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Integrating Water-Energy-Food Nexus Innovations and Practices into Policy, Governance and Institutional Frameworks for Sustainable Development in Vhembe District, Limpopo Province, South Africa: Literature Review

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Abstract

A review was conducted on the body of literature that covers areas such as global perspectives of water-energy-food (WEF) nexus, the need for WEF nexus solutions, WEF nexus interlink ages and frameworks, the WEF nexus research in South Africa, WEF nexus innovations and practices, policy and governance and institutional dimensions of WEF nexus and the application of WEF nexus solutions at the household and community levels. Literature searches were carried out in the indexed database Scopus©. Word clouds were used as indicators of search content summaries. Two searches on Scopus were carried out. The first search had search words of: ("Water-energy-food" OR “WEF” AND "South Africa" AND (Limit-To (Language, “English”)), and it yielded 32 articles from 2003 to 2022. The second search had search words of: ("Water-energy-food" OR "WEF" OR "water policy" OR "water governance" AND "South Africa" AND (Limit-To (Language, “English”)), and it yielded 260 articles from 1996 to 2022. The review findings showed that there are various methods and approaches for conducting research on the WEF nexus approach. These approaches provided the basis for developing the methodology for the current study. The literature review findings also highlighted the need to understand the existing and potential WEF nexus innovations and practices applied at the household and community levels and how existing policies and governance systems affect the use and management of WEF resources at these levels. Based on the literature review, it was decided that the ongoing research should focus on WEF nexus innovations and practices applied at the household and community levels, and on how existing policies, governance and institutional systems affect the use and management of WEF resources at these levels, in order to contribute to existing body of knowledge on WEF nexus.

Keywords

Water-energy-food, literature, review, innovation, policy, governance

1. Introduction

The paper reports on a research project funded by the Water Research Commission (WRC) on integrating water-energy-food (WEF) nexus innovations and practices into policy, governance and institutional frameworks for sustainable development in Vhembe District Municipality (VDM), Limpopo Province, South Africa. The main focus of the study was to identify WEF nexus innovations and practices, and policy, governance and institutional systems necessary to provide nexus-based sustainable development solutions at the household level, thereby empowering communities to effectively use nexus resources.

Water and energy are vital natural resources needed to resolve critical global challenges such as poverty, hunger, malnutrition, poor sanitation and hygiene, and health. Water, energy and food are complex aggregates formed and influenced by the collection of elements and managing them relies on several factors such as technology choices, fuel choices, resource availability and market factors, which can all be affected by national resource policies. Integrated management of the three resources or the WEF nexus is central to achieving the Sustainable Development Goals (SDGs) and economic growth and achievement of the various goals under the National Development Plan and Vision 2030 [1].

A lot of research has been conducted on WEF-nexus. Most of the existing research focuses on the technical assessments to enhance productivity, strategies for optimising synergies and reducing trade-offs across nexus sectors to inform natural resource policy and governance. However, resource 'security is not solely driven by the availability of the resources but also by access to resources, affordability and stability, the capacity to utilise resources, and dynamics of social power relations and the strength of institutions. Various studies (e.g., [2-7]) have shown that ineffective governance and institutional arrangements are some of the main factors that limit access to and sustainable use of water, energy and land resources at the household level.

Considering that the area of WEF nexus has been researched on and reported by various researchers, it was considered necessary to carry out a systematic review of literature on the WEF nexus in order to better guide the direction and approach of the ongoing research project. Hence, a literature review was conducted to examine existing knowledge on WEF nexus innovations and practices, policy, governance and institutional frameworks as they relate to management and utilisation of WEF resources. The main focus of the review was on the implementation of WEF nexus approach by communities in rural and peri-urban settings.

2. Purpose and objectives of the review

The purpose of the literature review was to determine what is known on the current research topic, how well this knowledge is established and where future research might best be directed. The objectives of the literature review were to:

a) Identify areas of prior scholarship to prevent duplication and give credit to other researchers;
b) Identify inconstancies: gaps in research, conflicts in previous studies, open questions left from other research;
c) Identify the need for additional research and hence justifying the current research;
d) Identify the relationship of works in the context of its contribution to the current research topic and to other works; and
e) Place the current research within the context of existing literature, making a case for why further study is needed.

3. Methodology

The review was on the literature on WEF nexus innovations and practices, and on policy, institutional and governance dimensions of WEF nexus.

Google Scholar and electronic archives, including the WRC Knowledge Hub, were searched for publicly available reports on the water-energy-food nexus. Literature searches were also carried out in the indexed database Scopus©. Word clouds were used as indicators of search content summaries. Two searches on Scopus© were carried out. The first search had search words of: ("Water-energy-food" OR "WEF" AND "South Africa" AND (Limit-To (Language, "English")), and it yielded 32 articles from 2003 to 2022. The second search had search words of: **(**"Water-energy-food" OR "WEF" OR "water policy" OR "water governance" AND "South Africa" AND (Limit-To (Language, "English")), and it yielded 260 articles from 1996 to 2022. These terms were used to facilitate the search, and inclusion/exclusion criteria were used to screen the articles that were found online. A number of articles were downloaded and those that met the screening criteria were then used in the analysis. In addition, the reference sections of the reviewed literature were examined for other relevant literature for inclusion.

4. Results

The results presented cover bibliometric literature search, the search on the existing body of literature, gaps in the existing body of literature, and the link of the existing body of knowledge to the current WEF nexus research.

4.1 Bibliometric literature search

The first search for article titles, abstracts, and keywords was conducted with search words: ("Water-energy-food" OR “WEF” AND "South Africa"AND (Limit-To (Language, “English”)). Thirty-two (32) results came out from 2003 to 2022. The results are presented in Figure 1.

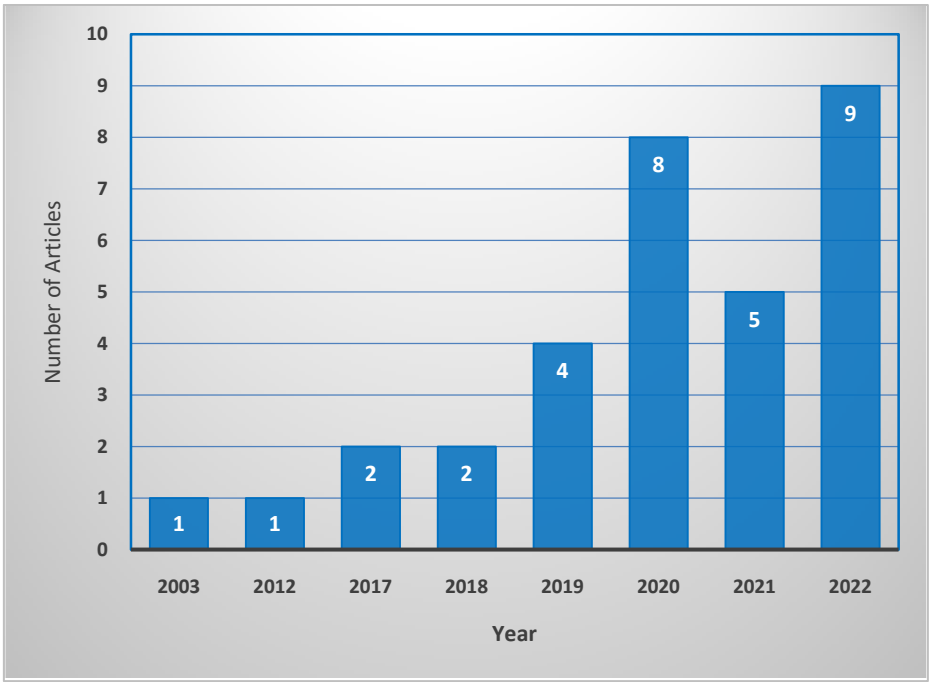

Figure 1. Bibliometric analysis output of the first search.

The output of the document type for the first search is given in Table 1.

Table 1. Output of the document type for the first search

Document type	Number
Article	17
Book Chapter	6
Review	5
Conference Paper	3
Conference Review	1

The second search for article titles, abstracts, and keywords was conducted with search words: **(**"Water-energy-food "OR" WEF "OR" water policy "OR" water governance "AND" South Africa" AND (Limit-To (Language, “English”)). Two hundred and seventy (270) results came out from 1996 to 2022. The results are presented in Figure 2.

The output of the document type for the second search is given in Table 2.

A word cloud of keywords was used to improve the systematic feature of the literature review. A ‘word cloud’ is a visual representation of word frequency, the more commonly the term appears within the text being analysed, the larger the word appears in the image generated [8]. Word clouds are increasingly being employed as a simple tool to identify the focus of written material [9]. In this case, the word cloud analysis was used to give a visual impression of priority given to the literature research of direct relevance to WEF nexus and related issues in South Africa. The word cloud shown in Figure 3 shows the most popular words used in the literature search for this study.

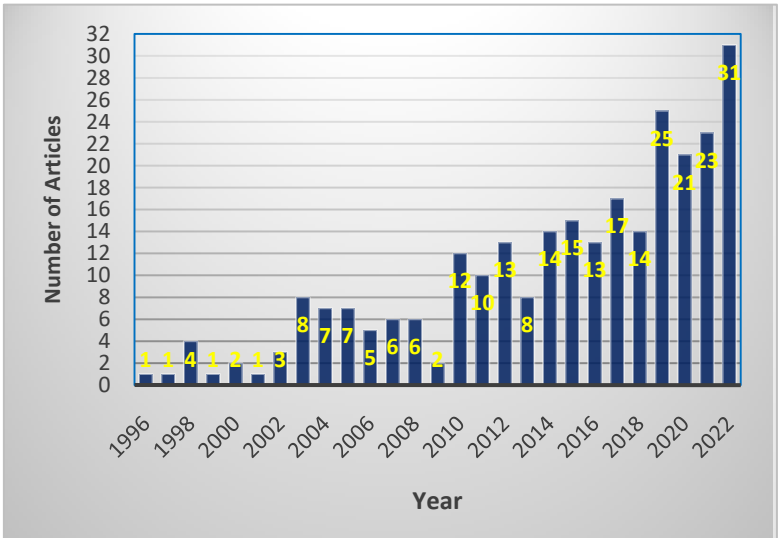

Figure 2. Bibliometric analysis output of the second search.

Table 2. Output of the document type for the second search

Document type	Number
Article	192
Book Chapter	33
Review	23
Conference Paper	9
Book	8
Editorial	3
Conference Review	1
Short Survey	1

Figure 3. The word cloud of keywords for the literature review search.

The output of the frequency analysis of the cloud is presented in Figure 4. The frequency and hierarchy followed the occurrences of the words: "water", "energy", "nexus", "food", "wef", "South Africa", "water-energy-food", "governance systems", "institutional framework", "policy framework", "energy innovations", "agricultural innovations", and "water innovations".

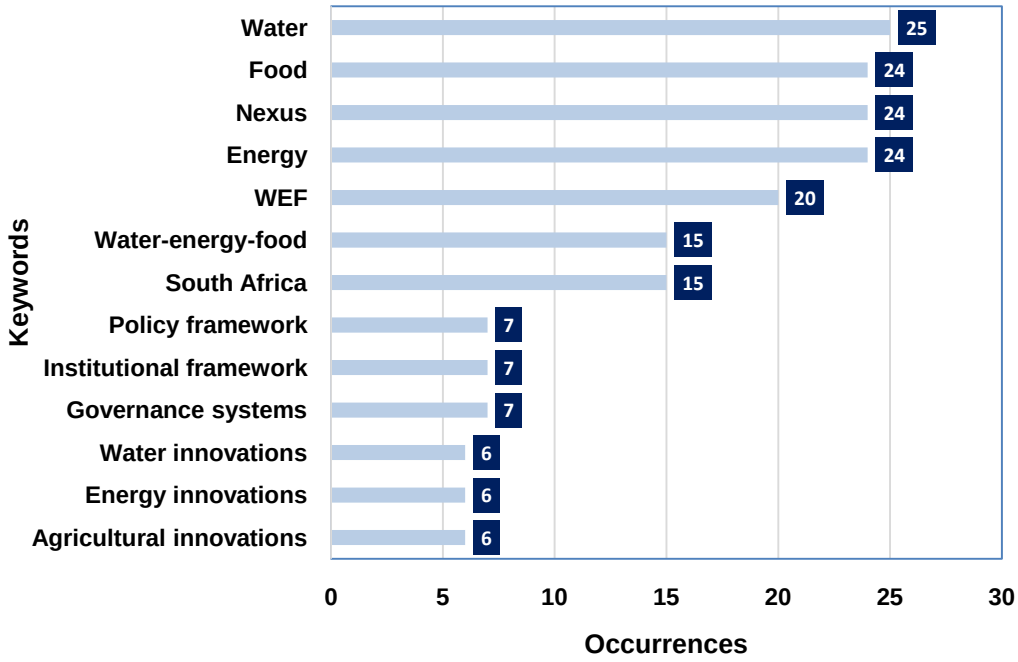

Figure 4. The words which occurred with the highest frequency in the dataset.

4.2 Existing body of literature

The review was conducted on existing body of literature on global perspective of the existing knowledge of the WEF nexus, the WEF nexus research in South Africa, the WEF nexus innovations and practices, the WEF nexus practices at the household and community levels, policy dimensions of the WEF nexus, and governance and institutional dimensions of WEF nexus.

WEF nexus global perspectives. Agriculture accounts for about 70% of global water withdrawal [10]. Roughly 75% of all industrial water withdrawals are used for energy production [11]. The food production and supply chain account for about 30% of total global energy consumption [12] and 90% of global power generation is water-intensive [11]. It is reported that global water demand (in terms of water withdrawals) is projected to increase by 55% by 2050, mainly because of growing demands from manufacturing (400% increase) [11]. More than 40% of the global population is projected to live in areas of severe water stress by 2050 [11]. By 2035, water withdrawals for energy production could increase by 20% and consumption by 85% [11]. These projections indicate that the demand for food, water, and energy is growing steadily, but the resources required to generate them are limited and, in many cases dwindling [13, 14].

The interdependencies among water, energy, and food are numerous and multidimensional, and their relationship is often called the food, water, and energy nexus [15, 16]. In order to advance the notion of the WEF nexus, a number of global and regional conferences, workshops and meetings were held in 2011-2012, during the preparation phase for Rio+20 in June 2012 [17]. Conferences and workshops that focused on elements of the WEF nexus at the global level included: 6th World Water Forum, Bonn 2011 Nexus Conference, World Congress on Water, Climate and Energy, and Water-Energy-Food Security: New Challenges and New Solutions for Water Management [17]. Since the issue of WEF nexus became a global concern, a number of frameworks that define the relationships between the WEF elements and the character of potential responses within the WEF nexus have been developed. These include those by Hoff [18], Rasul [19] and the World Economic Forum [20]. It is clear that water, energy and food nutrition security as basic needs have been crucial issues in human history dating back to the earliest days of civilization [21]. Global human society must now attempt to solve a set of complex and interrelated problems that Diamond [22] characterises as "fundamental threats to human civilisation".

The WEF nexus is central to sustainable development and has been highlighted as critical to achieving the SDGs [1]. The SDGs of zero poverty (SDG1), ending hunger and food insecurity (SDG 2), ensuring water security (SDG 6), ac-

cess to modern energy (SDG 7), sustainable economic growth (SDG 8), industry, innovation and infrastructure (Goal 9) through innovations linked to WEF nexus resource utilisation, development, management of sustainable consumption and production (SDG12), and conservation, protection, and sustainable use of marine and terrestrial resources and ecosystems (SDGs 14 and 15) are all closely interlinked and success in achieving them will depend heavily on ensuring the sustainable use and management of water, energy, land (food), and other natural resources [23]. Various researchers have argued that the nexus resources are not only interdependent, but they also reinforce and impose constraints on one another (e.g., [15], [19], [24-26]). The goals of each of them are interlinked in different ways. Achieving the goal of food security and ending hunger, for example, depends strongly on achieving water and energy security, which is needed to ensure water and energy are available for food production. Similarly, the ability to achieve the goal of water and energy security will largely depend on how food is produced, processed, transported, and consumed [27]. Understanding and managing the links among food, water, and energy is essential for formulating policies for more resilient and adaptable societies [28, 29].

Nerini et al. [30] reported that the WEF nexus could mitigate climate risks in southern Africa. This assertion is supported by Nhamo et al. [31], who argue that southern Africa is highly vulnerable to drought because of its dependence on climate-sensitive sectors of agriculture, hydro-energy and fisheries. Mpandeli et al. [32] reported in their study that climate change adaptation through the WEF nexus is imperative. Mabhaudhi et al. [33] supported this assertion, arguing that the WEF nexus is a potential tool to transform rural livelihoods and well-being in Southern Africa. Mabhaudhi et al. [33] developed a WEF nexus livelihoods adaptation and transformation framework which identified (i) the trade-offs and unintended negative consequences for poor rural households' livelihoods of current silo approaches, (ii) mechanisms for sustainably enhancing household water, energy and food security, whilst (iii) providing direction for achieving SDGs 2, 3, 6 and 7.

WEF nexus research in South Africa. A number of studies have been conducted to assess the application of the WEF nexus approach in South Africa. Mabhaudhi et al. [34] conducted a study in which they assessed the state of the WEF nexus in South Africa. In addition, they conducted a literature review on past, present and ongoing work on the WEF nexus focusing on current status, potential, challenges and opportunities for inter-sectoral WEF Nexus planning. Seeliger et al. [35] conducted a study in which they applied the WEF nexus to farm profitability in the Middle Breede Catchment, South Africa. They demonstrated how the WEF nexus approach could provide insights into how integrated water management can be applied in a particular agricultural context. Mabhaudhi et al. [33], in their study, argued that a better understanding of the policy and institutional dimensions at the household scale is important for the nexus approach to have a greater impact. According to the study of Nhamo et al. [36], who developed an integrative analytical model for the WEF nexus and applied it to assess progress towards the Sustainable Development Goals in South Africa, the country's management of the nexus resources is marginally sustainable.

To date, nexus framings and applications of the nexus approach have tended towards technical assessments to enhance productivity, optimise synergies and identify trade-offs across nexus sectors to inform natural resource governance [37]. However, resource 'security is not solely driven by the availability of the resources but also by access to resources, the capacity to utilise resources, and dynamics of social power relations and the strength of institutions [38], [39]. Various studies have shown that ineffective policies, governance and institutional arrangements are some of the main factors that limit access to and sustainable use of water, energy and land resources at the household level [40], [41]. Simpson et al. [42] conducted research in which they developed the WEF nexus index and its application to South Africa and the Southern African Development Community (SADC). Gulati et al. [43] reviewed the level of interconnectedness between the WEF systems in South Africa and discussed how energy and water costs influence food prices in the country and affect the country's level of food and nutrition security. Botai et al. [44] conducted a review of the WEF nexus research in Africa and contented that there is a need for more coordinated and collaborative research to achieve impact and transition from WEF nexus thinking to WEF nexus practice

WEF nexus innovations and practices. Water plays an important role in almost every stage of energy development, including extraction, production and processing of fossil fuels, electricity generation, and treatment of wastes from energy-related activities, as reported by various researchers (e.g., [45-49]). Water is needed for food production, mainly for irrigation and processing crops. Agricultural production is the largest consumer of water globally, accounting for about 90% of global freshwater consumption in the past century [50, 51]. Conversely, energy is needed to pump, collect, treat, and distribute water; at the same time, energy is crucial in food production and processing for mechanization, land preparation, fertilizer production and application, irrigation, packaging, processing and storage of food [18], [45], [52], and about 30% of the global energy consumptions are from food production and supply [53].

Irrigated agriculture is a key example of the WEF nexus due to the strong competition over water used for energy generation and water used for food production in water-scarce areas of the world [54-56]. In South Africa, agriculture is the largest water user at 60% of total water use, followed by municipal use at 27% (including industrial and commercial users provided from municipal systems), rural domestic at 5%, with power generation, mining and bulk industrial use, livestock and conservation and afforestation jointly making up the remaining 8% [57].

A significant amount of water is required to generate energy. Also, direct resource consumption in the food sub-system and indirect operations in the energy sub-system causes environmental impacts [58]. Inversely, water can also be an alternating source of energy through hydro-power. Energy security is defined as: "the uninterrupted availability of energy sources at an affordable price". A collapse of energy systems could disrupt food production, preservation, and supply [59]. Green-house-gas emission impacts WEF nexus management as well [16]. Without water, we cannot produce food and energy; and without energy, we cannot process or distribute food and water [59]. The inextricable linkages between these critical domains require a suitably integrated and transformative approach to ensuring water and food and nutrition security and sustainable agriculture and energy production in South Africa. A nexus approach is an approach that considers the interactions, synergies and trade-offs of water, energy and food when undertaking the management of these resources can increase overall resource use efficiency, provide additional benefits and secure the human rights to water and food. De Grenade et al. [60] pointed out that the WEF nexus fails to adequately acknowledge the environment as the set of natural processes underpinning the nexus, particularly interactions among water, energy, and food.

WEF nexus practices at the household and community levels. The assessment of implementing the WEF nexus innovations and practices at the household level can be considered through its link to the livelihoods of the people. According to Biggs et al. [61], the framework consists of internal factors (livelihoods, water, energy and food) which are influenced by external factors (hazards, economic growth and pressure, and institutions and policies). Nhamo et al. [36] researched the water-energy-food nexus as an adaptation strategy for achieving sustainable livelihoods at a local level in South Africa. In their study, Nhamo et al. [36], applied an integrated WEF nexus analytical model to holistically assess the availability, distribution, use and management of WEF resources at a local level in Sakhisizwe Local Municipality, South Africa.

Foden et al. [62] conducted a study on the water-energy-food nexus at home and explored new opportunities for policy interventions in household sustainability. In their study, they focussed specifically on domestic kitchens as a site where practices of cooking, eating, cleaning and disposing of waste come together. They argued that these practices have long been targets for policy intervention. Foden et al. [62] document the sequence of interrelated food provisioning activities through which WEF is used in domestic kitchens and contributes to FOG blockages in sewers.

Hussein et al. [63] developed an integrated model, capturing WEF interactions at the end-use level at a household scale in Iraq. Te model is also used to investigate the impact of change in user behaviour, diet, income, family size and climate on the use and management of WEF resources at the household level. Terrapon-Pfaff et al. [64] brought the household dimension of the WEF nexus approach through their study in which they conducted a systematic analysis of the linkages between small-scale energy projects in developing countries and the food and water aspects of development. Their study provides initial insights into how to identified interconnections and the potential benefits of integrating the nexus pillars into local level projects

Policy dimensions of the WEF nexus. Gulati et al. [43] report that policies related to different sectors of the economy could intensify or attenuate the interdependence: or worse, ignore the impact of one on the other and adversely impact the overall nexus. Bizikova [65] conducted a comparative review of case studies to explore integrating the identified nexus linkages into policy design and implementation. She focussed on local and regional challenges in the nexus context, using diverse research methods to assess WEF linkages and the activities integrating identified WEF linkages into the public policy design. She argued that designing successful, policy-relevant WEF assessments depends on focusing on synergies and trade-offs within the nexus; adopting solutions-centred approaches to challenges identified at the earlier stages of assessments; and effectively managing science and policy linkages through institutional partnerships and collaborations between researchers undertaking WEF assessments and key policy and decision-making agencies. In their book, Koulouri and Mouraviev [66] argue that effective engagement of multiple stakeholders can address difficulties arising from introducing an integrated approach to WEF policy design and implementation, increasing the potential benefits.

Shannak et al. [67] pointed out that WEF resources are complex aggregates formed and influenced by the collection of elements, and managing them relies on several factors such as technology choices, fuel choices, resource availability and market factors, which can all be affected by national resource policies. Scott and Pasqualetti [68] reported that multi-tiered institutional arrangements – specifically laws, policies, and organizations that operate across jurisdictional levels for the management of resources – offer a wider set of alternatives for decision-making in the management of water and energy resources. Scott et al. [69] conducted a study on the water-energy nexus policy dimensions in the United States of America. They found that contemporary water policy does consider the energy implications of water use, although often in basic terms of increased financial costs for the energy required to pump, treat, and reclaim water. Sovacool and Sovacool [70] and Carter [71] reported that it is important that national energy policy initiatives actively consider water resource implications.

Kim et al. [21] reported that numerous recent studies had emphasized the significant roles of the energy-water nexus, but institutional and policy directions of the nexus have not been dealt with significantly. Their study focussed on iden-

tifying policy dimensions that support the nexus interactions between water and energy systems and various nexus-based solutions that can address sectoral issues in both systems. Shah [72] conducted a study in which he used the nexus model to integrate water, energy & food for the development of policy framework and its realization. He argued that the nexus model had been used as a suggestive framework for the policy-making for the realization of UN-SDGs. According to Hamdy et al. [73], effective implementation of the nexus approach allows decision-makers to develop appropriate policies, strategies and investments, to explore and exploit synergies, and to identify and mitigate trade-offs among the development goals related to water, energy and food and nutrition security.

Gulati et al. [43] argue that there is an imbalance in the way the nexus plays out in the policy landscape in South Africa, in that the energy and water policies are developed in isolation with no links to each other. Thus, for example, while the aspects of cost, carbon, and energy security have been given significant attention, water needs have not been part of this process. Similarly, energy pricing has not formed part of the water pricing strategy for South Africa to date [43].

Governance and institutional dimensions of WEF nexus. Governance is defined as a government's ability to make and enforce rules and deliver services [4]. On the other hand, Rogers and Hall [3] refer to water governance as the range of political, social, economic and administrative systems that are in place to develop and manage water resources and the delivery of water services at different levels of society. According to the Water Governance Facility[1]., governing water includes the formulation, establishment and implementation of water policies, legislation and institutions, and clarification of the roles and responsibilities of government, civil society and the private sector in relation to water resources and services, and that the characteristics or the attributes of governance have also evolved from a state-centric and hierarchical problem-solving approach to 'good' governance, promoting openness, efficiency, the rule of law, justice, transparency, accountability, broad participation, decentralization and deliberation [2]. Thus, Jiménez et al. [7] argue that water governance is a combination of functions, performed with certain attributes, to achieve one or more desired outcomes, all shaped by the values and aspirations of individuals and organisations. Chiluwe and Nkhata [74], presented a review of the enabling environment for effective water governance in Malawi by specifically determining the extent to which water legislation and policies of Malawi reflect international water governance principles of participation, accountability, and transparency.

According to Scott [75], governance for the WEF nexus can be understood as the formal and informal processes and institutions for integrated policy- and decision-making across the WEF sectors. He further argues that this has similarities with environmental governance, which may be described as the regulatory processes and organisations used by different actors to influence environmental actions and outcomes, and the governance of food security, described by the Food and Agriculture Organization (FAO) as the "formal and informal rules and processes through which interests are articulated and decisions relevant to food and nutrition security in a country are made, implemented and enforced". Governance of the WEF nexus includes a wide range of private and public systems that manage the supply and demand of water, energy and food [76]. Simpson et al. [77] argue that the WEF available literature shows that the nexus framework holds promise for guiding policy development and governance structures in a world facing climate change, population growth, and inequality in terms of access to resources. Al-Saidi and Elagib [78] suggest that a governance focus is one of the missing ingredients in the nexus debate.

The concept of governance is defined differently by different academics (see [79-84]). In this study, the stance of Fukuyama [4] that governance's core is the execution of policy goals is adopted. Fukuyama [4] further argues that, in a more detailed way, governance can be defined as an institution's ability to make and enforce rules and deliver services; hence the quality of governance is defined as the ability of the institution to get things done. In this study, we assess the execution of policy goals in relation to the WEF nexus at the household level.

Cairney [5] argues that the governance and institutional landscapes and the processes, norms, rules and interests that dictate how resources are allocated critically influence how technical information on trade-offs between sectoral objectives is translated into action. A generally agreed principle is that sustainable development requires distinct environmental, social and economic policies combined with more integrated decision-making across all sectors of society [6]. However, these conditions are rarely observed and present a paramount challenge, which is addressed in the academic literature under various concepts of integrative environmental governance (e.g., [85-87]). The challenge of achieving such integrated decision-making and policy coherence is particularly acute in the context of the WEF nexus, which considers three sectors and policy areas with different institutional frameworks operating at different scales [69].

In their case studies, Mouraviev and Koulouri [88] concluded that the successful integration of the WEF nexus conceptualisation for the governance of these sectors is contingent on the effective management of the relational equity of all stakeholders/actors. They adopted the view on collective governance as an arrangement that brings together various actors and public agencies in collective forums, to engage in problem-solving-focused and consensus-oriented deci-

[1]https://www.watergovernance.org/governance/what-is-water-governance/

sion-making and that the collaborative approach is one of the most impactful means of nexus governance, enabled and facilitated by effective relational equity management. In their other study, Mouraviev and Koulouri [89] concluded that among the critical governance areas that require attention are: the integration of climate change in all nexus considerations at all stages, from policy design to implementation; recommendation to depart from unidimensional approach to energy security, water security or food and nutrition security and replace it with multidimensional; a suggestion to hold an ongoing transparent polylogue between all nexus network participants; social inclusion (i.e., women empowerment and youth participation); and securing network participants' commitment to the outcomes for the WEF nexus, rather than for a certain sector. Srigiri and Dombrowsky [90] argue that while WEF scholarship substantiates the biophysical interlinkages and calls for increased and effective coordination across sectors and levels, knowledge about the conditions for effective coordination is lacking. They further argue that effective coordination in complex social-ecological systems is unlikely to be achieved by a single governance model but rather by synergistic combinations of such modes. Particular coordination arrangements that emerge in a given context depend on the distribution of authority, information and resources within and across interlinked decision-making centres.

Naidoo [91], in one of his presentations, emphasized that the WEF resources crisis is rooted more in poor governance than in physical availability; hence, good governance holds the key to achieving sustainable water, energy, and food and nutrition security in Africa. Weitz et al. [92] reported from their work on closing the governance gaps in the water-energy-food nexus that connecting the nexus to decision-making processes requires: i) rethinking the boundaries of nexus analysis vis-à-vis other sectors and levels; ii) elaboration of shared principles that can guide decision-making towards policy coherence − or an appropriate form of fragmentation − in different contexts; iii) viewing policy coherence as a continuous process of changing values and perception rather than as an outcome.

4.3 Gaps in the existing body of literature

The review findings showed that while so much research has been conducted on the WEF nexus approach, there are some areas that still need more research. It is clear from the existing body of literature that there is a lot of research on WEF nexus in general. However, more research is needed to address WEF nexus related innovations and practices and policy, governance and institutional dimensions of WEF nexus. In their report, where they reviewed the water-energy–food nexus research in Africa, Botai et al. [44] contended that, while there is a lot of research which has been conducted on WEF nexus, there is need for more coordinated and collaborative research to achieve impact and transition from WEF nexus thinking to WEF nexus practice. This is why the current research focuses on WEF nexus innovations and practices to move WEF nexus from theory to practice. This assertion is supported by Markantonis et al. [93], who pointed out that the WEF nexus concept still needs to be translated from theory to practice. There is a great need to operationalise the WEF nexus solutions at the household and community levels. This household and community transformation requires understanding the existing and potential WEF nexus innovations and practices applied at the household and community levels and how existing policies and governance systems affect the use and management of WEF resources at these levels.

4.4 The link of the existing body of knowledge to the current WEF nexus research

There are clear links of the current study to the existing body of knowledge as contained in the reviewed literature. Much of the reviewed literature shows that transitioning from theory to practice in the WEF nexus requires multi-sectoral stakeholder capacity building to manage the interlink ages between resources, effective policies and governance systems, and technological innovations and practices. The existing literature also shows that improving the understanding of the nexus approach through innovations and practices is a key to the nexus implementation and informs planning and decision making for policymakers and other stakeholders. Furthermore, it is contended that the lack of innovations may hinder the implementation of WEF nexus agendas that allow, for example, the production of more food with less water and energy resources to help attain SDGs on poverty eradication (Goal 1), zero hunger (Goal 2), availing water to all (Goal 6) and provision of clean energy (Goal 7) [94, 95].

The literature review findings show that there is a need to understand the existing and potential WEF nexus innovations and practices applied at the household and community levels and how existing policies and governance systems affect the use and management of WEF resources at these levels. The current study is focusing on these areas and thus shall contribute immensely to the literature body of knowledge.

5. Conclusion

A review was conducted on the body of literature that covers areas such as global perspectives of WEF nexus, the need for WEF nexus solutions, WEF nexus interlink ages and frameworks, the WEF nexus research in South Africa, WEF nexus innovations and practices, policy and governance and institutional dimensions of WEF nexus and the ap-

plication of WEF nexus solutions at the household and community levels. The review focused on the body of literature that covers areas such as global perspectives of WEF nexus, the need for WEF nexus solutions, WEF nexus interlink ages and frameworks, the WEF nexus research in South Africa, WEF nexus innovations and practices, policy and governance dimensions of WEF nexus and the application of WEF nexus solutions at the household and community levels. Literature also provides a wide range of approaches and methods used to study WEF nexus approaches.

The literature shows that there is growing pressure on the WEF resources and that the WEF nexus approach offers the best ways of managing and utilising the resources sustainably. Sustainable management of the WEF resources requires effective policies and governance systems that create enabling environment for implementing WEF nexus solutions. The literature shows that various WEF nexus frameworks have been developed to understand the complexity and linkages of the nexus resources and provide tools for operationalised the nexus approach. The literature also shows a great need for appropriate WEF nexus innovations and practices that help translate the WEF nexus approach from theory into practice. There is a great need to operationalise the WEF nexus solutions at the household and community levels.

The review findings show that there are various methods and approaches for conducting research on the WEF nexus approach. The ongoing research benefited from the wide range of approaches and methods various researchers have used to study the WEF nexus approach. These approaches provided the basis for developing the methodology for the current study. The literature review findings also highlighted the need to understand the existing and potential WEF nexus innovations and practices applied at the household and community levels and how existing policies and governance systems affect the use and management of WEF resources at these levels. The reported research focused on WEF nexus innovations and practices applied at the household and community levels, and on how existing policies and governance systems affect the use and management of WEF resources at these levels. The next section shall present the research methodology.

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Abbreviations

FAO	Food and Agriculture Organization
SADC	Southern African Development Community
SDGs	Sustainable Development Goals
VDM	Vhembe District Municipality
WEF	Water-Energy-Food
WRC	Water Research Commission

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