European Economic Letters
ISSN 2323-5233
Vol 14, Issue 2 (2024)
http://eelet.org.uk

Boosters for Carbon Neutrality: A 360° Approach

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Abstract

Carbon information highlights the lacunae wherein eco-centric interventions are falling weak. In the present scenario of datafication, digitization & networking, it is imperative to resort to carbon-neutral pathways that may propel the society towards sustainability. Since, the attainment of carbon neutrality as per the objectives of G20 is a collaborative effort of both social sciences and sciences, a 360-degree approach for identifying the boosters of carbon neutrality is essential. These boosters may synergistically mechanize the achievement of carbon neutrality. This paper aims at drafting a conceptual frame that deciphers the boosting mechanism that may help in the attainment of carbon neutrality. Because of the novelty of the topic, this conceptual paper resorts to an exploratory research design with impetus on mixed qualitative approach engaging conceptual framework analysis & grounded theory. Based on the conceptual homogeneity of the sub-topics found relevant to the central theme, the literature was segregated into five conceptual frames for drawing inductive inferences. The deductions of the paper are anticipated to be a trailblazer for social advocates of carbon neutrality, green marketers, environmental strategists, academic cohort and even the statutory public bodies struggling to strike the chord of 'net zero' carbon emissions.

Keywords: Carbon neutrality, Eco-centrism, Net zero carbon, Sustainability.

1.0 Research Objective

To identify the boosting factors of carbon neutrality & subsequently propose a conceptual frame that deciphers the mechanism that may help in the attainment of carbon neutrality.

2.0 Introduction

Carbon information is crucial for reshaping the hierarchies of political, economic and social level interactions. The act of neutralizing greenhouse gases (including carbon dioxide) which are an outcome of anthropogenic interventions is termed as 'carbon neutrality' and is slated towards scientific comprehension of impacts on global warming (IPCC, 2018). Alternative term for carbon neutrality is carbon compensation which implies the calculation of the amount of CO_2 emissions in the environment & then absorbing these emissions via afforestation & tree plantation drives for attaining the objective of carbon balance. Carbon neutrality should take a center stage for streamlining human consumption patterns in the

direction of sustainability in contemporary times of datafication, digitization & networking it in carbon neutral pathway that is the way forward to an ecological equilibrium. Attainment of carbon neutrality is anticipated to be a collaborative effort of both sciences & social sciences. It is a concoction of technological innovations clubbed with an impact-oriented risk assessment that is paving way to the achievement of carbon neutrality. In several ways. The rampant industrialization has nearly super ceded the ecological carrying capacity (Ahmed, Ali & Saud, 2020a; Ahmed, Nathaniel & Shahbaz, 2020b; Ahmed, Zafar & Mansoor, 2020c). The issues of decarbonization and carbon neutrality are cross- disciplinary in character. In context to carbon neutrality, accounting & measurement of decarbonization efforts, opportunities & challenges in the way of climate change mitigation & sustainable transition have been discussed in lot of researches with reference to agriculture, transport, tourism, forestry and energy sectors. The datafication of carbon information entails knowledge-based approach from both social data science as well as scientific data science because they jointly advocate socio-technical transition to a carbon free sustainable future. These socio-technical transitions involve complex arrangement of information pertaining to carbon trading, sustainable consumption, decision making & blend of theoretical & empirical antecedents. Further, digital collaborations with impetus on blockchain, artificial intelligence, data analytics and cloud computing should emphasize on tracking & tracing of carbon footprints on the mother earth. For maintaining the sustainability equilibrium, it is imperative to interject those anthropogenic activities including industrialization should not exceed the carrying capacity of ecosystem. Carbon sequestration of the ecosystems & development of carbon neutral strategies should be emphasized in contemporary times.

3.0 Literature Review

3.1 Conceptualization of Carbon Neutrality

World's top carbon emitters are channelizing their economic policies in the direction of sustainability by attempts towards carbon neutrality (Harvey 2020; Mallapaty, 2020). The offsetting of exuded CO_2 via carbon capture, storage and subsequent conversion of CO_2 into non-harming forms within a stipulated time for the sake of attaining zero emission of green -house gases is termed as 'Carbon- neutrality'. Carbon neutrality is the prime objective of business organizations for prevention of global warming via control of emissions like CO_2, green-house gases, CH_4, N_2O (Smith & Fletcher, 2020). Reduction of carbon emissions with the intention of achieving carbon neutrality involves synergistic effect of various strategies (Broadstock et al., 2021). Carbon neutrality can be attained via new technologies engaging:

(i) Remote sensing big data for forest resource management
(ii) Effective policy and decision-making systems at the managerial level (Wang et al., 2021).

Under the umbrella institution of 'deep carbonization', there is a dire need for collaborative efforts at the global level for rapid exchange of pathway modeling capacities and findings (Bataille et al., 2016a; Bataille et al., 2016b). The realization of carbon neutrality is feasible via multiple objective collaborations between technology innovation, policy drafting in favour of eco-centrism and financial support (Can, 2012). Socio-technical transitions hold the potential to transgress from industrial alignments to eco-centric sustainable future (Wang et al., 2020). Carbon neutrality and low carbon regimes are efforts to minimize global warming effects (Wu et al., 2019; Wang & Li, 2019). Plethora of options like communication, behavioural change, international relations, investment, adaptation & policy influence carbon neutrality besides science & technology (Hawken, 2017; Farnworth, 2018). Low carbon energy transitions have been reviewed in detail by various researchers with the purpose of finding carbon neutral solutions (Sovacools & Griffiths, 2020; Lee et al., 2020; Carvalho et al., 2020).

3.2 Discipline-wise Advocacy of Carbon Neutrality

Plethora of disciplines speak in favor of carbon reduction and carbon neutrality as described in table 1 below.

Table 1: Advocacy of carbon neutrality by various disciplines

No.	Discipline	Advocacy of carbon neutrality	Propounder
1	**Energy Studies**	Measurement of unit energy of CO_2 pollution aimed at carbon neutrality not only helps us to understand the global climatic changes but also necessitate the technological shift from usage of coal to natural gas for mitigating climate erratic.	Grubler et al., 1999.

2	**Engineering**	Making carbon accounting & information modeling as the foundation of sustainable design structures propelled via engineering studies.	Stadel et al., 2011.
3	**Legal Studies**	• Seminal work done on the legal framework about the concept of carbon neutral individuals centers on advocacy of government law interventions on carbon neutrality. • Advancements in legal conformities that integrate the concept of carbon neutrality with individual responsibility have been emphasized by empirical studies and subsequent analysis of standards of carbon management carried by Green in the year 2013.	Vandenbergh & Steinemann, 2007. Vandenbergh & Steinemann, 2007, Green, 2013.
4	**Linguistics**	The term 'Carbon neutral' has moved from 'determinologized' trajectory to that of 'terminologized' trajectory i.e., it has observed a paradigm shift from mass appeal & moved and subsequently carved a space in the environmental lexicon.	Dury, 2008.
5	**Psychology**	Empowerment of community-based psychology can lay the foundation of a carbon neutral future by identifying certain factors that act as promoters (eg. Educational transformation, changing social norms etc.) and certain agents of retardation (eg. Time and money constraints, poor efficiency standards & hopelessness of individuals)	Quimby & Angelique, 2011.
6	**Public Administration**	Policy changes pertaining to climatic factors and policy drafting of smart sustainable cities are public administration initiatives inclined at attainment of carbon neutrality.	Hohne et al., 2017; Yigitcanlar & Lee, 2014.

3.3 Theories addressing Carbon Neutral Behaviour of Consumers

The entire gamut of consumer activities that aim at the reduction of indirect and direct CO2 emissions are regarded as 'Low carbon behaviours (Dubois et al., 2019; Williamson et al., 2019). For combating the problem of climate errands, it is imperative to study significant behavioural changes in the majority of people with respect to carbon neutrality (Williamson et al., 2019). Willingness to reduce the avoidable luxuries that have detrimental impact on the environment is exhibited by consumers who have eco-concerns and show environment-friendly behaviour when stimulated by an extrinsic stimulus like pollution (Geng et al., 2017; Clark, Chatterjee & Melia, 2016). The multitude of theories are addressing carbon neutral behaviour in the context to consumer behaviour as depicted in Table 2.

Table 2: Supportive evidences of carbon neutrality by various theories

No.	Theory	Description	Propounder
1	**Value- Belief Norm Theory**	• It is the outcome of superposition of eco-conservation behaviour research on the Norm Activation Model (NAM) in conjugation with inter-mixing of the Value theory and NAM (specifically new environmental paradigms). • When consumers are driven by strong values and beliefs for nature conservation, their eco-sentiments become a guiding force of their personal norms which propel them to adopt promotional activities in favour of environmental protection.	Stern, 2000 Davari & Strutton, 2014.
2	**Theory of Planned Behaviour (TPB)**	• The TPB model explains the mechanism by which final consumer behaviour may be molded by the consumer's intention to participate in carbon neutrality regimes.	Chen, 2016

		• Since there exists a gap between real behaviour & eco-intentions of the consumers, there are certain factors like financial constraints, time & even capabilities which contribute to the normative beliefs & personal values that may be pivotal in the gap formation.	Ajzen, 1985; Stern et al., 1999.
3	**Attitude-Behaviour-External Conditions Model**	Environment attitudes of consumers may have a lesser impact on the ecological behaviours depending upon the type of external factors (positive or negative) influencing the promotion or prevention of eco-centric philosophy.	Ding et al., 2018
4	**Norm Activation Model (NAM)**	• Various eco-protection behaviours like minimization of particulate matter & energy saving can be explained via NAM. • The three prime variables of NAM that can be extrapolated to cover the carbon neutrality are: (i) Awareness of consequences (ii) Personal norms (iii) Ascription of responsibility	Abrahamse & Steg, 2009; Shi, Fan & Zhao, 2017. Groot & Steg, 2009.

3.4 Factors Affecting Carbon Neutral Behaviour

Adequate public awareness and proper comprehension of low carbon products & adoption of carbon neutral lifestyles hold immense potential to lower carbon consumption. Consumer perceptions pertaining to product recycling may be influenced by extrinsic conditions, attitudes & perceived cost of the carbon neutral products (Guagnano et al., 1995) whereas individual behaviour towards merchandise recycling be affected by financial, economic & social factors (Suttibak & Nitivattananon, 2008), household income and family composition (Czajkowski et al., 2014) and demographic factors including age, gender, occupation, education & culture (Babaei et al., 2015). Myriad of factors like age, occupation, income, gender and even the educational level influence the purchase intention of carbon- neutral products (Shuai et al., 2014). Low carbon behavioural intentions are observed in people with high education standards (Babooram & Hurst, 2010). Well educated individuals tend to be better informed about eco-issues & may therefore develop favorable attitude towards natural environment & subsequently exhibit inclination towards low carbon products & technologies (Ciu, Xia & Hao, 2019).

An affinity to pay premium for carbon-neutral goods may be determined by the consumer attitude & the degree of eco-consciousness which often dictate the willingness to pay for low carbon products (Tang & Jiang, 2016; Trivedi, Patel & Acharya, 2018; Wong, Chan & So, 2019). Since carbon neutral goods are often more expensive than their non-green counterparts (Taghikhah et al., 2019) or because of lack of trust in carbon neutral products, the affluent consumers may not be ready to spend on them (Nguyen et al., 2019). Economic incentives in the form of subsidies along with adequate knowledge about carbon neutral products can encourage the consumers in developing a carbon neutral behaviour (Li, Long & Chen, 2017). Eco-values, environmental consciousness & a strong belief system in sustainability prompt the consumers to opt for eco-friendly transportation that is in line with carbon neutrality (Lind et al., 2015). Eco-consciously driven individuals having 'ecological personalities' were found to possess carbon-neutrality oriented behaviour intentions (Garling et al., 2003; Wei, Chen & Long, 2016). Urban consumers and women candidates possessing bachelor's degrees were found to have better low- carbon behavioural patterns in comparison to their counterparts (Chen & Li, 2019).

Empowerment of people for taking corrective actions for avoiding carbon emissions got escalation by the environmental policies that advocated interjection of eco-awareness & biosphere values into personal norms (Steg et al., 2005). Complete knowledge about climatic and environmental impacts of non-green merchandise on ecology is also a contributing factor responsible for poor consumption behaviour towards carbon neutral products (Schaefer & Blanke, 2014). The risk pertaining to climate change as perceived by the consumer can affect carbon behaviour & move it in the direction of carbon neutrality (Hu et al., 2017). Low carbon behaviours find a boost when there is a continuous market supply of carbon neutral products & availability of proper recycling facilities exist (Steg & Vlek, 2009). Reluctance to change high carbon consumption lifestyle habits cause rapid detrimental impact on environmental health (Mi et al., 2018). This becomes a

hurdle in the way of carbon neutrality. The inhibition or promotion of personal carbon neutral choices can be affected by external factors (Stern et al., 1999) like regional culture, economic factors, geographical location, social norms, natural resources, infrastructure systems, climatic factors etc. Energy conservation behaviour can be encouraged by increasing the energy prices (Shi, Wang & Wang, 2019). An increase in energy price through government interventions affects people's lifestyles & decisions and steer the community towards carbon neutrality. Government interventions like intelligent traffic information regimes, eco-oriented public transportation system, convenient infrastructure can put the consumer behaviour on the track of carbon neutrality (Shi, Wang & Wang, 2019). Carbon labeling giving complete information on carbon footprint of the product spread across its life-cycle can mold consumer behaviour in the adoption of carbon neutral behaviour (Liu et al., 2019).

3.5 Intertwining Carbon Neutrality with Ecological Efficiency

'Ecological efficiency' is stated as the ratio of input-output wherein minimal usage of ecological resources costs for more value (better worth) (OECD, 1998). In ecological efficiency, the maximum industrial value is accounted by optimal resource input & production investment in consonance with minimum resource consumption and least environmental burden (Ren, 2019). The concept of ecological efficiency can be empirically studied by utilizing the ecological (carbon) footprint (Ji, 2013). Eco-efficiency is the key to achieving Sustainable Development Goals (SDGs) and is vital for moving in the direction of carbon neutrality goals. Eco-efficiency is often related with sustainable development because it aims at improving the environmental performance of the business organizations imparting it core competency and bringing it on the trajectory of innovation (WBCSD, 2000). It is through rampant innovation & enhanced ecological efficiency that carbon neutrality be attained in the decades to come (Xu & Zhang, 2019; Gai & Zhan, 2019). Ecological efficiency can be attained via:

(i) Reuse of pollutants via strengthening its treatment
(ii) Promotion of resource recycling
(iii) Redesigning of products which requires less resource consumption
(iv) Reduction in pollutant emissions
(v) Enhanced resource utilization via product & equipment improvement (Ren et al., 2019a, 2019b; Ahmed et al., 2020a, 2020b, 2020c)

The sustainable development of the complex economy-environment-resource cascade is facilitated via ecological efficiency & lays down the foundation of bi-oriented society (Cheng et al., 2014). The following factors have impact on eco-efficiency:

a) Marketization level- It puts constraint on clean production efficiency
b) Capital investment- Fosters clean production efficiency
c) Technological progression- Improves clean production efficiency
d) FDI (Foreign Direct Investment)- Negligible impact on ecological efficiency (Chen & Gong, 2013).

At the regional level, 'environmental efficiency' implies that human needs are met by such competitive products that minimize resource consumption & environmental pollution but at the same time improves human life (Luks, 2000). Adjustment in the following two drivers can positively improve ecological efficiency:

(I) Encouragement of technological progress
(II) Promotion of institutional innovation (Wu et al., 2015).

4.0 Research Methodology

In order to derive conclusions, this conceptual paper employed an exploratory research approach. The foundation for locating relevant literature was a systematic search approach that employed specified keywords that were thought to be related to the study title and purpose. Various secondary data repositories were examined for the search depending on the data source's credibility and legitimacy. The collected material was then divided into sections or frames based on aspects of commonality (parity) discovered via comparable meanings (synonyms) or concepts. This promoted improved conception of the study project by structurally organizing related frames based on a pattern of similarity. By putting these critical frames to conceptual framework analysis, they received a qualitative approach of analysis. The study findings were

inductive in character, which allowed the representation of research output in the form of a flowchart (represented in Figure 1).

5.0 Findings

The candid application of above-mentioned research methodology yielded the following probable results:

- The understanding of complex economy- resource- environment cascade can be decoded via deep comprehension of theories (which act as theoretical boosters to carbon neutrality) like-
  - Value Belief Norm Theory
  - Theory of Planned Behaviour
  - Attitude- Behaviour- External conditions model
  - Norm Activation Model
- Synergistic effect of various disciplines like law, public administration, psychology, biotechnology, linguistics, engineering and energy studies work in orchestration to bolster the mechanism that steers carbon neutrality.
- Carbon neutral behaviour is greatly encouraged among consumers by theoretical foundations laid by concoction of above-mentioned theories & disciplines. This carbon neutral behaviour becomes the major force for attaining carbon neutrality.
- Multitude of factors propel the working machinery that drives eco-efficiency (as a booster) in the direction of carbon neutrality.
- 'Ecological efficiency' assists in achieving carbon neutrality by:
  - Reuse of pollutants & promotion of product recycling
  - Making less resource consumption as the basis of product redesigning
  - Improvement at both production level & equipment efficacy standards
  - Reduction in pollution emissions

The application of grounded theory embedded conceptual framework analysis has been depicted in the form of a framework which presents the possible mechanism based on qualitative (subjective) treatment of the filtered literature depicted in figure 1.

6.0 Conclusion

The key to achieving sustainable development goals (SDGs) in eco-centric terms revolve around the mechanism pertaining to attainment of carbon neutrality. Carbon neutrality is achievable via resorting to tools & techniques engaged by ecological efficiency systems. This may range from reduce, recycle, reuse strategies to restrictions on resource consumption. Environmental performance as reflected in the outcomes of eco-efficiency positively steer the attainment of carbon neutrality. Additionally, this conceptual paper identifies theoretical backups and even discipline-based justifications that propel the molding of consumer behaviour towards net zero consumption. The paper also discerned some factors like eco-consciousness, education, demographics, energy prices, values, distribution of carbon neutral goods, monetary incentives, carbon labeling & global warming which impart vital momentum to the goal of carbon neutrality. These boosters provide a 360° approach so that the objectives of G20 in context to carbon footprint reduction may be achieved. Energy conservation behaviours can be encouraged by increasing energy prices, via government initiatives, through changes in consumer lifestyles & consumption patterns. Low carbon behaviour can only be expected when the demand & supply forces for carbon neutral goods are in unison backed with good educational background of consumers with eco-sensitivity. Apart from science & technology, there are couple of factors like behavioural change, communication, global warming, international relations, willingness to spend on green products & policy framework of the government that may affect the carbon neutrality attainment machinery. It is pertinent to note that world's top carbon emitters are capitalizing on their economic policies in the direction of sustainability by attempts towards carbon neutrality. Also, carbon neutrality should take a center stage for streamlining human consumption patterns in the stride towards sustainability especially when the boosters to carbon neutrality are appropriately decoded via 360° approach.

European Economic Letters
ISSN 2323-5233
Vol 14, Issue 2 (2024)
http://eelet.org.uk

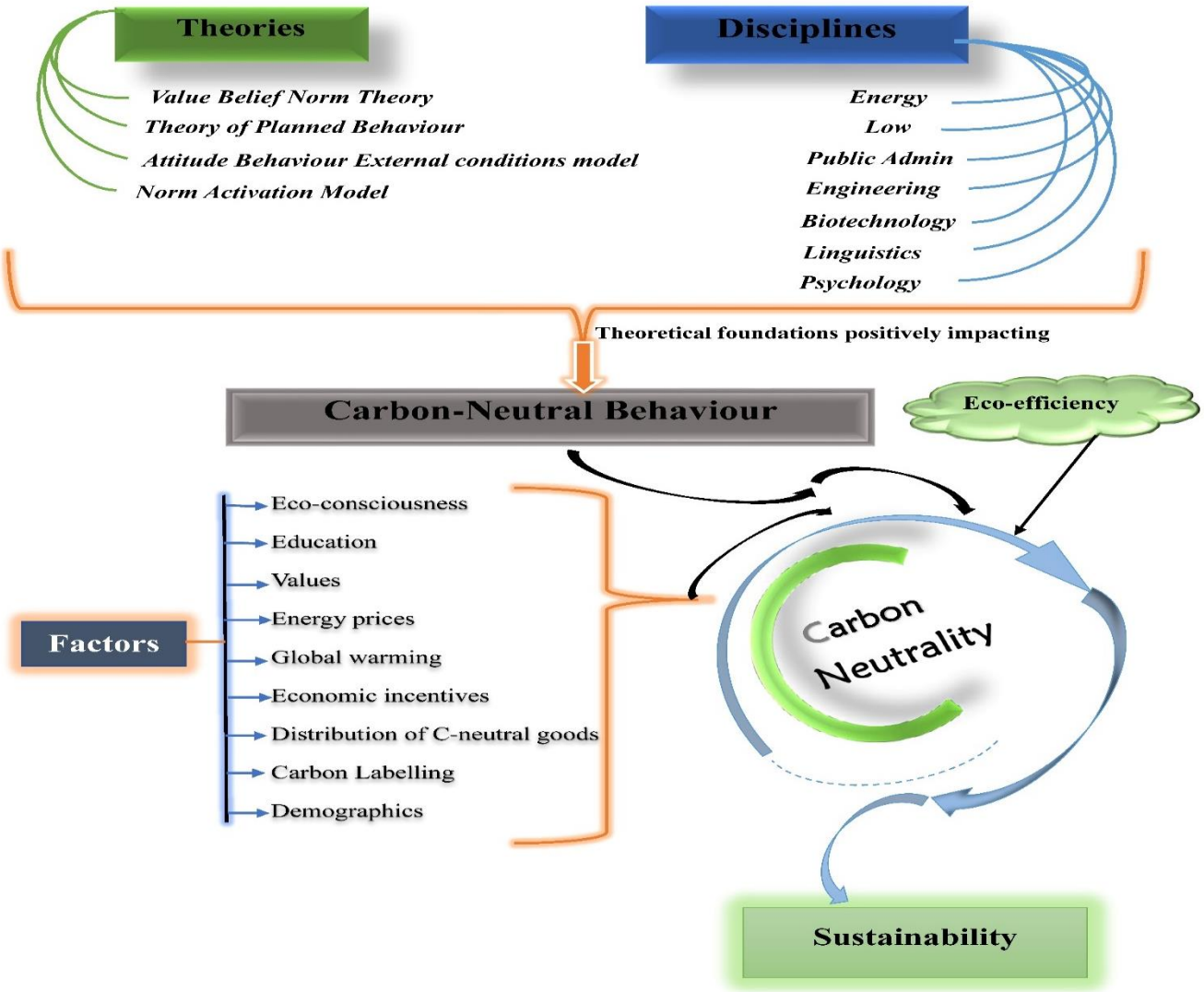

Fig 1: Framework signifying boosters to Carbon Neutrality for attaining Sustainability-A360° approach.

[Source: Authors conceptualization]

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