Unveiling the Ecological Costs of the Digital Era: Assessing the Carbon footprint for Sustainable Digital transformation

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ABSTRACT:

Although the digital revolution's rapid growth in Information and Communication Technology has had extraordinary advantages and revolutionised many aspects of human life, its environmental costs have become a major worry. By measuring the carbon footprint of information and communication technology and investigating options for sustainable digital transformation, this research study seeks to elucidate the ecological cost of the digital era. To be precise , Digital Carbon Footprint is the amount of green gas being emitted from the usage of digital devices .Every single activity (like scrolling social media, browsing, sending e-mails, streaming videos and music) in the internet leaves a carbon footprint. Digital Carbon Footprint is mainly caused by digital devices, data centers, emails etc..,.The study's findings show that data centres contribute to a significant amount of carbon emissions since they use a lot of energy. The research paper focuses on the causes of the digital footprint, methods to reduce, tools to measure the emission.The findings shed light on the environmental impacts of the digital era and provide insights for developing strategies to minimize the carbon footprint of ICT for a sustainable future.

KEYWORDS:

Digital carbon footprint, Sustainability, Data centres, Global warming, Climate change, CO2 emissions.

I. INTRODUCTION:

Digitalization is the incorporation of digital technologies into business or social sector to provide new revenue and value-producing opportunities. According to scientists, Digitization can be compared to rapid tsunami [1]. To define the term "Digital Transformation ", as in [2] "A process that aims to improve an entity by triggering significant changes to its properties through combinations of information , computing, communication and connectivity technologies". It is necessary to understand the association between the Digital transformation and Environmental Sustainability. [3]As everybody know, technologies have both advantage and disadvantages. Though digitalization has made the world perform tasks simpler, it also has made an environmental impact by emitting a large amount of greenhouse gases leaving its carbon footprint in the nature causing global warming. It is important for each individual to keep track of their usage of digital devices to avoid global warming and to create the world as a better place to live for the future generation. This research paper gives an idea of carbon emission and how to switch to energy-renewable sources to create a greener environment.

II. PROBLEM STATEMENT:

The energy consumption of network infrastructure, including data centres, network devices, and communication networks, has reached alarming levels contributing to a

significant carbon footprint. The rapid growth of Information and communication technology has increased energy demand and as a result carbon emissions. Through energy –efficient network designing and management practices it is vital to address the energy inefficiency and environmental effect of ICT networks .Additionally, companies encounter numerous challenges when implementing energy efficient network design and administration and the trade-off between network performance and cost makes it more difficult for them to make decisions.

III. METHODOLOGIES:

A. Carbon Footprint Analysis of ICT Components

Concept of Digital Carbon Footprint

The digital carbon footprint can be defined as the "CO2 emissions or the total amount of greenhouse gas emissions resulting from the production, use and data transfer of digital devices and infrastructure."[5] It encompasses the carbon emissions associated with the production, operation and disposal of information and communication technology and their supporting infrastructure.

Factors that contribute to Digital Carbon Footprint globally are

- Device Proliferation and Data Growth: The footprint is impacted by the exponential growth of data as well as the rising use of digital devices like smartphones, laptops, and IoT devices. Energy is needed for each device's manufacture, use, and disposal. Processing and storing enormous volumes of data also demands a lot of computing power and energy resources.
- Network Infrastructure: The energy use of network infrastructure, such as routers, switches, and transmission equipment, adds to the digital carbon footprint. Higher energy needs and carbon emissions are caused by the growing demand for data transfer and the expanding reach of telecommunications networks.
- Data Centres and Cloud Computing: Data centres, which contain the servers and networking equipment for storing and processing data, utilise a significant amount of electricity and increase the digital carbon footprint.
- Software and applications: It can influence energy consumption and carbon emissions by optimizing code, reducing computational requirements and minimizing data transmission. Inefficient software design, excessive data transfers and unnecessary background transfers can contribute to higher energy consumption and carbon emissions.

B. Data collection and analysis methods for carbon emissions estimations:

By employing appropriate data collection and analysis methods, researchers can obtain reliable and representative data on energy consumption and carbon emissions in the ICT sector. The below mentioned methods are more accurate assessment of a carbon footprint and support the development of effective strategies for sustainable digital transformation.

- Initial Data Collection:
  In some cases, direct measurement of energy consumption and emissions can be obtained using on-site monitoring equipment or sensors installed on data centers.This method provide accurate real-time data.
- Secondary data sources:
  Energy consumption databases: Emission factors which represent the amount of carbon emissions associated with a unit of energy consumption can be obtained from

established databases such as the Intergovernmental Panel on Climate Change (IPCC) guidelines or national emission inventories.

Calculation practices: Major calculation methodologies include System dynamics modelling & Activity-based approach.

a. The activity levels of ICT components, such as server utilisation in data centres, network consumption, or device usage time, are used to estimate carbon emissions. These activity levels were then multiplied by emissions factors to determine the corresponding carbon emissions

b. System dynamics modelling is a tool for simulating and analysing the intricate interactions between many components. These models may calculate carbon emissions and investigate the effects of various scenarios, such as increasing energy efficiency or incorporating renewable energy.

- Data validation and uncertainty analysis: It is essential to validate the data that has been gathered and evaluate the uncertainties related to projections of carbon emissions. To guarantee the accuracy and dependability of the data, this may use sensitivity analysis, statistical techniques, or comparison with other research or industry benchmarks.

C. Energy-efficient network design and management

- Network Planning and Deployment with Energy Consciousness: Take energy efficiency into account while planning and deploying networks. This includes choosing network hardware with low energy usage and creating energy-efficient network architecture.
- Integration of Renewable Energy Sources: Switching tot integrating renewable energy sources, such solar or wind power, to satisfy network energy demands. The carbon footprint of network operations can be greatly decreased (over 20%) by obtaining energy from renewable sources, encouraging sustainability.
- Dynamic Resource Allocation and Traffic Management: Use dynamic resource allocation strategies to match available network resources with demand at any given time. This enables network resources to be used as efficiently as possible while using less energy.
- Energy Monitoring and Management Systems: Implement energy monitoring systems to track and optimize energy consumption in network infrastructure.
- Green Networking Protocols & Architectures: Develop and implement energy-efficient networking protocols architectures.

IV. RESULTS AND DISCUSSIONS:

The below graph in Fig 1 depicts the rise in data centre workloads and energy usage from the year 2015.

Fig 1.

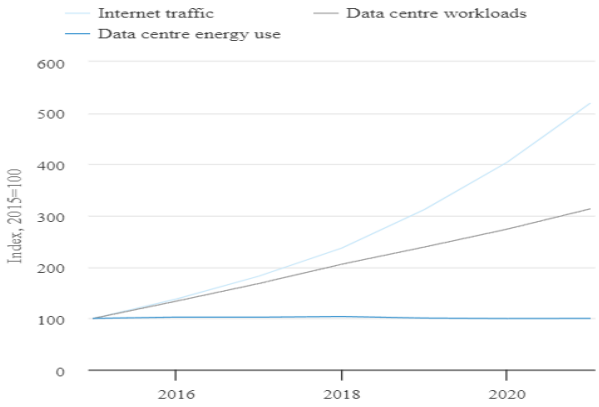

Fig1 – Data centre workloads from 2015

NET ZERO CARBON-EMISSION – A BIGGER STEP TO ATTAIN SUSTAINABILITY

The major problem for all the country is to attain global sustainability. So to promote people's safety and wellbeing , reducing digitization's CO2 footprint requires that people across the globe must work together towards reducing these numbers[5].Many global companies have initiated to implement a solution which will be achieved by the end of 2040.

- Amazon have initiated this Climate-Pledge that is to reach the net-zero carbon by 2040.
- #TogetherForBetter : Flipkart has set a Net Zero target by 2040, the only Indian e-commerce company to commit this environmental goal.
- Facebook has moved its data center to Sweden, reducing the energy used for system cool down.[6]
- Netflix has set a target to halve its emissions by 2030.
- Microsoft has invested $1 billion to Climate Innovation fund to accelerate the development of carbon reduction technologies and to provide some climate solutions.

Fig 2 depicts the Microsoft underwater data centre. Microsoft had placed its first underwater data center in Orkney Islands in 2015 for 2 years under Project Natick team The underwater data centers uses energy more sustainably and are highly reliable and powers the full suite of Microsoft Azure cloud services.These data centres are more reliable and doesn't need as much infrastructure as compared to land data centres.

Fig 2

Fig 2 - Microsoft under water data centre

V. CONCLUSION:

The main goal of the research paper was to unveil the cost of digital transformation and the steps taken to attain environmental sustainability amidst the developing technologies. [12]It is important to keep a check on digital carbon Footprint to reduce global warming and to attain a greener growth. Furthermore, this study gives an idea on the digital transformation's capability of being a boon and bane to the world if not handled properly. In this study the effects of the digital carbon footprint and how to overcome those by switching to renewable energy resource and how we can reduce the footprint by cutting on the usage of the digital devices has been presented. Our study has tried to give an bird view of the Digital carbon footprint.[8] Overall this paper serves as a ground work for the future research or on a study of how to attain environmental sustainability.

This research paper also includes some of the recent trends and actions taken by the major companies to reduce carbon footprint in the future.

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