Learning and adaptation as conservation practices in resilient traditional socio-ecological systems: The Elder Brothers of Sierra Nevada de Santa Marta

Aprendizaje y adaptación como prácticas de conservación en socioecosistemas tradicionales resilentes: los hermanos mayores de la Sierra Nevada de Santa Marta

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Abstract

A history of interaction between traditional social communities and the environment forms a relationship that can be understood by examining these interactions through the theory of complex systems. The process of interaction not only develops knowledge applicable to traditional agriculture or hunting and gathering but also promotes conservation practices. This paper examines the socio-ecological system established between the traditional inhabitants of Sierra Nevada de Santa Marta, and its ecosystem. It establishes theoretical foundations through literature review of topics such as learning and knowledge development, resilience and conservation management of socio-ecological systems. Traditional indigenous communities of Sierra Nevada de Santa Marta continually adapt and learn from their environment reinforcing their conservation customs. Further analysis of the social-environment relationship elicits a description of a robust traditional socio-ecological system. A system resilient to outside pressures and environmental change through active conservation.

Keywords: Resilience, adaptation, socio-ecological systems, learning, knowledge development.

Resumen

La historia de la interacción entre comunidades tradicionales y el medio ambiente en el que habitan, describe una relación que puede ser entendida mirando a las interacciones formadas en el sistema y, através de la teoría de sistemas complejos y la teoría de resilencia. En el proceso de interacción, no solo se desarrolla conocimientos aplicables a practicas tradicionales como la agricultura, la caza y la recolección, pero también se promueve prácticas de conservación. Este artículo examina el sistema socio-ecológico establecido entre los habitantes tradicionales de la Sierra Nevada de Santa Marta, y su ecosistema. Estableciendo fundamentos teóricos a través de una revisión bibliográfica de temas como, aprendizaje y el desarrollo de conocimientos, la capacidad de resilencia y prácticas de conservación en sistemas socio-ecológicos tradicionales. Las comunidades indígenas tradicionales de la Sierra Nevada de Santa Marta continuamente adaptan y aprenden de su entorno, reforzando así, sus costumbres de conservación y preservación del medio ambiente. Un análisis más detallado de las relaciónes sociales con el medio ambiente en la Sierra, deriva en una descripción de un sistema socio-ecológico tradicional robusto en el que la practica de conservación activa, promueve un sistema resilente a distintas presiones externas y a cambios en el medio ambiente.

Palabras claves: Resiliencia, adaptación, sistemas socio-ecológicos, aprendizaje, desarrollo del conocimiento.

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Introduction

Throughout the world traditional and local knowledge is being used in practices for community-based conservation and natural resource management [see, 1-4]. Berkes and Turner [5] highlight the important role that building local and customary knowledge has in achieving conservation goals. Likewise, several studies have increasingly acknowledged and recognised traditional communities as major contributors in conservation strategies [5-9].

However, as argued by Olsson et al. [10], different types of knowledge, learning processes and adaptation mechanisms are context specific considering that traditional knowledge evolves hand in hand between the communities and their local environment.

This paper constitutes, firstly a literature review of mainly peer-reviewed papers on the topics of resilience thinking, management and conservation. It will be developed having as a premise that, learning and knowledge development to adapt to changes and deal with uncertainty, are a key-stone of successful social ecological systems [6, 11-13].

Specifically, it looks at literature that contributes to the understanding of traditional socio-ecological systems, adaptive management, resilience and the building of knowledge from the perspective of traditional communities. As such, it aims to construct theoretical foundations for understanding the way in which the traditional communities in Sierra Nevada de Santa Marta and their social systems build knowledge and management practices applicable to conservation, taking into account the strong interdependence between local livelihoods and ecosystem functioning.

In light of the above, the socio-ecological system established between three traditional communities descendants of the Tayronas and the Sierra Nevada de Santa Marta will then be analyzed. Their adaptive responses, their learning process, their self-organization capacity, all of them from their cultural perspective, and how they apply this knowledge into conservation practices, will be used to frame a critical understanding of a resilient traditional socio-ecological system.

Learning Processes in Traditional Socio-Ecological Systems

Review Stage

Socio-ecological systems are defined as a mosaic of multiple subsystems, consisting of many different variables interacting within a complex system [14]. To put it another way, socio-ecological systems are understood as human groups that make a social fabric, while embedded in, and are in constant interaction with, the natural –ecological environment [15] in a "wide range of spatial and temporal scales" [15: 2]. This is a "human-in-ecosystem perspective" [16].

Although there is no specific definition of traditional socio-ecological systems, they seem in general to adhere to the definition of socio-ecological systems described above. Specifically though, traditional socio-ecological systems may denote processes such as the observation of local ecosystems over long periods of time by local people, or actions such as customary practices, and an important set of principles in the way in which people interact with or relate to their local environment [6]. Hence, traditional socio-ecological systems refer to the historical and cultural relationship between a specific community and the ecosystem in which they live [17].

Learning processes play a very important role in socio-ecological systems. While conservation - as with many other practices - is not an inherent practice in human societies [5], conservation knowledge can be generated as a response from the interaction between social and ecological systems [Vikers 1994 in 5]

Berkes and Turner [5] describe two models for learning and developing conservation knowledge that can be applied to traditional socio-ecological systems. The first model is the learning process derived from scarcity or depletion of resources, or what Johannes [18] describes as a type of awareness related to resource crisis. Other insights of this learning process can be found in ecological crises caused by natural disasters where abrupt changes in the ecosystem lead to problems in accessing resources [19], or where political tensions lead to an imbalanced distribution, use and/or access to ecosystem services by local communities [20]. In both cases, communities

are somewhat forced to engage with a rapidly changing resource base, which in turn leads to the production of adaptive and innovative types of knowledge.

On the other hand, the second model described by Berkes & Turner [5: 482], or "the ecological understanding model", emphasizes the development of knowledge through a "more sophisticated understanding of the ecosystem". This model is very relevant to traditional communities given the historical characteristic of traditional socio-ecological systems. In other words, it could be said that this learning process for developing conservation-applicable knowledge occurs by doing [21] in a practice of constructing and applying social and ecological memory [15].

Thus, over time communities produce knowledge, which evolves over time according to environmental changes and is therefore adaptive. An example of the production and constant evolution of environmental knowledge is in fact seen amongst aboriginal peoples, who have experienced the appropriation and use of their environment over long periods of time [22]. Similarly, Gómez et al. [23] examine the role that historical and traditional communities play in achieving sustainable practices within a specific socio-ecological system, which in turn can result in the preservation/protection of the environment. These examples highlight how customary societies interact with and respond to different situations and, as a result, develop knowledge that provide the means for subsistence livelihoods while protecting environmental systems. Clearly, one model could be considered reactive based on external factors, while the other is proactive due to the internalization of the environment in livelihoods strategies.

In resilience thinking, the use of the adaptive cycle concept is used to understand and describe how a social-ecological system "organizes itself and how it responds to a changing world" [15: 75]. Understanding knowledge-building processes as part of the socio-ecological system is also important and should thus be part of the adaptive cycle. Indeed, the natural complexity of socio-ecological systems and, because of the fact that the "manner in which the system behaves is different from one phase to the next" [15: 75], highlights the importance of comprehending learning as an adaptive process.

It would thus seem that the ecological understanding model takes place during the whole cycle. Admittedly, this particularity is more common in traditional communities learning. Traditional ecological knowledge describes an understanding of the means by which uncertainty or "surprises" are constantly present in the system [24: 359]. At the same time, traditional knowledge denotes an all-inclusive component and adaptation characteristics in an arrangement of practices used in conditions of "trial-and-error" [6: 1252]. This idea implies a passage through a moment of availability of resources while accumulating a defined structure, progressing to a phase of stability and development of tight interconnections within the system. Then, the presence of surprises might cause a failure, to later, reorganize the system and start over again [25]. In other words, learning experiences and construction of knowledge in traditional socio-ecological systems pass through the phases of growth, conservation, release and reorganization [6, 15, 25].

Uncertainty, Adaptive Management and Self-Organization: The Application of Knowledge in Conservation

Methods for natural resource management are usually constructed under the premise that it is possible to generate responses to predictable events [25]. This approach is also used in the management of conservation projects such as protected areas [26]. However, this type of approach does not consider some important elements within the system. Communities living within protected areas are often considered as an independent system to the ecological organization system, which is by and large characterized by physical and biological values within a particular area [25].

In socio-ecological systems - including traditional ones - this 'managerial' approach is largely inadequate. The establishment of the "human-in-ecosystem" shows that social-ecological systems are understood as complex systems which are neither deterministic nor predictable, but systems that depend on feedback processes at different levels giving place to self-organization [27, 28].

Consequently, considering and integrating those aspects of unpredictability and uncertainty, socio-ecological systems learn to adapt and to self-organize [10]. This is

the principle of adaptive management, which refers to the capacity of people and ecosystems to build resilience [13] through interaction with different variables within the system. In other words, adaptive management considers learning, knowledge and adaptation as the basis to deal with issues in an uncertain, erratic and dynamic world [29]. Instead of denying the complex nature of socio-ecological systems, adaptive management embraces it. This approach understands that knowledge about ecosystems is largely derived from local stewards [13, 30, 31], and through the use of collective actions.

Examples of this statement can be found throughout the world. A concrete example is discussed by Turner et al. [32] who studied how traditional ecological knowledge was used in times of change and uncertainty by Canadian indigenous communities. The results of knowledge development, learning processes and adaptive management were translated into positive outcomes reflected in "greater diversity of cultural capital maintaining their flexibility and resilience" [32: 439].

In relation to the learning process, Armitage et al. [33: 95] describes this approach as the clear bond between the "experiential and experimental" learning with different practices of governance to "resolve societal challenges". In view of the above, traditional socio-ecological systems for conservation management practices are not only a set of customary arrangements and actions that deal with the environment. Their management practices are indeed derived from an accumulated experience and history, but are also "adaptive responses" that result from learning and knowledge development processes [5: 487]. Therefore, learning processes in conservation practices in the context of traditional socio-ecological systems can be understood as, and homologous to, adaptive management [6]. This is when it is accepted that adaptive management is the scientific understanding of the arrangement of knowledge in traditional social-ecological systems [6]. The reason behind this and as previously mentioned, is that traditional ecological knowledge integrates factors of uncertainty and surprise in management practices to improve resilience within a system. It manages adaptive cycles and uses feedbacks from the ecosystem itself to promote self-organization [6, 15] or, for the case of this review, to promote conservation practices.

The Ecological System: The Sierra Nevada de Santa Marta, the Hearth of the World

The Sierra Nevada de Santa Marta is a mountain located at the North of Colombia on the Caribbean coast [8]. The Sierra rises until it reaches a high of 5864 m.a.s.l, for this reason, Sierra Nevada de Santa Marta is the highest mountain in the world located next to the ocean [34, 8, 35]. In its extension of almost 21.158 km2, this landscape has a broad variety of ecosystems. Among the most representative are, xerophytic formations, tropical deserts, cloud forests, Andean forests, snow covered systems and paramos [35, 36].

The Sierra Nevada is very important in hydrological terms. It is the source of about 30 rivers that contributes with almost 10.000.000.000m3 of water and feeds many communities until they reach the Caribbean plains [37].

As a consequence of its biotic and abiotic characteristics, Sierra Nevada de Santa Marta has a high biodiversity and several cases of endemism [34, 35]. In the words of Rodríguez [8: 455] "there are at least 600 genera and over 3000 species of higher plants. It is known that 14 of the 635 species of birds registered for the Sierra are unique. Among the 142 species of amphibians and reptiles, there are 29 which are endemic, and all those inhabiting the unique "páramo" ecosystems above the tree line are found no- where else."

As a result of its biological values, in 1979 the strategic ecosystem of Sierra Nevada was declared by UNESCO as a biosphere reserve, in an attempt to conserve and protect the landscape and the indigenous communities depending on it [34]. However, during more than 50 years the Sierra Nevada has been the object of unsustainable agricultural practices by immigrants and, several interventions to set illegal crops have resulted in deforestation and degradation of the Sierra Nevada [38].

Sierra Nevada de Santa Marta From the Eyes of the Indigenous Communities: The Socio-Ecological Territory

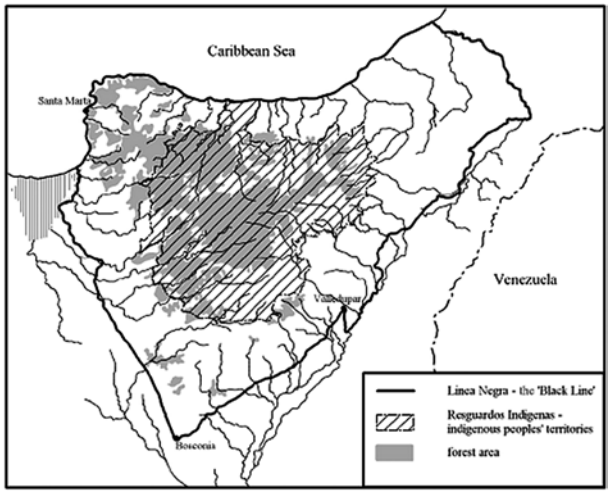
Territory from the perspective of the indigenous traditional communities is a symbolic construction that bears cultural, religious and social definitions [39]. As a consequence, the concept of territory is endogenous and starts

from its cosmology. The territory is an ancestral place and, therefore, the representation of its boundaries and organization is given by consensus, through the constant interaction between the individuals and their environment and, recognizing themselves as part of nature [39, 40].

For the elder brothers inhabiting the Sierra Nevada de Santa Marta, their territory is defined by the cultural concept of *Senunulang, niwi ka´sumu* [35]. Their territory is the space that contains the normativity/laws and the resources to allow the individuals to exist while ensuring the existence of life [35, 41]. Moreover, the territory is then also limited by the line that connects the sacred sites that were given to them since the origin [35], denoting the inherited characteristic of the landscape in which their traditional practices of life occurs. This boundary is called 'the black line' [38, 40; see Figure 1.], and is the line that organizes their territory and, as a consequence of the spiritual connotation of the line, it also organizes the laws that people have to follow [35].

This arrangement of beliefs and practices to define their territory, in accordance with their traditional cultural philosophy and their traditional law, is the backbone of the territorial management [40], and, at the same time highlights the understanding of the communities about their role in conserving the environment, which in essence, denotes a human-in-ecosystem [16] perspective to define their cultural and ecological space.

Figure 1: *Map of the Sierra Nevada de Santa Marta and the 'Black line' defining the ancestral indigenous communities' territory [38]*



The Social System: The Elder Brothers

The territory of Sierra Nevada de Santa Marta is mainly inhabited by three indigenous communities descendants of one of the most important groups that were present since times before the Spanish colony; the Tayronas [8, 42]. Despite the presence of other social groups, this case study will be focused on these communities as they are firstly, the most representative [35] and, secondly because they have traditional occurrence in the area [34, 38, 42]. Through this last affirmation, the Kogi, Arhuaco and Assario communities, constitute a traditional social system.

Kogi (also called *Kaggana* or *Gaggaba* which means 'The People'), Arhuaco (also called Ika) and Assario (also called Saha, Sanha or Malayo), are the survivors of the Tayronas [34, 8] and, until today, they still preserve their historic traditions [38]. While each of these groups has its own language and several different characteristics, all of them share a similar philosophy, have the same worldview, possess similar social organization and common practices to manage and conserve what they call the 'heart of the world' [Reichel-Dolmatoff in 38], thus, because of this divine duty they call themselves the Elder Brothers. As a consequence of these similarities, "the Sierra Nevada thus represents a single cultural area" [43: 290]

Their inherited ancestral knowledge plays a very important role among these communities as it defines their cultural and social characteristics [34]. Similarly, their cosmology and religious beliefs establish a strict code of moral practices while, at the same time, defines the social relations, not only between the three communities and its individuals, but also between people and nature [44]. The indigenous communities call this code 'the Law of the Mother' [8]. This customary set of rules is based upon the premises of reciprocity, collaboration, a non materialistic approach regarding life and collaboration [44]. Thus, the Law of Mother sets the behaviors and practices as a harmonic approach with living things, climatic conditions and other abiotic elements of "the sacred geography" [45: XVI] of Sierra Nevada. To do so, the traditional communities aim to maintain a balance between their practices and demands, and nature's resources offer [46].

External Social Actors Influencing the System and the Responses of the Elder Brothers

> *"Through the time, we Mamos of the Sierra Nevada, have been talking, saying and operating what correspond to us, always in accordance to the mandate given by our Mother since the beginning; then, we think that from now on, it is your duty and labor. It is a function that belongs to you, in the condition of being our legitimate spokespersons and representative institutions with the little brothers."*
>
> *Joint statement of the indigenous organizations of the Sierra Nevada de Santa Marta*

Even though the social system for this study is the one comprehended by the traditional communities, several external social actors have contributed to the development of knowledge and to generate adaptive responses among the indigenous communities.

The landscape of the Sierra Nevada de Santa Marta has been the object of different interventions in the hands of several social participants that are interacting with the system [47]. Ulloa [48] listed them as: Political leaders, indigenous researchers, researchers, local and international non-governmental organizations, governmental institutions, multilateral organizations, economic sectors and armed actors. However, not all of these institutions have affected the communities in the same way. Adaptations and cultural changes in their traditional practices have been more encouraged by the involvement of the economic sectors and armed groups, in the form of waves of migration and land grabbing [49, 34] and, by the influence of evangelization in the area [34]. All of these changes are manifested through modifications in their systems of production and land tenure [34]. Basically, these changes constitute adaptive reactions to external pressures over the system.

In addition to changes in their traditional practices, as a consequence of the diverse pressures, the social fabric of indigenous communities have encountered various challenges that propose responses in order to keep on with the pace of their changing environment, i.e. these responses constitute opportunities of "social self-organization for resilience" [50: 455]. In Sierra Nevada, building social capacity to address social issues has been a very important feature to overcome difficulties. In these terms, social memory and the organization of social capital have resulted in novel forms of governance that have the capacity to cope with the pressures set over the system [48, 50].

In the Sierra Nevada de Santa Marta, these new social movements are represented by the figures of organizations established by the same communities in collaborations with governmental and private organizations [35, 48]. Each of the indigenous communities that compound the social system, have organized their own organization with the objective of creating a channel of dialogue with other organisms, publics and private, to work for the reestablishment of their identity and to preserve the ecosystems present in their cultural territories [41]. This development of social movements can be understood as the "building of social capacity for resilience in social-ecological systems" [50: 455].

With reference to the learning processes, this social self-organization seems to adhere to the first model described above. As mentioned, the organization of the indigenous communities is a consequence of the interaction with different processes and social actors that produced experiences such as land grabbing and migration. These events made access to resources by the communities difficult [34, 49], therefore, these processes changed the resource base for Kogui, Arhuaco and Assario people. These experiences pushed them to learn and adapt. One of these adaptations was through the organization of their social capital and the creation of indigenous organizations. Consequently, these new social structures reflect complementary forms of governance, which in turn, became the enrichment of co-management practices [50] aiming to preserve, not only the cultural fabric, but also the ecosystems of the Sierra Nevada de Santa Marta.

The Socio-Ecological System: The Elder Brothers as the Guardians of the Hearth of the World

As the older brothers they are, and because they are living in the heart of the world, their relation and strategies involving nature are characterized by the promotion of cultural participation [35, 40, 42, 44], the application of traditional knowledge and customary laws [42].

The interactions at the level of the traditional socio-ecological system in Sierra Nevada de Santa Marta have also customary and religious roots. These interactions emphasize the tight relations between the social system and the ecological system. It is in these terms that communities introduce the concept of *Ezwama* as the practice of the relations between men and, between men and nature [40]. This implies the social relations among the three indigenous communities and, intercultural relations with local and national agents [40] in an exercise to promote a dynamic interaction with different stakeholders, resulting in a broad range of responses to solve problems. Consequently, as Walker and Salt [15] state, this ability to create solutions derived from the interaction between different actors, enhance the development of knowledge and thus, the resilience in the system.

Ezwama is also the principle of the practices for the collective use, management and ownership over the territory [35]. These practices are the result of the evolution and adaptation of the communities, which internalize knowledge about the natural environment applicable to their daily practices as a consequence of their constant interaction with the biotic and abiotic factors surrounding them [6].

In Sierra Nevada de Santa Marta, the traditional communities in observance of their traditional ecological knowledge as the "knowledge-practice-belief complex" [6: 1256], have developed several management and livelihood practices in accordance with their duty to preserve the heart of the world. Their knowledge has evolved to a point in which it forms a comprehensible set of techniques and anticipations, derived from their ecological awareness and the understanding of soil characteristics, slope exposure, rainfall, plant coverage, drainage, winds and temperature [42].

For the application of those different techniques and knowledge, the cultural institutions play a very important role. Hence, the management of proper resource use practices, in traditional societies, is delegated to leaders [6]. For the case of the Sierra Nevada de Santa Marta, the arrangement of knowledge is passed through one generation to another, especially on the social structures in head of the *Mamas* [38, 40] who are the figures of civil and religious authority among the individuals of the ethnic groups [44]. They bear a very deep knowledge about the environment in terms of meteorology, ecology and astronomy; ideas that are used in their productive systems and in the use of the natural resources [38].

The productive practices of Kogui, Arhuaco and Assario indigenous communities, are based on traditional ecological knowledge and some modern practices adopted from their intercultural interactions [35, 51]. In general terms, their productive systems are well adapted to the environments framed in the Sierra Nevada de Santa Marta [42, 51]. Several examples of these traditional practices are found along the Sierra Nevada. In the inclined productive fields, the indigenous communities have developed a practice in which they cultivate different species but not many individuals have the objective of creating "generalized ecosystem" [42: 293]. On the other hand, on flat ground near their settlements, they minimize the number of species to achieve a "specialized ecosystem" [42: 293]. Besides these practices, the traditional social and the ecological system in Sierra Nevada de Santa Marta, interact with each other through practices of natural resources monitoring [40], protection of specific places and habitats [44], the integration of knowledge into new practices of governance [48] and, by responding to feedbacks in reaction to surprises [34, 35, 42].

Figure 2: *Kogi settlement and crops of subtropical and highland products [Cervantes in 38]*

The examples mentioned above indicate a clear component of social and cultural adaptation to the environment as they evolve in a historical way through the incorporation of learning and knowledge in different scenarios

while they are in constant interaction with uncertainty. Through the maintenance of diversity at the levels of institutions, knowledge and practices among others, these adaptations have achieved the sustainable use of natural resources and the conservation of the landscapes that support the life of the communities [38] and at the same time, have managed to keep and, to increase the resilience [6, 24, 50] in the traditional socio-ecological system established between the elder brothers and the heart of the world.

Conclusion

This paper addresses the topics of adaptive learning and knowledge construction as one of the most important measures to understand successful and resilient traditional socio-ecological systems. It could be seen that the influence of learning processes derived from adaptation to changes, affect the ability of systems to self-organize.

In addition, it discusses management practices applicable to conservation of ecosystems from the understanding of nature and in the perspective of traditional social groups, with some examples. It is in this way that adaptive management, self-organization and the historical development of knowledge in traditional communities, are introduced as pillars for dealing with uncertainty and surprise and as a good way to enhance the resilience of socio-ecological systems.

Then, the explanation of the particular case of the traditional socio-ecological system established between Kogui, Arhuaco and Assario communities and the Sierra Nevada de Santa Marta, evidenced how the adaptive management that occurs in this particular landscape, is contributing to conserve and restore the ecosystems while enhancing the cultural identity in the communities [38, 42]. This is achieved by the use of management that is adapted to the environment and conditions present in Sierra Nevada; by the application of different traditional practices; by the use of accumulated traditional cultural, social and ecological knowledge that helps to deal with surprises and uncertainty; by the diversity of institutions, knowledge and resources; and by processes of internalization and feedbacks that contributes to the development of new knowledge [6, 38, 50].

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Bibliografía

[1] Dirhamsyah, "Traditional Fisheries Management of Flyingfish on the West Coast of Sulawesi, Indonesia," Maritime Studies, vol. 161, pp. 2-12, 2008.

[2] J. Kidegsesho and P. Mtoni, "The potentials for co-management approaches in western Serengeti, Tanzania," Tropical Conservation Science, vol. 1, pp. 334-358, 2008.

[3] M. Dowsley, "Community clusters in wildlife and environmental management: using TEK and community involvement to improve co-management in an era of rapid environmental change," *Polar Research*, vol. 28, pp. 43-59, 2009.

[4] D. Clark and S. Slocombe, "Adaptive Co-Management and Grizzly Bear-Human Conflicts in Two Northern Canadian Aboriginal Communities.," *Human Ecology*, vol. 39, pp. 627-640, 2011.

[5] F. Berkes and N. Turner, "Knowledge, learning and the evolution of conservation practice for social-ecological system resilience," *Human Ecology*, vol. 34, pp. 479-494, 2006.

[6] F. Berkes, J. Colding, and C. Folke, "Rediscovery of traditional ecological knowledge as adaptive management," *Ecological Applications*, vol. 10, pp. 1251-1262, 2000.

[7] J. Ford and D. Martinez, "Special issue on traditional ecological knowledge," *Ecological Applications*, vol. 10, 2000.

[8] G. Rodríguez, "Indigenous knowledge as an innovative contribution to the sustainable development of the Sierra Nevada of Santa Marta, Colombia," *Ambio*, vol. 29, pp. 455-458, 2000.

[9] N. Turner, M. Ignance, and R. Ignance, "Traditional ecological knowledge and wisdom of aboriginal peoples in Brithish Columbia," *Ecological Applications*, vol. 10, pp. 1275-1287, 2000.

[10] P. Olsson, C. Folke, and F. Berkes, "Adaptive comanagement for building resilience in social-ecological systems," *Environmental Management*, vol. 34, pp. 75-90, 2004.

[11] I. Davidson-Hunt and F. Berkes, "Learning as you journey: Anishinaabe perception of social-ecological environments and adaptive learning," *Conservation Ecology*, vol. 8, 2003.

[12] C. Folke, T. Carpenter, L. Elmqvist, C. Gunderson, C. Holling, B. Walker, J. Bengstsson, F. Berkes, J. Colding, K. Danell, M. Falkenmark, L. Gordon, R. Kasperson, W. Kautsky, A. Kinzing, S. Levin, K. Mäler, F. Moberg, L. Ohlsson, P. Olsson, E. Ostrom, W. Reid, J. Rockström, H. Savenije, and U. Svedi, "Resilience and sustainable development: Building adaptive capacity in a world of transformations," *International Council for Science*, vol. 3, 2002.

[13] C. Folke, J. Colding, and F. Berkes, "Synthesis: building resilience and adaptive capacity in social-ecological systems," in *Navigating social–ecological systems: Building resilience for complexity and change*, F. Berkes, J. Colding, and C. Folke, Eds., ed United Kingdom: Cambridge University Press, 2003.

[14] E. Ostrom, "A general framework for analyzing sustainability of social-ecological systems," *Science*, vol. 325, pp. 419-422, 2009.

[15] B. Walker and D. Salt, *Resilience thinking: Sustaining ecosystems and people in a changing world*. United States of America: Island Press, 2006.

[16] I. Davidson-Hunt and F. Berkes, "Nature and society through the lens of resilience: toward a human-in-ecosystem perspective," in *Navigating social-ecological systems: Building resilience for complexity and change*, F. Berkes, J. Colding, and C. Folke, Eds., ed United States of America: Cambridge University Press, 2003

[17] F. Berkes and C. Folke, " Linking social and ecological systems for resilience and sustainability," in *Linking social and ecological systems: Management practices and social mechanisms for building resilience*, F. Berkes and C. Folke, Eds., ed United Kingdom: Cambridge University Press, 1998.

[18] R. Johannes, "Did indigenous conservation ethics exist?," *Traditional Marine Resource Management and Knowledge Information Bulletin*, vol. 14, pp. 3-6, 2002.

[19] D. Pelupessy, D. Bretherton, and A. Ride, "Indonesia," in *Community resilience in natural disasters*, A. Ride and D. Bretherton, Eds., ed United States of America: Palgrave Macmillan, 2011.

[20] A. Escobar, "Whose knowledge, whose nature? Biodiversity, conservation, and the political ecology of social movements," *Journal of political ecology*, vol. 5, pp. 53-82, 1998.

[21] D. Keith, T. Martin, E. McDonald-Madden, and C. Walters, "Uncertainty and adaptive management for biodiversity conservation," *Biological Conservation*, vol. 144, pp. 1175-1178, 2011.

[22] C. Laudine, *Aboriginal environmental knowledge: Rational reverence*. England: Ashgate, 2009.

[23] E. Gómez, V. Reyes, P. Olsson, and C. Montes, "Traditional ecological knowledge and community resilience to environmental extremes: A case study in Doñana, SW Spain," *Global Enviromental Change*, vol. 22, pp. 640-650, 2012.

[24] C. Holling, F. Berkes, and C. Folke, "Science, sustainability and resource management," in *Linking social and ecological systems: Management practices and social mechanisms for building resilience*, F. Berkes and C. Folke, Eds., ed United Kingdom: Cambridge University Press, 1998.

[25] B. Walker, L. Gunderson, A. Kinzing, C. Folke, S. Carpenter, and L. Schultz, "A handful of heuristics and some propositions for understanding resilience in social-ecological systems," *Ecology and Society*, vol. 11, pp. 1-15, 2006.

[26] M. Hirschnitz-Garbers and S. Stoll-Kleemann, "Opportunities and barriers in the implementation of protected area management: a qualitative meta-analysis of case studies from European protected areas," *The Geographical Journal*, vol. 177, pp. 321-334, 2011.

[27] B. Walker, S. Carpenter, J. Anderies, N. Abel, G. Cumming, M. Janssen, L. Lebel, J. Norberg, G. Peterson, and R. Pritchard, "Resilience management in social-ecological systems: a working hypothesis for participatory approach," *Conservation Ecology*, vol. 6, 2002.

[28] C. Folke, "Resilience: The emergence of a perspective for social-ecological systems analysis," *Global Enviromental Change*, vol. 16, pp. 252-267, 2006.

[29] C. Allen, J. Fontaine, K. Pope, and A. Garmestani, "Adaptive management for a turbulent future," *Journal of Environmental Management*, vol. 92, pp. 1339-1345, 2011.

[30] P. Olsson and C. Folke, "Local ecological knowledge and institutional dynamics for ecosystem management: A study of Lake Racken atershed ,Sweden," *Ecosystems*, vol. 4, pp. 85-104, 2001.

[31] P. Olsson, T. Hahn, and C. Folke, "In press. Social-ecological transformation for ecosystem management: the development of adaptive co-management of wetland landscapes in southern Sweden," *Ecology and Society*, 2004.

[32] N. Turner, I. Davidson-Hunt, and M. O'Flaherty, "Living on the edge: Ecological and cultural edges as sources of diversity for social-ecological resilience.," *Human Ecology*, vol. 31, pp. 439-461, 2003.

[33] D. Armitage, R. Plummer, F. Berkes, R. Arthur, A. Charles, I. Davidson-Hunt, A. Diduck, N. Doubleday, D. Johnson, M. Marschke, P. McConney, E. Pinkerton, and E. Wollenberg, "Adaptive co-management for social-ecological complexity," *Front Ecol Environ*, vol. 95, pp. 95-102, 2009.

[34] M. Tribin, G. Rodríguez, and M. Valderrama, *The Biosphere Reserve of The Sierra Nevada de Santa Marta: A pioneer experience of shared and co-ordinated management of a bioregion*. France: UNESCO, 1999.

[35] G. Muñoz, L. Balaguera, J. Cantillo, I. Uribe, P. Villalba, L. Camargo, A. Gómez, M. Jiménez, G. Laverde, M. Molina, M. Montaña, and T. Rodríguez, *Plan de manejo Parque Nacional Natural Sierra Nevada de Santa Marta*. Santa Marta: Unidad Administrativa Especial del Sistema de Parques Nacionales Naturales, Territorial Costa Atlantica, 2005.

[36] Fundación Pro-Sierra Nevada de Santa Marta, Unidad de Parques Nacionales, The Nature Conservancy, and USAID, *Evaluación ecológica rápida: Definición de áreas críticas para la conservación en la Sierra Nevada de Santa Marta*. Bogotá, 1998.

[37] Fundación Pro-Sierra Nevada de Santa Marta, *Plan de desarrollo sostenible de la Sierra Nevada de Santa Marta*. Bogotá: Fundación Pro-Sierra Nevada de Santa Marta, 1997.

[38] G. Rodríguez, "Sacred natural sites in zones of armed conflicts: The Sierra Nevada de Santa Marta in Colombia," in *Sacred especies and sites: Advances in biocultural conservation*, G. Pungetti, G. Oviedo, and D. Hooke, Eds., ed United States of America: Cambridge University Press, 2012.

[39] G. Montañez and O. Delgado, "Espacio, territorio y región: conceptos basicos para un proyecto nacional," *Cuadernos de geografía*, pp. 120-133, 1998.

[40] A. Ulloa, "Indigenous peoples of the Sierra Nevada de Santa Marta-Colombia: local ways of thinking climate change," *IOP Science*, vol. 6, pp. 1-2, 2009.

[41] OWYBT, OIK, CIT, and OGT, "Declaración conjunta de las organizaciones indigenas (OWYBT, OIK, CIT, OGT)," in *Sabiduría, poder y comprensión: América se repiensa desde sus orígenes*, R. Restrepo, Ed., ed Colombia: UNESCO, Siglo del Hombre Editores, 2002.

[42] G. Reichel-Dolmatoff, "Cultural change and environmental awareness: A case study of the Sierra Nevada de Santa Marta, Colombia," *Mountain Research and Development*, vol. 2, pp. 289-298, 1982.

[43] G. Reichel-Dolmatoff, "Funerary customs and religious symbolism among the Kogui," in *Native South Americans: Ethnology of the least known continent*, P. Lyon, Ed., ed Boston: Little, Brown Co, 1974.

[44] G. Reichel-Dolmatoff, *The sacred mountain of Colombia's Kogui Indians*. Netherlands E.J Brill, Leiden, 1990.

[45] E. Kemf, Ed., *Indigenous peoples and protected areas: The law of Mother Earth*. United Kingdom: Earthscan Publications Limited, 1993, p. ^ pp. Pages.

[46] G. Reichel-Dolmatoff, "Training for the priesthood among Kogi of Colombia," in *Enculturation in Latin America: An Anthology*, J. Wilbert, Ed., ed United States of America: UCLA Latin American Center Publications, 1976.

[47] J. Munive, "Political ecology of environmental conservation and regional development in the Sierra Nevada de Santa Marta," Department of Political Science, University of Helsinki, Helsinki, 2004.

[48] A. Ulloa, *The ecological native: Indigenous peoples' movements and eco-governmentality in Colombia*. United States of America: Taylor & Francis Group, 2005.

[49] D. Ojeda, "Green pretexts: Ecotourism, neoliberal conservation and land grabbing in Tayrona National Natural Park, Colombia," *The Journal of Peasant Studies*, vol. 39, pp. 357-375, 2012.

[50] C. Folke, T. Hahn, P. Olsson, and J. Norberg, "Adaptive governance of social-ecological systems," *Annual Review of Environment & Resources*, vol. 30, pp. 441-473, 2005.

[51] J. Viloria, S*ierra Nevada de Santa Marta: Economía de sus recursos narutales* Cartagena: Banco de la República, 2005.

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