



Redes. Revista do Desenvolvimento Regional

ISSN: 1414-7106

ISSN: 1982-6745

revistaredes@unisc.br

Universidade de Santa Cruz do Sul

Brasil

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Sustainable development and social-ecological resilience: agenda for a sustainable transition of territories
Redes. Revista do Desenvolvimento Regional, vol. 26, 2021, January-December
Universidade de Santa Cruz do Sul
Santa Cruz do Sul, Brasil

DOI: <https://doi.org/10.17058/redes.v26i0.16759>

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Sustainable development and socio-ecological resilience: An agenda for sustainable territory transition

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Abstract

It is assumed that the various problems associated to the development process of Brazilian regions collide with a lack of consideration on issues and relationships concerning the environment-society binomial. In this article, we are concerned with the following question: how to make communities more resilient when facing a global climate change context and the acceleration of environmental degradation vectors? The article aims to develop a research and social practice agenda intended to explain and promote sustainable territory transitions through a bibliometric research based on the terms sustainable development and socio-ecological resilience. The bibliometric analysis focused on identifying the main theoretical and methodological references and central themes addressed in selected studies carried out between 2000 and 2020. The analysis of the obtained articles identified three main approaches: a) studies on the reduction of socio-environmental disaster risks; b) assessments concerning ecosystem service resilience and; c) the development of public policies for natural resource management. The common point among the analyzed articles is the search for the identification, analysis and solutions to minimize the negative impacts of anthropic action on the natural environment. Therefore, an agenda for future research comprising the examination of issues associated to the development of efficient methodologies for assessing the resilience capacity of the natural and social environment facing human activity effects and climate change is suggested. Furthermore, the results demonstrate the need for a risk and resilience governance practice agenda, with strong social participation.

Keywords: Sustainable Development. Social-Ecological Resilience. Bibliometric Research. Climate Change.

Desenvolvimento sustentável e resiliência socioecológica: agenda para uma transição sustentável dos territórios

Resumo

Pressupõe-se que os diversos problemas relacionados ao processo de desenvolvimento das regiões brasileiras esbarram na falta de consideração das questões e relações sobre o binômio ambiente - sociedade. Neste artigo, tem-se a preocupação com a seguinte questão: como fazer com que as comunidades sejam mais resilientes fazendo frente a um contexto de mudanças climáticas globais e à aceleração dos vetores de degradação ambiental? O artigo objetiva elaborar uma agenda de pesquisa e de prática social voltada a explicar e promover transições sustentáveis nos territórios, por meio de uma pesquisa bibliométrica a partir dos termos desenvolvimento sustentável e resiliência socioecológica. A análise bibliométrica centrou-se em identificar as referências teóricas e metodológicas e as temáticas abordadas em estudos de casos brasileiros publicados entre os anos 2000 e 2020. A análise dos artigos permitiu identificar três abordagens principais: a) estudos sobre a redução de risco a desastres socioambientais; b) avaliação da capacidade de resiliência dos serviços ecossistêmicos e; c) o desenvolvimento de políticas públicas para a gestão dos recursos naturais. O ponto comum entre os artigos analisados é a busca por identificar, analisar, avaliar e procurar soluções para minimizar os impactos negativos da ação antrópica no meio natural. Sendo assim, sugere-se como agenda de pesquisa o exame de questões relacionadas, com o desenvolvimento de metodologias eficientes para a avaliação da capacidade de resiliência do meio natural e social, frente aos impactos de atividades humanas e das mudanças climáticas. Além disso, os resultados expõem a necessidade de uma agenda de prática de governança dos riscos e da resiliência, com forte participação social.

Palavras-chave: Desenvolvimento Sustentável. Resiliência Socioecológica. Pesquisa Bibliométrica. Mudanças Climáticas.

Desarrollo sostenible y resiliencia socioecológica: una visión general de la producción científica internacional de 2000 a 2020

Resumen

Se asume que los diversos problemas relacionados con el proceso de desarrollo de las regiones se topan con la falta de consideración de los temas y relaciones sobre el binomio medio ambiente-sociedad. En este artículo, nos preocupamos por la siguiente pregunta: ¿cómo hacer que las comunidades sean más resilientes a las externalidades provocadas por las dinámicas productivas y, en consecuencia, desarrolladas en la lente de la sostenibilidad? El artículo tiene como objetivo desarrollar una agenda de investigación y práctica social orientada a explicar y promover transiciones sostenibles en territorios, a través de una investigación bibliométrica basada en los términos desarrollo sostenible y resiliencia socioecológica. El análisis bibliométrico se centró en identificar las principales referencias teóricas y metodológicas y los temas abordados en los estudios de caso brasileños seleccionados entre los años 2000 y 2020. El análisis de los artículos permitió identificar tres enfoques principales: a) estudios sobre la reducción del riesgo de desastres socioambientales; b) evaluación de la resiliencia de los servicios de los ecosistemas y; c) el desarrollo de políticas públicas para el manejo de los recursos naturales. El punto común entre los artículos analizados es la búsqueda de identificar, analizar, evaluar y buscar soluciones para minimizar los impactos negativos de la acción antrópica sobre el medio natural. Por ello, se sugiere como agenda para futuras investigaciones el examen de temas relacionados, principalmente, con el desarrollo de metodologías eficientes para la evaluación de la capacidad de resiliencia tanto del medio natural como social, frente a los impactos de las actividades humanas y los cambios climáticos. Además, los resultados exponen la necesidad de una agenda de prácticas de gobernanza de riesgo y resiliencia, con una fuerte participación social.

Palabras clave: Desenvolvimento sustentável. Resiliência socioecológica. Investigação bibliométrica. Mudanças climáticas.

1 Introduction

The current socio-environmental crisis is driven by environment-society relationship imbalances, where human activities are taking the earth into a planetary era of unknowns (STEFFEN *et al.* 2015; IPCC, 2018). In this context, the current changes in the planet's climate may be related to these socio-environmental asymmetries, where expansion of extreme weather events and their unpredictability, increased disease and contamination, greater incidence of social conflicts, exodus and social vulnerability and, consequently, social and environmental disasters, are noted (UNISDR, 2015; IPCC, 2018). In short, rapid planetary changes require both populations and risk management systems to adapt to the risk scenarios imposed by this crisis.

We may be now at a point where there is no turning back. Managing the impacts of human-induced pressures on the Earth's life support system is the greatest challenge humanity has ever faced (STEFFEN *et al.* 2015). Several authors look to the concept of resilience as an ecologically viable and socially equitable form of development. The concept of socio-ecological resilience refers to the ability of a socio-ecological system to recover easily or adapt to adversity or unexpected changes. However, it was not until the end of the 20th century that both terms entered the global agenda. These concepts demonstrate concerns with economic aspects, although undissociated from social and environmental problems. As such, sustainable development and resilience are inextricably linked. A content examination of the main theoretical and methodological references of recent research on development and socio-ecological resilience can comprise an agenda for sustainable territory transition. In this sense, an analysis on published studies is paramount, and the investigated concepts may display different approaches, enriching the framework concerning this thematic relationship.

This article aims to present new inferences concerning research and a social practice agenda aimed at explaining and promoting sustainable territory transitions through a bibliometric analysis based on the terms sustainable development and socio-ecological resilience. We sought to assess indicators concerning how this field of research developed between 2000 and 2020, considering the fulfillment of the following objectives: i) identify the main methodological theoretical references applied in Brazilian case studies used in research on sustainable development and resilience. The choice refers to Brazilian case studies, justified by the fact that sustainable transitions for specific territories need to be, in this case, appropriate for the Brazilian context and; ii) the classification of emerging themes in resilience and sustainable development research. Conclusions are drawn from the results on current research trends and patterns on the role of resilience on regional development, which, in turn, provides clues for a research agenda and social practices aimed at explaining and promoting sustainable territory transitions.

At first, this study seeks to recover the understanding of how the concept of development has manifested itself over the years, beginning with the correlated idea of economic growth in itself and reaching the perception of sustainability as a

feasible transformation condition. The aim then comprised understanding how development reflects on the quality of life of populations, which is, in fact, the main real characteristic. In this sense, international organizations aimed at promoting development recognize that no development is possible when progressive deterioration of the environment and natural resources takes place. New perspectives linked to Ecodevelopment studies emerge at this time and become disseminated, in contrast to strictly economic rationalization. Finally, the multidimensional development perspective is noted, comprising innovation with regard to developing territory transformation.

The perspective of eco-development, however, centered on sustainability, was not completely accepted by everyone in the international community, as this concept denotes a pattern of structural and social economic changes that, for some, hold back territorial productive capacities. The allegation that the environment cannot be considered an obstacle to economic expansion generated a series of discussions that culminated in the replacement of the term ecodevelopment with sustainable development, a milder way to describe the same concept for some nations that feared productive setbacks and loss of power capabilities. Even so, this concept was presented as a consequence of social, economic development and environmental preservation, aiming at socio-environmental justice, social inclusion, eco-efficiency and environmental preservation.

Sustainable development thus became an appeasing term much criticized for over three decades for representing a justified adjustment of the need for expansion and industrial production advancement. In this context, troubled urban relations are noted, evidenced by the growing exploitation of the natural environment in favor of so-called “progress” and “development”. This situation gives rise to a series of socio-environmental problems such as climate change. In this sense, we search for alternatives so that the planet does not reach its support limit, and is still able to maintain its balance and essential functions. In this proposal, the term socio-ecological resilience is associated to the model brought about by sustainable development.

The socio-ecological resilience evidenced in the 1970s by Canadian ecologist CS Holling demonstrated that ecological system balance takes place in the conservation of environmental services considered necessary for the social well-being of populations, making both society and the environment capable of withstanding certain levels of stress. Realizing that resilience is a factor that can minimize social vulnerability and foster sustainable development, an understanding of its approach in the scientific debate was sought out in recent decades.

In this study, a bibliometric survey was carried out employing the EBSCO database, investigating full texts in English, published in academic journals, analyzed by experts and published between 2000 and 2020 regarding sustainable development and later complemented by the term socio-ecological resilience. A research and social practice agenda is suggested from the analysis of the obtained publications, aiming at the promotion of sustainable territory transitions. Such proposals seek to examine issues associate to assessments regarding the impacts of human activities on the natural environment employing statistical samples of potential impacts at different scales and sector, assessments concerning climate

change effects at different scales and cycles (global-national-local; local-national-global), and studies on the protection of local ecosystem services as a sustainable economic development vector. Therefore, it is expected that the development perspective be based on an agenda that addresses climate change and that is vigilant in accelerating environmental degradation vectors, strengthening the resilience of socio-ecological systems.

2 Sustainable development and socio-ecological resilience relationships

The development concept is widely discussed in different social sciences areas. The term is highly complex, requiring understanding in addition to a reductionist view. The search for development is not only part of the daily life of territories, regions, states and countries, but also of individuals. Traditional development thinking is intrinsically linked to economic growth concepts (GOMES, 2018), i.e., for many centuries development was synonymous with economic growth. Socio-environmental problems and conflicts arise within this almost hegemonic framework. The challenge is to approach more sustainable development actions amidst the shackles imposed by the current economic system, which aims at

economic growth accompanied by an improvement in the quality of life, that is, it must include "changes in the composition of the product and the allocation of resources by the different economy sectors, in order to improve economic and social well-being (poverty, unemployment, inequality, health, food, education and housing conditions) indicators (OLIVEIRA, 2002 p. 38).

This thought only appeared in the second half of the 20th century, becoming more complex and less linear in its conception and application. During this period, the environmental issue was introduced within the discussion development. "Concerns regarding environmental preservation were generated by the need to offer the future population the same conditions and natural resources that we have" (OLIVEIRA, 2002, p. 42). From 1972, at UNCED in Stockholm, people begin to understand that there is no development in the face of environmental deterioration. In this context, Maurice Strong and Ignacy Sachs coined the term Ecodevelopment in 1973, seeking solutions for development in each ecoregion (2007). Ecodevelopment is born as one of the main concepts in opposition to economic rationalization, designating:

A new development style and (participatory) approach to planning and management, guided by an interdependent set of ethical postulates, namely meeting fundamental human needs (material and intangible), promoting the self-confidence of populations involving lives and the cultivation of ecological prudence (SACHS, 2007, p. 12)

The five ecodevelopment dimensions are developed from this configuration, as follows: i) social dimension – seeks to reduce inequalities, as well as substantially improve the rights and conditions of the population mass; ii) Economic dimension – aims to increase production and social wealth, without external dependence; iii) Ecological dimension – defends the improvement of environmental quality and the preservation of energy sources and natural resources for the next generations; iv)

Spatial dimension – aimed at a more balanced configuration and a better territorial distribution of human settlements and economic activities and; v) Cultural dimension – seeks to avoid cultural conflicts with regressive potential (SACHS, 2007). Despite environmentalist recognition, the term ecodevelopment did not gain strength globally, considering the cold war and political polarization context of the time.

In 1979, the environmental issue enters the Global agenda again with the publication of “The Responsibility Principle” by Hans Jonas. In the 1980s, the International Union for the Conservation of Nature and Natural Resources (IUCN) published the “World Conservation Strategy”, which established a precursor to the concept of sustainable development. In 1983, the Commission on Environment and Development (WCED) was created and constituted as an independent body by the UN General Assembly. Thus, the concept of Sustainable Development is coined in the debates of the famous “Brundtland Report”. This document entitled “Our Common Future” is part of a series of initiatives that reaffirm a critical view of the development model adopted by industrialized countries.

Development that seeks to meet the needs of the current generation, without compromising the ability of future generations to meet their own needs, means enabling people, now and in the future, to reach a satisfactory level of social and economic development and human fulfillment and cultural while making reasonable use of land resources and preserving natural species and habitats (Brundtland Report, 1987, p. 46).

Sustainable development should be a consequence of social, economic development and environmental preservation and aims at elements such as socio-environmental justice, social inclusion, eco-efficiency and the preservation of the environment (NÓBREGA; MUSSE, 2019, p. 319). The idea of sustainability arises derived from sustainable development. "This consists of finding means of production, distribution and consumption of existing resources in a more cohesive, economically efficient and ecologically viable way" (NÓBREGA; MUSSE, 2019, p. 321).

Despite criticism, the concept of sustainable development became a global consensus in 1992 at the emblematic Earth Summit that became known as Rio-92. One of the main results was the implementation of the Global Agenda 21, developed through a consensus of the governments and civil society institutions of 179 countries. Sustainable development aims to list the objectives to be achieved by societies in the move towards sustainability, such as partnership and awareness, commitment to global solutions, priority definitions, and projects that address the social, environmental and economic dimensions. Sachs (2007, p. 254) states that the recommendations derived from Rio-92 [...] advanced in the opposite direction to the liberal counter-reform which, at the time, was at its peak [...]. So much so that the ten years that followed the Rio conference were restricted, in several aspects, to a RIO+10, which took place in Johannesburg, South Africa in the year 2002. The conference was centered on sustainable development and aimed for the adoption of an action plan on various themes: poverty and misery, consumption, natural resources and their management, globalization and compliance with human rights, among others. This meeting was considered unproductive, reinforcing the role of

the economic market in appropriating ecological concepts. Sachs (2007, p. 254) states “I don't think the Johannesburg conference has put things back on track”.

In 2012, the Rio+20 conference opened space for a topic still scarcely discussed, namely governance in a sustainable development scenario. This event was a milestone, as the 17 Sustainable Development Goals (SDGs) were born at the United Nations Conference on Sustainable Development that is part of the UN's 2030 Agenda. The SDGs cover social and economic development issues, including poverty, hunger, health, education, global warming, gender equality, water, sanitation, energy, urbanization, environment and social justice and represent a decision to place the world on a sustainable path, encompassing all populations, especially those in more vulnerable situations (UN, 2020).

However, reality has exposed troubled urban relations evidenced by the growing exploitation of the natural environment and puts in check the maintenance of the so-called “progress” and “development” (SEN, 2018; FILHO, 2017). This rigid development process causes several socio-environmental problems such as climate change, stratospheric ozone loss, ocean acidification, the biogeochemical nitrogen and phosphorus cycles, changes in biosphere integrity associated with loss of biodiversity, land use changes, the indiscriminate use of water resources and increasing atmospheric aerosol particle charges.

Among these phenomena, climate change is a major challenge to humanity and governments worldwide, requiring urgent responses from governments, as well as management model and international policy adaptations. The Convention on Climate Change (CCC) and the Intergovernmental Panel on Climate Change (IPCC), which aim at scientific assessments in support of the CCC, employ different climate change definitions. The CCC defines climate change as “alterations directly or indirectly attributed to human activities that transform the global atmosphere composition and add to natural climate variability in comparable periods” (PIELKE Jr, 2004, p. 31; BLANK, 2015).

A consensus among scientists and several world leaders is noted, where atmospheric composition is changing due to gas and aerosol emissions caused by human activities (STEFFEN, 2015; EPA, 2016; DOW; DOWNING, 2016; IPCC, 2018; Walker et al. , 2020). According to the IPCC (2018), if the main emitting countries do not act, planetary temperatures could increase by up to 4.8° by 2100. To contain global warming escalation, a scientific report released in South Korea analyzed the prospects of limiting global warming to 1.5°C (IPCC, 2018). If greenhouse gas emissions continue to increase at current rates, sea levels could rise up to 82 cm and cause significant damage in most coastal regions around the globe (IPCC, 2018). Climate change may cause intense socio-environmental conflicts, such as disasters, urban exodus, enhancing social and cultural inequalities, including in Brazil.

[...] Poor regions in Africa, Latin America and Asia are those that have the least opportunity for adaptation and are, therefore, the most vulnerable to changes in rainfall dynamics (with floods and droughts), decreases in food production, including those obtained from fishing, biodiversity losses and human health effects. In other words, poorer areas are even more susceptible to climate change effects (IPCC, 2018, p. 28).

The climate crisis has received global attention in recent decades, during which important protocols and conferences to discuss the subject took place. The main climate document comprises the Kyoto Protocol 1997 - 2012. Currently, the main climate treaty is the Paris Agreement - 2015. The United Nations Framework Convention on Climate Change (UNFCCC) aims at greenhouse gas emission reduction measures from 2020, in order to contain global warming below 2° C, preferably 1.5° C, and strengthen the capacity of countries to respond to the challenge in a sustainable development context. Given this, it is paramount to insist on collective mobilization to implement new “socially fair and ecologically prudent development styles” (Vieira, 2007, p.26). Several scientists, researchers and scholars explore the resilience concept as an essential sustainable development model.

The concept of resilience basically comprises the ability to recover easily or adapt to adversity or change. Thomas Young was one of the first to use the term, in 1807, to define the ability to return to the original state in his experiments with malleable materials. The term researched in this article refers to socio-ecological resilience, which became known from the 1970s onwards, thanks to the work of Canadian ecologist CS Holling, with the publication of the article titled Resilience and Stability of Ecological Systems (1973) (GUNDERSON; FOLKE; JANSSEN, 2019). The concept of socio-ecological resilience has evolved considerably and shares several definitions, emerging from the urgent need for new values and behaviors through transdisciplinarity (SOUZA, 2017),

[...] the key idea is that the unavoidable uncertainties and surprises in the dynamics of complex systems make their management unfeasible for a predetermined trajectory; rather than driving in a specific direction, it is better to strengthen system capabilities and characteristics that maintain flexibility for survival, learning and adaptation during a dynamic and unpredictable change process. (Buschbacher, 2014, p. 12).

To Holling (1973, p.6) "socio-ecological resilience is the ability of an ecosystem to return to an equilibrium or steady state after a disturbance (which is also defined as stability by some authors)". Folke (2002, p. 14) states that “resilience is the intrinsic capacity of the ecosystem to maintain the desired environmental services, even in unstable environmental situations induced by human activities”. Biggs, Schluter and Schoon (2015) concerns “the system's ability to maintain its identity in disturbance, change and internal and external shock situations”.

It is understood that the promotion of socio-ecological resilience must pay attention to its three aspects: (i) proactive resilience, (ii) reactive resilience and (iii) post-active resilience (BIANCHI; ZACARIAS, 2016). Proactive Resilience refers to anticipating risk, identifying vulnerabilities and the limits of resilience. Adaptation and learning capacities are essential for minimizing crises. It is at this stage that the incubation period of biophysical and social vulnerabilities of the socio-ecological system occurs. The fundamental step is to anticipate collapses, identifying which element (natural, climatic, economic, social, etc.) can generate the so-called “trigger event”. Learning and adapting to the natural inserted physical environment, with the innovation of technologies and indicated constructive forms without devastating vegetation, can minimize the impacts of the triggering event and, consequently, of the crisis.

(ii) reactive resilience accepts living with risk, prepares for it, and reacts quickly and efficiently to disasters. This ability to react, however, may be preparing the next disaster due to reconstruction in risk areas, perpetuating socio-environmental risks (THE KRESGE FOUNDATION, 2015; LISTER, 2016; SIEBERT, 2018, p.326).

Focus on the socio-ecological resilience concept in the post-active sense concerns "the ability of a system to deal with change and continue to develop, using shocks and disturbances to stimulate renewal" (SIEBERT, 2018, p.325). Evolutionary resilience avoids living with risk, accepting that certain areas should not be urbanized, while reactive resilience focuses on returning to an illusory normality.

In this context, it is considered that the theoretical framework of resilience has, in its origins, a perspective aimed at the conservation of environmental services considered necessary for social well-being (BERNASCONI; BUSCHBACHER et al. 2015, p. 57). In other words, socio-ecological resilience aims to make both society and the environment capable of withstanding socio-environmental impacts, especially in the most vulnerable areas, and making cities/communities develop in the sustainability lens. However, it is common for systems that live in difficult circumstances to enter a "state of denial", and interventions are the key to breaking this state. Some of the most challenging interventions will involve transformation, which, in turn, requires high system transformation capacity. Therefore, resilience can mean transformation and adaptation.

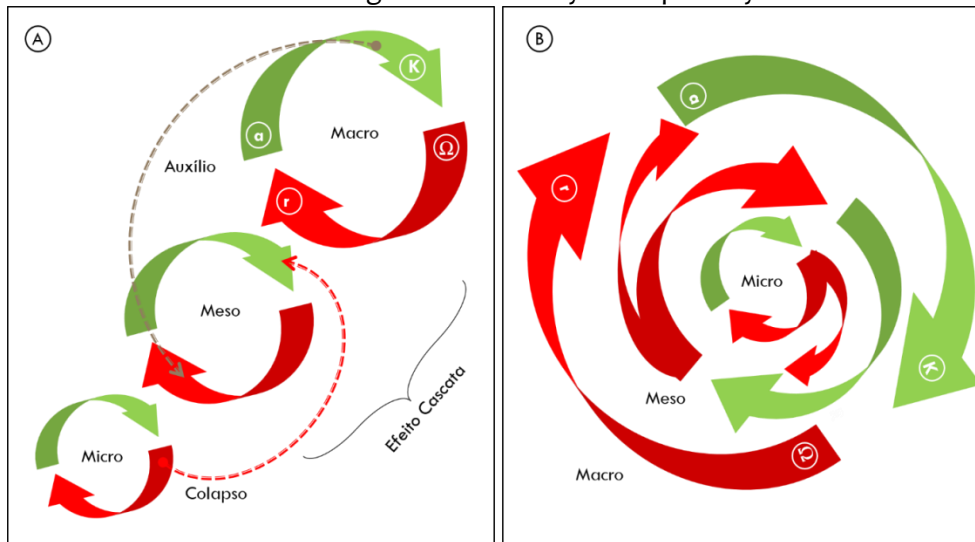
To understand why some places are resilient while others are collapsing, it is necessary to identify and analyze the relationships between the various levels of these systems (SOUZA, 2017). In this context, one of the main devices for assessing socio-ecological resilience comprises the "Adaptive Cycle" model developed by Holling and Gunderson (2002). This is used to characterize the dynamics of systems that may maintain an equilibrium for some time and then undergo a rapid and perhaps unexpected change (BUSCHBACHER, 2016). The cycle consists of four phases and is categorized into two parts.

The first is a slow-forward part, which begins with colonization or establishment of a system (phase r) and goes through a long process of gradual growth. The system can reach a relatively stable condition that lasts a long time (phase k). Theory says that while the system is stable (in phase k), it accumulates vulnerabilities and weaknesses and can withstand small disturbances for a long time, but at some point it suffers a disturbance that leads to a rapid and large collapse (phase Ω). The second part of the cycle (backward part) is much faster than the forward part, as the collapse (phase Ω) frees up resources and allows the reorganization of accumulated "assets" beginning a new colonization and growth cycle (BUSCHBACHER, 2014, p. 16).

The world is organized into nested hierarchies of systems at different space and time scales, *i.e.*, cells, trees, ecosystems, biomes, or people, families, communities, municipalities and nations (BUSCHBACHER, 2014). Thus emerges the concept of panarchy. The term "panarchy", incorporating the name of the Greek god of nature, Pan, integrates the adaptive cycle model and the nested hierarchy of systems at different scales (ANGELER, 2016). Panarchy integrates the adaptive cycle assessment model (Figure 1). Basically, it refers to changes in the larger-scale system that are typically slow compared to those in smaller-scale systems whose adaptive cycle is faster. Small but frequent changes in smaller systems can catalyze

a change in the larger system (GARMESTANI et al., 2020; COSENS; GUNDERSON, 2018), so what happens on one scale can affect other scales.

Figure 1 – Panarchy in adaptive cycles



a) Holling and Gundesson's model; b) authorial panarchy model.

Source: Authors (2021), adapted from Holling and Gunderson (2002) and Walker and Salt (2012)

The concept of specific and general resilience appears in this framework. Specific resilience recognizes change and even collapse and reorganization as inherent socio-ecological system processes. This is still somewhat static in being limited to predictable stresses and maintenance within a regime with predetermined structures and functions (BUSCHBACHER, 2014). General resilience is the ability to deal with uncertainty, change and surprise through adaptation, learning and self-organization. General resilience is more dynamic than specific resilience because it does not emphasize maintaining a regimen with predetermined attributes (BUSCHBACHER, 2014).

But what comprises the relationship between resilience and development? Objective 13 of the Sustainable Development Goals (SDGs) of the UN Agenda 2030, concerns Actions Against Global Climate Change, where “dealing with the climate issue is seen as strategic for the mobilization of actors capable of promoting necessary changes to prevent these projections from becoming reality”. Levin et al. (1998) argue that resilience is the preferred way of thinking about sustainable development in both social and natural systems. The World Bank emphasizes that building resilience and reducing the risk of environmental and social disasters are critical to alleviating poverty and boosting shared prosperity.

Resilience and development are inextricably linked. By sustaining and expanding global commitments to increase resilience to disasters, the development community presents the potential to make real and sustainable changes in the lives and futures of the world's poorest and most vulnerable (WORLD BANK, 2017, s.p).

In other words, making society capable of supporting and responding to social and environmental issues, especially the most vulnerable, is to make

cities/communities more resilient and, consequently, developed under a sustainability lens. Therefore, it is necessary to plan and invest in risk management and, above all, management to foster resilience. Strengthening resilience in a participatory, democratic and integrated manner is essential for the sustainable development process. In this sense, the analysis of previously performed assessments is paramount, while approaches can have different paths, enriching the framework of studies on the subject. In other words, both authors, social actors and public managers can be inspired by innovative analyses and management methodologies aimed at sustainable development based on resilience.

3 Methodological procedures

Realizing that resilience can minimize social vulnerability and foster sustainable development, an understanding of its approach in the scientific debate in recent decades was sought out. Thus, a bibliometric survey was carried out at the EBSCO database. According to Pritchard (1969), bibliometric analyses comprise the application of mathematical and statistical methods to analyze written communication and scientific literature and identify the most productive authors and institutions, as well as the core journals of each area of knowledge.

The terms “resilience” and “sustainable development” were included in the general search, obtaining 43,165 texts between 2000 and 2020.

In filter 1, the search was refined to only scientific articles reviewed by peers.

In the second filter, the research was refined to present Brazilian case studies. This filter limited the results to 54 articles, demonstrating the existence of few practical studies associated to the search terms. In the third filter, subjects related to the environment and society were selected, limiting the results to 33 articles. This filter was applied as studies outside the subject of interest were identified following article reading, for example: human resilience in the field of psychology. The survey was updated for the month of September 2020.

Table 1 – Bibliometric research on “Socio-ecological resilience” and “sustainable development”

STEP	FILTER	TOTAL ARTICLES
General research	“Sustainable development” and “Social-ecological Resilience” as keywords	43,165
Filter 1	Selection criteria	17,479
Filter 2	Selection criteria (Brazilian cases)	54
Filter 3	Selection of Subjects related to the Environment and Society topic	33
Refinement	Content analysis of articles	24

Source: The authors, 2020

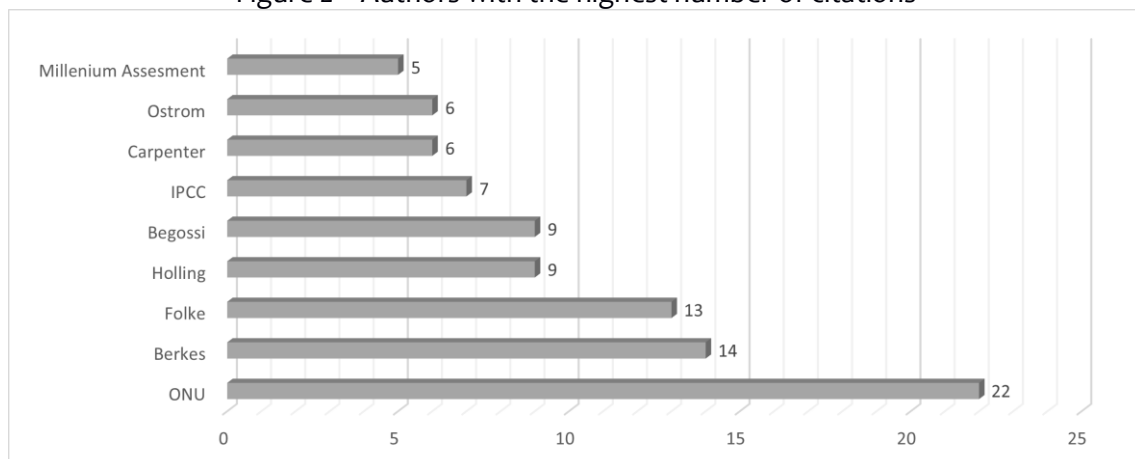
EBSCO system did not need to withdraw repeated studies from the 33 resulting articles. Of these, five were removed during the manual refinement due to unavailability. A spreadsheet was created using the Microsoft Excel software, structured with the following fields for the obtained data: author, title, year, scientific journal, keywords, objectives, references and main addressed topics. This worksheet served as the basis for the filing and content analysis of 28 articles,

resulting in the data presented in the next topic. Once the data was collected, each article was analyzed to determine whether the objectives or results were in fact focused on the chosen resilience and development theme. Four documents were not directly related to the topic and were therefore discarded. The other 24 publications were registered for the purposes of this study. The analysis focused on identifying the main theoretical and methodological references and the fundamental themes addressed in the articles.

4 Results and discussion

The 24 selected articles employed a total of 1,246 references. The knowledge areas comprised mainly geography, environmental sociology, oceanography, and forestry engineering, among others. The authors with the highest number of citations were regulatory frameworks and agendas of the specialized United Nations offices, Fikret Berkes Carl Folke, Crawford Stanley Holling, Alpina Begossi, the Intergovernmental Panel On Climate Change (IPCC), Elinor Ostrom, Stephen Carpenter, the Millennium Ecosystem Assessment and Bryan Walker (Figure 2). Scientific production was mainly published in the following journals: Plos One, Environmental Monitoring and Assessment, Environmental Management, Science and Collective Health and AMBIO: the Journal of the Human Environment.

Figure 2 – Authors with the highest number of citations



Source: The authors, 2020

Each of the articles identified by the bibliometric search was evaluated regarding its theoretical or methodological approach. The highest number of articles published on resilience and sustainable development during the analysis period were case studies on natural resource management and management techniques (10 articles) (BEGOSSI, 2016; ELFES et al., 2014; PRADO; ROSAFERES, 2014; ESCARPINATTI et al., 2013; LOPES et al., 2013; OVIEDO; BURSZTYN, 2016; DRUMOND; GUIMARÃES; SILVA, 2015; RAMIRES et al. 2015; MENDONÇA; MACHADO, 2010; KRAUSE, et al. 2004. Eight articles presenting an evaluative and explanatory nature in part of defined studies (TEUBNER JUNIOR; LIMA; BARROSO, 2018; KEYS; WANG-ERLANDSSON; GORDON, 2013; IMPERATRIZ-FONSECA, GIANNINI, 2019; MOREIRA; BOSCOLO; VIANA, 2015; SENA et al., 2014; HAYASHI et al. 2019; FREITAS et al. 2014 and MEDICI; DESBIEZ, 2012. Five studies focused on the

development of theoretical and methodological procedures (GRIGOLETTO et al. 2016; GIANNINI et al., 2015; LOUCKS; VAN BEEK, 2017; DENIZ et al., 2019 and; SCHENK et al., 2009). Only one was comparative (FREITAS et al. 2018).

The Brazilian regions most employed as case studies were the coast of the state of São Paulo, Amazon region ecosystems, the agricultural sector in the Cerrado biome and the semi-arid Northeast region and coastal areas on in the State of Rio de Janeiro. The selected studies covered the following themes as main topics: a) socio-environmental disasters risk reductions; b) the support capacity of socio-ecological systems in the face of anthropic phenomena and c) natural resource public policies and sustainable management.

a) Socio-environmental disasters risk reductions: these studies focused on examining the impacts of socio-environmental risks on the sustainable development local scale (FREITAS et al. 2014; 2018; GRIGOLETTO et al. 2016; SENA, 2013). Disaster risk reduction and building resilience are among the themes chosen by the Secretariat of the United Nations Conference on Sustainable Development, known as Rio+20 (FREITAS et al. 2018). Overall, these assessments seek to understand how development patterns aggravate natural disasters in Brazil. They also aim at risk management and resilience as a key concept to minimize social, environmental and economic impacts in vulnerable territories. A trend concerning the identification and mapping of risk scenarios through Geographic Information Systems (GIS) was also observed.

The bibliometric survey pointed out themes of interest related to a scarcity and/or excess of natural resources, mainly water, and the health effects on populations exposed to hydrometeorological events (droughts, mass landslides and floods, among others) (GRIGOLETTO et al. 2016; SENA, 2013). Another trend comprises assessments on territory socio-environmental vulnerability to natural disasters. According to Freitas et al. (2018, p.45) “disasters are socially produced, and the vulnerability of societies is closely and inversely related to the level of economic development”. Finally, current studies on socio-environmental disasters, resilience and sustainable development point to three methodological movements: i) the analysis of urban development patterns, ii) assessment of socio-environmental exposure to extreme weather events and iii) mapping of risk scenarios through GIS.

b) Assessment of the capacity to support ecosystem services in the face of climate change: these studies were dedicated to evaluating the resilience capacity of natural resources against anthropogenic phenomena. The analyzed studies basically present two interdependent movements: i) analysis of anthropic actions that enhance the impacts of extreme climate events (TEUBNER JUNIOR; LIMA; BARROSO, 2018; KEYS; WANG-ERLANDSSON; GORDON, 2013; DENIZ et al. 2019; HAYASHI et al. 2019) and; ii) assessment of the impacts of climate change on local biodiversity (GIANNINI et al. 2015; IMPERATRIZ-FONSECA, GIANNINI, 2019; MOREIRA; BOSCOLO; VIANA, 2015).

The articles that present the first movement as a proposal aim, mainly, at studies concerning urban and rural activities and their impacts on the environment and climate. Teubner Junior, Lima and Barroso (2018) quantitatively evaluated the greenhouse gas emissions into the atmosphere, as well as their effects on the study section (high rainfall, drought, acid rain, etc.). Another trend comprises the assessment of urban and rural activity climate impacts (KEYS; WANG-ERLANDSSON; GORDON, 2013; DENIZ et al. 2019; HAYASHI et al. 2019). Both articles recorded that economic activities within their territories are predatory and do not only influence the local microclimate, but also the global one. The same trend of identifying and mapping risk scenarios through Geographic Information Systems (GIS) was also observed in these assessments.

The studies aimed at the second movement explain biodiversity as a fundamental factor for the planet's resilience. Two articles evaluated the pollination capacity of bees in areas devastated by human action and climatic events (GIANNINI et al. 2015; MOREIRA; BOSCOLO; VIANA, 2015). Imperatriz-Fonseca and Giannini (2019) assessed the relationship between climate change and the disappearance of migratory bird species, which are important for the ecosystem. In this sense, the point of convergence of these studies is that “mobile” ecosystem services (insects, birds, mammals, etc.) are essential for sustainable development, as they guarantee natural resource recycling (vegetation, soil quality, plants and trees). On the other hand, these articles indicate that anthropic actions do not only directly affect ecosystem service maintenance through habitat devastation, but also have an indirect effect through changes climate caused.

c) Natural resource public policies and sustainable management: these assessments analyzed the importance of natural resource management for sustainable development. In general, the studies aim to analyze the management of natural resources from two themes: i) public management through the monitoring of environmental protection areas (ELFES et al., 2014; LOUCKS; VAN BEEK, 2017; ESCARPINATTI et al. ., 2013; LOPES et al., 2013; SCHENK et al., 2009; KRAUSE et al., 2004) and; ii) natural resource management in traditional communities (BEGOSSI, 2016; PRADO; ROSAFERES, 2014; OVIEDO; BURSZTYN, 2016; DRUMOND; GUIMARÃES; SILVA, 2015; RAMIRES et al. 2015; MENDONÇA; MACHADO, 2010;).

The articles that aim at public management through the monitoring of environmental protection areas present proposals and methods to this end. These methods are created from the development of public policy proposals and the use of aerospace technology to monitor sensitive areas. They also address the socioeconomic conflicts between the government, ruralists, extractive groups and artisanal fishers. The second movement presents existing alternatives for the management of sustainable natural resources which comprise, for the most part, management techniques employed by traditional communities (riparians, artisanal fishers, indigenous peoples and extractive groups, among others).

Based on the data obtained in this bibliometric research on the three axes analyzed above, an agenda of actions is proposed that allows for the development of a management model for socio-ecological systems, assisting in interventions that remedy the gaps observed in each axis. This management is i by Walker and Salt (2012, p118), which is based on four main types of interventions:

i) Management: it is necessary to analyze what is in force in the case study. The task is to investigate existing management models and proposals, in order to verify the need for new planning, or improvements to the socio-ecological system have been implemented. ii) financial interventions: Research whether financial interventions in favor of site management are required. It is important to identify these stakeholders, as financial investment is essential to drive management actions aimed at developing the system; iii) education: for the resilience of the system aimed at changing people's behavior. In this case, it may be that education influences people's actions to create a fertile environment for improving governance and, iv) Governance: comprises a combination of institutions (formal and informal, constitutions, laws, policies, regulations and norms) that mediate interactions between people and between people and organizations, social networks and sociopolitical processes (negotiations, incentives and information, among others).

It is important to remember that each category of interventions operates on a different time scale, and it is very complicated to think of general actions that address different events and territorial and resource scales. However, as a way to systematize an agenda that serves to guide possible future assessments, we propose to draw up a matrix of strategies that can be implemented (short, medium and long term) in each of the four intervention categories for each theme pointed out by the bibliometric research.

Table 2 – Agenda of actions to promote Socio-ecological Resilience

Intervention	Guidelines	Deadline
Management	Creation, maintenance and reinforcement of the work of institutions that address disaster prevention such as Civil Defense, observatories and plural agencies that promote education, prevention, aid and mitigation of problems caused by socio-environmental disasters;	Current and permanent
	Creation, maintenance and reinforcement of the mapping of risk areas, disaster warning systems, among other projects in favor of disaster resilience;	Current and permanent
	Constant observation of the land use and occupation model in relation to flood levels.	Current and permanent
	Efficient implementation of projects that seek the resilience of cities in line with the rural area of the municipalities.	Short term
	Develop efficient public housing policies aimed at preventing urban occupation of risk areas, especially those related to floods and landslides on hillsides and hills.	Mid-term
	Relocation of residents located in areas under imminent risk of disasters and conditions such as periodic floods (according to technical and geological reports), to safe and non-peripheral areas;	Mid-term
	Expansion of participatory monitoring and inspection of resources applied in the management of localities.	Short term
	Restructuring of urban infrastructure for basic sanitation and access to drinking water, in order to minimize problems caused by diseases and contaminations;	Short and medium term
	Formulation of public policies aimed at improving public transport, road infrastructure and other actions to facilitate the flow of people.	Mid-term
	Improvement of the rainwater drainage system, integrating the correct water treatment and direction system.	Mid-term
Financial interventions	Promotion of actions that curb the devastation of vegetation cover, especially on slopes and riparian forests, devise strategies for recovery of riparian forests and vegetation cover, depollution of water courses;	Short term
	Structuring the Water Resources Management System and implementing fair charging for water use;	Mid-term
	Development of strategies in public/private partnership with the objective of investing in projects aimed at training and generating employment for populations in the poorest communities;	Medium and long term
	Development of strategies and policies that consider the resilience of communities;	Mid-term
	Fundraising, through national and international bodies, to invest in infrastructure projects, such as community centers, libraries, community kitchens, sports and leisure areas;	Mid-term
Education	Creation and improvement of inspection instruments for the application of financial resources;	Medium and long term
	Investment in training, qualification and education in favor of resilience, for managers and the population;	Short and medium term
	Implementation of programs in primary and secondary schools, aimed at promoting resilience to socio-environmental disasters;	Short and medium term
	Promotion of ongoing training and training programs in partnership with Higher Education Institutions.	Short and medium term
	Implementation of educational actions for social awareness about ethics and citizenship.	Short and medium term
	Promotion of educational programs for socio-ecological resilience.	Short and medium term
Governance	Promotion of social participation programs regarding trade and service, such as trade, work and food fairs;	Short and medium term
	Enabling social participation in public policies aimed at disaster risk governance;	Medium and long term
	Improve the articulation between stakeholders, basin committees, city halls, residents' association and the community, aiming at the governance of the socio-ecological system;	Medium and long term
	Promotion of cultural events for the community, aimed at strengthening social networks, participatory engagement and consequently system governance;	Short term
	Encourage society's engagement to put pressure on authorities, in projects aimed at improving social conditions and socio-ecological resilience.	Mid-term
	Empowerment of committees and participants for the consensual resolution of socio-environmental conflicts over natural resources.	Medium and long term

Source: Authors (2021)

5 Final considerations

The results reported herein point to analysis patterns among the studies referenced by the socio-ecological resilience theme in promoting sustainable development. The main interest of the authors is to carry out experiments in order to minimize the negative impacts of anthropic action on the natural environment, towards sustainable development. Studies carried out on a regional scale represent most of the analyzed publications. This is noteworthy, as it indicates the consonance of the analyzed articles with one of the main points associated to sustainable development, the specificity of the area and the endogenous components that lead to thoughts on local constraints, opportunities and deficiencies.

Thus, an agenda regarding research and social practices to explain and promote sustainable transitions in territories was proposed as a way of developing better management of socio-ecological systems based on four main types of intervention: management, financial interventions, education. and governance. This does not mean that regional peculiarities would be abandoned, but it would evidence these specificities by grouping them in similar territories as a way of tracing an analysis and diagnosis pattern. Furthermore, when working on an interscale, some comparisons can be performed regarding the most successful actions at each scale, from the macro to the smallest breakdown.

The terms “climate change” and “global warming” appear in most articles, identified as the main critical issues, which triggers significant researcher concerns regarding this phenomena. Likewise, the theme “water” and/or “water resources” was recurrent, and its management is important to strengthen socio-ecological resilience. Another recurrent issue comprises governance, and some authors explain that strengthening resilience in terms of promoting sustainable development is a cooperation process between society, institutions and the state and social learning.

On this theme, of phenomena related to climate change and global warming, the challenge of developing an agenda for research and social practices that explains and promotes sustainable transitions in territories is even more challenging. This is due to the fact that we are not releasing anthropic responsibility for such phenomena. On the contrary, the inflection point should have already been overcome. In other words, a new glacial age began and did not occur only due to the atmospheric changes attributed to anthropic activities. Initiatives to develop the best use of spaces, observing flooding rates, erosive slope processes and adequate population redistribution in territories can be promoted to discuss new research and social practices.

This research presented expressive results, but also displays certain some limitations, albeit not significantly affecting the results. The first is associated to the analyzed period, as the conclusions are restricted to the considered time and relevant subjects from other time frames may not have been analyzed. The second limitation concerns the EBSCO platform which, despite being an excellent document and scientific study repository, does not cover the entire framework of pulished studies on te analyzed theme. The third limitation is related to the low number of samples found (only 24 articles, with Brazilian cases). Despite these limitations, the sample indicates that the terms "Sustainable development" and

"socio-ecological resilience" are currently in evidence in the scientific community, with a significant amount of publications carried out after 2015.

Concerning the findings of our assessment, an intervention agenda for the management of socio-ecological systems based on the themes highlighted by the bibliometric research is proposed, intended to expand research on the subject and contribute to socio-ecological resilience actions at different territorial scales. This is a challenge that graduate programs (*strictu sensu*) are increasingly accepting, employing bibliometric research to create a history and reality mapping of the studied phenomena to propose governance interventions. It is also important to expand the search beyond the platform employed herein, carrying out an increasingly cumulative comparison of data sources. Sample amplification also reflects actions that contribute to the development of alternatives to promote territorial development while increasingly bringing together the epistemic community, spreading the concepts and issues on specific themes.

Thus, based on the analysis of the publications obtained in this study, a research and social practice agenda is suggested, aimed at promoting sustainable transitions in territories, which examines issues relative to assessing the impacts of human activities on the natural environment, with statistical samples regarding potential impacts at different scales and sectors, the assessment of climate change impacts at different scales and cycles (global-national-local; local-national-global); studies on the protection of local ecosystem services as an economic development vector.

In this context, the development of an agenda facing global climate change and the acceleration of environmental degradation drivers must consider strengthening the resilience of socio-ecological systems.

ACKNOWLEDGMENT

The authors thank the National Council for Scientific and Technological Development (CNPq) through the project "ARENAS, DISPUTES AND CHALLENGES IN MULTIPLE WATER MANAGEMENT ARRANGEMENTS" (process 424330/2018- 0 - in force, UNIVERSAL/MCTIC CNPQ/ 2018 public notice), to which this article is linked. The authors would like to thank the Universidade Regional de Blumenau (FURB) for their institutional support and the State University of Paraíba, who defined the project's research team. They also thank Bruno Jandir Mello (Coordination of Higher Education Personnel - CAPES/ 2020-2024) and Anderson Miranda de Gomes (Foundation for Research and Innovation Support of the State of Santa Catarina - FAPESC/ 2014-2018). Furthermore, author Cristiane Mansur de Moraes Souza is grateful to CNPq for her research productivity grant.

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Received: 30/07/2021

Accepted: 09/11/2021

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Sources of funding:

Artigo vinculado ao projeto ARENAS, DISPUTAS E DESAFIOS NOS MULTIPLOS ARRANJOS DE GESTÃO DAS ÁGUAS (processo n. 424330/2018-0) - Chamada MCTIC/CNPQ n. 28/2018 UNIVERSAL - Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq; os autores agradecem ao CNPq pela bolsa produtividade em pesquisa (processo n. 309787/2020-3) referente a Cristiane Mansur de Moraes Souza, professora permanente do programa de pós-graduação em Desenvolvimento Regional da Universidade Regional de Blumenau – FURB. Também agradecem à Comissão de Avaliação de Pessoal de Ensino Superior - CAPES – pela bolsa de doutorado demanda social oferecida à Bruno Jandir Mello.