On Studying the Various Challenges Faced by AEC Industry Combatting Carbon Emissions and further studying the Hierarchical Inter-relationships amongst them

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ABSTRACT
Climate change is having a significant impact on businesses, society, and individuals. It is increasingly understood that a shift towards a low-carbon economy is needed. The building and construction sector plays a central role in this shift. The sector's greenhouse gas (GHG) emissions account for approximately 40% of global GHG emissions (WBCSD 2018). The major contributors to these emissions are the materials used as well as the heating, cooling, and lighting of buildings and infrastructure. India is the fastest-growing major economy in the world. It is the fourth largest greenhouse gas (GHG) emitter, accounting for 5.8 percent of global emissions. The following research work discusses about the challenges faced by AEC industry regarding carbon emissions. It thereafter, studied the inter-relationships amongst them using ISM methodology.

Keywords
Micro- finance; Inhibiting factors; ISM Methodology

1. INTRODUCTION
India's emissions increased by 67.1 percent between 1990 and 2012, and are projected to grow 85 percent by 2030 under a business-as-usual scenario. Coal accounted for 43.5 percent of the total energy supply in 2011, followed by biofuels and waste (24.7 percent), petroleum (22.1 percent), natural gas (6.7 percent), hydropower (1.5 percent) and nuclear (1.2

percent) 1. India is working to meet growing energy and it aims to provide electricity to the 25 percent of the population (more than 300 million people) who don't have it.

The ongoing climate change has recently become the most important topic in the world. All due to the dramatic deviations from the approved standards and norms as well as per alarming levels of atmospheric pollution. This discussion also spilled over to the construction industry in the way of carrying out construction investments and what impact it has on the climate.
In order to illustrate the level of the investment's impact on the environment, the carbon footprint factor is used 2-10. The most frequently analyzed factor is the level of carbon dioxide emissions to the atmosphere, which is expressed in terms of the amount of CO_2 per measurement unit. Most often it is m3, kg, ton, person. Using this approved Carbon dioxide emission factor, various activities involved in the construction process could be measured. Among others, the production process of building materials, transport of material to the construction site and the process of incorporating the material (heavy machinery) could also be measured. The sum of all variables gives us the total value of greenhouse gas emissions. An example of this could be that a truck transport produces 40 kg CO_2 during a 20 km journey with cargo and back without (14 m3) and also that Production, transport and installation of an energy-consuming barrier 15 kg / m emits about 35 kg of CO_2 into the atmosphere.
The paper is arranged as follows : Section 2 deals with challenges faced by AEC particularly in construction sector. Thereafter, section 3 deals with ISM methodology . Section 4 deals with case example.

2. CHALLENGES FACED BY AEC PARTICULARLY CONSTRUCTION SECTOR[2-10] [1-13]
The building materials and construction sector is confronted with two major challenges, which expose sector stakeholders along the construction value chain to climate change risks in two ways.
2.1 Climate change [CC]: Construction sector contributes to climate change through greenhouse gas (GHG) emissions and is then exposed to carbon taxes in the production of building materials as well as from power and heat supply in the use phase of buildings. Moreover, the sector must address infrastructure and sector de-carbonization goals (transition risks). Building resilience against the environmental consequences of climate change is therefore , necessary .

2.2 Physical risks [PR]: Extreme weather events and floods may unfold in the near future and require the forward-looking analysis of physical risks. Preparatory measures against the negative effects of these events during the use phase of buildings and infrastructure are therefore required. The expansion of buildings and infrastructure will also influence the natural environment's resilience to negative climate change impacts on the environment due to increases in precipitation and the ability to seize carbon in the natural environment. This will include activities aimed at increasing the durability of materials against extreme weather conditions; Overhauling heating/cooling and insulation concepts during the construction and use phases of buildings.

2.3 Challenge of soil sealing [CSS]: Lowering the potential negative effects of the construction sector on the environment from soil sealing (change in water flows from heavy rain) or land use change (carbon sequestration).

2.4 Embodied carbon challenge [ECC]: Any built structure has carbon emissions in the form of embodied carbon and operational carbon. Operational carbon comes from heating, cooling, and lighting the building, and anything else that draws power. Embodied carbon is the sum total of emissions, including those in the supply chain, from extracting resources, refining them, manufacturing, and logistics. Embodied carbon can account for up to 70% of a building's lifetime carbon emissions. For example, an office for 750 people could contribute 10,000 tons of embodied carbon, about the same as driving 30 million miles in a car.

2.5 **Urban heat island Effect [UHI]:** These solutions make it easier and faster for architects, urban planners and developers to evaluate the optimal choices around daylight, noise, views, wind, run-off and many more. Early-stage site analysis can help mitigate the urban heat island effect. With technology, architects and developers can evaluate the thermal comfort of outdoor spaces, detect problematic areas, and simulate ideal solutions to implement more efficient and sustainable changes before major design decisions are locked in.

2.6 Challenge of creating sustainable cities and spaces [CCSCS]: Many factors contribute to creating cities and spaces that people enjoy spending time in and improve their wellbeing. For example, people who live beside a train station want good public transport but also be able to sleep well at night. Using early-stage site analysis tools helps architects and planners to visualize these factors and to talk about them.

2.7 Challenge of performing early-stage energy analysis [CESEA]: Equipped with energy analysis tools, they can model the predicted energy use of building designs from the earliest stages of conceptual massing through to hand-off. This enables them to visualize and interact with key performance indicators like predicted energy use and operating costs with real-time cause and effect feedback.

2.8 Challenge of handling Operational carbon [CHOC]: Many companies are already quite good at calculating operational carbon. Where the AEC sector can have a profound impact is on embodied carbon—and most companies don't take that seriously. Digital tools exist that can automate some of this complex task, allowing design teams to create and test solutions that can boost successful responses to clients' briefs.

2.9 Emission Reduction Challenges [ERC]: This is to be fulfilled based on the following which includes (a) Rising consumer and/or industrial demand for energy-intensive products and services; (b) Dependence on fossil fuels for economic growth combined with a strong fossil fuel lobby; (c) Deforestation; (d) High energy-use encouraged by government policies and programs.

2.10 **Difficulty in adhering to GHG standards [DAS]:** The government agencies have not been able to keep tab on these illegal activities due to limited resources and the geographic vastness of the country. Second, many mining and industrial enterprises do not adhere to rules for emission of gas and pollution.

3. INTERPRETIVE STRUCTURAL MODELING METHODOLOGY

Interpretive Structural Modeling (ISM) is an interactive learning process in which a set of unique, interrelated variables are structured into a comprehensive model presented as a hierarchy graph. It involves the steps such as identifying the elements and establishing the contextual relationship between elements with respect to which pairs of elements will be examine. Thereafter, developing a self-interaction matrix (SSIM) which includes establishing VAXO relationship amongst the two variables i.e. 'i' and 'j'. Thereafter, reachability matrix is formed which first includes an initial reachability matrix and thereafter and final reachability matrix . Thereafter , level partition matrices and canonical matrices are created from the final reachability matrix using reachability set , antecedent set and the intersection set . The element for which the reachability and intersection sets are the same is the top-level element. The whole process of partitioning is based on establishing the precedence relationships and arranging the elements in a topological order. Classification of variables Based on relative driving power and dependence power, factors are classified in various categories like autonomous, dependent, driver and linkage and finally development of Diagraph/ ISM from the canonical matrix form.

4. CASE EXAMPLE

Ten challenges discussed above in section 2.1 viz. Climate change [CC], Physical risks [PR], Challenge of soil sealing [CSS]; Embodied carbon challenge [ECC]; Urban heat island Effect [UHI], Challenge of creating sustainable cities and spaces [CCSCS]; Challenge of performing Early-stage energy analysis [CESEA]; Challenge of handling Operational carbon [CHOC]; Emission Reduction Challenges [ERC] ; Difficulty in adhering to GHG standards [DAS] are further studied for possible inter-relationships with the help of ISM methodology. Similarly, the four challenges studied in section 2.2 could be studied in the similar way.

Explanation: Physical risks are susceptible to climate change particularly the negative climate change . Again it is important to minimize the potential negative effects of the construction sector. Soil sealing is further influence by embodied carbon challenge. Operational carbon challenge is related to emission reduction. This explanation is every author's independent view. This could subject to changes in perception and viewpoint of other researchers and architectural consultants. Early-stage site analysis can help mitigate the urban heat island effect.

4.1 Construction of Structural self-interaction Matrix (SSIM)

This matrix gives the pair-wise relationship between two variables *i.e. i and j* based on VAXO. SSIM has been presented below in Fig 1.

4.2 Construction of Initial Reachability Matrix and final reachability matrix

The SSIM has been converted in to a binary matrix called the initial reachability matrix shown in fig. 2 by substituting V, A, X, O by 1 or 0 as per the case. After incorporating the transitivity, the final reachability matrix is shown below in the Fig 3.

Fig 1: SSIM matrix for pair wise relationship amongst barriers

S. No.	Barriers	1	2	3	4	5	6	7	8	9	10
		CC	PR	CSS	ECC	UHI	CCSCS	CESEA	CHOC	ERC	DAS
1	CC		A	A	A	X	V	V	V	V	V
2	PR			A	A	A	X	X	X	X	X
3	CSS				X	X	X	X	X	X	X
4	ECC					X	X	X	X	X	X
5	UHI						X	A	A	A	V
6	CCSCS							X	A	A	X
7	CESEA								V	V	V
8	CHOC									X	V
9	ERC										X
10	DAS										

Fig 2: Initial reachability matrix

S. No.	Barriers	1	2	3	4	5	6	7	8	9	10
		CC	PR	CSS	ECC	UHI	CCSCS	CESEA	CHOC	ERC	DAS
1	CC	1	0	0	0	1	1	1	1	1	1
2	PR	1	1	1	1	1	1	1	1	1	1
3	CSS	1	1	1	1	1	1	1	1	1	1
4	ECC	1	1	1	1	1	1	1	1	1	1
5	UHI	0	1	1	1	1	1	0	0	0	1
6	CCSCS	0	1	1	1	1	1	1	0	0	1
7	CESEA	0	1	1	1	1	1	1	1	1	1
8	CHOC	0	1	1	1	1	1	0	1	1	1
9	ERC	0	1	1	1	1	1	0	1	1	1
10	DAS	0	1	1	1	0	1	0	0	1	1

Fig 3 : Final reachability matrix

S. No.	Barriers	1	2	3	4	5	6	7	8	9	10	D.P
		CC	PR	CSS	ECC	UHI	CCSCS	CESEA	CHOC	ERC	DAS	
1	CC	1	1	1	1	1	1	1	1	1	1	10
2	PR	1	1	1	1	1	1	1	1	1	1	10
3	CSS	1	1	1	1	1	1	1	1	1	1	10
4	ECC	1	1	1	1	1	1	1	1	1	1	10
5	UHI	0	1	1	1	1	1	0	0	0	1	6
6	CCSCS	0	1	1	1	1	1	1	0	0	1	7
7	CESEA	0	1	1	1	1	1	1	1	1	1	9
8	CHOC	0	1	1	1	1	1	0	1	1	1	8
9	ERC	0	1	1	1	1	1	0	1	1	1	8
10	DAS	0	1	1	1	0	1	0	0	1	1	6
	De.P	4	10	10	10	9	10	6	7	8	10	

D.P : Driving power ; De.P : Dependence power

4.3 Level Partition

From the final reachability matrix, reachability and final antecedent set for each factor are found. The elements for which the reachability and intersection sets are same are the top-level element in the ISM hierarchy. After the identification of top level element, it is separated out from the other elements and the process continues for next level of elements. Reachability set, antecedent set, intersection set along with different level for elements have been shown below in table 1.

Table 1: Iteration I

S. No.	Reachability set	Antecedent set	Intersection set	Level

1.	**2,3,4,10,6**	1,2,3,4,5,6,7,8,9,10	2,3,4,10,6	I
2.	2,3,4,10,5,6	**1,2,3,4,5,6,7,8,9**	2,3,4,5,6	
3.	2,3,4,10,5,6,9	**1,2,3,4,7,8,9**	2,3,4,9	
4.	2,3,4,10,5,6,9,8	**1,2,3,4,7,8,9**	2,3,4,8,9	
5.	2,3,4,10,5,6,9,8,7	**1,2,3,4,7**	2,3,4,7	
6.	1,2,3,4,5,6,7,8,9,10	1,2,3,4	1,2,3,4	

Table 2: Iteration II

S. No.	**Reachability set**	**Antecedent set**	**Intersection set**	**Level**
2.	**5**	**1,5,7,8,9**	5	**II**
3.	5,9	1,7,8,9	9	
4.	5,9,8	1,7,8,9	8,9	
5.	5,9,8,7	1,7	7	
6.	1,5,7,8,9	1	1	

Table 3: Iteration III

S. No.	**Reachability set**	**Antecedent set**	**Intersection set**	**Level**
3.	**9**	**1,7,8,9**	**9**	**III**
4.	9,8	1,7,8,9	8,9	
5.	9,8,7	1,7	7	
6.	1,7,8,9	1	1	

Table 4: Iteration IV

S. No.	**Reachability set**	**Antecedent set**	**Intersection set**	**Level**
4.	**8**	1,7,8	8	**IV**
5.	8,7	1,7	7	
6.	1,7,8	1	1	

Table 5: Iteration V

S. No.	**Reachability set**	**Antecedent set**	**Intersection set**	**Level**
5.	**7**	1,7	7	**V**
6.	1,7	1	1	

Table 6: Iteration VI

S. No.	**Reachability set**	**Antecedent set**	**Intersection set**	**Level**
6.	**1**	1	1	**VI**

4.5 ISM DIAGRAPH

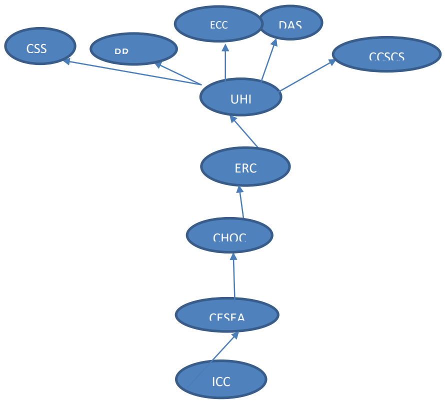
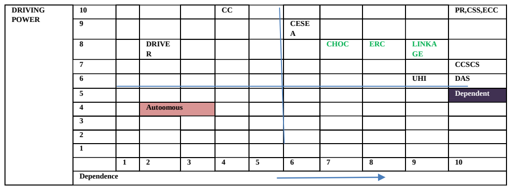


Figure 1 : ISM Diagraph

4.4 DRIVING POWER –DOMINANCE DIAGRAM



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