GENERATION OF EMERGY CONSUMPTION INDICATOR USING SUSTAINABLE APPROACH

Ms. S. S. Chaudhari[1]; Prof. S. D. Ghodmare[2]; Dr. B.V.Khode[3]

[1]PG Scholar,GHRCE, Nagpur, India, Email- chaudharisukanya01@gmail.com
[2]Assistant Professor,GHRCE, Nagpur, India, Email-sujesh.ghodmare@raisoni.net
[3]Professor, GHRCE, Nagpur, India, Email- bhalchandra.khode@raisoni.net

---

ABSTRACT

Sustainability is very important for the transportation system and for overall development of the city. Therefore, assessment of sustainability is a vital issue. Very few methodologies are available for assessing the sustainability, whereasthe numbers of method areavailable for the attainment of sustainability. If metro system is taken into consideration for sustainability assessment as, it is directly related to the issues of sustainability attainment and related development of a city. Out of few, available approaches the concept of energy analysis and triple bottom line TBL are used in this paper for assessing the sustainability of the metro system.The many advantages of assessment of sustainability had demonstrated and the concept of emergy analysis used to assess the sustainability of many aspects related to regions, product, project, etc. In this emergy analysis the three energy indexes, Emergy Yield Ratio (EmYR), Environmental Loading Ratio (ELR). In addition, a relative ratio of EmYR and ELR called as Emergy Sustainability Index (EmSR) is taken into consideration first stage of Nagpur metro studied as a case. The methodology used in this paper is assumed to be easily replicable is also can be used for optimization of the metro system is in early stages.

Keywords—TBL, Emergy analysis, EmYR, ELR, EmSI.

INTRODUCTION

The first metro system in the London that was underground, opened in 1863. It is non-electrical it converted intoelectricity in 1890, then many other regions such as America, Asia, North Africa, Middle East have also established their new metro system. In view of increasing population and various developments going on the in various fast-developing cities in India, the means of transportation needs to be improved as a part the metro system is proposed in central India city Nagpur. The first commercial metro services opened in Kolkata 1984 than many cities in the India metro constructed like, Hyderabad, Chennai, and Mumbai etc.More than one million populations in 53 cities of India by Censusof India,in 2011 out of 53 cities were 27 cities were having population more than two million.Whereas in 2011 these counts were as in other countries because of excessive transit volume, low pollution, punctuality other features such as swiftness metro systems is a need as well a priority for the development of an urban transit system. In India (Zhong et. At 2008) currently metro rail system running in Delhi, Mumbai, Kolkata cities in India and total stretch length is approximately about 215 km. Along with the various advantages metro system has few disadvantages also, enhanced quality requirements enhanced the cost finalization of orientation and establishment the connections with existing traffic networks are few of them. The cost ranging from US$15 million to 03 billion per route km is required for installation of a metro system (Loo and cheng 2010), this expenditure is without any guarantee of financial returns. flyovbjerg et al. (2003) also stated that a rail

project may cost 45%more than what estimated and the expected patronage may be less than 39% of the predicted values similarly siemiatycki's (2006) and liu's (2006) worked on Delhi metro and Guangzhou metro (in china) and (in India) concluded the finding aligned with some judgment as above. According to koo (2007) almost all construction actives including metro system development may result in various issues such as accumulation of construction waste, use of new materials with performance uncertainties new technology, historical and archeological site preservation.Metro system due to its huge extent and infrastructural involvement will infer local social, economic development along with environmental and ecosystem parameters main parameter involved will be the decision making criteria's construction activities and operational activities. Therefore, it can quoted that the sustainability of a metro system plays the vital role in handling the various sustainability-related parameter, it must be noted that a single trivial fault that is relevant to the metro system may result in huge and unaccountable losses affecting the future of numbers of dgenerations (lieu et. al 2008). Various sustainability issues and their interrelations are very complicated in actual practice. Therefore, development of methodology for its sustainability assessment can considered as the very first stage in integratingthese complication interrelations this can also utilize for providing the directions for comparison of scheme and for the purpose of design optimizations. But very few intension of design optimization and very few researchers are working on sustainability assessment of the metro system on the basis of energy analysis the concepts of energy analysis havea number of signs and the concept has been utilized by few researchers for sustainability assessment. The objective of this paper is to develop the analytical framework by deriving the emergy analysis based assessment methodology for sustainability. For this a case study Nagpur is considerd for emergy consumption indicator index for Nagpur Metro Sustainble Approach. As indicated by Area, Nagpur is the 3rd biggest city in Maharashtra. Nagpur is winter capital of Maharashtra. It has 25 lakhs population, the around the territory of Nagpur is the thirteenth biggest urban combination in India. It is a moment greener city of India and as of late positioned as the cleanest city in India. The area of Nagpur is from the inside if the nation with zero mile markers that implies it demonstrates the geological focal point of India. It is the second capital of Maharashtra and "Tiger capital of India. The Nagpur city prevalently called as "orange city of India". Chronicled populace information for the Nagpur Municipal Corporation (NMC) is accessible for 1921 from the statistics office and is exhibited in the according to the Census of India (2001), Nagpur's population was around 20.52 lakhs.

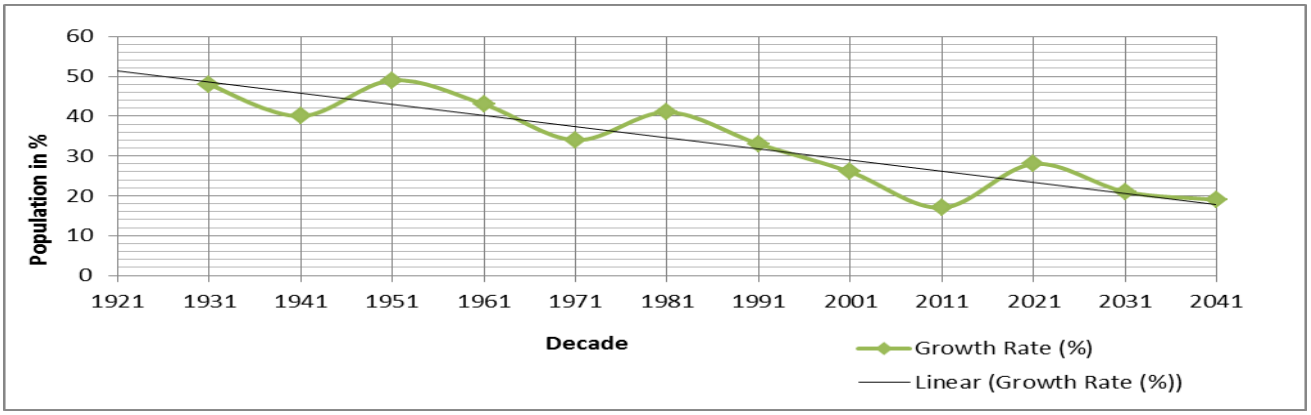

Fig 1.1Decadal population growth for Nagpur City.

The city traffic and congestion level depend on two important factors, namely; transport supply i.e availability of transport infrastructure and the number of registered vehicles. There has to be a balance between vehicular demand and available road space to avoid traffic jams and for safety purpose. Fig.2.Representslast three year's number of registered vehicles. The Intermediate transport is taken care by auto Rickshaws (almost 17000) and Tourist Cabs (almost 2900).As far as the future and environmental equities are concerned, we neglect equity and environmental impacts generating at various stages. Thus, we can say that ultimately sustainability reflects the various goals of equity, human betterment and ecological integrity regardless of time and location. Therefore, sustainable decision-making referred as planning which takes into considerations, goals along with impacts. Originally, sustainability treated as a concern about resource consumption at present and related along term risks. This no doubt reflects goal related to justice to the coming generation along with ecological integrity. Assuming that resource depletion and air pollution problems are representing maximum long term ecological risk and usually consider minor in transportation planning.Thesustainable and the parallel means in which it assumed that every node could use up to its best utilization. Transport includes the newest mode alignment improvement of all useful modes. Therefore, in some cities, improving walking and cycling may be the most beneficial strategy support to the public transportation and transit or certain type of restriction on regulation for use of a vehicle in congested area may be the beneficial strategies.This means that only faster travelling mode or more, mileageis only not the issues, including in improved transport, but comfort, safety, cost saving or a reduction in total need for travel is the vital issues of improved transport.

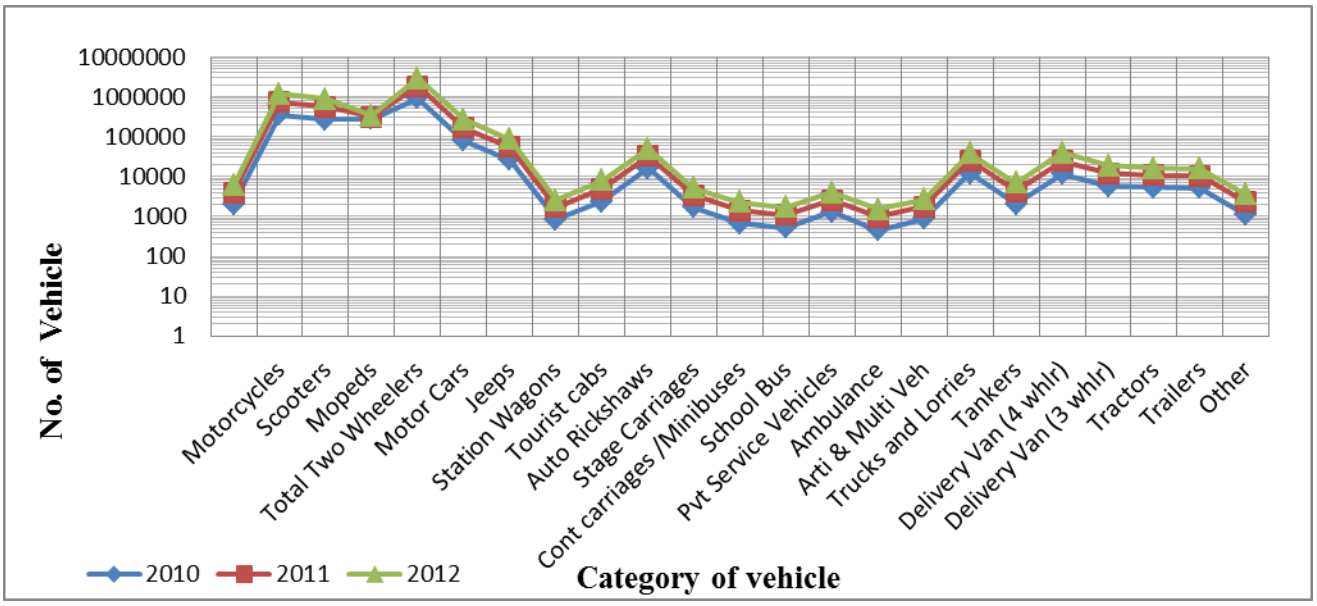

Fig 2. Category wise Vehicles in Nagpur City

Sustainable Transportation Indicator

Indicators are the units used for translating physical and scientific parameters into sustainability units. The different indicators commonly used as tools for public communication in many ways (Singh et al. 2009) for framing the policies. In this view, only referring chapter No-40, of agenda 21 near about 178 government organizations during 1992.. As on a solid basis for the purpose of decision making at every level, this resulted in a proposal for developing the sustainability indicators in various perspectives by many organizations and institutes. The sustainability indexes can be summarized into 12 different categories as proposed by (Singl et at. 2009) based on Innovation knowledge, technology Development, Market and economy, ecosystem (performance &ecology), Composite performance of Industrial Cities Industries Policies,Nations,Regions Energy, Social and Quality of life.

As transportation and its related activities are capable of using substantial quantities of globally available resources and emission of wastes, it plays an important role in the improve of quality of life and socioeconomic development. This is the main reason that sustainability concept are essentially adopted in transportation industry there is no single universally accepted definition of sustainability. (Castillo and Pitfield2010).In order to provide the transportation policies and to finalize the strategies some researchers Allresearchers' studies on a region are by, (Castillo and Pitfield 2010, chi and stone 2005,Hull 2008,Johnson and white 2010,May et.2008, Lu and Quereshi 2007) on scooter power (Hwang 2010). On cross country transport (Bojkovic et al.2010) and mass transit railway (Tang and Lu 2010). Emergy analysis is an important distinctive part of vast theory of functions of ecological and other system development by(H. T. Odum in the 1980s (Dezi Li et at. 2012). The theory proposed describes the system survived and its organization in hierarchies at the energy with efficiency generating maximum power (Bakshi and Hau 2004). Hence, for creating the unique synthetic indicators of sustainability, emergy analysis can be comfortably utilized in spite of proven advantages being a new idea emergy analysis, concept was treated with huge resistance and criticism (Siche et.al 2010) following are the notable advantages of emergy analysis as far as the assessment of sustainability is concerned .

- Additional flows influencing sustainability is accounted.
- Every type of role of nature and human economy is accounted.
- All emergy intensity factors, including all energy forms.
- Fundamental basic Theory of synthetic thinking is utilized (siche et.al 2010, Odum 1988).

Hence, Emergy analysis methodology utilized, directly or indirectly. The emergy analysis methodology is congenital in sustainability evaluation of metro system.It can also be contributing in the variety of research area such as sustainable transportation, sustainable development and in emergy analysis.

Methodology

In present Research work the two conceptsare triple bottom line and then the formation emergy index to calculate the level of sustainability.John Elkington strove to measure sustainability amid the mid-1990s by incorporating another structure to quantify execution in corporate America. The TBL is an accounting system that consolidates three measurements of execution: social,

ecological and economical related. This varies from customary revealing structures as it incorporates biological (or ecological) and social measures that can be hard to allot proper method for estimation.

Calculation the TBL

The 3Ps do not have a normal unit of measure. Benefits measured in dollars and that dollar esteem changed over into Rupees. While that would have the advantage of having a typical unit dollars many items to putting a dollar esteem on wetlands or jeopardized species on entirely philosophical grounds. Others doubt the strategy for finding the correct cost for lost wetlands or imperiled species. Another arrangement has ascertained the TBL as far as a record. Along these lines, one dispenses with the contradictory units issue and, the length of there is a generally acknowledged bookkeeping technique, takes into account examinations between substances, e.g., looking at execution between organizations, urban communities, advancement undertakings or some other benchmark.

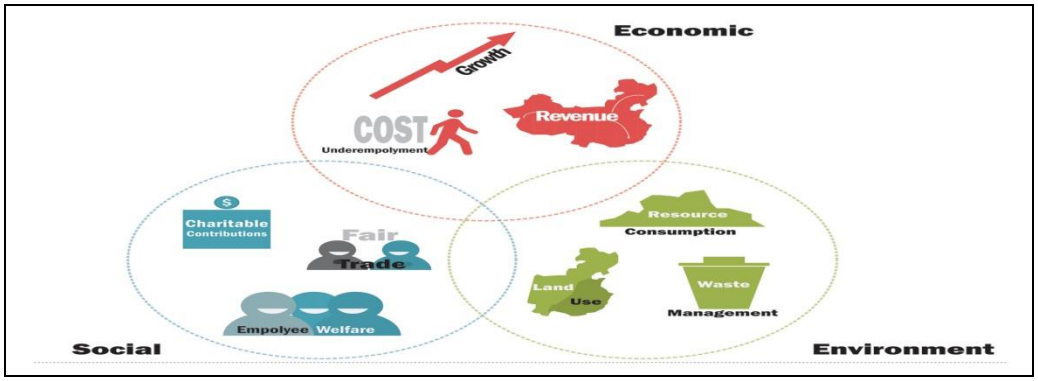

Fig.3.Schmatic Arragemnet of Sustinability

Theortical Equation and limiting value of Emergy

The measure of vitality of one frame that is utilized as a part of changes specifically and in a roundabout way to make an item or administration.Utilizing emergy, sunlight, fuel, power, and human administration be put on a typical premise by communicating each of them in the emjoules of sun-based vitality that is required to create them. The energybolsters the era of one unit of a financial item (communicated in many related terms). It is utilized to change over cash into emergy units. Cash is paid for merchandise and enterprises, yet not to nature, the commitment to a procedure spoke to by financial installments is the emergy that cash buys. The measure of assets that cash purchases relies on upon the measure of emergy supporting the economy and the measure of cash flowing.

Table1. EMERGY yield ratioEnvironmental Loading ratio

Name	Abbreviation	Equation
Emergy yield ratio	$EmYR$	$EmYR = \frac{Em_Y}{Em_F} = \frac{Em_E + Em_W}{Em_F}$
Environmental Loading ratio	ELR	$ELR = \frac{Em_F + Em_N}{Em_R}$
Emergy sustainability index	$EmSI$	$EmSI = \frac{EmYR}{ELR} = \frac{Em_R \times (Em_E + Em_N)}{Em_F \times (Em_F + Em_N)}$

Table.2. Limiting values of three indexes

Ratio	Limiting value	Descriptions
EmYR	<5	It denotes primary materials like cement and steel and secondary energy resource. (Ulgiati and Brown)
	>5	Primary energy resource, greater values of EmYR stronger competition ability and more economic benefit (Zhang et.al 2010)
	<2	Not contributes as an energy resourceis associated with consumables or manufacturing process
ELR	<2	Low impact on the environment (Siche et al.2008)
	2 to 10	Moderate impact on the environment
	>10	Relatively concentrated impact on the environment (Brown and Ulgiati 2004; Cao and Feng 2007)
EmSI	<1	Not sustainable at long time period (Brown and Ulgiati 2004; Giannetti et al 2010; Yang et al 2007))
	1 to 5	Sustainable of medium period
	>5	Clearly, sustainable, sustainable for long time period
RWY	More	Lower environmental management level and less sustainable.
	Smaller	More sustainable (Xu 2010: Yi 2010)

DMRC presented the answer to the nodal organization Nagpur Improvement Trust on 12 February 2013.The aggregate cost of the venture was assessed at around ₹90 billion. The venture comprised of two courses: Automotive Square to Hingna. There would be 17 stations on Route no. 1 with a terminal cum warehouse at MIHAN and 19 stations on Route no. 2 with a terminal cum stop at Lokmanya Nagar. Across rail station was proposed at Munje Square, where the two courses would meet and the suburbanite would have the capacity to trade the courses. It's normal that 12.21 percent of Nagpur's evaluated populace of 2.9 million in 2021, i.e. around 363,000 Commuters would utilize the Metro by 2021. There would be 19 feeder courses covering all stations and an aggregate separation of around 160 km. To execute the venture, the Cabinet endorsed setting up of Nagpur Metro Rail Corporation Limited (NMRCL). NMRCL is a Special Purpose Vehicle (SPV) made for the smooth usage and operations of the Nagpur Metro Rail Project and is a joint wonder of Government of India and Government of Maharashtra. The venture is planned tobe finished by March 2018. Nagpur Improvement Trust (NIT) asked DMRC to give Consultancy administrations to the planning of a Detailed Project Report for Metro Rail System in Nagpur, Maharashtra at first for 30 km, which reexamined to 42 km on July 2012. From there on, DMRC directed Traffic Surveys, Topographical Surveys, Geotechnical Investigations and Environment Impact Assessment Survey. The review region comprised of the Nagpur Municipal Corporation Area. The review region totaled to roughly 217Km^2. In light of the diverse sorts of reviews done by the DMRC, metro arrangements settled after rehashed assessment of the street organize, convergences, traveler activity stream, movement blockage, interfacing with imperative land employments.

Fig.4. Nagpur Metro Rail Route Map

Parameter and Assumptionfor Emergy Condition

Imported and Exported emergy is the move from fundamental information to emergy though, and hence these Indicators. As indicated by the accessibility of information accumulation, a few assumptions must be made ahead of time, including

1. As specified beforehand, the construction time of Nagpur metro system from year 2013 to 2018, in this period the starting two year required for total land acquisitionfor temporary Construction Depot/office accommodationDuring construction period,

huge quantities of construction materials like reinforcing bars, cement, steel sections, shutters, pre-cast segments etc. are to be stored ansufficient land is required for storage of these materials and acquisition of privet land passing through the route of metro, After 2015 actual work is started in field means construction phase,total cost of construction is available of the fact that the contribution to these five years is difficult to separate every year and is along these lines regarded as an approximate;

2. Transformityutilized are not used in this paper, direct cost is fined by using the TBL method in Rupees according to the market rate of India in 2011 and the growth rate is applied;
3. The passenger capacity in taken form Nagpur metro rail DPR,Nagpur CMP draft final report feeder final report and some rout manual checking is done by using video recording realistic value is taken
4. Regarding Em_RIn Table 3, only sunlight means solar energy are considered in this paper;
5. Regarding Em_NIn Table 3, only two construction main construction materials (steel, and cement) in the construction period, are consideredin this paper;
6. Regarding Em_FDuring the construction period, all the construction material, construction machinery, work equipment information and management
7. Regarding Em_F In the O&M period, Recurring Cost
8. Regarding Em_EIn Table 4,It can be evaluated directly orestimated indirectly, whereas 'Benefit from reducing abovegroundpublic transportation, like annual time, cost saved by metro passengers, Annual on fuel cost saved by metro passenger, Annual vehicle operating cost saved by metro passengers, Emission saves cost, Accident cost saving, Annual time cost saved by road passengers, Annual fuel cost saved by road passenger, Annual infrastructural maintains cost saved.
9. Regarding Em_WIn Table 4, Environmental monitoring in the construction period, solid waste is considered estimated in the O&M period.

Table 3. Imported Emergy of Metro Ecosystems

Type	Sources
Renewable resources emergy, Em_R	Sunlight, wind, rain, earth cycle, flowing water, tides, biomass, and heat from within the earth
Nonrenewable resources emergy,Em_N	Top soil loss, metals, minerals, woods, and fossil fuels
Socioeconomic feedback emergy,Em_F	Investments, labors, construction materials, construction machinery, work equipment,

Table 4. Exported Emergy of Metro Ecosystems (in the Dimension of Yield Aspect)

Type	Yield aspect	Sources	Yield stage
Socioeconomic yield emergy,	Economic yield	The sales income of tickets, surrounding land appreciation, income from the platform and carriage advertisement	O&M
	Social yield	Benefit from reducing aboveground public transportation, C_1	
		Annual of fuel cost saved by metro passenger,$C_{1.1}$	
		Annual time cost saving by road passengers, $C_{1.2}$	
		Annual infrastructural maintains cost saved,$C_{1.3}$	
	Communication yield	Benefit from time saving of passengers, C_2	
		Annual time cost saving by metro passengers,$C_{2.1}$	
		Annual vehicle operating costs saved by metro, $C_{2.2}$	
		Accident cost saving $C_{2.3}$	
	Environmental yield	The annual fuel cost saved by road passenger, C_3	
		Emission saving costC_4	
Waste yield emergy,	Wastes yield	Waste water, exhaust gases, solid waste, domestic garbage	O&M

Emergy Analysis- Based Sustainability Indicators

After obtaining all the emergy values into cost of Rs. Crore, then relative Emergy indices can calculated as shown further in Graphical form 1.First index is the EYR Emergy Yield Ratio. In this, we get the ratio of the exported emergy to socioeconomic feedback emergy, which gives a measure of efficiency of the ecosystem to use or take advantages of local resources. Exportedemergy is the summation of socioeconomic yield energy, social yield,communication yield, Environmental yield and the waste yield emergy. This value denotes the wages or service profit due to existing project. This yield obtained mostly in the O &M phase. The Socioeconomic feedback contains the emergy value of total construction cost and O & M cost for the overall life of the

project. According to Ulgiati and Brown (2002), EYR values less than five denotes primary materials, such as cement and steel, and secondary.

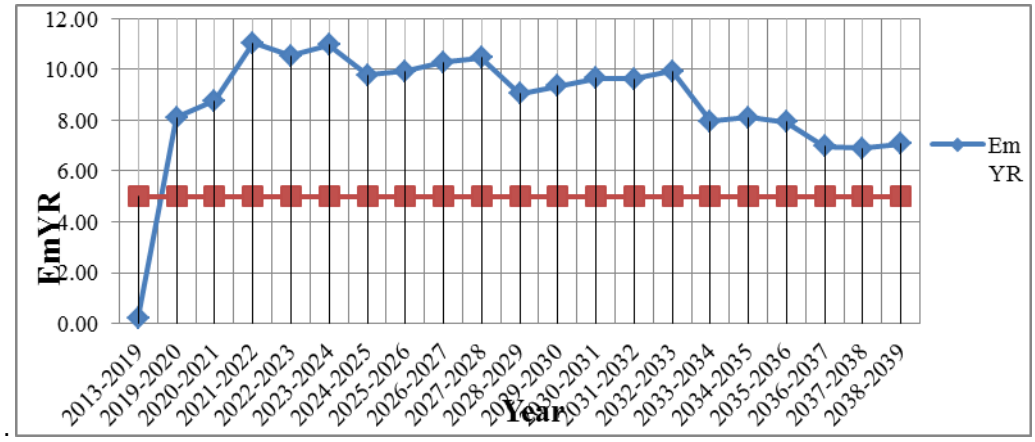

Fig 5. EmYR of Nagpur Metro Project

In the Fig 5. The EYR value per year and limiting value of EYR for the sustainability condition should be 5. According to the figure from year 2020-2040, the given project is sustainable for a long period of time, but for the construction period2013-2019 value is less than 5, that period of the project contributes as an emergy resource is associated with consumables or manufacturing process.

The relative index is ELR Environmental loading Ratio which is the ratio of nonrenewable resource and socioeconomic Inputemergy partitioned by renewable assets, emergy which measures the weight of neighborhood natural on account of the creation action. Concurring ELR can give data on the reliance of a neighborhood framework on the renewable and nonrenewable (nonlocal).(Some portion of the criticism from the general public (Siche et al. 2008)). ELR values below 2, demonstrate a moderately low effect on nature. (or, on the other hand, it utilize a substantial territory of a nearby domain to weaken the effect); values in the vicinity of 2 and 10, imply that the framework has a direct effect. Estimations of more than 10 have strong impact on ecological system (Brown and Ulgiati 2004; Cao and Feng 2007).

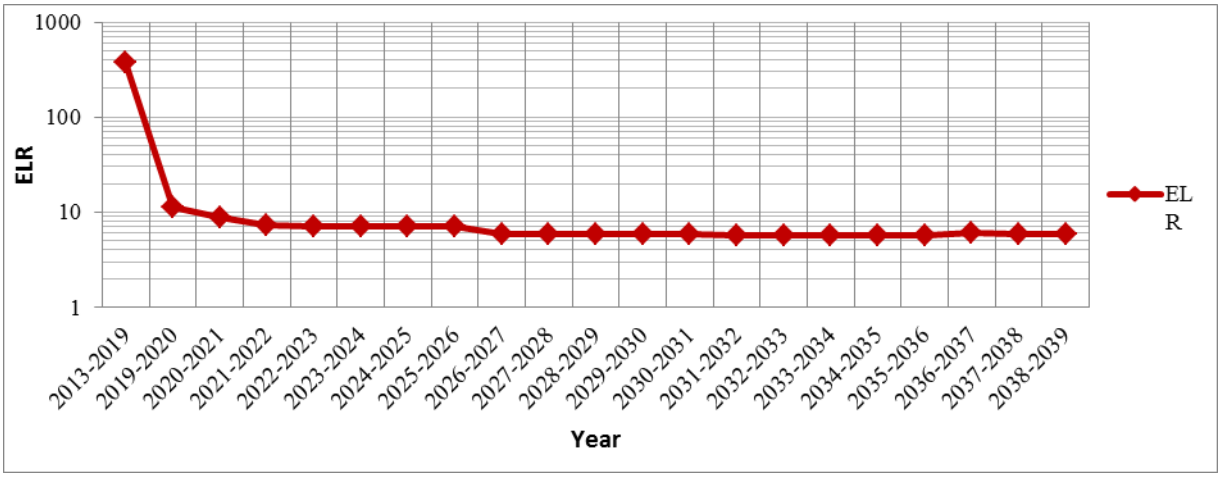

Fig 6. ELR of Nagpur metro Project

In the Fig.6 ELR value of the construction phase is greater than 10.That period is concentrated impact on the environment because of construction activity disturbance is occurring in the natural environment and the flyover constructed in the mid of road many problems like congestion or traffic jam so fuel loss, time loss, discomfort, sound pollution due to the machinery at construction activities. Also used large amount of resources like cement and steel, after 2020 ELR value is less than 10. so at operation phase moderate impact on the environment up to 2039.

The aggregate ratio of emergy yield to environmental load ratio provides sustainability functions for the process or economy of given metro system. This aggregate ratio shows that the given project is economical,environmentally friendly and socioeconomically. The value of ESI is more frequently used as an aggregate sustainability indicator.This index can aim the optimization of a given systemwith more yields and less environmental loading (Brown and Ulgiati 2004). Combining emergy indices systems or processes are not sustainable at a long time period when ESI less is than one, whereas they are rather sustained for medium periods of 1to 5and if the ESI is greater than 5 then it is clearly and longtime sustainable (Brown and Ulgiati 2004; Giannettiet al. 2010; Yang et al. 2010).

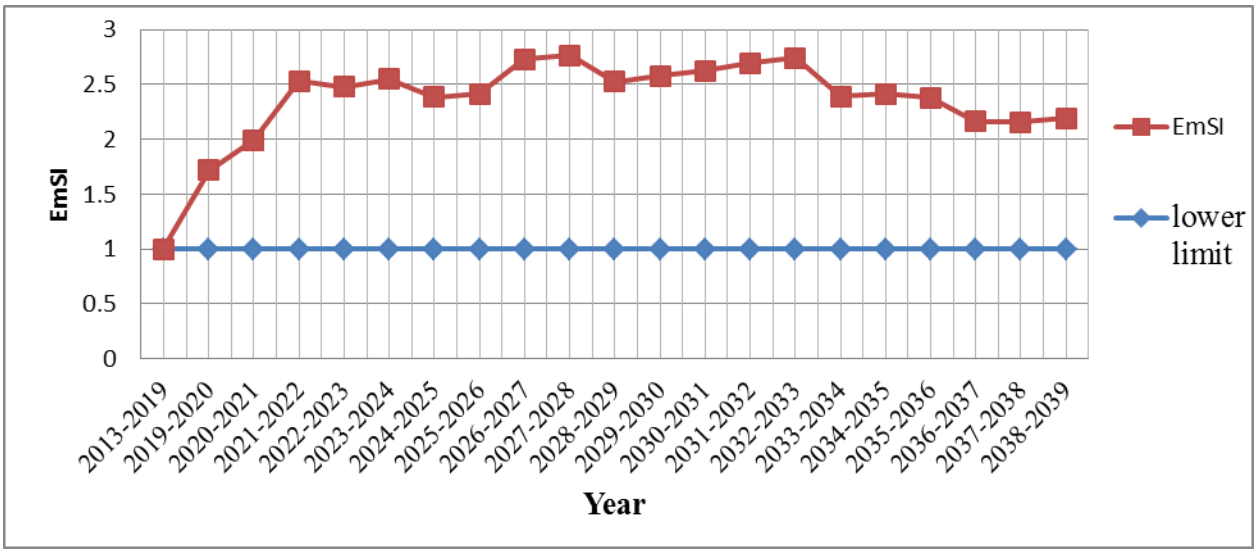

Fig. 7. EmSI of Nagpur Metro Project

From given Nagpur metro project EmSI value is always greater than 1 but less than 5, so the project is medium sustainable. During the construction period, EYR value is slightly more than 1 but as the year passes the value of EYR increases 2.5 Up to 3. One more additional index to cross check the environmental sustainability is RYW Ratio; this is the ratio of Waste yield to the total exported energy yield which is also called waste efficiency indicators; more value of RWY was indicated very harmful to the environment and a lower environmental management level. In addition, if smaller the RWY value means more sustainable.

.

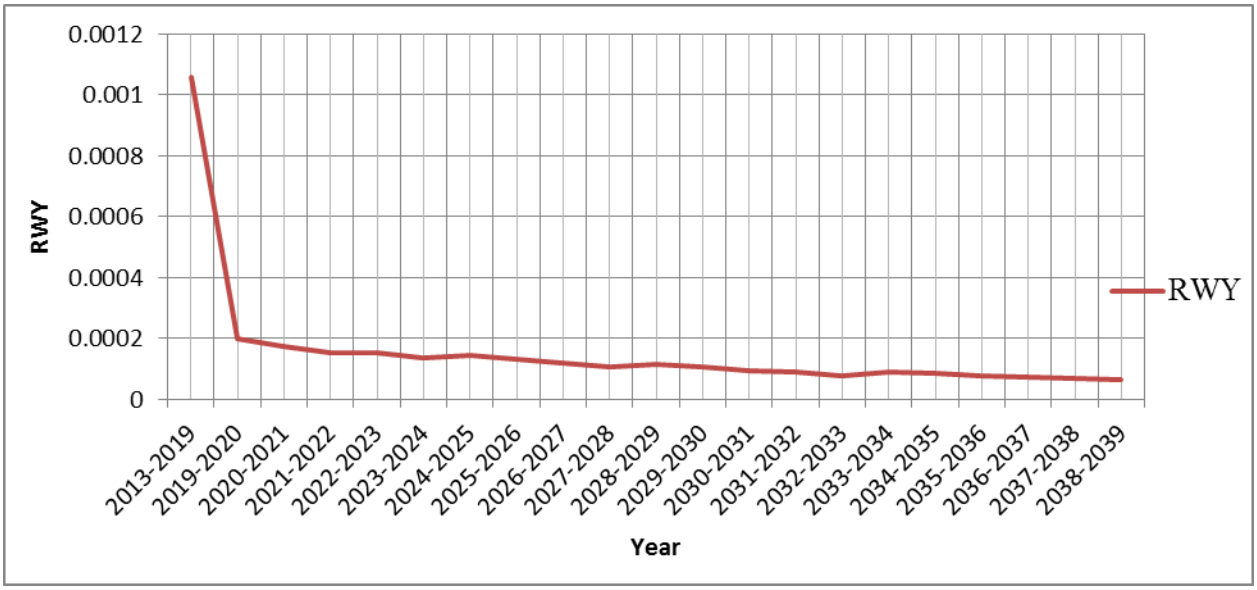

Fig.8. RWY of Nagpur Metro Project

From above Fig.8 value of RWY is greater at the construction phase and gradually decreases at the operation and maintenance phase, so the conclusion gives metro system is sustainable at the operation and maintenance phase. Both the index having same indication or conclusion is not necessary for finding the metro's emergy sustainability index.

SUMMARY AND CONCLUSION

The propose technique for surveying the sustainabilityof the metro systemon the premise of energy analysis, and TBL, method containing three emergy indexes, to be specific emergy yield proportion, environmental loading ratio, and the proportion of waste to aggregate yield. Each of them represents to a particular significantsustainability, meaningfrom alternate points of view, the main phase of Nagpur metrostudied as a case, which demonstrates the proposed methodology's applicability and serviceability. By utilizing the proposed methodology, a metro framework's sustainabilitycan surveyed, and the relating enhancement measures can extricated. In addition, the required data can obtain primarily from the census report 2011, DPR of Nagpur metro, and RTO office. Subsequently, the proposed methodology is effortless and generally pertinent furthermore, helpful for members, particularly for approach producers in the early phase of plan outline correlations with a view to sustainability. Some factor is quantified separately are difficult, but we get approximately correct result. By emergy and TBL method, Nagpur metro project is sustainable for medium time approximately 20 years after that some extra route planning is required to control the traffic smooth flow.

REFERENCES

Baral, A., and Bakshi, B. R. (2010). "Emergy analysis using US economic input-output models with applications to life cycles of gasoline and corn ethanol." Ecol. Model., 221(15), 1807–1818.

Koo, D. H. (2007). "Development of sustainability assessment model for underground infrastructure." Ph.D. thesis, Arizona State Univ., Phoenix.

Loo, B. P. Y., and Cheng, A. H. T. (2010). "Are there useful yardsticks of population size and income level for building metro systems? Some worldwide evidence." Cities, 27(5), 299–306.

Brown, M. T., and Ulgiati, S. (2007). "Emergy accounting." Encyclopedia of energy engineering and technology, B. L. Capehart, ed., Taylor & Francis, Oxford, UK, 420–429.

Chen, B., Chen, Z. M., Zhou, Y., Zhou, J. B., and Chen, G. Q. (2009). "Emergy as embodied energy based assessment for local sustainability of a constructed wetland in Beijing." Commun. Nonlinear Sci. Numer. Simul., 14(2), 622–635.

Lungu, M., Lanza, M., Gîrba, T., and Robbes, R. (2010). "The small project observatory: Visualizing software ecosystems." Sci. Comput. Program., 75(4), 264–275.

Amekudzi, A. A., Khisty, C. J., and Khayesi, M. (2009). "Using the sustainability footprint model to assess development impacts of transportation systems." Transp. Res. Part A Policy Pract., 43(4), 339–348.

Paoli, C., Vassallo, P., and Fabiano, M. (2008). "An emergy approach for the assessment of sustainability of small marinas." Ecol. Eng., 33(2),167–178.