Enrollment in forest carbon credit programs in the U.S.

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Dedication

This thesis is dedicated to my lovely daughter, Naïlath Bakary and my wife Eve Botchi. Your sacrifices for my academic achievements are deeply appreciated. To my parents Saliou Bakary and Soubedatou Liamidi, I hope this makes you proud. Lately, I extend this dedication to my beloved sister, Sabiatou Bakari for her unconditional support.

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Abstract

Climate change is one of the world's greatest challenges. A high concentration of greenhouse gas emissions in the atmosphere is the main cause. Forests can play a crucial role in carbon sequestration by absorbing carbon dioxide and acting as natural carbon sinks through forest carbon programs. The effectiveness of its mitigation solution, driven by forest carbon programs depends significantly on various factors. In this study, forest carbon programs in the U.S. were reviewed. Secondly, this study used panel data from 2005 to 2022 to analyze how economic factors, politics, and climate change perception influence enrollment in forest carbon programs in the U.S. The results show that climate change perception and the political affiliation of state governors are critical factors influencing enrollment into forest carbon programs in the U.S. These findings suggest that policies aiming at promoting forest carbon offsets programs need to consider landowners' perceptions toward climate change and political factors to increase participation in forest carbon programs.

Keywords: Political party, Economics, Forest carbon, Environmental Perception

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

The significant amount of greenhouse gases (GHG) in the atmosphere still places climate change as a major challenge experienced across the world. By 2050, many countries aim to implement effective policies driving to net-zero GHG emissions (Van Soest et. al., 2021). Various mitigation instruments and strategies have been proposed to achieve this long-term objective. Most countries across the globe are formulating their approaches to build resilience and mitigate climate change effects relying on forest ecosystems (Grassi et. al., 2017). Forests are critical in regulating the earth's climate and maintaining ecological stability. In addition, forests have demonstrated a strong potential for climate change mitigation (Gustavsson et. al., 2022), acting as a reservoir that contributes to the sequestration of significant amounts of carbon from the atmosphere (Roshani et. al., 2022). This includes delaying harvests, improving forest management, and converting agricultural lands to forests (Shinbrot et. al., 2022). The prospect is to sell carbon credits generated by forestland owners in markets by trading carbon emissions. This market-based mechanism has, therefore, gained widespread recognition as a cost-effective strategy for mitigating environmental concerns, and forestland owners are anticipated to emerge as significant contributors to the carbon credit supply (Hein, 2018, Poudyal et al., 2011).

In the U.S., forests cover 308 million hectares, representing about 33 % of the nation's land (Wang and Yang, 2023), and forestland owners can play a vital role in forest carbon markets. While the potential cost of forest carbon sequestration (e.g., Callaway and McCarl, 1996; Krcmar et. al., 2004; van Kooten et. al., 2004), relationship between the attributes of forest carbon offsets and landowners' willingness to accept payment (e.g., Soto et. al., 2016; Nielsen et. al., 2018; White et. al., 2018; Alhassan et. al., 2019) have received lot of attention from researchers, little is known on how macroeconomic characteristics influence enrollment into forest carbon credit programs. The existing literature only investigated how economic conditions, political orientation, and perception of environmental issues influence GHG emissions and the perceptions of climate change effects (e.g., Hamilton and Saito, 2015, Jorgenson et. al., 2017, Shao and Hao, 2020). For instance, Wang et. al., (2022) analyzed the correlation between political orientations and GHG emissions in 98 countries during the period 1990–2016. Jorgenson et. al., (2017) conducted a state-level analysis in the U.S. based on inequal distribution of income and carbon emissions from 1997 to 2012. McCright et. al., (2016) identified the strongest and most consistent predictors of key dimensions of climate change within many countries worldwide to explain public perceptions in the U.S.

This study investigates how economic, political, and environmental perceptions influence participation in forest carbon programs. By addressing this gap, this study is positioned as the first study that explores how income level, public perceptions, and the political affiliation of state governors influence landowners' enrollment into forest carbon credit programs in the U.S. By focusing on how income, public perception, and political affiliation influence the development of forest carbon offsets, the outcome of this study further contributes to a better understanding of the hurdles that slow the development of carbon credit programs. The contribution of our study should also be seen in the context of debates about the role of politics in the development of forest carbon markets.

The objective of this research is to characterize the Forest Carbon Credit programs and to determine the factors influencing the forest landowners' participation in the forest carbon credit program in the U.S.

Chapter 2

Literature Review

Although Forest Carbon offset markets are not new concepts in the U.S. and worldwide, the existing literature rarely shows direct relationships between enrolment by forest landowners with economic, political, and environmental factors. Yet, two major categories of studies are available. The first category is made up of a wide range of empirical studies that have investigated the factors mentioned above in the context of climate change while focusing on their influences on climate policy designs or GHG emissions. The second category is predominantly recent and analyzes the drivers of the willingness of forestland owners to participate in forest carbon programs.

Role of Forests and the Carbon Cycle

The quality of life in rural regions, the health of populations, and the environment in general, particularly the richness of flora and fauna are all directly impacted by the presence of forests (Nowak et. al., 2014). Mankind faces an enormous challenge to ensure its survival in the face of the reality of global climate change, which is also being brought about by the significant loss of forest cover on our planet, which is due to the expansion of agricultural borders and livestock, freaking rural fires, overexploitation of resources, and the emission of greenhouse gases (GHGs) from industrial activities and the transportation of people and goods (Mbow et. al., 2017; Pant et. al., 2018).

There are only two complementary ways to address this transcendental challenge: lowering the amount of undesired greenhouse gas emissions into the atmosphere and recapturing and storing some of these gases (Kammann et. al., 2017). Reducing emissions takes a variety of strategies, the most crucial of which is drastically cutting back on the use of fossil fuels like coal and oil and improving the processes that utilize them to make them less harmful.

The protection, restoration, and sustainable management of existing forests as well as the establishment of new forests under a sustainable forest management framework appear to be the sole methods for recovering hazardous gases, particularly carbon dioxide (CO2), from the atmosphere (Grubb et. al., 2019). During photosynthesis, trees take in CO2 and transform it into six-carbon sugar molecules, which is how they "fix" or collect carbon (**Figure 2.1**). When these sugar molecules are needed to sustain a tree's activities and to construct more complex molecules to create plant tissues and organs, trees respire and release CO_2 back into the environment (Vogt et. al., 2006). For this reason, forests are also critical in carbon cycling and storage and play a significant role in mitigating climate change (IPCC 2023). If management techniques are changed (e.g., longer rotations, planting trees on barren ground, enhancement of young and mature forests), these forests might absorb even more carbon, boosting their potential as a tool for policy toward mitigating global climate change.

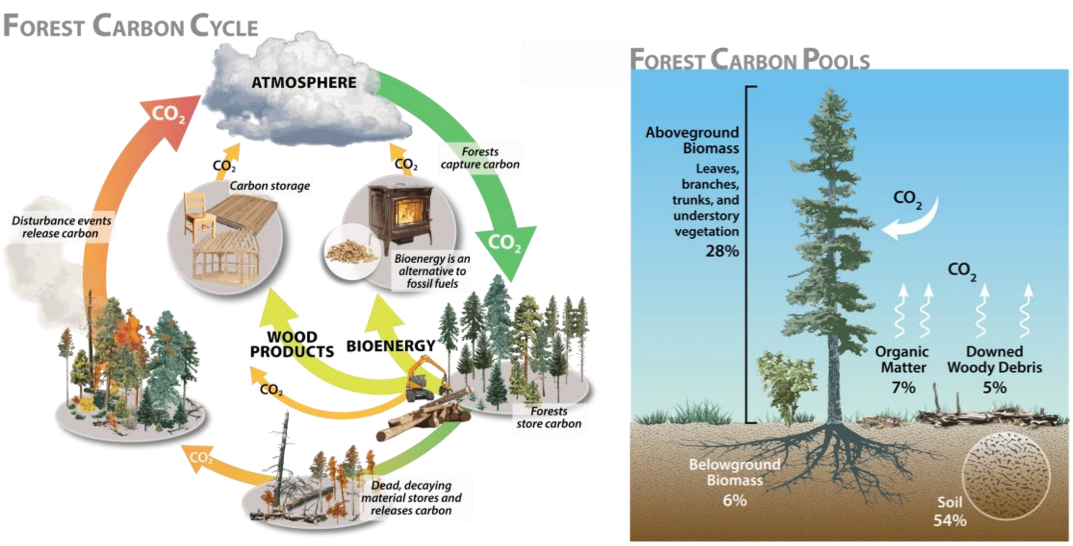

Figure 2.1 : Forest carbon and photosynthetic cycles
Credit: Gretchen Bracher, © Oregon State University

Importance of Carbon Programs Attributes in Landowner's Enrollment

The relationship between forest carbon offset programs attributes and landowners' enrollment has received a lot of attention in the literature. Participation rates in carbon offset markets among Non-Industrial Private Forest (NIPF) landowners are subject to variables related to both carbons offset program design and landowners' characteristics. With previous studies addressing the willingness to participate in carbon markets (Kelly et. al., 2015; Khanal et. al., 2019; Soto et. al., 2016; White et. al., 2018), the prospect of financial revenue consistently emerges as a robust predictor. Previous feasibility studies employed logit and probit models to analyze the effect of carbon credit program characteristics on landowner enrollment. Fletcher et. al. (2009) and Markowski-Lindsay et. al. (2011) utilized these models to analyze landowner preferences, considering factors such as expected payment and withdrawal penalties. Their studies revealed that preferences increased with payment but decreased with the inclusion of withdrawal penalties considered as a loss in revenue. Empirical studies in Texas and the Lake States by Miller et. al., (2012) further contributed insights, revealing specific compensation thresholds required for participation. Recent advancements, such as the best-worst choice (BWC) method employed by Soto et. al. (2016), shed light on new aspects of small forest landowners' willingness to participate, emphasizing revenue as an important attribute.

Income and Climate Policy Adoption in the U.S.

Carbon market dynamics, as highlighted by Feng et.al, (2011), introduce fluctuations in carbon prices, potentially impacting landowner revenues. The evolving landscape prompts a crucial question: would NIPF landowners in the US be willing to delay their timber harvest for carbon sequestration when carbon revenue is uncertain? This uncertainty in revenue scenarios adds complexity to understanding U.S. landowner decision-making and participation behavior in climate change mitigation and carbon-sequestration activities.

Limited or uncertain revenues, coupled with high costs associated with carbon project implementation and accounting, act as disincentives for NIPF landowners (Charnley et. al., 2010; Dickinson et. al., 2012; Fletcher et. al., 2009; Khanal et. al., 2019; Markowski-Lindsay et. al., 2011; Miller et. al., 2012).

The complexity of predicting financial gains, influenced by various factors such as carbon stocking, property characteristics, and market dynamics, introduces financial viability concerns and increased price risks, further impeding participation (Kerchner and Keeton, 2015). An alternative perspective, termed propensity to emit, indicates that at different income levels, households' propensity to consume carbon-intensive goods varies, leading to changes in emissions. Grunewald et. al. (2012) show that the link between inequality and emissions is nuanced, varying with the level of inequality in a country. High-inequality countries witness lower emissions with reduced inequality, while low-inequality countries exhibit higher emissions with less inequality. This insight adds depth to the understanding of how income distribution can impact emissions, providing a broader context for discussions on economic factors influencing carbon-related decisions.

Influence of Perceptions on Climate Change or Environmental Issues

There is a diversity in how perceptions are captured and analyzed in the context of climate change. Several authors referred to perception as the level of individual owners' concern regarding the impact of climate change and the extent it affects their decisions in this regard. For instance, White et. al., (2018) conducted an empirical study of Vermont Forest landowner's willingness to accept carbon credit programs. Their findings showed that Non-Industrial Private Forest (NIPF) landowners who express concerns about climate change prioritize environmental considerations over financial gains, showing a decreased emphasis on revenue from carbon programs. In contrast, skeptics are less likely to enroll in such markets (Kelly et. al., 2015). This suggests that the motivations and willingness of landowners to engage in carbon sequestration activities are strongly influenced by their perceptions of climate change and its impact on forests. Miller et. al., (2012) referred to climate perception as starting with climate consciousness. Their results revealed that climate conscious NIPF landowners would require lower payments to participate in carbon offset programs.

Beyond a simple concern and consciousness, Kilgore et. al., (2008) on the one hand, and Bromley-Trujillo and Poe (2020) on the other hand analyzed perception as a belief meaning high and ethical concerns of climate change with policy support, respectively. From these studies, it appeared that the landowners with ethical considerations for climate change issues were more willing to contribute to carbon sequestration efforts, emphasizing the broader impact of personal beliefs and values on participation in climate change initiatives. However, in states where climate change is perceived as a significant problem, and environmental concerns are high, climate policies, such as environmental standards and emission regulations, are more likely to be implemented. This provides a ground for the important role of public perception and belief in shaping climate mitigation policies.

Public opinion also plays a critical role in the success of environmental policies. Ostrom (2009) emphasizes that policies ensure more success when citizens support them and perceive effective and fair enforcement. Burstein (2003) underlines the impact of public opinion on policy outcomes, while research by Anderson et. al. (2017) and Tjernström and Tietenberg (2008) showed a positive correlation between public awareness of climate change and climate policy effectiveness. The literature also suggests that environmental attitudes are influenced by information on environmental issues. Greitemeyer (2013) and Hart and Nisbet (2012) underline the importance of information in shaping environmental attitudes, emphasizing the need for effective communication and education to influence public perceptions and attitudes toward climate change and environmental issues.

Political Ideology and Climate Change Policies Support

The relationship between political ideology and climate change is multifaceted and extends to GHG emissions, climate change denial, and policy implementation. Recent studies conducted by Wang et. al., (2022) on the influence of political ideology on greenhouse gas emissions utilized multinational panel data covering 98 countries from 1990 to 2016 to examine the causal link between political ideology and national greenhouse gas emissions. Their results revealed a political divide, indicating that left-wing governments tend to exhibit lower carbon dioxide emissions compared to right-wing governments. This ideological effect varies across countries with different levels of political globalization, and democratic statuses, highlighting the intricate relationship between political orientation and emissions.

Regarding individual policy support, Daniels et. al. (2012) analyzed individual preferences in the United States to evaluate the influence of political orientation and party identification on climate policy support. The author found that Republicans and individuals with conservative worldviews are less likely to support government-led climate actions, echoing the findings of the 2018 Pew Research Center. At the state level, political factors emerge as dominant predictors of climate policy decisions. Recent quantitative empirical work (Lyon and Yin, 2010; Berry et. al., 2015; Carley and Miller, 2012) highlighted the strong influence of political factors, with a focus on state-level climate policy decisions in areas such as renewable portfolio standards (RPS), distributed generation (DG), energy efficiency, and severance taxes on oil and gas extraction.

Public support for climate policies, as argued by Bumann (2021), is primarily shaped by party identification rather than socio-demographic factors. For instance, the study carried out by Trachtman (2020) provides insights into the nuanced dynamics of political partisanship, revealing that energy efficiency policy tends to be more responsive under unified Democratic control of state government. In contrast, the work of Bromley-Trujillo and Poe (2020) identified a weaker link between climate change awareness and policy adoption in states controlled by Republicans. This underscores the ongoing debate on the role of political ideology in shaping attitudes towards climate change and the subsequent policy landscape.

Chapter 3

Materials and Methods

A review of the characteristics of the Forest Carbon Programs in the U.S.

The characterization of forest carbon programs (FCP) in the U.S. was done through a review conducted on the Forest Carbon Programs and the willingness to accept carbon sequestration in the U.S . This review provides a comprehensive understanding of the state of FCPs in the country.

Firstly, a meta-Analysis was employed, using statistical methods to combine and analyze the results of multiple studies on forest Carbon Sequestration and willingness to accept payment for carbon sequestration in the U.S.

Secondly, a traditional systematic review identified and described key elements that influence how these programs operate. For instance, the legal and regulatory framework is a crucial component that shapes the way FCPs function in the U.S.
Furthermore, the types of FCP available were explored and the attributes of a high-quality carbon credit were also identified.

Thirdly, the key stakeholders and the mechanisms driving these programs were mapped out, and the active FCPs currently operating in the U.S were presented.

Area of Study

This research was conducted in the United States. The country spans diverse geographical and climatic regions, from the frigid expanses of Alaska to the tropical climate of Hawaii. In the country, forests are a vital carbon reservoir covering a significant part of the landmass in more than 40 states. This study covered 33 U.S. States where three carbon programs ACR, CAR, and Verra enrolled forest landowners for carbon sequestration. The selected areas included 31 states with more than 25% of forest coverage . These specific years and states also provided similar data for longitudinal studies of the factors studied (**Figure 3.1**).

Data

We used panel data spanning the period from 2005 - 2022 to investigate the relationship between state socioeconomic characteristics and enrollment in carbon credit programs. We used the total acreages enrolled into forest carbon by states as a proxy for landowners' enrollment to carbon offset programs. This data was obtained from the Berkeley Carbon Trading Program database. The average annual income by state was used as measurement of the state-level income. This data was obtained from the Federal Reserve Economic Data (FRED, 2024). We used the political party of the state governor as a proxy for the role of partisanship in the promotion of carbon offset programs. Data on the political party of the state governors was obtained from Jacob (2021). Public perceptions toward climate change at the state level were measured using the Google trend metric for climate change perception. **Table 3.1** summarizes the variables' definition and data sources.

Model Specification

To investigate the relationship between state socioeconomic characteristics and enrollment to carbon credit programs, an empirical equation of the following form were specified as follows:

$$AE_{j,t} = \delta_0 + \delta_1 Income_{j,t} + \delta_2 GovParty_{j,t} + \delta_3 Gtrend_{j,t} + T'\beta + \varepsilon_{j,t} \quad (1)$$

Where :

$AE_{j,t}$ is the number of acres enrolled into carbon program in the j-th state in year t,

$Income_{j,t}$ is the income level in the j-th state in year t,

$GovParty_{j,t}$ is the political party of the governor in the j-th state in year t,

$Gtrend_{j,t}$ is the google trend measuring the public perception toward climate perception in the US in year t.

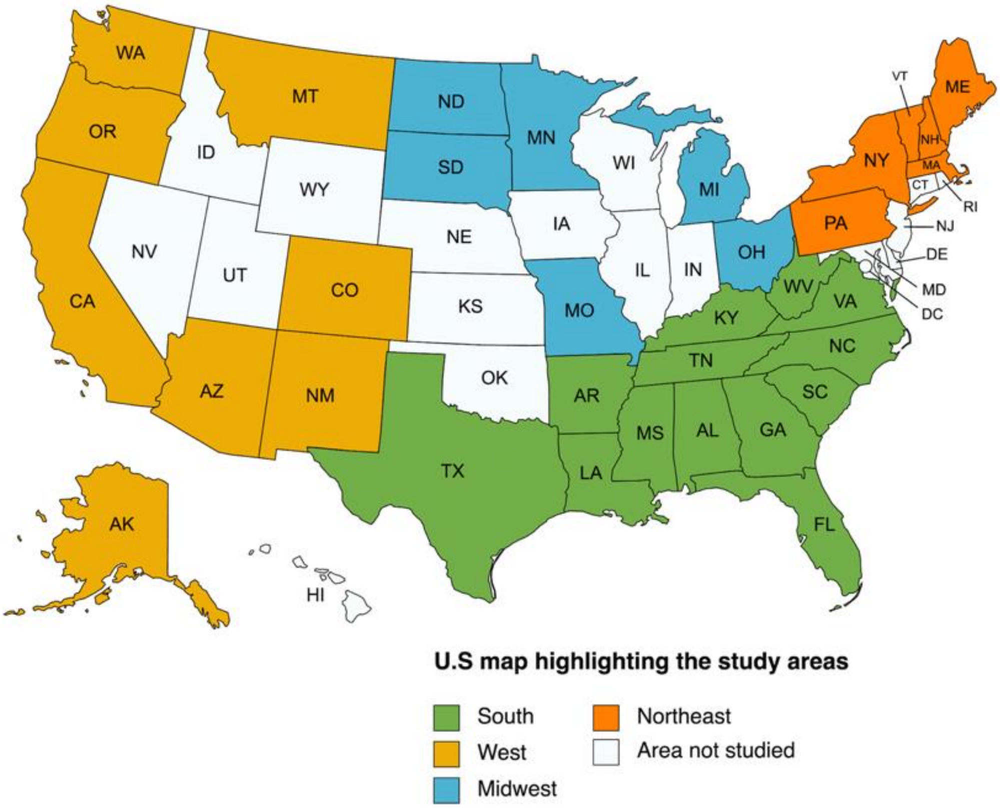

Figure 3.1 **:** US map highlighting the states comprising the area of study
Source: Designed by authors

Table 3.1 : Variables definition

Variables	Variables definition	Sources
Acreage enrolled	Total acreage enrolled in Carbon Program by States (acre)	Berkeley Carbon Trading Project
Income	Average Annual Income by States (U.S. $)	FRED Economic Data
GovParty	A dummy variable defining the political party identification of the state's governor (taking the value of 1 if the political party of the governor is Republican and 0 otherwise)	Jacob (2021) https://doi.org/10.3886/E102000V3
Google Trend	State level google trend metric for climate change concerns.	Google trend https://trends.google.com

Source: Author (2024)

T' and ε is a vector of time fixed effect and the error term.

β is a vector of parameters.

The correlation between income level and enrollment into carbon offset programs has been reported in the literature (Cariappa et. al., 2024). Perez et. al. (2007) noted that low-income households are more responsive to payment level from carbon program offset programs compared to high income households. The responsiveness to income varies with the opportunity costs associated with the adoption of carbon offset programs. Areas with higher opportunity costs are less likely to respond to payments compared to places with lower opportunity costs (Diagana et. al., 2007).

Several studies used Google trend as a proxy for public attention to health and environmental thematic (e.g., Mccalum and Bury, 2013; Rovetta et. al., 2021; Deb et. al., 2023; Kim and Kim, 2023). Public perceptions toward climate change have been reported as essential for the success of carbon offset programs (Whitmarsh et. al., 2019). Stroik et. al. (2019) observed a positive correlation between the public support for environmental concerns and the implementation of climate mitigation policies and projects. Furthermore, they pointed out that positive public support for climate mitigation policies could be explained by the adverse effects of climate change on households' livelihood and social welfare. However, several studies have observed notable differences in the public support within and across countries (Ashworth et. al., 2013; Braun, 2017).

The role of partisanship in the promotion of environmentally friendly projects has also been reported in the literature. Political leaders and partisans are more likely to promote and accept policies and projects that align with their parties' viewpoints. While state governments with liberal leadership tend to be favorable to environmentally friendly policies, other authors have documented the support of such policies by conservative leadership in the U.S (Hess et. al., 2015; Mayer, 2019). Similar trends have been observed in other parts of the world, although the support for environmental policies is not identical within the same political party (e.g., Hamilton and Saito, 2015; Cadoret and Padovano, 2016).

Table 3.2 summarizes our hypothesis on the relationship between the income level, public perception toward climate change, and partisanship on enrollment into carbon offset programs.

Table 3.2**.** Hypothesized signs of the independent variables in the empirical model

Variables	**Expected sign**
Income	+/-
GovParty	-
Google Trend	+

Chapter 4

Results and Discussion

Forest Carbon Programs : Definition of Attributes and landowner's Characteristics

- ***Attributes of Forest Carbon Programs***

The analysis of the attributes used to define forest carbon programs across the studies reviewed revealed that "land area", the "number of years enrolled in the carbon program" and "per unit price" (the financial consideration of the programs proposed to the landowners) are the most frequently represented attributes. In contrast, the attributes "Requirement or No forest management plan" and "harvesting allowed during contract" were critical attributes but less commonly discussed in this research area (**Figure 4.1**).

- ***Landowner's characteristics and willingness to accept for carbon sequestration***

The results also revealed that "Age" is the most frequently used landowner's characteristics, appearing in 69.23% of the papers reviewed. Similarly, "total forest acreage", "education", and "gender" were discussed in 53.85% of the studies, indicating their significant importance in addressing forest carbon sequestration and landowner's willingness to accept payment. "Income level" and "land tenure" are also crucial factors, included in 38.46% and 30.77% of the papers, respectively. The "number of years of landownership" was included in only 7.69% of the studies, while no studies addressed the "membership" of forestland owners. This indicates that while demographic and economic characteristics of forestland owners are critical for understanding their willingness to accept payment for carbon sequestration, the duration of landownership and the membership are less frequently examined in these studies (**Figure 4.2**).

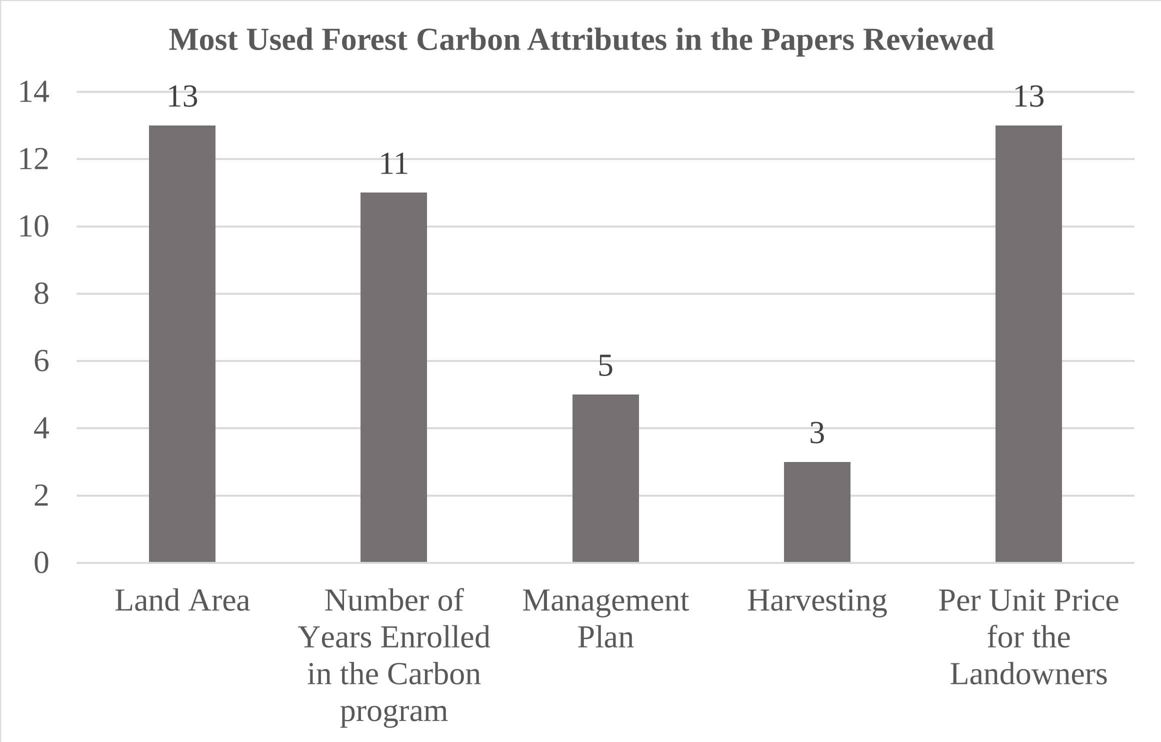

Figure 4.1 **:** Most used attributes to define forest carbon programs

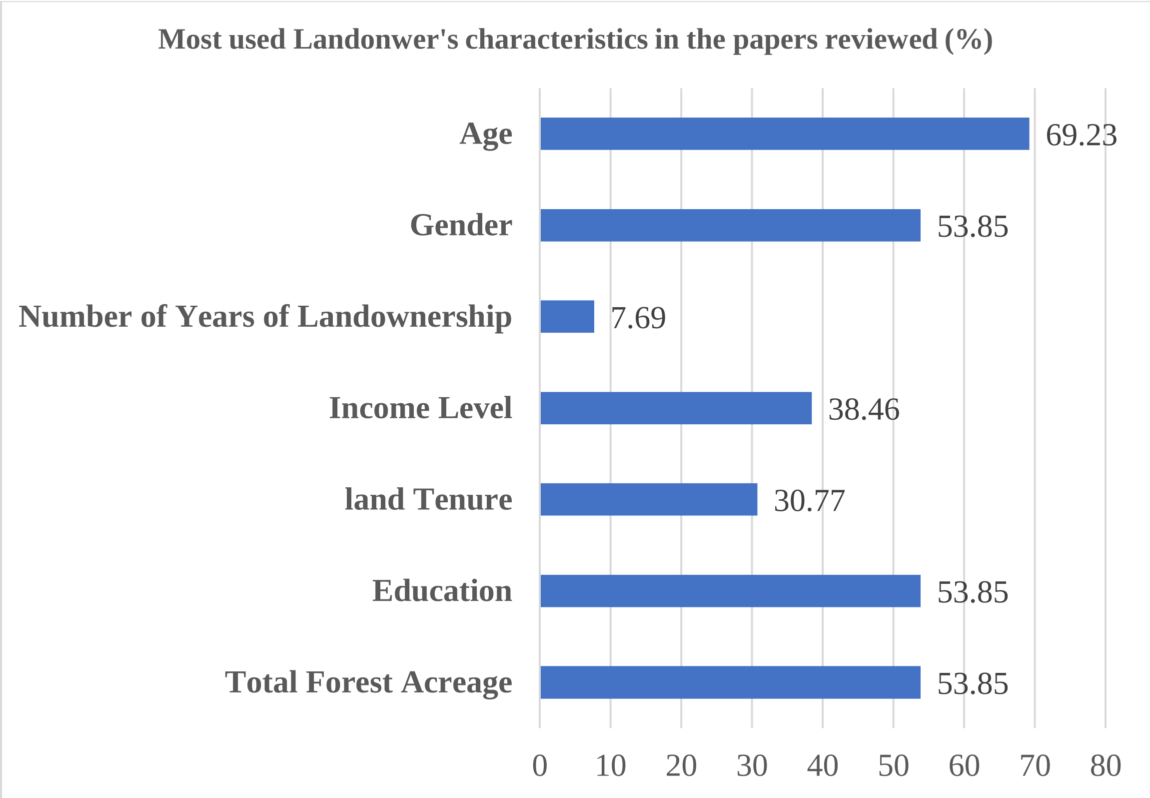

Figure 4.2 : Most used Landonwer's characteristics in the papers reviewed

Characteristics of Carbon Credit Programs in the U.S.

The United States has a multi-dimensional regulatory framework in Carbon Credit Programs such as federal regulations, state-level initiatives and international agreements. The section below reviews the main regulatory efforts for carbon credits and GHG emissions in U.S. with more detailed emphasis on federal vs state level and international agreements impact.

- ***Federal regulations***

The Act, first enacted in 1970 and heavily amended since that time, "grants the Environmental Protection Agency (EPA) the authority to set National Ambient Air Quality Standards (NAAQS), promulgate standards for sources of air pollution based on technology performance, and limit harmful air pollutants (Rogers, 1990). The EPA is responsible for the implementation and enforcement of federal regulations pertaining to air quality such as GHG emissions. The Act addresses both emission standards which are set by either State or the EPA, and standards for Ambient Air Quality required to achieve the objective of air quality mission. This office administers the Clean Air Act; develops, implements and enforces national standards for each of these programs overseeing investigations processes compliance oversight. This agency plays a central role in developing regulations and enforcing all aspects of laws governing clean air. California Air Quality Standards: The EPA also assists state and local agencies in managing their air quality plans and projects.

3 Primary Provisions: Under the CAA, the EPA has set NAAQS to ensure public health and welfare. They are :

- Carbon Pollution Standards: The EPA proposes standards to limit carbon emissions from new and modified power plants.

- Greenhouse Gas Reporting Program - a rule to require mandatory reporting of GHG from large emission sources and suppliers, the confidential data collected will support: 1) policy development; and 2) regulation addressing this.

- Clean Power Plan (CPP) - Although the CPP is currently stayed due to ongoing legal challenges, state-by-state carbon emission reduction targets came with this plan designed for cutting emissions from power plants.

- ***State-level initiatives***

How GHG regulation and carbon trading are pursued differs among states in the U.S., reflecting inherently different approaches to regulating."; States range from those leading with cap-and-trade programs to others using forms of renewable energy mandates or carbon pricing mechanisms (EPA, 2024).

- **California's Cap-and-Trade Initiative**

It was established by AB 32, known as the Global Warming Solutions Act of 2006. It is one of the biggest regional carbon trading programs in a country that caps its greenhouse gas emissions at state level and allows companies to trade pollution permits if they can meet their emission reduction goals. The program includes large sources of GHGs such as power plants, industrial facilities and fuel suppliers.

- **Regional Greenhouse Gas Initiative (RGGI)**

This is a program spanning multiple Northeastern and Mid-Atlantic states at reducing carbon dioxide (CO_2) emissions from the power sector. The provisions include states including New York , Delaware, Vermont Virginia, New Hampshire , Maryland, Connecticut, Massachusetts, Maine, Rhode Island.

This initiative places a regional cap on CO_2 emissions from power plants and requires power plant owners to buy credit or through an auction (EPA, 2024). The revenue derived from these auctions is used to finance energy efficiency, renewable projects in energy sector and other consumer programs.

- **Oregon Clean Fuels Program**

This program aims to implement a performance-based standard and increase the availability of low carbon transportation fuels in state. The program mandates that fuel producers and importers comply with carbon-intensity goals by blending biofuels of lesser carbon intensity, purchasing credits or otherwise. Thus, it promotes cleaner energy fuels and renewable technologies.

- **Washington Clean Air Rule**

Administered by the Washington State Department of Ecology, focused on capping and reducing GHGs from large industrial sources as well as first position users at fuel distributors and other significant emitters. The rule establishes emissions reductions mandates and a framework to operate an interstate trading system as well as utilize offset projects.

- **New York State's Climate Leadership and Community Protection Act (CLCPA)**

This Act stands out as one of the most advanced climate laws in country, aiming for a 100% carbon free electric grid by 2040 and a reduction in GHG emission through at least an 85 % from current level. The legislation requires the state to adopt ambitious renewable energy targets, efficiency standards and clean-energy industries. It even has provisions to make sure that environmental justice and community resilience are part of the deal.

- **Colorado Greenhouse Gas Pollution Reduction Roadmap**

Colorado Plot map lay out a high-level strategy to reach deep cuts in GHG emission that target every sector of the economy. The plan contains actions that would address emissions from electricity generation, transportation, buildings (highlighted as the third largest source of GHGs), oil and gas operations in Canada and agriculture. This will stress renewable energy, efficiency and plug-in transportation technologies.

- **New Jersey Global Warming Response Act**

The Act limits statewide emissions of greenhouse gas (GHG) and details a plan for reducing GHGs by 80% from the 1990 baseline. These include Renewable Portfolio Standards, energy efficiency policies and at the federal level-participation in RGGI.

- **Hawaii Clean Energy Initiative**

Hawaii has established a goal to be powered 100% by renewable fuels for electricity in all sectors other than transportation by the year 2045. Through this initiative the Village will promote measures that generate more renewable energy, improve facility energy efficiency, and shift towards a clean-energy economy.

- **International Climate Agreements and the U.S. Participation**

Adopted in 2015, the Paris Agreement aims to strengthen the global effort against climate change by limiting the rise in global temperatures this century to well below 2 degrees Celsius above pre-industrial levels, while striving to limit the increase to 1.5 degrees Celsius. Additionally, the agreement seeks to improve countries' capacity to manage the impacts of climate change through:

- **Mitigation**: Reduction of greenhouse gas emissions to limit the rise in global temperature.
- **Adaptation**: Increasing the capacity of countries to adapt to the negative impacts of climate change.
- **Finance**: Directing financial resources to support climate action and sustainable development initiatives.

To achieve these goals, the Paris Agreement set ups a framework for transparent monitoring, reporting, and progressively increasing both individual and collective climate efforts by participating countries through nationally determined contributions (NDCs). Each country must submit their NDCs, outlining their plans for climate action, and update them every five years, with the expectation that these plans will become increasingly ambitious over time. The agreement also emphasizes the importance of technology transfer, capacity-building, and climate finance, particularly for emerging countries.

Carbon Credit Market Structure

- **Forest carbon projects**

A carbon offset is a unit of greenhouse gas (GHG) reduction equal to one ton of CO2 or equivalent gases. Carbon offsets are created by Carbon offset projects as the activities that reduce, avoid or sequester emissions and can be used to cancel out carbon dioxide elsewhere.

In a forest context, those actions generally refer to one where the carbon is taken from the atmosphere in more than what was otherwise stored. All activities which make up an offset project must be registered , be independently verified by a third-party and approved carbon registry. When the carbon in a project is demonstrated to offset emissions elsewhere or are otherwise approved, generated offsets become known generically as "carbon credits" which can then be further verified and registered by independent standards associations but can only actually be traded or sold once certified under one of the regulated (voluntary) established forms. It is important to remember carbon offsets are the outputs or products of a specific kind of activities (carbon offset projects) whereas carbon credits refer solely to being traded in various types/levels/procedures within credit/bond markets, including emissions trading as well.

- **Types of forest carbon credit projects**

In the U.S., afforestation/reforestation, avoided conversion and improved forest management are currently eligible projects that can generate offsets under major carbon programs. These modes also have different methodologies, obligations, rules and follow-up and verification needs for the projects.

- **Afforestation or reforestation:** the process of restoring a forest that once existed but got removed at some point either by afforestation (tree planting) or just remove unwanted debris and vegetative competition to help encourage natural regeneration.
- **Avoided conversion**: Keep projects make certain that the forest land is not converted to non-forest use. Projects must show that lands are in imminent risk of conversion. Usually involve permanent conservation easements.
- **Improved forest management (IFM):** Projects that include IFM activities which result in maintenance or enhancement of the carbon stock from forests, afforestation of lands missing a forest land use/cover for more than fifty years and reforestation projects.

Table 4.1 summarizes the characteristics of a carbon credit project.

- **Carbon project registries and verification entities**

- ***Carbon project registries***

The registries were introduced to record, make publicly available and track the creation, transfer and possible retirement of credits. Registries create liquid marketplaces and record-keeping mechanisms for credits. This is especially the case for those wanting to play in both voluntary and compliance markets. The most recognized carbon registries within the U.S. are presented in **Table 4.2**.

- ***Validation and verification entities***

Compliance verifiers are essentially independent, third-party certification bodies that verify the project's documentation and processes to confirm whether the carbon offset calculation is right and if all program standards have been satisfied. These third-party verification bodies are required to conform with ISO principles and rules for validation/verification of environmental information statements.

Table 4.1 **:** Characteristics of carbon credit projects

Characteristics	**Description**	**Eligibility requirements**
Additionality	Project captures and stores more carbon compared to a "business as usual" or "baseline" scenario.	Project must demonstrate that the carbon sequestration would not have occurred without the development of the offset project
Permanence	Requires that the removals be maintained and equivalent to the emissions being offset.	The permanence of a project is shown by measuring the length of time carbon is stored, third-party verification of inventory, and periodic auditing throughout the life of the project.
Measurability	Carbon must be accurately measured and inventoried so that benefits can be calculated.	Projects require an inventory carried out through approved methodologies and verified by a third party. Confirmation of protocols and accuracy are crucial for ensuring proper project verification.
Non leakage	Reductions of carbon emissions in one area causing an unintended increase in another area leads to leakage.	As part of approved protocol, projects must demonstrate they do not cause excessive leakage.

Source: Grean Earth (2024)

Table 4.2 : Active project registries in the U.S.

Project Registries	Description
American Carbon Registry (ACR)	• The ACR, established in 1996 was the first private registry in the voluntary market. • ACR protocols is approved by California Air Resource Board (ARB) allowing offsets projects registered with ACR to trade their credits on California's cap-and-trade market. ACR has developed protocols for each of the three categories of forest carbon projects.
Climate Action Reserve (CAR)	• The CAR operates in the voluntary market, but its protocols have also been verified by ARB. Projects registered with CAR are eligible to trade their offset credits on California's cap-and-trade market. • CAR also comprises all three types of forest carbon projects.
Verified Carbon Standard/Verra (VCS)	• The VCS is the most widely used registry in the global voluntary market. • VCS registers offsets for Improved Forest Management, Afforestation , Afforestation and reforestation projects. • Once a carbon project is validated according to VCS protocols, the project developers receive Verified Carbon Units (VCUs) to be traded.
Gold Standard	Gold Standard is an international registry founded by the World Wildlife Fund and based in Switzerland.

- ***Forest Carbon project developers: Creating and Selling Credits in the Forest Carbon Market***

Project developers are either for-profit (private) companies or not-for-profit organizations that implement an activity to increase the package of carbon stored in a forest, and/or to reduce their own emissions on their land. These contracts are typically those made between a project developer and forestland owners, including their roles for one another and how the landowner will be paid. **Figure 4.3** illustrates the forest carbon credit generation, verification and the market process in the U.S

- ***Carbon market types***

Given the growing interest and funding to reduce greenhouse gas emissions from deforestation as a climate-change mitigation strategy, higher people´s willingness to pay for forest-based action that offsets or abates CO2 is expected. Forest carbon markets offer a way for these payments to happen. The good being traded is a carbon credit. A carbon credit equates to 1 ton of CO2-equivalent (CO2e) either removed from or not emitted in the first place into the earth's atmosphere. Forest carbon programs also offer a range of management services that can help forestland owners increase the carbon sequestration on their land and store more in trees, translating into additional units representing each ton to be marketed as (forest) carbon credits. Two categories of markets purchase and consume carbon credits produced by the projects that remove or absorb GHGs, in the U.S.: compliance and voluntary programs. These systems essentially cohabitate in the markets. However, the requirements of one or another may still limit which offset projects are eligible to participate in it. The carbon Credit buyers differentiate the two markets.

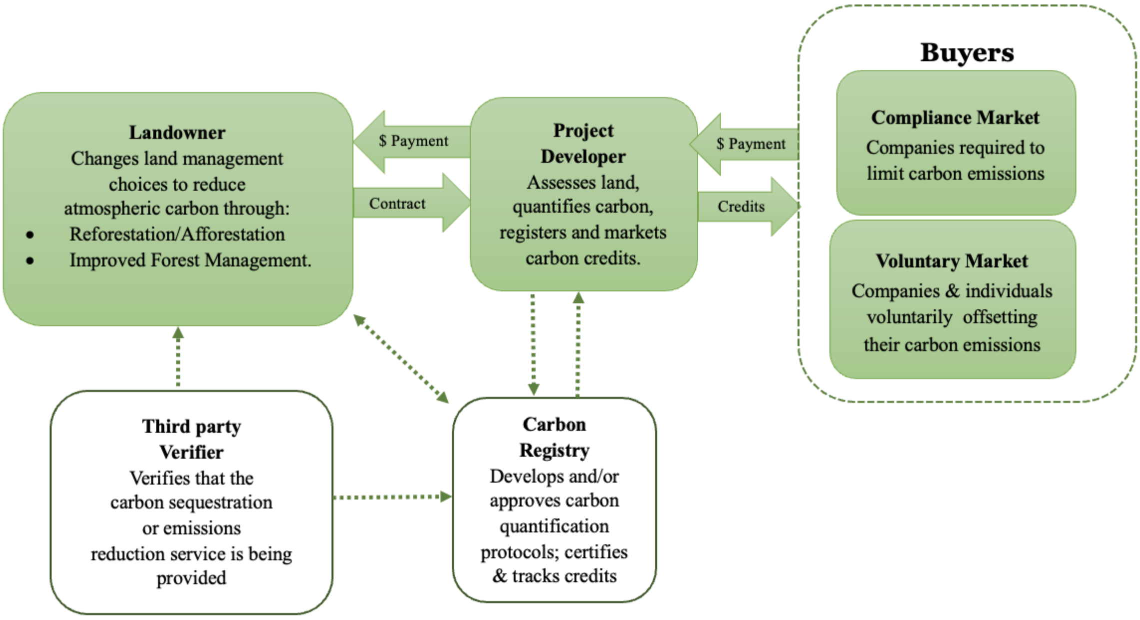

Figure 4.3 **:** Forest Carbon Credit Generation, Verification and Market Process in the U.S.
Source **:** Maggard and Curtis (2022)

- **In the case of compliance carbon market,** companies which newcomers must buy from companies that Government has ordered to limit how much CO_2 they can make take in their facilities or operations. Examples of compliance markets in the US are The California cap and trade program and Regional Greenhouse Gas Initiative (RGGI). They are technologies providers to reduce emissions for the companies, or they pay others (emitters) to increase atmospheric carbon, but jointing manages trees and soils as a sequestration bank. It is up to the national governments of participating states as to how much forest carbon credits that companies can count toward their compliance efforts.

- **In Voluntary Carbon Markets:** When it comes to the voluntary carbon markets, there are potential buyers that include companies (some on behalf of individuals), governments as well as other entities which can offset their own emissions or meet some sort of social and environmental goals with these activities. Microsoft and Google want to become net zero carbon emission companies (they plan on spending as much money as it takes for this). Voluntary carbon market growth remains a significant issue in recent years. In a forest carbon credit market, virtually all of the opportunities for economic return to forestland owners occur in what is called voluntary markets.

- ***Forest carbon market : Incentive programs***

A third type of program, generally referred to as incentive programs may be more relevant in the context of forest carbon. They are also designed to help landowners who may have been deterred from engaging in carbon markets by barriers such as costly up-front costs, and/or administrative complexities and burdens. The two most prevalent types of incentive programs are practice-based and pay-for-performance.

- **Practice-based programs** :

These programs deliver on-the-ground technical assistance and financial incentives to landowners for transitioning forest storage, sequestration improving and health enhancing practices. Practice-based programs Practice based means some NRCS offering, like Environmental Quality Incentive Program (EQIP).

- **Pay-for-performance initiatives**

The pay-for-performance programs provide compensation in the form of payments to a landowner on carbon sequestered and could generate tradable carbon credits by nature, like any other potential offset that defined in Copenhagen. A pay-for-performance program, like The Family Forest Carbon Program developed by the American Forest Foundation and The Nature Conservancy.

The intent of this program is to reduce/eliminate barriers that would otherwise prevent family forest owners from participating in the carbon markets (through hefty up-front costs and minimum acreage requirements). An independent examination of the program approved its approach by Verra (the non-profit that oversees the Verified Carbon Standard) in October 2022. Since, only landowners in eight states (Maryland, Michigan, Minnesota, New York, Pennsylvania Vermont and West Virgina and Wisconsin) are eligible to enroll.

Table 4.3 presents the active forest carbon project developers in the U.S.

Factors Influencing the Forest Landowner's Participation in the FCP in the U.S.

Table 4.4 presents the descriptive statistics of the independent variables in the models. The average acreage enrolled in carbon offset programs was 19,027 at the state level with a standard deviation of 66,361.46. The annual income varies between the states with an average of $67,390. The lowest and highest average annual income levels were $39,670 and $100,200, respectively. Most of the state governors were affiliated to the Republican party. The average number of searches registered by Google Trend regarding climate change was 47 with a standard deviation of 15.29. The lowest Google trend index was 32 while the highest was 100.

Table 4.3 **:** Forest carbon project developers in the U.S.

Project Developer	**American Forestry Foundation and The Nature Conservancy**	**Blue source**	**EP Carbon**	**Finite Carbon**	**Forest Carbon Works**	**Natural Capital Exchange**
Program	Family Forest Carbon	Forest Carbon and Working Woodlands	Forest Carbon	Forest and CORE Carbon	Forest Carbon	Forest Carbon
Registry	Verra	CR, ACR, Verra	GS Impact Registry, CR, ACR, Verra	CR, ACR, Verra	CR, ACR, Verra	N/A
Market	Voluntary	Voluntary and Compliance	Voluntary and Compliance	Voluntary and Compliance	Voluntary and Compliance	Voluntary
Project	Growing Mature Forests, Enhancing Future Forests	AC, IFM, A/R	AC, IFM, A/R	AC, IFM, A/R	AC, IFM, A/R	Harvest Deferral
Minimum Acres	30	3,000	Unknown	40 (CORE Carbon)	40	None

Table 4.3 : Continued

Fee	Potentially for forester	Yes (with restrictions)	Unknown	Unknown	$75 application fee	No
Region	Pennsylvania (International pending review)	North America	International	North America	Lower 48 states (US)	Lower 48 states (US)
Harvesting Permitted	Yes (with restrictions)	Yes (with restrictions)	Yes	Yes	Yes, after the first 6-year period	No

Figure 4.4 shows the distribution of public concerns toward climate change by the political affiliation of the state governors. Most of the states with lower public concerns for climate change (Google Trend score < 50) were led by Republican governors.

Table 4.5 presents the results of the estimation of factors influencing enrollment into the carbon programs. Model 2 differs from Model 1 with the inclusion of the year fixed effect to account for unobserved time differences that may affect enrollment into carbon programs. The Likelihood Ratio (LR) test statistics in both models were statistically significant, suggesting a good fit of the models. Additionally, all the independent variables have the expected signs. The results in both models show that the political party affiliation of the state governor is a critical factor influencing enrollment into carbon programs. The coefficient of this variable is negative and statistically significant at 5 percent in both models. This suggests that enrollment into carbon programs tends to be lower in states led by Republican governors than in states with non-republican governors. The negative correlation between the conservative affiliation of the state governors and enrollment into forest carbon programs could be explained by skepticism about climate change and environmental issues traditionally expressed by Republicans. Similar findings have been reported in the literature (Hamilton and Saito, 2015; Evensen, 2016; Hart et. al., 2021). Hess et. al. (2016) observed that conservative politicians tend to be less favorable to environmentally friendly projects. Bromley-Trujillo and Poe (2020) also reported a negative relationship between the Republican Party affiliation and the adoption of climate policies in the U.S. However, considerations over environmental policies. The primary role of party identification in supporting climate policies rather than socio-demographic factors has been discussed (Berry et. al., 2015; Bumann, 2021).

Climate change perception is a critical factor when accounting for the time fixed effect. The coefficient of this variable is positive and statistically significant at 5 percent in

Table 4.4 **:** Descriptive statistics of the variables used in the models.

Variables		**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
AE	Acreage Enrolled	19,027	66,361.46	0	623,729
Income	Income	67,390	118,33.95	39,670	100,200
GovParty	Governor Political Party	0.53	0.50	0	1
GTrend	Google Trend	47.36	15.29	32	100

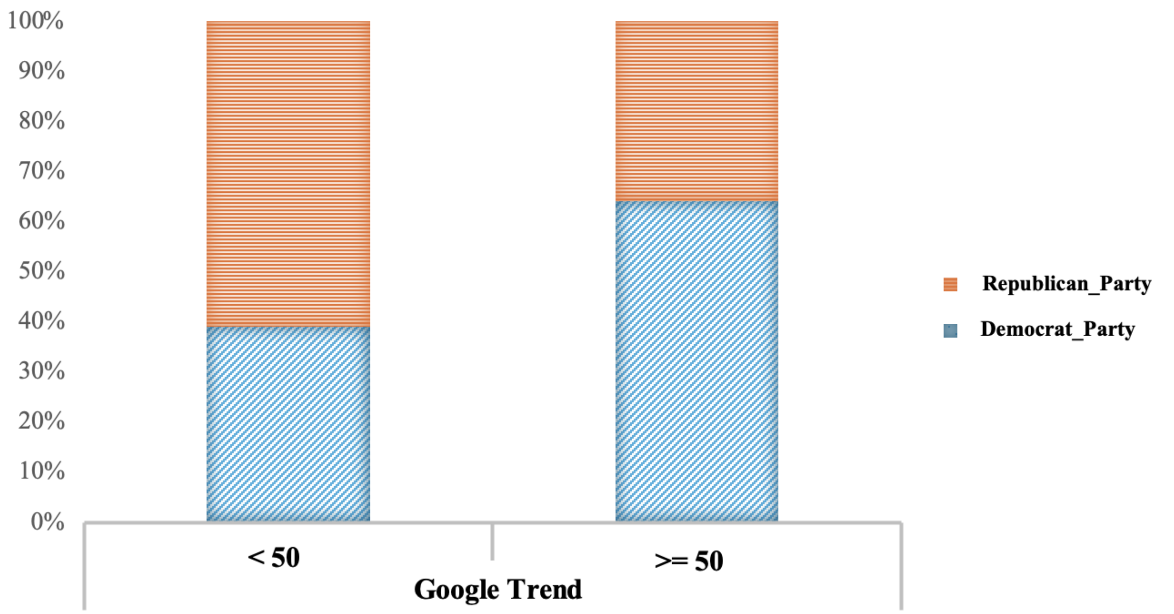

Figure 4.4 : Popularity of Climate change topics across state's political representations

Table 4.*5* **:** Estimation of the factors influencing the enrollment in carbon programs

Variables	**Model 1**		**Model 2**	
	Coefficients	**S.E.**	**Coefficients**	**S.E**
Income	0.0004	(0.0003)	0.0001	(0.0003)
Google Trend	0.2696	(0.1847)	0.3595[b]	(0.1805)
GovParty	-11.1720[b]	(5.2880)	-10.8130[b]	(4.7485)
Year Fixed Effect	No	/	Yes	
Constant	-13.3070	(15.8510)	-18.8450	(16.3510)
Observations	594		594	

([a]) Significant at the 10% level ($p < .10$)
([b]) Significant at the 5% level ($p < .05$)
([c]) Significant at the 1% level ($p < .01$)
S.E.: Robust Standard Error

Model 2. This suggests that an increase in the climate change perception is positively associated with land enrollment into carbon credit programs. The correlation between climate change perception and engagement into carbon program has been reported in the literature (Beddoe and Danks, 2009). White et. al. (2018) also observed that climate conscious landowners tend to be willing to enroll into carbon offset programs than landowners less concerned with climate change effects. Their findings showed that Non-Industrial Private Forest (NIPF) landowners who express concerns about climate change prioritize environmental considerations over financial gains, showing a decreased emphasis on revenue from carbon programs. In contrast, skeptics are less likely to enroll in such markets (Kelly et. al., 2015). As for the income level, no evidence was found for the correlation between state level income and enrollment into forest carbon programs.

Chapter 5

Conclusion and Policy Implications

Forest Carbon Programs in the U.S. have a well-established structure, and their implementation plays an important role in carbon reduction. Using a unique dataset on land acreages enrolled in forest carbon programs, we investigated how income level, public perception toward climate change, and the political affiliation of state governors influence landowner enrollment in forest carbon offsets. Our results revealed that climate change perception and the political affiliation of state governors were the factors associated with enrollment into carbon credit programs. The higher the concerns for climate change effects, the higher is land areas enrolled into carbon credit programs. As for the political affiliation of state governors, enrollment in forest carbon programs is lower in state with republican led governors than in states with non-republican governors. These findings highlight the role of public perceptions and political engagement in the promotion of forest carbon programs.

Our findings also have practical implications on the promotion of forest carbon offsets. Implementing educational programs toward increasing awareness and understanding of the adverse effects of climate change among landowners could increase enrollment in forest carbon programs The training programs could be group-based, especially considering the needs of demographic groups among forest landowners. This will help the forest carbon project developers to understand the needs of landowners and align their priorities, such as financial or environmental. Similarly, increasing the involvement of local and state leaders in promoting the benefits of carbon offsets programs may contribute to positively influence public awareness. Additionally, developing state specific policies that account for the political landscape could help reduce perceived risks associated with environmental policies and economic efficiency. Policy makers should support future research to explore the barriers to enrollment to forest carbon programs in different political and economic contexts. The aim would be to present forest carbon credits as a means of contributing to the fight against climate change, but also as one of several ways for landowners to diversify their income. Moreover, this could be softened by special economic incentives such as tax reductions, subsidies for landowners or financial support for infrastructure development. These incentives could help balance the upfront costs and help landowners understand the long-term economics of participating in the carbon credit programs.

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Vita

Sofwaan Bakary's educational journey began at the University of Tennessee, Knoxville, where he pursued a master's degree in forestry from January 2023 to December 2024. Prior to this, he earned a bachelor's degree in Agricultural Economics at the University of Abomey-Calavi in the Benin Republic, graduating with First Class honors in March 2011. He furthered his studies at the same institution, obtaining a Master of Science degree in February 2016, also with First Class honors.

Sofwaan's served as Research Assistant under Dr. Perceval Assogba with a primary research interests focusing on the economics of forest carbon at the landowner level. He is also keen on exploring macro-level factors that influence enrollment in forest carbon credit programs in the United States.

His scholarly contributions include co-editing a publication titles "Influence of climate change on Food crop Yield in Benin Republic" in 2019 . he has also submitted an article examining forest carbon sequestration in the U.S. looking beyond economic incentives. His conference presentations have covered topics such as reviewing of attributes that define forest carbon credit programs worldwide and analyzing various factors influencing forest landowner's participation the U.S., reflecting his diverse interests within the field of forest carbon.

In addition to his academic pursuits, Sofwaan also served as a Teaching Assistant under Dr. Augustin Engman (January -May 2024). This role involved grading and helping students for a better understanding of their assignments. This experience allowed him to gain deeper familiarity with key concepts and methods for identifying and evaluating populations characteristics in the fisheries science.

Sofwaan is proficient in a range of technical and interpersonal skills. He is skilled in Microsoft products, R , Stata for data analysis, and has a basic operation knowledge of

Python software. His academic diligence is evident from his consistent First-Class honors. Sofwaan’s curriculum vitae showcases a committed and multifaceted professional with a strong foundation in agricultural and forest economics, poised to contribute significantly to his field of interest.