

Public Policy Tool For Sustainable Management Of Socioecological Systems

Outil de Politique Publique pour la Gestion Durable des Systèmes Socioécologiques

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ABSTRACT: This article presents a theoretical-practical approach as a basis for decision-making for the application of mostly environmental public policy tools, which contributes to understanding and dimensioning socio-ecological systems from a new approach which deals with a complex conceptual proposal that integrates the articulation of ecosystems, the human system, ecosystem services and the actions that intervene in them, under a multifunctional exchange of energy to satisfy the goods that humanity occupies for its subsistence. In this sense, the results of the work present some approaches and points of view in the complex, holistic and multivariate understanding of management actions around socio-ecological systems, where it seeks to understand how they should be managed sustainably through the acting of the theoretical conceptualization of the Pentahelix, (environment, society, government, industry, and academia) in the face of current new challenges, therefore, this proposal presents the instruments and actions that could be implemented for the strategic management of these systems.

KEY WORDS: management, geosystem, actions, multifunctionality, plans.

RÉSUMÉ : Cet article présente une approche théorique et pratique comme base de décision pour l'application d'outils de politique publique, principalement environnementaux. Elle contribue à la compréhension et au dimensionnement des systèmes socio-écologiques à partir d'une nouvelle approche. Cette approche aborde une proposition conceptuelle complexe intégrant l'articulation des écosystèmes, du système humain, des services écosystémiques et des actions qui y interviennent, dans le cadre d'un échange énergétique multifonctionnel visant à satisfaire les besoins de l'humanité en matière de subsistance. En ce sens, les résultats de ce travail présentent des approches et des points de vue sur la compréhension complexe, holistique et multivariée des actions de gestion des systèmes socio-écologiques. L'objectif est de comprendre comment ces derniers devraient être gérés de manière durable, en s'appuyant sur la conceptualisation théorique de la Pentahélice (environnement, société, gouvernement, industrie et milieu universitaire) face aux nouveaux défis actuels. Cette proposition présente donc les instruments et les actions qui pourraient être mis en œuvre pour la gestion stratégique de ces systèmes.

MOTS CLÉS : gestion, géosystème, actions, multifonctionnalité, plans.

1. Introduction

State Starting from the fact that the study of socio-ecological systems is dominated by concepts such as resilience, vulnerability, adaptation and robustness, according to Hernández et al . (2019), we must start from the knowledge of the public policy tools that the state has, to strengthen the resilience of socio-ecological systems, making their adaptation (structural and non-structural) viable, in addition to their robustness, in this sense we propose to visualize the instruments of territorial, environmental and socio-natural risk management in such a way that they can be applied.

2. Study area

The theoretical and methodological approach of this work focuses on the context of Latin America and particularly on the administrative management system of Mexico articulated in three levels and orders of government, together with society, academia, industry and the environment, where it seeks to generate an articulated management process that serves as a basis for the design, formulation and implementation of public policies.

3. Methods

A social-ecological system refers to the regular interaction between biophysical and social factors, with emergent properties, and self-organizing capacity (Norberg & Cumming 2008; Folke et al. 2005). The different elements and their interactions generate observable dynamics and adaptive processes from their self-organization (Gunderson & Holling 2002).

Based on Figure 1 below, socio-ecological systems constitute complex and adaptive systems in which human societies are part of nature. The social component refers to all human activities including economics, technology, and institutional and cultural politics. On the other hand, the ecological component refers to the biosphere, that is, the part of the planet in which life and ecosystems develop. Both parts are interrelated, the limits of the system are arbitrary and depend on the question, hypothesis, or perspective of analysis (South American Institute for Resilience and Sustainability Studies, SARAS) (2024).

3.1 Who makes up this Socioecosystem?

Within the human system there are government institutions , NGOs, the family, human settlements, human groups, and indigenous groups, which operate in the territory, made up of different ecosystems.

The institutional part and its vulnerability constitute topics of great interest, but not of much approach when reviewing the results of the studies of environmental and socio-natural risks, perhaps one of the reasons is due to the complexity that it implies and the lack of information to manage it. The institution is a dimension that can present vulnerability and that could be denoted in the way the State is organized and its expression in risk management and emergency response (Acuña, 2016). According to Altez (2009) it is part of a process of social construction of risk, and states that it is "derived from certain and changing social processes derived largely from the styles

and models of development and the processes of social and economic transformation in general" (Acuña, 2016).

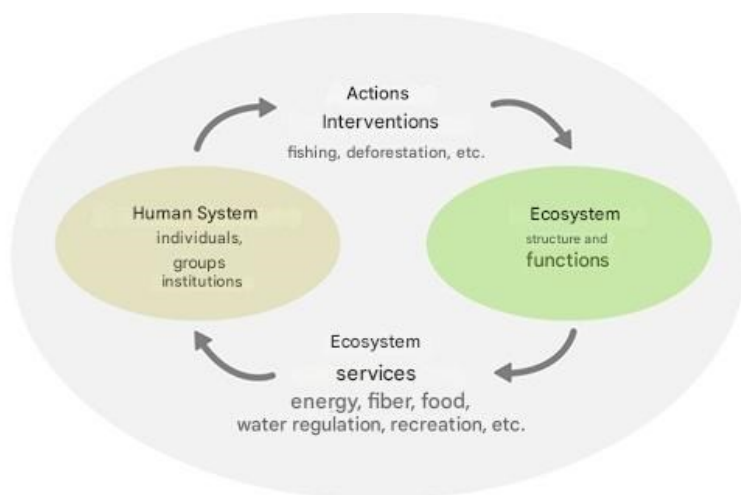


Figure 1 Socioecological system. Source: Adapted from Resilience Alliance (2007). *Assessing and Managing Resilience in Social-Ecological Systems: Supplementary Notes to the Practitioners Workbook*, Vol.2.

Socioeconomic vulnerability is linked to inequality and social and economic marginalization of human settlements. This vulnerability constitutes a factor in the construction of risk scenarios in the spaces where natural phenomena impact. It is linked to the forms of social organization, in particular with the distribution of space, access to goods (tangible and intangible) and ultimately to the distribution of social wealth. Vulnerability to environmental risk is thus linked to the forms of social organization, which include, among other complex relationships, those of social class, labor stratification, territorial planning, among other social conditions related to the distribution of benefits and wealth. Social conditions aggravate or mitigate the risk in which people live in their daily lives. They do not only depend on natural variables but there are also social determinants that affect risk as well as insecurity (Sandoval, 2018).

Structural vulnerability is focused on the construction typologies of the dwellings that make up the different human settlements. These construction characteristics will depend greatly on the conditions of marginalization and access to resources or funds by the population.

Environmental or ecological vulnerability includes the capacity to respond to the two major global environmental problems: global warming and biodiversity loss, including the internal self-adjustment of the environment to direct or indirect effects of anthropogenic origin (Esparza and Díaz, 2019). In this sense, we include the susceptibility to damaging, deteriorating, or degrading the different environmental assets together with the goods and services they provide, turning them into environmental liabilities.

3.2. Forces of change or environmental pressures

Intervention actions (environmental pressures, deforestation, intensive fishing, changes in land use, growth of urban sprawl, growth of crop areas, construction of socio-natural risk scenarios, contamination of different environmental assets, creation of environmental liabilities).

All results from violations of laws, rules, regulations, codes, and other environmental and territorial management tools, starting with the General Law on Ecological Balance and Environmental Protection, regarding: ecological planning, and environmental impact assessment, among other regulations.

3.3. Ecosystem, structure and functions

It is essential to know the characteristics and dynamics of each of the ecosystems where we carry out our activities and their survival conditions. So that we come closer to finding a balance that allows for acceptable functioning of the same.

Mexico's geographic location, its variety of climates, topography, and geological history have produced a great biological diversity. This diversity is shown in the richness of flora and fauna species, and the genetic diversity that accompanies them, which integrate a great variety of communities in the continental and insular territory. These communities range from high mountain grasslands to coastal dunes and wetlands, passing through temperate forests, mountain mesophilous forests, jungles, xerophilous scrublands, and natural grasslands (SEMARNAT, 2016: 61).

Ecosystems in general, and terrestrial ones in particular, have been the sustenance of human populations since the beginning of their history, and have provided them with goods such as food (meat, fruit, vegetables, and oils), wood and fibers for construction, firewood as a source of energy, and wood pulp for paper, among others. In addition to these goods, ecosystems offer environmental services - not obvious but vital for the development of any human society - such as air and water purification, soil generation and conservation, waste decomposition and recycling, movement of nutrients, protection of soil from erosion by wind and water, climate regulation and cushioning of the effects of extreme weather events, among others (SEMARNAT, 2016: 61).

The growth and expansion of the human population during the 20th century, accompanied by industrial and urban development, brought about the greatest transformation of terrestrial ecosystems caused by humans. According to the Millennium Ecosystem Assessment for the year 2000, 42% of the world's forests, 18% of arid zones, and 17% of island ecosystems had been transformed. The changes were mainly in favor of crop and pasture areas for livestock, or for the establishment and development of towns, cities, and infrastructure for communication routes, power lines, and product storage, among others (SEMARNAT, 2016: 61).

3.4. Environmental goods and services

As a result of environmental pressures or forces of change and interventions and the lack of knowledge of the functions of the ecosystems in which we carry out our activities, the environmental services and goods provided by ecosystems are affected.

Ecosystem or environmental services are those that nature or ecological processes provide to living beings and the planet. The Food and Agriculture Organization of the United Nations (FAO), they are the driving force of the environment. They are essential for life, so land, water, air, climate, and genetic resources must be used responsibly for present and future generations. There are four types of services: supply, regulation, support, and cultural (SEMARNAT, 2021):

- **Supply.** These are the material benefits that people obtain from ecosystems, such as water, food, medicines, and raw materials. For many populations, these services represent their means of subsistence, so their value is greater than if they were commercialized.

- **Regulation.** Regulating services include climate and air quality, carbon sequestration and storage, moderation of natural phenomena, wastewater treatment, erosion prevention and soil fertility conservation, pest control, pollination, and regulation of water flows. To many people, they are invisible and taken for granted, but when they are affected, such as air or soil quality, the consequences are significant and in some cases difficult to repair.

- **Support.** Ecosystems provide vital spaces for flora and fauna. They also maintain a diversity of plants and animals through complex processes that support other ecosystem services. Some habitats have an exceptionally high number of species, making them more genetically diverse than others.

- **Cultural.** The non-material benefits that people derive from ecosystems are called cultural services. They include aesthetic inspiration, cultural identity, a sense of attachment to the homeland, and spiritual experience related to the natural environment. This group includes recreational and tourism activities.

To protect, conserve, and sustainably manage the environmental services and goods provided by socio-ecological systems based on the ecosystems that comprise them, there are a set of legal, administrative, financial, research, and educational tools, that need to be visualized and made known to society.

4. Results and discussion

To control, mitigate, and regulate the effect of intervention actions that are the environmental pressures mentioned above on environmental goods and services, we have a set of public policy tools that contribute significantly to reducing vulnerability and increasing the robustness and resilience of socio-ecological systems (Balvanera, *et al.*, 2017).

Below we will mention some of the basic management and administration tools for socio-ecological systems to promote their sustainability. It is important to highlight the transversal nature of these tools in terms of environmental, territorial, socio-natural risk, and watershed management.

Types of tools

Regulators. Legal, normative, and regulatory instruments:

1. Environmental impact assessment and study. Environmental license
2. Territorial impact studies
3. National Territorial Planning Strategy 2020-2040
4. Issuance of Opinion on Civil Protection Matters
5. General Law on Civil Protection and its regulations
6. Building permit for more than 60 m²
7. Land use license
8. Mexican Standards on Educational Physical Infrastructure (National Institute of Educational Physical Infrastructure)
9. Seismic standard

Regulators. Programs and plans:

1. Integrated watershed management plans
2. Municipal urban development plans or programs
3. Municipal Land Use and Urban Development Plan
4. Municipal Civil Protection Program
5. National Program of Protected Natural Areas

6. National Program for Territorial Planning and Urban Development
7. National Civil Protection Program
8. National Reconstruction Program
9. Program for dealing with emergencies caused by natural threats
10. Sectoral Program for Agrarian, Territorial and Urban Development
11. Metropolitan or conurbation area programs
12. Ecological Territorial Planning Programs
13. State programs for territorial planning and urban development
14. Internal Civil Protection Programs (PIPC)
15. Special Civil Protection Program
16. Municipal construction regulations and their complementary technical standards
17. Drills
18. National Civil Protection System
19. Early Warning Systems (EWS). Alerting and monitoring

Financial

1. Recovery fees
2. Emissions trading carbon
3. State funds
4. Municipal taxes,
5. Risk management and transfer instruments:
 - Insurance
 - Reinsurance
 - Microinsurance
6. Specific operating guidelines to address the damage caused by disruptive natural phenomena
7. Program for dealing with emergencies caused by natural threats
8. General Law on Budget and Fiscal Responsibility
9. Payment for environmental services (hydrological, landscape, recreational and others).

Research and education

1. Environmental Education
2. Environmental Diagnostics
3. Environmental risk study (pollution)
4. Risk Analysis
5. State Risk Atlas
6. Municipal Risk Atlas
7. National Risk Atlas
8. Population census. Index of marginalization
9. Economic censuses
10. Local and regional hydrometeorological, meteorological and geological studies
11. Studies related to climate change
12. Risk assessment (socio-economic and environmental impact of disasters)
13. Cadastral information
14. Scientific innovation and technology. Geotechnology (GIS)
15. Inventory and historicity of disaster.

4.1. How do we land the tools in the territory that makes up the socio-ecological system?

Firstly, to guarantee the resilience and robustness of the socio-ecological system, it is necessary to have financing for management, suitable trained and certified human resources, in short, a professional resource that has the capacity and knowledge to transmit to society the usefulness and forms of operation of the aforementioned tools, all this through different collective actions of agreement, citizen participation, dissemination and adaptation that allow a balanced dynamic of development of the socio-ecological system (Figure 2):

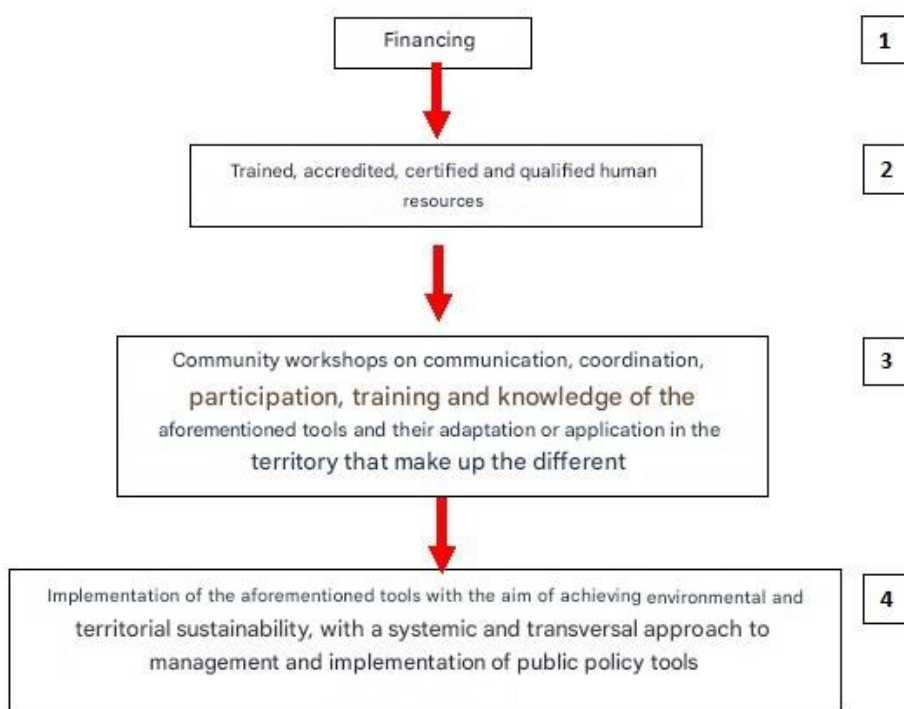


Figure 2 Socioecological system. Source: own elaboration.

All actions to implement public policies on vulnerability reduction must involve broad social coordination among the different actors: NGOs, private, public, institutional, indigenous peoples, and society in general.

5. Conclusion

We can conclude that many of the problems that arise in the socioecological system are a consequence of the lack of application, ignorance, or lack of understanding of the different environmental and territorial management tools. The environmental liabilities and social-natural risk scenarios we experience are the result of extreme institutional vulnerability, so we must begin by strengthening institutions in their relationship with the different actors that make up the human system and their actions (intervention, expression, and force of change) with ecosystems.

It is recognized that new trends and critical paths of analysis should be explored in this emerging current of research from a geographical perspective to address multi-complex and multi-variable problems from a comprehensive and dynamic perspective, thus contributing to the unprecedented environmental crisis that humanity is experiencing today.

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