Title: Climate Change Mitigation Legislation in Developing Countries: An SESs-Based Framework

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Abstract

Background: Climate change is the greatest environmental threat of the century, and developing countries, being most vulnerable, need to reduce their greenhouse gas emissions. Passing climate mitigation legislations is a crucial step toward this goal.
Materials and Method: This research analyzes 226 climate change mitigation legislations from 88 developing countries since 1980, using data from the Climate Change Laws of the World (CCLW) database. A mixed-methods approach was employed, combining quantitative time-series analysis to examine trends in legislative activities and qualitative content analysis using the Social-Ecological Systems (SES) framework to explore legislative texts.
Results: Africa has the most legislative activity, followed by Asia and the Americas. The energy sector is the most emphasized across all regions, particularly in Africa, while Asia and the Americas focus on energy, transport, and building sectors. This highlights the concentration of legislative efforts on the actors system, especially regarding energy-related issues.
Discussion: Despite the increase in climate mitigation legislations, the focus remains largely on the actors' system, with less attention to governance and resource systems. Strengthening enforcement, institutional capacity, and international collaboration is essential for effectiveness.

Conclusion: This research emphasizes the importance of a comprehensive approach to climate mitigation in developing countries. Effective implementation of existing legislation, along with strengthening resource and governance systems, enforcement mechanisms, and international cooperation, is crucial for achieving significant emissions reductions.

Keywords: Developing countries, Legislation, Climate change.

1.Introduction

Since the mid-19th century, atmospheric CO_2 levels have risen by over 40%, driving global warming and climate change [1, 2]. The Intergovernmental Panel on Climate Change (IPCC) defines climate change as long-term shifts in climate patterns, identified through statistical analysis [3]. This phenomenon is evident in rising global temperatures, sea level increases, and melting ice caps [4].

The impacts of climate change are becoming more severe, with extreme weather events intensifying worldwide [5, 6]. Developing countries face significant vulnerabilities while also contributing substantially to greenhouse gas emissions [7, 8]. In 2022, global greenhouse gas emissions reached a record high, with China, the United States, India, the European Union, Russia, and Brazil accounting for more than half of total emissions [9]. If current trends persist, emissions from China and India alone are projected to surpass the combined output of all EU member states [10].

The IPCC's Sixth Assessment Report highlights the urgent need to limit global warming to 1.5°C above pre-industrial levels [11]. To achieve this, CO_2 emissions must decline significantly by 2030 and reach net zero by 2050 [12]. Mitigation efforts, which focus on reducing or preventing greenhouse gas emissions, are essential to meeting these targets [13]. Many developing nations, including China, Mexico, and Vietnam, have already set independent reduction targets and established emissions trading systems [14].

Addressing climate change requires a fundamental shift in societal policies and practices. Legislation plays a key role by setting emission targets, encouraging sustainable practices, and creating investment opportunities for clean energy [15]. Recognizing the need for a structured response, world leaders at the 1992 Rio Earth Summit laid the foundation for institutional, legal, and procedural frameworks to combat climate change [16].

Climate legislation is essential in reducing emissions and fostering sustainable development. It employs mechanisms such as emission limits, energy efficiency standards, renewable energy mandates, tax incentives, subsidies, and carbon pricing. Beyond driving innovation, these policies create a stable environment for long-term investments in sustainable infrastructure. Effective climate laws not only help mitigate environmental damage but also protect public health and promote economic stability. However, success depends on comprehensive policies that consider equity, ensure proper implementation, and encourage international cooperation [17–21].

Several studies have evaluated the effectiveness of climate policies. Eskandar and Fankhauser (2020) analyzed 1,800 climate-related laws and policies implemented in 133 countries between 1999 and 2016. Their research found that each new piece of legislation led to a 0.78% reduction in CO_2 emissions per unit of GDP in the short term and a 1.79% reduction over the long term [22]. Similarly, Farzaneh and Banimostafaarab (2023) examined climate adaptation legislation in both developed and developing countries, showing how these laws have evolved to address climate change more comprehensively over time [23, 24].

In developed countries, legal frameworks in sectors such as water, agriculture, and the environment have largely prioritized mitigation. Studies on climate legislation in urban and rural sectors reveal a

similar focus on reducing emissions [25–28]. However, there remains a gap in research regarding the effectiveness of mitigation laws, particularly in key areas such as water, agriculture, the environment, and rural and urban development.

In the context of global climate change, many developing countries face significant vulnerabilities and challenges. However, despite these challenges, there is limited research specifically focusing on the effectiveness and legislative frameworks for climate change mitigation in these regions. This study aims to fill this gap by analyzing the climate change mitigation legislation in developing countries, focusing on legislative trends, priorities, and effectiveness.

This study aims to bridge that gap by providing a comprehensive review of mitigation-focused legislation in developing countries. It relies on data from the Climate Change Laws of the World (CCLW) database, which compiles legislation directly related to climate change, along with policies that support low-carbon transitions. Developed through a collaboration between the Grantham Research Institute and Globe International, this database is part of a broader effort to assess climate legislation worldwide [29].

2.Materials and method

Classification of developing countries

The Human Development Index (HDI) is a widely used measure for assessing a country's progress in three key areas: life expectancy, education, and income [30, 31]. It helps distinguish between developed and developing nations by providing a numerical value between 0 and 1, with higher scores indicating greater human development [32, 33]. Countries with an HDI of 0.8 or above are classified as developed, while those below this threshold are considered developing [34,35]:

- Very High Human Development (HDI ≥ 0.800): Countries in this category exhibit strong socio-economic conditions, characterized by high life expectancy, advanced education systems, and high-income levels.
- High Human Development (0.700 ≤ HDI < 0.800): Countries in this range have good access to education and healthcare but may still experience inequality and economic fluctuations.
- Medium Human Development (0.550 ≤ HDI < 0.700): Countries in this category often face challenges such as lower life expectancy, limited educational opportunities, and moderate income levels.
- Low Human Development (HDI < 0.550): Countries with low HDI scores tend to struggle with poverty, weak healthcare systems, low literacy rates, and economic instability.

However, some countries, including North Korea, Monaco, and Taiwan, do not have a defined HDI. Despite this, these countriess are included in the analysis of mitigation legislations alongside other developing countries. Table 1 provides an overview of the HDI values of developing countries and the number of mitigation legislations enacted in each:

Table1. HDI of developing countries along with their number of mitigation legislations

Country	HDI	Number of mitigation legislations	Country	HDI	Number of mitigation legislations	Country	HDI	Number of mitigation legislations
Mongolia	0.739	3	Antigua and Barbuda	0.788	1	Ivory Coast	0.550	2
Myanmar	0.585	1	Bolivia	0.692	1	Kenya	0.575	1
North Korea	---	5	Brazil	0.754	13	Liberia	0.481	1
Pakistan	0.544	3	Colombia	0.752	5	Libya	0.718	1
Palestine	0.715	3	Dominica	0.720	1	Madagascar	0.501	1
Philippines	0.699	5	Dominican Republic	0.767	4	Malawi	0.512	2
Sri Lanka	0.782	1	Ecuador	0.740	2	Mali	0.428	2
Syria	0.577	2	El Salvador	0.675	3	Mauritania	0.556	1
Taiwan	---	2	Guatemala	0.627	1	Morocco	0.683	6
Tajikistan	0.685	3	Honduras	0.621	5	Nigeria	0.535	1
Thailand	0.800	2	Mexico	0.758	7	Republic of the Congo	0.479	3
Uzbekistan	0.727	1	Nicaragua	0.667	2	Rwanda	0.534	1
Vietnam	0.703	1	Paraguay	0.717	3	Senegal	0.511	2
Yemen	0.455	1	Peru	0.762	5	Seychelles	0.785	1
Laos	0.607	1	Saint Lucia	0.715	1	South Africa	0.713	4
Tuvalu	0.641	1	Saint Vincent And the Grenadines	0.751	1	Togo	0.539	2
Vanuatu	0.607	1	Suriname	0.730	1	Tunisia	0.731	1
Algeria	0.745	3	Venezuela	0.691	3	Zambia	0.565	4
Angola	0.586	2	Albania	0.796	7	Zimbabwe	0.593	2
Burkina Faso	0.449	2	Armenia	0.759	2	Afghanistan	0.478	1

Cameroon	0.576	1	Bosnia and Herzegovina	0.780	1	Bangladesh	0.661	2
Central African Republic	0.404	2	Moldova	0.767	4	Bhutan	0.666	1
Congo	0.571	2	Monaco	---	1	China	0.768	6
Djibouti	0.509	2	North Macedonia	0.770	2	India	0.633	3
Egypt	0.731	5	San Marino	0.800	3	Indonesia	0.705	2
Ethiopia	0.498	4	Ukraine	0.773	14	Iran	0.774	5
Gambia	0.500	2	Papua New Guinea	0.558	1	Iraq	0.686	1
Ghana	0.632	2	Samoa	0.707	2	Jordan	0.720	2
Guinea	0.465	1	Tonga	0.745	1	Kyrgyzstan	0.692	4
Guinea-Bissau	0.483	1						

Source: [30,36]

Quantitative Analysis

This study employs a quantitative time-series approach to examine climate change mitigation trends. The main objective was to identify long-term trends and fluctuations in climate change mitigation legislation enacted by the 88 developing countries. The primary goal was to identify long-term patterns, shifts, and fluctuations in legislative activity.

To conduct this analysis, we collected data from the Climate Change Laws of the World (CCLW) database on climate change mitigation legislations enacted annually by each of the 88 developing countries (see Table 1). We analyzed the frequency and timing of the legislations passed to detect significant trends or notable variations in legislative activity. By focusing on these trends, we were able to identify the main patterns of legislative changes over time in different countries. This trend analysis helped us to better understand the legislative developments in the context of climate change mitigation.

Additionally, the study applies Ostrom's socio-ecological system (SES) framework to understand the legislative process. This model examines the interplay between three key systems—resource, actors, and governance—to identify patterns in policy development and implementation.

Qualitative analysis

To complement the quantitative findings, a qualitative analysis will be conducted. This involves a detailed examination of legislative texts to identify recurring axes, policy priorities, and underlying motivations. Unlike numerical analysis, this approach captures the nuances of climate legislation, shedding light on the broader context of policy decisions and their implications.

For this analysis, we used an inductive approach to review the mitigation legislation. Initially, open coding was applied to identify key concepts, followed by axial coding to group related categories and identify higher-order themes. The analysis focused on key areas such as resources, actors, and governance systems, based on the Social-Ecological Systems (SES) framework. This approach helped us understand the main themes in climate change mitigation legislatiob.

By integrating both quantitative and qualitative methods, the study aims to provide a well-rounded perspective on climate mitigation efforts in developing countries. The quantitative analysis will track legislative trends over time, while the qualitative analysis will offer a deeper understanding of how these legislations are framed, structured, and implemented.

Ostrom's Socio-Ecological System Framework

Ostrom's SES framework provides a structured approach to analyzing complex environmental governance systems [37]. This study focuses on three core components:

- **Resource System** – The environmental settings where resources are located or managed.
- **Actors System** – The individuals, institutions, or sectors that influence or are impacted by resource policies.
- **Governance System** – The mechanisms through which policies are designed, enforced, and adapted over time [38].

Each of these systems consists of multiple interrelated subsystems, categorized as follows:

- **Resource System**: Land Use, Land Use Change and Forestry (LULUCF); coastal zones; cross-cutting areas; environment; waste; water.
- **Actors System**: energy; buildings; transport; industry; agriculture; health; tourism.
- **Governance System**: economy-wide; public sector; finance; rural; urban; social development.

The research employs both quantitative and qualitative analyses in the following sections:

- Exploring common axes of mitigation.
- Time and spatial analysis of mitigation legislations.
- Time and spatial analysis of mitigation legislations within socio-ecological systems.
- Time and spatial analysis of mitigation legislations in each system of resource, actors, and governance separately.

3.Results

Exploring common axes of mitigation

Mitigation has been a major focus in climate legislation across developing countries, leading to the enactment of numerous legislations. These legislations can be categorized as follows:

— 73 legislations address both mitigation and adaptation.

— 8 legislations cover mitigation, adaptation, and disaster risk management.

— 4 legislations focus on mitigation and disaster risk management.

— 2 legislations include mitigation, adaptation, disaster risk management, and loss and damage.

— 2 legislations address mitigation, adaptation, and loss and damage.

— 1 legislation focuses on mitigation and loss and damage.

The most common approach among these legislations combines mitigation and adaptation. The first legislation in this category was China's Forest Law of the People's Republic of China, enacted in 1984. Legislative activity in this area peaked in 2012, with 12 new legislations passed that year. Other categories, particularly those addressing loss and damage, remain less common and have only recently begun to receive legislative attention.

Time and spatial analysis of mitigation legislations

A total of 429 climate-related legislations have been enacted in developing countries, 226 of which specifically target mitigation—accounting for 53% of all climate-related legislations in these nations as of 2022. On a global scale, developing countries have implemented 38% of the 593 climate change legislations enacted worldwide.

Figure 1 presents a timeline of mitigation legislations. The first legislation in this category was passed in 1980. However, legislative activity remained limited until 1996, with only six legislations enacted. From that point onward, the number of mitigation legislations steadily increased, peaking at 22 new legislations in 2014.

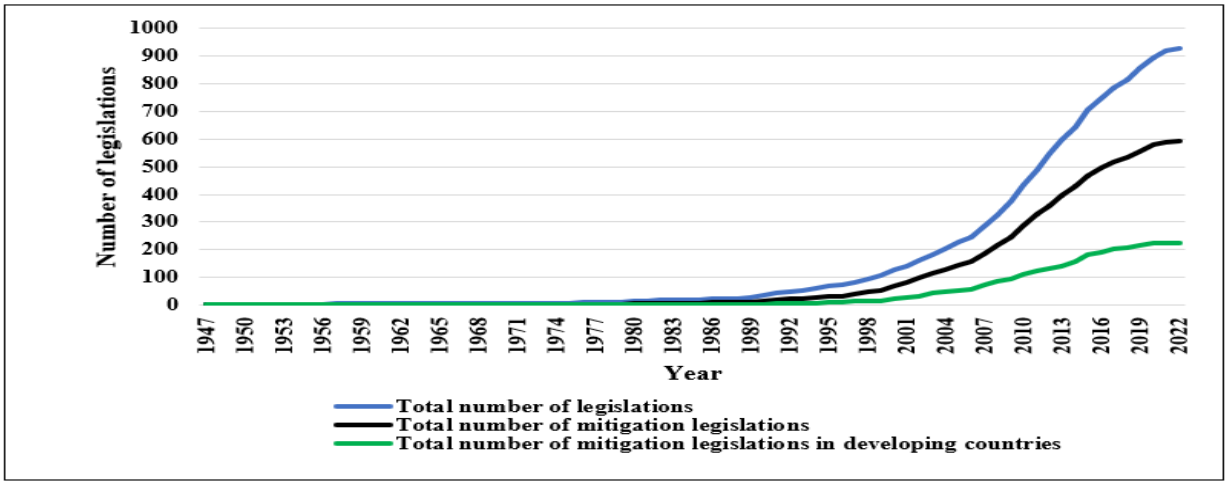

Figure 1. Time analysis of mitigation legislations

For spatial analysis, 88 developing countries were grouped by continent. As shown in Figure 2:

- 13 countries are in Europe and Oceania
- 18 countries are in the Americas
- 25 countries are in Asia
- 32 countries are in Africa

Africa leads in mitigation legislation, with 67 legislations (30%) of the total. Asia follows with 61 legislations (27%), the Americas with 59 (26%), and Europe and Oceania with 40 (18%). Among individual countries, Ukraine and Brazil have enacted the highest number of mitigation legislations, with 14 and 13 legislations, respectively.

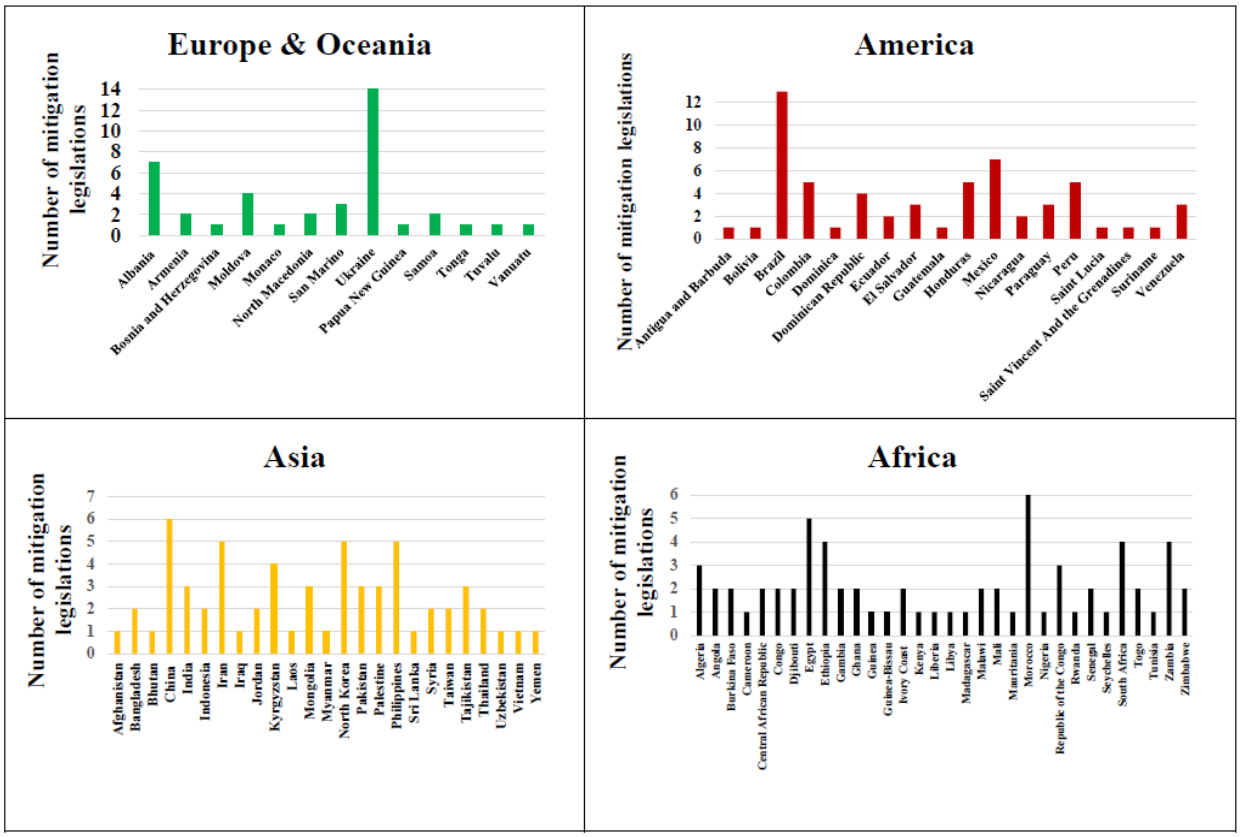

Figure 2. Spatial analysis of mitigation legislations

Time and spatial analysis of mitigation legislations in social-ecological systems

Based on the analysis of socio-ecological systems for mitigation legislation shown in Figure 3, actors systems were mentioned 340 times, whereas resource and governance systems were mentioned significantly less, with 50 and 35 mentions, respectively. This highlights a notable disparity, with actors systems receiving far more attention than governance and resource systems.

Legislation within the actors system was first mentioned in 1980, but it took five years before it was approved. From 2002 to 2017, there was a steady increase in mentions, peaking at 30 in 2015. The governance system had its first mention in 1987, while the resource system followed in 1992. Both systems exhibited a slower upward trend, with governance legislation reaching a maximum of 3 mentions in 2013 and resource legislation peaking at 7 mentions in 2010.

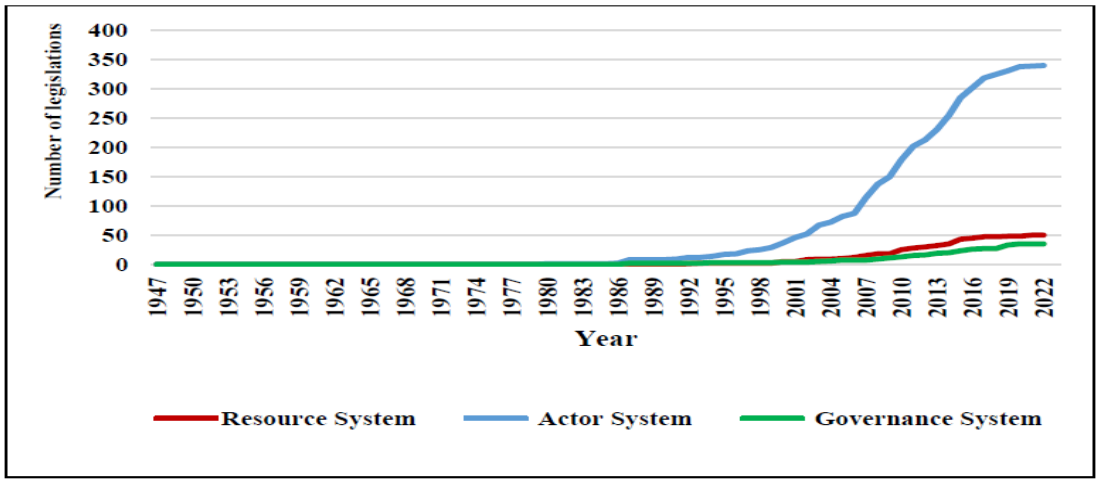

Figure 3. Time analysis of mitigation legislations in social-ecological systems

Figure 4 presents the spatial distribution of socio-ecological legislation across different continents.

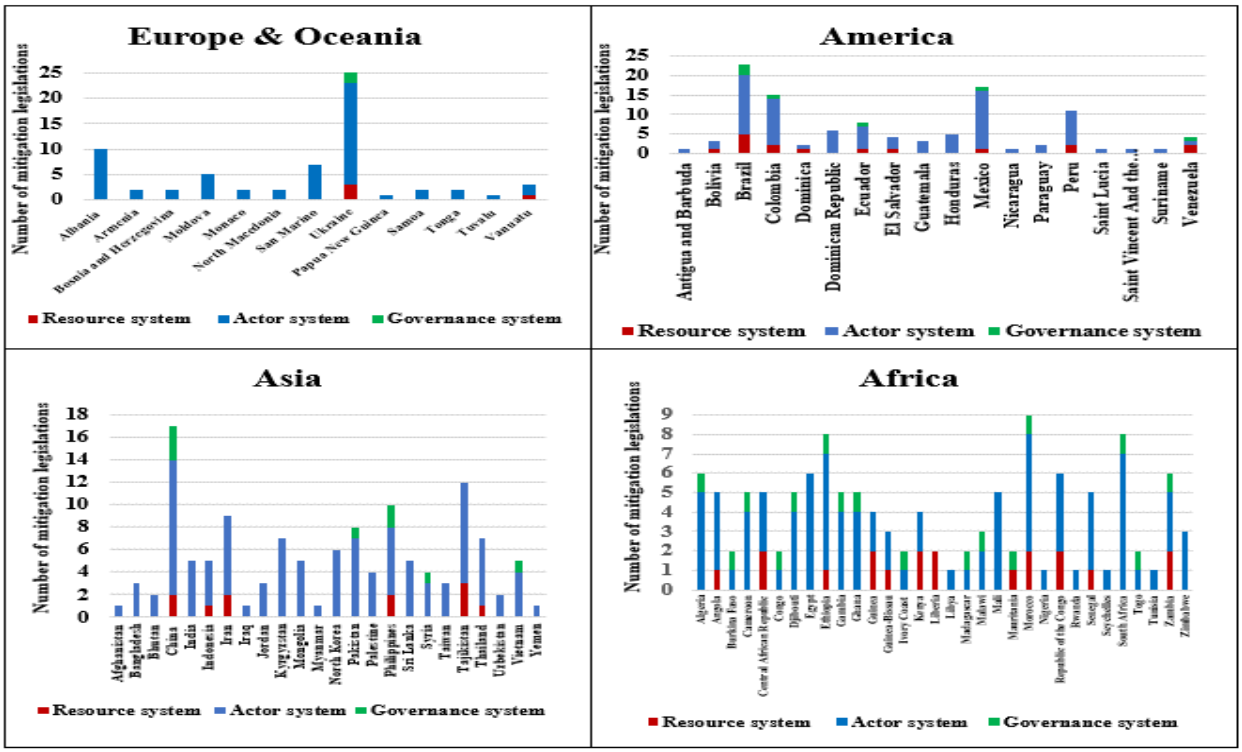

Figure 4. Time analysis of mitigation legislations in social-ecological systems

Asia

In Asia, the actors system was the most frequently mentioned, with 117 mentions. The resource and governance systems were mentioned far less, with 11 and 7 mentions, respectively. Asia had the highest number of countries legislating actors systems, with 26 countries enacting relevant laws. Among them, China led with 12 mentions, followed by Tajikistan (9 mentions), and Iran, Pakistan, and Kyrgyzstan (7 mentions each). For the resource system, six countries (China, Indonesia, Iran, the Philippines, Tajikistan, and Thailand) enacted legislation. Tajikistan had the highest share, with 3 mentions. Governance system legislation was recorded in five countries: China, Pakistan, the Philippines, Syria, and Vietnam, with China leading at 3 mentions.

Africa

Africa had the highest number of resource system mentions, totaling 19 across 12 countries. However, governance systems received comparatively less attention, with 16 mentions across 16 different countries. Despite this, the actors system dominated, accounting for 72% of all approved legislation, with 90 mentions across 32 countries. Notably, 30 of these countries had at least one mention in the actors system. South Africa led with 7 mentions, followed by Morocco, Ethiopia, and Egypt (6 mentions each).

America

All 18 countries in America had at least one mention of the actors system, demonstrating its significance in this region. Of the 108 total mentions, 88% (85 cases) referred to the actors system. Brazil and Guatemala led with 15 mentions, followed by Colombia with 12 mentions. Brazil also had the highest number of mentions in the resource system, with 5 mentions, making it the leading country in America for socio-ecological system legislation, with a total of 23 legislations.

Europe and Oceania

Legislation related to the actors system remained dominant, with 13 countries enacting 58 legislations. Ukraine had the highest number of mentions (20), making it the leader in this system. Ukraine was also the only European country with governance system legislation, with 3 mentions. Meanwhile, two other countries, along with Vanuatu, accounted for a total of 4 mentions in the resource system.

Time and spatial analysis mitigation legislations in the resource system

The resource system in developing countries includes four key subsystems: LULUCF (18 mentions), waste (16 mentions), water (12 mentions), and environment (4 mentions). There is a significant gap between developing and developed countries in terms of resource system legislation.

According to Figure 5, legislation on waste management has been in place since 1991. Legislations governing LULUCF, water, and the environment were introduced later, in 1999, 2001, and 2007, respectively. Since 2001, legislation on LULUCF, water, and waste has steadily increased. However, environmental legislation has stagnated, with no new legislations enacted between 2008 and 2015 in developing countries, creating a stark contrast with the other subsystems.

The highest number of legislations was recorded in 2015, with 8 new enactments. However, between 2018 and 2022, only 4 new legislations related to resource subsystems were approved in developing countries. This highlights a concerning lack of attention to critical areas such as water and environmental protection.

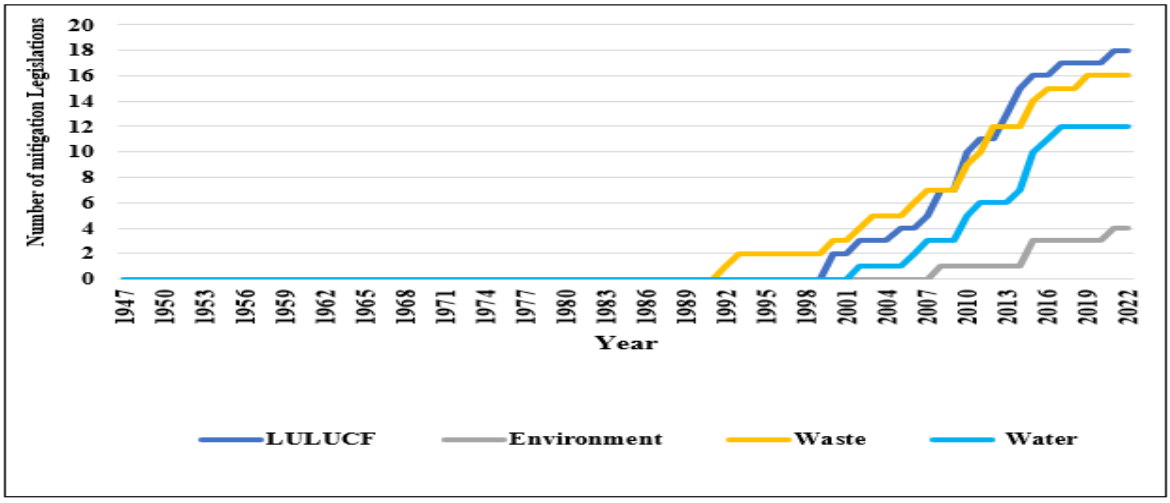

Figure 5. Time analysis of mitigation legislations in the resource system

Figure 6 shows the legislative landscape for the resource system across different continents.

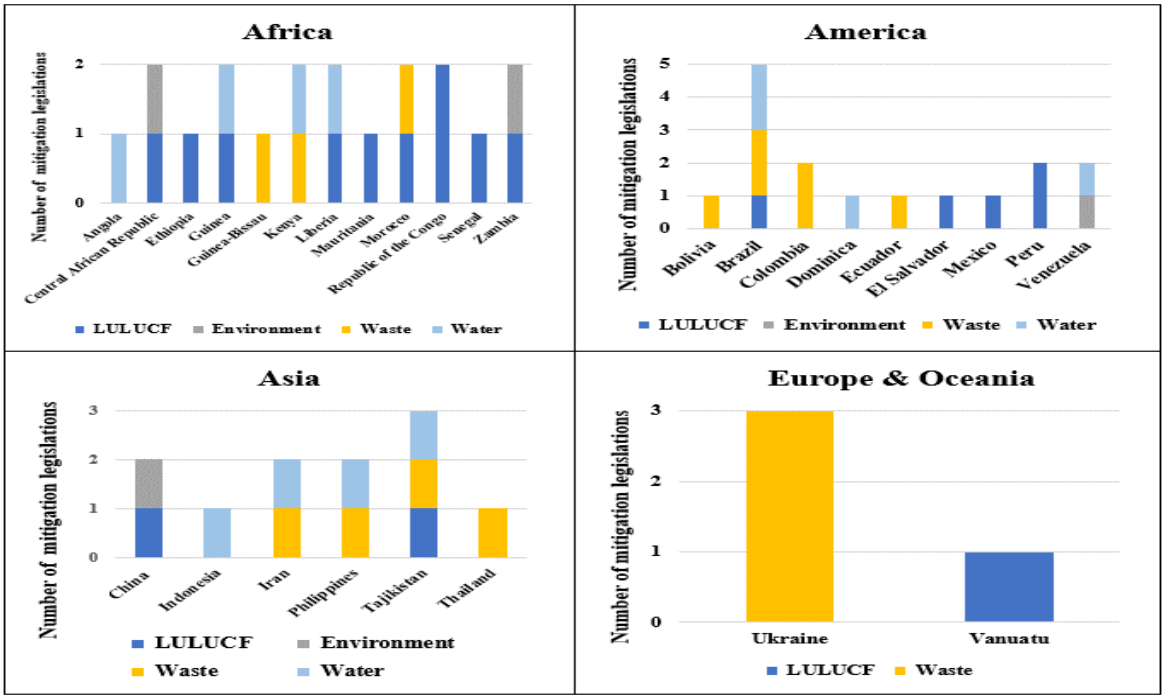

Figure 6. Spatial analysis of mitigation legislations in the resource system

Europe and Oceania

Only two countries in this region have legislation related to resource subsystems:

- Ukraine has 3 mentions related to waste management.
- Vanuatu has 1 mention related to LULUCF.

Overall, Europe and Oceania have the lowest number of legislations in this system compared to other continents.

America

Out of 18 countries, 9 have enacted legislation related to resource subsystems:

- Waste management has the highest number of mentions (6 laws), with Bolivia and Ecuador each having 1 mention, while Brazil and Colombia have 2 each.
- LULUCF is mentioned in 4 countries, with Peru having 2 mentions, and Brazil, El Salvador, and Mexico each having 1.
- Water-related legislation is found in Brazil, Dominica, and Venezuela (total 4 mentions).
- Venezuela is the only country in the region with legislation on the environment subsystem (1 mention).

Asia

In Asia, 6 countries have approved legislation related to resource systems:

- Tajikistan leads with 3 legislations, mostly related to water and waste management.
- China has 2 legislations covering environment and LULUCF.
- Indonesia, Iran, the Philippines, and Thailand each have 1 legislation related to different subsystems.

Africa

Out of 32 countries, 12 have enacted a total of 19 legislations related to resource systems:

- LULUCF has received the most attention, with 10 legislations approved.
- Water legislation has been enacted in Angola, Guinea-Bissau, Guinea, and Liberia (4 mentions).
- Waste management has 3 mentions across the continent.
- Environmental legislation has been the least prioritized, with only 2 mentions.

Time and spatial analysis mitigation legislations in the actors system

The actors system in developing countries includes six key subsystems: Energy (174 mentions), Transport (68 mentions), Building (44 mentions), Industry (30 mentions), Agriculture (15 mentions), Health (9 mentions)

As shown in Figure 7, most legislation in these sectors has been enacted since 1997, with approximately 75% of legislations approved after 2007. The earliest legislation in this system was for transport in 1980, followed by energy in 1986. The industry, agriculture, and building sectors were first regulated in 1987.

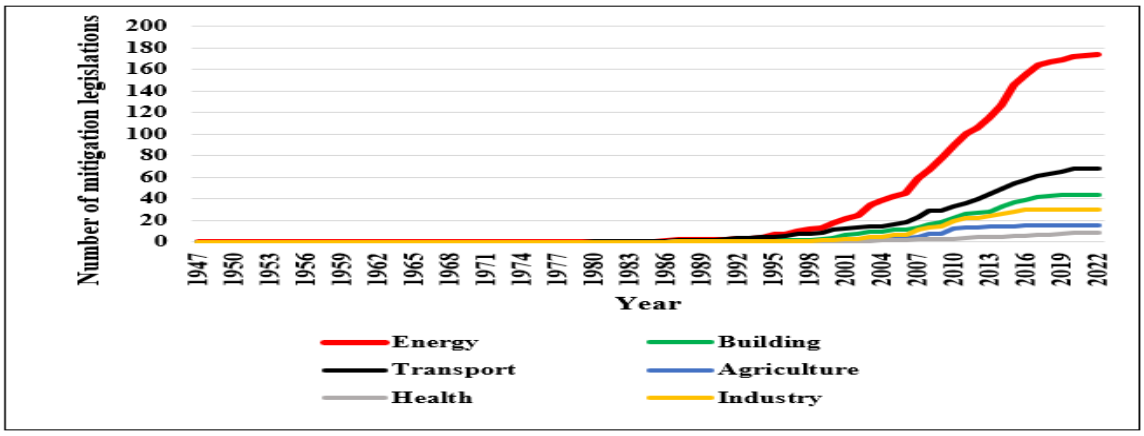

Figure 7. Time analysis of mitigation legislations in the actors system

Figure 8 shows the legislative landscape for the actors system across different continents.

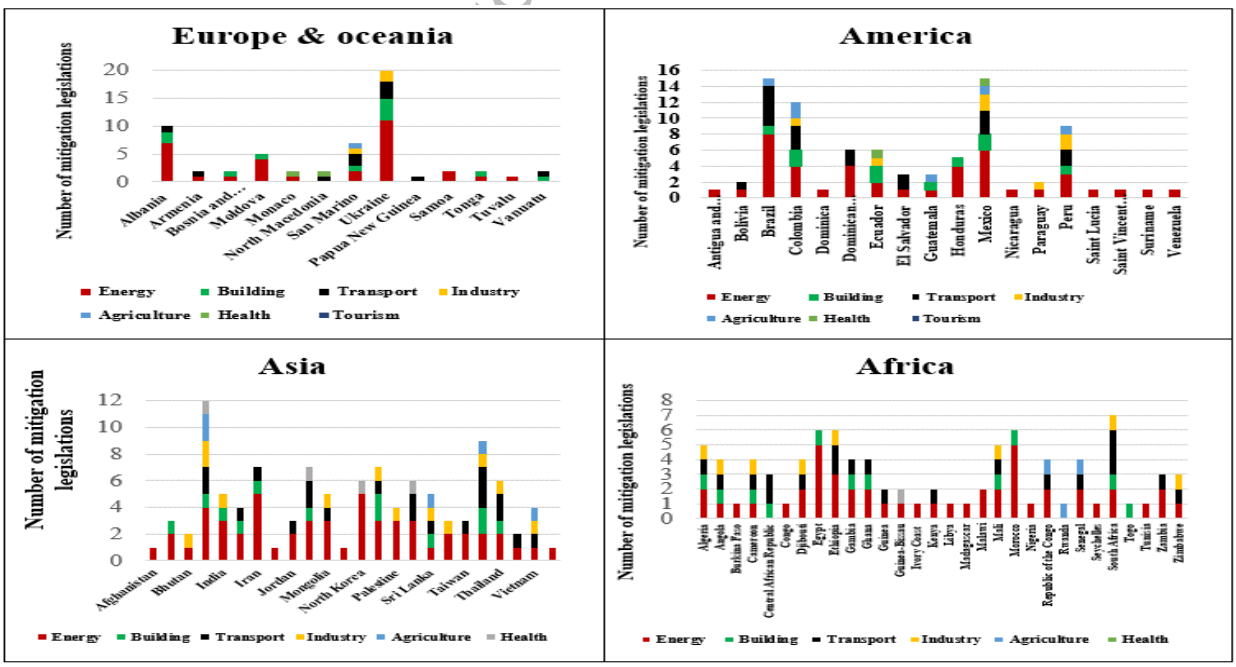

Figure 8. Spatial analysis of mitigation legislations in the actors system

Europe and Oceania

- The energy sector has the most mentions (31), followed by building (11), transport (10), industry (3), health (2), and agriculture (1).
- Ukraine (11 mentions) and Albania (7 mentions) lead in energy sector legislations.
- Ukraine (4 mentions) and Albania (2 mentions) have the most regulations in building.
- Ukraine (3 mentions) and San Marino (2 mentions) lead in transport.
- Ukraine is the only country with multiple mentions (2) in the agriculture and health sectors.

America

- Energy sector has the highest mentions (42), followed by transport (18), building (11), industry (4), health (3), and agriculture (2).
- Brazil (8 mentions) and Mexico (6 mentions) have the most legislation in the energy sector.
- Brazil (5 mentions), Mexico (3 mentions), and Colombia (3 mentions) lead in transport.

Asia

- The energy sector dominates with 54 mentions, followed by transport (20), building (12), industry (12), agriculture (5), and health (4).
- Iran and South Korea (5 mentions each) have the most legislation in the energy sector.
- Tajikistan (3 mentions) leads in transport.
- In other sectors, each country has a maximum of 2 mentions in the legislations.

Africa

- The energy sector has the highest number of mentions (47), followed by transport (20), building (11), industry (8), agriculture (3), and health (1).
- Djibouti and Morocco (5 mentions each) have the most energy-related legislations.
- South Africa (3 mentions) leads in transport-related regulations.
- In other sectors, each country has a maximum of 2 mentions.

Time and spatial analysis mitigation legislations in the governance system

The governance system in developing countries includes five main subsystems: Economy-wide (6), Social Development (4), Rural (3), Urban (2), and Finance (1). As shown in Figure 9, the first legislation was approved in 1987, covering the urban and economy-wide sectors. This was followed by the social development sector in 2000, and the rural sector in 2003. From 2004 onwards, all four

sectors saw a continuous increase in legislation approval, which peaked in 2011. Since 2019, the trend has remained stable with no significant changes.

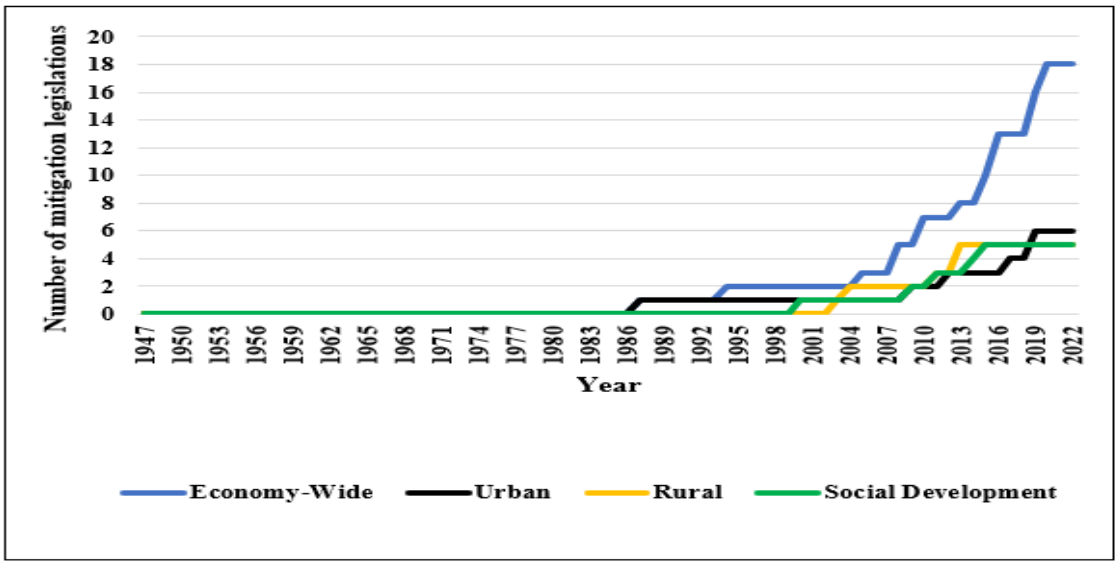

Figure 9. Time analysis of mitigation legislations in the governance system

Figure 10 shows the legislative landscape for the governance system across different continents.

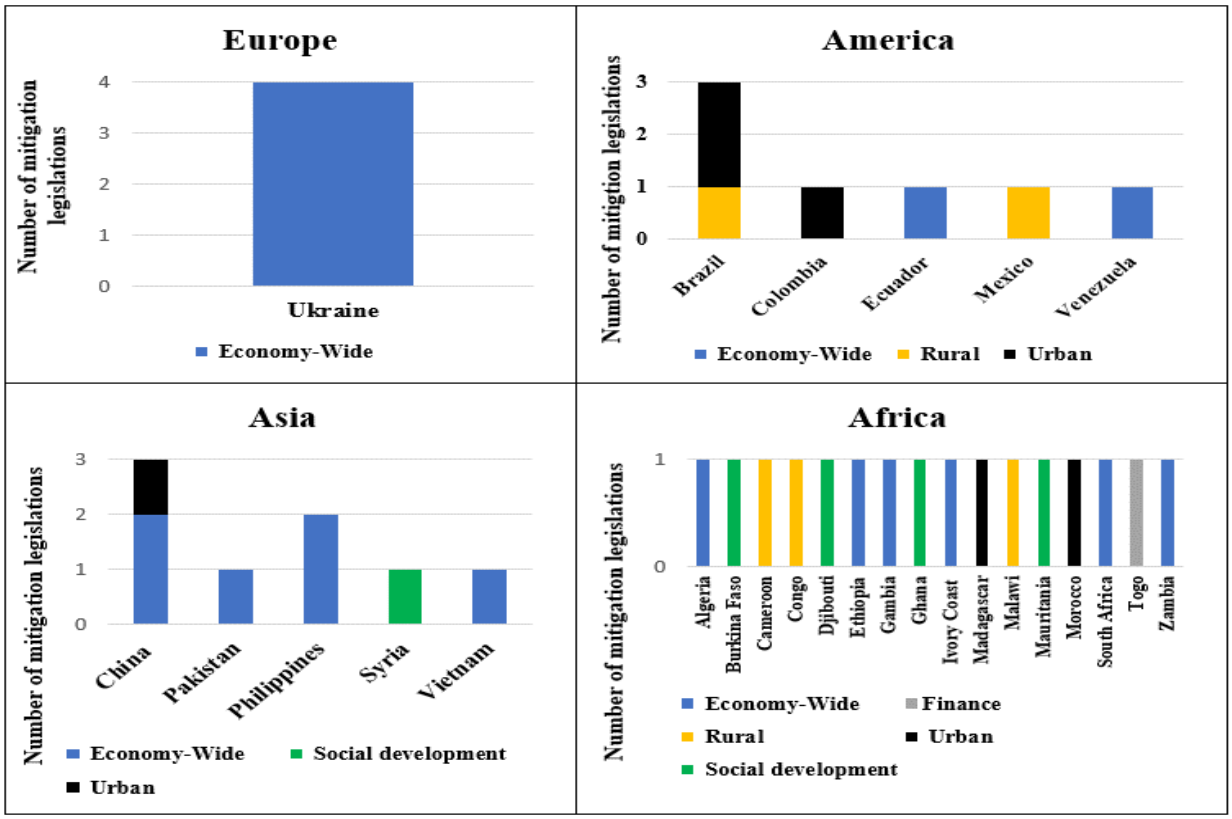

Figure 10. Spatial analysis of mitigation legislations in the governance system

A survey of legislation mentions by continent reveals that the economy-wide subsystem is the most frequently mentioned across all regions.

- America, Europe, and Oceania exclusively mention the economy-wide subsystem.
- In Africa, the economy-wide sector is mentioned the most (6 times), followed by rural (3 mentions) and finance (1 mention). Each African country includes a maximum of one mention per legislation.
- In Asia, the economy-wide subsystem is the most frequently mentioned (6 times), followed by urban (1 mention) and social development (1 mention). Notably, the Philippines and China each have two mentions in the economy-wide sector, while China and Syria each have one mention in the urban and social development sectors.

4. Discussion

A study of mitigation legislations in developing countries shows a steady increase in both their number and scope over time.

- 1980s: Only three legislations were passed—in Mexico, North Korea, and China—mainly focusing on environmental protection due to limited awareness of climate change.
- 1990s: The number of legislations quadrupled, with most addressing energy-related issues. Countries like Thailand, Ukraine, Kyrgyzstan, and North Korea introduced legislations to promote energy conservation and production.
- 2000s: This decade saw a significant rise, with 80 new legislations covering a broader range of issues, reflecting a growing awareness of mitigation. Brazil, Ethiopia, Guatemala, and El Salvador enacted laws on energy conservation, renewable energy, and rural electrification.
- 2010s: The trend continued, reaching 120 legislations. New topics emerged, such as basic environmental laws, energy efficiency in buildings, and green jobs. Guinea-Bissau, Ivory Coast, Zambia, and the Republic of Congo introduced new environmental legislations, while Iran, Kyrgyzstan, and Moldova focused on energy efficiency.
- 2020s: Recent legislations have addressed COVID-19 impacts, wetlands conservation, and electric vehicle promotion, with countries like the Philippines and China leading in these areas.

While these legislations contribute to mitigation, their effectiveness depends on strong enforcement and governance. In the long term, they have the potential to significantly curb greenhouse gas emissions.

Despite the progress, several challenges remain:

- Uneven legislative distribution: Some sectors, like energy and transport, receive considerable attention, while others, such as environmental protection and water management, remain underrepresented. A more balanced approach is needed to address all critical areas.

- Effectiveness of implementation: The success of mitigation policies depends on institutional capacity, funding, implementation mechanisms, and public awareness. Many developing countries lack the resources and expertise needed for proper enforcement.

Finally, the following actions are recommended to enhance the impact of mitigation legislations:

- Strengthen institutional capacity to improve governance and enforcement.
- Prioritize key sectors to ensure all relevant areas receive adequate attention.
- Enhance international cooperation for financial and technical support.
- Promote public awareness to encourage participation and compliance.
- Monitor and evaluate policies to assess effectiveness and make necessary adjustments.

While these overarching recommendations provide a solid foundation for climate mitigation, their effectiveness depends on region-specific adaptations. The following strategies can help countries implement them effectively:

- Africa: Strengthen governance through regional climate policy hubs (e.g., African Union) and enhance enforcement. Prioritize off-grid renewable energy and climate-smart agriculture, while expanding public-private partnerships (PPPs) for climate finance.
- Asia: Improve local policy enforcement in South and Southeast Asia and integrate climate laws into national economic plans in high-emission countries like China. Accelerate public transport electrification and expand carbon trading initiatives.
- Americas: Enhance policy transparency through independent monitoring agencies and boost reforestation efforts in the Amazon. Implement net-zero building policies in urban areas and expand carbon pricing mechanisms (e.g., Brazil, Mexico) to support climate funding.
- Europe: Strengthen the EU Green Deal and promote green innovation. Enhance cross-border cooperation on renewable energy, expand carbon pricing mechanisms, and invest in sustainable urban mobility and infrastructure. Focus on climate adaptation in southern Europe through water conservation and resilient infrastructure.
- Oceania: Invest in resilient infrastructure for Pacific island nations, promote renewable energy projects, and strengthen climate adaptation measures for agriculture and fisheries. Expand access to climate finance and promote regional cooperation through initiatives like the Pacific Islands Forum.

By addressing these challenges and implementing effective policies, developing countries can play a vital role in mitigating climate change and building a sustainable future.

5. Conclusion

This study provides a comprehensive analysis of mitigation legislations in developing countries, based on data from the Climate Change Laws of the World (CCLW) database. The findings reveal a significant increase in the number and scope of these legislations over time, reflecting a growing awareness of the urgent need to combat climate change.

While most mitigation legislations focus on the actors system, particularly in the energy, transport, and building sectors, there is a growing—but still insufficient—emphasis on resource and governance systems. This imbalance suggests a need for greater attention to these areas.

Our analysis underscores the importance of a multifaceted approach to climate mitigation, combining sectoral and systemic changes. Although the rising trend in climate legislation is encouraging, effective implementation and enforcement remain crucial to achieving real emissions reductions. These legislative efforts in developing countries contribute to global emission reduction targets, highlighting their role in the broader global climate framework. By adopting a comprehensive and coordinated approach, the global community can accelerate progress toward a sustainable, low-carbon future.

Limitation

This study may have missed some mitigation legislations. We used the CCLW database, but it might not include all the legislations. This could mean that we underestimated the number of legislations in developing countries.

While this study provides valuable insights into climate change mitigation legislation in developing countries, there are several limitations to consider. First, although we relied on the CCLW database, it may not include all relevant legislations, leading to the possibility that some mitigation measures were overlooked. This limitation could result in an underestimation of the number of legislations in developing countries. Additionally, the CCLW database may not capture the full scope of legislative activity in certain regions, particularly if new or emerging policies were not added in time for inclusion.

Another limitation is the inability to assess the quality of implementation of these legislations. While we analyzed the presence and trends of mitigation legislations, we did not examine how effectively these legislations were enforced or their actual impact on greenhouse gas emissions. The quality of implementation, including institutional capacity, political will, and resources, can significantly affect the success of climate mitigation efforts but was beyond the scope of this study.

Finally, the focus of our analysis was on legislative trends, and we did not account for other important factors such as social, economic, or cultural influences that may shape the adoption and success of climate change mitigation measures.

Ethical Considerations

Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflicts of interest.

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