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Understanding Relationship Between Carbon Emissions And Internet Penetration In Order To Promote Environment Sustainability.

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Abstract:
In today's growing world, everyone wants to retain their competitive edge. With changing consumer requirements there is need to take steps that are focussed on more productivity. But there are repercussions to this. This huge amount of data generated and exchanged on internet has resulted in digital pollution. The aim of this work is to understand consequences of digital pollution. This work used both exploratory and primary survey in order to gain awareness about digital footprint impact on environment. This study will focus on combating digital pollution since it is also major contributor towards global climate change. This is done by forming different hypothesis and application of different statistical methods.

Keywords: Digital footprint, Digital Pollution, E-Commerce, Environmental awareness, Carbon Emissions, Environment Sustainability, Internet

1 Introduction

Our Earth has undergone various changes and has seen along a lot of disasters but its ability to heal and reboot itself as per the change is what has brought it to the habitable state. However, what we are doing now to our environment is what has caused the earth to go through drastic changes which may be beyond anyone repair. In the last few decades, there has been vast increase in adapting and adopting the digital[1]. This has happened primarily because ease of use via digital has been the way to live in today's era. Whether its bringing automation and innovation in daily activities or continuously improving our overall manual processes, there has been huge advent of change that we are seeing. One thing, that we forget about is insane amount of data that gets exchanged on the internet due to so many activities that data has become a new oil these days. Whether you are watching something on Netflix or exchanging chats via WhatsApp or exchange emails over Gmail or searching for something on Google we are leaving our data footprint everywhere. Our data footprint (which we are not aware) has huge carbon footprint that itself is leading to greenhouse gas emissions [2].
Information Technologies (IT) has always been contemplated as the industry that would bring disruption to the whole economic growth by making it more and more efficient. ICT has always been brought in as a change that would bring in substitution to mundane day to day work that we do and replace it with more efficient and more sustainable solution[3]. Our huge data centre's exist and are increasing were created to bring a solution to the problems but in turn it entirely created Data centres were created to increase the efficiency and produce more sustainable results, but overall situation has entirely backfired where the overall energy consumption from these center have caused ever increasing footprint thus leading to whole new tangent of pollution that we have not thought off[4]. This entire occurrence of Jevon's Paradox is valid here [5]. There has been an unsubstantial increase in internet users from 1 to 5.3 billion by 2022 as per the internet last stats [6]. The goal of this study is multifield but essentially to inspect the impact of Digital on the natural ecosystem. The very first goal is aimed at identifying the digital consumers , their reaction and overall behaviours on every increasing internet usage and their awareness towards its impact to the environment. The secondary objective is to do deep dive exploratory study on identifying and establishing if there is any relationship between overall carbon emissions and increasing usage of Internet via ecommerce or Social media or Binge.

2 Background

There have been lot of research on how using or adapting to Information technology or digitization has led to whole system being more environmentally sustainable[7]. ICT in these researches have assisted in reducing the overall

emissions and has allowed business to come out has lower cost enabled businesses , however, internally these businesses internal footprints have never been methodically analysed or studied [8].

Today, any internet search on any web browser that we do is not carbon emissions free, in fact any search that is being done will put the whole ecosystem of client-server data centre's to work in such way that it brings the desired results. In order to do so, it will consume electricity that is being generated by renewable resources i.e. fossil fuels and eventually leading to carbon emissions[9]. So, in fact the emissions from web search is surely very small in comparison to lets say driving a car or eating non-vegetarian food but when you scale it up to billions and billions of searches, there is no end to it. There has been a study being done where every search that we have done on Google would emit approximately 0.2 grams of Carbon dioxide [10]. Now, researchers say that around 600 Internet searches is equivalent to driving a Toyota car for 1 KM [11]. We are not even imagining about emissions of the devices that are being used to access the internet. Similarly, in another study, it was observed that watching 10-12 minutes of You-tube video would emit approximately 1 gram of CO2. Each unused, undeleted email that we have kept in our inboxes for year and years is emitting on an average 10 grams of carbon dioxide. Now, if we start scaling and collating all the data, results of overall carbon-emissions from digital world will be equivalent to the civil aviation industry. The issue is that overall complexity of the technology and dynamics behind such emissions is where no one is able to analyse it holistically [12].

In the past two decades, the growth on overall traffic on the internet has been exceptional which has caused huge surge in overall energy demands[13]. Data being new oil has changed our day-to-day practices and we prefer everything to be on tip of our phone in terms of availability [14]

The very key thing to comprehend is that this exponential increase in number of internet users has also let to increase in manufacturing of ICT's devices like mobile phones, desktops, laptops, smart phones etc which further has led to generation of lot of data that has led to increase in expanding Data Centres [15]. Therefore, this contribution of digital Internet towards CO2 has become sizable enough to get spotted [16]. Digital commerce has also increased the online capability of consumers who are fully embracing , accepting and adapting to the way Online shopping operate [17]. 2.1 and increasing billion people as per latest report from eMarketer survey have shopped online by 2021 and most of the transactions have been done via our smartphones that we use. The overall consumption of smartphones has also increased to atleast 5 hours a day[18].

With the advent of population explosion of internet users carbon footprint at individual level is needed to be taught , informed to these users so that something can be done soon [19]. To make these individuals more responsible they need to be aligned with the methods and best practices and then the importance of using these best practices needs to be enacted[13]. The mentioned will help in bringing that awareness and will also try to establish a relationship between the increasing footprint in the digital world with increase in the internet users using techniques like descriptive statistics[20] This paper will also try to determine the motivation factors and measures that can be applied to reduce the digital carbon footprint.

3 Hypothesis Interpretation and Findings

The mixed research is based on the Research questions asked and the Hypothesis set to find conclusions for those questions. Below is the short table to extract the relationship between RQs and Methods used.

Research Question (RQ)	Hypothesis(H)	Method(M)	Interpretation		Results
RQ1: How technological	Hypothesis (H1a+) percentage of individuals impacted	Survey, Content	Figure 1-6		H1a+, H1b+,H1c+,
changes is having an adverse on environment?	Carbon Emissions directly due to Internet usage Hypothesis (H1a-) percentage of individuals not impacting Carbon Emissions directly due to Internet usage Hypothesis (H1b+) Direct Effect of Increasing internet speed on Carbon Emissions Hypothesis (H1b-) Indirect Effect of Increasing internet speed on Carbon Emissions Hypothesis (H1c+) percentage of individuals using the Internet that has resulted in increased percentage of Fossil Fuel Consumption Hypothesis (H1c-) percentage of individuals using the Internet has not impacted percentage of Fossil Fuel Consumption Hypothesis (H1d+) Increase in Internet Speed has a directly percentage of Fossil Fuel Consumption Hypothesis (H1d-) Increase in Internet Speed has not direct impacted increase in percentage of Fossil Fuel Consumption Hypothesis (H1e+) Increase in internet pollution due to Digital e-commerce and binge watching Hypothesis (H1e-) Digital ecommerce and binge watching has not led to increase in internet pollution	Analysis	Figure 8-9		H1d+, Accepted
RQ2: What is role of awareness in motivating users	Hypothesis (H2a+) Different Motivation factors with right measures can positively influence the consumers towards	Survey	Figure 10,11	7,	H2a+ accepted

for reducing digital pollution?	performing environment friendly practices Hypothesis (H2a-) Different Motivation factors with right measures cannot influence the consumers towards performing environment friendly practices			
RQ 3: What ways are available and can be executed to reduce carbon footprint?	Hypothesis (H3a+) Available ways are implemented by users to reduce digital pollution Hypothesis (H3a-) Available ways are not implemented by users to reduce digital pollution	Survey, Literature Review	Figure 10,11	H3a+ accepted
RQ 4: What is the perception of users with reference to the digital pollution?	Hypothesis (H4a+) Users having no awareness about increasing carbon footprints and negative impact on environment. Hypothesis (H4a-) Users having awareness about increasing carbon footprints and negative impact on environment. Hypothesis (H4b+) Users are not aware that they will also suffer from Carbon Dioxide Emissions Hypothesis (H4b-) Users are aware that they will also suffer Carbon Dioxide Emissions	Survey	Figure 12-19	H4a+, H accepted
RQ 5: Will different measures to reduce digital pollution be accepted?	Hypothesis (H5a+) Users awareness wont' be overwhelmed by the benefits they are receiving from internet. Hypothesis (H5a-) Users awareness will be overwhelmed by the benefits they are receiving from internet. Hypothesis (H5b+) Digital pollution will be an acceptable side effect that comes with benefits of internet usage Hypothesis (H5b-) Digital pollution will not be an acceptable side effect that comes with of internet usage	Survey, Literature Review	Figure 20-23	H5a+, H accepted

TABLE 1 : MAPPING RESEARCH QUOTIENT WITH HYPOTHESIS ,METHOD, INTERPRETATIONS AND RESULTS

To prove Hypothesis 1a,1b,1c,1d secondary survey was conducted. World Bank data was utilized to understand internet users percentage and speed of internet. The sample size analyzed via regression. Least Mean Square Methodsis used to find the cause and effect of these variables on the overall emissions. The data is collected from database of worldbank.org[21].

In order to prove Hypothesis 2 to 5 , a detailed survey on "Digital pollution" was done through social media platforms and word-of-mouth campaigns [22]. There were 350 responses. Post filtration 336 responses were analyzed with help of trend charts, plots in order to have better insights about digital pollution, motivations factors to act against digital pollution as well as current environment friendly practices that are followed. All the charts and insights are mapped with the respective hypothesis as discussed in Table 1 to create better understanding as well as to corelate survey response and its contrary hypothesis [23] [24] [25].

A descriptive statistics analysis was undertaken for every key section of survey response and sample t-test was conducted for all key questionnaire[26]. One sample t-test is a statistical procedure used to find the mean difference between the sample and the known value of the population mean[27]. The random sample data gathered with help of research survey was used to compute the sample mean and compared with the population mean in order to validate the hypothesis (level of significance taken as 0.05 as per 95% level of confidence).

Dependent Variable: CO2_EMISSION_IN_GIGATONNE
Method: Least Squares
Sample: 1990 2020
Included observations: 31

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.991	0.054	18.259	0.000
INDIVIDUALS_USING_THE_INTERNET...	0.070	0.008	8.978	0.000
INTERNET_SPEED_IN_MBPS	-0.203	0.050	-4.089	0.000

R-squared	0.890	Mean dependent var	1.479
Adjusted R-squared	0.882	S.D. dependent var	0.691
S.E. of regression	0.237	Akaike info criterion	0.052
Sum squared resid	1.575	Schwarz criterion	0.190
Log likelihood	2.200	Hannan-Quinn criter.	0.097
F-statistic	113.183	Durbin-Watson stat	0.635
Prob(F-statistic)	0.000		

FIGURE 1: REGRESSION ANALYSIS FOR CARBON DIOXIDE EMISSION VS INTERNET USAGE

Dependent Variable: FOSSIL_FUEL_ENERGY_CONSUMPTION_%_OF_TOTAL
Method: Least Squares
Sample: 1990 2020
Included observations: 31

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	62.522	0.897	69.720	0.000
INDIVIDUALS_USING_THE_INTERNET_%_OF_POPULATION	0.556	0.104	5.365	0.000
INTERNET_SPEED_IN_MBPS	(1.520)	0.726	(2.094)	0.045

R-squared	0.706	Mean dependent var	66.739
Adjusted R-squared	0.685	S.D. dependent var	7.039
S.E. of regression	4.015	Akaike info criterion	5.709
Sum squared resid	451.258	Schwarz criterion	5.848
Log likelihood	(85.497)	Hannan-Quinn criter.	5.755
F-statistic	32.110	Durbin-Watson stat	0.239
Prob(F-statistic)	0.000		

FIGURE 2: REGRESSIONS ANALYSIS BETWEEN FOSSIL FUEL ENERGY USED VS INTERNET USAGE AND INTERNET SPEED

Sample: 1990 2020

	CO2 EMISSION	INDIVIDUALS USING THE INTERNET	INTERNET SPEED
Mean	1.479	10.364	1.158
Median	1.223	2.388	0.128
Maximum	2.817	54.000	11.000
Minimum	0.619	0.000	0.000
Std. Dev.	0.691	15.648	2.445
Skewness	0.539	1.629	2.724
Kurtosis	1.920	4.486	10.193
Jarque-Bera	3.012	16.569	105.173
Probability	0.222	0.000	0.000
Sum	45.843	321.289	35.910
Sum Sq. Dev.	14.306	7345.344	179.336
Observations	31	31	31

FIGURE 3: DESCRIPTIVE STATISTICS FOR CARBON DIOXIDE EMISSIONS

Sample: 1990 2020

	FOSSIL FUEL ENERGY CONSUMPTION	INDIVIDUALS USING THE INTERNET	INTERNET SPEED
Mean	66.776	10.364	1.016
Median	65.990	2.388	0.256
Maximum	78.491	54.000	11.000
Minimum	53.764	0.000	0.000
Std. Dev.	7.095	15.648	2.233
Skewness	-0.085	1.629	3.270
Kurtosis	1.959	4.486	14.253
Jarque-Bera	1.438	16.569	218.804
Probability	0.487	0.000	0.000
Sum	2070.044	321.289	31.482
Sum Sq. Dev.	1510.262	7345.344	149.588
Observations	31	31	31

FIGURE 4: DESCRIPTIVE STATISTICS FOR FUEL CONSUMED AND HYPOTHESIS

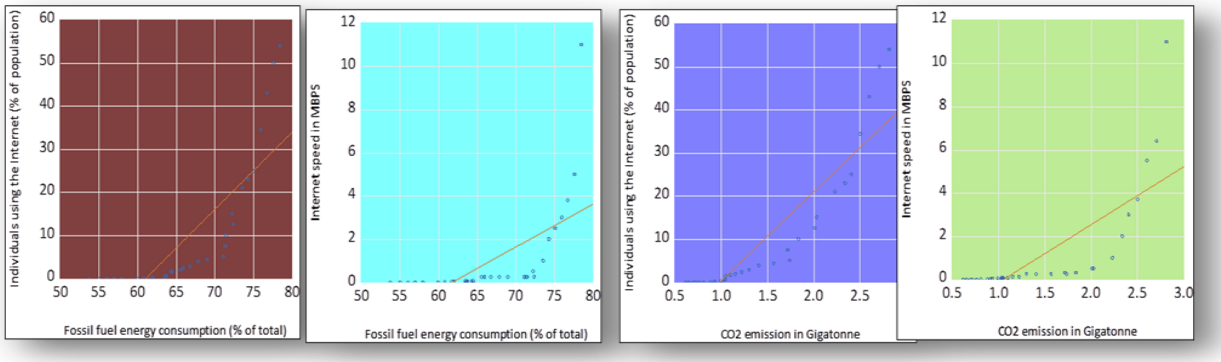

FIGURE 5: HYPOTHESIS AND DEPENDENT VARIABLES

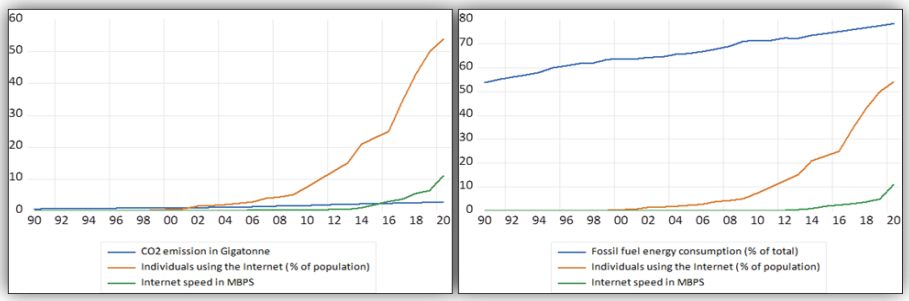

FIGURE 6: DIFFERENT BETWEEN DEPENDENT VARIABLES AGAINST INDEPENDENT VARIABLES

Covariance Analysis: Ordinary
Sample: 1990 2020
Included observations: 31

Covariance	CO2_EM...	INDIVDUALS_...	INTERNE...
CO2_EMISSION	0.461500		
INDIVDUALS_USI...	9.493554	236.9466	
INTERNET_SPEE...	1.236915	34.59542	5.785034

Correlation	CO2_EM...	INDIVDUALS_...	INTERNE...
CO2_EMISSION	1.000000		
INDIVDUALS_USI...	0.907858	1.000000	
INTERNET_SPEE...	0.757009	0.934416	1.000000

Covariance Analysis: Ordinary
Sample: 1990 2020
Included observations: 31

Covariance	FOSSIL_FU...	INDIVIDUAL...	INTERNET_...
FOSSIL_FUEL_E...	48.71812		
INDIVIDUALS_USI...	87.18268	236.9466	
INTERNET_SPEED	9.626509	30.16013	4.825432

Correlation	FOSSIL_FU...	INDIVIDUAL...	INTERNET_...
FOSSIL_FUEL_E...	1.000000		
INDIVIDUALS_USI...	0.811446	1.000000	
INTERNET_SPEED	0.627849	0.891949	1.000000

FIGURE 7: COVARIANCE AND CORRELATION ANALYSIS

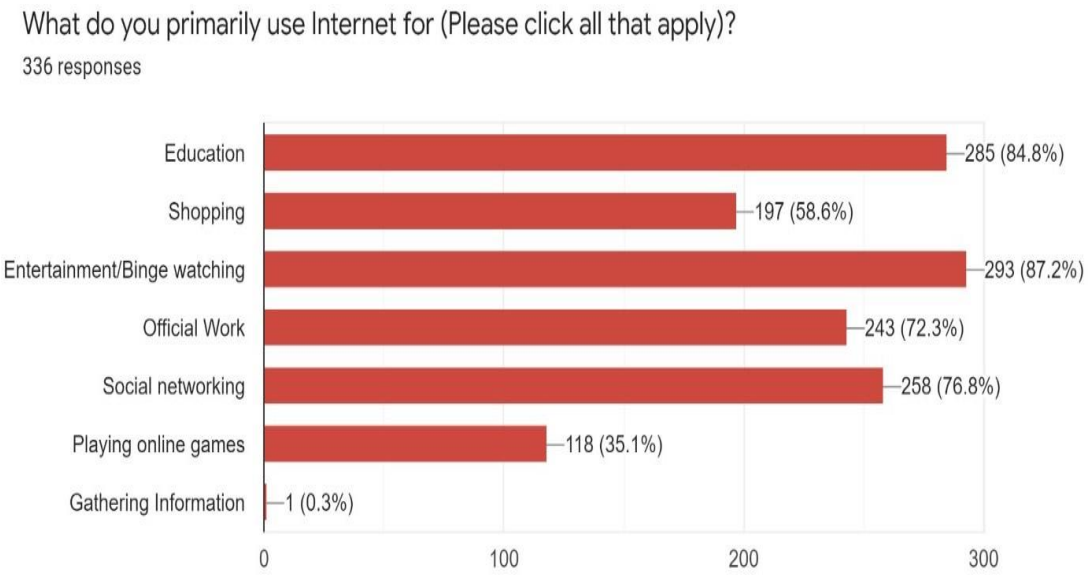

Figure 8: Primary Internet Usage Analysis

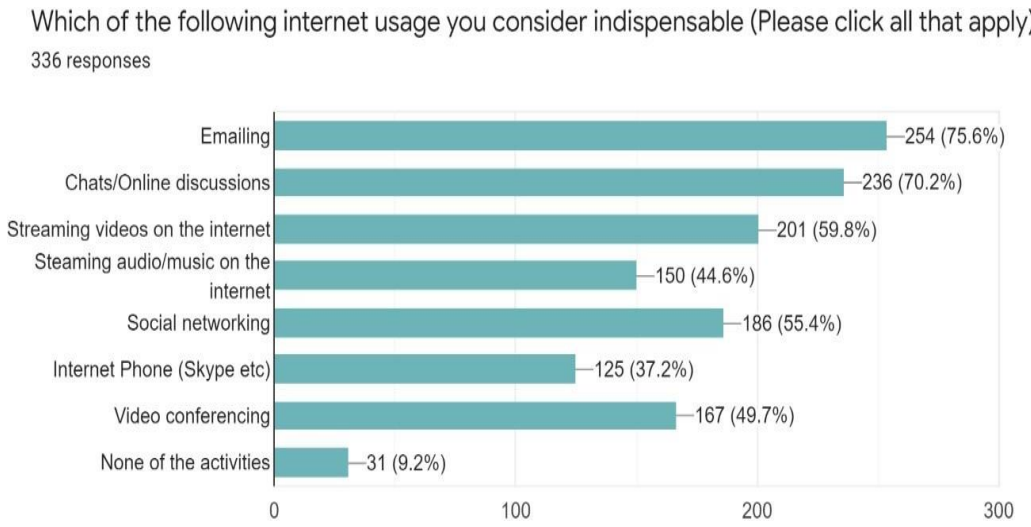

FIGURE 9: SERVICES AVAILABLE ON INTERNET

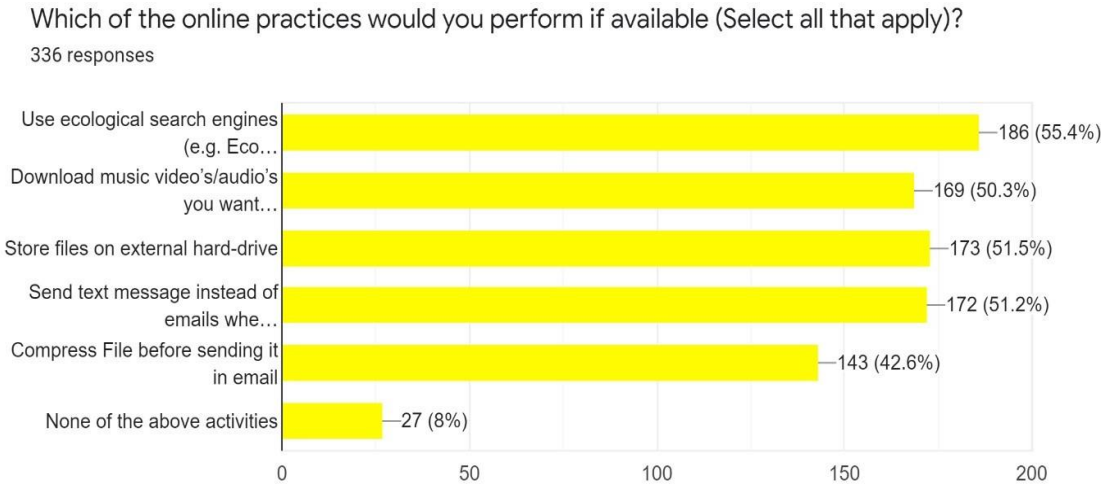

FIGURE 10: DIFFERENT ONLINE PRACTICES

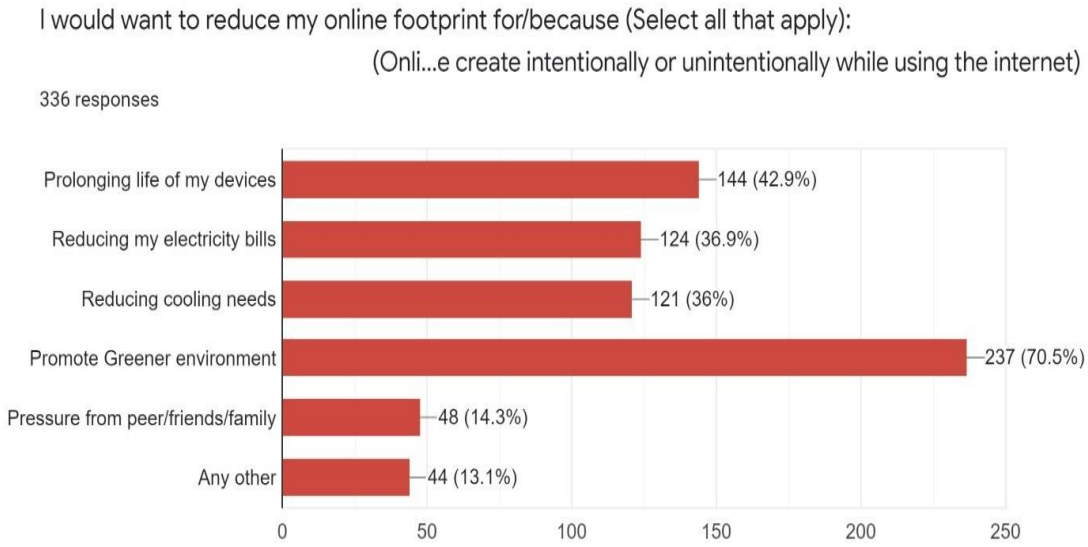

FIGURE 11: PRACTICES THAT SHOULD BE PERFORMED

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.722
Bartlett's Test of Sphericity	Approx. Chi-Square	561.149
	df	66
	Sig.	.000

FIGURE 12: KMO AND BARTLETT'S INTERPRETATION

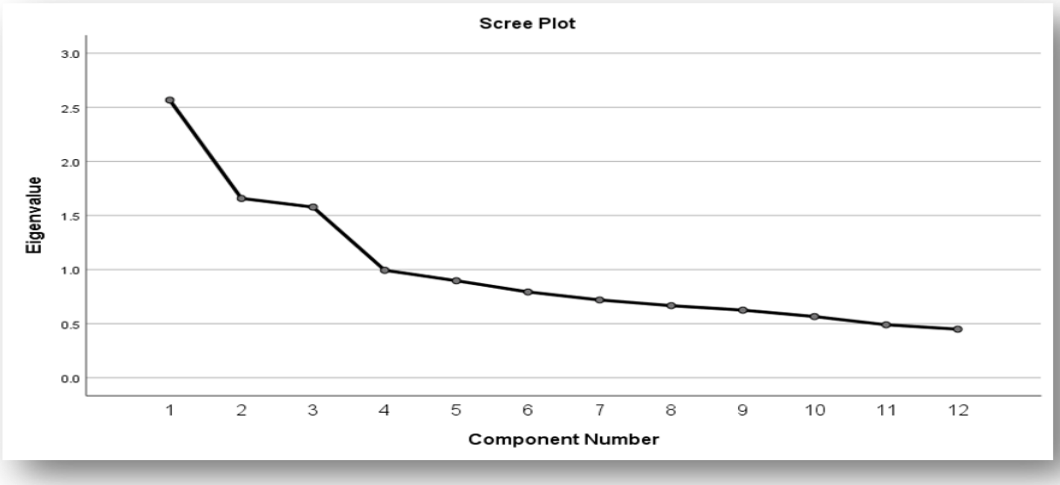

FIGURE 13: SCREE PLOT OF FACTORS

Rotated Component Matrix[a]

	Component			
	1	2	3	4
RQ4b	.769			
RQ4f	.760			
RQ4c	.739			
RQ4a		.697		
RQ4e		.694		
RQ4d		.601		
D1		.560		
RQ5e			.702	
RQ5c			.672	
RQ5a			.535	
RQ5d				.763
RQ5b				.691

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

FIGURE 14: ROTATED COMPONENT ANALYSIS FOR RESEARCH QUOTIENT 5 AND 6

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.709	.710	6

FIGURE 15 : CRONBACH ALPHA - RELIABILITY TESTING

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
HPY4	335	3.3662	.76425	.04176

FIGURE 16: HYPOTHESIS 4A ONE SAMPLE STATISTICS

One-Sample Test

	Test Value = 3					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
HPY4	8.769	334	.000	.36617	.2840	.4483

FIGURE 17: HYPOTHESIS 4A T- TEST

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
HPY4b	335	3.3940	.70685	.03862

FIGURE 18: HYPOTHESIS 4B ONE SAMPLE STATISTICS

One-Sample Test

	Test Value = 3					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
HPY4b	10.203	334	.000	.39403	.3181	.4700

FIGURE 19: HYPOTHESIS 4B T-TEST

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
HYP5a	335	3.6602	.66009	.03761

FIGURE 20: HYPOTHESIS 5A ONE SAMPLE STATISTICS

One-Sample Test

	Test Value = 3					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
HYP5a	17.552	334	.000	.66017	.5862	.7342

FIGURE 21: HYPOTHESIS 5A T-TEST

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
HYP5b	335	3.4692	.76349	.04350

FIGURE 22: HYPOTHESIS 5B ONE SAMPLE STATISTICS

One-Sample Test

	Test Value = 3					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
HYP5b	10.784	334	.000	.46916	.3836	.5548

FIGURE 23 : HYPOTHESIS 5B T-TEST

4. Conclusions

This study was performed on multiple factors to understand and analyse the term Digital/Internet Pollution and its understanding with the directed audience. The findings obtained from the above study and research will have serious implications on different corporations. It will also establish newer prospects for start-ups to think on lines of sustainable IT. The proved hypothesis has clearly specified that there is a very less consciousness among the consumers of the digital world and about the overall impact of internet on environment (Carbon emissions) and hence it becomes essential to involve these users in order to have less carbon emissions. It thus, becomes responsibilities of all stakeholders to create awareness in form of different campaigns to educate the end users about environmental effects due to excessive usage of the internet.

On the other hand, it also becomes responsibility of the consumers to keep a check of their own internet usage and understand that excess of everything will have a negative impact. Many internet users are willing to cooperate and work on solutions that is beneficial to environment. Different incentives can be given to these users as they can assist in experiment and hence formation of sustainable policies. Some pricing model can be devised if users are willing to reduce consumptions. Displaying screen time on different devices and advising them to control it can be one of the

measures. By looking at above findings it is clear that there is urgent need to introduce sustainable practices for reducing carbon emissions due to internet usage.

Conflict of Interest

No potential conflict of interest was reported by the author(s).

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