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Mangroves require social-ecological systemic research

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Introduction

The concept of social-ecological system (SES) has taken off since the publication in 1998 of the book “Linking social and ecological systems: management practices and social mechanisms for building resilience” (Berkes and Folke, 1998). While the SES concept has quickly spread among studies dealing with many terrestrial or marine ecosystems, it only recently made its appearance in mangrove research. Yet, the complex dynamics of connections and feedbacks within and between societal and ecosystemic components that generate the emergent properties contributing to the system's identity and trajectory would be better understood through this systemic approach (Biggs et al., 2022). The study of human-mangrove relationships with a systemic approach implies looking at “a set of things – people, cells, molecules, or whatever – interconnected in such a way that they produce their own pattern of behavior over time” (Meadows, 2008). In the systemic field, mangrove social-ecological systems (MSES) “are therefore not merely social plus ecological systems, but cohesive, integrated systems characterized by strong connections and feedbacks within and between social and ecological components that determine their overall dynamics” (Biggs et al., 2022).

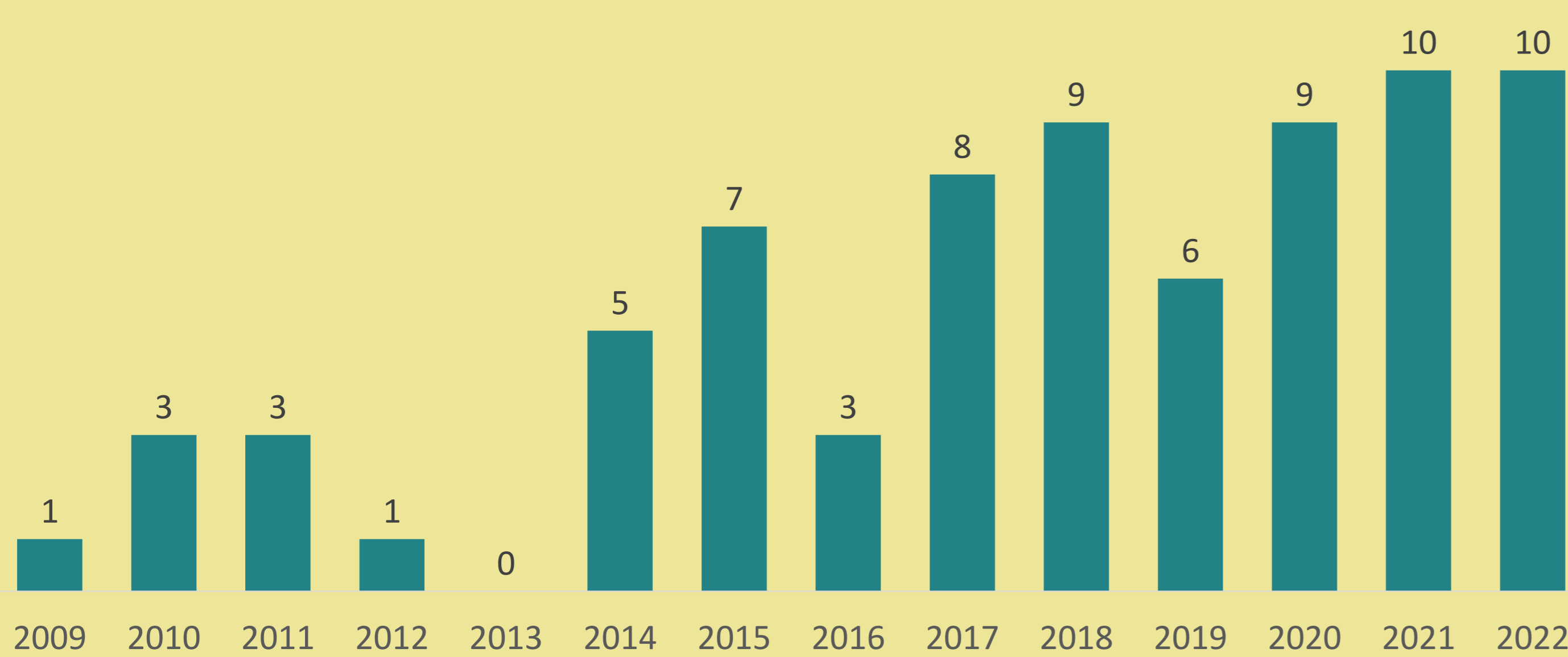
This review analyses how the SES concept has been integrated in mangrove research and the benefits that studies on human-mangrove interactions could draw from fully applying the SES concept.

Results

Table synthesizing the main descriptive information about the publications

Descriptive information about the publications	Results (n=75)
Type of publication	Empirical study (n=54), review (n=18), opinion paper (n=3)
Language	English (n=74), French (n=1)
Top five authors	Dahdouh-Guebas F. (n=11), Hugé J. (n=6), Friess D. (n=5), Stringer L.C. (n=4), Quinn C.H. (n=4)
Top five journals	Ocean and Coastal Management (n=8); Frontiers in Marine Science (n=5); Estuarine, Coastal and Shelf Science (n=3); Journal of Environmental Management (n=3); Regional Environmental Change (n=3)
Number of references with “SES” in the title	17 references: 4 between 2010-2014 and 13 between 2018-2022
Top first author working country	United Kingdom (n=12); United States (n=10); France (n=7); Belgium (n=6); Brazil (n=4); Bangladesh, Indonesia, Puerto Rico (n=3)
First author domain	Social scientist (n=24); natural scientist (n=24); mixed (n=27)
All author domain	Social scientist (n=13); natural scientist (n=11); mixed (n=51)

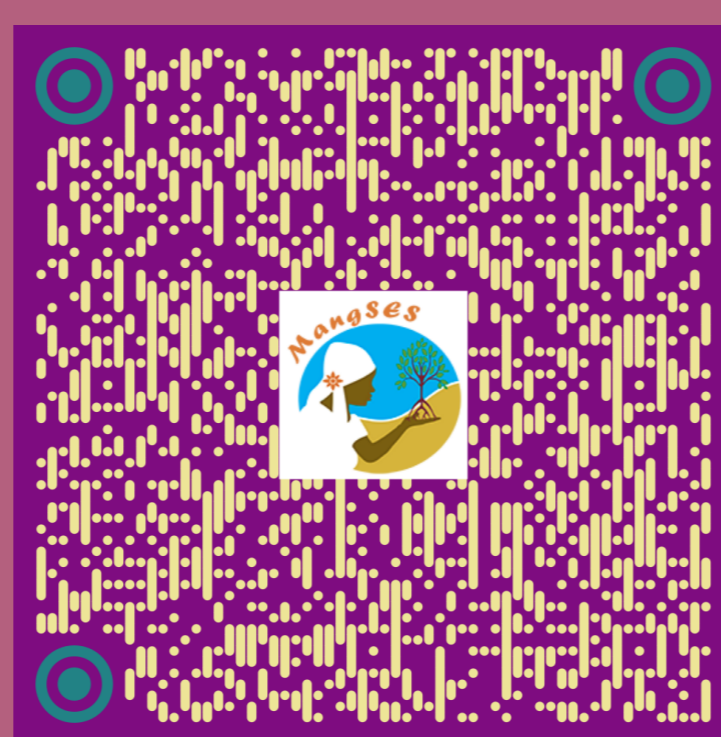
Number of publications per year related to SES and mangroves until 2022



The first publication on mangroves mentioning the SES concept dates back to 2009, 11 years after the publication of the book of Berkes and Folke (1998). This empirical study was published in the *Journal of Environmental Management* by Marschke and Sinclair and titled “Learning for sustainability: Participatory resource management in Cambodian fishing villages”. The number of publications increased from an average of 3 studies per year between 2009 and 2016 to 9 between 2017 and 2022.

Bibliography

Berkes, F. and Folke, C. 1998. *Linking social and ecological systems: management practices and social mechanisms for building resilience*. Cambridge: Cambridge University Press
 Biggs, R., de Vos, A., Preiser, R., Clements, H., Maciejewski, K., Schlüter, M. (ed.), *The routledge handbook of research methods for social-ecological systems*. London and New York: Routledge
 Gomez-Santiz, F., Perevochtikova, M., Ezzine-de-Blas, D., 2021. Behind the scenes: Scientific networks driving the operationalization of the social-ecological system framework. *Science of the total environment*, 787
 Meadows, D.H. 2008. *Thinking in systems*. London: Earthscan
 Oström, E. 2009. A general framework for analyzing sustainability of social-ecological systems. *Science (New York, N.Y.)*, 325(5939), 419–422



Selected publications for the review

Method: a systematic review of the literature

ELIGIBILITY CRITERIA

- Articles containing the term **SES** and **mangrove** until 2022
- Only journal articles and book chapters
- Language: includes English, French, Portuguese, Spanish

SEARCHING FOR STUDIES

- Research limited to **title, keywords** and **abstract** with syntax in all four languages
- Syntax for the search for documents in SCOPUS database: TITLE-ABS-KEY (“Soci* ecolog* system*” AND (mangrove*))
- Syntax for the search for documents in Web of Science database: TO=(“soci* ecolog* system*” AND mangrove*)

Documents found: 98

SELECTING STUDIES

Records removed because of:

- Other language (n=1)
- A data paper (n=1)
- Focus on another ecosystem than mangrove (n=3)
- Focus on aquaculture while mangrove is just an element of contextualization (n=2)
- Focus on landscape level with thematic entries, mangrove is just an “element” (n=6)
- The mangrove is not among the case studies from review references (n=9)

Studies included in the synthesis: 75

COLLECTING DATA

- Coding information are on:** (i) descriptive information about the publication; (ii) SES information; (iii) concepts and frameworks other than SES; (iv) main methodologies and case studies; (v) main outputs
- Variety of coded questions: predefined set of answers and qualitative answers
- Each publication was **double-coded** by two authors reaching a final agreement

SUMMARIZING THE RESULTS

- Preliminary analysis:** descriptive statistics and qualitative analysis on information about the publication and SES information
- Full analysis:** descriptive statistics, multiple correspondence analysis and qualitative analysis on all data

Adapted from Gomez-Santiz et al., 2021

The different ways to define SES in mangrove literature

Among the publications, the results regarding SES definitions or explanations show:

❖ **69% do not define what is a SES.**

❖ For the 23 publications giving a definition:

- 28 different references are quoted in association with the SES definitions/explanations

The **most cited references** are:

- Berkes, F. and Folke, C. 1998. *Linking social and ecological systems: management practices and social mechanisms for building resilience*. Cambridge: Cambridge University Press (n=5)
- Ostrom, E. 2009. A general framework for analyzing sustainability of social-ecological systems. *Science (New York, N.Y.)*, 325(5939), 419–422 (n=5)
- Folke, C., Hahn, T., Olsson, P., and Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources*, 30, 441–473 (n=4)

The **giving definitions** can be analyzed as:

- All definitions except one refer, with different words, to the **interactions between the societal and ecological system** (« coupled », « intertwined », « interdependent », « integrated »)

Ex. “Human-environment interactions, including in mangrove systems, function as integrated social-ecological systems (SES) (Berkes et Folke, 1998)” (in Orchard et al., 2015)

- Some definitions also explain that SES are: **complex or adaptive systems** (n=8); multi-level, **nested systems**, systems with different spatio-temporal scales (n=7); systems with **feedback** or **thresholds** (n=4)

Ex. “This management approach requires understanding SES in an integrative way in order to capture the complex interaction between causal factors and responses, as well as lags, feedback and thresholds in social and ecological systems (Biggs et al. 2012).” (in Hossain et al., 2020)

Ex. Holistic approaches that integrate social and ecological system perspectives can help unravel the complex linkages and feedbacks occurring across different temporal and spatial scales (Berkes and Folke, 1998)” (in Stringer et al., 2018)

We also coded whether the publication involves a SES framework. It was the case for 7 publications out of 75. In these 7 publications, 6 use an existing methodological framework such as those of Berkes and Folke (1998) and Oström (2009) and 2 propose an adapted methodological framework (one of them with both existing and adapted frameworks).

Conclusion

Most publication retrieved do not define the SES. Instead, the term SES appears in the list of keywords (buzz word?) or abstract or it is scarcely mentioned in the publication as a common expression, showing its fast integration into the scientific vocabulary in three decades.

When the SES concept is at the core of the study, it is often defined. Most publications, however, use the concept to place the studies on the society-mangrove relation topic. Instead, few actively apply a systemic approach or use SES frameworks. For instance, very few studies deal with feedbacks within the MSES or try to determine the threshold of variables that have a paramount role in the resilience of the SES. In the SES literature, the emergent properties of SES are increasingly studied (Biggs et al., 2022) which is not the case in the mangrove literature. The steeper increase of recent publications on MSES suggests that part of the mangrove research is going down this path.