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Transformative Innovation Policy and Sustainable Development: Identifying Elements and Gaps in Environmental Institutions in Colombia[1]

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Abstract

Introduction. In Latin America and Colombia, progress towards sustainable development has not kept pace with regional disparities and achieving the Sustainable Development Goals (SDGs) through policies and actions has become a social, economic, and political challenge that demands a disruptive and holistic approach. The Transformative Innovation Policy (TIP) has emerged as a new way to address these problems. This co-creation proposal, along with the participation and co-responsibility of all those involved, allows solutions to be reached and agreed upon from an interdisciplinary and difference-based approach. **Objective**. This study aims to identify, in a set of environmental institutions, elements of the TIP, as well as gaps in their innovation management processes to propose improvement actions for this type of organizations. **Materials and methods**. For such purpose the methodology implemented in this study, we compared the information contained in the documents published by the Transformative Innovation Policy Consortium (TIPC) with data collected from four Colombian environmental institutions working toward sustainable development: information from primary sources (stakeholder semi-structured interviews) was compared with that from secondary sources

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(transformative innovation policies, the Green Book 2030, and local development plans) to assess whether the selected institutions apply such transformative elements. **Results.** Some of the most relevant findings include the identification of certain transformative elements in the institutions under analysis. **Conclusions.** Some of existing processes that could be strengthened in order to create a shared vision of sustainable development among all actors in a given region; a vision that, with the help of such environmental institutions and through learning, experimentation, directionality, participation, interdisciplinarity, anticipation of outcomes and effects, and inclusion, leads to the achievement of the SDGs.

Keywords: Sustainable Development Goals, Regional Autonomous Corporation, Environmental Institutions, Learning, Experimentation, Directionality, Participation, Interdisciplinarity, Anticipation of Outcomes and Effects, Inclusion.

Política de innovación transformativa y desarrollo sostenible: identificando elementos y brechas en las instituciones ambientales en Colombia

Resumen

Introducción: los principales problemas globales como el hambre, la pobreza, la desigualdad, la falta de inclusión, la pérdida de biodiversidad y el cambio climático continúan empeorando; corregir su dirección implica abordarlos de una manera diferente a como se ha hecho hasta ahora. La política de innovación transformativa (TIP) es una nueva forma de abordar estos problemas, al compartir la responsabilidad de todos los actores involucrados para llegar a soluciones concertadas y trabajadas desde la interdisciplinariedad y la diferencia. **Objetivo:** identificar los elementos mencionados en las corporaciones ambientales, para establecer brechas y proponer mejoras en este tipo de organizaciones. **Materiales y métodos**: se contrastó la documentación del Consorcio de Políticas de Innovación Transformativa (TIPC) y la información recopilada de cuatro corporaciones ambientales colombianas orientadas al desarrollo sostenible, así como entrevistas a actores con políticas de innovación transformadora y planes de desarrollo local para encontrar la aplicación de estos elementos en las corporaciones ambientales en Colombia. **Resultados:** algunos resultados relevantes tienen que ver con la existencia de algunos elementos presentes en las corporaciones regionales analizadas. **Conclusiones:** se pudo constatar que algunos procesos existentes podrían ser fortalecidos para que este enfoque permita la construcción de una visión de desarrollo sostenible común a todos los actores de la región. Es posible la construcción de un territorio que, desde el aprendizaje, la experimentación, la direccionalidad, la participación, la interdisciplinariedad, la anticipación de resultados y la inclusión, permita el logro de los Objetivos de Desarrollo Sostenible de la mano de estas corporaciones.

Palabras clave: Objetivos de Desarrollo Sostenible, corporación autónoma regional, instituciones ambientales, elementos transformadores, aprendizaje, experimentación, direccionalidad, participación, interdisciplinariedad, anticipación de resultados y efectos, inclusión.

Política de Inovação Transformativa e Desenvolvimento Sustentável: Identificando Elementos e Lacunas nas Instituições Ambientais na Colômbia

Resumo

Introdução: Os principais problemas globais, como a fome, a pobreza, a desigualdade, a falta de inclusão, a perda de biodiversidade e as alterações climáticas, continuam a agravar-se; corrigir a sua orientação implica abordá-los de uma forma diferente da que tem sido feita até agora. Na América Latina e na Colômbia, os indicadores não avançam ao ritmo exigido pelas disparidades regionais; Alcançar os Objectivos de Desenvolvimento Sustentável (ODS) através de políticas e acções é um desafio social, económico e político que requer uma abordagem disruptiva e holística. A Política de Inovação Transformativa (TIP) é uma nova forma de resolver estes problemas. É uma proposta de cocriação que, com a corresponsabilidade de todos os atores envolvidos, permite chegar a soluções concertadas trabalhadas a partir da interdisciplinaridade e da diferença. **Objetivo:** O objetivo desta pesquisa é identificar os elementos mencionados nas corporações ambientais, o que permitirá estabelecer lacunas para propor melhorias neste tipo de organizações. **Materiais e métodos:** A metodologia apresentada neste trabalho é criada a partir do contraste entre a documentação do Consórcio de Política de Inovação Transformativa (TIPC) e as informações coletadas de quatro empresas ambientais colombianas orientadas para o desenvolvimento sustentável: entrevistas com atores foram contrastadas com políticas de inovação transformativa e planos de desenvolvimento local para encontrar a aplicação desses elementos nas corporações ambientais da Colômbia. **Resultados:** Alguns resultados relevantes têm a ver com a identificação da existência de alguns elementos dentro das corporações regionais analisadas. **Conclusões**: Constatou-se que alguns processos existentes poderiam ser fortalecidos para que esta abordagem permita a construção de uma visão de desenvolvimento sustentável comum a todos os atores da região. É possível construir um território que, por meio do aprendizado, da experimentação, da direcionalidade, da participação, da interdisciplinaridade, da antecipação de resultados e da inclusão, permita o alcance dos ODS, de mãos dadas com essas corporações.

Palavras-chave: Objetivos de Desenvolvimento Sustentável, Corporação Autônoma Regional, instituições ambientais, aprendizagem, experimentação, direcionalidade, participação, interdisciplinaridade, antecipação de resultados e efeitos, inclusão.

Introduction

In recent years, innovation has emerged as a pivotal force, driving growth in countries worldwide, significantly improving the quality of life for millions (Aldieri and Vinci, 2021). However, despite these advancements, the global challenges humanity faces have intensified over the past century. Consequently, there is an urgent expectation for innovation to play a critical role in addressing these pressing issues (García et al., 2018). Responding to these challenges, the Sustainable Development Goals (SDGs) have become a focal point for the 195 countries that ratified the agreement. As the year 2030 approaches—a critical deadline for progress—it is imperative that we rethink our interactions with the world.

Traditional approaches to innovation have primarily aimed at enhancing countries' technological capacities, resulting in successful products and markets (Frame 1 and Frame 2). However, these approaches have also contributed to unsustainable environmental and social issues (Schot et al., 2018; Schot and Steinmueller, 2018) Tecnología e Innovación (CTI. To address the need for transformative changes that can lead to sustainable systems, a new approach (Frame 3) has been proposed. It is anchored in the concept of transformative innovation, which aims to induce significant changes in socio-technical systems to enhance sustainability (Schot et al., 2018; Schot and Steinmueller, 2018).

Colombia has been profoundly affected by the challenges of the traditional development model, with issues such as inequality, exclusion, poverty, climate change, water scarcity, and biodiversity loss prevalent across the nation (Departamento Nacional de Planeación [DNP], 2011, 2019; OCDE, 2015)sin embargo, los sectores aún son intensivos en el uso de los recursos y han generado impactos en el capital natural, que inciden tanto en su oferta como en su calidad (DNP, Fedesarrollo, GGGI y PNUMA, 2017. In response, the national government, along with regional and local administrations, has explored various strategies to tackle these issues. The Regional Autonomous Corporations (CARs) have been instrumental in this process, ensuring that regional models promote sustainable social development and contribute to achieving the SDGs by 2030 (Corantioquia, 2020; Corporación Autónoma Regional de Cundinamarca [CAR], 2008).

This paper aims to identify elements from Frame 3 –also known as the Transformative Innovation Policy (TIP)– within four institutions in Colombia. Additionally, we will uncover gaps within their innovation management processes to propose improvements for these organizations. To achieve this, we will conduct a comprehensive literature review and a state-of-the-art analysis of transformative innovation, the SDGs, and the role of CARs. Importantly, the TIP is articulated in Colombia's National Policy of Science, Technology, and Innovation, referred to as the Libro Verde 2030 (Green Book 2030), which was published in 2018 by the Ministry of Science, Technology, and Innovation (Minciencias) in collaboration with the Transformative Innovation Policy Consortium (TIPC). This framework is further reinforced by studies and experiments

conducted by Minciencias, the TIPC, and the Latin American and Caribbean Hub of the TIPC (HUBLAyCTIP) (Colciencias, 2018).

Theoretical Background

Innovation has brought wealth and welfare to a large percentage of the population in industrialized countries, which have focused on producing innovations by solving some of their "major problems" with increased production and stretching resources to the limit because business competitiveness demands it (Mazzucato and Li, 2021). This production cycle, however, has affected the low-income population, the global economy, the life of millions of beings, and even the planet's sustainability (Østhassel, 2020). These negative effects have increased and accumulated over the years, and authors like Meadows et al. (1972) and Brown (1984) have expressed their concern about their implications and highlighted the need to change production, distribution, and consumption patterns while keeping in mind the growing pressure exerted on the current socio-technical systems (cited in Schot and Kanger, 2018).

In Latin America countries, progress towards sustainable development has not kept pace with regional disparities, and their effort to catch up to industrialized countries has exacerbated their problems. According to authors such as Navarro and Olivari (2016) and Visseren-Hamakers et al. (2021) reduced income, unemployment, housing and transport issues, climate change, soil degradation, pollution, damage to water sources and ecosystems, social inequality, and social exclusion due to age, gender, race, or socioeconomic status are such deep problems that countries' scarce resources cannot be invested in technological advances and innovation, even though these latter are considered drivers of social dynamism and economic growth.

Traditional innovation policies, which were initially adopted by countries to achieve high economic growth and improve the quality of life of their citizens, have caused a series of problems. In Colombia, for instance, these problems have impacted society and ecosystems, thus affecting the natural capital and environmental services upon which production processes –the basis of the country's economy– depend (Consejo Nacional de Política Económica y Social [Conpes], 2018b).

In Colombia, the impact of production processes on natural resources and the environment, together with the characteristic climatic phenomena of the region, evidences that, as its National Planning Department (DNP, 2011), states in the CONPES 3700 document, the country is highly vulnerable to the effects of climate change and variability. This threatens its sustainable development and demands a coordinated strategy to adapt to the impacts of these phenomena on the population, the environment, and the economy.

To understand the seriousness of the environmental crisis –which, besides involving social aspects, also affects the economy–, Colombia's National Planning Department (DNP, 2011) reported, in the CONPES 3700 document, that La Niña climate pattern caused losses of about COP 11.2 trillion at the end of 2010 and

the beginning of 2011. El Niño, for its part, caused losses of around COP 3.1 trillion in 2015, which is equivalent to 0.6% of the country's gross domestic product in the same year. As a result of this, the country's social, environmental, and economic spheres were severely affected (DNP, 2011). There is thus a need to rethink how Colombia and other countries have structured their development models, as well as for supranational bodies to mobilize new strategies for sustainability (Colciencias, 2018).

As stated in the study by Schot and Kanger (2018)but also to increasing global ecological degradation and social inequality. The socio-technical systems that underlay contemporary societies have substantially contributed to these outcomes. This paper proposes that these socio-technical systems are an expression of a limited number of meta-rules that, for the past 250 years, have driven innovation and hence system evolution in a particular direction, thereby constituting the First Deep Transition. Meeting the cumulative social and ecological consequences of the overall direction of the First Deep Transition would require a radical change, not only in socio-technical systems but also in the meta-rules driving their evolution – the Second Deep Transition. This paper develops a new theoretical framework that aims to explain the emergence, acceleration, stabilization and directionality of Deep Transitions. It does so through the synthesis of two literatures that have attempted to explain large-scale and long-term socio-technical change: the Multi-level Perspective (MLP, "recently [in 2015], the United Nations formulated 17 Sustainable Development Goals, calling for revolutionary greener production, increased social justice, a fairer distribution of welfare, sustainable consumption patterns, and new ways of producing economic growth" (p. 1). In 2018, 193 countries, including Colombia, signed the 2030 Agenda for Sustainable Development. This challenge brings in new responsibilities for Colombia and its government system.

As noted in the CONPES 3918 document (2018a)el bienestar de las personas y la conservación del ambiente. La Agenda 2030 para el Desarrollo Sostenible y sus ODS integran en sus tres dimensiones social, económica y ambiental, importantes retos a nivel global y nacional. Entre ellos se encuentra la necesidad de fortalecer la coordinación interinstitucional para promover acciones transversales, la capacidad del Gobierno para cuantificar los avances de las metas propuestas, la alineación de la agenda con los instrumentos de política territoriales, la coordinación de acciones con diferentes actores sociales, así como la movilización de recursos en todos los niveles. Colombia se ha destacado por liderar la implementación de agendas como la de los ODS, las alianzas por el cambio climático y la adopción de estándares mundiales como los desarrollados por la Organización para la Cooperación y el Desarrollo Económico (OCDE, the SDGs will become an element that integrates all the country's current development agendas, as well as a framework to coherently align public and private initiatives around a common goal. The SDGs were also a key

pillar in the National Development Plans (NDPs) 2014-2018 and 2018-2022, the country's process to join the OECD, the Paris Agreement on Climate Change, and the green growth strategy. Although the national government is responsible for the implementation of the SDGs, the regional and local administrations, the various decentralized institutions, and especially the CARs have an enormous responsibility in contributing to the achievement of most of them.

The CARs were created as part of Colombia's commitments made at the Rio Earth Summit in 1992. These decentralized institutions are responsible for managing natural resources and the environment, as well as working toward the sustainable development of a region that, by its very nature, geographically forms an ecosystem or a geopolitical, biogeographical, or hydrogeological unit (Ramírez, 2022). Moreover, they are the most important environmental authority in their jurisdiction. Hence, achieving the SDGs is a fundamental component of their action plan (Corantioquia, 2016).

As reported in Corantioquia's action plan 2016-2019 (2016), the NDP 2014-2018 establishes the need to incorporate prospective strategies that allow the country to comply with the UN Post-2015 Development Agenda, as well as to achieve the SDGs and targets set for 2030, to irreversibly eradicate poverty and create the necessary conditions to achieve sustainable development. Based on the national environmental policies and in order to achieve the SDGs, Corantioquia launched the "Gestión Sectorial y Urbana para el Crecimiento Verde" program (Sectoral and Urban Management for Green Growth), which seeks to promote sustainable actions in the region in collaboration with the different municipalities and production sectors. This articulation is also reflected in its three-year action plan, which directly addresses SDGs 2, 4, 6, 7, 11, 12, 13, 15, and 17 and is transversal to all areas (Corantioquia, 2016).

Considering the above, the CARs are essential to implement transformative innovation in Colombia because it, as well as the SDGs, is a novel concept that started to be studied in the middle of the second decade of the twenty-first century. The literature on this matter is quite recent, and although the number of publications in the world is growing every year, it only increased by 30% from 2007 to 2016 in Colombia. This concept thus needs to be further studied and disseminated in other fields. In our country, new publications will lead to a broader debate and provide tools for sharing ideas and addressing the need for socio-environmental changes (Colciencias, 2018).

In Colombia, the CARs are one of the main actors to influence the achievement of the SDGs and induce transformations in socio-technical systems. To do so, they must implement policies and take actions that address social, environmental, economic, and political challenges from a holistic and systemic approach to turn problems around and bring about the desired changes. For these organizations, achieving the SDGs

by 2030 requires them to change the traditional methodologies they have used so far to solve their problems and adopt new concepts such as those found in the TIP and the Green Book 2030.

Materials and Methods

We employed an inductive qualitative approach in this study to analyze data collected from primary and secondary sources, i.e., academic documents, panels, specialized workshops, and semi-structured interviews. The methodology we developed consisted of three stages: (1) exploration, (2) identification of transformative elements in the selected institutions; and (3) formulation of gap-closing proposals.

Exploration

In this first stage, we conducted a literature review on sustainable, inclusive, co-creative, government, and transformative innovation to identify the various innovation management methodologies that have been implemented and contain transformative elements. Then, we performed a secondary data analysis using bibliometric techniques to analyze trends and theoretical aspects in the field. Also, we examined different CARs or environmental institutions in Colombia to determine which incorporate transformative elements into their management methodologies and based on such analysis, selected those organizations and individuals to be interviewed.

Identification of transformative elements in the selected institutions

In this second stage, we identified transformative elements in the management methodologies of the selected institutions. To do so, we interviewed employees from the Corporación Autónoma Regional de Cundinamarca (CAR of Cundinamarca), Corporación Autónoma Regional de Chivor (Corpochivor for its Spanish acronym), and Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAVH for its Spanish acronym). After the interviews, we reviewed the documents provided by the participants to compare the management methodologies implemented by the different institutions and identify common elements with that of Corporación Autónoma Regional del Centro de Antioquia (Corantioquia for its Spanish acronym).

Formulation of gap-closing proposals

In this last stage, we analyzed the information obtained from the two previous stages to make recommendations based on the objectives of this study.

Findings/Results

This study focused on transformative innovation and SDGs, as well as on the CARs as organizations capable of executing, leading, and promoting projects on those two topics. Transformative innovation and the SDGs first appeared in the scientific literature at different times and have evolved in distinct ways. Transformative innovation, on the one hand, is a relatively

new term. It first appeared in databases such as Scopus in 2005. However, regarding the approach considered in this study, which is the same used by the TIPC, it first appeared in Scopus in 2012 in an article entitled Transforming Innovation for Sustainability, in which some representatives from the University of Sussex (one of the founding members of the consortium) participated as co-authors. Transformative innovation, according to the TIPC, must lead to changes in socio-technical regimes, a condition that we applied here to limit the bibliographic search (Colciencias, 2018; Science Policy Research Unit, 2016). To broaden the scope of transformative innovation while keeping its ultimate purpose in mind, we also considered other types of innovation that can induce socio-technical changes as well, such as inclusive innovation, open innovation, sustainable innovation, social innovation, and co-innovation.

The SDGs, on the other hand, emerged in the final period of the Millennium Development Goals (MDGs) and first appeared in the scientific literature in 2012, with the document entitled From Millennium Development Goals to Sustainable Development Goals by J.D. Sachs being the publication with the highest number of citations (423 citations) in Scopus. The scientific production on the SDGs between 2012 and 2019 is quite profuse in Scopus, with 7282 articles published in that period.

Transformative innovation

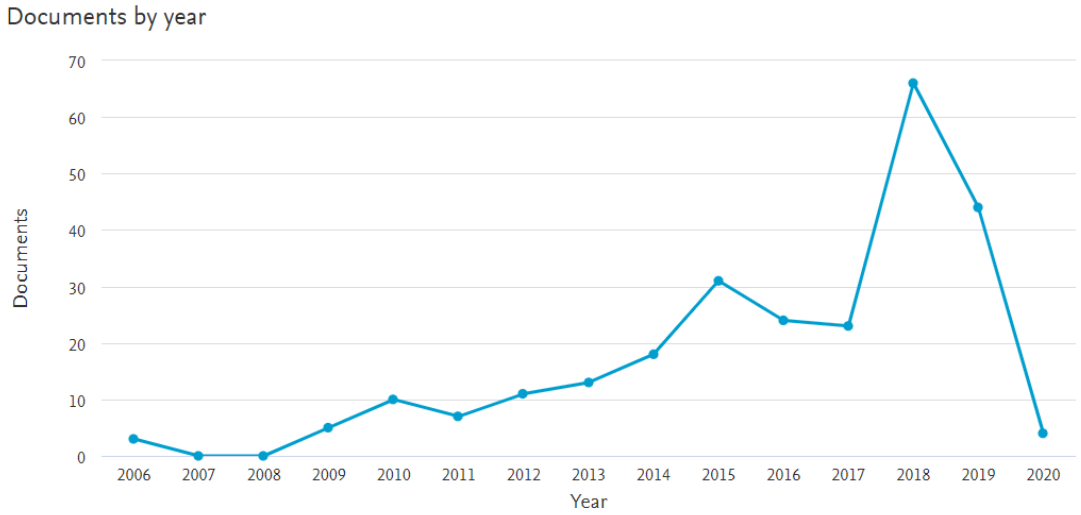
Transformative innovation is a compound term that should not be separated into bibliographic searches. Joining both words with AND or OR operators can generate many results that cover a wide range of topics but do not always correspond to the very concept introduced by the TIPC. Therefore, the search was performed using the compound term: TITLE-ABS-KEY ("transformative innovation"). In addition, it was restricted to documents published between 2012 and 2019. This search retrieved 79 documents. To obtain records closer to the concept developed by the TIPC, the compound word "socio-technical" was added to the search equation: TITLE-ABS-KEY (("transformative innovation") AND ("socio-technical")). This new search yielded only 8 results, demonstrating great precision in the title, abstract, and keyword search.

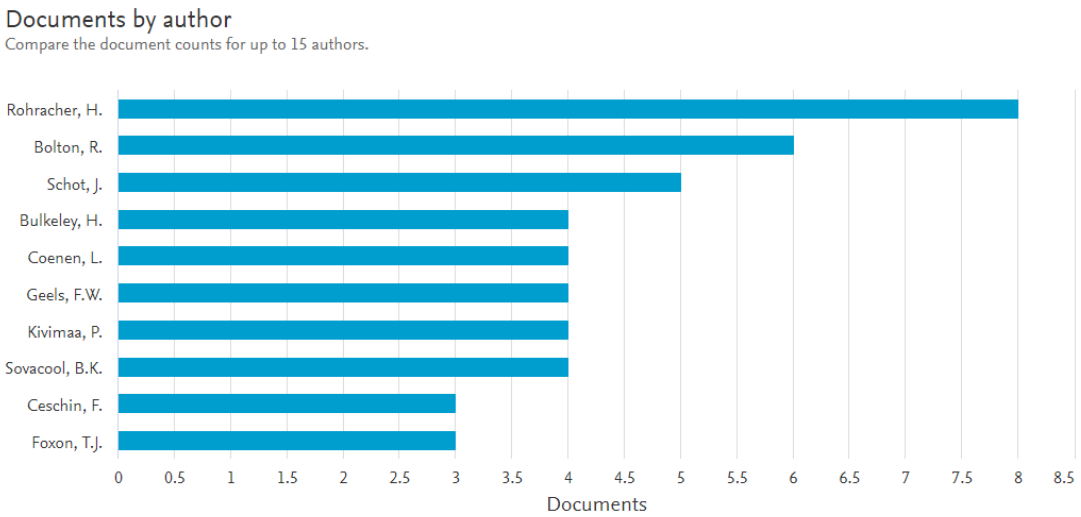
According to Schot and Steinmueller (2016), transformative innovation must cause changes in socio-technical models, which would also imply that other types of innovation could induce those changes and be transformative as well. Considering this, we broadened the search to look for other types of innovation that may lead to socio-technical changes and transitions.

The results of the bibliometric analysis show that the concept developed by the TIPC is in its early stages of research and began to be studied around 2006 through the adoption of other types of innovation (such as sustainable innovation) associated with the concept of socio-technical change. In addition, the scientific production in the field has markedly increased in the last two years, with the United Kingdom (particularly the University of Sussex), along with the Netherlands, having the highest number of publications.

Figure 1.

Search results for transformative innovation





Source: Created by the authors based on the results of the bibliometric analysis.

Identification of Regional Autonomous Corporations or Environmental Institutions that use elements of transformative innovation

A search was performed in Scopus to identify existing studies on the CARs or environmental institutions and their innovation management methodologies. Since this search yielded no results, the next search term we used was "regional autonomous corporations": TITLE-ABS-KEY ("Regional Autonom* Corporatio*"). This search retrieved only 12 documents published between 2010 and 2020, but none of them addressed innovation management in said institutions. A new search using traditional search engines such as Google revealed that the CAR of Cundinamarca is the only regional autonomous corporation in Colombia that has an innovation management system. Most CARs execute projects in which innovation stands out, but they do not have a defined methodology for their implementation.

For the characterization, we selected the CAR of Cundinamarca because it is the only one with an innovation management system and a large portfolio of sustainable projects that seek transformations in small-scale systems; Corpochivor because of its Sustainable Research and Innovation Centers initiative for the Department of Boyacá; and the IAVH for being a leading reference in environmental research in Colombia and for its Socio-ecological Transitions Towards Sustainability program, which aims to manage Colombia's biodiversity in the midst of undeniable social and ecological changes (Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, 2019).

Comparison of the methodologies implemented by the selected institutions and identification of common transformative elements.

We analyzed information from the four selected institutions to see whether they view innovation as a process and apply the principles of transformative innovation from the perspective of the TIPC. According to the results of this analysis, the CAR of Cundinamarca, through its Directorate of Laboratory and Environmental Innovation, is the only public organization in Colombia, as of 2020, that has been certified in innovation management under Colombian Technical Standard 5801:2018. It is also the only CAR to implement an innovation management system (CAR, 2020b). As for Corpochivor, knowledge and environmental innovation management appears as a process integrated into its comprehensive management system, and it, along with the CAR of Cundinamarca, are the only institutions that regard innovation as a process (Corpochivor, 2020b).

Another aspect we examined was the application of the six principles of transformative innovation already discussed and their impact on system transformations. We found that all six principles have been applied by the four selected institutions, but their implementation is not a strong indicator of the search for changes in socio-technical systems, which is the main idea behind the TIPC's understanding of transformative innovation (Colciencias, 2018).

Table 1.

Learning and experimentation from the perspective of the transformative innovation policy

Characteristics of learning and experimentation applied from the perspective of the transformative innovation policy	
1.	**Corporación Autónoma Regional de Cundinamarca (CAR of Cundinamarca)**
	This element can be found in multiple programs and areas of the CAR of Cundinamarca and is one of the three cross-cutting principles in its four-year action plan. It facilitates the appropriation of environmental knowledge to build attitudes that foster sustainable development. In this CAR, learning and experimentation are systematized through an open platform called *Sistema de Gestión del Conocimiento y la Innovación Ambiental* (Knowledge Management and Environmental Innovation System). After comparing these characteristics with the concept of learning and experimentation from the perspective of transformative innovation, this CAR is found to adhere to this transformative principle.
2.	**Corporación Autónoma Regional de Chivor (Corpochivor)**
	Through knowledge and environmental innovation management and, most importantly, through education, Corpochivor creates spaces for reflection, transmission, and acquisition of knowledge and experiences that allow different actors to participate in public policy decisions and in the search for sustainable development. As a result, the learning and experimentation element in this CAR is elevated to the level of a transformative principle. With an eye to the future, Corpochivor works using STEM+B (Science, Technology, Engineering, Mathematics, and Business) methodologies.
3.	**Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAVH)**
	From the IAVH's viewpoint, different types of knowledge, collaborative learning, and co-creation enable the comprehensive management of the territories through the appropriation and democratization of science. This organization uses learning and experimentation as a tool to foster debate and contribute to better decision-making through collective knowledge. Thus, the learning and experimentation element in the IAVH fits the criteria for being considered a transformative principle.
4.	**Corporación Autónoma Regional del Centro de Antioquia (Corantioquia)**
	The learning and experimentation element in Corantioquia can be regarded as a transformative principle because it seeks to provide tools for debate and inspire actors to look for potential sustainable scenarios.

Source: Created by the authors.

The learning and experimentation element in the four institutions under analysis fits the criteria for being considered a transformative principle from the perspective of the TIPC.

Table 2.

Directionality from the perspective of the transformative innovation policy

Characteristics of directionality applied from the perspective of the transformative innovation policy	
1.	**Corporación Autónoma Regional de Cundinamarca (CAR of Cundinamarca)**
	In collaboration with the various actors in the territory, the CAR of Cundinamarca seeks to implement the necessary and desired changes to achieve sustainable development. It encourages them to participate in planning by becoming protagonists in the challenges and engaging in the achievement of the SDG´s. Directionality in this CAR meets the criteria for being considered a transformative principle.
2.	**Corporación Autónoma Regional de Chivor (Corpochivor)**
	One of Corpochivor's key objectives is to achieve sustainable development. To this end, it seeks to mitigate climate change through the sustainable use of biodiversity and transform the production sector by managing knowledge, as well as its interactions and dynamics (Corpochivor, 2020b). Directionality in Corpochivor fits the criteria for being considered a principle from the perspective of transformative innovation.
3.	**Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAVH)**
	Directionality, as a transformative principle, is present in the work of the IAVH because this organization is in constant search for sustainable transitions in management processes. According to the IAVH these processes can be agreed upon by society based on knowledge in order to attain the desired conditions in the territories to make them resilient and encourage the necessary modifications in change trajectories.
4.	**Corporación Autónoma Regional del Centro de Antioquia (Corantioquia)**
	Directionality in Corantioquia is based on government regulations. It allows the corporation to create shared visions of the future based on the premise of sustainable development. This element is thus seen as a transformative principle.

Source: Created by the authors.

Directionality is applied as a transformative principle in the four institutions.

Table 3.

Participation from the perspective of the transformative innovation policy

Characteristics of participation applied from the perspective of the transformative innovation policy	
1.	**Corporación Autónoma Regional de Cundinamarca (CAR of Cundinamarca)**
	The CAR of Cundinamarca actively promotes participation. Through its *Gestión Ambiental Participativa* (Participatory Environmental Management) plan, it seeks to ensure that all the actors in the territory engage in the programs, action plans, and oversight activities. It also aims to empower communities to jointly find creative solutions to existing problems and recognizes that interactions between diverse social actors produce innovative experiences that drive social and environmental development. This, added to its implementation of an open platform called *Sistema de Gestión del Conocimiento y la Innovación Ambiental* (Knowledge Management and Environmental Innovation System), allows this CAR to meet the criteria of the participation principle and contribute to sustainable development through experimentation and innovation.

2.	**Corporación Autónoma Regional de Chivor (Corpochivor)**
	Participation is present in the action plans of Corpochivor. Its goal is to prepare, through education, the various actors to participate in the planning, management, and evaluation of programs and projects. Considering these characteristics, participation is regarded as a transformative principle.
3.	**Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAVH)**
	Participation in the IAVH is aligned with the characteristics of transformative innovation because aspects such as negotiation and respect for difference are highly important, as well as because knowledge is constructed and exchanged to favor citizen participation (Julio, 2016). As a result of this, the various actors can contribute to sustainable development.
4.	**Corporación Autónoma Regional del Centro de Antioquia (Corantioquia)**
	Corantioquia integrates participation into its action plans so that sustainable development is fostered through the voices and purposes of social, economic, political, cultural, and environmental actors having an impact on the territory (Corantioquia, 2020). Therefore, this principle is applied from the perspective of transformative innovation.

Source: Created by the authors.

Participation in the four institutions under analysis fits the criteria for being considered a transformative principle from the perspective of the TIPC.

Table 4.

Interdisciplinarity from the perspective of the transformative innovation policy

Characteristics of interdisciplinarity applied from the perspective of the transformative innovation policy	
1.	**Corporación Autónoma Regional de Cundinamarca (CAR of Cundinamarca)**
	The CAR of Cundinamarca incorporates interdisciplinarity into its planning, structuring, design, development, and even replication processes. This principle with a transformative approach has been employed in projects such as *Jerusalén–Municipio Ecosostenible* (Jerusalén, an eco-sustainable municipality), which aims to address some of the SDGs and transform some systems.
2.	**Corporación Autónoma Regional de Chivor (Corpochivor)**
	Although interdisciplinarity is present in various programs, projects, and processes implemented by Corpochivor, as well as in its environmental education initiatives through the *Proyectos Ciudadanos de Educación Ambiental* (Citizen Environmental Education Projects) (PROCEDA for its Spanish acronym), it is not applied as a transformative principle.
3.	**Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAVH)**
	Interdisciplinarity in the IAVH is based on the integration of different types of knowledge to achieve sustainable development. This principle, therefore, is implemented with a transformative approach.
4.	**Corporación Autónoma Regional del Centro de Antioquia (Corantioquia)**
	Interdisciplinarity was only found in Corantioquia's documentation on education. Hence, it does not fit the criteria for being considered a transformative principle.

Source: Created by the authors.

Interdisciplinarity as a transformative principle is present in the actions of the CAR of Cundinamarca and the IAVH. However, it is unclear whether this principle is applied with a transformative approach in Corpochivor and Corantioquia.

Table 5.

Anticipation of outcomes and effects from the perspective of the transformative innovation policy

Characteristics of anticipation of outcomes and effects applied from the perspective of the transformative innovation policy	
1.	**Corporación Autónoma Regional de Cundinamarca (CAR of Cundinamarca)**
	In its action plan 2020–2023, the CAR of Cundinamarca recognizes forward planning as a tool to establish impacts within the environmental culture. Even though its application is not prevalent in all projects, this principle is applied with a transformative approach in this CAR.
2.	**Corporación Autónoma Regional de Chivor (Corpochivor)**
	Anticipation of outcomes and effects is neither documented nor reported as a transformative principle in Corpochivor's documentation.
3.	**Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAVH)**
	Anticipation of outcomes and effects appears as a cross-cutting element in the work of the IAVH. Forward planning is used in research activities, and it, based on co-creation, allows different options to be analyzed in order to anticipate the future and seek balance in the social, economic, cultural, and environmental systems. Anticipation of outcomes and effects in the IAVH thus meets the criteria for being considered a transformative principle.
4.	**Corporación Autónoma Regional del Centro de Antioquia (Corantioquia)**
	In Corantioquia, anticipation of outcomes and effects is only addressed in risk management, and although this element might be required for sustainable development, we did not find it in the materials we reviewed. Therefore, it fails to meet the criteria for being considered a transformative principle.

Source: Created by the authors.

Table 6.

Inclusion from the perspective of the transformative innovation policy

Characteristics of inclusion applied from the perspective of the transformative innovation policy	
1.	**Corporación Autónoma Regional de Cundinamarca (CAR of Cundinamarca)**
	Inclusion from the perspective of transformative innovation can be found in some of the projects developed by the CAR of Cundinamarca, such as *Jerusalén–Municipio Ecosostenible* (Jerusalén, an eco-sustainable municipality). This initiative has had a significant impact, and all the actors have actively participated in it. However, their contribution in the planning and evaluation processes is not clear, as the documentation we analyzed did not provide information on their involvement in these two stages.

2.	**Corporación Autónoma Regional de Chivor (Corpochivor)**
	Inclusion is present in the actions of Corpochivor because this CAR encourages all actors in the territory to participate in the development, monitoring, and control of the designed plans, programs, and projects (Corpochivor, 2020a). There is, however, no mention of processes that require niche actors (those who, in most cases, provide disruptive ideas that lead to transformations). From the transformative approach, this principle is thus partially fulfilled.
3.	**Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAVH)**
	The IAHV seeks to involve all actors in the different stages of its programs and projects in order to achieve the desired outcomes through negotiation. For this reason, inclusion in the IAHV can be said to meet the criteria for being considered a transformative principle.
4.	**Corporación Autónoma Regional del Centro de Antioquia (Corantioquia)**
	Inclusion is reflected in Corantioquia's idea of co-responsibility, which elevates it to the level of a transformative principle.

Source: Created by the authors.

Inclusion as a transformative principle is clearly observed in the work of the IAVH and Corantioquia but not in the actions of the CAR of Cundinamarca and Corpochivor.

The results of this characterization reveal that the IAVH applies all the principles of the TIP and has also worked on concepts like transformative change, sustainable transitions, and sociological systems, which allows it to accomplish the same goal as transformative innovation: to drive changes in socio-technical systems. Furthermore, through projects such as Jerusalén–Municipio Ecosostenible (Jerusalén, an eco-sustainable municipality), the CAR of Cundinamarca, which meets nearly all the criteria and has an innovation management system, addresses multiple SDGs and fosters changes in at least small-scale socio-technical systems.

Discussion

Through the TIPC and the STI policy set forth in the Green Book 2030, Colombia is contributing to the development of a non-traditional innovation framework, which seeks to complement its two traditional counterparts and maximize their potential. The numerous innovation frameworks available can be rethought to produce, fundamental changes in the way we live, work, and do business (United Nations, n.d.). Various documents issued by the Colombian government confirm the need for these changes that the UN has defined as "fundamental." For instance, the CONPES 3934 (Green Growth Policy) document (2018b) states that the current economic development model will, indeed, become unsustainable in the long term because it degrades and exhausts the resource base required for economic production and has serious repercussions on the environment and society. As a result, policies and

strategies seeking the country's sustainable development must be devised.

Colombia's compliance with the SDGs is governed by its NDP 2014–2018, which, according to the CONPES 3918 document (2018a)el bienestar de las personas y la conservación del ambiente. La Agenda 2030 para el Desarrollo Sostenible y sus ODS integran en sus tres dimensiones social, económica y ambiental, importantes retos a nivel global y nacional. Entre ellos se encuentra la necesidad de fortalecer la coordinación interinstitucional para promover acciones transversales, la capacidad del Gobierno para cuantificar los avances de las metas propuestas, la alineación de la agenda con los instrumentos de política territoriales, la coordinación de acciones con diferentes actores sociales, así como la movilización de recursos en todos los niveles. Colombia se ha destacado por liderar la implementación de agendas como la de los ODS, las alianzas por el cambio climático y la adopción de estándares mundiales como los desarrollados por la Organización para la Cooperación y el Desarrollo Económico (OCDE, adopts green growth as a cross-cutting and all-encompassing approach that aims to strengthen the economic and social well-being of the population while ensuring that the natural resource base provides the environmental goods and services that the country requires for its sustainable economic development. This NDP also establishes guidelines and recommendations for incorporating the SDGs into local planning tools.

There is thus a pressing need to find a way to promote the attainment of SDGs, with transformative innovation playing a key role. This should, in turn, be supported by an innovation management methodology that contributes to achieving the goals and targets in a differentiated manner while remaining true to its primary purpose: triggering transformation and sustainable development (Colciencias, 2018). Achieving the SDGs concerns all Colombians; however, this effort must be led by the public sector, particularly the CARs.

The purpose of this study was to identify, in four selected institutions, transformative elements that foster the achievement of the SDGs and induce socio-technical changes that lead to greater sustainability and cause current socio-economic and socio-environmental relations to be reoriented; this in order to prove that innovation must become a means to achieve equity, justice, and sustainability (Villa et al., 2017) and that it can help to solving the country's major social, economic, and environmental problems (Colciencias, 2018). Such socio-technical changes require the creation of spaces for participation so that companies, the scientific and academic community, various government entities, and the general public appropriate knowledge and contribute to finding solutions to their problems (Colciencias, 2018).

After comparing our findings with information from secondary sources, we may conclude that the SDGs have become a priority for the Colombian government and the CARs and environmental institutions considered in this study. For instance, the

CAR of Cundinamarca (2020b) believes that the SDGs are an element that integrates all the country's current development agendas, as well as a framework to coherently align public and private initiatives around a common goal. For its part, Corpochivor (2020b) states that regional, departmental, municipal, and institutional planning shall, according to the competencies of each entity, contribute to the implementation and achievement of the 17 SDGs by 2030. For Corantioquia (2020), the SDGs should be considered in the formulation and implementation of the Regional Environmental Management Plans (REMPs) because they offer a comprehensive context that helps a region become more sustainable and viable with the support of the local authorities and other regional actors.

According to Schot et al. (2020), the SDGs should not be regarded as individual goals but as missions to achieve transformation. The best possible course of action could only be adopted through disruptive responses that drive transformative change (Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, 2019). Schot and Steinmueller (2018) state that, to turn around problems concerning accomplishments and impacts, the TIP must be used to seek a change in socio-technical systems. This should be done by applying transition studies to sustainability, as well as the theory of change, particularly the concepts of niche, regime, and panorama (Ghosh et al., 2020).

In Colombia, the CARs are one of the main actors to influence the achievement of the SDGs and induce transformations in socio-technical systems. To do so, they must implement policies and take actions that address social, environmental, economic, and political challenges from a holistic and systemic approach to turn problems around and bring about the desired changes. For these organizations, achieving the SDGs by 2030 requires them to change the traditional methodologies they have used so far to solve their problems and adopt new concepts such as those found in the TIP and the Green Book 2030.

According to our findings, the CARs under analysis have adopted the basic principles of the TIP but not the guidelines of the new science and innovation policy. In addition, most of them do not develop innovative processes in a systemic way. For instance, innovation is regarded as a system only in one of them, while it does not even appear as a process in the others. The necessary transformations to achieve the SDGs require new systemic practices that can bring together and connect different experiments, best practices, and achievements so that the effects, resources, and actions are strengthened.

The policy in the REMPs and action plans of the CARs under analysis reveals that these organizations seek to impact the SDGs through challenges and that they are evaluated based on their achievement of such goals. They have demonstrated in their management reports that they can achieve the proposed goals with partial impacts on the SDGs but without seeking a transformation in socio-technical systems. The CAR of Cundinamarca, however, is the only one that has managed to cause changes in socio-technical systems and thus

impact multiple SDGs through its Jerusalén–Municipio Ecosostenible (Jerusalén, an eco-sustainable municipality) project (Alcaldía de Jerusalén, 2018). For its part, IAVH's work on transitions to sustainability, which aims to transform some systems, is a medium- and long-term initiative that is now underway in a variety of fields.

Few institutions in Colombia (for instance, two of the four analyzed in this study) develop policies and initiatives aimed at systemic transformations, which also occurs in other countries around the world. This demonstrates the enormous difficulties in facing this and in integrating these rationalities into existing practices and tools (Ghosh et al., 2020). The TIP in the 2030 Green Book, as well as other documents published by the TIPC, serves as a foundation for institutions to adapt their plans, in the short, medium, and long term, to exert an impact beyond the achievement of the goals set forth in the REMPs through experimentation and evaluation (Boni et al., 2023; Santos and Coad, 2023)in the food domain, conducted at the Swedish Agency of Innovation (Vinnova.

Conclusions

The analysis of the Regional Autonomous Corporations (CARs) and their innovation methodologies from the perspective of the Transformative Innovation Policy Consortium (TIPC) reveals that there are significant advances in the use of transformative innovation principles within these institutions. However, their implementation varies considerably. The CAR of Cundinamarca stands out for its certified Innovation Management System, being the only entity in Colombia with this certification, which allows it to structure innovation processes that promote changes in small-scale socio-technical systems. Initiatives such as Jerusalén–Municipio Ecosostenible are examples of how the transformative innovation approach can be applied to address the Sustainable Development Goals (SDGs) in a local context.

On the other hand, the Alexander von Humboldt Biological Resources Research Institute (IAVH) demonstrates a comprehensive application of all TIPC principles, aligning its efforts with concepts of sustainable transition and sociological system management. This alignment enables it not only to adhere to transformative innovation policy but also to foster changes toward sustainability in complex and multiscale systems. As for Corpochivor and Corantioquia, although both institutions incorporate certain TIPC principles, their application in specific practices does not always meet the necessary criteria to achieve large-scale transformative change. In conclusion, while the CARs have integrated some elements of transformative innovation into their processes, only the IAVH and the CAR of Cundinamarca apply principles that promote significant transitions toward more sustainable systems.

However, the findings indicate that a transformative approach to the SDGs requires more than partial compliance with the goals. As Schot and Steinmueller (2018) note, transformation involves a fundamental change in current systems and a long-term

orientation toward sustainability; only through disruptive responses that foster deep changes in socio-technical systems will a true integration of the SDGs into environmental policy be achieved.

To advance the SDG agenda in Colombia, it is essential to promote greater adoption of these principles in innovation management methodologies within the CARs and other environmental institutions, to achieve systemic and lasting transformations. Continuous experimentation and evaluation, supported by a strategic alignment of their plans with transformative principles, could enhance the effectiveness and impact of these agencies in meeting the SDGs, positioning them as leaders in sustainability and sustainable development in Colombia.

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