Title

Autonomous Agents, Smart Contracts and Distributed Ledgers for engineering trust in the Carbon economy

Abstract

Carbon credits hold significant potential to support climate mitigation efforts by providing financial incentives for emissions reductions and carbon sequestration. However, the current carbon credit ecosystem faces critical challenges that undermine its integrity, transparency, and trustworthiness. A primary issue is *double counting*, where the same carbon credit is claimed by multiple parties, leading to unreliable emissions reporting and inflated climate mitigation claims. This issue is exacerbated by the absence of robust frameworks for carbon credit provenance, including unclear ownership histories and ambiguous project documentation. Consequently, it is challenging to verify and ascertain whether a credit is emanating from a genuine emissions reduction activity, or is previously unused, or accurately represents its claimed environmental benefit. These problems are aggravated by manual and inconsistent reporting processes, which introduce inefficiencies and human-induced errors into the evaluation of carbon offset projects. Without intelligent, reliable and standardised mechanisms for automatically assessing project impact, the credibility of carbon markets is severely compromised.

Emerging technologies offer promising solutions to these longstanding issues. Artificial intelligence and advanced sensing technologies now enable high-frequency, real-time tracking of carbon-related activities. These tools could be used to intelligently detect land-use changes, estimate carbon sequestration, and monitor emissions with a level of precision and scalability that manual inspections cannot achieve. When combined with blockchain infrastructure, this data can be securely recorded and time-stamped, providing an immutable audit trail for each carbon credit.

This tutorial systematically explores how blockchain technologies and AI can be leveraged to engineer more trustworthy systems that support the transition to achieve Net-Zero emissions. We focus on two high-impact sectors, namely agriculture and transportation, to illustrate current applications, implementation challenges and emerging best practices.

Finally, the tutorial concludes by outlining future research directions, including the deployment of autonomous agents for intelligent and continuous verification, the integration of smart contracts for automating carbon credit issuance, and the concept of carbon tokens and fractionalisation. Collectively, these innovations offer a path towards restoring the credibility and impact of the carbon markets, while opening new avenues for research, government policy and research translation.

Biographies

Dr Asma Alkhalaf

Dr. Asma Alkhalaf is a leading researcher who is particularly interested in engineering research-inspired solutions that leverage the use of emerging technologies to advance environmental sustainability. With a PhD in Distributed and Cloud Computing, her work bridges environmental sustainability with emerging digital technologies such as blockchain, AI, etc.

She provided leadership to several high-impact projects, such as enhancing transparency in carbon markets through blockchain, IoT, and AI to address issues like double counting and greenwashing. Furthermore, she led another project that conceptualised the notion of Social Carbon and developed an innovative and reliable solution to manage social carbon. Her sustainability-related work spans various sectors, including transportation and agriculture. A key facet of her work across all projects is that they are translational in nature, wherein the developed solution is grounded in research and is being translated into practice.

Asma Mistadi:

Asma Mistadi is a researcher with a strong commitment to the use of technology for environmental sustainability, with a focused interest in the tokenisation and fractionalisation of carbon credits. With a PhD topic grounded in Artificial Intelligence and Blockchain, Asma is uniquely positioned to pioneer the research and development of intelligent and reliable solutions for carbon credit ownership provenance, tokenisation, and fractionalisation.

Asma has pioneered the research and development of AI-driven and reliable frameworks for Carbon tokenisation and fractionalisation, thereby contributing to novel frameworks and methods for establishing transparency in the carbon markets.

Asma has been a key member of several carbon projects, focusing on enhancing transparency in carbon markets through decentralised architectures that leverage the power of blockchain, IoT, and AI. Each of these projects resulted in translational research outcomes with real-world commercial applications.