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Sustainability In NFT: Discrepancies Between The Discussion and Actualization Of Environmental Friendly NFT

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Abstract. *As the globe faces difficulties in 2019, NFT grew popular in making, buying, selling, and trading more efficient while lowering the possibility of fraud. [1] This study aims to examine the claims made in academic literature regarding the sustainability of non-fungible tokens for the environment. Despite the growth of NFTs in 2019, the environmental impact of this technology has received little attention. Using a qualitative exploratory approach, this research analyzes relevant academic journals to understand the theoretical sustainability of NFTs and how that aligns, or fails to align, with the reality. The goal is to raise awareness about the environmental implications of NFTs and provide a critical assessment of the existing claims surrounding their sustainability.*

Keywords*: NFT, Environmental Sustainability, Proof of Stake, Carbon emission.*

1. INTRODUCTION

NFT (Non-Fungible Tokens) is a term that has gained significant traction in recent years, especially within the realm of digital art and collectibles. [2] The concept of NFTs revolves around the idea of providing a unique digital representation of ownership for various assets, such as artwork, or music using blockchain. [3] In simple terms, blockchain is a system that manages and provides record and safety for the NFT. It's a digital ledger that stores data, according to David Rodeck, and Benjamin Curry. [4] A graph from Statistia shows the increasing trend of NFTs from the year 2020-2022:

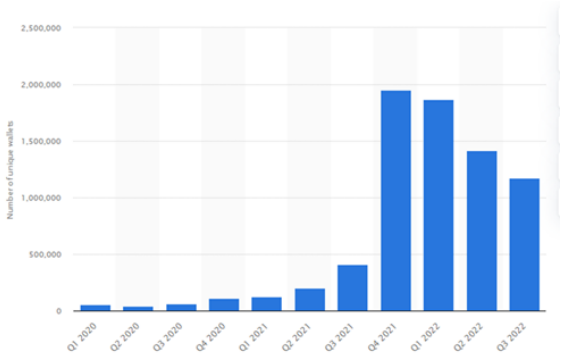

Figure 1. Quarterly number of NFT users worldwide 2020-2022 (Best, 2023)

From the graph above, it can be seen that NFT reached its peak in the fourth quarter of 2021. However, alongside the growing popularity and monetary value of NFTs, questions have arisen regarding their impact on sustainability and the environment. Interestingly, while the environmental implications of NFTs has been extensively discussed and acknowledged, the

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adoption of sustainable practices within the NFT ecosystem has yet to be realized. The primary concern regarding the sustainability of NFTs stems from the high energy consumption and carbon footprint associated with the blockchain technology that underpins them. The mining process required to verify and record the transactions within the blockchain requires significant energy consumption which results in large carbon emissions.

According to research by J. Truby et. al[5], "Based on the assumption that 4434 metric tons could kill a person unnecessarily - Hypothetically, the mining devices verifying NFT sales in one month in 2021 would be responsible for approximately 18 unnecessary future deaths from carbon emissions." This shows how dangerous NFT transactions are, not only for the environment but also for humans. In another research conducted by the World Health Organization[6], exposure to pollution, both long and short term, can cause detrimental effects towards our body. Several include respiratory infections, heart diseases, and lung cancer. Which is why immediate measures must be taken to minimize the damage.

2. OBJECTIVES

This research aims to find the gap between the theories and actualization of sustainable NFTs, and to discuss whether it is possible to apply it in the real world. The purpose of this research is to compare and provide solutions to the NFT's problem, the difference in the discussion and the practical implementation of making NFTs environmentally sustainable.

We selected the qualitative research method as it aligns with the conducted investigation and provides a systematic approach to processing the gathered information. This method is valuable for examining complex phenomena, as it can track unique or unexpected events, while also helping to prevent bias and identify data that contradicts initial or emerging hypotheses. In the context of our research, qualitative methodologies can assist us in determining and mitigating potential biases and inaccuracies when examining the evidence.

Figure 2. Research Flow Chart

3. METHODS

This study was conducted using a literature review in journals, with qualitative exploratory methods. We use qualitative research methods from secondary sources to support our research questions and findings. According to the Sage Publications library guide, explanatory research is the research to formulate problems, clarify concepts and form hypotheses. It is a method of processing the information gathered and checked for its reliability and validity, as well as making sure the resources used for the research paper itself are very clear and sort through any additional information that presents itself after the research is finished. [7] Therefore, it is a process where most or all resources used are being put into question. As researchers, we think it's important that we exercise this method since it might as well encourage the notion of double checking the information used, which can be vital to solving the topic being discussed in the research.

The literature review in this study involved selecting relevant articles, reviewing and analyzing them, and synthesizing their findings. The focus of this research is to explore the topic of sustainability in Non-Fungible Tokens (NFT) and investigate the inconsistencies between the discussion and the actual implementation of environmentally friendly NFTs. We review the latest journal to the journals that focus and discuss the negative effects in NFT. We decided to filter our journal by the oldest year 2016 to make sure that the information that we obtain are still relevant with the current situation. According to Wang Jian[8], "3-year time window is sufficient for the biomedical research fields and

multidisciplinary sciences, while a 7-year time window is required for the humanities and mathematics."

4. RESULTS AND DISCUSSION

This study reports the discrepancies between the theory of sustainable NFTs and the actualization of sustainable practices for NFTs. After conducting a qualitative literature analysis using secondary sources and examining real-world practices, significant gaps are found between the discussion of sustainable NFTs and the implementation. While studies claim that sustainable NFTs are possible to be accomplished, in reality, there are several factors that complicates the path to make NFTs environmentally friendly.

Previously, few research suggested that there are ways to improve the sustainability of NFTs. Theoretically, NFTs could be sustainable. According to Mark Radka [9], Chief of UNEP's Energy and Climate Branch, NFT, can play a role in reducing global warming by making correct distribution through effective data utilization. The problem with NFTs lies in their crypto trading, which requires mining from a person's computer that uses a lot of electricity from burning coal and fossil fuels. [1]

Below is the graph of total Bitcoin yearly electricity consumption:

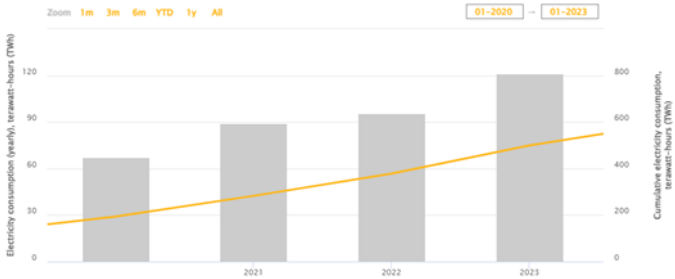

Figure 3. Total electricity consumption Bitcoin

As an example, 1 bitcoin is equivalent to taking 155,000 KWh of electricity. [10] As seen on the graph above, according to the Cambridge Centre for Alternative Finance (CCAF), Bitcoin now consumes around 150 Terawatt Hours per year, or roughly the annual energy usage of small countries such as Malaysia or Sweden. [11,12] The most probable solution to create a more sustainable NFT is to change its source of electricity to either renewable energy, or improve the efficiency of the mining hardware. [5] There are some companies who are already starting to be sustainable like Chia (0.023kWh), Iota (0.00011kWh), Cardano, and Nano. [13] They mostly use efficient hardware, which reduces their carbon footprint. However, it can be deduced that smaller NFT ecosystems tend to have a lower environmental impact due to the reduced volume of transactions processed.The World Wildlife Fund attracted criticism after

announcing intentions to use Polygon for NFTs. This prompted 'digiconomist' Alex de Vries[14] to write a blog post in which he examined Polygon's activities on the Ethereum network. He said that a Polygon transaction has a carbon footprint of over 430 grams of CO2, which is 2,100 times greater than the WWF's optimistic estimate, implying that Polygon is not as sustainable as advertised. Ethereum is one of the most polluting NFT firms. As a result, while some organizations claim to be beginning to reduce their carbon footprint, larger corporations generate more pollution due to the number of transactions.

Previous studies also suggest that changing the blockchain from Proof of Work (PoW) system to Proof of Stake (PoS) can reduce carbon emissions, it is found that Proof of Stake (PoS) alone is not effective enough to reduce carbon emissions. [15] Although PoS may be more energy efficient, “A single Ethereum transaction, often required for the purchase or sale of NFT art, is still quite energy-consuming. Consequently, the carbon emissions from NFT art transactions are still substantial and cannot be disregarded.” [16] Which means that although changing the blockchain system may help reduce the amount of carbon emitted by transactions, it is still notably high. Currently in 2023, after the change in the blockchain system, Ethereum still emits 870 tonnes CO2 yearly as reported by the company itself, showing that although this transition to another system can be recognized as the first step towards reducing the carbon footprint of NFT, this alone cannot address the climate concerns of NFT. Consequently, even with less significant energy consumption for individual NFT transaction, “the cumulative effect of increased numbers of validators operating on fossil dominant grids will lead to a further rise in the carbon debt associated with NFTs”. [19] Which further demonstrates how sustainable NFTs is something that require multi approach and is incredibly challenging to be achieved. [17]

Table 1. Main findings from several journals

Non-fungible tokens (NFTs)-survey of current applications, evolution and future directions (Razi et al., 2023).	The paper highlights the technical aspects, minting process, and various applications of NFTs across different sectors. It also discusses the challenges in implementing NFT technology, including issues related to ownership, governance, security, privacy, and environmental impacts, suggesting future directions to address these challenges. The reference aligns with the task by acknowledging the potential for NFTs to promote sustainability through practices like carbon offsets or other environmental incentives. [18]
Climate concerns and the future of nonfungible tokens: Leveraging environmental benefits of the Ethereum Merge (Lal & You, 2023).	To address the sustainability concerns surrounding NFTs, Lal and You[19] suggest leveraging untapped renewable energy sources in the United States

	to power the sector, as outlined in their study on the environmental benefits of the Ethereum Merge.
Post-Merge Carbon Footprint Analysis and Sustainability in the NFT Art Market (Tian Zhongbo., 2023)	This study discusses the rapid growth of NFT and the ongoing concerns of environmental sustainability, highlighting the Ethereum "Merge" to Proof-of-Stake, offering various solutions, including carbon neutrality, lazy minting, alternative consensus mechanisms, Layer 2 scaling, and policy interventions. The strategy is emphasized to be able to mitigate the environmental footprint of NFT. [20]
Critical Factors and Trends in NFT Technology Innovations (Wu & Weng.,2023)	This study analyzed NFT products, fashion characteristics, and trends in NFT artwork. The opportunities and challenges of NFT applications and sustainable NFTs are discussed in this study. This study also analyzes the applications of NFTs in sustainable education that can contribute to sustainable educational development, aligning with the objective of achieving quality education as outlined in Sustainable Development Goal 4. [21]

From the journal observation done, it can be observed that currently, there is no concrete proof that NFT can be built sustainably. In short, the majority of existing articles have only been able to make suggestions. Several articles and journals have proclaimed that sustainability can be achieved through different means such as using proof-of-stake as part of the transaction process and the possibility of using renewable energy, however as mentioned before sustainable NFT requires a multi approach which makes it hard to attain. Instead, companies that were able to show proof of sustainable NFT practices and crypto currency are minor companies that not a lot of people heard of, therefore, not well known compared to its more popular counterparts.

Following the previous point, the biggest carbon footprint is more often created by popular and successful NFT and crypto companies, namely Ethereum, which is very well known for its usage for purchasing NFT. Not only Ethereum, other companies and collections that also dabble in similar practice such as Solana, Sorare, Art Blocks, and CryptoKitties, in which the last is known to be the most damaging in comparison. But as our point suggests, there are indeed companies that have succeeded in creating eco-friendly cryptocurrencies such as Chia, IOTAm Cardano, Nano and Bitgreen, all which has succeeded by the means of making the system use less power, or using different devices which allows electricity control and leading to reduced power usage. [13]

The main gap that we found is the lack of research into trying to solve the issue, or otherwise affirming and proving the claim that NFT can be environmentally sustainable. From our research, we found that there are seldom articles that discuss how an NFT can be

sustainable, and almost no explanation for the claim in the articles, and with the lack of research paper on that specific topic, we concluded that these are the factors that contribute to the imbalance of supporting evidence. This is most notable when searching up the process of how a company came up with a sustainable resource for cryptocurrency when purchasing an NFT. With the lack of research papers, we had to rely on articles and environmental reports from the company, although most of them refused to elaborate on the details. Along with the lack of research, other requirements for valid research are also lacking, especially the subjects of research. In relation to the subjects, few people had actively used NFT in the first place, therefore the research can only be done with a very specific group of people. This also contributes heavily on why research into the topic is very minimal.

5. CONCLUSION

In the end, it can be concluded that NFT (Non-Fungible Tokens) is a term providing a unique digital representation of ownership for various assets, such as artwork or music. Its peak performance occurred in 2021. NFTs are generated by mining, which is the act of publishing assets on a blockchain network for buying, selling, and transferring, with ownership recognized and recorded on the blockchain. However, as NFTs' popularity and monetary worth have grown, concerns about their influence on sustainability and the environment have arisen. There are multiple articles that claim NFT could be sustainable by using renewable energy such as the use of wind turbines or even hydropower generators, and through it. In addition, it is also mentioned that companies are already taking actions in reducing carbon footprint. But those companies are smaller companies that have fewer transactions. As such, even though there might be improvements that can be considered as the first step in reducing NFT carbon footprints, the sustainability of NFT requires a multi approach to further reduce the carbon footprints generated which demonstrates the difficulty of making NFT environmentally friendly. Our research found the gap in making terms of NFT could be sustainable without having concrete evidence or activities that have succeeded in significantly reducing carbon footprint.

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