water-Energy Nexus of Resource-Saving Policy Assessment*", International Journal of Environmental Research*, Vol.15, 2021, 349-369. doi.org/10.1007/s41742-021-00321-5.

[16] Y. Teitelbaum, A. Yakirevich, and S. Sorek, "Simulations of the Water Food Energy Nexus for Policy driven intervention", *Heliyon*, Vol. 6, No. 2, 2020. doi.org/10.1016/j.heliyon. 2020.e04767.

[17] Sim4Nexus, "ICT4Water", *Water Europe*, 2020. available at: https://sim4nexus.eu/page.php?wert=Projectoverview. Accessed on: 08 October 2022.

[18] K.M. Kapp, "The gamification of learning and instruction: game-based methods and strategies for training an education", 2012, John Wiley & Sons. San Francisco, CA: Pfeiffer.

[19] J.E. Brooks-Harris, and S.R. Stock-Ward," Workshops: Designing and facilitating experiential learning". SAGE Publications Inc, 1999, doi.org/10.4135/9781452204864.

[20] D.E. Gray, "Doing research in the real world (2nd ed.). Thousand Oaks, California: *SAGE Publications Inc*., 2009.

[21] P. Hamilton, "The Workshop Book (1st edition)", *Pearson Business*, 2016. ISBN-13 978-1292119700.

[22] A. Mirchi, K. Madani, D.W. Watkins, and S. Ahmad, "Synthesis of System Dynamics Tools for Holistic Conceptualisation of Water Resource Problems", *Water Resource Management*, Vol. 26, No. 9, 2012, 2421-24422, doi.org/10.1007/s11269-012-0024-2

[23] iSee Systems, "iSee Systems", 2021, Wheelock Office Park, 31 Old Etna Rd, Lebanon, US. Available at: https://iseesystems.com/, Accessed on: 02 February 2018.

[24] K.K. Ndalamba, "An exploration into the problematic public policies and the leadership challenge for socio-economic transformation in South Africa", International Journal of Excellence in Government, Vol. 1, 2018, 7-47. doi.org/10.1108/IJEG-09-2018-0003.

[25] Organisation for Economic Co-operation and Development, "Systemic Thinking for Policy Making – The potential of systems analysis for addressing global policy challenges in the 21st Century", 2019, Paper presented at the OECD Conference Centre on the 17-18 September 2019. Available at: https://www.oecd.org/publications/systemic-thinking-for-policy-making-879c4f7a-en.htm, Accessed on: 12 February 2022.

[26] F. Erdem, J. Ozen, and N. Atsan, "The relationship between trust and team performance" *Work Study*, Vol. 52, No. 7, 2003, 337-340. doi.org/10.1108/00438020310502633.

[27] N. Mahr, and A. Cheprasov, "Iceberg Model in Systems Thinking - Overview, Analysis & Examples Related Study Materials", 2022. Available at: https://study.com/learn/lesson/iceberg-model-systems-thinking-overview-analysis-examples.html, Accessed on: 10 August 2022.

[28] Bloomberg, "Eskom Ordered to Fix Pollution Issues at Three Power Plants", 2020. Available at: https://www.bloomberg.com/news/articles/2020-11-12/eskom-ordered-to-rectify-pollution-issues-at-three-power-plants, Accessed on: 16 June 2021.

[29] P.M. Senge, "The Fifth Discipline: The Art and Practice of the Learning Organization", 1990, Crown, New York.

[30] M. Reynolds, C. Blackmore, R. Ison, R. Shah, and E. Wedlock, "The Role of Systems Thinking in the Practice of Implementing Sustainable Development Goals", *Handbook of Sustainability Science and Research*, 2017, 677-698. doi.org/10.1007/978-3-319-63007-6_42

[31] Finland Futures Research Centre, "Practical Guide for Facilitating a Futures Workshop", Turku School of Economics, University of Turku, 2014. ISBN 978-952-249-297-5.

[32] D. Aluwihare-Samaranayake, "Ethics in Qualitative Research: A View of the Participants' and Researchers' world from a critical viewpoint", *International Journal of Qualitative Methods*, Vol. 11, No. 2, 2012, 64-81. doi.org/10.1177/160940691201100208.

[33] L. Naor and O. Mayseless, "How Personal Transformation Occurs Following a Single Peak Experience in Nature: A Phenomenological Account", *Journal of Humanistic Psychology*, Vol. 60, No. 6, 2017, 865-888. doi.org/10.1177/0022167817714692.

[34] A. Birney, "How do we know where is the potential to intervene and leverage impact in a changing system? The practitioner's perspective", *Sustainability Science*, Vol. 16, 2021, 749-765. doi.org/10.1007/s11625-021-00956-5.

JDFEWS 5 (1): 146 - 158, 2024
ISSN 2709-4529

[35] Chaos Theory, "20 Incredible Environmental Games from the Last Decade", 2021, Article posted on 1 Dec 2020, available at: https://www.chaostheorygames.com/blog/20-environmental-sustainability-video-games-from-the-last-decade-2021, accessed: 10 August 2022.
[36] J. Kirchherr and K. Charles, "Enhancing the sample diversity of snowball samples: Recommendations from a research project on anti-dam movements in Southeast Asia", *PLoS ONE*, Vol. 13, No. 8 (2013). e0201710. doi.org/10.1371/journal.pone.0201710.
[37] C.Y. Hsu and T.T. Wu, "Application of Business Simulation Games in Flipped Classrooms to Facilitate Student Engagement and Higher-Order Thinking Skills for Sustainable Learning Practices", *Sustainability*, Vol. *15*, 2023, 16867. doi.org/10.3390/su152416867.
[38] B. Chang, "Reflection in learning", *Online Learning*, Vol. 23, No. 1, 2019, 95-110. doi:10.24059/olj.v23i1.1447.
[39] J.D. Sterman, "System Dynamics Modeling: Tools for Learning in a Complex World", *California Management Review*, Vol. *43*, *Issue*, 8-25. doi.org/10.2307/41166098.
[40] F. Kapmeier, A.S. Greenspan, A.P. Jones, and J.D. Sterman, "Science-based analysis for climate action: how HSBC Bank uses the En-ROADS climate policy simulation", Systems Dynamics, Rev. 37, 2021. 333-352. https://doi.org/10.1002/sdr.1697.
[41] S. Janakiraman, S.L. Watson, and W.R. Watson, "Exploring the Effectiveness of Digital Games in Producing pro-Environmental Behaviors when Played Collaboratively and Individually: A Mixed Methods Study in India", *TechTrends, Vol.* 65, 2021, 331–347. doi.org/10.1007/s11528-020-00571-8.

8 Authors

Steven Mathetsa is a senior lecture and programme director (Postgraduate Diploma in Energy Leadership) at the African Energy Leadership Centre, Wits Business School, University of the Witwatersrand. He is a registered scientist with the South African Council for Natural Scientific Professions (SACNASP).

Corne du Plooy is a research associate focusing on pandemic preparedness at the Access-To-Medicines Research Centre, Ku Leuven University. He has worked in system dynamics for almost a decade, mostly in water and energy applications. In 2018, he initiated the first SA System Dynamics Modelling competition.

Khabeer Tayob is an Electrical Engineer at Eskom Research, Testing and Development in the system dynamics and digitalization space.