

A double layer decision modeling for evaluating the conceptual arena of air pollution and linked measures

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Abstract

From last few decades, sustainability becomes a key concern for the sake of society survival. Therefore; firms, practitioners, academicians etc. are required to respond towards ecological deprivation, exhaustion of natural resource and variation in climate; as these are tremendously increasing on behalf of firm's productions and for satisfying households and related daily needs of human beings. Accordingly, the present study is framed by the authors to create alertness about exhaustion and degradation about the ecological aspects in the form of computation and modeling. The present research has exploded the conceptual field of DEMATEL technique to respond towards decision making under socially sustainable field i.e. air pollution and the respective measures. The present modeling is sketched into two layers to bestow an idea to the readers, learners and researcher about the basic perception about air pollution and decision making. In the first layer, the questionnaires are framed to identify the valuable opinion for structuring decision making problem surrounded by decision measures. In the second layer, the identified decision criteria are evaluated based on DEMATEL technique to disclose important outcomes. An attempt towards exploring the theoretical domain of air pollution and its issues are critically addressed in this study.

Keywords: Decision modeling, DEMATEL, Critical Evaluation, Theoretical Dimensions, Pollution

1. Introduction:

The study of sustainability has gained momentum thrust over the last two decades (Mani et al., 2014). Environmental sustainability is significant and is surrounded by varieties of measures and characterises, which requires proper evaluation, awareness and assessment. The same can be achieved by modelling, awareness programmes, technological development and automation. Modeling assists in critically reviewing the system characteristics (Sahu et al., 2015) and thus, modeling based on double layer features pertaining to air pollution is attempted by the authors in this study. A swift towards urbanization are propelling CO₂ emissions a chief byproduct owing to developed economy (Wang and Zhao, 2018). Additionally, the improvement in life standard are gratifying the community towards owning distinguish varieties of private vehicle ownership, which thereby crucially increasing the CO₂ emissions in the atmospheric zone (Wang and Zhao, 2018; Holešovský et al., 2018). Moreover; in long run, evident blow by the consumption of the renewable and non-renewable energy sources are increasing emissions (Frey and Linke, 2002; Bilgili et al., 2016). Moreover; it is found that the consumption and exploitation of renewable energy mechanism are relatively small as compared with non-renewable energy means. Accordingly; today, there is an emergent need to explore significant literatures under the purview of pollutant, carbon emission, energy sources etc. for largely gratifying human needs and deeds (Cerdeira and Moutinho, 2016; Frey and Linke, 2002).

The presence of a mixture of solid particles, harmful matters and toxic gases in the ambient air is reviewed as air pollution and is generally dangerous to the human beings and other inhabitants (He et al., 2017; Gulia et al., 2018). The aforesaid are suspended in the atmosphere in the form of emission from vehicles, factories, chemicals etc. Gradual and extensive encroachment of the forest area by industrialization, agricultural work, construction work, utilization of vehicles etc. are crushing the usual essence of ecology by produces unwanted dust particle, smokes and gases (Devara et al., 2015; Commins et al., 1967; Saha and Padhy, 2011; Sahu et al., 2018a, Rajeevan et al., 2018). Due to urbanization people forgot to take care of their environment and spending all time in search of healthy environment by avoiding all the important factors, which are essential not for environment as well as for them also. Pollution are responsible for causing short term illness as well as long term effects on human health to all

group of age people and childrens. Air pollution contaminates the surface of air and surface of water and soil, which can kill crop or reduce their yield. The presence of harmful gases in air can cause acid rain (Zhang et al., 2017), which damage the river, lakes, crops and propel building monuments to decay. The present study attempted towards investigating interaction relationship amongst distinguishes measures pertaining to air pollution.

Few literatures have focused about identifying the major and multiple factors which causes air pollution and accordingly, there is a need to develop decision modeling for evaluating critical factors and there dependency on each other under the zone of air pollution. There is a need to identify the critical measures of air pollution and is also required to determine the industrial and various other measures responsible for causing air pollution. Accordingly, questionnaires are framed to react towards the critical factors in the first layer, which are evaluated by DEMATEL in the second layer to understand the degree of dependency on each other. The study furnished major and important responsible factors for air pollution causes. It is found that the appraisal level of any structure can be defined by exploring computational models (Chakraborty et al., 2018; Sahu et al., 2018c; Sangwan and Choudhary, 2018) and thus, a computational work for appraising the significant measures under second layer is evaluated by DEMATEL technique in this study.

2. First layer of decision modeling:

It is evident, that in today's scenario pollution is grooming due to vast requirement of manufacturing, industrial, agricultural, construction and other numerous stuffs. Correspondingly, it is required to identify the vast varieties of measures responsible for causes of air pollution under regional domain. Accordingly, the present study is conceptualized by the authors. The technical execution of this study is represented in Figure 1. Today's for satisfying and gratifying consumers need; heavy steel industries, cement industries, agricultural practices, construction machineries & stone crushing, vehicles and automobiles etc. are required, which thereby are responsible for pollution and degradation of environmental performance. Accordingly, in the first layer the questionnaires are framed to identify the valuable opinion for structuring decision making problem surrounded by decision criterions. The below mentioned segments entail an essence of questionnaires, which are projected used to understand the perceptions pertaining to environmental pollution.

Qs1- This pertains towards assessing the overall air quality under regional domain as compared to previous year and briefly point towards garbing the perceptions of the individuals residing in a particular region over last decades. The questioner to briefly define the rating of air quality under regional domain as compared to previous year in a likert scale is required to be framed for the purpose of modeling and assessment.

Qs2- This pertains towards grabbing the characteristics of steel making and its influence on pollution. Steel making entails the course of producing steel from iron ore and scrap, where impurities such as nitrogen, silicon, phosphorus, sulphur and surplus carbon compounds are removed from raw iron and additionally, in steel making other alloying elements such as manganese, nickel, chromium and vanadium are added to produce different grades of steel (<https://en.wikipedia.org/wiki/Steelmaking>). Accordingly, the questioner is required to be defined to briefly explicate major precaution in the form of rating used by the steel plants to control the aforesaid aspects.

Qs3- This pertains towards assessing the status of sintering plant and its effect on generating pollution. Sintering plants utilizes iron ore fines (dust) with other fine materials at high temperature, to create a product that can be used in a blast furnace (https://en.wikipedia.org/wiki/Sinter_plant) and accordingly rating to explicate the working condition and control measures are required to be recognized by way of questioner for modeling and assessment.

Qs4- This pertains towards rating the proper implementation of greenbelt around and within the industrial regional domain to reduce the air pollution within your city for environmental concern. A greenbelt reciprocates a policy towards utilizing and planning the land with the purpose top protects natural or semi-natural environments (https://en.wikipedia.org/wiki/Green_belt).

Qs5- This pertains towards embracing an effort towards recognizing the influence towards pollution by burning of coke, petroleum and other frequent combustibles used in logistics, industries and households. Here, the rating to briefly discuss about the extent of pollution by the aforesaid are required to be recognized by the concerned. The role of factory owners for reducing pollution is also required to be capture for precise outcomes.

Qs6- This pertains towards assessing the role of nitrogen containing compounds emitted to the atmosphere from agricultural activities for generating pollutants in air from decision makers point of view. Corresponding questioner to rate the role of agricultural activities are required to be recognized and assess.

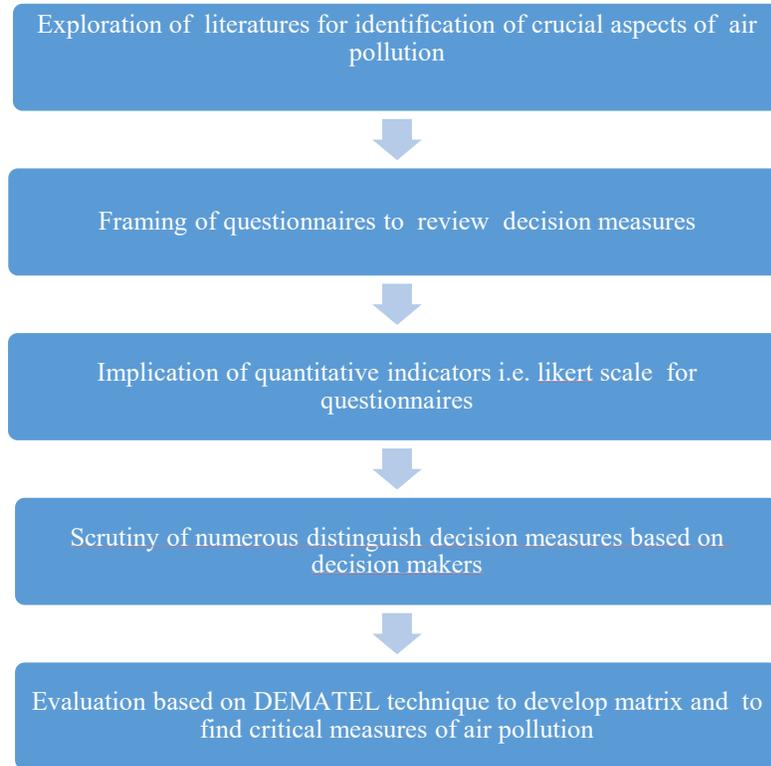


Figure 1. Technical execution of the presented study

Qs7- This pertains towards identifying the intensity of increases of usage of automobiles for satisfying day to day life. The role of increment in utility of automobiles under regional domain causing air pollution and its effect to human life are required to be rated. The concept of clean vehicles and eco-friendly fuel technologies adapted by regional individuals are required to be noted for assuming significant outcomes under decision modeling.

Qs8- This briefly indicates towards defining the role of awareness program and their functioning on a related area to prevent air pollution. Correspondingly, questioner to rate the role of aforesaid programmes is required to be recognized for modelling and assessment.

Qs9- This pertains towards assessing the extent of consumption of more environment friendly fuels i.e. natural gases/ liquefied petroleum gas, instead of petroleum and solid fuel will reduce air pollution from the perspective of group of decision makers. Additionally, perception towards identifying the effective way for reducing the pollution are also required to be modeled in decision making framework for effectual consequences.

Qs10- This pertains towards defining numerous measures responsible for generating air pollution from the decision makers for the purpose to react towards the second layer and its corresponding evaluation and assessment. Here the major carriers responsible for pollution of ambient air quality affecting the environment area are subjectively required to be determined.

Table 1: Status of the decision makers for evaluation

First layer decision makers status						
	(DSP_1)	(DRP_1)	(DAP_1)	(DSP_2)	(DCP_1)	(DRP_2)
Qs1	Steel plant	Regional domain	Agricultural practitioner	Steel plant	Cement plant	Regional domain
Qs2	Steel plant	Regional domain	Agricultural practitioner	Steel plant	Cement plant	Regional domain
Qs3	Steel plant	Regional domain	Agricultural practitioner	Steel plant	Cement plant	Regional domain
Qs4	Steel plant	Regional domain	Agricultural practitioner	Steel plant	Cement plant	Regional domain
Qs5	Steel plant	Regional domain	Agricultural practitioner	Steel plant	Cement plant	Regional domain
Qs6	Steel plant	Regional domain	Agricultural practitioner	Steel plant	Cement plant	Regional domain

<i>Qs7</i>	Steel plant	Regional domain	Agricultural practitioner	Steel plant	Cement plant	Regional domain
<i>Qs8</i>	Steel plant	Regional domain	Agricultural practitioner	Steel plant	Cement plant	Regional domain
<i>Qs9</i>	Steel plant	Regional domain	Agricultural practitioner	Steel plant	Cement plant	Regional domain
<i>Qs10</i>	Steel plant	Regional domain	Agricultural practitioner	Steel plant	Cement plant	Regional domain

3. Second layer and implicated methodology:

In the second layer, the identified decision criteria are evaluated based on DEMATEL (Decision making trial and evaluation methodology) to disclose important outcomes. The DEMATEL is developed by the Battelle Memorial Institute of the Geneva Research Center (Fontela and Gabus, 1976). The procedural steps of the same are illustrated in Figure 2. The technique is considered for classifying the cause and effect chain amongst components in a complex system (Sumrit and Anuntavoranich, 2013; Yang et al., 2013). Evaluation for defining interdependent relationships among scrutinized measures is the main benefit of enrolling DEMATEL techniques in a decision problem. It replicates a visual structural model of the system under evaluation (Shih et al., 2013). The technique explicates the degree of impact and interrelations amongst considered measures and alternatives (Tzeng et al., 2007; Lee et al., 2013). This technique is helpful in defining the role of independent measures in the process of decision making (Wu and Lee, 2007). The procedural steps as presented by Jiunn et al., 2010; Sahu et al., 2018b; Miriam et al., 2018 is utilized in this study to draft a cause and effect relationship and to define the most significant measures responsible for pollution and environmental degradation. In the first layer reactions of the decision makers are approached and accordingly the below mentioned measures are identifying for evaluating in the second layer.

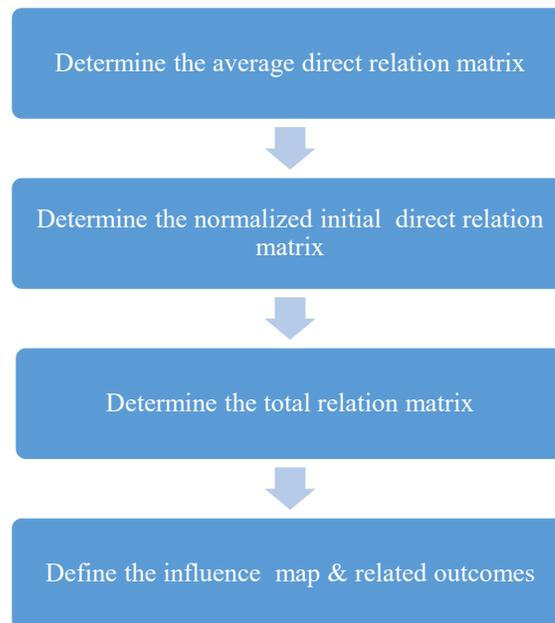


Figure 2. Significant procedural steps of DEMATEL

3.1 Population growth (SL1)- Population growth refers towards the increment in population over time and space. This briefly points towards the requirement of industrial stuffs, transport facilities, agricultural belongings for the sake of satisfy their increased evident requirement and thus thereby responsible for environmental degradation and pollution. The amplification in population demands added exploitation of natural resources and leads numerous environmental problems.

3.2 Mining operations (SL2)- Mining refers to the extraction of natural minerals beneath the earth. The same point towards the utilization of heavy bulky equipments & machineries and release of dust and chemical compounds

from them, which thereby are responsible for creating pollution and ecological exploitation.. The same signifies a significant aspect as major demands of the human beings requires exploitation of mining resources and technologies.

3.3 Agricultural Expansion (SL3)- Agricultural expansion entails towards developing agricultural land, so as to react towards required increased agricultural productivity and production. This briefly refers to the point that ammonia is a common by-product from agricultural activities and is risky to the atmosphere. Additionally, the elevated utilization of distinguish fertilizers, insecticides and pesticides emits damaging chemicals onto the air. Today's for satisfying the growing economy forests lands are getting inverted into agricultural farms.

3.4 Deforestation (SL4)- Deforestation refers towards cutting forests for the sake of fulfilling the raw materials and the respective demands of the industries and human beings for shelter and their migration. The forests are the home for numerous animals, their roots protects soil erosion and acts as a natural inhaler of carbon dioxide. The deforestation leads to pollution by way of upsetting aforesaid practices and affecting towards the process of photosynthesis.

3.5 Exploitation of Fossil Fuels (SL5)- Exploitation of fossil fuels refers to the burning of numerous available fossil fuels like coal, petroleum and other frequent combustibles to be used in logistics, transportation, households etc. This briefly indicates towards the environmental degradation by smoke, gases and dust particles emitted from vehicles including two wheelers, commercial vehicles i.e. trucks, cars, JCB, trains, airplanes.

3.6 Poverty (SL6)- Poverty refers towards the incapability of attaining minimum requirement for living and sustainability. This briefly indicates towards the point about planning the life by the poor, which responded towards less concentration towards child birth and elevated consumption of natural resources. The same exerted heavy pressure on the ecological surroundings by way of fulfilling their daily needs from forest and its products.

3.7 Industrial Development & related Exhaust (SL7)- Industrial development & exhaust from factories and industries basically reciprocates towards the requirement of manufacturing and operational needs for satisfying daily needs of human beings. This briefly indicates towards emission of hydrocarbons, smokes, dust particles, harmfully gases, ashes, toxic wastes and organic compounds from industries and thus leads to the degradation of ecological aspects and responsible for polluted surroundings. Today's, speedy industrialization for augmented engineering outputs are resulting fast exploitation of natural resources and pollution. The same are responsible for CO₂ contamination in the environment and is shifting the usual natural gaseous atmospheric concentration and influencing ozone layer.

3.8 Urbanization (SL8)- Urbanization entails towards the migration of rural population onto urban centers for the sake of employment, economic circumstances etc. and thus thereby creating atmospheric imbalance by over exploitation the natural resources of a particular region. The same demands industrial and agricultural expansion and elevated exploitation of logistics and food means in a particular area and thereby responsible for creating environmental problems.

4. Data collection and interpretation:

Today's, for social survival and sustainability of human dimensions; financial development and trade are required, which adversely producing emissions and pollutants (Grossman and Krueger, 1995; Sahu et al., 2016, Bölük and Mert, 2014). Air pollution occurs when concentration of gases exceed safe limits and hazardous gases and toxic matters starts influencing the health and normal life of human beings and other inhabitants (Owoade t al., 2015; Begum et al., 2013; Begum et al., 2011). The throw increments in automation and automobiles are leading to increased emission from vehicles, which adversely degrading the air quality (Giovanis, 2018). Accordingly, in this study, DEMATEL technique is used by the authors to identify the critical factors and interdependency of various factors based on modeling and evaluation. The present modeling is based on the perception of six decision makers related to the work group of steel making plant, cement plant, agricultural practitioners and common peoples belonging to regional domain for defining the distinguish aspect of pollution and related measures accompanied by two layers. The status of the same is represented by Table 1. Ten point scales are used in the present study for decision modeling and to assess the decision judgment, where 1 signifies the poor performance and 10 signifies the

very high performance of the decision aspects and the residual ranking defines the intermediate responses. In this study, the perceptions are received in the form of questionnaires in the first layer, so as to grab a group of respective measures pertaining to air pollution and its influences. Consequently, decision measures are identified in the second layer and are evaluated based on the exploration of the respective steps of DEMATEL techniques as shown in Figure 2. to disclose important outcomes. Tabulated, Tables 2-10 discloses the significant entries of the implicated DEMATEL technique. Today's, public awareness program, public involvement and understanding are needed to rectify the mistakes and that will lead to a better environment, clean place and healthy environment. Public transport network, metro, buses, e-rickshaws and numerous other renewal resources are the need of today sustainable survival. Drafting effective norms and policies for industries towards disposal of hazardous gases into the environment and its proper implementation is a must required practices for safe future.

Table 2: Direct relationship matrix by first decision maker from steel plant (DSP_1)

	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8
SL1	0.0	2.0	5.0	7.0	7.0	3.0	8.0	8.0
SL2	6.0	0.0	7.0	7.0	8.0	9.0	4.0	9.0
SL3	6.0	10.0	0.0	2.0	10.0	3.0	10.0	7.0
SL4	9.0	4.0	5.0	0.0	1.0	10.0	5.0	7.0
SL5	9.0	3.0	10.0	10.0	0.0	10.0	8.0	1.0
SL6	1.0	10.0	6.0	5.0	4.0	0.0	8.0	6.0
SL7	5.0	2.0	1.0	9.0	2	10.0	0.0	6.0
SL8	8.0	10.0	7.0	7.0	8.0	8.0	10.0	0.0

Table 3: Direct relationship matrix by first decision maker from Regional domain (DRP_1)

	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8
SL1	0.0	9.0	9.0	1.0	4.0	9.0	6.0	6.0
SL2	10.0	0.0	8.0	8.0	2.0	1.0	7.0	10.0
SL3	2.0	10.0	0.0	10.0	9.0	9.0	7.0	2.0
SL4	10.0	2.0	5.0	0.0	8.0	8.0	3.0	4.0
SL5	7.0	6.0	6.0	7.0	0.0	2.0	10.0	10.0
SL6	7.0	4.0	4.0	7.0	8.0	0.0	6.0	6.0
SL7	8.0	2.0	9.0	3.0	8.0	4.0	0.0	7.0
SL8	8.0	6.0	6.0	9.0	7.0	7.0	9.0	0.0

Table 4: Direct relationship matrix by decision maker from Agricultural practitioner (DAP_1)

	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8
SL1	0.0	7.0	2.0	3.0	9.0	4.0	6.0	6.0
SL2	5.0	0.0	8.0	1.0	5.0	2.0	8.0	7.0
SL3	10.0	4.0	0.0	9.0	3.0	7.0	8.0	3.0
SL4	2.0	6.0	6.0	0.0	3.0	7.0	1.0	10.0
SL5	10.0	4.0	7.0	9.0	0.0	10.0	10.0	10.0
SL6	2.0	10.0	7.0	3.0	10.0	0.0	10.0	2.0
SL7	3.0	5.0	2.0	5.0	4.0	9.0	0.0	8.0
SL8	10.0	7.0	7.0	7.0	6.0	6.0	9.0	0.0

Table 5: Direct relationship matrix by second decision maker from Steel plant (DSP_2)

	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8
SL1	0.0	9.0	1.0	2.0	8.0	2.0	6.0	6.0
SL2	7.0	0.0	4.0	4.0	1.0	3.0	1.0	10.0
SL3	4.0	8.0	0.0	5.0	2.0	6.0	6.0	1.0
SL4	9.0	2.0	7.0	0.0	7.0	3.0	7.0	4.0
SL5	10.0	10.0	5.0	9.0	0.0	7.0	7.0	10.0
SL6	6.0	6.0	9.0	2.0	10.0	0.0	10.0	2.0

SL7	2.0	3.0	5.0	4.0	4.0	4.0	0.0	10.0
SL8	7.0	7.0	2.0	10.0	8.0	8.0	9.0	0.0

Table 6: Direct relationship matrix by decision maker from Cement plant (DCP_1)

	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8
SL1	0.0	7.0	1.0	5.0	7.0	2.0	1.0	7.0
SL2	1.0	0.0	5.0	2.0	4.0	4.0	1.0	5.0
SL3	10.0	9.0	0.0	8.0	8.0	9.0	6.0	6.0
SL4	2.0	1.0	1.0	0.0	3.0	9.0	2.0	8.0
SL5	7.0	10.0	6.0	6.0	0.0	9.0	4.0	4.0
SL6	7.0	2.0	10.0	10.0	10.0	0.0	10.0	10.0
SL7	4.0	5.0	3.0	2.0	1.0	10.0	0.0	10.0
SL8	2.0	10.0	10.0	10.0	8.0	8.0	8.0	0.0

Table 7: Direct relationship matrix by second decision maker from Regional domain (DRP_2)

	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8
SL1	0.0	5.0	5.0	2.0	1.0	1.0	10.0	4.0
SL2	1.0	0.0	10.0	3.0	10.0	5.0	2.0	9.0
SL3	9.0	9.0	0.0	10.0	3.0	10.0	7.0	9.0
SL4	3.0	2.0	7.0	0.0	5.0	1.0	7.0	2.0
SL5	10.0	4.0	7.0	5.0	0.0	10.0	8.0	1.0
SL6	4.0	9.0	9.0	6.0	6.0	0.0	8.0	10.0
SL7	2.0	2.0	1.0	10.0	5.0	3.0	0.0	10.0
SL8	6.0	6.0	10.0	8.0	8.0	7.0	7.0	0.0

Table 8: Total relationship matrix

	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8
SL1	0.4501	0.5699	0.5899	0.5433	0.5663	0.5700	0.5750	0.6090
SL2	0.2837	0.2362	0.2910	0.2968	0.2918	0.3100	0.3526	0.3248
SL3	0.3758	0.3305	0.2749	0.3396	0.3703	0.3738	0.3787	0.3624
SL4	0.3952	0.3340	0.3508	0.3034	0.3762	0.3684	0.4197	0.4392
SL5	0.3307	0.3449	0.3592	0.3231	0.2548	0.3260	0.3387	0.3218
SL6	0.3159	0.3167	0.3021	0.3050	0.2702	0.2386	0.2923	0.2914
SL7	0.3158	0.3067	0.2738	0.3104	0.2825	0.3105	0.2612	0.3055
SL8	0.2808	0.2807	0.2864	0.3283	0.2760	0.3018	0.2950	0.2485

Table 9: Tabulated determined cause & effect values

Measures	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8
d_i	4.4735	2.3868	2.8059	2.9870	2.5993	2.3322	2.3665	2.2974
r_j	2.7480	2.7195	2.7281	2.7499	2.6881	2.7991	2.9133	2.9027
$(d_i - r_j)$	1.7255	-0.3326	0.0778	0.2372	-0.0888	-0.4669	-0.5468	-0.6053

Table 10: significant determined values of prominence

Measures	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8
$(d_i \oplus r_j)$	7.2216	5.1063	5.5340	5.7369	5.2874	5.1314	5.2797	5.2001
$w(d_i \oplus r_j)$	0.1623	0.1148	0.1244	0.1289	0.1188	0.1153	0.1187	0.1169

5. Conclusions:

Today, alertness and voices in developing countries are hoisted by the social organizations for enrolling a mixture of social and ecological issues for coping sustainability during manufacturing, supply chain management, design,

development etc. Accordingly, an effort towards devising novel technologies for supporting ease production processes is the need of present scenario, as the same can results in less emission of detrimental pollutants towards environment. The presented study can assists in identifying the most significant dimensions associated with the pollution and society. Today's, urbanization leads towards loading a vast dimensions of inhabitants in a particular region and fiscal expansion are pleasing consumers with the opportunity to acquire more energy consuming stuffs such as vehicles, household items etc. for coziness and attractiveness. Thus, it is required to be reacted by urban planning and development authorities towards devising effectual policies, strategies and means for maintaining and reducing elevated traffic for the sake of improving air quality. Growth in population is found as the first significant measures in the presented work, which is followed by deforestation and agricultural expansion as the second and third significant measures respectively. Moreover, mining operations and activities is found as least significant measure in the presented decision modeling as shown in Figure 3 Accordingly, today's; there is a need to draft cluster of strategies including legal and motivational to react towards the problem of population growth amongst others for sustainable development and healthy surroundings.

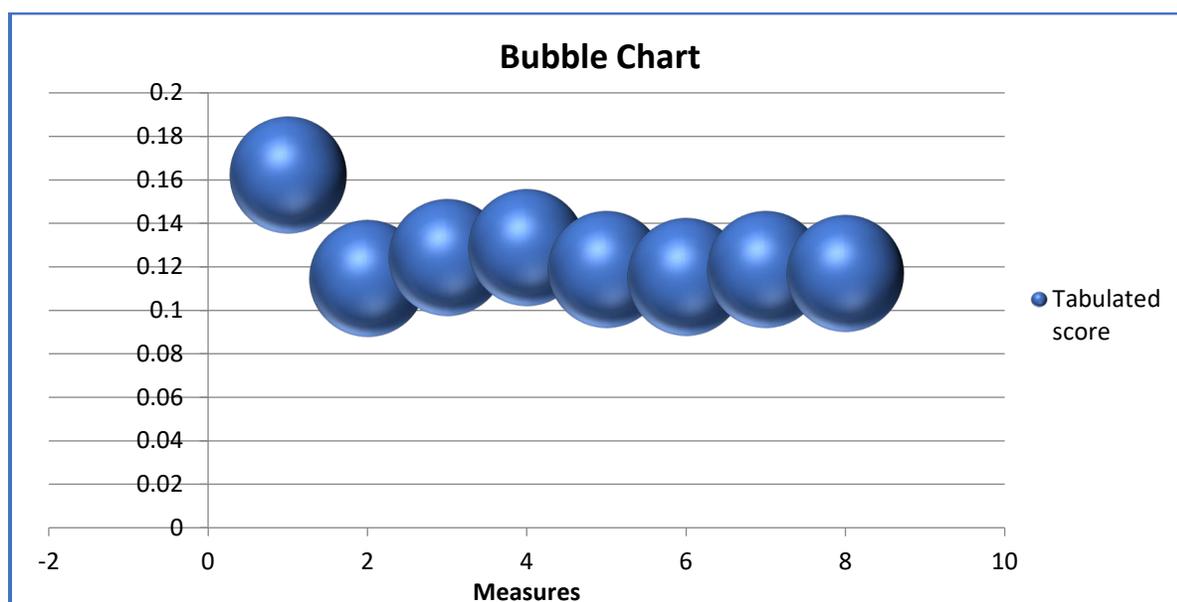


Figure 3. Tabulated scores of measures

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