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Cascading Sustainable Engineering to actualize Green Advertising aided Eco-Centric Bioeconomy

By

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Abstract

The magnitude of change that engineering and technology are capable of unfolding in the direction of sustainability is impeccable. This leaves footprints on the bioeconomy as well. An alignment between sustainable engineering & bioeconomy mediated via green communication can better streamline the sustainability quotient. The myriad of facets of sustainable engineering viz. biotechnology, environmental engineering, engineering design, computer science & electronics, civil engineering etc. synergistically acts to positively impact the bioeconomy. This gets momentum through green advertising about the achievements of sustainable engineering. Also, the detrimental environmental impact of sustainable engineering projects is very low. This exploratory research paper interlaces sustainable engineering, bioeconomy and green advertising through a common thread by engaging grounded theory-embedded conceptual framework analysis. The meta-synthesis of ideas gathered from multi-disciplinary sources resulted in the production of inferences based on these theoretical analyses by labelling comparable types of data with conceptual labels. The inferences drawn in the paper are inductive in character and heralds promise for project engineers, social advocates of green advertising, players in the field of bio economics and marketers at large.

Keywords: Bioeconomy, Green advertising, Sustainable engineering, Sustainability.

Research Objective

To create a nexus between forms of sustainable engineering for actualizing eco-centric bioeconomy for subsequent green advertising.

Introduction

The environment should be treated as a living space and technology as a human instrument for laying the foundation of sustainable ecological environment. The ideology of sustainability has become a goal & ethical concept for both industry and government in contemporary times (Brundtland, 1987). This will help in preserving both macro and micro quality of life that is in consonance with the sensitive ecological equilibrium and may be considered as a step towards sustainable development. Issues like loss of biodiversity, food security, global warming and overconsumption of natural resources create a vacuum for the interjection of sustainability through viable engineering practices. Utmost cooperation is required between nations and among researchers of the world for bridging the gap between anthropogenic activities and environmental challenges. An application-oriented approach in close association with science, industry and administrative agencies can lay the foundation of sustainable circular economy (Velenturf and Purnell, 2021). The preservation of ecological

environment is not the sole task of sustainable engineering but is actually a joint effort of all branches of engineering working in orchestration (Gagnon et al., 2012). Sustainable engineering not only includes good product design but also improves upon quality of life via better economic performance & preservation of natural resources by reduction of material consumption. Responsible engineering can result in products with reduced cost burdens coupled with superior engineering performance & improved environmental performance (Meyer, 2004). Various engineering specializations such as mechanical, computer science, chemical engineering, civil etc. permit the method of modelling that allows optimum utilization of resources at a scale which does not compromise with the natural environment. Also, the advent of machine learning bases itself on the evaluation of its manifestation on sustainable achievements. In today's scenario, the civil engineers are observed as the custodians of constructed as well as natural existing environment (Agenda, 2003). Engineers are expected not only to design and construct within limited confines of natural resources but also exhibit environmental stewardship. It is therefore vital to extrapolate the tenets of sustainable engineering so that it may contribute to bioeconomy and whose green communication (advertising) can lay the foundation of sustainable society. This paper attempts to create a nexus between Sustainable Engineering, Bioeconomy & Green advertising to actualize eco-centric management philosophy.

Literature Review

3.1 Essence & Need of Sustainable Engineering

The urgency to curb world carbon emissions and further realign the sustainability trajectory has gained eminence in the last two decades (IPCC, 2007). Spurt in various interventions to address issues pertaining to social equity, monetary development & ecological protection led to the foundation of 'Sustainability Revolution' (Edwards, 2005) thereby paving way to newer fields of engineering that can palliate sustainability obstacles. There is a dire need to represent both sustainable engineering & conventional engineering on a continuum rather than creating a dichotomy between them. In the light of global warming, the approaches of integrated sustainable engineering can escalate all sections of the society on a sustainable trajectory. Studies reveal that conventional engineering addresses limited set of issues pertaining to environmental impact, flexibility, cost minimization and other technical aspects (Ashley et al., 2008). This calls for broadening the thematic areas of sustainable engineering & steering them in the orientation of sustainability. In the conventional design process opted by engineers, one aspect is pertaining to responsible consumption (Dhillon, 1996). This could be seen as embedding of sustainability quotient in engineering practices & outcomes. The product design process adopted by engineers need to be extrapolated to cover aspects of sustainable design process. The product design process opted by engineers should also be coupled with its suitable communication (Mosborg et al., 2005). If sustainability is to be included then this product design could be propagated via green advertising. All design processes of an engineered project must embed sustainability in its implementation (Mulder, 2006).

3.2 Sustainability Embedded Design Processes in Engineering

In engineering design process, the traditional tasks are coupled with sustainability product analysis and one of the central components in sustainable product development rests on the tenets of sustainability (Byggeth, 2001). The engineering design work teams must interject environment, economy and social system including the individuals into the engineering project for attaining sustainability (Gagnon et al., 2009). The evaluation criteria for sustainable product development includes:

(i) Life cycle assessment
(ii) Life cycle quality
(iii) Life cycle costing (Lu & Gu, 2003)

In contrast to conventional projects, the sustainable engineering projects are anticipated to yield:

1. Increase in efficiency standards
2. Reduction in ecological impact due to engineering projects (Weaver et al., 2000)

The selection of sustainability criteria should be observed as a causal chain reaction encompassing interactions between the project, ecology and economy rather than choosing it on an ad-hoc basis (Lundqvist, 2000). Description of technical know-hows about the mannerism pertaining to integration of ecological underpinnings with product design & its subsequent development should always be made mandatory (ISO, 2002). Modifications in 'Design for Sustainability' referred to as D4S suggest the following with respect to sustainability (Crul & Diehl, 2006):

(i) Product life cycle assessment
(ii) Sustainability oriented communication (Green communication)
(iii) Solution designing based on criteria of:
(a) Economic value
(b) Social value
(c) Ecological value

Sustainable solution must be focused at carbon footprint reduction (from factor-10 to factor- 50) with respect to life cycle assessment as the basis (Weaver et al., 2000). Amalgamating 'sustainability reviews' and 'sustainability tasks' in all the designing phases of sustainable urban decision making in reference to VivaCity 2020 project (Boyko, 2009). Inclusion of sustainability criteria encompassing four considerations namely (i) environmental (ii) technical (iii) social and (iv) economic have been mandatory in project on sustainable water industry by the name of SWARD project (Ashley et al., 2008).

Phase-wise Inclusion of Sustainability in Engineering Design

Table 1: *Interjection of sustainability principles in engineering design*

No.	Phase Name	Sustainability Principle Interjection
1	Problem Definition & Project Planning	Identify issues that circumvent the ecological environment at the problem definition phase. Define sustainability principles in correlation to project planning.
2	Phase of Conceptual Analysis	Create alternative courses of action based on sustainability criteria using tools of sustainability. Define indicators of sustainability.
3	Preliminary Prototype Design	Assess performance of 'benchmark alternatives' based on criteria of sustainability.
4	Finalized Design	Project monitoring from the perspective of applied sustainability indicators.

Source: *Gagnon et al., 2012 in 'From a conventional to a sustainable engineering design process: Different shades of sustainability' in Journal of Engineering Design*

Table 2: *Applied areas of engineering in the direction of sustainability*

No.	Engineering Application Areas	Propounded by
1	Application of machine learning algorithms towards decoding instructional environment sustainability in context to educational management.	Hussain et al., 2019.
2	Evaluation of ecological impacts due to anthropogenic consumption by heterogenous bottom- up approach of environmental engineering engaging clustering algorithms & random forest regression.	Froemelt et al., 2020
3	Supervised machine learning is used to judge advertising popularity & observe that the crafted commercials perform well in the real market scenario.	Anon.
4	Application of sub-slicing method of channels in context to sustainable 5G worlds.	Singh et al., 2020.
5	Statistical machine learning algorithms enable the prediction of energy efficacy standards of residential buildings.	Athanasios Tsanas, AngelikiXifara, 2012.
6	Unsupervised machine learning assists in keeping a check on the buying tendencies of consumers & their algorithms help in segregating consumers in accordance with commonality in purchasing habits. Organizations use this in recommending product options based on the points of parity as applied by machine learning algorithms.	Anon.
7	Sustainable production engineering is based on machine tools and applied production technology.	Blume at al., 2015.
8	The design and composition of sustainable concrete mixtures can be discerned by application of progressive machine learning algorithms.	Jahanbaksh et al., 2020.
9	The potent application of neuro-linguistic programming for enhancing sustainability of projects.	Conforti et al., 2020.
10	With reference to forecasting of water level reservoir in sustainable hydropower generation, machine learning softwares may be useful.	Michelle Sapitang, Wanie M. Ridwan et al., 2020.
11	By application of deep learning, the mitigation strategies for averting any dangerous climatic condition may be decoded through predictive statistical analysis.	Gulati et al., 2020.
12	Optimization of industrial facilities and engineering projects for the sake of environmental protection can be made possible via application of Bayesian network models and neural networks.	De La Heras et al., 2020.
13	Application of computer engineering in statistically measuring the energy consumption of commercial buildings.	Robinson et al., 2017.

3.3 Inclusion of Sustainability in Bioeconomy

In contemporary times, sustainability should be treated as an inherent characteristic of the bioeconomy. The economy in which renewable biological resources contribute the fundamental building blocks like energy, materials and chemicals is referred to as 'bioeconomy' (EC, 2012; OECD, 2009; BECOTEPS, 2011). Such sort of economy meets the following perspectives of sustainability namely: (i) Economic (ii) Environmental and (iii) Social. Inadequate comprehension of the concept of bioeconomy in context to sustainable production and consumption as well as ethical issues is a big concern in the way (EC, 2011).

The scale of biogenic interventions needs to be parallelly increased for meeting the sustainability goals (Bunger, 2013). In the scientific driven bioeconomy, it cannot be assumed that is self- evidently sustainable in nature and there is an urgent need for interjection of sustainability in bioeconomy (Pfau et al., 2014). Several social advocates of environmentalism state that public goods-oriented bio-based economy emphasize on:

(a) Conservation of natural eco-systems
(b) Recycling community services
(c) Equitable sharing of environmental responsibility (Pollack, 2012).

Both science and policy have diverted their attention towards inclusion of bioeconomy & policy documents are increasingly emphasizing on sustainability (EC, 2012; OECD, 2009; BECOTEPS, 2011). Engaging a good band width of stakeholders via integrated and supportive policy schemes will contribute towards increased social commitment towards sustainability thereby making it a base ingredient for flourishing bioeconomy. The advent of bioeconomy has brought about a paradigm shift in the economic arena driven by technology (Langeveld & Sanders, 2010). The ability to utilize biological intervention embedded practical knowledge by enhanced technical expertise of scientific domain has led to the progression of bioeconomy (OECD, 2006). For the sake of production of joint knowledge, integration of scientific knowledge from myriad trans-disciplinary studies is observed with vital inputs from all societal stakeholders (Tress et al., 2004). Societal challenges like ecological pollution, resource scarcity and climate change are witnessing a transformational change after embedding of sustainable forms of production and consumption.

Transitory move of bio-based economy can result in the following advantages:

(a) Optimal management of natural resources
(b) Decrease in greenhouse gases emissions
(c) Improvement in food security
(d) Lesser dependence on fossil fuels
(e) Employment generation opportunity at both urban and rural level.

Inadequate comprehension of the concept of bioeconomy in context to sustainable production & consumption as well. as ethical issues are a big concern in the way (EC, 2011). The improvement in the knowledge base for bioeconomy can be brought about by:

(i) Developing production systems that adapt to changing ecological climate
(ii) Enhancing the productivity of natural resources through sustainable practices (EC, 2012).

The European Commission (EC) has highlighted bioeconomy as a concept that encapsulates both smart and green growth (EC, 2009). Advances in biotechnology are addressing the global issues by considering these concerns as a part of bioeconomy. The principal stimulant impacting the proliferation of bioeconomy includes the demand for sustainable supply of raw materials, food and fuels (German Presidency, 2007). Biotechnology is offering viable sustainable options that hold potential to drive the global economy for the upcoming 30 years in the form of giving booster to bioeconomy & palliating resource and health challenges faced by the world (OECD, 2006). Deep monitoring of sustainability performance by application of stringent sustainability criteria for bio- fuels is required in context to bioeconomy (Edwards et al., 2013). The dominant narrative of knowledge-based bioeconomy supports magnification of ‘sustainable capital’ through substantial increment of biological productivity & natural processes by fixing shortage of natural resources via biological ways (Birch et al., 2010). With reference to

sustainability, market development is significantly impacted by the social implications of bioenergy (considered a part of bioeconomy) (Peck et al., 2009). The application of industrial biotechnology for attaining sustainable processing & subsequent production of materials, fuels & chemicals from biomass lays the foundation of bio-based economy (EuropaBio, 2011). At the local level, there exists an urge for distributed production models & proliferation of international bioeconomy (Luoma et al., 2011).

3.4 Advocacy of Sustainable Bioeconomy via Green Advertising

Consumers exhibiting environmental stewardship show positive responses towards green advertising and get influenced to the extent of altering their perceptions and magnitude of brand engagement by adopting such eco-centric themes (Shin, Ki & Griffin, 2017). Eco-friendly marketing through the medium of Green Advertising is saving the planet by restoring ecological balance. Green advertising creates compelling ecological messages that conscientious customers cannot ignore (Mahato, M. K., Seth, S., & Yadav, P., 2023). Such positive perceptions & brand engagements with eco-centric advertising may give a booster to the economy. For escalating consumer's green behavior, it is imperative to focus on the propagation of eco-information (Siriwardena et al., 2012). This can be attained via green advertising. Organizational sustainability is based on two tenets of:

a) Ecological conservation
b) Business accountability (Gangadharbatla H; Paladino, 2014)

These tenets coincide with the principles of bioeconomy.

Bioeconomy is impacted by both individual & organizational behavior. Sustainable (Green) advertising not only affects the economy at individual & organizational level but also communicates the prospective ecological trepidations (Hartmann, 2014). Bioeconomy is influenced by consumer's attitude & pre-disposition for green products. Green advertising plays a pivotal role in molding the purchase intentions & attitude of consumers towards green products (Schuhwerk & Lefkoff- Hagius, 1995). Myriad of advertisements transmit information pertaining to benefits offered by products & the subsequent advantages that it offers to ecological environment (Grimmer & Woolley, 2014). Several consumers believe in talking about eco-centrism but they don't reflect the same in their buying behavior & consumerism (Chang, 2011; Essoussi & Linton, 2010). Such consumers do not contribute to bioeconomy. Green advertising entails communication pertaining to social commitment of business towards ecological sustainability (Reich & Armstrong Soule, 2016). Green advertising claims that the advertised products are eco-friendly in nature or that their production interventions conserve energy or resources (Chang, 2011). This, in turn, contributes to bioeconomy.

Research Methodology

This conceptual paper employs an exploratory research design. The article bases its conclusions on a large body of literature culled from diverse secondary data sources. Given the topic's multidisciplinary character, the material was obtained from periodicals comprising, engineering disciplines, management (marketing) and environmental scientific knowledge. To provide a full grasp of the vast issue, the interconnected ideas were first separated into frames based on areas of commonality (similarity in meaning). The intended and congruent frames/concepts described the broader issue, gave it direction, and developed a framework-specific philosophy. The conceptual frameworks provided an explanatory approach to social reality and were developed via a qualitative analytical method. The meta-synthesis of ideas gathered from multi-disciplinary sources resulted in the production of inferences based on these

theoretical framework analyses by labelling comparable types of data with conceptual labels. Grounded theory informed the coding paradigms that aided conceptual growth. Following a meaningful synthesis of all thoughts, the conceptual framework was evaluated by specialists and inputs were included. This paper's conclusions are inductive in nature, and the framework offered includes the philosophy of science, epistemological, and pragmatic assumptions.

Findings

The application of grounded theory embedded conceptual framework analysis of the filtered literature yielded the following probable results:

- The advent of bioeconomy has brought about a remarkable change at the perceptual level of consumers in context to sustainability.
- Various facets of sustainable engineering act as stimulants & precursors by working in orchestration for eco-centric management philosophy thereby laying the foundation of bioeconomy. These facets include:

(i) Eco-centric Engineering Design
(ii) Biotechnology Engineering
(iii) Environmental Engineering
(iv) Computer Science & Electronics Engineering

- The literature suggests that there are two foundation pillars of sustainable bioeconomy:

(i) Integrated sustainable engineering approach
(ii) Eco-friendly policy schemes

- Practice, propaganda & subsequent adoption of the above-mentioned foundation pillars of sustainable bioeconomy can be enabled via green advertising.
- Green advertising facilitates the communication of essence of bioeconomy in contemporary times & further justifies the propulsion of concepts of sustainable engineering in the minds of consumers through various technological interventions.

Same has been depicted in the form of conceptual construct clearly bringing out the nexus between Sustainable Engineering, Bioeconomy & Green Advertising post application of grounded theory embedded conceptual framework analysis (See Fig. 1).

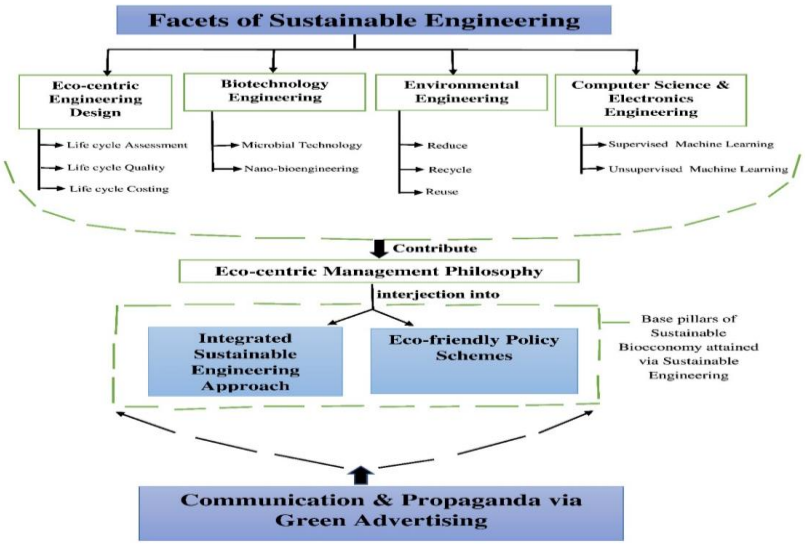

Figure 1: Construct showing the nexus between Sustainable Engineering, Bioeconomy & Green Advertising

[Source: Authors Conceptualization]

Conclusion

Holistic sustainable bioeconomy guarantees that socio-economic structures are never jeopardized by engineering and technology. Micro and macro quality of ecological environment should be in consonance with quality of life aided by technology. The various facets of sustainable engineering have percolated into all aspects of human life & we have entered an era that is continually altered, enriched and updated. Sustainability is a key element of bioeconomy because it entails responsible production & consumption of goods. For ensuring that bioeconomy operates within the permissible limits and yield optimal results at both social and economic horizons, it is imperative to upscale sustainable engineering branches & channelize it in the direction of environmental citizenship. This qualitative research has extrapolated how the various branches of sustainable engineering are contributing towards propulsion of eco- centric management philosophy which when interjected into eco-friendly policy schemes of the government become the tenets of sustainable bioeconomy. Further, the base pillars of sustainable bioeconomy are strengthened with widespread propaganda of eco-friendly policy schemes via approaches of sustainable engineering. The paper neatly interlaces fruitful learnings not just for green project managers, engineers, ecological strategists but also for social advocates of green advertising. This is an endeavor for augmenting future generations with optimal production & consumption through an approach that is engineering and technology savvy.

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