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RESEARCH ARTICLE

SUSTAINABILITY STUDIES OF TRANSPORTATION CORRIDORS:A REVIEW.

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Abstract

Introduction:-

Development as standalone feature has got no status, unless it is sustainable. Sustainable development keeps a balance between environmental, social and economic aims. When we speak the term development, it may include active actions in various sectors like medical field, information technology, education sector, space exploration programmes, etc. etc. **But, one field which is an inherent part of every such field is the transportation sector**. With the development of society and for the development of society at all the fronts, a sustainable transport system is most vital component connected to every other field and without which the development in any other sector cannot be sustainable.

The first United Nations Conference on the Human Environment was held in Stockholm, Swedenin 1972.After the conference, an influential book named **The Limits to Growth**was published by Meadows et al. (1972). While describing the prospects for growth in the human population and the global economy for the 20th century, it said thatif the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, then the limits to growth on this planet will be reached sometime within the next 100 years. However, it is possible to achieve ecological and economic stability that is sustainable far into the future. Sooner the action to attain this stability starts, the greater will be the chances of success and a sustainable future.

In order to evaluate the sustainable transportation system, various approaches have been proposed worldwide in various conferences, research programmes and other transportation boards all over the world, which have been reviewed and summarized in this paper.

Towards sustainable development:-

In 1984, the World Commission on Environment and Development (WCED) was established with the task of formulating `a global agenda for change', which resulted in 1987 in the publication of the **Our Common Future**, or Brundtland report. Also, a conference was organized by the Organization for Economic Co-operation and Development (OECD) in Vancouver in March 1996 on the subject "**TOWARDS SUSTAINABLE TRANSPORTATION",** in whichtheexponential growth in the mobility of both people and goods was considered. The eroding benefits of the advancements in social and economic areas and challenges imposed due to the trends in

transport activity volume and growth, for the societies aiming towards sustainable development were brought forward for consideration.

The Brundtland Commission:-
Initially, the term **sustainable development** was introduced in 1980, popularised in the 1987 report of the WCED. This term was given the status of a global mission by the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992. The Brundtland Commission defined sustainable development as**"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."**

Two key concepts i.e. '**needs' and 'limitations'**were noted and elaborated. Needs, meaning "in particular the essential needs of the world's poor," and limitations, meaning "limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs."

OECD paper distributed at the Vancouver conference provided a preliminary qualitative definition of Environmentally Sustainable Transport (EST), as**transportation that does not endanger public health or ecosystems and meets mobility** needs consistent with the use of renewable resources at below their rates of regeneration and non-renewable resources at below the rates of development of renewable substitutes.

The OECD paper had set out six criteriarelated to control on emissions of nitrogen oxides (NOx), volatile organic compounds (VOCs), carbon dioxide (CO_2), particulates, Land surface and Noise caused by transportation for the attainment of EST in the target year of 2030:

Sustainable Transportation and Quality of Life:-
In the paper titled "**Sustainable transportation and quality of life"** published in the Journal of Transport Geography 13 (2005), Linda Steg and Robert Gifford highlighted the continuing increase in the use and density of automobiles (more vehicles with fewer people in them travellinggreater distances over proportionally shorter roads) was considered as short term gains at the cost of long-term losses to society in regard to transportation sustainability and quality of life.

Definition of Sustainability and Sustainability Indicators
Although no common accepted definition of sustainability, sustainable development or sustainable transport was available (Beatley, 1995), it was generally accepted that sustainable development, and more specifically, sustainable transport, implied finding a proper balance between (current and future) environmental, social and economic qualities (e.g., OECD, 1996; Ruckelhaus, 1989; Litman, 2003; WCED, 1987). However, detailed Environmental, Social and Economic parametersrequired for a sustainable development were not identified till then.

Geurs and Van Wee (2000) examined whether various future transport scenarios would be sustainable. First, they defined environmentally sustainable transport criteria, such as emissions of CO_2, NOx, VOS, particles, noise, and land use. Second, they defined three environmentally sustainable transport scenarios that would meet these criteria, following a back casting method: a high-technology scenario (only technological changes), a mobility-change scenario (only behaviour changes aimed to reduce car dependency) and a combination scenario (technological and behavioral changes).**Their study revealed that environmentally sustainable transport goals can be met only if a large increase in technological development is assumed, and/or very stringent behavioral adaptations and changes in spatial and economic structures are assumed.** However, they focused on social indicators threatened by motorized transport, such as safety, health, perceived environmental qualities, and community relationships.

The Brundtland Commission had also stressed the importance of quality of life in their definition of sustainable development (WCED, 1987, p. 43). Thus, sustainable transport should also be concerned with human needs and values. The effects of strategies aimed at stimulating sustainable transport should also be assessed in terms of human needs and values.

Based on an extensive literature review of needs, values and human well-being, a list of Quality of Life (QoL) indicators had been developed and used in various research projects on sustainable household consumption at the University of Groningen (see Gatersleben, 2000; Poortinga et al., 2001, 2004; Skolnik, 1997; Slotegraaf and Vlek, 1996; Steg et al., 2002; Vlek et al., 1998, 1999). Table 1 provides an overview of the most recent version of these QoL indicators. The mean importance rating of each QoL indicator is included. The data are from a questionnaire

study of 455 Dutch respondents in 1999; scores could range from 1 'not important' to 5 'very important' (see Poortinga et al.,2001, 2004, for more details).

Table 1 : An overview of the most recent version of the qol indicators.

Indicator	Description	M
Health	Being in good health. Having access to adequate health care.	4.9
Partner and family	Having an intimate relationship. Having a stable family life and good family relationships	4.7
Social justice	Having equal opportunities and the same possibilities and rights as others. Being treated in a just manner.	4.7
Freedom	Freedom and control over the course of one's life, to be able to decide for yourself, what you will do, when and how	4.5
Safety	Being safe at home and in the streets. Being able to avoid accidents and protected against criminality.	4.5
Education	Having the opportunity to get a good education and to develop one's general knowledge	4.3
Identity/self-respect	Having sufficient self-respect and being able to develop one's own identify.	4.2
Privacy	Having the opportunity to be yourself, to do our own things and to have a place of your own	4.2
Environmental quality	Having access to clean air, water and soil. Having and maintaining good environmental quality.	4.2
Social relations	Having good relationships with friends, colleagues and neighbours. Being able to maintain contacts and to make new ones.	4.2
Work	Having or being able to find a job and being able to fulfill it as pleasantly as possible.	4.2
Security	Feeling attended to and cared for by others	4.1
Nature/biodiversity	Being able to enjoy natural landscapes,parks and forests. Assurance of the continued existence of plants and animals and maintaining biodiversity.	4.1
Leisure time	Having enough time after work and household work and being able to spend this time satisfactorily.	4.0
Money/Income	Having enough money to buy and to do things that are necessary and pleasing.	3.6
Comfort	Having a comfortable and easy daily life	3.5
Aesthetic beauty	Being able to enjoy the beauty of nature and culture	3.5
Change/variation	Having a varied life. Experiencing as many things as possible	3.3
Challenge/excitement	Having challenges and experiencing pleasant and exciting things	3.2
Status/recognition	Being appreciated and respected by others	3.0
Spirituality/religion	Being able to live a life with the emphasis on spirituality and/or with your own religious persuasion	2.9
Material Beauty	Having nice possessions in and around the house	2.6

Sustainable Urban Transport Development:-

M.H.P. Zuidgeest**,** during his Ph.D. study concluded in 2005 on the subject **"sustainable urban transport development- a dynamic optimisation approach"**highlighted that the Traffic and transport policies differ greatly from city to city, from country to country, as do the travel patterns of the people in these cities and countries. Mobility and accessibility provided by the transport system have played a major role in shaping countries, influencing the location of social and economic activity, the form and size of cities, and the style and pace of life by facilitating trade, permitting access to people and resources, and enabling greater economies of scale, worldwide and throughout history.

In the summary of the thesis, Zuidgeest mentioned thatCurrent developments in urban transport realities force authorities to plan, manage and maintain their transport systems more accurately and take into account the requirements of a growing number of complex and sometimesconflicting interests like congestion relief, pollution reduction, efficient resourceuse, equity and accessibility.The common solution to such emerging problems and

changing requirementsin transport is to build extra capacity, make better use of existing infrastructure, discourage and/or promote other means of transport or even influencetravel patterns of people as well as freight, following the principle of predict-provide-manage. His framework based on a paradigm for sustainable urban transport development, advocatesa more efficient, equitable, and environmentally sensitive transport system.

Performance measures of sustainability:-

Performance Measures of Sustainability as reviewed by Jeon and Amekudzi (2005) provided an extensive list of indicators sorted by the relative frequencies with which they appeared in the sixteen initiatives. All the transportation sustainability indicators reviewed may be classified into four major categories **i.e. transportation system effectiveness-related, economic, environmental, and socio-cultural/equity-related indicators.**Itwas inferred that the transportation-related and environmental indicators seem to be the most widely used indicators for sustainable transportation. The synthesis of indicators suggested that sustainable transportation gets largely captured more by transportation effectiveness and efficiency indicators and environmental indicators and to a lesser extent by economic and social indicators.

Sustainable Transportation Performance Measures:-

A Guide to sustainable transportation performance measures released in August 2011 was prepared by ICF International for the U.S. Environmental Protection Agency after a one-day workshop conducted at the Southwestern Pennsylvania Commission and the Mid-America Regional Council. The environmental, economic, and social sustainability was incorporated into transportation decision-making through the use of performance measures, which allow decision-makers to quickly observe the effects of a proposed transportation project to monitor trends in transportation system performance over time. While many transportation agencies use performance measures as part of planning and project development, their use to promote sustainability has historically been limited. The measurement of environmental, economic, and social outcomes had yielded positive results. Many agencies had found that, once they begin to report sustainable transportation performance measures, stakeholders quickly see their value and come to expect regular reporting of measures and more explicit linkages between the measures and public agency decisions.

Sustainability in Transportation Decision-Making:-

Many transportation agencies were called upon by their stakeholders to plan, build, and operate transportation systems that – in addition to achieving the important goals of mobility and safety – support a variety of environmental, economic, and social objectives. These include protecting natural resources, improving public health, strengthening energy security, expanding the economy, and providing mobility to disadvantaged people. Other important societal priorities were also driving the need to consider these goals in transportation decisions:

- **Environmental Quality:-** While pollutant emissions from motor vehicles have dropped dramatically over the last three decades, air quality problems persist in many metropolitan areas, driven in part by growth in vehicle miles traveled (VMT).

- **Economic Development:-** Efficient and reliable movement of people and goods improves productivity and can spur economic growth. Moreover, with rising regional competition, quality of life has become increasingly important for drawing and retaining a talented and productive workforce.

- **Social Equity:-** People who are economically, socially, or physically disadvantaged need transportation options to give them opportunities to work, learn, and participate in society. Transportation is a large and growing expense for many families. Households in locations with poor accessibility to employment opportunities and other destinations and no alternatives to driving tend to spend more on transportation.

Other Performance Measures:-

Since these initiatives were reviewed, an increasing number of sustainability-related studies have been conducted around the world. Such studies on sustainable transportation range from case studies on sustainability measurement for a particular region to the development of new or comprehensive sustainability metrics at different planning levels, such as corridor-level, intra- and inter-city level, urban-level, and macro level global indicators. Corbiere-Nicollier and Jolliet (2002) develop indicators usable at the communal level, to determine the socio-economic and environmental impacts of various alternatives using the case of three communities in Switzerland. Federici et al. (2003) measured efficiency and sustainability for passenger and commodities transportation systems of a medium

size district of central Italy: Siena. Van Den Berg et al. (2005) set out to measure the transportation performance of one South African city, the Tshwane Metropolitan Municipality (TMM), against a number of world cities. **Amidst various studies, Litman (2005 and 2007) attempted to provide the most important indicators for comprehensive and sustainable transportation planning that can be applied across the board in most situations.**

Sustainable transportation indicators:-

A Research Program for Developing Sustainable Transportation Indicators and Data was conducted by Sustainable Transportation Indicators Subcommittee of the Transportation Research Board under the chairmanship of Todd Litman, which submitted the report on 10 November 2008. He identified**the Sustainable Transportation Indicators** that can be used for sustainable transportation evaluation. The **Principles for Selecting Sustainable Transport Indicators were** variables selected and defined to measure progress toward an objective. Indicators reflected various levels of analysis, For example, the decision-making process (the quality of planning), responses (travel patterns), physical impacts (emission and accident rates), effects these have on people and the environment (injuries and deaths, and ecological damages) and their economic impacts (costs to society due to crashes and environmental degradation). A sustainability index can include indicators that reflect various levels of analysis, but it is important to take their relationships into account in evaluation to avoid double-counting. For example, reductions in vehicle-mile emission rates can reduce ambient emissions and human health damages; it may be useful to track each of these factors, but it would be wrong to add them up as if they reflect different types of impacts.

Sustainable transportation indicators are an important tool for better transportation planning. In the absence of standard set of sustainable transportation indicators, variety of indicatorsappropriate and useful for planning and policy analysis was used. There was a needto develop standardized, indicator sets with consistent definitions and collection methods, suitable for comparing impacts and trends between different organizations, jurisdictions and times. All indicators may not be appropriate under all circumstances and even specific conditions may need to be supplemented with specific indicators for defining and analyzing the situation prevalent to those places only. Todd Litman proposed a set of the indicators applicable virtually every situation. Another subset was proposed for application where they are relevant and feasible for a project, plan, or program. A third subset was proposed for specific applications.

The transportation sector was one of the focus topic of UN commission for sustainable development (CSD) process during 2010/2011. In March 2011, a document titled "Sustainable transport Evaluation" was released. As per the document, a more sustainable transportation system (Adapted from CST 2005) is one that allows the basic access and development needs of people to be met safely and promotes equity within and between successive generations **(Social dimension), i**s affordable within the limits imposed by internationalization of external costs, operates fairly and efficiently, and fosters a balanced regional development (**Economic dimension),** limits emissions of air pollution in GHGs as well as waste and minimizes the impact on the use of land and the generation of noise **(Environmental dimension) and** is designed in a participatory process, which involves relevant stakeholders in all parts of the society **(Degree of participation)**

In conclusion, low-carbon, **sustainable transport** reduces short and long term negative impacts on the local and global environments, has economically viable infrastructure and operation, and provides safe and secure success for both persons and goods. (Dalkmann and Huizenga 2010). Ten key indicators for more sustainable transport in given in Table 2

Table 2 : Ten key indicators for more sustainable transport.

Dimension/Indicator	Underlying Sustainability Goal	Indicator Type	Current availability of Data
ENVIRONMENT			
Land consumption by transport infrastructure (as % of total surface)	Avoid sprawl and destruction of the environment by transport infrastructure	Effect/ Impact	Low
Transport GHG emissions per capita	Reduce transport contribution to climate change	Effect/ Impact	Medium
Percentage of population affected by local air pollutants(e.g. PM_{10} concentration, Non-Methane Hydrocarbons [NMHC] emissions …)	Reduce detrimental effects on human health and the environment	Effect/ Impact	Medium
EQUITY/SOCIAL			
Road fatalities	Reduce the number of people killed or injured in road traffic accidents	Effect /impact	High
Modal share of PT/NMT	Faster transport modes that are both accessible for a large part of the population and environmentally sound	Outcome	Medium
Share of transport cost from total household expenditure	Provide affordable transportation for all members of the society	Outcome	Medium
ECONOMY			
Minimum taxation on fuel	Consider the external costs caused by transportation based on fossil fuels (especially road traffic)	Performance	High
Transport investments by mode	Prefer transport modes that are accessible and environmentally sound	Performance	High
PKM/TKM per unit GDP	Decouple economic growth from transport demand	Effect/ impact	Medium
GOVERNANCE			
Participatory transport planning	Involve the public in the decision process for transport policies and projects	Performance	Low

Evaluation methodologies -- sustainable transportation:-

A growing number of qualitative and quantitative studies on assessing transportationsystem sustainability have been conducted around the world. Various tools and methodologies such as scenarioplanning; graphical models; system dynamics approaches; economic-based models;integrated transportation and land use models; simulation and decision analysis models;environmental impact analysis; and life cycle assessment (LCA) had been proposed.

Scenario planning approaches essentially incorporate uncertainties associatedwith key drivers, such as population, employment, and travel demand, in planning. Thetransportation planning process may incorporate scenario analysis that explores a list ofreasonable options/scenarios to address various sustainability issues such asenvironmental integrity, safety, and mobility. Since the standard methodology ofscenario assessment, based on the benefit-cost framework, has failed to investigate cause-and-effect relationships within and affecting transportation systems, the system dynamicsapproach has been proposed to investigate the cause-and-effect relationships betweenstate and flow variables organized in feedback loops within an integrated system.Influence diagrams, one of the most relevant methodologies among graphical models,also capture the dependency structure among events and factors. The wide range offactors influencing the conditions of sustainability, such as market forces, low-price fuel,and vehicle-dependent land use patterns, can be identified and used in the analysis.

Quantitative sustainability models have been applied in several European studies,including such models as SPARTACUS (Systems for Planning and Research in Townsand Cities for Urban Sustainability) and ESCOT (Economic Assessment of SustainabilityPolicies of Transport) initiatives. The SPARTACUS study uses an

integratedtransportation and land use model to evaluate the sustainability ofselected transportation and land use scenarios. The transportation and land use interactionmodel captures how the degree of access (accessibility) provided by the transportationsystem can influence land use distribution, and, in turn, how the spacing of developmentcan greatly influence regional travel patterns. The ESCOT study, on the other hand,focuses more on evaluating the "economic" feasibility of environmentally sustainablescenarios using a system dynamics model. Emerging methods of evaluating sustainabilityare based on the comprehensive concept of sustainability, defined earlier as includingeconomic, environmental, and social parameters of sustainability, incorporating varioustypes of integrated transportation - land use - environment models.

The Federal Highway Administration (FHWA) under the United StatesDepartment of Transportation has developed a toolbox for regional policy. The toolboxis designed for use by metropolitan planning organizations (MPOs), state departments oftransportation (DOTs), and other analysts would like to assess a range of impacts inregional transportation and/or land use planning..

Synthesis – Tools and Techniques:-

The review of analytical methods for sustainability evaluation revealed that while there wasno standard method. Rather, there are several important elements to consider in the developmentof robust methodologies for sustainability evaluation. These critical elements arediscussed below.

- The analysis methods that can capture both causal and impact elements ofsustainability (e.g., those that incorporate systems dynamics or graphical models)will typically present a broader systems view of the infrastructure system underconsideration, and enable the analyst to identify and consider the key drivers thataffect the sustainability of the system under consideration, to the extent that this ispossible.
- Most models are based on the multidimensional themes of economic,environmental, and social impacts, indicating that a robust method should at theminimum consider these dimensions as decision making criteria. This would seemto indicate that multi-criteriamulti-objective methods are better suited tosustainability assessments than single-criterion/single objective methods.
- The uncertainties inherent in the planning process may be addressed by introducingscenario methods which in essence postulate plausible scenarios based on keysystem drivers, and then proceed to develop plans that would ensure acceptableoutcomes for all the plausiblescenarios. Because of the uncertainties associatedwith planning, particularly in the context of rapid metropolitan growth and theproliferation of major and megacities, it would seem that such a construct wouldbecome integral element of transportation planning to inject robustness into theprocess.
- A truly sustainability-oriented analysis should consider accessibility as well asmobility to properly integrate land use considerations.A truly sustainability-oriented analysis should also incorporate the systemsinteractions not only among the causal factors influencing sustainability but theimpacts as well.
- Emerging analytical approaches for sustainable transportation tend to incorporatemore integrative models or software suites which allow the analyst to evaluate awider range of sustainability issues. Ideally, sustainability evaluation shouldincorporate broader environmental, economic, social impacts of transportationsystems and model the necessary interactions among these multi-dimensions.

Multiple Criteria Decision making in Transportation:-

The multidimensional nature of sustainability indicates that multicriteria ormultiobjective methods would be more appropriate for sustainability assessments thansingle-criterion/single-objective methods.

Multi-Criteria Decision Making (MCDM) Method:-

Multi-criteria decision making (MCDM) is one of the established branches of DecisionTheory, and it is especially useful when making preference-based decisions overavailable alternatives that are characterized by multiple, usually conflicting, attributes(Hwang and Yoon, 1981; Triantaphyllou, 2000) Unlike single-objective decision-makingtechniques, such as benefit-cost or cost-effectiveness analysis, MCDM approaches cantake into account a wide range of differing, yet relevant criteria (Zietsman et al., 2003).MCDM methods are generally divided intomulti-objective decision making(MODM) that studies decision problems with a continuous decision space and multiattributedecision making (MADM). In many cases, the terms MADM and MCDM areused interchangeably, and they concentrate on problems with a discrete decision space(Triantaphyllou 2000).

MACBETH (Measuring Attractiveness by a Categorical Based EvaluationTechnique) is a relatively new methodology used in multi-criteria decision aids,developed in the early 1990s by Bana e Costa and Vansnick (2003).

MACBETH utilizesone of the most common MCDM techniques, the weighted sum model (WSM), whichemploys an additive value aggregation model. In addition, MACBETH's interactiveapproach requires only qualitative judgments about differences to help a decision makerquantify the relative attractiveness of options. It employs an initial, interactive,questioning procedure that compares two elements at a time, requesting only a qualitativepreference judgment. As judgments are entered into the software, it automaticallyverifies their consistency. A numerical scale is generated that is entirely consistent withall the decision maker's judgments. Through a similar process weights are generated forcriteria. The M-MACBETH software provides tools to facilitate: complete modelstructuring, management of complex problems involving qualitative value scores andweights, and interactive sensitivity and robustness analyses (Bana e Costa, 2003).

The WSM approach is used interchangeably with the additive utility modelwhich has various strengths over the other methods. This model is particularly simple as its technical parameters have a clear and explicable substantiveinterpretation. It allows processing of the difficult problem of the relative importance ofcriteria in a precise way and it permits avoidance of the difficulties that are inherent inevery ordinal aggregation (Bana e Costa, 2003).

MCDM Applications in Transportation:-

Because the transportation planning process includes many different objectives andreflects the interests of a wide range of stakeholders, appropriate techniques need toincorporate these multiple and conflicting objectives into the assessment process.Moreover, decision-making in the context of sustainable transportation should involvethe evaluation of a discrete set of alternatives while simultaneously consideringconflicting objectives. In 1980, Black and Kuranami introduced interactive multiple objectiveprogramming in the field of strategic land use and transportation planning as a promisingmethod of helping decision makers examine competing objectives (Black and Kuranami,1980).

The research trends indicate that MCDM methods have been often applied toproject-level studies since the early 1980s. One of themost common methodologies of MCDM is Saaty's Analytic Hierarchy Process (AHP)developed in 1970s to provide a systematic approach to setting priorities and decisionmaking based on pairwise comparisons between criteria (Saaty, 1995). Since Saatyintroduces the application of this method in transportation decision making, the AHPmethod is frequently used to incorporate multiple decision criteria in the evaluation oftransportation alternatives.

The most common MCDM schemes include the weighted sum model (WSM), theweighted product model (WPM), and the analytic hierarchy process (AHP). Different types of fuzzy MCDM methods aremore frequently used in transportation decision making to confront uncertainties. Thesefuzzy-type MCDM methods attempt to cater for uncertainty, vagueness, or fuzzinesscommonly inherent in human decision making due to a lack of information or constraintsin human thinking.

Fuzzy-based and ahp methods in sustainability evaluation:-

Riccardo Rossi, Massimiliano Gastaldi & Gregorio Gecchele made a comparison of fuzzy-based and AHP methods in sustainability evaluation in April 2011 (as published in Springer on 13 September 2013), approaches to evaluate sustainable transport systems as proposed by Awasthi et al., are divided in eight categories.

- Life-cycle analysis (LCA) combines pollution emissions and resources used during the life course of a product in order to calculate some criteria.
- Cost-Benefit Analysis (CBA) examines the monetary equivalent of all the positive and negative effects of a project alternative, with the aim of minimising the costs related to that alternative.
- Deeper analysis of project alternatives can involve Environmental Impact Assessment (EIA).
- Optimisation models, applied in the context of sustainable transport, aim at optimal solutions under the specified constraints of social, economic and environmental objectives.
- In the case of complex systems, System Dynamics Models are useful to describe the relationships between the elements of the system by examining time-varying flows and feedback mechanisms.
- Assessment indicator models define indicators which evaluate the sustainability of a practice or a project.
- The Data Analysis approach uses statistical techniques, such as hypothesis testing or structural equation modelling, to evaluate sustainability.

- Multi-Criteria Decision Analysis (MCDA) methods represent an ample set of methods, including the well-known Multi-Attribute Utility Function Theory (MAUT), Analytic Hierarchy Process (AHP) and ELECTRE methods.

Formalising the concept of the "three pillars of sustainability", the Fuzzy-Based Evaluation Method (FBEM) method determines an overall fuzzy index of sustainability for each analysed alternative policy and provides further information about combined dimensions of sustainability. Analysis of the results conclude that in general terms, the interpretability and simplicity of the FBEM structure makes it a valuable tool for solving sustainability evaluation problems. It can deal with non-homogeneous indicators, maintaining the kind of uncertainty associated with them and the interrelation between the dimensions of sustainability.

Sustainability Evaluation of Transport Networks for Selected European Countries:-
Reference is made to the paper on the title **"Multicriteria Sustainability Evaluation of TransportNetworks for Selected European Countries"** byO.Ilker Kolak, Darcin Akın, S. Ilker Birbil, Orhan Feyzioglu and Nilay Noyan ;published in WCE July 2011 The paper contributes to the relatively scarce literature particularly related to sustainable transport by introducing a method for evaluating the sustainability of the country-wide transport systems.

As an essential economic activity, transportationhas complex interactions with the environment and society.Since the concept of sustainable development has become oneof the top priorities for nations, there has been a growinginterest in evaluating the performance of transport systemswith respect to sustainability issues. The main purpose of thisstudy is to introduce a decision making framework to assess thesustainability of the transport networks in a multidimensionalsetting and a technique to identify non-compromise alternatives.In the transportation literature, existing indicators mainlyreflect the economic, social and environmental effects of asystem, thus sustainability indicators are generally categorized in these three dimensions. There are also additionaldimensions mentioned in some studies such as technical,operational or institutional. Alternatively,the indicators can be classified based on the transportationgoals and objectives and can be relatedto more than one category. For example, accessibility canbe classified as a social or economic indicator, since theaccessibility to public services and the accessibility to employment opportunities correspond to social and economicaspects, respectively. Similarly, the energy consumed by thetransport means can be associated with the environmentalor economic dimension. When the number of indicators islarge, being able to identify an indicator as a member ofa single category simplifies any decision making analysis.

Sustainability Evaluation of Urban Projectduring construction in New Delhi, India:-
Recently, as a part of M.Tech Thesis. Sameer Verma along with Shishir Bansal, Research Scholaron the subject, in 2013, conducted Sustainability analysisof two corridors under construction by PWD (Public Works Department) Govt, of Delhiand DMRC (Delhi Metro Rail Corporation). The corridors selected for the case study application was a 3.2 Kms long elevated road project under construction from Vikaspuri to Meerabagh in West Delhi by PWD and Metro rail elevated corridor (part) from Punjabi Bagh to Mayapuri as a part of phase 3, line 7 by DMRC.

The first step involved in the Research work was the Typical **Reconnaissance survey** in moving car with intermediate stops to appreciate the various issues during different times of the day. By and large the traffic scenario was same throughout the day except at night from 09:00 PM to 08:00 AM. During the survey, the major issues observed were those which affects the smooth flow of traffic, execution and protection of ongoing works, security hazards, comfort level of commuters, residents, maintenance of existing infrastructure and surroundings, relief measures, deviations in following rules and regulatory measures etc. were identified and **a list of 39 issues was framed**.The list of 39 issues identified was classified into six categories and each category is defined as **Sustainability Indicators** with these 39 criterias. It is established that for an Urban Environment and developing city like New Delhi, the triple bottom line concept of sustainability does not get fit. It requires extension to suit the local conditions. Accordingly the triple bottom line concept is enlarged to **six broad sustainability indicators**.
Based on the classification of these indicators, a questionnaire was framed and opinion of experts in this field from CRRI, PWD, BRO, Consultants, RITES etc. was obtained and with the opinion of experts, **rating to these indicators was assigned** based on Fuzzy methodology. The opinion was obtained in two scales for their quantitative analysis on a scale **0 to 9**(Scale 1) and qualitative analysis on a scale from Very Low (VL to Very High (VH) on the basis of its importance.Finally the rating based on Fuzzy theory was assigned to these 39 indicators, which is reflected in Table 3.

Table 3 : Criteria, sustainability indicators and rating.

CRITERIA	SUSTAINABILITY INDICATORS	RATING
A. ENVIRONMENTAL		
A1.	Control on Air Pollution	8.03
A 2.	Control on drainage due to construction activities	7.47
A3.	Control on water logging during Monsoon/rains	7.07
A4.	Control on noise pollution due to during day	5.40
A5.	Control on noise pollution during night	7.67
A6.	Removal of trees/ depletion of Green Belt	7.07
A7.	Plantation scheme	6.80
A8.	Other techniques to make the Project Eco-friendly	6.89
B. SOCIAL		
B1.	Increase in the stress level of commuters	6.33
B2.	Health of workers	7.67
B3.	Welfare activities for family of workers	6.20
B4.	Sanitation conditions	7.53
B5.	First Aid facility on site	8.07
B6.	Safety measures	8.67
B7.	Impact on Health of residents	7.33
B8.	Impact on safety of residents	8.07
B9.	Public conveniences in the project area	7.07
C. ECONOMICS		
C1.	Increase in Travel time	7.33
C2.	Increase in travel cost	7.07
C3.	Disturbance to the business/Employment	6.07
D. TECHNICAL		
D1.	Display of Project Details	5.44
D2.	Display of Regulatory Signages	8.07
D3.	Traffic Diversions	8.20
D4.	Visibility and sight distance to moving traffic	7.33
D5.	Lighting of Construction site	8.07
D6.	Barricading the site	7.93
D7.	Aesthetics of Project	6.00
D8.	Handling of C & D Waste	6.93
E. GOVERNANCE		
E1.	Ensuring the mobility of Traffic in the project area	7.67
E2.	Effective Functioning of Traffic Marshalls	7.80
E3.	Unauthorized/Improper parking in Project area	6.13
E4.	Maintenance of existing drainage system	7.93
E5.	Maintenance of Barricades	6.80
E6.	Ensuring the safety, Health and Environment (SHE)	7.93
E7.	Maintenance of existing utilities	7.80
E8.	Maintenance of existing greenery	7.40
F. INNER ENGINEERING		
F1.	Facilities of Yoga/meditation	3.73
F2.	Performance of Rituals at site	5.00
F3.	Celebration during Festivals at site	4.33

Thereafter a survey amongst commuters and residents nearby was conducted to appreciate the measures adopted by client and the construction agency in the form of questionnaire. The rating from 0 to 9 was assigned by the commuters and residents depending upon the inconvenience caused to the public. Best arrangements were to be assigned higher marks and least arrangements causing maximum inconvenience were assigned minimum marks.

Setting guidelines for identifying sustainable transport challenges:-

In August 2012, Guido Nijenhuis of University of Twente published her Master of Science Thesis on the subject **"Setting guidelines for identifying sustainable transport challenges in medium-sized cities in Indonesia".** As per the thesis, in the recent climate change debate much focus is placed on low carbon development. The transportation sector is one of the major contributors to greenhouse gases. Therefore CO_2 mitigation is a key issue in transport planning. On a local level however other transport externalities receive more attention. The use of co-benefits captures the effect on CO_2 emissions from transport measures. The concept of sustainable transport includes low carbon development concerns and these co-benefits.

The framework applied in this research started with making an initial long-list of possible indicators. **Criteria that related to the methodological quality of indicators and the relevance of these indicators to the concept of sustainable transport were used in the Analytic Hierarchy Process (AHP) to select a set of indicators.** In the process of selecting indicators stakeholder participation was found to be important. In this research transport experts' judgments were used for selecting the indicator criteria and the surveys for the AHP were conducted among transport experts and users.

The lessons learned from the application of the evaluation framework in Yogyakarta and Surakarta has been used to develop guidelines for future sustainable transport evaluations in medium-sized cities in Indonesia. These guidelines also apply to cities in other developing countries, when they have to deal with the same issues. The following guidelines can be used as a road map by these cities:

- **Adopt a sustainable transport strategy** : Evaluating the sustainability of transport systems is important as input for sustainable transport strategies.
- **Strengthen institutional capacity and knowledge :**An important task is to strengthen institutional capacity and knowledge. International organizations can help local governments doing this, but also national knowledge centers can be established, where knowledge and best practices are shared.
- **Choose an evaluation method :**The evaluation framework has to specify how the transport system is evaluated. First the context should be established as input for the selection of indicators. In this process stakeholders should be asked to evaluate the set of indicators.
- **Choose the right indicators :**In the evaluation indicators have to be used to provide information on the sustainability of the transport systems. For the selection of indicators from a long-list criteria have to be used to assess the methodological quality of the indicator. The final set of indicators should be balanced, covering all dimensions of sustainable transport.
- **Standardize the measurement of indicator data :**The measurement of indicator data should be standardized temporally and spatially. This will allow making trends that provide useful information. Also the same units should be used, to be able to compare the data. For each of the indicators targets will have to be defined.
- **Structure public participation :**Through the whole process of evaluation there should be public participation. This is advocated by many literature sources, but it is not clear how this should be done. As it is difficult to include the public in this process, interest representatives can be asked to join.

Conclusions:-

Initiallyin the absence of any accepted definition of sustainable development, it was generally accepted it implied finding a proper balance between environmental, social and economic qualities. It was less clear which environmental, social and economic qualities should be guaranteed and balanced.

In fact, the Traffic and transport policies differ greatly from city to city, from country to country, as do the travel patterns of the people in these cities and countries. Current developments in urban transport realities force authorities to plan, manage and maintain their transport systems more accurately and take into account the requirements of a growing number of complex and sometimes conflicting interests like congestion relief, pollution reduction, efficient resource use, equity and accessibility. A more sustainable transportation systemis one that allows the basic access and development needs of people to be met safely and promotes equity within and between successive generations**,** is affordable within the limits imposed by internationalization of external costs, operates fairly and efficiently, and fosters a balanced regional development, limits emissions of air pollution in GHGs as well as waste and minimizes the impact on the use of land and the generation of noise and is designed in a participatory process, which involves relevant stakeholders in all parts of the society.

Number of methodologies like Multi-criteria decision making, Fuzzy techniques, Analytical Hierarchy Process are available to evaluate the sustainability, but each method is required to be examined before its application as most relevant to particular area and particular field.

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