Ostrom's SES Framework: a Meta-Analysis of Community Forests in Mexico

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Abstract. The importance of using Social-Ecological System (SES) framework to improve sustainability in complex social-ecological systems is highly accepted. However, as far as diagnosis in complex SES is concerned, the concept of wholes and parts in complex systems rarely exists in an absolute sense. Normally what are found, are intermediary structures on a series of levels in ascending order of complexity, each of which has two faces looking in opposite directions; the face turned toward the lower levels, that of an autonomous whole, and the one turned upward, that of a dependent part. In this paper, reffering to three aspects of decomposability of complex systems, and using E. Ostrom SES framework theory and a meta-analysis of 31 case studies of community forests in Mexico, the importance of opposite directions in the course of explaining variable interactions and configurations to achieve desired system outcomes is explained.

Key words: Complex Social-Ecological System, autonomous whole, dependent part, meta-analysis, interaction of variables, configuration of variables.

1. Introduction

The E. Ostrom´s SES framework has currently gained interest of researchers in the governance of the Common-Pool Resources (Hill, et al., 2015). This is because, it helps accumulation of required scientific knowledge from different disciplines for sustainable complex SESs in which CPRs are embedded in (McGinnis & Ostrom, 2014). However, in order to maximumly benefit in the SES utilization, a proper diagnosis into the framework and congruent analytical methods are necessary. In this paper, a diagnosis in SES framework is focused on two faces looking in opposite directions; the face turned toward the lower levels, that of an autonomous whole, and the one turned upward, that of a dependent part. It uses community forests of Mexico as a case study, and this has been chosen based on the fact that it has got governance issues related to inter-community collective action as a key link in multi-scale governance (Bray, Duran, & Molina-Gonzalez, 2012), and consequently a conservation through community approach was highly recommended as an urgent measure (Merino, 2007), the use of a meta-analysis of case studies is highly important because it is a multi-method approach (Poteete, Janssen, & Ostrom, 2012) and its advantage of considering both quantitative and qualitative data help advancement in diagnostical analysis into SES framework. This work is organized as follows; description of E.Ostrom Social-Ecological System Framework, cased-based meta-analysis, variable interaction and confgurations, methodology, results, and conclusion.

2. E. Ostrom Social-Ecological System Framework

The E. Ostrom's SES framework is delivered and closely related to Institutional analysis development framwork (McGinnis & Ostrom, 2014). It was developed as a response to a riticism of that the later

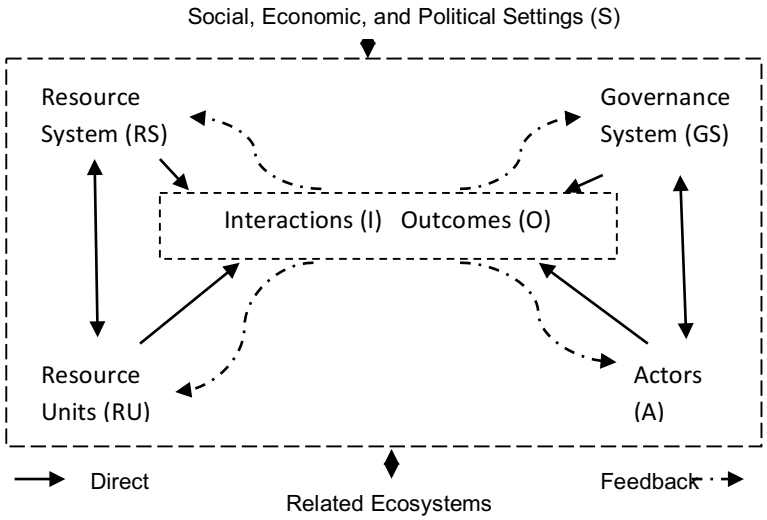
framework was not paying sufficient attention to to ecological and larger socio-economic contexts and to the multiple levels and social–ecological complexity in which common-pool resources management takes place (Thiel, Adamseged, & Baake, 2015). Thus, E. Ostrom had to shift to a new framwork in order to be able to study impact of human behavior towards the ecosystem in the course of sustainable governance. However, traditional studies on the impact of human behavior towards the ecosystem studied these two concepts in isolation which resulted in undermeaning the concept of SES, whereas the concept of a SES goes beyond this view (Rommel, 2015). Social–Ecological System (SES) comprises a social system, an ecological system, and the interactions between the two (Cumming, 2011). Hence, SESs are defined as coherent systems with multiple (often non-linear) interactions that span across (hierarchically linked) scales, which consist of critical resources, whose flows and uses are affected by both social and ecological factors, and which are dynamic and adaptive (Redman, J.M., & L.H., 2004). In this view, SESs are inherently complex (Ostrom E. , 2009). Because scholars use different concepts and languages to describe and explain these complex systems, without a common framework to provide common language to multitheories of collective action, scientific knowledge cannot accumulate to guide an effective analytical focus. Thus, SES framework is highly necessary, and it provides a metatheoretical language that can be used to compare theories. In this course, it attempts to identify the universal elements that characterize any theory relevant to the phenomena of the study, hence, SES is considered as a conceptual map, and it also identifies basic working parts and critical relationships among those elements. In this view, SES is considered as a decomposable system. SES as a meta-theorical concept, it often draws confusion with theory and model concepts (Ostrom E. , 2011). Thus, we cannot talk about a framework concept, without talking about a theory and model concept in the the SES conceptual analysis whereas sometimes are erroneously used interchangeably.

The development and use of theories help diagnosis into the framework and enable the analyst to specify which elements of a framework are particularly relevant to particular questions and to make general working assumptions about the shape and strength of these elements. Theories make assumptions that are necessary for an analyst to diagnose aspecific phenomenon, explain its processes, and predict outcomes. Multiple theories are usually compatible with one framework. In the case of community forests governance, theories help identifying core variables to be included in the analysis, and making assumptions about variable interactions and configurations among case studies. In contrast, the development and use of models involve making precise assumptions about a limited set of variables and parameters to derive precise predictions about the results of combining these variables using a particular theory. Multiple models are compatible with most theories. A model of meta-analyses of case studies is highly recommended for SES analysis due to its flexible analytical method.

A diagnostical analysis into SES framework is built on three aspects of decomposable complex system which are; the conceptual partitioning of variables into classes and subclasses, the existence of relatively separable subsystems that are independent of each other in the accomplishment of many functions and development but eventually affect each other's performance, and complex systems are greater than the sum of their parts. Based on these aspects, SES framework is composed of four ''first-level core subsystems,'' namely: (i) a resource system, (ii) resource units, (iii) a governance system, and (iv) users, and they affect each other as well as linked social, economic, and political settings and related ecosystems. These subsystems contain a set of variables which are also set of ''second-level'' variables of the SES and they constitutes a basis in the SES analysis (Ostrom E. , 2007). As far as a view of SES in the two faces of opposite directions is concerned, each part of the

framework is autonomous agent of the whole system and though interactions with other variables or individual parts, dynamically evolves to form changing configurations in the system. The decomposition of SES framework is given in the following figure of its conceptual map.

A Figure of a Multitier Framework for Analyzing a Social-Ecological System



Source: E. Ostrom, 2007

The above figure focuses on how a Resource System, Resource Units, Governance System, and Actors embedded in larger or smaller Social, Economic, and Political Settings and Related Ecosystems might affect interactions and outcomes within action situation (Ostrom E, 2011; 2007). And they are said to be subsystems or variables of the first level of the whole system. These subsystems are further decomposed into second level or second-tier independent variables, and they help diagnosing the causal patterns that affect outcomes. A list of these variables is found in the table below.

In this view, SES framework is considered as a whole. Whereas, its subsystems and their sets of variables are its parts on the first order and second order respectively. As far as diagnosis into SES is concerned, the view in the face turned towards the lower levels where SES parts on the first order and second order are considered as autonomous whole is expressed.

However, in the view of the face turned upward, that of a dependent part, a variable is taken as a unit part of the SES, in this case, it is considered as outonomous whole where its variability depends on its inner characteristics and its interactions with other variables within SES. As parts of a system, these variables interact and form patterns of interactions to determine overall outcome of the system, and any change in formed patterns of interactions may affect positively or negatively the system outcome (Ostrom E. , 2007). Hence, the system is not only considered as a sum of its parts, but also the interactions among its parts in dependent phenomena and this helps tackling emergency of complexity which a critical concern in the management of the common pool resource system (VanWey, Ostrom, & Meretsky, 2005).

Thus, a diagnosis into SES within two faces looking in opposite directions; the face turned toward the lower levels, that of an autonomous whole, and the one turned upward, that of a dependent part are very important in the course of explaining how variable interactions and configuration into patterns

of interaction affect desired system outcomes. It is also a basis of futher methods to determine variable interactions and patterns of interactions affect outomes. This is a case of Social-Ecological System Meta-analysis Database (SESMAD) method as it is explained later.

Table 1. Second-Tier Variables in Framework for Analyzing an SES

Social, Eonomic, and Political Settings (S) S1-Economic development. S2-Demographic trends. S3-Political stability. S4-Government settlement policies. S5-Market availability.	
Resource System (RS)	**Governance System (GS)**
RS1-Sector (e.g., water, forests,pasture, fish) RS2- Clarity of system boundaries RS3- Size of resource system RS4- Human-constructed facilities RS5- Productivity of system RS6- Equilibrium properties RS7- Predictability of system dynamics RS8- Storage characteristics RS9- Location	GS1- Government organizations GS2- Non-government organizations GS3- Network structure GS4- Property-rights systems GS5- Operational rules GS6- Collective-choice rules GS7- Constitutional rules GS8-Monitoring & sanctioning process
Resource Units (RU)	**Users (U)**
RU1- Resource unit mobility RU2- Growth or replacement rate RU3- Interaction among resource units RU4- Economic value RU5- Size RU6- Distinctive markings RU7- Spatial & temporal distribution	U1- Number of users U2- Socioeconomic attributes of users RU3- History of use U4- Location U5- Leadership/entrepreneurship U6- Norms/social capital U7- Knowledge of SES/mental models U8- Dependence on resource U9-Technology used
Interactions (I) ? Outcomes (O)	
I1- Harvesting levels of diverse users I2- Information sharing among users I3- Deliberation processes I4- Conflicts among users I5- Investment activities I6- Lobbying activities	O1- Social performance measures (e.g., efficiency, equity, accountability) O2- Ecological performance measures (e.g., overharvested, resilience, diversity) O3- Externalities to other SESs
Related Ecosystems (ECO) ECO1-Climate patterns. ECO2-Pollution patterns. ECO3-Flows into and out of focal SES.	

Source: E. Ostrom, 2007

According to this table, SES framework contains 42 variables which have been increased along with its interest in research field and now we have 175 variables (SESMAD, 2014). Even if second level variables have been augmented, research on how their interactions impact overall outcome of the whole system is still lacking. Thus, using a cased-based meta-analysis, the importance of opposite directions of two faces of the diagnosis into SES is explained.

3. Cased-Based Meta-Analysis

A meta-analysis is a technique used to make a synthesis of research analysis. Until now, it may be divided into two cathegories; a statistical meta-analysis and cased-based meta-analysis. The former is normal and too widely applied technique and it attempts to aggregate across systems. By this technique, data are pooled on the same phenomenon gathered in multiple studies in order to test effect sizes, and informal literature reviews which summarize and compare the findings of multiple studies. Statistical meta-analysis is a powerful technique, yet it can only be used when data gathered in multiple studies address the same questions using the same or similar techniques (Harrison, 2011). However, studies of SESs rarely have these required characteristics. Informal literature reviews, meanwhile, can provide a meaningful comparison, but are inherently non-systematic. Thus, a meta-analysis of case studies is a suitable method.
Meta-analyses of case studies combine the rigor of formal statistical meta-analysis with some of the flexibility of a literature review, hence it is suitable for qualitative analysis. They do not require that the case studies to be conducted in an identical fashion in order to produce comparable data, but instead rely on standard coding protocols utilizing nominal, ordinal, interval and qualitative variable definitions to create a database which uses existing information to compare across cases (Cox, 2013). In this case, Social Ecological Mata-analysis Database (SESMAD) is used as a guiding tool of data from the case studies.
Based on the SESMAD method, the variables used in this paper, are classified as:

- Variable type which comprises; 14 binary variables, 15 categorical variables, 1interval variable, 28 ordinal variables, and 3 text variables.
- Variable Component Type: this type of classification allows getting types of variable component such as; environmental common, natural pollutant resource unit, and natural resource system which are the components of resource system, actors, governance system and formal system which form governance system as a unique component. This is because, as far as the case studies of community forests in Mexico are concern, it is identified that there are no big difference in environmental common and natural resource system, and natural pollutant resource unit and natural resource unit. Hence, in this research four components or subsystems (resource system with 23% of variables, resource unit system, governance system with 15% of variables, and actors with 62% of variables) are considered. In order to know how they influence the outcomes of the community forests, it is needed to identify how far are represented in the interactions and outcomes process, this is given by viewing how variable are distributed in the attached component.
- Variable attached component. The variables are attached to either case component or component-interaction. Thus, in this work, 70% of variables are in component interaction

and meaning the high viability and reliability on the information got for analysis and the existence of diversity in the outcomes resulting from various possible patterns of interactions.

- Theme: spatial, outcomes, institutions, context, enforcement, incentives, heterogeneity, basic, external, leadership, technology, social capital, biophysical, knowledge and uncertainty. The most predominant themes concerned with the variables in this research work are institutions, incentives and outcomes.

Each variable is integrated into one of the four components or subsystems of the SES framework, and it can only play a role of characterizing a subsystem component or/and goes further to be part of interactions or outcomes from the whole SES. Thus, outcomes result from variables interactions and threir patterns of interactions. Any change within that configuration affect the SES outcomes.

4. Variable Interactions and Configuration of Patterns of Interacions

According to E. Ostrom SES framework (2007), the outcomes from the use of community forests as SES are results of variable interactions and formation of patterns of interactions. In case the outcomes are unsatisfactory, the SES framework helps in knowledge accumulation required for proper governance. Any decisional change towards governance in place implies modifications into variable configurations, which are often complex.

As it was seen that, SES comprises four ‘‘first-level core subsystems,’’ namely: (i) a resource system, (ii) resource units, (iii) a governance system, and (iv) users, and they affect each other as well as linked social, economic, and political settings and related ecosystems. The variables in this work are spread into these four subsystems under a common name of a set of ‘‘second-level’’ variables, and their configuration is what determine the outcomes of the whole system.

The SES framework in this work comprises analysis of patterns of interactions of 27 variables out 61 selected from 175 variables of the SESMAD to study community forest in Mexico. Due to the process of configurations and interactions which affect outcomes, a variable can be a component kind or both component and interaction kind. Those that appear only in component part of the SES are said to have an indirect effect on the outcomes, whereas those that appear as an interaction part of the SES, are said to direct affect the outcomes. By a criteria of 2.23 of average points of realized outcomes, the case studies are divided into a group of 13 successful case studies and another one of 18 unsuccessful case studies.

Based on the impact of variable patterns of interactions on outcomes in the case studies, there are; common variables which generate common characteristics within the case studies from which their contribution to successful or unsuccessful situations is invariable, undentified variables which are considered to have neutral behavior in the patterns of interactions and on results, variables which appear in all cases and have null variance which means that they have common behavior in the patterns of interactions and on outcomes, and variables with variance greater than zero which are subject to the analysis of their influence on the success and unsuccessful situation in the case studies and their perfomance within case studies are shown in the following table:

Table 2. Variable performance

Variable	Total points of successful cases	Total points of unsuccessful cases	General total
Boundary Clarity	26	32	58
Economic Dependence	17	28	45
Interest Heterogeneity	11	29	40
Cultural Dependence	20	18	38
Monitoring Technology	12	13	25
Perverse Incentives	8	10	18
Regulating Services Condition	8	10	18
Regulating Services Use	9	9	18
Commons Boundary Negotiability	10	7	17
Commons Political Participation	17	-2	15
Regulating Services Effect	12	3	15
Collective Action	18	-4	14
Trust	11	1	12
Past Collaboration	9	0	9
Biodiversity Trend	14	-6	8
Trust	9	-2	7
Leadership Accountability	9	-3	6
Commons Political Power	10	-5	5
Leadership Authority	6	-5	1
Effect	10	-14	-4
Self-Monitoring	4	-8	-4
Economic Heterogeneity	-4	-1	-5
Cultural Heterogeneity	-6	-2	-8
Total	240	108	348
Average	10.43478	4.695652	15.13043

Source: Proper design according to the concept of E. Ostrom, 2007& SESMAD, 2014

From the above table, bold and italic variables are the ones by which their behaviors in the patterns of interactions and configurations determine successful and unsuccessful situations. These variables are divided into two groups; variables which have high performance in successful case studies and low performance in unsuccessful case studies, and these are: commons boundary negotiability, commons political participation, regulating services effect, collective action, trust (governance system), past collaboration, biodiversity trend, trust (Actors), leadership accountability, commons political power, leadership authority, effect, self-monitoring, and the variables which are lowest in successful cases and low in unsuccessful cases, and these are economic heterogeneity and cultural heterogeneity. This is because an increase in scoring points in these variable negatively affect the

outcomes whereas a decrease in their scoring points positively affects the outcomes.

5. Methodology

The methodology of this research consists of both theoretical and empirical analysises. The former analysis is all about E. Ostrom concept of self- governance of common pool resources and institutional design taking the SES framework a central point as meta-theoretical framework and it serves as organizing toll of multidisciplinary theories on institutional analysis for CPRs governance. Whereas, empirical analysis applies the SES meta-analysis method (SESMAD) to study how variable interactions and formation of patterns of interactions affect the outcomes.
SESMAD is an internationally collaborative meta-analysis project that builds on previous seminally synthetic work on small scale common-pool resource systems conducted at the Workshop in Political Theory and Policy Analysis at Indiana University, and it was applied to 31 case studies of the community forests in Mexico for a period of 2000 to 2014. This goes hand in hand with what F. V. Laerhoven says that generally, the study of community forest governance relies heavily on case-study materials (Laerhoven, 2010) and also reflects Ostrom methodology of case studies to identify similarities and differences (Ostrom, 1990).
The meta-analysis of the case studies method allows using qualitative and quantitative data in order to get accurate information from the sample of case studies. 61 out of 175 variables which characterize the SES of the common-pool resources have been systematically chosen from SESMAD. The idea of selecting 61 variables is based on the criteria of how much they are implicated in the characterization of community forests governance performance.

6. Results

The diagnosis into SES framework through two faces looking in opposite directins and the use of meta-analysis of cased-based meta-analysis is an important undertaking to solve issues related to the sustainability of complex SESs. Carrying out a theoretical and empirical analysis of meta-analysis of case studies to explain how these methods are complement, the following results were achieved:

i) There are common characteristics in the cases of community forests in México. They are identified by a number of variables which are constant in all cases of the analysis. These are:

- Common actions (extraction, monitoring, conflict resolution, rule-making, sanctioning, trading, consumption). The actions are currently extended and acted under management plan by large group size, with rights of access, use, exclusion, management, and alienation. The proportionality of these rights is not identified, and according to SESMAD project, a lack of proportionality of rights implies lack of motivation to contribute to the successful governance of the common resources, thus for example in this research there is no habit of self-sanctions. But, even if there is no self-sanctions, community forests are governed to the extent to which conflicts are solved.

- It is also commonly identified in all cases that:

- The scales of resource markets are not identified, and this handicaps the control and decision making on benefits from the use of the resources.
- Policy instrument and rights granting have not also identified. Policy instruments structure the behavior and incentives that members of an actor group face. In turns, these incentives and behaviors play a key role in affecting commons outcomes. Initial granting of rights is widely considered to influence the use of those rights. Rights granting processes that are viewed as more fair or legitimate may be more likely to be respected. Rights granting processes that are based on current or past uses may grandfather in historical practices, incentivizing increases in pollution or resource extraction levels, but may also protect vulnerable populations.
- Special extent. It has been identified that all cases are larger systems. Larger-scale commons are generally more difficult to manage because of the increased likelihood of negative externalities between distinct actor groups.
- The following variables have got zero variance and their contribution to success among case studies is unexplained. There are; boundary fuzz, costs/ benefits, costs of exit, ecosystem service markets, external recognition, flexible rights, governance scale, incentive type, leadership, markets, overcapitalization, rights proportionality, roads, accessibility, external recognition, and physical boundaries, Black markets, size and traditional knowledge.

i) Variable configurations

The remaining 23 variables generate different configurations in 31 case studies from which the success and failed case studies can be identified. According to the above table of variable performance, the variables whose performance is clearly distict in either successful or unsuccessfull case study are in two groups; variables which have high performance in successful case studies and low performance in unsuccessful case studies, and these are: commons boundary negotiability, commons political participation, regulating services effect, collective action, trust (governance system), past collaboration, biodiversity trend, trust (Actors), leadership accountability, commons political power, leadership authority, effect, self-monitoring, and the variables which are lowest in successful cases and low in unsuccessful cases, and these are economic heterogeneity and cultural heterogeneity. This is because an increase in scoring points in these variable negatively affect the outcomes whereas a decrease in their scoring points positively affects the outcomes.

7. Conclusions

The way SES framework is viewed affects its contribution to research analysis and results. Hence, in order to increase its contribution, the researchers should have in mind two faces looking in opposite directions; the face turned toward the lower levels which is that of an autonomous whole, and the one turned upward which is, that of a dependent part. This complies with the three aspects of the decomposability of complex systems which help tackling complexity embedded in these systems and hence achieve accurate policy solutions for their longterm sustainability.
Using a meta-analysis of case studies, it was identified that these two apposite directions of the SES diagnosis deals in a complex structure of subsystems and a set of variables interact and form

structured patterns of interactions wich do not existe in absolute sense. hence, a multimethods analysis is highly important and this implies indistinctive importance of qualitative and quantitative in this kind of analysis.

Bibliography

Bray, D., Duran, E., & Molina-Gonzalez, O. A. (2012). Beyond harvests in the commons: multi-scale governance and turbulence in indigenous/community conserved areas in Oaxaca, Mexico. International Journal of the Commons, 151–178.

Cox, M. (2013). The SESMAD project. http://dlc.dlib.indiana.edu/dlc/revised on 14.03.2016.

Cumming, G. S. (2011). Spatial Resilience in Social-Ecological Systems . Dordrecht Heidelberg London New York: Springer Science+Business Media.

Elinor, O., A., J. M., & M., A. J. (2007). Going beyond Panaceas. National Academy of Sciences, 15176-15178.

Harrison, F. (2011). Getting started with meta-analysis . Methods in Ecology and Evolution, 2, 1-10.

Hill, R., Dyer, G., Lozada-Ellison, M., Gimona, A., Martin-Ortega, J., Munoz-Rojas, J., & Gordon, I. (2015). A social–ecological systems analysis of impediments to delivery of the Aichi 2020 Targets and potentially more effective pathways to the conservation of biodiversity. Global Environmental Change. www.elsevier.com/locate/gloenvcha, 34, 22-34.

McGinnis, M. D., & Ostrom, E. (2014). Social-ecological system framework: initial changes and continuing challenges . Ecology and Society , 19(2)(30), 06387-190230 .

Merino, L. (2007). CONSERVACIÓN COMUNITARIA EN LA CUENCA ALTA DEL PAPALOAPAN, SIERRA NORTE DE OAXACA. NuevaAntrop, 37.

Ostrom, E. (2007). A DIAGNOSTIC APPROACH FOR GOING BEYOND PANACEAS. Workshop in Political Theory and Policy Analysis Indiana University, 513 North Park Avenue, Bloomington, IN 47408-3895 USA.

Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science, 325, 419-422. Obtenido de www.sciencemag.org

Ostrom, E. (2011). Background on the Institutional Analysis and Development Framework. The Policy Studies Journal, Vol. 39(No. 1).

Poteete, A. R., Janssen, M. A., & Ostrom, E. (2012). Trabajar Juntos. Acción colectiva, bienes comunes y múltiples métodos en la práctica. Universidad Nacional Autónoma de México, Av. Universidad 3000, Delegación Coyoacán, Ciudad Universitaria, 04510, México, D. F.: IMPRESO Y HECHO EN MÉXICO. ISBN: 978-607-02-3577-1.

Redman, C., J.M., G., & L.H., K. (2004). Integrating social science into the Long-Term Ecological Research (LTER) Network: Social dimensions of ecological change and ecological dimensions of social change. SCOPUS, 7(2), 161-171.

Rommel, J. (2015). What can economic experiments tell us about institutional change in social–ecological systems? e n v i r o n m e n t a l s c i e n c e & p o l i c y. Available online at www.sciencedirect.com. journal homepage: www.elsevier.com/locate/envsci, 53, 96-104.

SESMAD. (2014). Social-Ecological Systems Meta-Analysis Database: Background and Research Methods. Recuperado el 2014;2015;2016, de http://sesmad.dartmouth.edu

Thiel, A., Adamseged, M. E., & Baake, C. (2015). Evaluating an instrument for institutional crafting: How Ostrom's social–ecological systems framework is applied. e n v i r o n m e n t a l s c i e n c e & p o l i c y(53), 152-164. Obtenido de Available online at www.sciencedirect.com

VanWey, L. K., Ostrom, E., & Meretsky, V. (2005). Theories Underlying the Study of Human-Environment Interactions . En E. F. Ostrom (Ed.), Seeing the Forest and the Trees Human-Environment Interactions in Forest Ecosystems (págs. 38-71). Cambridge, Massachusetts and London, England: The MIT Press.