Carbon Credit Market: A Comparative Analysis of Consolidation in Brazil and the World

Natália Fernanda Santos Silva[1]*, Victor Menezes Vieira[1]
[1]SENAI CIMATEC University; Salvador, Bahia, Brazil

The carbon credit market has established itself as an essential mechanism for mitigating climate change. Its relevance is evidenced by the persistent growth in annual project submissions, reflecting global engagement in sustainable initiatives. This article aims to analyze the number of submissions of carbon credit projects in Brazil over the years and the performance of other countries, seeking to identify submissions and stratify them according to the type of market, the most active certification companies, the type of project, and the Brazilian regions most active in these initiatives. The methodology used was document analysis and bibliographical research through certification databases and studies that dealt with the topic.
Keywords: Carbon Credits. Kyoto Protocol. Regulated Market. Voluntary Market. Environmental Sustainability.

The carbon credit market, which emerged as a direct response to the global challenge of climate change, represents one of the most innovative and promising tools in the fight against greenhouse gas (GHG) emissions. This market was conceived through the Kyoto Protocol, signed in 1997, which established flexible mechanisms such as the Clean Development Mechanism (CDM) to encourage global emissions reduction through sustainable development initiatives. Companies and governments from different nations are increasingly involved in the creation and trading of carbon credits, either through regulated markets, such as the European Union Emissions Trading System (EU ETS), or through voluntary markets (Figure 1) [1].

The carbon credit market has gained significant relevance over the last two decades. Its main objective is to create an economic incentive to reduce GHG emissions, allowing companies and countries that reduce their emissions beyond established targets to sell excess credits on the voluntary market to those unable to achieve their reduction objectives. This system encourages initiatives to reduce greenhouse gas emissions and stimulates technological innovation, energy efficiency, and sustainability associated with economic activities. Since its creation, the carbon credits market has maintained constant growth, which can also be confirmed through the evolution of global revenues from taxes arising from the commercialization of carbon credits. Initially dominated by projects in developing countries, mainly in Asia and Latin America, it has expanded to include a variety of sectors such as renewable energy, reforestation, sustainable agriculture, and industrial efficiency (Figure 2) [2].

Globally, the carbon credit market is maturing. The implementation of the Paris Agreement in 2015 gave a new boost to this market, with more ambitious emissions reduction targets and greater private sector participation. Countries like China and the European Union are ahead of others in implementing robust emissions trading systems and establishing strict policies to reduce GHGs. The regulated carbon credits market in Brazil is currently in the process of being implemented following the enactment of bill (PL 182/2024) in the national Congress. This legislation involves the creation of the Brazilian Greenhouse Gas Emissions Trading System (SBCE), which holds great potential due to the country's vast forest coverage and rich biological diversity [1].

Despite advances, the carbon credit market has faced adversities such as the volatility of credit prices, the complexity of verification and certification mechanisms, and the need for transparency and environmental integrity. Furthermore, the

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Address for correspondence: Natália Fernanda Santos Silva. SENAI CIMATEC University. Avenida Orlando Gomes, 1845. Zipcode: 41650-010. Salvador, Bahia, Brazil. E-mail: natalia.fernanda@fbter.org.br.

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Figure 1. Types of carbon credit mechanisms and market segments [2].

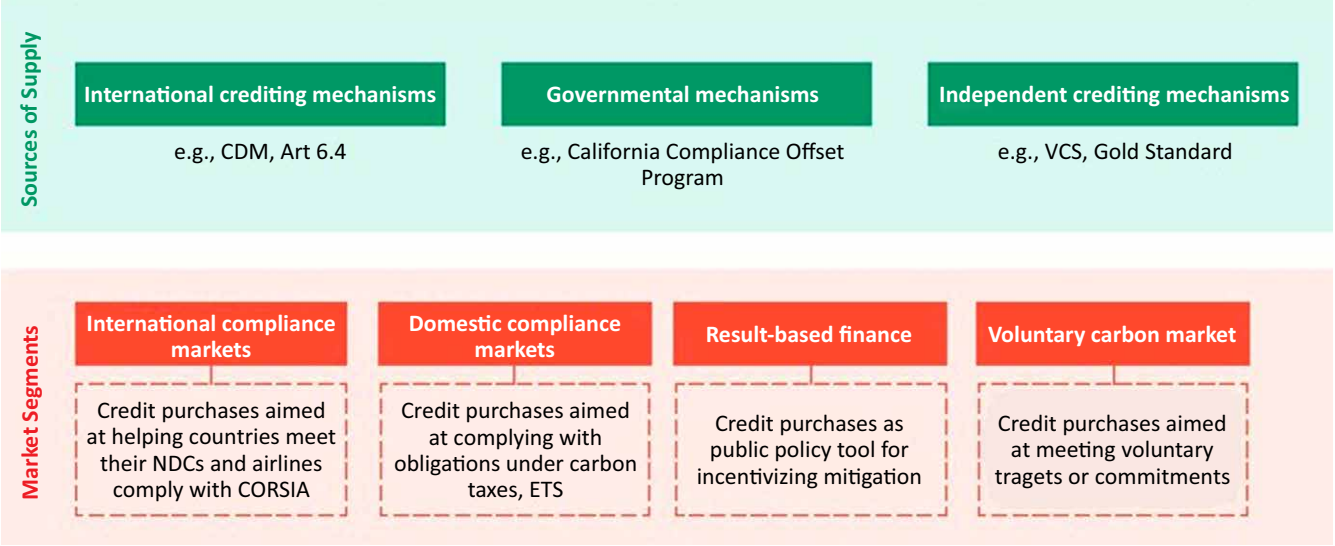
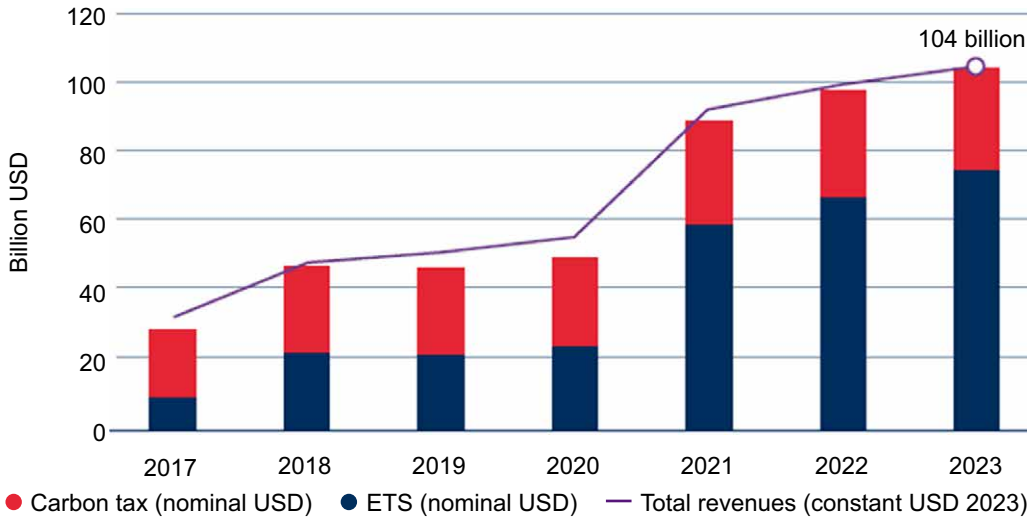


Figure 2. Evolution of global revenues obtained from the carbon credits market [2].



heterogeneity of regulations between countries and the lack of a unified global market complicates the negotiation and commercialization of credits. Forest restoration initiatives, biodiversity conservation, and clean energy projects are key areas that can boost the generation of credits and attract international investments in Brazil. In this way, the country can become a leader in the carbon credit market [3, 4].

The future of the carbon credit market looks promising, with a forecast of continued growth driven by stricter climate policies and increased environmental awareness. Therefore, this article aims to analyze the evolution of the global and Brazilian carbon credits markets based on data points illustrating market evolution, project categories, regional distributions, and sectors covered.

Materials and Methods

The method adopted followed a process of prospecting, selection, analysis, and documentary synthesis, which involved scientific publications, reports from organizations, and databases from carbon credit certifiers (Table 1).

Table 1. Scope of the literature review.

Scope of Bibliographic Review	
Analysis Period	The search covers recently released publications and reports, ensuring up-to-date and relevant data is included.
Data Sources	Reports from organizations such as the World Bank Group, Ecosystem Marketplace, and FGV, as well as information from carbon credit certifiers such as Verra, Gold Standard, and UNFCCC, were selected.
Inclusion Criteria	Reports that presented quantitative and qualitative data, trend analyses, and recommendations for public policies were included. Furthermore, the projects considered, extracted from the certification bodies' databases, were only those registered; they were not considered projects rejected or in the analysis process.
Data Extraction	Data was extracted from publicly available databases on these certifiers' platforms, including information on certified projects, the number of credits issued, methodologies used, and project locations.

Results and Discussion

The global carbon credit market has evolved in recent years, expanding to include initiatives such as the Paris Agreement, which sets more ambitious and comprehensive targets for reducing GHG emissions. Despite the variations over the years due to possible political and/or economic interference, it is still possible to observe a persistence in the evolution of the markets. It is possible to use Brazil as a reference since it is one of the countries that has grown in this area, is consistently positioned among the Top 10 countries with the most significant presence in the carbon credit markets, and is also affected by external influences that directly impact the annual volume of credits generated (Figure 3).

Comparing the volume of credits generated in the clean development mechanism (CDM) and the voluntary carbon market in Brazil is essential to understanding the contribution of each mechanism to the country's carbon economy. Figure 3 shows consistent growth in the voluntary market, with significant spikes in specific years that may be related to stricter environmental policies, demand for carbon credits, or the price of credits.

Considering the evident growth of the voluntary market, it is important to provide an example of where these carbon credits are being generated, as project records are categorized according to area of activity (Figure 4). The diverse categories, ranging from reforestation to carbon capture and storage technologies, indicate a broad and varied market. It is important to highlight the growth of the "domestic/community devices" category over the years, gaining greater prominence than the other categories in 2023. Another important point to be observed is the decline in the volume of projects in the renewable energy sector.

Globally, it is possible to see a big difference in the volume and value of carbon credits generated in different regions. Variations in the volume and prices of transactions within these classifications show that some regions are more active and valued in the carbon market, as shown by the information obtained in the report on the situation of the voluntary carbon market published in 2024, which in 2022 had Asia with a volume of 102.7 MtCO2 and sold per ton at 7.45 dollars and Europe with a volume of 0.61 MtCO2 and sold at 13.82 dollars. Regions with more excellent activity may receive more investment and technical support, while others may fall behind. This raises questions about public policies, access to opportunities in the carbon market, and trust in regional projects [3]. Different mechanisms can operate in the same

Figure 3. Volume of credits generated in Brazil's clean development mechanism (CDM) and voluntary carbon market from 2006 to 2021 [4].

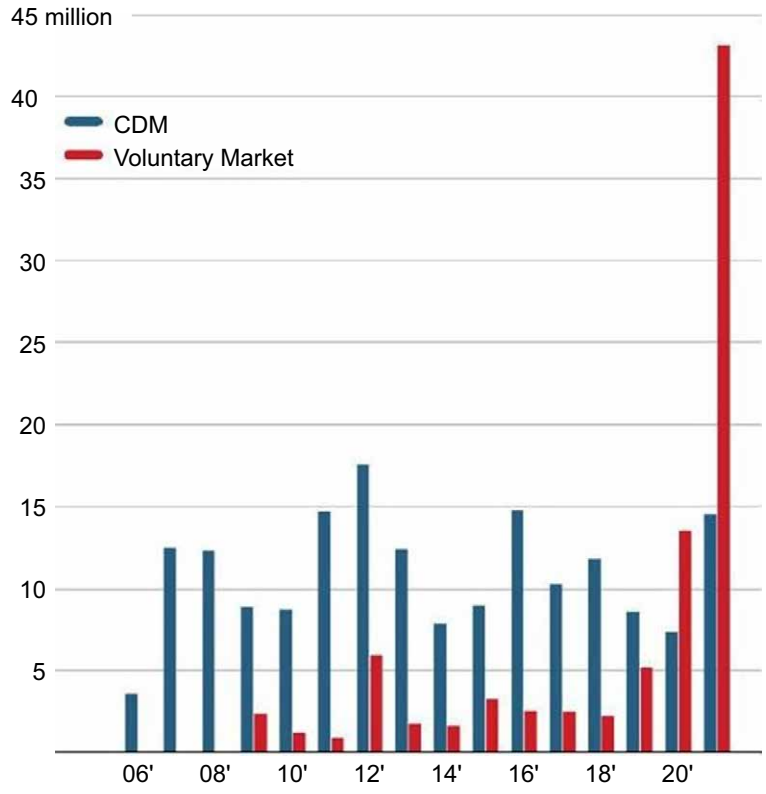
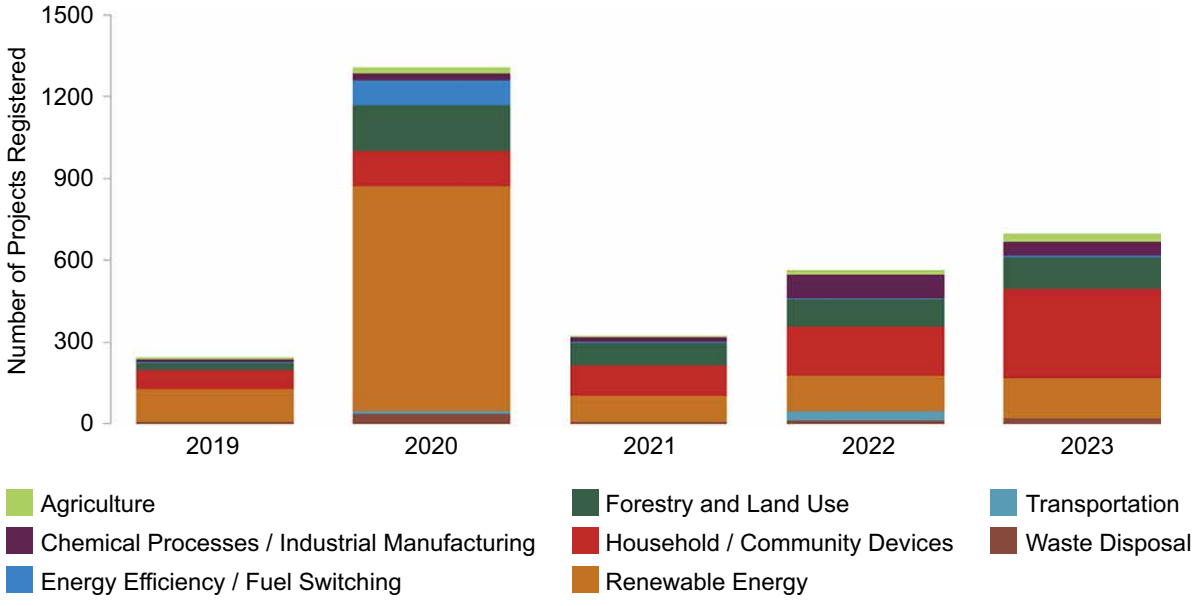


Figure 4. Register of carbon credit projects by category from 2019 to 2023 [3].



Note: Includes data on project registrations from ACR, CAR, CDM, City Forest Credits, Global Carbon Council, Gold Standard, Plan Vivo, and VCS registries.

region, but some are sometimes restricted to some regions because they are governmental mechanisms (Figure 5).

Figure 5 presents annual project registrations by type of credit mechanism, highlighting which mechanisms are most used and how preference for these mechanisms has evolved over the years. However, there may be mechanisms that, despite being less popular, are more effective or suitable for specific regions or sectors, such as the government mechanisms created to meet the needs of Thailand and Australia. These mechanisms have stood out, but in addition to other government mechanisms, they represent a significant portion. Due to their time of operation, reliability, and broad global presence, Gold Standard and Verra are mechanisms that play an important role in the voluntary carbon credits market and the United Nations Carbon Offset Platform (UNFCCC) in the global market through CDM projects. Based on this, seeking to understand the performance of these mechanisms in registered projects from Brazil and around the world, graphs were generated with the variation in the annual number of these projects submitted on the platforms (Figure 6).

Over the years, the variation in the number of projects registered on the UNFCCC, Gold Standard, and Verra platforms reveals a pattern of growth and decline possibly influenced by global events, initiatives, and government policies such as those listed in Table 2.

Conclusion

The carbon credits market, both globally and in Brazil, represents a strategic tool for tackling the global climate emergency. Despite the adversities, its prospects are positive, with the potential to promote environmental and economic sustainability on a global scale, as can be seen throughout the article given the data presented. It was found that the number of projects registered over the years can be closely linked to global events, government policies, and international initiatives. The initial growth of this market was driven by policies such as the Kyoto Protocol, the Clean Development Mechanism, and financial incentives. The decline after 2012 can be attributed to political uncertainty and the global economic crisis, while the stimulus for recovery can be

Figure 5. Comparison of annual project registrations by type of credit mechanism [2].

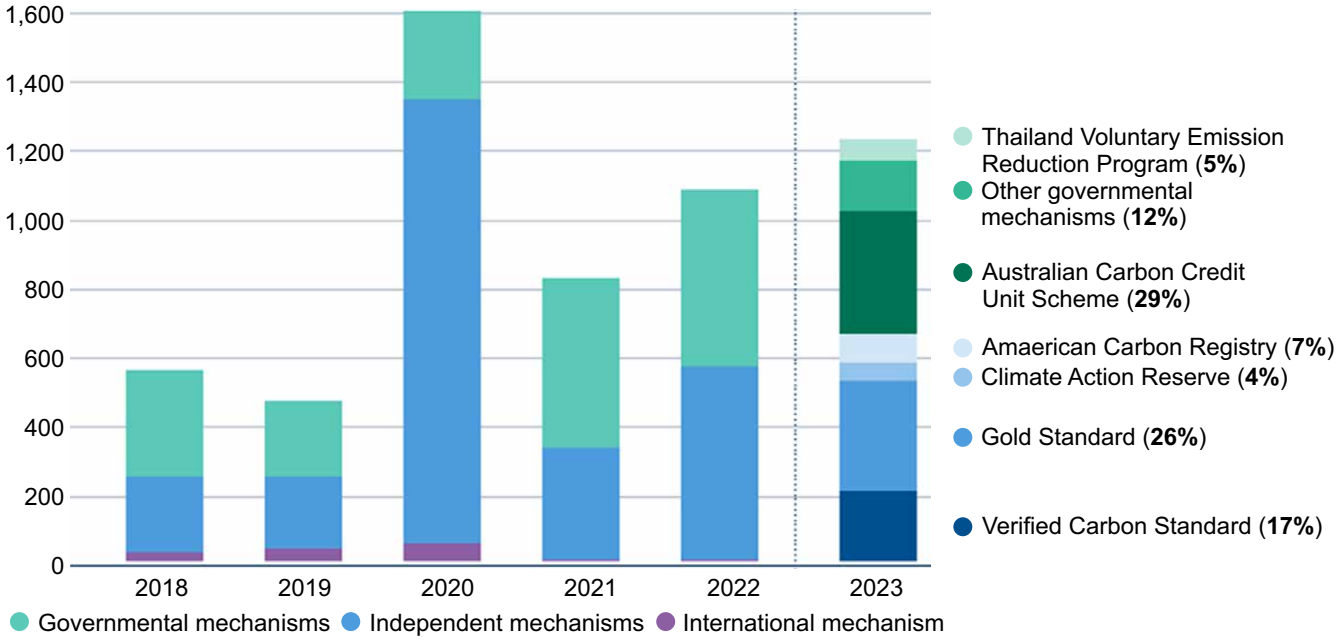


Figure 6. Comparison of the number of projects registered in Brazil and around the world in UNFCCC, b) Gold Standard, and c) Verra [5-7].

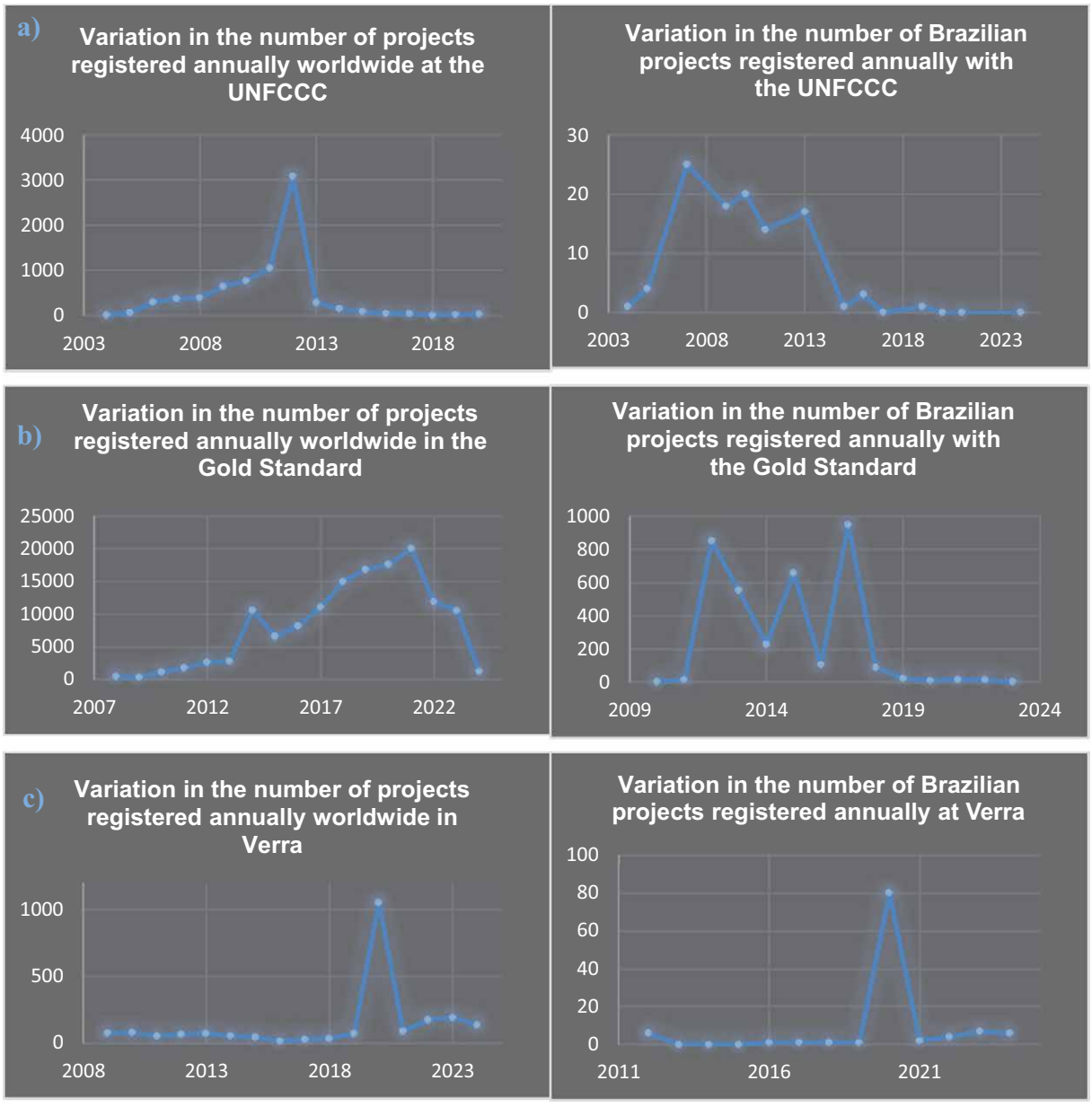


Table 2. List global events, initiatives, and government policies that may have affected the carbon credits market [1-7].

Global Events, Initiatives, and Government Policies	
Initial Growth (2005-2012)	**Global Policies and Initiatives**: The creation of the Kyoto Protocol (1997) and its implementation in 2005 encouraged many countries to register emission reduction projects. Several environmental policies and initiatives were implemented globally, stimulating significant growth in registrations until 2012. **Financial Incentives**: The CDM and other financial incentives, such as the carbon credit market, encouraged companies and countries to register projects that were particularly attractive in developing countries such as China, India, and Brazil.
Decline (2013-2014)	**End of the First Kyoto Protocol Period:** The first commitment period ended in 2012, leading to uncertainty about the future of climate policies and financing mechanisms. This uncertainty decreased project submissions as many countries waited for precise directions on new policies. **Global Economic Crisis:** The 2008 global economic crisis also delayed project registrations. The slow economic recovery in many countries limited investment in new environmental projects, contributing to declining submissions after 2012.
Recovery and New Peaks (2015-2021)	**Paris Agreement**: The signing of the Paris Agreement in 2015 revitalized global efforts to combat climate change, increasing project submissions on platforms such as Gold Standard and Verra. The Paris Agreement established clear targets and commitments to reduce emissions through Nationally Determined Contributions (NDC), encouraging new registrations. **National Initiatives**: countries launched national initiatives to meet their Paris Agreement goals, and from this, new mechanisms emerged, mainly governmental, which gained prominence, such as those created in Australia and Thailand. In Brazil, policies such as the National Plan on Climate Change and incentives for renewable energy and reforestation projects contributed to the increase in submissions.
Recent Decline (2022-2024)	**Changes in Policies and Funding Availability**: Changes in international funding policies and the completion of some support programs also contributed to the decrease in submissions. The transition to new post-Paris Agreement financial mechanisms is ongoing, causing uncertainty and a temporary reduction in registrations. Furthermore, the reduction in project financing was one of the late consequences of the COVID-19 pandemic, which can only be identified after the pandemic period as the bureaucratic procedures for project registration require a certain amount of time.

related to the Paris Agreement and national initiatives. The recent drop is likely linked to the consequences of the pandemic period, policy transitions, and the availability of financing.

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