Journal of Geography and Cartography (2022) Volume 5 Issue 2
doi:10.24294/jgc.v5i2.1761

REVIEW ARTICLE

The systemic approach to risk analysis in geography

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ABSTRACT

This paper presents a brief review of risk studies in Geography since the beginning of the 20th century, from approaches focused on physical-natural components or social aspects, to perspectives that incorporate a systemic approach seeking to understand and explain risk issues at a spatial level. The systemic approach considers principles of interaction between multiple variables and a dynamic organization of processes, as part of a new formulation of the scientific vision of the world. From this perspective, the Complex Systems Theory (CST) is presented as the appropriate conceptual-analytical framework for risk studies in Geography. Finally, the analysis and geographic information integration capabilities of Geographic Information Systems (GIS) based on spatial analysis are explained, which position it as a fundamental conceptual and methodological tool in risk analysis from a systemic approach.

Keywords: Systemic Approach; Complex Systems Theory; Risk; Geography; Geographic Information Systems

ARTICLE INFO

Received: 21 August 2022
Accepted: 13 September 2022
Available online: 20 September 2022

1. Introduction

Geography as a human science, whose material object of study corresponds to the spatial manifestations of social processes, has a long history in the study of the society-nature relationship. Since the end of the 19th century, and particularly with the work of Ratzel[1,2], we have the first systematization of Human Geography, in which the field of relational study is defined.

The fields of Physical Geography and Human Geography arise depending on whether the focus of spatial analysis was supported by physical-natural or human-social components respectively, however dualism is always overcome when aspects of the major components are considered in their formal object of study corresponding to the spatial point of view.

Any epistemological perspective for approaching reality from a geographic point of view considers these relationships in the search for unity in diversity by looking at the structuring aspects from a generalization that leads to the conformation of systems as models of analysis.

The objective of this paper is to present the systemic approach in risk analysis in Geography, for this purpose, successive approaches will be made by outlining a state of the question with central antecedents, analyzing the scope of the general theory of systems, the theory of complex systems and ending with the consideration of the role that can be played by Geographic Information Systems.

This journey will allow us to analyze how the systemic perspective offers the possibility of delineating the relational aspects of geographic analysis in the search for multivariate modeling that will provide results oriented towards solutions for populations exposed to different types of risks.

2. Risk studies in geography

Within the geographic field, there is a great diversity of approaches to risk issues. Several studies have made a historical analysis of how the different approaches evolved[3-5], mainly since the beginning of the 20th century.

Some with an emphasis on technical knowledge related to the dynamics of different geophysical events, with significant support from disciplines such as Climatology, Geomorphology, Hydrology, with a naturalistic and sometimes reductionist view, which contribute to characterizing the hazards; others with an emphasis on social aspects, incorporating the analysis of vulnerability with its multiple dimensions and considering the meanings and identities of places, placing special importance on subjective aspects of risk at the individual or group level, based on sociological theories of risk[6,7] that consider that risk is socially constructed and, therefore, can be minimized or avoided if one is aware of it or has the means to do so. And finally other contributions that incorporate a systemic approach seeking to understand and explain risk issues at a spatial level based on an analysis that integrates the physical-natural system and the human system, as part of a complex reality and where spatial analysis with Geographic Information Systems (GIS) presents great potential for application.

Despite being a long-standing subject in Geography, there is still no consensus on the definition of risks. Among the aspects taken into account to define and analyze risks are hazard, vulnerability, exposure, response capacity or resilience, prevention, mitigation, among others[1] . Within the different lines of analysis, all of them coincide in considering two of the aforementioned aspects as inseparable parts of risk: hazard and vulnerability.

On the one hand, the hazard (or danger) to which the population is exposed as a result of the occurrence or threat of occurrence of some natural or anthropogenic event is considered. In other words, an analysis is made specifying what type of hazard is present and, mainly, where it is located. On the other hand, vulnerability is considered, which is defined as the population's capacity to face the occurrence or probability of occurrence of a hazard and the possibility of recovery, and which is linked to the characteristics of the population in a given place and which can be modified through improvements in the quality of life. An integral analysis of vulnerability must consider the natural, physical, economic, social, technical, political, technical, ideological and cultural dimensions, according to what Wilches Chaux[9] calls "global vulnerability".

Both components of risk have a spatial correspondence that Geography, as an analytical and synthesizing science, together with the spatial focus provided by GIS, can address through a systemic approach that allows them to be integrated.

It is important to mention the conceptual contribution made within the framework of the so-called School of Human Ecology at the University of Chicago. Although the origins of this School are in the field of Sociology, it expanded into different areas of knowledge and, from the Department of Geography, through Harlan Barrows in the 1920s, the idea of "Geography as human ecology" was introduced, emphasizing research that analyzed the relationships between human beings and their natural environment, from an ecological point of view. This idea was continued in the 1960s by his disciple, the geographer Gilbert White, and his colleagues Robert Kates and Ian Burton, who ventured into disaster risk studies, incorporating into the analysis the response of people in relation to their environment and the uncertainty linked to the difficult forecasting of natural events. It is important to highlight White's contributions since he is considered the precursor of risk and disaster analysis in Geography[4].

White[10] defined risk as the result of multiplying hazard by vulnerability. Thus, vulnerability is emphasized as the most important factor in the definition of risk:

Risk = hazard * vulnerability

[1]In the doctoral thesis of Mauricio Ruiz Pérez entitled "Territorial vulnerability and post-disaster damage assessment. An approach from the geography of risk" a detailed analysis of the different definitions of risk from Geography, over time, is carried out (Ruiz Pérez[8]).

This definition contemplates that in the face of the same hazard scenario, the risk will be greater for those people and/or places that present a higher vulnerability. Thus, from Geography, it is possible to make contributions that make it possible to demonstrate situations of vulnerability and thus help in spatial decision making, in order to improve the quality of life of the population, promoting greater spatial justice. This definition, still in force, is the one to which this work adheres.

3. Complex systems theory as a conceptual-analytical framework for the study of risk

The systemic approach makes it possible to analyze a reality that is complex and that, in the specific case of risk analysis, becomes necessary to be able to integrate various physical and social variables in permanent interrelation into the analysis, and in some way, to break with monoparadigmatic postures in order to carry out an integral analysis that makes it possible to address complex issues.

In contrast, the traditional approach to science is based on discovering causal and linear chains or relationships between two variables, in order to understand processes, mainly biological. From this approach, the main way of arriving at knowledge consists of isolating the elements under study, which could be considered as fragmentation, and then linking them conceptually or experimentally to understand the "whole". In contrast, the systemic approach considers the study of the whole, with principles of interaction between multiple variables and a dynamic organization of processes. In this approach, the use of models, simulations, and representative constructions of the object of analysis constitutes the general method of science. This is part of a new formulation of the scientific world view, in which the importance of the analysis of systems in different fields of knowledge is highlighted from an integral point of view.

The conceptual-analytical framework that incorporates this perspective is the Complex Systems Theory (CST) proposed by García[11], as an advance from the Systems Theory (ST) developed by von Bertalanffy[12]. CST argues that there is no single discipline with the capacity to consider all the particular aspects of an object of study and, therefore, it questions the excessive disciplinary specialization that leads to the fragmentation of knowledge, but values disciplinary solidity as indispensable to advance towards interdisciplinary studies. The aim is to reduce, as far as possible, the duplication of theoretical efforts in different disciplinary fields and to promote the unity of science by improving communication among specialists.

García[11] states that the situations and processes that occur in the real world are not classified to be approached from a particular discipline but develop in what he calls a complex reality. The complex systems that exist in empirical reality do not have precise limits, so it is necessary to make "cuts", but we must define limits that minimize arbitrariness and consider the interactions of the system that are outside the cut system. In this sense, it is important to keep in mind that all knowledge involves abstracting some elements of reality.

A complex system always consists of a set of objects that are in continuous interaction and, as a whole, has properties that are not the simple addition of the properties of the elements. Within the system it is possible to identify subsystems that are linked to each other. This makes it possible to establish hierarchies of subsystems within a system and to define levels of analysis corresponding to the levels of organization within the system. This facilitates the study of complex systems and shows that within complexity, which is not used here as a synonym of complication, it is possible to determine levels of analysis, which are in interaction with the other levels but which present their own dynamics that are important to know.

This organization into different levels of analysis means that the same system can be analyzed from different points of view. Buzai[13] conducted an analysis in relation to the evolution of different paradigms in Geography and the consideration of a spatial focal level as a framework that allows studying reality stratified by levels of analysis. In this sense, he mentions a supra-local level that can be linked to the perspective of Critical Radical Geography, which is oriented to the attempt of the transformation of social reality in pursuit of a fairer society. An intrafocal level that is associated with the perspective of Humanist Geography, with emphasis on studies of individual perception and the valorization of place as a lived space. And the focal level, linked to the rationalist and systemic perspective with emphasis on the spatial dimension, seeking regularities in spatial patterns with predictive possibilities.

At the focal level, which is the one adopted here, it is understood that Geography must advance towards the search for explanations and possible solutions to specific socio-spatial problems, and this is possible within the framework of an Applied Geography, with the possibility of prospecting and where Land Use Planning is situated as an area with great potential for application, and where the geographer "can fully manifest his two essential qualities, the sense of synthesis and that of space"[14].

The same problem, within Geography, can be seen differently if different points of view are considered, because it is linked to the scientific image of the world and in that sense, we can say that it has only relative validity. "Each of these ways of looking at things is perfectly legitimate and it has no less case to pretend to confront one to the other"[15].

In CST, when analyzing a complex system, observables and facts are considered. Observables are defined as data from experiences already interpreted. Facts are defined as relationships between observables. Therefore, one cannot be a neutral observer who becomes aware of an "objective reality" and record "pure" data. The records will always correspond to interpretative schemes based on rationalism[11]. In this sense, TSG has an empirical basis, but this does not mean that it endorses empiricism as an approach that considers objectivity and, therefore, the neutrality of the researcher at the moment of capturing the facts of experience; rather, as previously stated, the system must be defined by highlighting a constructivist posture of knowledge.

In the case of risk analysis, we are talking about a complex system where different subsystems interact, such as the physical-natural and socio-spatial, each of them with their own functioning dynamics that, as a constituent part of the system, generate changes that can mean an increase in the vulnerability or even resilience of the system, i.e., levels of adaptability that mean that despite minor changes or alterations in the system, the essence of the system is not lost, but rather it reaccommodates to the new characteristics.

Thinking about risk in this way allows us to carry out analyses with a higher level of integration and to advance in the development of modeling and simulations to analyze the behavior of the system if there are changes in the subsystems. If we can carry out a prospective study of urban growth in a city at risk of flooding, we can predict what the risk conditions will be in urban areas that tend to expand and thus act to reduce the increase in risk. The same happens with the flood simulations that allow us to observe what would happen if there is a greater than average flood and to link it with the most vulnerable areas of the system. The examples highlight, on the one hand, the spatial issue associated with the consideration of Geography as an applicable or applied science that would provide information and tools to act on the geographic space. And on the other hand, the simulation, which "...serves to explore what type of individual interactions are compatible with a known behavior of the whole or, inversely, to know certain rules of action of the elements, to venture certain predictions about the behavior of the whole"[16]. This is possible because in systems there is a tendency to repetition, or redundancy, of patterns of functioning.

Within the framework of complexity analysis, simulation is considered as a new way of approaching reality, which can be nourished by theory or experience, indistinctly, and where new computational technologies acquire a fundamental relevance. In the field of Geography, this can be associated with the incorporation of GIS, which allow approaching reality from a spatial point of view, positioning itself as the appropriate conceptual and methodological tool for the incorporation of the systemic approach.

4. Geography and Geographic Information Systems in risk analysis

The analysis and geographic information integration capabilities of GIS based on spatial analysis position it as a fundamental conceptual and methodological tool in risk analysis from a systemic approach.

When analyzing the complexity of risk issues, the central concepts of geographic analysis of location, spatial distribution, spatial association, spatial interaction and spatial evolution[17] and their combinations, integrated in a GIS, allow us to systemically analyze different risk characteristics. The possibility of cartographic modeling through GIS using different thematic layers that represent central aspects in risk analysis is a significant advance, since it allows us to consider risk from a current perspective but also with a vision of the future, by allowing the modeling and simulation of different variables that influence risk.

The systemic approach in risk analysis becomes necessary in order to integrate diverse physical and social variables in permanent interrelation, and in some way, this forces us to break with the mono-paradigmatic postures in order to carry out an integral analysis that allows us to address this type of complex issues.

From the perspective of Quantitative Geography, which is temporally located in the mid-1950s, with the advance towards the so-called Automated Geography, in the 1980s, which was linked to the technological advances in computing that were incorporated into Geography, among them GIS, and which later gave rise to what Buzai called Global Geography and which is associated with a geotechnological paradigm that makes it possible to analyze reality as a complex system. It is here where we find the theoretical basis of risk analysis from the approach proposed in this article, highlighting in turn the applied nature of Geography.

Buzai[18] expresses very clearly that although the bases of GIS are found in rationalism and quantitativism, the problems of reality as a complex totality cannot be addressed only by these, nor by any other paradigm individually, but must take a step further towards multi-paradigmatic approaches to provide explanations at different scales of reality. This is positioned as the great challenge for geographers today.

5. Final considerations

Throughout this work it became evident that Geography, from its position as a Human Science, has a wide capacity and experience in risk studies from different approaches, which positions it as one of the sciences with a great tradition in dealing with this subject. This does not mean that there is currently a consensus regarding the definition of risk, but it is important to point out that it has been agreed from the different current perspectives of risk analysis in Geography that there are two aspects that are constitutive and inseparable parts of risk: hazard or threat, and vulnerability.

The CST proposed by García[11] is presented as an appropriate conceptual-analytical framework for the study of risks from the perspective of geographic science. Mainly because approaching the analysis from the consideration of a complex system as a cutout of the empirical reality, allows us to delimit this “complexity”, taking into account the existence of multiple variables in constant interaction, and to focus on a spatial focal level as a specific field of Geography, where GIS as a methodological and conceptual tool, supported by spatial analysis, present a great potential to incorporate the systemic perspective and from here advance towards interdisciplinary studies.

Finally, it is important to note that the systemic approach presented in this work allows us to consider that in all fields of knowledge, it is possible to analyze complex systems with dynamics that determined by the interaction of the different subsystems that compose it and that condition the total functioning of the system. But that by knowing these aspects it is possible to model and generate predictions about the operation of the system even taking into account its internal or external changes.

In Geography, when spatial analysis makes it possible to make predictions about the spatial distributions of the constituent aspects of risk, hazard and vulnerability, it is possible to move towards an Applicable Geography and an Applied Geography which, by modeling future spatial configurations, is very useful for decision-making in spatial planning within the framework of Land Use Planning.

Conflict of interest

The author declared no conflict of interest.

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