

AI and Public Decentralized Networks for Voluntary Carbon Trading

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Abstract

This paper explores the use of artificial intelligence (AI) and public decentralized networks “for social good,” investigating their use in carbon trading. Carbon trading provides an important capability in support of the Kyoto Protocol, sponsored by the United Nations’ efforts on climate change. We differentiate between voluntary and mandatory carbon markets. Unfortunately, there can be fraudulent trades in either type of market, such as reusing carbon credits multiple times, overstating the amount of a carbon credit, and falsely verifying carbon credits. We discuss the use of public decentralized networks and AI as approaches to facilitate carbon trading, focused primarily on voluntary markets. Our AI analysis includes the use of large language models, sentiment analysis and GOFAI as we review recent potential approaches and developments in voluntary carbon trading.

Introduction

The 1997 Kyoto Protocol provides limits on greenhouse gas emissions in thirty-seven countries. The Kyoto protocol operationalizes the United Nations Framework convention on climate change. The protocol offers three market mechanisms, including international emissions trading. Under the protocol, countries’ actual emissions must be monitored and records of emission trades are required. Reporting is done with the different parties submitting national reports on transactions and inventories.

Our focus here is on carbon trading and there is substantial information available about carbon trading. As an example, there is a joint publication of the World Bank and the International Carbon Action Partnership, ICAP (2021) that outlines emissions trading in practice.

There are roughly 55 different emissions trading systems (ETS) around the world, Of those 55, including 8 from China, several are pilot systems, such as Beijing’s pilot system.

In carbon trading markets, carbon credits are bought, sold, and traded by individuals and organizations. Organizations that emit greenhouse gases can purchase carbon credits from organizations that reduce or remove those gas

emissions from the environment. For example, a manufacturer can purchase carbon credits from an organization that preserves a forest. One ton of carbon dioxide credits can be traded for the equivalent amount of greenhouse gas. After a credit is used to avoid, reduce or sequester emissions, it is offset and it can no longer be traded. As discussed further below, there are several organizations that can provide audits to ensure the credits are appropriate.

Voluntary vs. Mandatory

Markets for carbon trading can be either mandatory or voluntary. Although mandatory trading has received the majority of the attention, there are also voluntary carbon offsets, and the two settings differ substantially.

In some cases, companies need to find ways to offset their emissions quickly, but they do not have the resources to reduce or eliminate their emissions. In those settings, companies can trade in voluntary carbon markets (VCMs). VCMs include new projects that remove carbon from the atmosphere or reduce greenhouse gas emissions. Accordingly, those VCMs can provide substantial revenues to the receiving company for the carbon reducing activity. According to Dickinson (2023), although companies are increasingly turning to VCMs, there is a significant risk of fraud, manipulation, and abuse with VCMs.

Voluntary carbon markets operate in parallel to the mandatory compliance markets, allowing private companies and individuals to voluntarily purchase carbon credits. Voluntary carbon markets apparently are motivated mostly by corporate social responsibility or individual social responsibility. As an example, an individual taking a trip could go to a voluntary market and buy carbon offsets, as discussed below.

Organizations that have mandatory carbon offset responsibilities, employ staffs of workers who specialize in carbon markets and choose carbon offsets. However, according to IPEI (2025) those involved in voluntary carbon offset management have limited expertise, limited knowledge,

limited resources, and limited time. These limitations affect their ability to choose carbon offsets. Furthermore, voluntary users have limited access to system resources to facilitate the choice and implementation of their carbon offsets.

Carbon Trading – Social Good?

Although, carbon trading is endorsed by the United Nations and thought of as “for the general good,” one perspective is that there is a certain amount of concern that “nature” is being commoditized with the advent of carbon trading markets (Huff 2023). However, on the other hand, carbon offsets offer the potential protection of different ecological systems and support for building future conservation communities. For example, forests absorb carbon dioxide and thus act as natural carbon sinks. Organizations managing forests can generate carbon credits and sell those credits to those pursuing either mandatory or voluntary carbon credits.

Fraud and Errors in Carbon Offsets

Unfortunately, there are several ways that fraud can occur in carbon trading. In some cases, a credit has been sold multiple times. As noted by Whiting (2023), this can occur because it has been “issued” multiple times, “used” or been “claimed” multiple times. Further, in some cases the credit used is actually greater than the actual effect. As an example, Blake (2023) noted a situation where a carbon offset project was awarded thirty times its actual value. These problems apparently are prevalent enough that there have been standards issued to address these issues (Gold Standard 2015).

Further, there are several organizations that perform carbon credit certifications and audits. Unfortunately, this activity also has difficulties. Recently, the Chief Executive Officer (CEO) resigned from Verra, a Washington, D.C., nonprofit firm that apparently had approved millions of dollars in carbon offsets (Greenfield 2023). In some cases, the credits certified did not actually provide the specified greenhouse gas credits. Apparently, Verra verified over one billion credits over that CEO’s tenure raising several questions.

More recently, Coglianese and Giles (2025) argued that the use of such auditors has basic limitations: “Auditors selected and paid by the entities being audited have both economic incentives and an unconscious bias to make findings that work to their client’s advantage.”

Accordingly, it is clear that there is a need to develop the appropriate tools and approaches to measure and keep track of the use of carbon offsets and there is a need for alternatives to the current auditing approaches for the review of carbon trading offsets.

This Paper

This paper proposes using a combination of public decentralized networks, distributed ledgers, and artificial intelligence to attack these issues. We survey the literature and review emerging company products to determine a potential integrated architecture. We propose using a public decentralized network with a distributed ledger, with immutability, for the voluntary carbon market. Such a platform provides broad information availability and works to mitigate information asymmetries in markets. In addition, because of their broad accessibility, they support market inclusiveness. As part of that platform, AI can be used to analyze existing data and provide supplemental information to guide inexperienced users to appropriate solutions. We investigate some of those emerging AI applications.

Accordingly, this paper proceeds as follows. The next section reviews background information about decentralized networks, including characteristics of those markets, such as whether they are private or public. The following section briefly reviews some issues in the use of AI in decentralized carbon trading systems. The subsequent section examines some emerging AI approaches in carbon trading and offsets. The penultimate section analyzes some potential issues in digital fraud and carbon trading, while the concluding section summarizes the paper and some of its contributions.

Centralized and Decentralized Networks

This section provides a brief overview of different concepts of blockchains, decentralized networks and Web 3.0 used in this paper (e.g., Lacity and Lupien 2022). We drill down on private vs. public markets, centralized vs. decentralized markets, first generation blockchain applications, and limitations of these network markets,

Public vs Private

Public markets are open to anyone without the need for permissions to perform network activities. A well-known public market is for Bitcoin.

On the other hand, private markets limit participants through the permissions that they grant to users. In those private markets, participants are typically governed by a centralized leadership or ownership, which establishes the permissions, rules, and processes. Often these private decentralized networks are limited to virtual organization members (O’Leary 2019).

Centralized vs. Decentralized

A key difference in markets is between centralized and decentralized. Computing in decentralized markets typically is distributed. Centralized markets often use cloud-based

computing. Centralized indicates that there is a designated leader or sponsor who is responsible for generating the appropriate governance rules for the market. That centralized source could be a government agency or corporation. Those rules that they enforced include who is or is not allowed in the market, what roles they have, etc. In centralized markets, the sponsor monitors, and controls behaviors. In decentralized markets, users are self governed which can lead to inappropriate behaviors, including so-called wash and spoof transactions designed to get the markets moving in particular directions. However, decentralized markets are known for their inclusiveness. These different types of networks are summarized in figure 1.

Decentralized	Crowd Managed	Bitcoin, Ethereum
Centralized	Corporate	Government Applications
	Private	Public

Figure 1: Types of Networks

Public Decentralized Networks

Public decentralized networks (PDNs) are open to all potential users and do not have a centralized source providing governance for the networks. Bitcoin is a classic example of this approach.

Unfortunately, although they facilitate inclusiveness and mitigate some information asymmetries, there are some limitations of public decentralized networks. As an example, O’Leary (2018) investigated some of the market manipulation potential associated with public and decentralized markets, focusing on issues such the potential for market manipulation. For example, if there is no control over who has accounts, then it is easy for a market participant to have multiple distinct accounts and sell to themselves, pushing prices arbitrarily high.

Distributed Ledgers

As with supply chain and other types of virtual organization activity, an important part of tracking carbon trades comes with a life cycle tracking of key assets, such as potential and actualized carbon offsets. Research instantiations for carbon trading increasingly include blockchain

and other distributed ledger designs with its immutability as a control (e.g., Yang et al 2025).

As a result, at a basic level, designs of carbon trading include a distributed ledger that would include information about carbon offsets, their amount, the source, the buyer, the extent it has been used, the nature of the particular activity on which the offset is based (forest), etc. The ledger provides transparency and eliminates some information asymmetries. The distributed ledge keeps track of the carbon offsets and provides a transparent and broadly available summary of activity.

First Generation Private Networks - Supply Chains

Most first generation blockchain applications were created using centralized private networks, typically by specific enterprises, often in supply chains (O’Leary 2023a, 2023b). There are some similarities between those classic supply chain systems and the buying and selling of carbon offsets, where the supply chain links supplier carbon offsets to the buyers.

Unfortunately, as noted by O’Leary (2023), those enterprise-base applications have largely failed, for several reasons. Private networks, as compared to public networks, can limit the inclusiveness of participation, potentially limiting access to carbon offsets and asymmetries of information about the access of information. Similarly, centralized markets can limit access over decentralized markets. Furthermore, centralized markets can employ rules that can limit participation and again provide asymmetric information to participants and those that govern.

Approach: Web 3.0

Because of the limitations of private networks in supply chain settings, recently researchers have called out for a change in the way that supply chains work, breaking away from private centralized blockchains to public decentralized markets (Lacity et al. 2024).¹ This paper extends those arguments to the voluntary carbon trading settings.

GOFAI² in Decentralized Markets

This section drills down on some potential issues associated with using AI in building PDN for carbon trading. In this section, we focus on classic “good old fashioned AI,” and in the next section we examine large language models.

Democratization of AI

Lee (2024) suggested that integrating AI and blockchain is leading to a democratization of AI. As noted by Lee (2024) “Blockchain’s transparent, collaborative framework

¹ A recent Google search for “public decentralized market” and “carbon trading” resulted in 0 (zero) documents. As a result, in this paper we focus on analyzing a potential change in that approach.

² Good old fashioned AI.

enables AI models to be created, funded, and managed by decentralized networks, promoting open innovation on a global scale. Rather than a few tech giants controlling AI's development, blockchain-based AI democratization empowers developers and end-users to shape AI's evolution and usage." This approach is aimed at developing ways to allow a variety of investors and developers to own a portion of the AI ecosystem. Blockchain technology and decentralized networks are used to create a marketplace where AI models can be bought, sold, and developed, as with the carbon credits proposed in this paper.

However, others have suggested that the current trend toward generative AI and large language models (LLM) was having a centralizing effect on AI, because of the need to have substantial computational resources. We examine some emerging large language models applications in the next section of the paper.

Continuous Monitoring Systems

O'Leary and Spangler (2016) describe a monitoring system that monitors text sources, about food and food manufacturers, concerned with finding problems with the food. That system monitored a range of text available from different sources, such as Internet sites and news sources, for issues such as obesity, choking hazards, allergies, and other concerns. That system did that search and analysis based on an ontology generated to capture those concerns. That ontology laid out over thirty concepts of concerns and provided various patterns of concern regarding the concept.

When that approach is applied to carbon credits, such systems can have wide application. For example, an important process is to continuously monitor a credit to make sure it is only used once and that any uses are for the appropriate amount, determining that it is a virtuous credit. In addition, carbon credit suppliers can be monitored for news about them to contribute to their reputation. Similarly, carbon offset users can be monitored for the offsets that they use.

Ontologies

Historically, ontologies have played an important part in AI and continuous monitoring systems, providing the language associated with the events of concern. If public decentralized markets are to be used, or if a continuous monitoring system is to be used, then there would be need an ontology to determine when the various events had occurred. It is likely that an important characteristic of any carbon trading ontology would be that it would be an open ontology, which could be contributed to and change over time, possibly as part of the some PDN. Unfortunately, a recent Google Search of "open ontology" and "carbon trading" found no pages. As a result, as part of generating a voluntary carbon trading system would include development of such an ontology.

Smart Contracts

A classic AI approach associated with decentralized blockchain networks are so-called smart contracts, which are typically rule-based. There have been various smart contract approaches proposed for use with carbon trading in blockchain (e.g., Zhang et al. 2023). However, those proposed approaches largely have been embedded in private and centralized networks in mandatory carbon offset systems.

In addition, in the case of voluntary markets, it may be that such systems add another layer of complexity to a situation that they already find overly complex. However, smart contracts could be an important aspect of a voluntary system if they are set up as a "back office" function that the voluntary user does not need to directly address. In that setting, development of these contracts in a public decentralized network could be an important contribution.

Emerging AI Uses for Carbon Offsets

Recently, some companies have reported using AI as part of their carbon offset systems and capabilities. This and the next section report on several new uses of AI for carbon offsets, primarily focused on uses related to large language models or AI integrated with other technologies for digital transformation.

Forest Carbon Monitoring (IETA 2025)

One approach to providing carbon offsets requires the ability to monitor and verify carbon capture in forests. Thus, this approach is useful for monitoring forest projects, addressing deforestation and reforestation. Companies such as "Planet" do earth observation using satellites, which image the earth every day and have been taking that approach for roughly the last eight years. Their analysis is global over all forested parts of the world. As part of their analysis, they use ecology, remote sensing, and AI to take satellite imagery and transform it into information about forest structure and carbon, using three ascertainable data layers, canopy cover, canopy height and above ground live carbon. The databases are pixel-based and thus have quantitative values that can be tracked over time.

Data Quality, Consolidation and LLMs

One of the key concerns in carbon trading markets is fragmented and unverifiable data. Projects are located in different sources and information about sources is often not consolidated. In addition, there are potential data integrity issues such as misrepresentation of the carbon credits and over-crediting. In private markets there are limited participants, and the owner of the private market owns the data.

As a result, it appears that one change occurring over time is that data consolidators are bringing together multiple sources of transaction data and data about suppliers.

Reportedly, as discussed in IETA (2025) Abatable uses large language models as part of the transaction process requirements associated with carbon trading and the information registry (EU 2015). They aggregate multiple sources of disparate data, such as data embedded in Web pages, Excel, and Pdfs, and then feed them to a large language model. Further, as information beyond carbon offset project registry data becomes available it is included and tagged. Using this approach, Abatable (IETA 2025), reported reductions in manual labor and team time spent making sure data is accurate. Finally, they reported that they were able to provide data to users more rapidly.

Political Risk and LLMs

Abatable (IETA 2025) also is examining the approach of training LLMs, such as ChatGPT and Claude on proprietary frameworks – “what is Abatable’s opinion of political risk?” They include policy documents and regulations, and query those documents, providing clients a “vetted” set of opinions to their clients.

Sentiment Analysis

Abatable also is examining the use of sentiment analysis with a focus on “counter party risk” (will both parties to a transaction fulfill their obligations?). In some cases, suppliers have substantial information on the web. Using news and that information on the web pages they gather sentiment and use that to better understand the extent to which carbon offsets are virtuous.

Translate Activity and Data into Forms

Both mandatory and voluntary carbon offset efforts need to be turned into reports. LLMs can be used as tools to help populate those forms and facilitate their instantiation.

Human in the Loop

Throughout these activities, as has been the case in AI research, several companies have stressed the importance of putting human-in-the-loop, to ensure that data quality and system actions are reasonable (e.g., IETA, 2025). For example, reports would be verified.

Unique User Issues in Voluntary Carbon Markets

It has been suggested (IETA 2025) that the biggest problem in voluntary markets is the lack of buyers. The limited number of buyers and their limited experience contribute to market inefficiencies. Ultimately, there are thousands of carbon offset projects to choose from and between 35 – 40 different registries summarizing those projects, creating information overload. Thus, users may find that it is not clear

how they choose among the alternatives and what variables they should consider.

Perhaps artificial intelligence and a decentralized network ledger could be used to mitigate some of these concerns. One approach has been implemented by CNaught using ChatGPT. As an example, ChatGPT can help a user determine the amount of the carbon offset needed and then guide them to a source to choose a carbon offset.

Example: ChatGPT and Offset Calculation

This section is a summary of my interaction with ChatGPT through its “loosely coupled” link to CNaught, the carbon offset company, to help me determine the right number of offsets that I should purchase to make up for my trip to Washington, D.C. I have edited the ChatGPT dialogue, removing unnecessary information. My query is an extended query developed from information in Stankova (2025). As seen below, my one way trip generates around .4 tons of CO_{2e}. Carboncredits.com indicates that the cost is about \$3 to \$5 per ton, so buying carbon credits for my trip would cost about \$1.20.

MY QUERY: *I have a trip to Washington, D.C. I will drive to LAX from Pasadena, California and take a Delta flight, nonstop. When I arrive at DCA Airport, I will take a cab to Westin Arlington Gateway Hotel, in Arlington, Virginia. Can you help me calculate the total emissions for this one way flight and help me select the right amount of offsets for the carbon impact at <https://www.cnaught.com/calculators>.*

ChatGPT said:

Here’s a detailed breakdown of your one-way trip’s carbon emissions and how to offset them using CNaught’s calculator:

1. Drive Pasadena → LAX (≈28 mi / 45 km)

Using CNaught’s car/SUV factor:

- Fuel economy: 22.9 mpg
- CO₂: 8.887 kg/gallon

Calculation:

$$28 \text{ mi} \div 22.9 \text{ mpg} \approx 1.22 \text{ gallons}$$

$$1.22 \times 8.887 \approx 10.8 \text{ kg CO}_2 \approx 0.011 \text{ tonnes CO}_2e$$

2. Flight LAX → DCA (approx. 2,311 mi / 3,719 km)

Using CNaught’s default 95 g CO_{2e} per passenger-km:

$$3,719 \text{ km} \times 95 \text{ g/km} = 353,305 \text{ g} = 353 \text{ kg} = 0.353 \text{ tonnes CO}_2e$$

3. Taxi from DCA to Westin Arlington (approx. 5 mi / 8 km)

Using same car factor:

5 mi ÷ 22.9 mpg = 0.218 gal
 0.218 × 8.887 kg/gal = 1.94 kg ≈ 0.002 tonnes CO_{2e}

Total Estimated Emissions (one-way)

Segment	Tonnes CO _{2e}
Drive to LAX	0.011
Flight LAX→DCA	0.353
Taxi to Hotel	0.002
Total	0.366 tonnes CO_{2e}

4. Offsetting with CNaught

1. Visit CNaught's Flight+ Ground calculator at the link.
2. Input:
 - Flight distance ≈ 3,719 km
 - Ground miles: 28 mi (drive) + 5 mi (taxi)
3. The output should be ~0.37 t CO_{2e} total.
4. To fully neutralize:
 - **Offset ≈ 0.37 tonnes CO_{2e}**
5. CNaught will display suggested credit projects and prices.
6. You can choose to **round up**, e.g., to **0.4 t CO_{2e}**, for extra responsibility.

Example: ChatGPT and Choice of Offset

After finding out about the impact of my travel, I asked ChatGPT another question to help complete the transaction.

MY QUERY: *Where and how can I buy a carbon offset for one ton of CO_{2e}*

ChatGPT said:

You can buy a carbon offset for one ton of CO_{2e} (carbon dioxide equivalent) from a number of reputable organizations and platforms that support certified offset projects. Here's **where** and **how** you can do it:

Where to Buy Carbon Offsets (1 Ton CO_{2e})

Here are trusted platforms offering offsets for individual or small business use:

1. **CNaught**
 - Focus: High-quality offsets, transparency.
 - Type: Verified Carbon Standard (VCS), Gold Standard projects.
 - Cost: Typically, \$10–\$25 per ton.
 - How: Go to the calculator, choose 1 ton, and purchase from their marketplace.

³ <https://zeedimension.com/blogs/f/detecting-fraud-in-carbon-trading?fbclid=IwY2xjawLo4whleH-RuA2F1bQIxMQBicmlkETE4aEg4YW9qTVZGaTV2VGJhAR7v5JWw>

2. Cool Effect

- Focus: Nonprofit platform with verified global projects.
- Cost: Around \$15 per ton.
- How: Choose a project → select “1 ton” → checkout.

Directing Offsets to a Project

As part of countering your carbon footprint, you can either choose a project, say at CNaught, or you can choose Cool Effect which at this time appears to direct carbon offsets to a source, as seen in figure 2.

Donations for travel offset will be directed to:

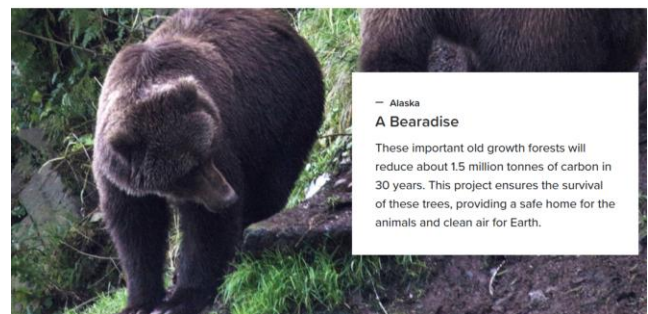


Figure 2 – Project Choice at Cool Effect

A Potential Dark Side of Carbon Trading

Carbon trading takes carbon related events and puts them in a market, whether operating under mandatory compliance or within voluntary carbon markets, carbon assets that serve as carbon credits capture the quantifiable environmental benefits. However, those assets have dollar values, as a result, there is a potential for fraud. For example, credits have been issued to stop deforestation in Brazil, where an estimated 50,000 credits were issued for one million dollars. Unfortunately, deforestation continued and undermined the efforts to do social good.³

Using AI for Digital Fraud

Increasingly, AI is being used to commit fraud. Although there are limited examples available in today's carbon markets it is likely that AI will be used to help create deep fakes that will be treated as legitimate carbon trading assets.

One of the key responses to help limit fraud is to understand how AI is being used in those particular settings. Accordingly, one approach would be to determine how AI could commit fraud in carbon trading.

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Summary and Contributions

This paper has examined the interaction of AI and public decentralized networks in the area of carbon trading. We have differentiated between mandatory and voluntary carbon trading. We have sought to find different uses of artificial intelligence ranging from classic GOFAI such as continuous monitoring systems and ontologies, to emerging large language models. We have illustrated the use of loose coupling with LLMs to facilitate access to key concepts in voluntary carbon offsetting.

This research has identified several approaches that can be used in alternative settings as we explore methodologies associated with using AI for Social Good, including the following:

- Public Decentralized Network – to eliminate information asymmetries and promote transparency, while facilitating inclusiveness and providing an environment with multiple carbon trading opportunities.
- Use of continuous monitoring systems to facilitate the constant capture of changing information
- Development of an open ontology capturing appropriate event information in the continuous monitoring system.
- Using sentiment analysis to infer information about agents involved in the process.
- Using LLMs to facilitate the capture of information for use and to translate for forms to communicate about into forms.
- Using LLMs to summarize political positions associated with the AI for Social Good.
- Loosely couple LLMs to help with determining how much and where to push carbon offsets, more generally, determine alternative action states.
- If possible, integrate with other technologies for information gathering, such as satellites.
- Don't just take any solution as given but instead embed the human in the loop.
- Anticipate future developments, such as the potential of AI for fraud.

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