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Green Digital Currencies: Towards a Sustainable Digital Economy

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Abstract :
This paper explores the potential of green digital currencies as a tool to promote sustainable practices in the digital economy and evaluates their effectiveness in reducing carbon emissions compared to cryptocurrencies and traditional currencies. The study employs a descriptive-analytical methodology.
The analysis results reveal that green cryptocurrencies represent a promising path towards mitigating the environmental impact of digital currencies while promoting responsible investment and renewable energy use. By adopting these innovative solutions, we can build a more sustainable digital economy and support sustainable development goals, despite the challenges and limitations faced by green digital currencies.

Keywords: Green digital currencies; Digital economy; Sustainability; Environmental impact.

JEL Classification Codes : E42; O330; O440; Q5

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Introduction:

In recent years, the rise of cryptocurrencies has sparked a global debate about their environmental impact, particularly concerning energy consumption and carbon emissions. "The annual electricity consumption of Bitcoin is estimated to reach up to 45.8 terawatt-hours" (Stoll & al, 2019), and "studies indicate that Bitcoin's total carbon footprint exceeds that of some of the world's most populous cities such as Beijing, São Paulo, and New Delhi, with annual carbon emissions from its network alone potentially exceeding 90 million tons of carbon dioxide" (Lamba, 2022). Additionally, (Gallersdörfer & al, 2020) found that "Bitcoin represents 2/3 of total energy consumption, and unstudied cryptocurrencies represent the remaining 1/3. Therefore, we find that these unstudied currencies add nearly 50% on top of Bitcoin's energy hunger, which may already cause significant environmental damage on its own." In response, a new wave of digital currencies known as green cryptocurrencies has emerged, prioritizing sustainability and environmental friendliness in their operations. These innovative financial tools leverage advanced technologies and environmentally conscious practices to reduce their carbon footprint. They are defined as those that use less energy and resources than traditional currencies and are designed to be more environmentally friendly. They use renewable energy sources to power their mining operations and can be mined using solar, hydroelectric, wind, and other renewable energy sources (Crypto Reporter PR, 2022). Green and non-green cryptocurrencies are defined based on the mining process; green cryptocurrencies are mined through Proof of Stake (POS), while non-green currencies are mined through Proof of Work (POW) (Lantto, 2022).

Green cryptocurrencies are digital currencies designed with sustainability in mind. They use environmentally friendly consensus mechanisms such as Proof of Stake (PoS) or Delegated Proof of Stake (DPoS), which require significantly less energy compared to traditional Proof of Work (PoW) systems. Additionally, many green cryptocurrencies are committed to offsetting carbon emissions or supporting renewable energy projects, aligning their operations with environmental sustainability goals. Various methods are being explored to make cryptocurrencies more sustainable, with two main approaches. The first approach involves directly removing carbon from cryptocurrencies by reducing emissions, meaning the transition of digital currencies that operate on the energy-intensive Proof of Work (POW) protocol to more efficient algorithms such as Proof of Stake (POS) or Delegated Proof of Stake (DPoS), which require much less energy to run digital currency networks and often use renewable energy sources in mining and transactions. The second approach involves negative emissions from carbon offsets, also known as "carbon credits," which represent projects that reduce emissions or remove carbon dioxide from the atmosphere, such as forest conservation, building wind and solar farms, or capturing methane gas (Kessler, 2024). In simpler terms, we take a preventive measure in attempts to justify a high level of carbon already emitted into the environment by contributing to another project or organization designed to reduce carbon emissions and enhance positive environmental impact (Normand, 2023).

To achieve carbon neutrality, both measures must be used side by side. However, it appears that linking cryptocurrencies to carbon offsets is the most practical approach to mitigating their climate impact, as many significant constraints limit future carbon removal from this sector (Lamba, 2022). Green cryptocurrencies emerge as a tool to eliminate and reduce carbon emissions and play a vital role in promoting the trend towards a sustainable digital economy. They not only provide an alternative to traditional cryptocurrencies that rely on consuming large amounts of energy but also encourage investment in more environmentally friendly technologies and initiatives. By aligning blockchain principles with environmental stewardship, green cryptocurrencies pave the way for a more sustainable financial future and promote responsible practices that can contribute to mitigating the environmental challenges we face in our current era and support sustainable development goals.

- **Research Question:**

To what extent do green digital currencies impact sustainable economic practices, stimulate environmentally friendly behaviors, and contribute to driving a sustainable digital economy?

- **Hypothesis:**

The implementation of green digital currencies will significantly enhance the adoption of sustainable economic practices, leading to measurable reductions in carbon emissions and increased investments in environmentally friendly initiatives.

- **Study Aim**:

Our study aims to assess the potential of green digital currencies as a tool to promote sustainable practices in the digital economy and evaluate the effectiveness of green digital currencies in reducing carbon emissions compared to traditional cryptocurrencies and paper currencies.

We relied on the descriptive analytical method, using reports and studies related to the topic as well as specialized websites.

The original contribution of our research paper is highlighted by increasing the focus on the importance of green cryptocurrencies in achieving access to a sustainable digital economy through objective analysis of studies.

The rest of the paper after the introduction is organized as follows: Section 2 reviews the literature. This is followed by Section 3, which presents the importance of green cryptocurrencies. Section 4 presents the limitations and challenges of green cryptocurrencies. Section 5 provides a comparison between green cryptocurrency, paper currency, and cryptocurrency. Section 6 uses building a sustainable digital economy using green cryptocurrencies. In Section 7, we discuss the results and conclude.

2. Literature Review:

This paper relates to the literature on green cryptocurrencies in promoting sustainable practices and reducing carbon impacts. (Karim & al, 2023) explored

sustainability paths in digital currencies and resource-backed cryptocurrencies, focusing on the positive effects of energy-saving technologies such as Proof of Stake (PoS) and supporting renewable energy projects. They concluded that if resource efficiency is enhanced and waste reduced, blockchain has the potential to increase transparency, reduce corruption, and promote sustainability. They acknowledged that there are many different and complex aspects to the sustainability of cryptocurrencies. (Astri & al, 2024) systematically reviewed the driving forces behind the acceptance of green cryptocurrencies and identified key factors such as environmental awareness and regulatory support. When (Wendl & al, 2023) conducted a systematic literature review to investigate the environmental impact of Proof of Work (PoW) and Proof of Stake (PoS) cryptocurrencies, they found that Proof of Stake cryptocurrencies are a more sustainable alternative and a more environmentally friendly option to Proof of Work cryptocurrencies, which have a significant environmental impact. a study by (Ali & al, 2023) identified green cryptocurrencies such as Cardano, Tezos, EOS, Stellar, and IOTA as greener than other cryptocurrencies, offering similar or superior diversification benefits to traditional energy-intensive cryptocurrencies. (Boru1 & Brian, 2022) argue that clean cryptocurrencies have been transmitting volatility shocks to dirty cryptocurrencies since 2021, but dirty cryptocurrencies still dominate the cryptocurrency market as return transmitters. Apparently, the current policy to promote sustainability is not attractive enough for cryptocurrency founders; policymakers should create incentives for dirty cryptocurrencies to transition from the Proof of Work consensus mechanism to energy-efficient non-Proof of Work consensus.

Using the TVP-VAR (Time-Varying Parameter Vector Autoregression) extension model, (Zaghum & al, 2023) studied the dynamic link between fossil fuels and digital ESG assets represented by green cryptocurrency. They also studied the hedging characteristics of green cryptocurrencies and fossil fuels using the minimum correlation model. They found that green cryptocurrencies are the primary shock transmitters in all asset systems, and green cryptocurrencies showed significant hedging effectiveness against fossil fuels. (Sharif & al, 2023) applied a new quantitative extension index approach to study correlations and indirect relationships between green economy indices and five dirty cryptocurrencies and five clean cryptocurrencies for US, Euro, and Asian markets. The results showed that there is a strong general correlation between green economy indices and clean cryptocurrencies compared to dirty cryptocurrencies. Moreover, they found the overall indirect effect to be very high for all quantities in the three markets, especially for Asia. This indicates a safe haven property for green economy diversification purposes. The findings of (Boru & Brian , 2022) argue that policy efforts to shift investors towards cleaner cryptocurrencies may falter as long as dirty cryptocurrencies remain dominant in terms of volume and prominence. This is due to the tendency of clean cryptocurrency investors to follow the behavior of dirty cryptocurrency investors in emerging markets.

3. Importance of Green Cryptocurrencies: (3Decrypt, 2023)

- **Reducing Carbon Footprint:**

Traditional cryptocurrencies, such as Bitcoin, have been criticized for their high energy consumption and carbon emissions. Green cryptocurrencies aim to reduce this footprint, contributing to global efforts to combat climate change.

- **Promoting Renewable Energy:**

Many green cryptocurrencies incentivize the use of renewable energy sources for mining and transactions. This not only supports the transition to a sustainable energy economy but also creates demand for clean energy technologies.

- **Encouraging Responsible Investment:**

With increasing awareness of environmental issues, investors are increasingly looking for sustainable investment opportunities. Green cryptocurrencies provide a viable option for environmentally conscious investors, promoting responsible financial practices.

Additionally:

- **Enhancing Public Trust:**

By prioritizing sustainability, green cryptocurrencies can boost public confidence and acceptance of digital currencies. Transparency in environmental practices can promote a positive image and encourage wider adoption.

- **Supporting Sustainable Development Goals (SDGs):**

Green cryptocurrencies can contribute to various Sustainable Development Goals, particularly those related to climate action, sustainable cities, and responsible consumption and production. By aligning with these goals, they play a crucial role in promoting a more sustainable global economy.

4. Limitations and Challenges of Green Cryptocurrencies: (ai-essay, 2024) (claude-ai, 2024)**:**

While green cryptocurrencies aim to reduce the environmental impact of traditional cryptocurrencies, they still face several limitations and challenges:

- **Questionable Carbon Offsetting:**

Many green cryptocurrencies claim to offset their carbon emissions, but the effectiveness of these measures is often unverified. Without stringent standards and accountability, it's difficult to ascertain whether these offsets genuinely contribute to environmental sustainability or are merely marketing gimmicks. Some critics view carbon offsetting as a temporary solution that doesn't address the fundamental problem of energy consumption.

- **Reliance on Renewable Energy**:

While some green cryptocurrencies promote the use of renewable energy, the overall energy demand in the cryptocurrency space still outstrips supply. This can lead to increased competition for renewable resources, potentially driving up costs and limiting their availability for other critical sectors. Additionally, renewable energy infrastructure may not be ready in some regions, limiting the effectiveness of these initiatives.

- **Investor Misconceptions:**

The increasing popularity of green cryptocurrencies may create a false sense of security among investors regarding their environmental impact. Many investors may not fully understand the complexities involved, leading to investments that don't truly align with their sustainability goals.

- **Public Trust Issues:**

Although promoting sustainability can enhance public trust, the cryptocurrency space is fraught with skepticism due to past scandals and volatility. Green cryptocurrencies may struggle to gain acceptance if they are perceived as just another attempt to capitalize on environmental concerns without taking substantial action.

- **Limited Impact on Broader Issues:**

While green cryptocurrencies may contribute to some Sustainable Development Goals (SDGs), they don't address the fundamental issues of economic inequality and access to technology. Focusing solely on environmental aspects may divert attention from these critical social challenges, limiting their overall effectiveness in promoting a sustainable global economy.

- **Implementation Costs:**

Transitioning to environmentally friendly technologies such as the Proof of Stake (PoS) mechanism requires significant investments in technology and infrastructure. These costs may be a barrier for some small businesses and projects.

- **Regulatory Challenges:**

Green cryptocurrencies may face regulatory and policy challenges, as environmental policies and financial regulations vary from country to country. This may affect the spread and adoption of these currencies on a large scale.

- **Technology and Development:**

Continuous technology development is challenging, as innovation in cryptocurrencies requires significant resources and time. There is an ongoing need to improve efficiency and reduce energy consumption.

- **Residual Environmental Impact:**

Despite efforts made, there is still an environmental impact from green cryptocurrencies. Operations associated with mining and trading cryptocurrencies consume natural resources and produce carbon emissions, even if less than traditional cryptocurrencies.

- **Market Competitiveness**:

Green cryptocurrencies face strong competition from traditional cryptocurrencies that have a large user base and huge investments. This makes it difficult for them to attract users and investors.

The limitations and challenges indicate that the shift towards using green cryptocurrencies needs joint efforts from governments, companies, and society to achieve the desired environmental benefits.

5.Comparison between Green Cryptocurrency, fiat Currency, and Cryptocurrency:

Cryptocurrencies, fiat currencies, and green digital currencies are characterized by distinct features, advantages, and disadvantages. Consequently, we have conducted a comparison between them (Table 01). This comparison will enable an evaluation of these currencies and highlight which is superior in terms of contributing to a more sustainable financial environment.

Table number (01): Compare the three currencies

	Green Cryptocurrency	fiat Currency	Traditional Cryptocurrency (e.g., Bitcoin)
Energy Consumption	Relies on environmentally friendly technologies such as Proof of Stake (PoS) mechanisms that require much less energy compared to Proof of Work (PoW) mechanisms used in traditional cryptocurrencies	Requires significant resources for production and distribution, such as paper, ink, and transportation, but consumes less energy than traditional cryptocurrencies	Relies on the Proof of Work (PoW) mechanism, which consumes enormous amounts of electrical energy. For example, the Bitcoin network consumes energy equivalent to the consumption of some small countries
Carbon Emissions	Contributes to reducing the carbon footprint thanks to its reliance on renewable energy and carbon emission offsetting	Causes carbon emissions resulting from manufacturing and distribution processes, but remains lower compared to emissions from traditional cryptocurrencies.	Causes huge carbon emissions due to high energy consumption, making it environmentally unsustainable.
Sustainability	Commits to supporting environmental projects and sustainable initiatives, promoting sustainable development.	Depends on government policies and central banks, and may not always be environmentally sustainable.	Does not focus greatly on environmental sustainability, and its contribution to environmental projects is limited.
Public Trust	Encourages responsible investment and increases public confidence in environmentally friendly blockchain technologies.	Enjoys public trust due to its long history and widespread use.	Enjoys great popularity and trust among investors due to high market value and wide use, but faces criticism regarding its significant environmental impact.

Source: by Authers.

5.1: Common Points and Key Differences:

- Energy Consumption: Green cryptocurrencies consume less energy compared to traditional cryptocurrencies, while paper currencies require different resources but with less energy quantity.
- Carbon Emissions: Green cryptocurrencies seek to reduce the carbon footprint, while traditional cryptocurrencies cause significant carbon emissions, and paper currencies fall in the middle.
- Sustainability: Green cryptocurrencies focus on environmental sustainability, while traditional cryptocurrencies often ignore this aspect, and paper currencies depend on government policies.
- Public Trust: Paper currencies enjoy great trust, traditional cryptocurrencies are in the early stages of building trust, while green cryptocurrencies seek to build this trust through adopting responsible environmental practices.

6. Building a Sustainable Digital Economy Using Green Cryptocurrencies:

The digital economy encompasses all economic activities that result from billions of daily online connections between people, businesses, devices, data, and processes (Deloitte, 2021). Sustainability in this context refers to practices that ensure economic growth without depleting natural resources, causing environmental damage, or contributing to climate change (Mollenkamp , 2023).

Digital currencies can play a pivotal role in shaping a more sustainable digital economy by facilitating efficient transactions, reducing the need for physical resources, and potentially supporting environmentally friendly initiatives. They can also drive financial inclusion, create economic opportunities aligned with sustainable development goals, and promote and support the use of renewable energy sources. By stimulating the use of clean and renewable energy, green cryptocurrencies can accelerate the transition towards a more sustainable energy landscape. This also has the potential to create new job opportunities in the renewable energy sector, contributing to overall economic growth. Moreover, green cryptocurrencies can also enhance transparency and accountability in the digital economy. Blockchain technology, which underpins most cryptocurrencies, allows for a decentralized and secure way to record and verify transactions. This means that transactions made using green cryptocurrencies can be transparently tracked, reducing the risks of fraud and enhancing trust in the digital economy.

Therefore, green cryptocurrencies are essential in developing a sustainable digital economy. Their ability to reduce carbon emissions, lower costs, and increase scalability makes them a desirable alternative to traditional cryptocurrencies. However, they also face challenges and limitations, such as adoption and availability. To fully realize the potential of green cryptocurrencies, there must be a concerted effort from governments, regulators, and the general public. By promoting and supporting the use of green

cryptocurrencies, we can create a more sustainable and environmentally friendly digital economy for future generations.

7. Overview of the most important countries in the implementation of green cryptocurrencies:

Green cryptocurrencies like Cardano, Tezos, BitGreen, and others demonstrate that balancing innovation with environmental responsibility is achievable. By selecting more environmentally conscious cryptocurrency solutions, we can support the transition toward a more sustainable digital economy and a greener financial future. Several countries have successfully implemented green cryptocurrencies, focusing on sustainable practices and renewable energy sources in their cryptocurrency systems. Here are notable examples: (Ishida & Yoshida , 2024) (Volek, 2023):

- **Ethiopia:**

Ethiopia is leading the charge in Africa for bitcoin mining powered by renewable energy. The country has been developing its energy infrastructure to support sustainable mining operations, leveraging its abundant hydroelectric power to minimize the environmental impact of cryptocurrency mining.

- **Kenya:**

Kenya has embraced geothermal energy for bitcoin mining, making it a pioneer in utilizing renewable resources for crypto activities. The country's largest electricity provider, KenGen, has invited bitcoin miners to use its geothermal energy, which is both abundant and environmentally friendly.

- **Zambia:**

Zambia is emerging as a potential hub for green cryptocurrency mining due to its low electricity costs and favorable business environment. Although the central bank has issued warnings about cryptocurrencies, it has not banned mining activities, allowing for the development of small-scale operations that can utilize renewable energy sources.

- **Switzerland:**

Switzerland ranks high on the Crypto Adoption Index and is known for its supportive regulatory environment for cryptocurrencies. The country encourages innovation in blockchain technology and has a robust infrastructure that includes many crypto exchanges and services focused on sustainable practices.

- **United Arab Emirates (UAE):**

The UAE has established itself as a leading jurisdiction for crypto investment and innovation, with zero taxes on crypto transactions. Its regulatory framework encourages the development of sustainable cryptocurrency projects, attracting a high percentage of crypto users relative to its population.

- **Malta:**

Malta has developed a reputation as a "Blockchain Island," promoting innovation and regulatory clarity in the cryptocurrency sector. The government supports initiatives that encourage environmentally friendly practices within the blockchain ecosystem.

8. Results and Discussion:

While traditional cryptocurrencies are criticized for their environmental impact as they suffer from fundamentally unsustainable structural problems, the emergence of green digital currencies aiming to support green and sustainable practices raises questions about their effectiveness and adoption. The idea that green digital currencies can effectively mitigate the environmental impact of cryptocurrencies as a whole is overly optimistic and may not address broader systemic issues. This is despite green digital currencies representing an apparently positive shift towards sustainability in the economic sector, especially digital, and supporting green practices.

As mentioned earlier, green digital currencies are often marketed as environmentally friendly alternatives, using mechanisms such as Proof of Stake (PoS), Delegated Proof of Stake (DPoS), Proof of Authority (PoA) (Natali, 2023), and other mechanisms that require less energy. However, the reality is that these systems are not entirely free from environmental impact, as the infrastructure supporting these currencies, including servers and data centers, still consumes significant energy. Moreover, reliance on PoS can lead to centralization, where a small number of stakeholders control the majority of the currency, undermining the decentralized spirit of cryptocurrencies.

In reality, the promotion of green cryptocurrencies offers the potential to foster an economy that prioritizes not only financial gains but also environmental stewardship. Additionally, these currencies can support projects and organizations focused on sustainability, despite the fact that the development and adoption of green cryptocurrencies may necessitate new regulations and policies to ensure their positive contribution to environmental objectives. Governments and regulatory bodies may need to establish frameworks that encourage the use of cryptocurrencies in a sustainable manner. Although not all green cryptocurrencies are perfect, they have the potential to improve the financial industry and provide a sustainable alternative to the traditional monetary system, making it more environmentally friendly. This can be achieved through lower energy consumption or the use of renewable resources such as solar or wind power, which do not produce carbon emissions. Furthermore, people can reduce their carbon footprint and help mitigate emissions without relinquishing their investments, thus aiding in the fight against climate change (Crypto Reporter PR, 2022). Ultimately, the transition from environmentally harmful practices to sustainable ones requires significant effort and collaboration from multiple stakeholders.

Conclusion

The importance of integrating sustainability into the cryptocurrency space cannot be overstated, especially as the digital economy continues to evolve. Green cryptocurrencies represent a promising path towards reducing the environmental impact of digital currencies while promoting responsible investment and the use of renewable energy. By embracing these innovative solutions, we can build a more sustainable digital economy that benefits both people and the planet. However, the potential benefits of green cryptocurrencies should not overshadow the real challenges and limitations they face.

While they provide an innovative approach to incorporating sustainability into the cryptocurrency sector, it is crucial to critically evaluate their effectiveness and the broader implications of their adoption. A more comprehensive strategy is needed to ensure that the digital economy evolves in a manner that truly benefits both the environment and society as a whole. In summary, green cryptocurrencies offer a promising approach to integrating sustainability into the digital economy, although their effectiveness and challenges require further investigation.

Recommendations:

Our findings hold significant implications for policymakers, stakeholders, and environmental advocates. Policymakers can support innovation in digital assets while promoting sustainability by leveraging renewable natural resources and creating a regulatory environment conducive to greener cryptocurrency practices. They can also reformulate and develop environmental standards for green digital currencies to ensure alignment with sustainable development goals and encourage investment in them.

For stakeholders, our findings emphasize the imperative transition toward renewable natural resources to protect the environment and climate while achieving long-term digital sustainability. Meanwhile, our results support environmental advocates in promoting investment in clean and renewable energy to protect against climate change and environmental degradation.

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