

The complex socio-ecological landscape in Latin America: Transdisciplinary knowledge production to address diversity

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Abstract

We start this article by seeking analogies between the cultural landscape and socio-ecological system concepts. Whereas the former has played a pivotal role in geographical research since its introduction in the nineteenth century, the latter has only recently become popular in inter- and transdisciplinary science. The results of this theoretical and conceptual endeavour are used to build a distinctive analytical category: the ‘complex socio-ecological landscape’. We then apply this novel concept to the Coffee Cultural Landscape of Colombia, declared a UNESCO World Heritage Site in 2011. In doing so, we demonstrate that this landscape in fact exhibits complex adaptive behaviour. We end the article with an analysis of the Cañamomo-Lomapieta indigenous reservation in the north of the Coffee Cultural Landscape. Participatory mechanisms of transdisciplinary knowledge production have stimulated the emergence of an ancestral governance system in Cañamomo-Lomapieta, which has reduced the vulnerability of its socio-ecological systems to the effects of small-scale gold mining activities. This case provides important insights into how to stimulate transdisciplinarity in other complex socio-ecological landscapes in Latin America that bear the brunt of extractive activities. *Keywords:* complex socio-ecological landscape, transdisciplinarity, Coffee Cultural Landscape of Colombia, adaptive governance, small-scale gold mining.

Resumen: Paisaje socioecológico complejo en Latinoamérica: Conocimiento transdisciplinario para tratar la diversidad

Comenzamos este artículo buscando analogías entre los conceptos de paisaje cultural y sistema socioecológico. Mientras que el primero ha desempeñado un papel fundamental en la investigación geográfica desde su introducción en el siglo XIX, el segundo se ha hecho popular solo recientemente en la ciencia inter y transdisciplinaria. Los resultados de este esfuerzo teórico y conceptual se utilizan para construir una categoría analítica distintiva: el ‘paisaje socioecológico complejo’. Luego aplicamos este novedoso concepto al Paisaje Cultural Cafetero de Colombia, declarado Patrimonio de la Humanidad por la UNESCO en 2011. Mostramos que este paisaje efectivamente exhibe un comportamiento adaptativo complejo. Finalizamos el artículo con un análisis del resguardo indígena Cañamomo-Lomapieta en el norte de este paisaje. Mecanismos participativos de producción de conocimiento transdisciplinario

han estimulado el surgimiento de un sistema de gobernanza ancestral en Cañamomo-Lomaprieta, lo que ha reducido la vulnerabilidad de sus sistemas socioecológicos ante los efectos de las actividades de minería aurífera a pequeña escala. Este caso permite comprender cómo se puede estimular la transdisciplinariedad en otros paisajes socioecológicos complejos en América Latina afectados por actividades extractivas. *Palabras clave:* paisaje socioecológico complejo, transdisciplinariedad, Paisaje Cultural Cafetero de Colombia, gobernanza adaptativa, minería aurífera a pequeña escala.

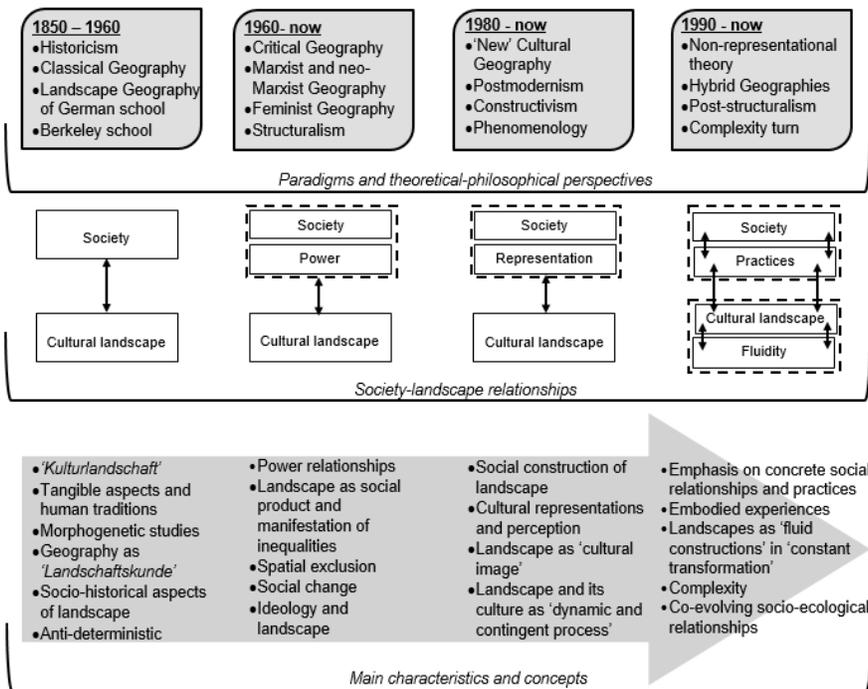
Introduction

The academic origins of the cultural landscape concept date back to German geographers and polymaths such as Carl Ritter, Carl Vogel and Friedrich Ratzel, who started to employ the term *kulturlandschaft* in the nineteenth century (Jones, 2003; Potthoff, 2013). The work of another German geographer, Otto Schlüter, has been widely recognized for reorienting geography towards the science of landscape (*Landschaftskunde*) and for deepening the divide between natural and cultural landscapes (Folch & Bru, 2017). Inspired by these German approaches to landscape studies, the renowned North American geographer Carl Sauer introduced the cultural landscape concept to the Anglo-Saxon world in the 1920s. In his renowned text entitled *The Morphology of Landscape*, Sauer argued that human beings had become “the most important morphological factor” in the transformation of natural landscapes (Sauer, 1965[1925], p. 341). Largely due to Sauer and other Berkeley School scientists, the cultural landscape became a central analytical category in modern English-speaking geography. By explicitly emphasizing the intrinsic and two-way relationship between human beings and nature, the concept played an important role in the growing revolt against the environmental determinism and cultural universalism paradigms (Kirchhoff, Brand & Hoheisel, 2012). However, during the 1960s, landscape studies inspired by the Berkeley School were increasingly criticized by both neo-Marxist and interpretivist scholars (Oakes & Price, 2008; Taylor & Lennon, 2012). Whereas the former began to place greater emphasis on unequal power relations and spatial exclusion within landscapes (Oakes & Price, 2008), the latter, in the context of the so-called ‘cultural turn’, sought a more interpretative approach, placing greater emphasis on the key role of culture in the complex (re)configurations of socio-spatial relationships within landscapes (Moore & Whelan, 2016).

Thus, the cultural dimension of landscapes came to be considered as, a continuous and evolutionary process which is socially constructed and much more dynamic and multifaceted. Consequently, geographers began to advocate for a more profound understanding of the socio-cultural elements that constitute a cultural landscape, including its affective, emotional, immaterial and intangible aspects (Jackson, 1987). This perspective of the so-called ‘new’ cultural geography movement increasingly gained prominence at the end of the last century and is based, in short, on an intertwining of the social constructionism perspective that includes aspects of Heidegger’s phenomenology (Tilley, 1994) with Lefebvre’s (1991) ideas on the social construction and production of space. The

result of this confluence has come to be known as the ‘social construction of landscapes’ (Greider & Garkovich, 1994), which continues to be an important analytical lens for geographical theory. The turn towards ‘postmodern culturalism’ has led many geographers to assert that cultural landscapes are not merely physical manifestations of human and non-human elements, but rather highly complex, symbolic, immaterial and even ideological spaces (Cosgrove & Daniels, 1988; Cresswell & Verstraete, 2003), to such an extent that certain groups or communities even metaphorize their identities as cultural landscapes (Moore & Whelan, 2016). This transition from *interpretation* to *representation* in landscape studies (Wylie, 2007; Oakes & Price, 2008) has had a significant impact on the production of geographical knowledge, but has not been exempt from controversy.

Figure 1: Evolution of the cultural landscape concept in geographical theory, adapted from Mons (2021)



For example, in an attempt to divert attention away from representation, British geographer Thrift (1996; 2008) and Scottish geographer Lorimer (2005) argued for a ‘non-representational theory’ or ‘more-than-representational theory’ that focuses primarily on practices, processes, materiality and ‘embodied experiences’ in cultural landscapes. Another important milestone in contemporary geographical theory has been the development of so-called ‘hybrid geographies’. This analytical approach, inspired by the work of British geographer Whatmore (2002), emphasizes the fluidity of socio-spatial relationships within different geographical contexts. Importantly, hybrid geographies also consider that the

social and the natural are co-constitutive. Whatmore (2002) and Castree (2002), for example, argue that the separation of nature and society is a misconception, since no phenomenon is completely social or natural, but rather evolves through interaction and hybridization (Plieninger & Bieling, 2012). This entails, among other things, approaching landscapes as fluid constructions that are in a continuous process of transformation, evolution and adaptation (Thrift, 2008; Oakes & Price, 2008; Bohnet & Konold, 2015; Bürgi et al., 2017). As we will explain in the next section, the above is in line with recent interdisciplinary scholarly work. Figure 1 synthesizes the historical evolution of the cultural landscape concept in geographical theory, as explained in this first section.

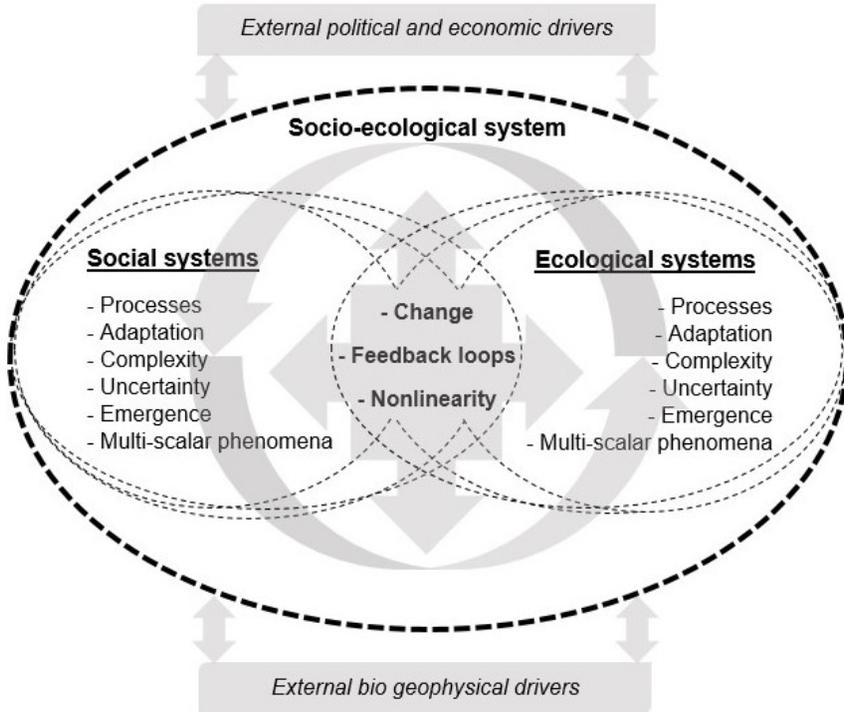
Building adaptation and resilience in socio-ecological systems

The break away from traditional positivist and reductionist approaches at the beginning of the twenty-first century led to a rapprochement of both social and natural scientists with the analysis of complex and adaptive phenomena (Whatmore, 2002; Urry, 2005). Dubbed the ‘ontological turn’ by some (De La Cadena, 2010; Blaser, 2013; 2014) or the ‘relational turn’ by others (Latour 2005; Donati & Archer 2015), this has caused a conclusive and irrevocable break with modern-positivist doctrine, which is founded on a ‘dualist ontology’ that artificially separates the human and the non-human, nature and culture, the mind and the body, the individual and the community, and so on (Boisier, 2003; Escobar, 2015). The ‘post-dualist’ paradigm shift rethinks modern scientific thought, deconstructs dualist concepts and reconsiders society-nature relationships in a fundamental way, leading to a continuous process of deconstruction of the once dominant positivist paradigm (Escobar, 2012; Gudynas, 2011). Within this context, many interdisciplinary scientists now adopt more holistic and relational approaches, explicitly recognizing complexity as an inherent characteristic of our contemporary world (Welsh, 2014). From this perspective, societies and their natural environment are coupled, co-evolutionary and adaptive systems, linked through multifaceted feedback loops (Berkes, Colding & Folke, 2003; Armitage & Plummer, 2010).

One of these interdisciplinary currents of thought is known as Resilience Thinking, which conceptualizes ecosystems as complex and adaptive systems intrinsically linked to social systems (Chapin et al., 2009; Plummer, Armitage & Løe, 2013; Berkes, 2017). These complex and co-evolutionary geographical spaces are called socio-ecological systems (SES), an increasingly popular concept for inter- and transdisciplinary scientists studying nature-society relations. Theories about coupled SES emerged almost simultaneously with ideas and perspectives on socio-ecological resilience (Berkes & Folke, 1998), which paved the way for the rapid interdisciplinary expansion of Resilience Thinking (Welsh, 2014). SES typically exhibit, to a lesser or greater extent, characteristics of complexity, such as uncertainty, multi-scalar interactions, non-linear behaviour, co-evolutionary socio-ecological relationships, positive and negative feedback

loops and complex and ever-changing emerging phenomena (Berkes, Colding & Folke, 2003; Chapin et al., 2009; Cote & Nightingale, 2012; Plieninger & Bielinger, 2012; Schultz et al., 2015). These complex and co-evolutionary geographical spaces are called socio-ecological systems (SES), an increasingly popular concept for inter- and transdisciplinary scientists studying nature-society relations (see Figure 2).

Figure 2: Abstraction of an SES, adapted from Mons (2021)



The socio-ecological perspective of Resilience Thinking directly opposes the classical dualistic and reductionist school of thought linked to modernist and positivist philosophy. A key concern within this analytical framework is the way uncertainty and change in SES can be adaptively analysed and managed. The rationale behind this approach is the idea that adaptive capacity and resilience reduce the vulnerability of SES in the face of systemic crises (Folke et al., 2002; Chapin et al., 2009; Beymer-Farris et al., 2012). Resilience is generally understood as “the ability of complex systems to absorb disturbance without shifting into a qualitatively different and less desirable state” (Crumley, 2012, p. 310). Thus, resilience, in simplified terms, refers to the “capability to avoid harm”, whereas vulnerability refers to a system’s “susceptibility to harm” (Kelman, Gaillard & Wisner, 2018, p. 172). Adaptive capacity plays a somewhat mediating role, in the sense that it controls the latent potential of an SES to transform and adapt to socio-ecological change (Matthews, 2014) through

experimentation, social learning, knowledge sharing and the stimulation of innovative solutions in the face of a crisis or severe disturbance (Armitage, 2005; Armitage & Plummer, 2010; Schultz et al., 2015). Therefore, adaptive capacity controls the degrees of vulnerability and resilience of an SES in response to socio-ecological change (Walker et al., 2004; Berkes, 2017; Angeler et al., 2019) in the sense that SES that stimulate adaptation and learning tend to have less systemic vulnerability and a higher degree of resilience (McCarthy et al., 2011; Baker & Durance, 2018).

Given the intrinsic complexity of an SES and the uncertainty associated with its socio-ecological processes, resilience scholars have proposed adaptive governance as a particularly appropriate approach capable of managing crises and associated change (Dietz et al., 2003; Folke et al., 2005). An adaptive governance system can be considered the social context necessary to manage resilience and adaptation (Chaffin et al., 2016), in which the active participation of all social actors involved in an SES – that is, not only formal organisations but also academic institutions, communities, NGOs and other key social networks – is encouraged. Accordingly, Chaffin, Gosnell & Cosens (2014, p. 1) define adaptive governance as “a range of interactions between actors, networks, organizations, and institutions emerging in pursuit of a desired state for social-ecological systems”. Importantly, in a dynamic and emergent adaptive governance system, change is accepted as an inherent and unavoidable characteristic of SES that often contributes positively to renewal and socio-ecological diversity (Dietz et al., 2003; Walker et al., 2004; Folke et al., 2005; Chaffin, Gosnell & Cosens, 2014; Schultz et al., 2015). Therefore, encouraging the emergence of an adaptive governance system in SES essentially consists of rethinking and reconfiguring the relationship between society and nature through the creation of transdisciplinary networks that stimulate adaptation and resilience (Chaffin et al., 2016; Mehmood, 2018).

In this emergent process, the mutual construction and continuous exchange of local, traditional, ancestral, technical and scientific knowledge about the socio-ecological dynamics of an SES is paramount (Prager, 2012; Schultz et al., 2015). This implies that different actors across a variety of scales all form an integral part of the adaptive governance system, and that they cannot be separated from it (Berkes, 2017). By adopting such a transdisciplinary approach that tackles sustainability challenges (Lang et al., 2012) and engages all knowers in meaningful cooperation (Wang et al., 2019), mechanisms of social learning, a more equitable distribution of power, trust-building, conflict resolution and the creation of polycentric networks are stimulated, as they are all key ingredients for the construction of adaptive capacity and resilience in the face of uncertainty and change in SES (Folke et al., 2005; Adger et al., 2005; Clark & Clarke, 2011; Carlisle & Gruby, 2017; Thiel & Mukhtarov, 2018).

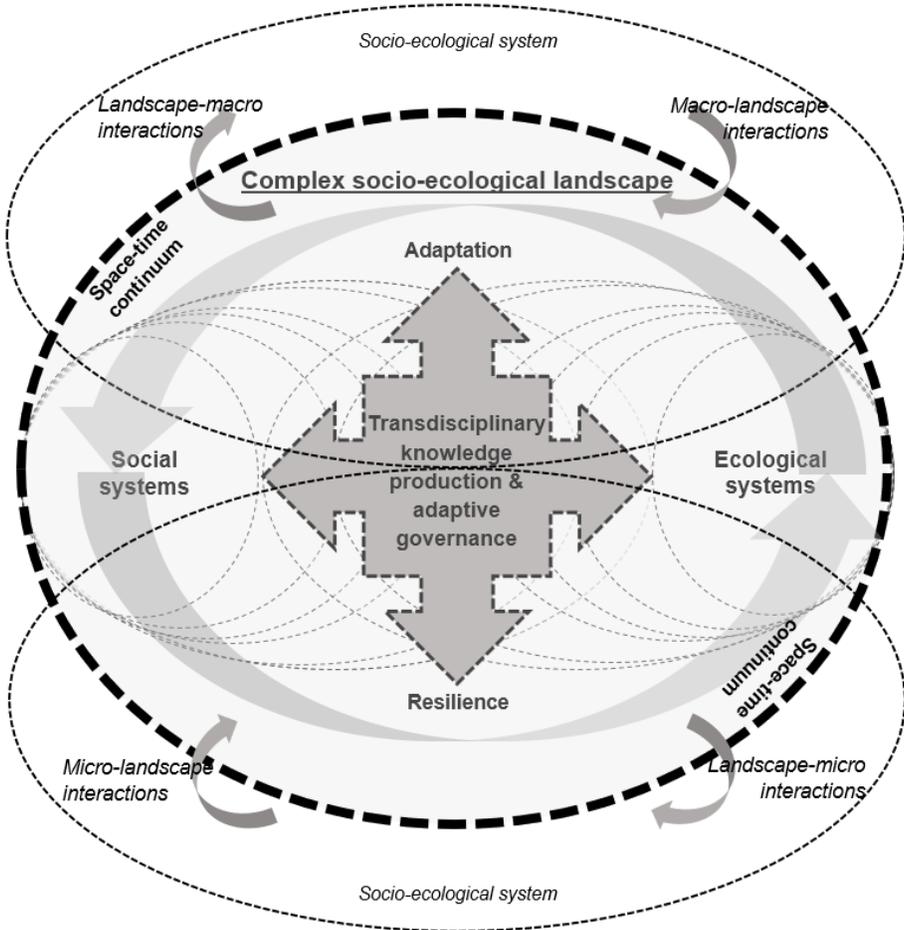
The complex socio-ecological landscape

Based on the two previous sections, we can draw some interesting parallels between the evolution of the cultural landscape and SES concepts. This demonstrates that geographical science, in a way, has always applied the socio-ecological perspective that characterizes contemporary resilience literature. The similarities are largely due to the fact that both focus primarily on the relationships and interactions between society and nature in diverse geographical spaces. The way in which these socio-ecological relationships and interactions are theorized is quite similar, since both research strands agree that they are bidirectional, dynamic and co-evolutionary. Although resilience researchers are perhaps more explicit in emphasizing the systemic and bidirectional character of SES, we argue here that cultural landscapes can also be viewed as an adaptive and complex set of intrinsically connected social and ecological systems. This is largely in line with recent developments in geographical science and resonates with various contemporary definitions. Selman (2012), for example, argues that cultural landscapes are territories in which human and environmental processes find their explicit integration. Baker & Durance (2018, p. 374) argue that the complex and interrelated trajectory of the social and the natural in landscapes is proof that “there are no simple relationships between human behaviour and landscape outcomes”. Other recent studies tend to confirm that cultural landscapes, through slow processes of socio-ecological co-evolution and adaptation, have taken centuries to reach their current configurations (Cumming, 2011; Plieninger & Bielinger, 2012; Rivera & Kapucu, 2015; Bürgi et al., 2017; Saito et al., 2019). Consequently, they have been altered by societies in a plurality of both positive and negative ways (Munárriz, 2011; Rescia et al., 2012; Cumming et al., 2013; Taylor, Clair & Mitchell, 2015).

However, most contemporary research continues to emphasize the binary oppositions between *Naturlandschaft* and *Kulturlandschaft* developed by nineteenth-century German landscape science, which in turn is rooted in positivism and Cartesian dualism. We argue here that this dichotomy is not only outdated but also counterproductive, since it lacks a holistic and socio-ecological perspective that explicitly theorizes and analyses landscapes as an integrated and indivisible whole. Given the compatibility of cultural landscape studies with the fundamental principles of SES research conducted by resilience scholars, an interesting opportunity arises to build a ‘bridge’ between both academic disciplines. We therefore consider it appropriate to apply the socio-ecological lens developed by resilience thinking, within which geographical spaces are theorized as interconnected and coupled SES, to the study of change in cultural landscapes. Based on research conducted by Mons (2021) we introduce the term complex socio-ecological landscape (CSEL), which could replace the binary and inherently contradictory concepts of cultural and natural landscape. This novel and ‘progressive’ analytical lens for studying landscapes fundamentally focuses on the socio-ecological connections, relationships and flows that run within and

through landscape systems. The explicit integration of social and ecological systems in CSELs implies that particular attention is paid to its continuous change, adaptation and evolution. Figure 3 is an abstraction of a CSEL, which we define as the spatial expression of the socio-ecological interactions, flows and adaptations that continuously transform and cut across the landscape system.

Figure 3: Complex socio-ecological landscape, adapted from Mons (2021)



We argue that most, if not all, characteristics of complexity that are frequently associated with SES, including uncertainty, nonlinearity, continuous socio-ecological interactions, different states of disequilibrium, among others, are also inherent properties of CSELs. Furthermore, the fundamental duality between local and global drivers of change (Marsden, 2018) implies that no landscape can be considered purely regional or local, but rather evolves through multi-scalar interactions. CSELs are, to use Sassen's (2005) words, 'glocal' systems that are interdependent and interconnected, existing in relation to other complex systems at smaller and larger scales. CSELs are therefore characterized by fuzzy

boundaries and complex interconnections across multiple scales. Since they are not homogeneous, and do not have a unique identity, CSELs are in a continuous state of construction and deconstruction and are characterized by ambiguous, complex and sometimes even conflicting socio-ecological relationships. To manage these contradictory flows, we consider it essential to foster emerging adaptive governance systems. As we explained in the previous section, this will help to create networks of transdisciplinary knowledge production that stimulate adaptation and resilience of the landscape system in the face of continuously changing socio-ecological dynamics. These transdisciplinary systems are a fundamental part of the evolution of the CSEL and are essential to confront the systemic crises that occur within them.

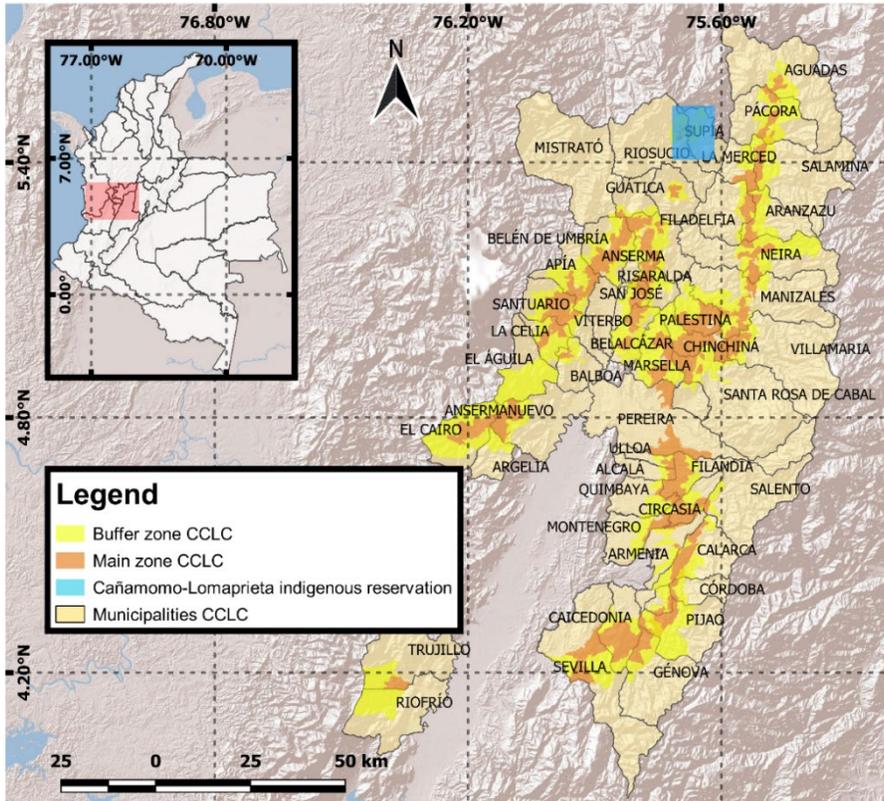
Unfortunately, many current landscape management policies have significant deficiencies that are the result of a failure to recognize the systemic nature of landscapes and their drivers of change. These include reductionism and the fragmentation of landscape policies, the consideration of the social and the ecological as separate spheres with little or no connection between them, the failure to recognize processes of globalization and ‘glocalization’ in landscapes, the equation of landscape with natural scenery and a lack of enabling conditions for transdisciplinary knowledge production (Bieling & Plieninger, 2012; Hajer et al., 2015; De Castro et al., 2016; Folch & Bru, 2017; Baker & Durance, 2018). This is especially the case for Latin America, a region whose landscapes are characterized by an unprecedented plurality and heterogeneity (Ospina, 2013). We argue that these highly complex and socio-ecologically diverse landscapes can and should be theorized as CSELs. In the next section we therefore apply the CSEL framework to arguably one of the most emblematic landscapes in Latin America, which will broaden our understanding of socio-ecological complexity while simultaneously demonstrating how transdisciplinary knowledge production can be stimulated in this vast and highly diverse region.

The Coffee Cultural Landscape of Colombia

The Coffee Cultural Landscape of Colombia (CCLC), declared a UNESCO World Heritage Site in 2011, is located in the Central and Western Cordillera of the Colombian Andes. It includes 858 *veredas*,¹ located in a total of 51 municipalities in the departments of Caldas, Risaralda, Quindío and Valle del Cauca (see Figure 4). Although the production of the cherries from which coffee is extracted is an important activity in many rural areas of the Colombian Andes, its production and related socio-ecological practices are especially evident in the CCLC due to its “particular conditions, and at a level of consistency in the landscape that is difficult to find in the rest of the [coffee] producing areas of the country” (Rincón Cardona, 2010, p. 5). The main element that led UNESCO to inscribe the CCLC on the World Heritage list was its coffee culture, transmitted across generations. The cultivation of coffee “defines the way of life of the inhabitants” (Conpes, 2014, p. 9) and unites the 858 *veredas* included in the 2011

UNESCO declaration. The continuous evolution of the landscape has resulted in the definition of 16 socio-ecological attributes (see Table 1 and Figure 5) and four core values which, according to UNESCO (2011), demonstrate its ‘Out-standing Universal Value’.

Figure 4: Coffee Cultural Landscape of Colombia



Sources: Coffee Cultural Landscape of Colombia (2018); Mons (2021)

The physiognomy of the CCLC is, to a great extent, the result of the interactions and synergies between the extreme geographical, geological and climatic conditions of the Andean region and the traditions, practices and values of its local and regional communities. An example that can illustrate these complex socio-ecological dynamics is the passage of the Intertropical Convergence Zone, an area of low atmospheric pressure formed where the North-eastern Trade Winds meet with those from the Southeast, near the Equator. This natural phenomenon which frequently occurs in the CCLC generates “unique cycles of coffee blossoming and ripening” (Ministry of Culture, 2016, p. 14), where the movements of the Intertropical Convergence Zone determine the months with the highest precipitation values. These natural cycles, in turn, influence harvesting methods, growing cycles, the celebration of the traditional harvest festivals and other dynamics of the CCLC’s social systems. The volcanic soils and rough

geomorphology are also typical characteristics of the landscape's ecological systems that fundamentally influence the configuration of its social systems. The 51 municipalities that make up the CCLC are characterized by steep slopes, highly variable climatic conditions and volcanic activity. This has not only resulted in an exceptionally biodiverse landscape, but has also favoured soil fertility, allowing coffee plants to grow in deep soils with moderate permeability and adequate levels of aeration. Importantly, it has been an important factor in the development of the cultivation of coffee on steep slopes, with most farms located in areas with slopes steeper than 25 per cent (Velandia, 2016).

Table 1: Synthesis of the socio-ecological attributes of the CCLC

| Attribute | Short description |
|---|---|
| 1. Mountain-grown coffee | High mountain coffee (1,000-2,000 meters above sea level) |
| 2. Slope-grown coffee | Adaptation of coffee crops in steep slopes |
| 3. Age of coffee growing | Renovation of coffee plantations, keeping landscape productive |
| 4. Natural Heritage | High number of habitats of strategic interest for conservation of biological diversity |
| 5. Water source availability | High presence of priority units for water retention and regulation |
| 6. Coffee institutions and related networks | Existence of institutional and economic networks influencing the functioning and dynamics of the CCLC |
| 7. Architectural heritage | Regional architecture of bahareque |
| 8. Archaeological heritage | Archaeological remains of craftwork and ceramics, domestication of animals and food crops, agricultural techniques |
| 9. Coffee predominance | Preferential use of land for coffee cultivation |
| 10. Concentrated settlement and fragmented property structure | Predominance of small productive units, evidence of a significant redistribution or democratization of rural property |
| 11. Smallholding as a landownership system | Prevalence of smallholding |
| 12. Influence of modernization | Adaptation of landscape to conditions of modern life (e.g. infrastructure, public services, health and education) |
| 13. Urban heritage | Hispanic model of grid layout of urban structures |
| 14. Coffee production historical tradition | Persistence of coffee cultivation and resistance to changes in land use despite coffee crises |
| 15. Multiple crops | Multiplicity of crops |
| 16. Sustainable production and technologies in productive chain | Specific conditions to produce coffee more sustainably |

Sources: Ministry of Culture of Colombia (2016); Coffee Cultural Landscape of Colombia (2018)

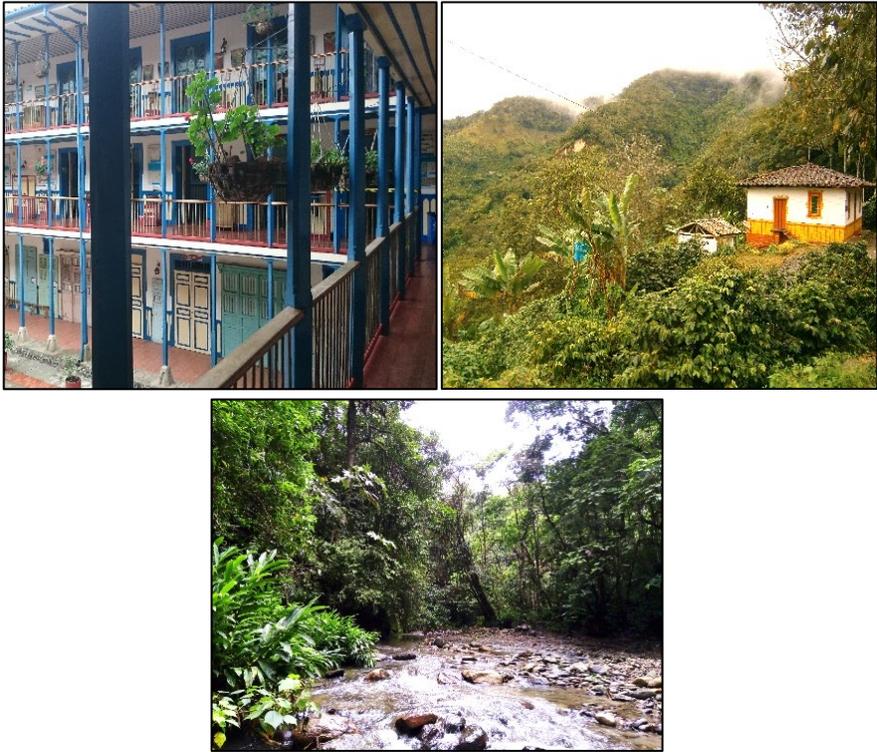
These typical characteristics, that is, mountain-grown coffee and slope-grown coffee, are the two most important socio-ecological attributes of the CCLC (see Table 1) precisely because they have transcendental consequences for the development and adaptation of coffee growing in the region. Due to the cultivation of

coffee on steep slopes, specific soil conservation techniques have been introduced, including the planting of native trees. This not only helps to prevent erosion, but also maintains adequate shade levels for the coffee plants and increases the diversity of flora and fauna. Furthermore, as slope-grown coffee makes the mechanization and automation of coffee picking difficult, coffee cultivation in the CCLC is relatively labour-intensive and is typically done by family members and, in some cases, coffee pickers who work seasonally (Ministry of Culture, 2016). This has assured the prevalence of smallholding as a landownership system and related traditional small-scale coffee cultivation methods (such as selective hand-picking and sun-drying of coffee beans) over time.

These are some of the characteristics that set the CCLC apart from other coffee landscapes in countries such as Brazil,² where coffee is cultivated mainly on large-scale coffee farms in relatively flat areas. This facilitates the mechanization of the picking process, making it more efficient and less labour-intensive compared to the CCLC. However, these mechanized processes have also resulted in the progressive disappearance of traditional coffee cultivation methods and values. Land use and local resource allocation policies developed by organizations such as the non-profit National Federation of Coffee Growers (FNC, in its Spanish acronym)³, are human elements that have partially determined the evolution of the CCLC's ecosystems over time. For example, the expansion of coffee growing in the region around Risaralda's capital Pereira between 1997 and 2014 has caused a loss of 149,184 hectares of forest and semi-natural areas (Murillo-López et al., 2022).

On the other hand, the FNC and other coffee institutions such as The National Coffee Research Centre (Cenicafé, in its Spanish acronym) have been key in the search for solutions to some of the major natural threats that the CCLC faces, including landslides, volcanic eruptions, floods and avalanches (Corpocaldas, 2007). Studies from the FNC and Cenicafé aim to achieve "a competitive and sustainable coffee growing model that will lead to the improvement of the quality of life of coffee growing families" (Ministry of Culture, 2016, p. 58), focusing on the interface processes between sustainability, economic development, agronomic productivity and adaptation to the above-mentioned natural threats. Ultimately, these complex connections and persistent feedbacks between human and natural dimensions have forged a dynamic and emergent landscape reality that comprises several inextricably interwoven social and ecological systems that have co-evolved over centuries. As we will explain in the next section, the landscape's adaptive capacity and resilience have been fundamental in this ongoing process.

Figure 5: Socio-ecological attributes of the CCLC. Casa de la Cultura with typical bahareque architecture in Marsella, Risaralda (March 2019); typical coffee farm on a steep slope in El Cairo, Valle del Cauca (September 2018); Navarco river with native vegetation in Salento, Quindío (November 2019).



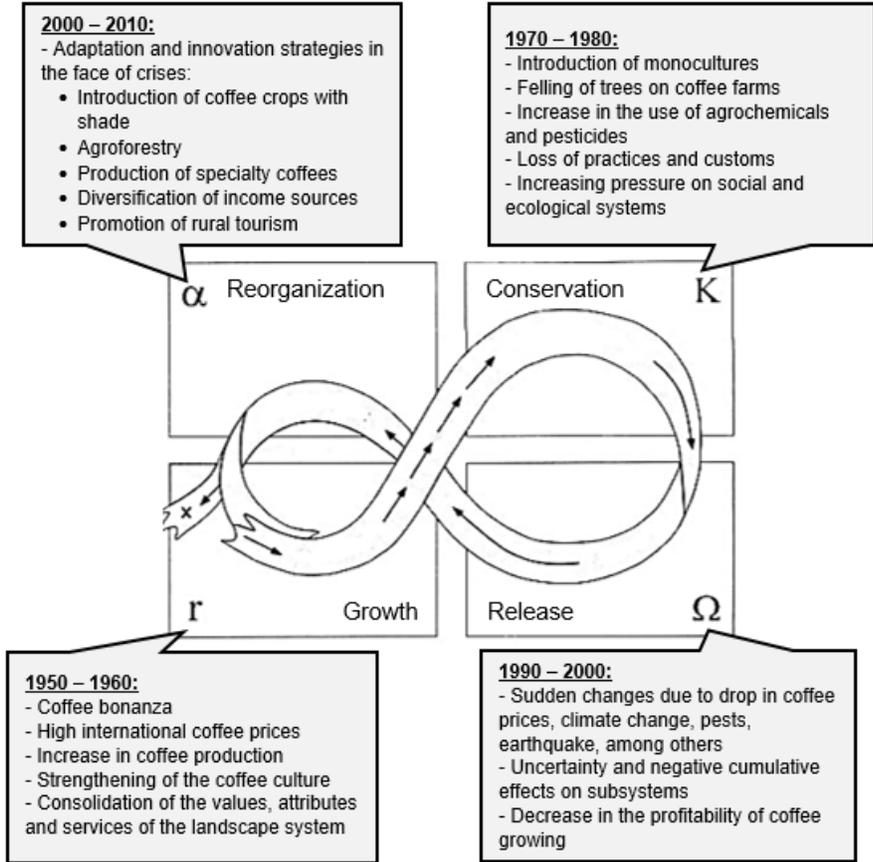
Source: Steven Mons

Adaptation and resilience in the CCLC

The continuous socio-ecological co-evolution of the CCLC implies that it is constantly being transformed and reconfigured. The CCLC is not exactly a static postcard seemingly frozen in time, but rather a dynamic, living and highly productive system, always in the process of adapting and becoming. In this sense, we argue that the CCLC is a landscape that passes through cycles of bonanzas and crises characterized by phases of growth, conservation and reorganization. As is the case with SES, the CCLC goes through the four general phases of change of the adaptive cycle, a hypothesis developed by Gunderson & Holling (2002) to understand and analyse continuous change and fluctuations in complex systems. To illustrate this, we show an example of such an adaptive cycle in Figure 6. The CCLC began a phase of growth or exploitation (r) in the 1950s, due to high international coffee prices and the resulting coffee boom. These developments increased coffee production, strengthened the coffee sector and thereby consolidated the unique values and attributes of the landscape system.

The fore loop that marked the transition from phase (r) to phase (K) was characterized by increased productivity of the coffee sector and, simultaneously, progressive pressure on social and ecological systems due to the felling of trees, the introduction of monocultures, the use of agrochemicals and pesticides, among others.

Figure 6: Example of an adaptive cycle in the CCLC, adapted from Gunderson & Holling (2002) and Mons (2021)



The resulting progressive erosion of the traditional socio-ecological landscape values in combination with sudden internal and external shocks such as the sharp falls in international coffee prices, different kinds of pests and an earthquake, paved the way for the back-loop phases (Ω) and (α) at the end of the last century. This period was characterized by uncertainties, surprises and negative cumulative effects on the social and ecological systems of the CCLC. In response to these changing dynamics, several innovative and adaptive strategies have been introduced during phase (α), including stimulation of production of specialty coffees, replanting of native species of trees to provide shade for coffee cultivation, agroforestry as a strategy to ensure biodiversity and food security and

diversification of income sources through promotion of tourism through creation of the so-called ‘Coffee Routes’ (Ministry of Culture, 2016; CCLC, 2018). These fluctuations show that the CCLC is, indeed, an evolutionary and adaptive system, subject to cyclical changes characterized by fore and back loops. This generates constant spatial reconfigurations and adaptations and shows that the CCLC has a certain degree of resilience, largely regulated by its values and attributes (see Table 1 in Section 4.1). These are therefore not only mere expressions of the socio-ecological relationships that unfold daily in the landscape, but constitute fundamental emergent properties that configure the adaptation and resilience of the landscape system. From the above we can also deduce that the CCLC is a nested system integrated into other hierarchical multi-scaled systems, since the crises that triggered the phases (Ω) and (α) were mainly caused by external socio-ecological forces. Hence, in addition to being constantly reconfigured by relationships and interactions between its internal social and ecological systems, the CCLC also fundamentally is a ‘glocalized’ system (Sassen, 2005) in which local, regional, national and global pressures continuously alter the structure of the landscape system.

The resulting fluctuations in space and time are a key characteristic of open systems (Baker & Durance, 2018) and render the CCLC complex adaptive properties and behaviours. The mosaic of internal and external socio-ecological processes unstoppably shapes transformation and emergence in the CCLC. Altogether, its systemic, adaptive and highly complex nature allows it to be theorized as a CSEL, that is, as the spatial expression of the socio-ecological interactions, flows and adaptations that continuously transform and cut across the landscape system (see Section 3). This means that the evolution of the CCLC is directly and indirectly linked to various socio-ecological processes and drivers of change at multiple scales, such as the volatility of international coffee prices, climate change (Ministry of Culture, 2016), volcanic eruptions (Velandia, 2016), threats of earthquakes (Duque-Escobar, 2017), mass tourism (Londoño, 2014) and extractive activities (Mons, 2021). These complex multi-scalar processes are essentially systemic crises that produce both slow and rapid changes in the CSEL. The next section will give an example of how transdisciplinary knowledge production can help to tackle some of the effects of such drivers of change.

Stimulating transdisciplinary knowledge production in the CCLC

An important example of a governance system that explicitly seeks the co-production of transdisciplinary knowledge comes from the Cañamomo-Lomapieta indigenous reservation, located in the municipalities of Riosucio and Supía in the extreme north of the CCLC (see Figure 4). Cañamomo-Lomapieta is inhabited mainly by the Emberá Chamí, a native population that lives in several small settlements scattered throughout Colombia’s Western Mountain Range. Although part of the economy of Cañamomo-Lomapieta is currently based on coffee production by smallholder farmers (Mons, 2021), the socio-ecological

dynamics of this northern region of the CCLC after the arrival of the Spaniards have largely been determined by the intertwined processes of gold mining (Herrera & García, 2012), colonization (Vinasco, 2015) and dispossession of indigenous lands (Weitzner, 2017). Given these conflicting territorial relationships, the representative authorities of Cañamomo-Lomapieta have developed a comprehensive transdisciplinary governance framework that manages gold mining activities within the indigenous reservation. Essentially, the representative indigenous authorities have sought to decolonize mining activities in Cañamomo-Lomapieta while simultaneously aiming to protect its social and ecological systems. The result is an “ancestral governance system” (Mons, 2021, p 210) that seeks to promote transdisciplinary knowledge co-production through community participation, strengthening of democratic decision-making processes and creation of spaces of resistance such as environmental committees and *mingas*.⁴ Examples of the latter include cooperative river clean-ups, re-forestation campaigns in micro-basins affected by mining activities and the establishment of a nursery for native plant species (Vinasco, 2015).

The different formal and informal resolutions (see Herrera & García, 2012) contain a series of technical measures established in collaboration with a wide range of different social actors, including specialists from NGOs, universities, mining agencies and departmental secretaries. Examples range from regulation of mining waste, physical distance between mines and protection of vital water sources to the use of mercury-free and cyanide-free processing techniques. Importantly, each mining unit is required to create an Environmental Management Plan with proposals for noise mitigation, mine closures, stabilization and protection of steep slopes and reincorporation of wastewater. Altogether, the numerous collaborative transdisciplinary mechanisms in Cañamomo-Lomapieta have stimulated the active participation of not only ancestral miners but also a wide variety of other stakeholders that operate at different scales, creating the social context necessary to manage confidence-building, learning, collective action, knowledge co-production and polycentricity. Thus, the indigenous authorities, without expressly mentioning these terms, attempt to manage gold mining activities in Cañamomo-Lomapieta according to some of the criteria of adaptation and resilience that have been explained previously in this article. This offers an interesting bridge between the resilience literature and the knowledge, cosmology and *praxis* of the Emberá Chamí, which is all the more noteworthy given that the above mentioned formal and informal resolutions have stimulated the emergence of a transdisciplinary adaptive governance system that addresses some of the negative impacts of small-scale gold mining activities. As the research of Mons (2021) has demonstrated, the SES of Cañamomo-Lomapieta show a relatively low systemic vulnerability to the effects of small-scale gold mining activities. At least in part, these differences are the result of significantly less contamination and depletion of water sources, as well as lower deforestation rates and less mining accidents, making the SES of Cañamomo-Lomapieta less vulnerable as compared to non-indigenous small-scale gold mining areas in

surrounding municipalities such as Filadelfia, Quinchía and Anserma, where the same extractive activities take place (Mons, 2021). The Cañamomo-Lomapieta case thus provides important clues on how to successfully promote transdisciplinary processes of joint knowledge production in a CSEL where “all knowers – and their knowledge systems – are of equal merit and equally deserving of consideration” (Schreiber et al., 2022, p. 6). We argue that future research agendas should consider how transdisciplinary knowledge production can be implemented in other Latin American CSELS in whose social and ecological systems are affected by extractive activities.

Conclusions

We started this article by showing the compatibility of geographical theory with resilience literature, introducing the CSEL as a distinctive analytical concept that explains the complex and often conflicting multi-scalar socio-ecological relationships in contemporary Latin American landscapes. We then applied this novel concept to the CCLC, a truly complex system in the mountainous heartland of Colombia which is, as we have demonstrated, much more than just an aesthetically pleasing linear landscape. It is, in fact, an emerging and adaptive system in which there is a deep, reciprocal and co-evolutionary relationship not only between its social and ecological dimensions but also between the CSEL and other complex systems at smaller and larger scales. However, the CCLC is not unique in its complexity; co-evolving multi-scalar interactions are a fundamental characteristic of virtually all contemporary Latin American landscapes. Therefore, there is a need to work towards a better understanding of the complexity and interrelatedness of the region’s socio-ecological landscape dynamics. We argue that the CSEL framework as presented in this article is particularly suitable for this purpose. In order to adaptively manage the inherently multifaceted and conflicting socio-ecological relationships caused by multiple drivers of change, we advocate for the creation of inclusive adaptive governance systems that explicitly consider the diversity and heterogeneity of Latin American CSELS.

The Cañamomo-Lomapieta case presented in this article has revealed that a fundamental pillar in this process is transdisciplinary knowledge co-production. We are convinced that the articulation of academic expertise with native peoples’ profoundly rich understanding of the diversity and complexity of the landscapes they inhabit will lead to innovative ways in which humans establish a more respectful relationship with their surroundings. Transdisciplinary research alliances offer the tools for such an integrative approach by actively seeking the inclusion of different onto-epistemologies through joint knowledge production. Ultimately, this will help in finding solutions to the wide range of socio-ecological conflicts revolving around the access to, and control of, resources that continue to shake countless CSELS in Latin America.

* * *

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Notes

- 1 In Colombia, a *vereda* comprises a set of dispersed settlements, generally in rural areas.
- 2 Brazil is, by far, the largest producer and exporter of coffee in the world (Volsi et al., 2019).
- 3 The FNC nowadays is one of the largest rural NGOs in the world and has been a key driving force behind the successful development of Colombia's coffee sector.
- 4 Etymologically, the word *minga* comes from Quechua and refers to an indigenous tradition of cooperative and voluntary work for the common good that is of reciprocal nature. It remains an important tradition for many ancestral communities in Andean countries, including Colombia.

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