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Original Article

FEW Nexus approach (water-energy-food nexus) to sustainable development through the UN SDGs

Abordagem FEW Nexus (nexo água-energia-alimento) para o desenvolvimento sustentável através dos ODS da ONU

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ABSTRACT

Objective/Purpose: To analyze how the FEW Nexus Approach can contribute to the promotion of sustainable development, having the UN SDGs as a goal and serve as a new epistemological and ontological approach in solving problems related to a complex reality of the present day, such as the sustainable development.

Design/methodology/approach: Literature review on the current state of research involving the use of the FEW Nexus Approach, from a global overview to the research scenario on the subject in Brazil. The characterization of the FEW Nexus approach was also made, and its connection with the concepts of sustainable development.

Results: It was demonstrated that the FEW Nexus approach, when related to the concept of sustainable development, can seek in the Sustainable Development Goals the tangible goals that, eventually, this paradigm is criticized for not offering. The analysis helps to understand how, from this perspective, FEW Nexus considers the tradeoffs in the management of natural resources, the possibilities for directing public policies and social and economic programs, using the UN SDGs as targets.

Originality/Value: Demonstrate the applicability of the FEW Nexus Approach within Applied Social Sciences, where this approach is used much less frequently compared to the Hard Sciences. Possibility of offering a contribution to the elaboration of public policies that can address a crucial problem for sustainability, which is the attack on poverty in Brazil and worldwide.

Keywords: Sustainable development; FEW Nexus; UN SDGs

RESUMO

Objetivo/Finalidade: Analisar como a Abordagem do FEW Nexus pode contribuir na promoção do desenvolvimento sustentável, tendo os ODS da ONU como meta e servir como uma nova abordagem

epistemológica e ontológica na resolução de problemas relacionados a uma realidade complexa dos dias atuais, como o desenvolvimento sustentável.
Desenho/metodologia/abordagem: Revisão da literatura sobre o estado atual das pesquisas envolvendo o uso da Abordagem do FEW Nexus, a partir de um panorama global até o cenário da pesquisa sobre o tema no Brasil. Também foi feita a caracterização da abordagem de FEW Nexus, e sua ligação com os conceitos do desenvolvimento sustentável.
Resultados: Se demonstrou que abordagem de FEW Nexus, quando relacionada ao conceito de desenvolvimento sustentável, pode buscar nos Objetivos do Desenvolvimento Sustentável as metas tangíveis que, eventualmente, este paradigma é criticado por não oferecer. A análise auxilia no entendimento de como, nessa perspectiva, o FEW Nexus considera os tradeoffs na gestão de recursos naturais, as possibilidades de direcionamento de políticas públicas e programas sociais e econômicos, utilizando como metas os ODS da ONU.
Originalidade/valor: Demonstrar a aplicabilidade da Abordagem do FEW Nexus dentro das Ciências Sociais Aplicadas, onde essa abordagem é utilizada numa frequência muito menor em comparação às Ciências exatas. Possibilidade de oferecer uma contribuição para a elaboração de política públicas que possam atender um problema crucial para a sustentabilidade, que é o ataque a pobreza em nível de Brasil e mundial.

Palavras-chave: Desenvolvimento sustentável; FEW Nexus; ODS ONU

1 INTRODUCTION

In a context of growing demand, economic development, urbanization and climate change, resources such as water/energy/land/food/human resources are experiencing high pressure to meet increased consumption and support social and economic development, in addition to maintaining current service standards. Within this perspective, the FEW Nexus concept was conceived to study and manage global water and energy resource systems aimed at food production (Hoff, 2011). The word “nexus” means “to connect” (De Laurentiis et al., 2016), and expresses the interactions between two or more elements, whether dependencies or interdependencies. FEW Nexus studies the connections between the elements water, energy and food, as well as their synergies, conflicts and tradeoffs, which arise from the way they are managed, in other words, water for food and food for water, energy for water and water for energy and food for energy and energy for food.

In this sense, the studies adopted the English acronym FEW as representation, which at the same time makes a play on words with the English meaning of the term –

"few", which means "little" – lists two of the most representative natural resources aimed at an essential activity, in a nexus (interaction): Food, Energy and Water. The term, thus, is used broadly, and as an approach oriented towards sustainable development (Liu et al., 2018). By proposing the use of the FEW Nexus as an approach to sustainable development, this study seeks to demonstrate its applicability within Administration and Applied Social Sciences in general, an area that uses the FEW Nexus at a much lower frequency compared to the Exact Sciences.

Population growth, one of the determining factors for this pressure, according to projections by the Food and Agriculture Organization of the United Nations [FAO] (2019), projects that the population will reach between 8.4 and 8.6 billion people by 2030, and between 9.5 and 11 billion in 2100, compared to 7.8 billion in 2020. Historical problems have had positive and significant advances in recent decades, according to data from the United Nations [UN] (2020). The understanding of the limits that natural resources offer has been increasing and gaining prominence in discussions regarding the security of adequate supply of water, energy and food, resources that, in addition to being limited, are interconnected in ways that are not yet fully understood (Bazilian et al., 2011; Biggs et al., 2015; Hoff, 2011; Meadows et al., 1973; Weitz et al., 2014).

In terms of water resources, the rate of water use has grown twice as fast as population growth over the past century. Agriculture accounts for 70% of the global demand for fresh water (FAO, 2017), and the world has 1,400 million cubic kilometers of water, but only 0.003% of this total, about 45,000 cubic kilometers can be considered "fresh water resources", those that can be used for drinking, hygiene, agriculture or industry. With regard to energy, according to the World Economic Forum [WEF], the World Economic Forum (2019), consumption, in all its forms, in addition to allowing the contemporary way of life, influences the way we live, how we cultivate and the we eat, how we move, and even how we work and communicate.

In agriculture, water and energy are complementary resources, substitutes and, in some environments, each is an input in the generation of the other (Liu et

al. 2018). And, when trying to manage and optimize the use of a certain resource, the other will be directly impacted. Each sector tends to adopt its FEW Nexus perspective, depending on the priority given to each of the elements (Allouche et al., 2015). As examples, the construction of a hydroelectric project can impact food production when farmers are removed from land that will be flooded by the reservoir, or how changing an irrigation system that uses canals to a sprinkler or drip system will generally decrease the water direct expense, but the energy expense will be greater. The production of biofuels, for example, demonstrates this interaction between water, energy and food, and how decisions about production affect the interaction between these resources (Mahlknetch et al., 2020). In areas where land and water are limited, the decision to grow sugarcane, corn or soybeans or canola, used in biofuel production, reduces the amount of crops available for food production.

The impacts of such decisions on families, local and distant, are linked to market prices for food and energy and the returns obtained in each activity. Furthermore, the perception of allocating scarce resources to energy at the expense of food production could have policy implications, especially if consumer food prices rise. The scarcity of resources, the difficulty in establishing public policies and adequate management, combined with a growing criticism of the current model of production and consumption, and an increasingly emphatic defense of development that respects social and environmental resources, which has been agreed as sustainable development.

2 METHODOLOGY

A systematic literature review was adopted as a research strategy for the construction of this article, through a qualitative approach, with an exploratory objective and intended to identify, evaluate and interpret relevant research for a given subject (Kitchenham & Charters, 2007).

For this analysis, we searched the literature for studies that brought the scenario of academic research on the approach of the FEW Nexus focused on sustainable development and that has the UN SDGs as goals, with studies aimed at understanding the state of the art on this topic, ranging from a review of the literature on the subject in recent decades, analyzes that present the current state of studies on the FEW Nexus and its trends, highlighting how academic research on the FEW Nexus has been treated, starting from a general perspective and moving forward in details down to the Brazilian context, seeking to demonstrate the potential of using this approach, hitherto unexplored within the Applied Social Sciences, including Administration. Then, a literature review was carried out guided by the findings of the initial stage of analysis, supported by the literature on the FEW Nexus and its connection to the UN Sustainable Development Goals.

In the study by Wiegleb & Bruns (2018), from a discourse analytical perspective, what is driving the study of the FEW Nexus was investigated. Constant publications on the Web of Science (WOS) were used as a research base, using the combinations of the keywords water, energy, food and nexus, and selecting only peer-reviewed files. The authors point out that WOS naturally tends towards the natural sciences, to the detriment of the social and human sciences, as well as older journals.

Since 2009, according to Wiegleb & Bruns (2018), there has been an almost exponential growth in interest in FEW Nexus research, with a sharp increase in publications between 2014 and 2015. The authors relate this increase to the adoption of the SDGs in 2015, where the FEW Nexus plays an important role. According to Wiegleb & Bruns (2018), the analyzed journals explicitly focus on resource management, environmental science topics, technology and sustainable development. In general terms, according to the authors, the most influential FEW Nexus line is shaped by scientific, engineering and natural economic perspectives, which focuses on evaluating the interconnections, trade-offs and synergies

between water, energy and food systems through measurements quantitative data and computational modeling. Articles associated with this line of discourse are cited more frequently and prevail in terms of quantity, having many more researchers and authors.

The alternative FEW Nexus discourse, defined by Wiegleb & Bruns (2018) as marginalized, is characterized by a critical social science community. An alternative perspective predominates, adopting a social constructivist and political approach to resource management and governance, with articles often of a conceptual and theoretical nature. The posture is a criticism of the main line, since few authors shape the alternative discourse and the articles associated with this alternative discourse are cited less frequently, and consequently end up being less influential in conceptualizing the structure of the FEW Nexus.

However, according to Wiegleb & Bruns (2018), both lines refer to practically the same actors, events and institutions, which are part of the international political sphere. Some of these common references include, for example, the United Nations (FAO is included), Rio+20, the Millennium Goals (MDGs) and SDGs and the IPCC platform (Intergovernmental Panel on Climate Change). The World Economic Forum is identified as one of the main promoters of the Nexus and the Bonn 2011 conference is identified as an important milestone in the development of the FEW Nexus concept. The authors conclude their analysis by stating that the current FEW Nexus concept is fragmented and shaped more by separation than by integrative approaches to resource governance.

Newell et al. (2019) conducted a review of FEW Nexus research from 1973 to 2017, also using the Web of Science (WOS) as a basis. According to the authors, research involving the FEW Nexus is relatively recent, with the year 1988 being the year of the first publication on the subject involving the water-energy nexus, which documented how rainfall could affect energy production in Ontario, Canada (Cohen & Allsopp, 1988). Since then, the research domain of the nexus

involving two or all three factors – water, energy and food – has expanded rapidly. According to the authors, most of the articles used quantitative approaches, to the detriment of qualitative ones, especially using integrated evaluation and system dynamics modeling, although the spatial scale was generally recognized, the explicit consideration of multi-scalar interactions was limited. Issues involving institutional structure, governance, and equity in access to resources were also little explored.

In the case of Latin America and the Caribbean, according to Mahlknetch et al. (2020), in their research, also stated that, when compared to other regions, it has few publications and projects related to FEW Nexus. Research in Latin America and the Caribbean focuses on water-energy interactions, considering the water balance and the implications of the water footprint in unconventional oil and gas extraction, as is the case of exploration in oceanic basins, the so-called deep waters, where the Brazil emerges. Studies that analyze the implementation of resource management policies managed by the FEW Nexus approach are incipient, even more considering the characteristics of regional particularities, and their environmental and socioeconomic impacts.

Fontana et al. (2020), in an analysis of the current state of research on the FEW Nexus approach, defined the scope of research carried out by Brazilian and/or international institutions that focus on the study of the FEW Nexus involving the interactions between two or three of the factors water, energy and food in the Brazilian context. To this end, the authors searched for academic documents, including articles, reviews, book chapters and conference papers, in the Scopus, Web of Science (WOS) and SciELO databases. The latter presented a single result, which had already been found in Scopus, and therefore was disregarded.

The search used the terms “water”, “energy”, “food”, “nexus” and “Brazil”, both in Portuguese and in English, and the word “Brazil” was searched both in the title, abstract and words fields, keyword and author affiliation. Documents from

research areas such as medicine, dentistry, genetics, toxicology and limnology were excluded, remaining, finally, in studies that dealt with the FEW Nexus as an approach to resource management, in the Brazilian context. Existing studies in the form of reports, theses and dissertations were not considered, as they are not accessible through the international academic publication system.

Fontana et al. (2020) found 57 academic articles, 44 in the Scopus database and 13 in the Web of Science database. After review, the authors excluded 11 of the articles, for the following reasons: the article was not about the FEW Nexus in any of its variations; the article is not about Brazil nor does it have an author from a Brazilian institution; the words “Brazil” or “nexus” appear in documents referring to other matters; it is a poster or cover of conference proceedings. Also, a document was deleted as it could not be located online.

According to these authors, the first publication on the subject, according to the research parameters, took place in 2014, and research on the FEW Nexus in Brazil, or with the participation of academics from Brazilian institutions, has increased significantly since this year. The period from 2017 to 2018 was marked by the most significant scientific production on the subject, going from 5 to 20 publications. According to the authors, this increase may be related to two calls for research projects by the National Council for Research and Development (CNPq) and the Ministry of Science, Technology, Innovation and Communication (MCTIC). According to Fontana et al. (2020), most dealt with specific case studies in the Brazilian context (35), while the others referred to cases located in other countries or centered on the development of conceptual and methodological issues.

In the analysis by Fontana et al. (2020), the FEW Nexus survey on Brazil also demonstrated that the exact sciences predominate in relation to the social sciences, accounting for a ratio of 3 to 1 of published articles, with 43 and 14 publications respectively. Approaches from a multidisciplinary perspective also have the most publications, with 27, to the detriment of monodisciplinary approaches, with 15

occurrences and only 2 articles were transdisciplinary. Engineering, from different fields, predominates in publications, which in a way also explains the predominance of quantitative studies, and the low participation of social sciences and qualitative or hybrid studies.

2.1 FEW Nexus and Sustainable Development

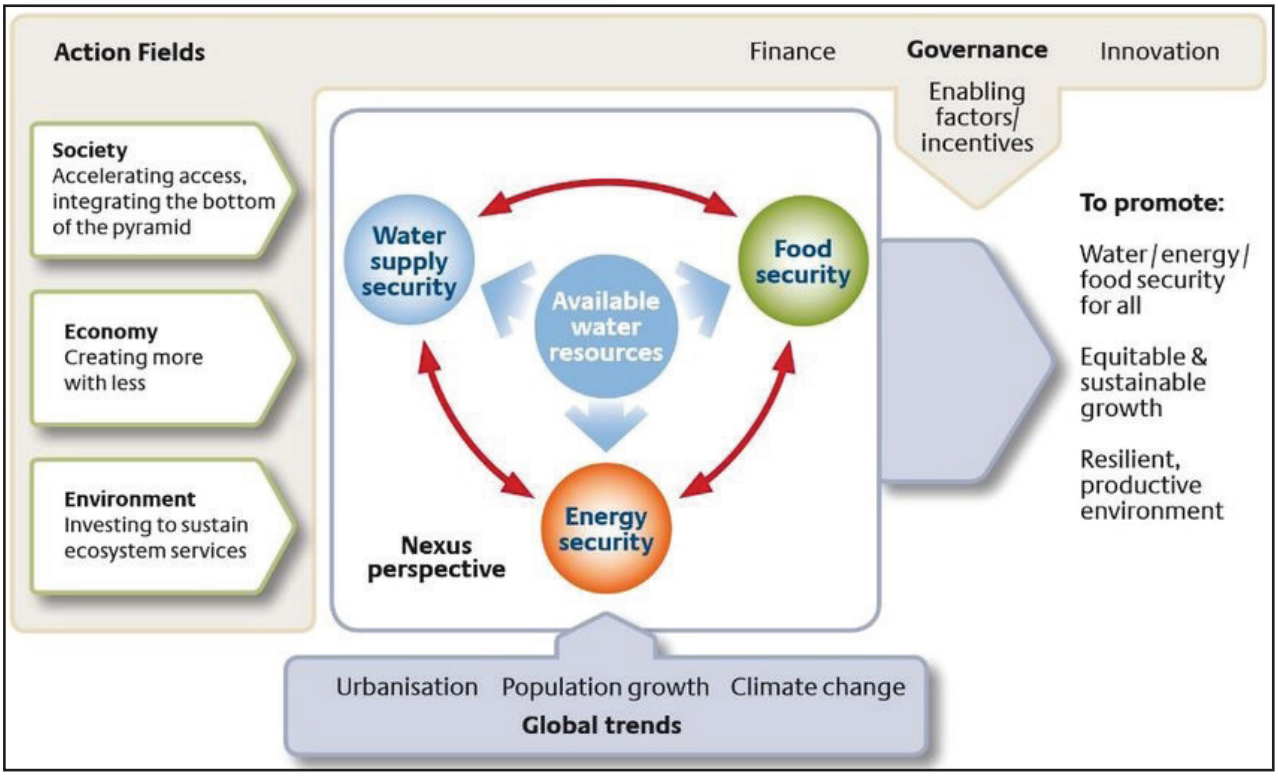
The first mention of the concept of the nexus between water, energy and food occurred at the 2008 World Economic Forum (Cairns & Krywoszynka, 2016), and gained wider prominence and dissemination as part of discussions at the United Nations Conference on Sustainable Development (Rio+20), also known as the Bonn Conference, which was held in 2011, organized by the Federal Government of Germany, the study called "The Nexus of Hydropower and Food Security - Solutions for the Green Economy", by Hoff (2011). The concept drew attention to the possibilities of using this approach in the issue of sustainable development.

This direction can use tangible goals and objectives, already established and widely accepted, represented through the UN Sustainable Development Goals. Raya et al. (2017) describe the two main challenges linked to the implementation of this approach, which are: how to improve the effectiveness of incoming resources without sacrificing development goals; and, the adoption of offset options to implement SDG objectives and national or local development targets.

The dissemination of the FEW Nexus concept gained prominence at the United Nations Conference on Sustainable Development (Rio+20), the Bonn Conference, held in 2011, the work carried out by Holger Hoff brought the FEW Nexus concept as an approach that represents a response to climate and social changes such as population growth, globalization, economic growth and urbanization. The year 2011 was marked as the dissemination of the term, but its genesis dates back to 1983, when the first nexus was established between food and energy, and it has been analyzed and elaborated over the last three decades (Endo et al., 2017 , p.2).

According to Hoff (2011), there is initial evidence of how a FEW Nexus approach can improve water, energy and food security by increasing efficiency, reducing tradeoffs, creating synergies and improving governance across sectors, in addition to supporting public policy recommendations, that can be used in this regard. Hoff (2011), presented at the Bonn Conference, 2011, the scheme, shown in Figure 1, for the FEW Nexus.

Figure 1 – The FEW Nexus, according to the Bonn Conference, 2011



Source: Hoff (2011, p.16)

This link presents both opportunities and potential risks that need to be considered in any approach, since, according to Howells et al. (2013), the implementation of any strategies, policies or initiatives, when concentrated in a specific sector, can influence and even harm the goals in another area. Zhang et al. (2018), for example, cite how the development of bioenergy gained momentum to mitigate climate change, moving away from fossil fuels, but after a few years

it became evident that it has the potential to cause loss of biodiversity and food crisis, as plantations of biomass can compete with food for water and land.

Although the FEW Nexus has been much discussed and researched in recent years, for Cai et al. (2018), despite many reviews and elaborate articles, there is still no consensus on the definition of exactly what FEW Nexus is. This is because the concept is being used by several areas of knowledge.

The authors state that the production, use and safety of food, energy and water are inextricably linked and, like Hoff (2011), combined with a global demand for these resources in continuous increase, together with population growth, guarantee the supply of these resources. Resources with current levels of consumption becomes an increasingly complex and insecure task. According to Hoff (2011), the FEW Nexus proposal is that by assuming that these resources are intrinsically linked, this approach can be used to improve the transition of societies to a green economy and, therefore, broader sustainability. Bhaduri et al. (2015) state that the human and environmental dimensions are and should be the core of the FEW Nexus approach, and address the ecological sustainability on which the well-being of future generations depends.

For Biggs et al. (2015), nexus thinking is designed to promote the inseparable links between resource use to provide basic and universal rights to food, water and energy security. This perspective can be transposed to the SDGs, since the signatory countries committed themselves precisely to new action goals aimed at achieving the sustainable use of water, energy use and agricultural practices, with the general objective of promoting a more inclusive economic development, with focus on poverty reduction. Thus, the FEW Nexus became central to discussions on the development and subsequent monitoring of the SDGs.

More than 40% of the global population is projected to live in areas of severe water stress by 2050. By 2035, water withdrawals for energy production could increase by 20% and consumption by 85%, driven by a shift to more efficient plants

with more advanced cooling systems (which reduce water withdrawal but increase consumption) and increased biofuel production (FAO, 2014).

With regard to energy, the food production and supply chain consumes about 30% of the global total. Energy is needed to produce, transport and distribute food, but it is also directed to extracting, pumping, lifting, collecting, transporting and treating water. Not only hydroelectric power plants, but nuclear power plants or those that use fossil fuel (gas, coal, oil), use water for cooling, and this consumption is responsible for 43% of the total freshwater abstraction in Europe (more than 50 % in several countries), almost 50% in the United States of America and more than 10% of the national water supply in China.

Energy and water are very interconnected and interdependent, as today 90% of global energy generation depends on water (FAO, 2014). Growing demand for a limited supply of water puts increasing pressure on water-intensive food and energy producers to look for alternative approaches, particularly in areas with water scarcity and strong intersectoral competition for water. According to Mohtar & Daher (2012), in the opposite direction, the energy cost of capturing water also tends to increase. The water system is the largest user of energy, mainly through the consumption of electricity for pumping fresh water, drainage and management of the water table, desalination, water treatment and water distribution, whether in rural areas for agricultural production, or in cities for everyday life.

The relationship between the development of bioenergy and food security, as indicated by Mirzabaev et al. (2014), impact that differences in the economic efficiency of resource uses in bioenergy and food production mean that resources will be allocated to the activity with the highest return, which results in higher food prices and change in resource prices natural resources, such as land and water, with significant economic, social and livelihood implications.

According to Bhaduri et al. (2015), the FEW Nexus concept has gained a lot of attention, as developments in water, energy and food are increasingly intertwined

by joint demand, price evolution, technology and resource constraints, being even more influenced by trade, markets and speculations. Political debates on the food price crisis, especially the one that occurred in 2007, raged and the tradeoff between fuel and food was identified as one of the main causes underlying the spikes in food prices. An example is the conversion of agricultural land for the production of biofuels, which puts upward pressure on food prices.

Biggs et al. (2015) demonstrate that FEW Nexus processes allow for making the connection both in the context of local livelihoods as well as broader environmental sustainability, while this multifaceted approach of FEW Nexus makes it applicable to multiple subject areas and disciplines, given its transdisciplinary nature, with multiple scales and meanings of action.

Finally, the FEW Nexus approach, even with the lack of consensus, in some aspects and discussions, is still in progress, demonstrating the potential to act as an integrator of different disciplines, whether exact or social sciences; act on time and space scales simultaneously; and allowed the focus both on micro actions, which can impact on a larger scope, and on macro actions, whether through intersectoral governance or public sector policies, which can contribute to the UN SDGs.

2.2 United Nations Sustainable Development goals and the FEW Nexus

In 2000, during the Millennium Summit, the UN defined the eight Millennium Development Goals (MDGs) in its Millennium Declaration, and which, in 2015, underwent a breakdown and revision, becoming the 17 Goals of the Sustainable Development (SDGs).

With its genesis in international agendas of instruments aimed at the protection of Human Rights, environmental preservation and social equity, the SDGs were constituted in a joint effort between governments and citizens around the world, conducted through supranational organizations, in order to create a global model aiming at eradicating poverty, promoting socioeconomic prosperity,

and the well-being of all, also protecting the environment and combating climate change (FAO, 2017).

The link between the FEW Nexus and the Sustainable Development Goals will be addressed in this study based on the criterion of its representativeness in relation to the FEW Nexus, that is, those indicators that explicitly express the dynamics of the FEW Nexus and socioeconomic development through the reduction of poverty, associated with environmental preservation. Thus, according to Bormann et al. (2017) and UNU-FLORES (2021), eight objectives are relevant for the analysis, SDGs 2, 6, 7, 11, 12, 13, 15 and 17, detailed below, demonstrating their textual correlation with the objectives of this study.

Three of the objectives directly represent Nexus resources. Goal 2, "End Hunger, Achieve Food Security and Improve Nutrition and Promote Sustainable Agriculture", is directly related to the research topic, given agricultural production and food systems. Goal 6, "Ensure the availability and sustainable management of water and sanitation for all", related to the use, availability and optimization of water resources, access to safe water and sanitation for families, as well as opportunities for tradeoffs when combining their use with energy resources in food production. Objective 7, "Ensure access to accessible, reliable, sustainable and modern energy for all", with the evaluation of information on access to electrical energy, the quality of this energy, reliability and sustainability, relating its use within the dynamics of FEW Nexus, geared towards sustainable development.

Goal 11, "Sustainable Cities and Communities", seeks to make cities and human settlements inclusive, safe, resilient and sustainable. Goal 13, "Action against global climate change", which seeks to strengthen resilience and adaptive capacity to climate-related risks and natural disasters in all countries. Goal 15, "Life on Earth", seeks to protect, restore and promote the sustainable use of Earth's ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss. Finally, Goals 12, defined as

"Ensure sustainable production and consumption standards", and 17 "Partnerships and means of implementation", which advocates strengthening the means of implementing and revitalizing the global partnership for sustainable development, as it is understood which represent the integration of the other previously described objectives, while enabling the analysis and focus on productive practices of food production, which, by extension, will involve the distribution, commercialization and consumption of the products generated.

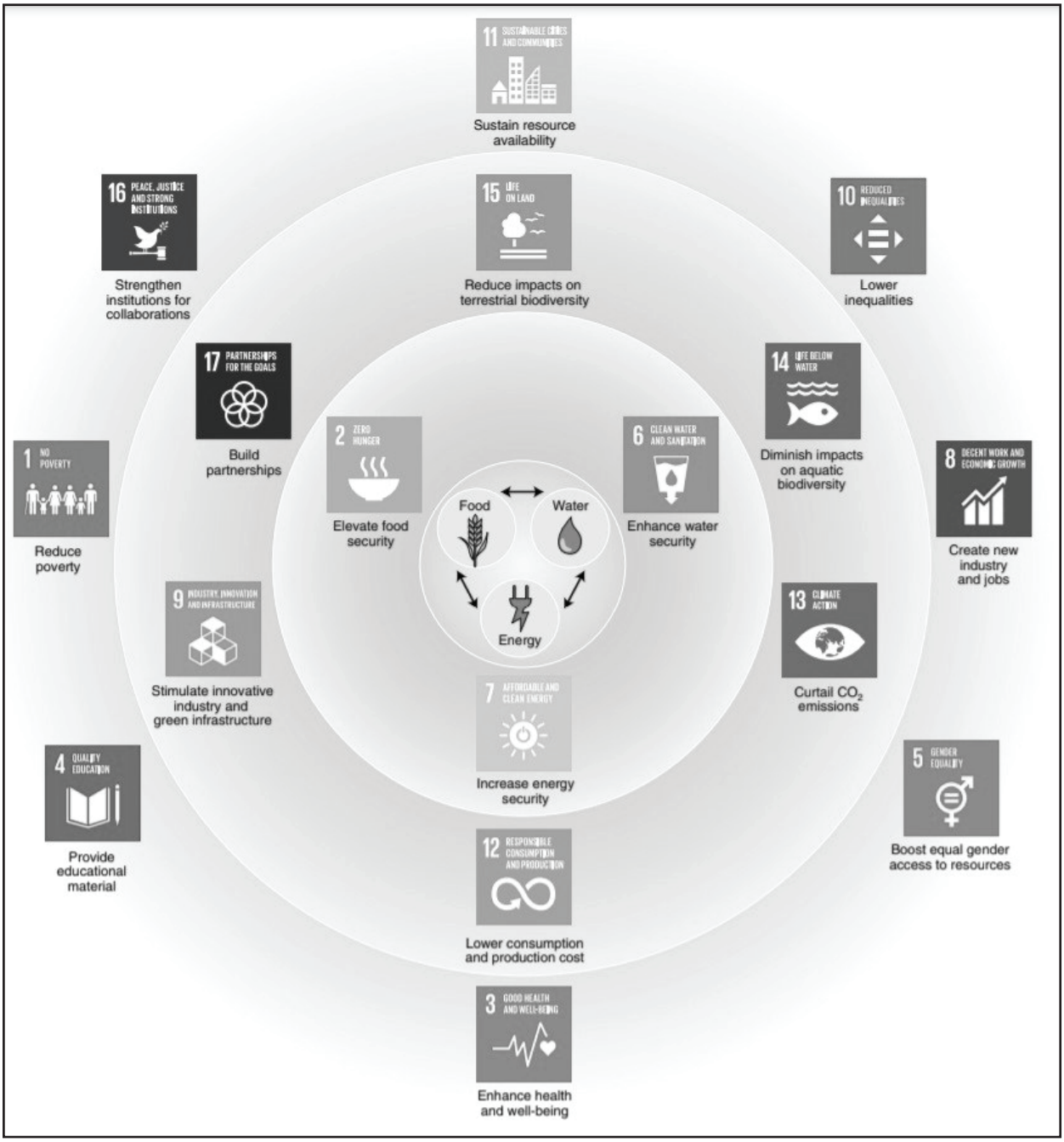
Bormann et al. (2017) state that the value and practicality of the FEW Nexus framework to catalyze and revise delivery against the SDGs has yet to be exactly determined, but what is clear is that with SDGs 2, 6 and 7, the achievement of one without considering the interconnections with the others could result in risks. Furthermore, the authors claim, viewing the SDGs through the lens of the FEW Nexus makes it possible to explain implications for other goals and achieve targets across multiple goals.

According to Raya et al. (2018), the FEW Nexus approach directed at the SDGs requires intersectoral governance that goes beyond individual sectors, and this is not a common practice at the national level, an even more complex challenge when it comes to cross-border levels. The authors suggest that this task should be entrusted to an intersectoral coordination body, which provides the integrated management of the three resources and the various stakeholders involved, with authority to monitor the FEW Nexus modeling process, evaluate results and decide on the allocation of resources. resources and necessary trade-offs between stakeholders' development priorities – managing tradeoffs. For Mohtar & Daher (2017), fulfilling these steps results in the creation of new resources for consumers and, at the same time, does not compromise the availability of existing resources.

So, as stated by Liu et al. (2018, p.467), "water, energy, food interact and can affect all SDGs, although each one is often treated separately", and bring a representation of the interconnection possibilities, illustrated by Figure 2.

Even with such opportunities, Liu et al. (2018) state that few FEW Nexus structures integrated sectors across regions or established specific links with SDG targets and indicators. In addition, they claim that efforts should be made to integrate sociopolitical and biophysical processes, thus making the frameworks more applicable to the real world.

Figure 2 – Impacts of the FEW Nexus Approach on the SDGs



Source: Liu et al. (2018, p.468)

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As stated by Weitz et al. (2014), the FEW Nexus is becoming increasingly prominent on policymakers' agendas, particularly in relation to the post-2015 sustainable development agenda and the Sustainable Development Goals (SDGs), currently under debate at the United Nations, are on the agenda center of this agenda.

The possibilities of this approach associated with clear and recognized objectives, such as the SDGs, make clear the opportunity to develop studies about its application. These are global objectives, jointly defined and recognized both by academia, the market and public authorities, which are easy to understand and adopt, but which nevertheless represent complex challenges, suited to the necessary depth in solving problems related to sustainability and sustainable development.

Endo et al. (2017) state that, although there is no clear definition of the term nexus so far, the FEW Nexus is internationally interpreted as a process to link ideas and actions of different stakeholders, from different sectors, to also achieve sustainable development.

For Liu et al. (2018), the FEW Nexus approach can adequately address sustainable development, as long as it includes the expansion of nexus structures that consider the interactions between different sectors, scales, in adjacent and distant places, and linking them to the Sustainable Development Goals (SDGs) of the UN. To demonstrate how several links are directly correlated to the theme of sustainable development, these authors indicated the connection of these links to the SDGs proposed by the UN, as shown in Table 1.

These interactions formulated by Liu et al. (2018) demonstrate some of the possibilities, none of which extrapolated four of the Objectives. The authors consider

that the FEW Nexus approach allows bringing, in addition to the elements already considered in the scope of the SDGs, other contexts, variables and important actors, creating a dynamic system with an almost infinite number of combinations and interactions. When interacting, the components of a nexus create a new scenario that is greater than the simple sum of each variable, since the interaction itself is a new element.

According to Fontana et al. (2020), was the lack of integration, or of an integrator, between the goals, when defining the MDGs, the reason why the goals were not achieved, or even because they were harmed by actions aimed at achieving other goals, but that did not contemplate mutual interference, or impacts, between objectives.

Table 1 - Direct relationship between nexuses and SDGs

Continue...

Nexos	ODSs
food – energy – water	
water – food – energy – climate	
food – water	
energy – water	
water – energy – land	
energy – water – food – education	
water – energy – people	
women – water	
food – energy – water – health	
tourism growth – water security	
mining – water	
financial autonomy – service delivery – stakeholder participation – water allocation	

Table 1 - Direct relationship between nexuses and SDGs

Conclusion

Nexos	ODSs
climate change – water and food security – energy – social justice	
water supply – property development	
urbanization – water-energy – climate	
food – energy	
energy – economic growth – CO2	
energy – poverty – climate	
renewable energy consumption – economic growth	
food – biodiversity	

Source: adapted from Liu et al. (2018, p.2)

The FEW Nexus approach fulfills this function when defining the subsequent Sustainable Development Goals (SDGs), which at the time of their definition, or redefinition if considered the MDGs, already contemplated the intention of promoting the development of integrated solutions, for the fulfillment of the 2030 Agenda for Sustainable Development.

For Cai et al. (2018), the interdisciplinarity proposed by the FEW Nexus approach, and the complex nature of the topics addressed by it, is not new, especially for researchers in the area of water resources, who face the need for integrated management of resources beyond water, but that affect it directly. According to the authors, the objective of some studies on the FEW Nexus is to improve the efficiency of the system, seek sustainability and increase its performance through the holistic understanding and management of resources, increase cooperation and reduce conflicts, a path that is also followed by those who research sustainable development. Thus, there is convergence with the approach proposed by Allouche et al. (2015)

and the use of FEW Nexus as a tool to face complex problems, such as sustainable development.

Smajgl et al. (2015) deepen this understanding for a system in continuous evolution, arguing that the interactions between the FEW Nexus nodes must be addressed dynamically, since the interactions themselves modify the FEW Nexus continuously. Keskinen et al. (2016) argue that the FEW Nexus content is so rich and complex that it cannot be interpreted from a single perspective, and defined the approach from three aspects, including an analytical method, a governance tool and an emerging discipline , which complement each other.

In addition to factors directly related to the FEW Nexus, such as resource consumption, Zhang et al. (2018) state that FEW Nexus operates as a system, which is usually defined in a given circumstance. Thus, it is necessary to consider that changes in the external environment can complicate the performance of this system, shaping the production and use of water, energy and food through interconnected processes, which go beyond the internal factors of this system. As the authors describe, “external threats refer to the impacts of external forces, entities or actors (climate change, pollution incidents, population growth, politics, etc.)” (Zhang et al., 2018, p.626). The importance of separating external and internal factors lies in identifying the main factors that drive the dynamics of the FEW Nexus system, as well as its usefulness in defining the system boundary and clarifying early-stage research or modeling questions where the FEW Nexus approach will be applied.

There are several methodologies for FEW Nexus research, and no single approach is applicable for all situations (Liu et al., 2018), there is no consensus on FEW Nexus definitions (Endo et al., 2017), and the same presents varied interpretations in different sectors, contexts and by different researchers.

According to Zhang et al. (2018, p.626), in general, there are two categories of definitions. In the first category, the FEW Nexus is interpreted as the interactions between different subsystems within the FEW Nexus system. For example, the water-energy

nexus can be presented as the interdependencies between energy and water, as they are coupled in their supply, processing, distribution and use (Liu et al., 2015). Likewise, when the system boundary is extended to a water-energy-food system, the nexus can be defined as the interconnection between water, energy and food. Thus, water is needed during energy and food production processes. (2018) advance in the analysis of these interactions between water, energy and food, including the interconnected processes, such as the physical and chemical, the input-output relationships during the production of resources, as well as the interactions dominated by institutions, markets and infrastructure.

In the second, more prevalent category, FEW Nexus is presented as an analytics approach to quantify the linkages between nexus nodes (i.e., water, energy, and food). This category presents many interpretations of this approach.

This search and promotion of integrated management, and for energy, water and food security, is reflected in the concept of sustainable development, with global research around the FEW Nexus presenting a holistic structure, which at the same time aims to address development sustainability, usually presented through the Sustainable Development Goals (SDGs) recently proposed by the United Nations, also makes a criticism by stating that they are not properly integrated, especially when referring to the FEW Nexus. For Bazilian et al. (2011) there is an advantage in a FEW Nexus approach, as what changes when treating water, food and energy separately, is that they result in suboptimal decisions, compared to adopting a systems thinking, which allows issues to be resolved. are addressed in a more sustainable and integrated way.

For Allouche et al. (2015), the FEW Nexus approach represents the interconnection between energy, water and food resources in order to resolve tradeoffs and seek synergies between them. Thus, the FEW Nexus is an equation approach for the use of natural resources that conducts the decision-making process based on empirical data, of an analytical and multidisciplinary nature, and which understands that in order to meet the demand for a given resource, such as food, another(s) must be consumed,

such as energy or water. Overall, there is no fixed concept and FEW Nexus is interpreted as a process to link ideas and actions of different stakeholders to achieve sustainable development.

3 PRESENTATION AND ANALYSIS OF RESULTS

Like other approaches, Allouche et al. (2015), if the concept is analyzed in a simplistic way, the FEW Nexus can more easily lead to the commodification of resources, in a utilitarian logic, close to the logic of weak sustainability, minimizing long-term environmental aspects, such as the protection of biodiversity, increased pollution or climate change. This trend could be an attempt to bridge the gap between the approach and the market.

This departure from the initial perspective, of use as an instrument for sustainable development, is explained, in part, because the initial proposal of the FEW Nexus gained great support from the analyzes carried out in previous decades, such as that of Meadows et al. (1973) – which is considered a seminal work on the systemic FEW Nexus by Bazilian et al. (2011) –, based on the approach of environmental limits and which adopt a pessimistic tone, of uncertainties and which, as seen in FAO data (2014), point to a depletion of environmental resources, and focus on the alarmist bias of forecasts . At the same time that this bias contributed to the dissemination of the concept due to its strong appeal, it distanced it from the perspective of its use as a tool for sustainable development.

The FEW Nexus approach presents possibilities to instrumentalize the study of sustainable development, according to Liu et al. (2018). Many of the global challenges, although interconnected, were, until recently, addressed individually, eventually reducing one problem and exacerbating others, and for the authors the FEW Nexus approach allows to simultaneously examine the interactions between several sectors. Recent quantitative studies have revealed that FEW Nexus approaches can uncover synergies and detect tradeoffs across sectors. If implemented well, FEW

Nexus approaches have the potential to reduce negative surprises and promote the integration of planning, management and governance.

Even with potential flaws, if interpreted inappropriately, the FEW Nexus approach demonstrates the potential to be a tool for sustainable development. Allouche et al. (2015) consider that the FEW Nexus approach can create alternative paths of sustainable development. To be effective, it must address poverty and remedy inequality and social injustice, adopting an approach that: a) explores the interaction of ecological, social and technological systems at all scales; b) consider the role of science and technology and technological choices; c) highlight the importance of the local context and the diversity of forms of knowledge; d) recognize the value of plural ways of understanding problems and solutions, and defining development and its objectives; and, e) recognize the highly political nature of associated decision-making.

According to Pedrozo et al. (2014), when there is a discussion about sustainable development, in a context of stakeholder participation, the most important thing is not the attempt to answer whether something is sustainable or not, but to adopt a process logic, in which progress is made continuously towards more sustainable practices and actions. In this understanding, the FEW Nexus approach is adequate to serve as a reference framework in the process, as well as to provide an approximation with the social aspects, which were in the background in the 1990s and 2000s, which strengthened the concept of development sustainability adopted by the organizational environment, normally linked to environmental and social development supported by business success. However, this does not prevent and, on the contrary, encourages its use as a natural resource management methodology, as long as the complexity of the methodology is understood, and the key sectors for sustainable development are involved, making the FEW Nexus approach a tool for this solution.

For Biggs et al. (2015), the FEW Nexus provides approaches that include both top-down (from top to bottom) and bottom-up (bottom to top) directions. Approaches to sustainable development have focused on top-down quantitative indicators, based

on scientific knowledge and have tended to measure progress at national, regional and global levels; and sustainable livelihoods approaches tend towards more bottom-up qualitative analyzes of data obtained at household, community and local levels.

Hussien et al. (2017, p.379) demonstrate the scope of the FEW Nexus by presenting the structure of an integrated model developed for the consumption of water, energy and food on a household scale. In the developed model, the impact of changes in lifestyle, family size, family income, equipment efficiency and climate change - increase or decrease in the duration of summer - on the future demand for water, energy and food was considered, but they also point out that the same model "can be expanded to include the demand for water, energy and food and their interactions in the other sectors (agricultural, industrial and commercial) of a city".

According to Mercure et al. (2019), the FEW Nexus is one of the most complex sustainability challenges facing the world, and this is particularly true in Brazil, where poorly understood interactions within the FEW Nexus contribute to large-scale deforestation and changes in land use, in water and energy scarcity, and greater vulnerability to climate change. According to the authors, there is a combination of global environmental and economic changes that place unprecedented pressure on the Brazilian environment and ecosystems, and the FEW Nexus can especially help in identifying governance deficiencies, and they conclude that it is necessary to adjust the scientific approach to these challenges as an enabling condition to strengthen scientific policy bridges for sustainability policy making.

Liu et al. (2018, p.6-7) state that the FEW Nexus structures need to be expanded in several ways, and draw a link with the SDGs by listing four main perspectives:

1) more and different sectors need to be included, such as alternative energy sources. The numerous links between agriculture, diet, health, Greenhouse Gas (GHG) emissions, biodiversity, water and energy are strong enough for effective policies to consider all these sectors simultaneously.

2) establish connections at different scales and levels, from small to large. For

example, FEW Nexus at the state level can affect multiple city sectors as well as the national and international levels;

3) Application-wide FEW Nexus frameworks are needed to simultaneously address multi-place nexuses and the growing spatial separation between resource production and consumption, which can reallocate costs and benefits across different places. In other words, achieving the SDGs in one place can improve or compromise the SDGs elsewhere. A very clear example of how the FEW Nexus works globally: food trade can affect the FEW Nexus (a) in food exporting countries, increasing water and energy consumption for the food produced, (b) in food importing countries reducing water and energy use for the food consumed, and (c) globally increasing or decreasing the overall efficiency of resource use and associated environmental impacts;

4) Fourth, FEW Nexus approaches can help achieve the SDGs because SDG goals are interconnected and linked to sectors of a particular nexus. For example, as already seen, the FEW Nexus is directly linked to SDG 2 (zero hunger), 6 (clean water and sanitation), 7 (clean and affordable energy) and 12 (responsible consumption and production), and this nexus affects directly or indirectly all other SDGs, such as improving human health and well-being (SDG3), and especially SDG 1 (poverty reduction).

According to Venzke & Nascimento (2013), problems related to sustainability could be easily embedded in traditional disciplinary approaches, such as chemistry, ecology, physics, geography, history, sociology and economics. However, what makes problems related to sustainability peculiar and distinct, when analyzed from the perspective of these disciplinary approaches, is that the real world is much more complex, and requires an integrative approach that offers a dynamic solution of systems thinking, and in constant change and evolution, which does not tend towards simplifying solutions or idealized compensation (citing the Kyoto Protocol).

As Batie (2008) states, even when dialogue takes place, and even if it includes all actors, clear solutions rarely emerge; rather, negotiation processes are identified that are judged to be better or worse - not right or wrong - in addressing the complex

problem. On the other hand, this difficulty of the normal sciences can be interpreted as an opportunity to apply the FEW Nexus paradigm as an integrative solution.

It is interesting to note that the nexus paradigm as an approach to sustainable development is little explored in Brazilian academic research. In a survey carried out at the Brazilian Digital Library of Theses and Dissertations (BDTD) looking for theses and dissertations on the subject, only 2 works included sustainability or sustainable development in their subjects or abstracts, in the period of 1983, date of the oldest study that appears in the basis, until the year 2020.

One from Mechanical Engineering and another from the area of Sustainable Development. The first (Ferreira, 2020) uses them as ancillary literature in the historical construction of sustainable development, and the other (Moraes dos Santos, 2020), addresses the Sustainable Development Goals (SDGs) both in the historical construction, and as a complementary perspective to the FEW Nexus paradigm, used, in this case, as an approach aimed at sustainable development, and fundamental in the construction of his thesis.

And finally, the area of Administration, Applied Social Sciences, presents only one master's thesis (SOBROSA, 2017), which involves the economic benefits of integrating beef cattle breeding in the area of photovoltaic plants, but does not deal with the social benefits, or includes the nexus and sustainable development in its title.

CONCLUSION

Sustainable development is directly linked to one of the most complex contemporary issues, both for society in general and in the field of academic studies: the rational use of natural resources. The water-energy-food nexus approach, better known as FEW Nexus (Food-Water-Energy), through the principles contained therein, has the potential to act as a guide and contribute to the promotion of sustainable development.

The FEW Nexus approach focused on sustainable development already finds a solid base of initiatives with field tests, academic and institutional research, offering frameworks that contemplate multiple levels, sectors and scales, as well as different indicators and types of modeling, with greater use of quantitative analysis in the exact sciences, or that seek to privilege qualitative issues in the applied social sciences, in addition to allowing both the top-down and bottom-up approaches, via a process logic that integrates ideas and actions towards a green economy, that is, an effort to integrate sociopolitical and biophysical processes.

In this way, the approach of FEW Nexus when related to the concept of sustainable development, can seek in the Sustainable Development Goals, the tangible goals that, eventually, this paradigm is criticized for not offering, in addition to enabling the approximation with different areas (Borman et al., 2017; FAO; 2017; Raya et al., 2018). And, in the case of this proposal, specifically with the area of management and administration, which as a rule are restricted to the area of governance or, sectorally restricted, to aspects of inputs represented by natural resources, in addition to involving actors who are directly affected, but that as a rule do not participate in the modeling decisions or even their use. In this way, there is an effort to resolve the tradeoffs and seek synergies through the integration between planning, management and governance. And, this is a prominent role that the academy can offer.

This study intends, therefore, to have demonstrated the connection between the FEW Nexus approach and the Sustainable Development Goals, which by nature are interconnected, in addition to demonstrating its applicability within the applied social sciences where, according to the authors, this approach is used in a much lower frequency compared to the exact sciences. In addition, there is the possibility of offering a contribution to the elaboration of public policies that can address a crucial problem for sustainability, which is the attack on poverty in Brazil and worldwide, and, by proposing the adoption of the Sustainable Development Goals (ODS) of

the United Nations (UN), allows the adoption of goals that are widely recognized, disseminated and already used.

Thus, the FEW Nexus approach, when correctly modeled, can act as a new epistemological and ontological approach in solving problems related to a complex reality of the present day, as the object of this analysis, sustainable development, within Applied Social Sciences, including the administration. In addition, the consumption and production of natural resources, mainly water, energy and food resources, can adopt the SDGs as guidelines and goals, and therefore enhance the integrated management of such resources, in addition to improving their safety, availability, quality and management.

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Contribution	[Author 1]	[Author 2]
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2. Development of hypotheses or research questions (empirical studies)		
3. Development of theoretical propositions (theoretical work)	√	
4. Theoretical foundation / Literature review	√	
5. Definition of methodological procedures	√	√
6. Data collection		
7. Statistical analysis		
8. Analysis and interpretation of data		√
9. Critical revision of the manuscript		
10. Manuscript writing	√	

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