TITLE:

TWO STRONG SUSTAINABILITY INDICATORS: ENVIRONMENTAL EFFICIENCY (EE) AND CARRYING CAPACITY (CC)

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ABSTRACT

Cities are the engines of economic growth and the hub of human development where innovation occurs. Also cities are the major consumption centres of natural resources /energy and centres of green house gas (GHG) emissions. If managed efficiently they are the hope of the nations and thus the situation warrants the innovative development management system wherein environmental protection and economic development goes hand in hand by taking the confidence of the society.

Environmental Efficiency (EE) and Carrying Capacity (CC) based development planning and management of nations, states and cities across the world gives a promising future towards the prosperity of the nations and the globe. Environmental Efficiency is the new term introduced based on an output/input approach while carrying capacity is the capacity of the supporting region to sustain the total consumption including the waste assimilation. EE and CC are two effective indicators of sustainability which can be calculated at local / state /national level with reliable data.

EE and CC of different nations have been calculated based on UN published data. Different types of countries are identified. Improvement of EE and CC values of the nations are inevitable to attain sustainability and prosperity as it reduces the spare capacity and losses. Effective policies can be evolved at the national, state and local level aiming at a better EE and CC values.

In EE and CC monitoring platform at international level, instead of carbon trading ***biocapacity-trading in lieu of human development*** between resource-rich underdeveloped nations and resource-deficient developed nations can be worked out and is the most practicable solution to attain a sustainable and equitable globe. EE and CC monitoring map can be evolved for cities and metropolitan regions using remote sensing and GIS capabilities.

FULL PAPER

1. INTRODUCTION

World urbanization trajectory is going high decade after decade. Presently every other person on the earth lives in a city. As per the UN population estimates[1] by the year 2050 nearly 70% of the world population will be urban. World urbanization is mostly happening at two extreme ways. In less developed countries there is tendency of big cities becoming bigger day by day. This often causes overcrowding and overload to the existing infrastructure, resulting in urban decay, chaos and miseries and thus environmentally less efficient. Also there are urbanized regions in countries which are under-populated and affected by urban sprawl creating spare capacity of infrastructure, fossil fuel wastage and under-performing ecosystems resulting in less environmental efficiency. The morphology of urbanization across the world indicates that the above two extreme cases mostly exist. Innovative development management solutions are the need

of the hour to enable nations to accommodate optimum number of people in cities, with high quality of life supported by prosperous metropolitan regions.

2. WORLD URBANISATION TREND AND CLIMATE CHANGE SCENARIO

As per the United Nations population estimates 2009 revision[1] the population living in urban areas is projected to increase from 3.4 billion in 2009 to 6.3 billion in 2050. Urbanization is on the upward trend and projections show that by 2050, 69% of the people are urban with 86% of inhabitants from more developed countries and 66% from less developed countries as indicated in Table 1. Also it is noticed that today's 3.4 billion urban dwellers are distributed unevenly among different size urban settlements with a bias on large cities. Presently there are 21 urban agglomerations in the world which are having population of over 10 million.

Table 1 WORLD URBAN POPULATION IN BILLIONS AND PERCENTAGE

Year	1975		2009		2025		2050	
	pop	%	pop	%	pop	%	pop	%
world	1.51	37.2	3.42	50.1	4.54	56.6	6.29	68.7
more developed	0.7	66.7	0.92	74.9	1.01	79.4	1.1	86.2
less developed	0.81	27	2.5	44.6	3.52	52.3	5.19	65.9

Source: United Nations Population Division, 2010

There is a strong relationship between urbanization and economic development of the countries. Urbanization has often been driven by concentration of investment, profitability and employment opportunities supplemented with quality and variety of services for the inhabitants. It is estimated that lion's share of the world gross domestic product is generated by the people living in urban areas.

However, bad products are also produced in cities. Earth's climate is warming day by day alongwith the rate of urbanization of people. UN-Habitat[2] reports the observations made by Intergovernmental Panel on Climate Change (IPCC) that there was an increase of 0.74^{O} C between 1906 and 2005. Emissions due to large scale industrial production, fossil fuel consumption and reduction in carbon sequestration capacity of the earth due to deforestation, landuse changes etc have caused carbon dioxide equivalent (CO_2e) of

atmosphere exceeding the threshold limit. As per the UN-Habitat estimates[2] if consumption based figures are taken upto 60- 70% of global GHG emissions are from urban residents.

3. INTRODUCTION TO EE AND CC BASED DEVELOPMENT PLANNING AND MANAGEMENT

The terms Environmental Efficiency (EE) and Carrying Capacity (CC)[3] are two powerful sustainability indicators which are like two sides of a coin. Attainment of environmental efficiency at metropolitan city contributes to the carrying capacity elsewhere and vice versa. While environmental efficiency can be quantified by adopting an output/input approach, carrying capacity can be quantified by taking the ratio of the total ecological capacity of the supporting region to the total consumption.

3.1 HUMAN SETTLEMENT OUTPUT AND INPUT INDICATORS

Human Development Report of UNDP

Human Development Report is published by United Nations Development Program (UNDP) giving the world's state of development and is published yearly from the year 1975 onwards. Human Development Indices of nations across the world are calculated on a five yearly basis from the year 1975 to 2010. Human Development Report 1990[4] defines Human Development as the process of enlarging peoples' choices. 'Human Development Approach' for a sustainable globe[5] is explained in Human Development Report 2008.

Human Development, the intended output—Human Development Index

Human Development Index (HDI) is a composite index that measures the average achievements in a country in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. These basic dimensions are measured by life expectancy at birth, adult literacy alongwith combined gross enrolment in primary, secondary and tertiary level education and gross domestic product per capita in purchasing power parity in US Dollars (PPP US$) respectively. The index is constructed from indicators that are available globally using a methodology that is simple and transparent.

Living Planet Report-WWF

Living Planet Report is published by WWF from the year 1998 onwards. Two indicators of consumption and their consequent effect on the physical environment is included in the report. They are as follows:

1. Ecological Footprint
2. Biocapacity

Ecological Footprint measures the humanity's demand on the bio-sphere in terms of the area of biologically productive land and sea required to provide the resources we use and absorb our waste. In 2005 global ecological footprint was 2.7 global hectares per person. A global hectare is a hectare with world average ability to produce resources and absorb waste.

Biocapacity of bio-sphere is the carrying capacity of the bio-sphere in terms of productivity and waste-absorbing capability to produce what is required for consumption and to absorb the waste generated by human activities. As per the Living Planet Report 2008[6], biocapacity of the earth is estimated as 2.1 global hectares per person.

Ecological Footprint—the Comprehensive Input Indicator

Ecological Footprint calculations provide compelling evidence of impacts of consumption. Ecological Footprint compares the natural resources and energy consumption with the nature's biologically productive and assimilative capacity.

Going through the available literature and research works across the world no other indicator is so comprehensive and highly exhaustive to accommodate the total input of a human settlement system. Various inputs of a human settlement system are built-up land, energy, fishing ground, forest, grazing and cropland, assimilation required for CO_2 from fossil fuels etc. All kinds of consumption are brought to a common platform in units of global hectares.

3.2 DERIVATION OF ENVIRONMENTAL EFFICIENCY (EE) AND CARRYING CAPACITY (CC)

The ratio of the output to the input of any human settlement system is considered as environmental efficiency and it determines the total quality of the system.

Efficiency of the total environment of a human settlement system

EE = Output/Input

= human development achievements / Ecological Footprint

= HD/EFp

Similarly the ratio of the supportive capacity with respect to total consumption can be named as carrying capacity.

CC = supportive capacity/ total consumption

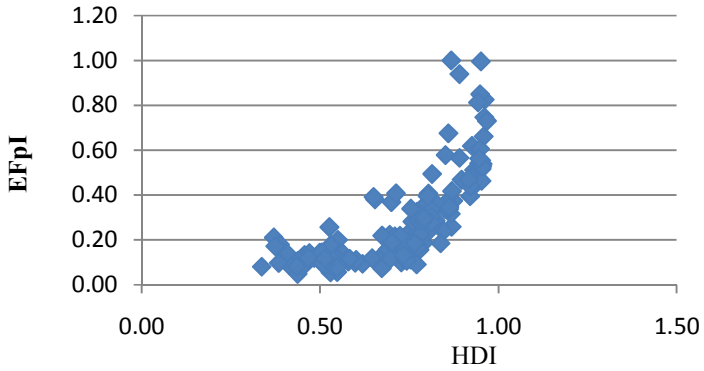
= biocapacity / ecological footprint

= Bc/EFp

3.3 HD, EE AND CC EVALUATION OF NATIONS ACROSS THE WORLD

HDI and EFp achievements of world countries are downloaded from UN agencies websites of WWF and UNDP and country-wise analysis are carried out. The countries which have both HDI data and EFp data for the year 2005 are taken. Scatter diagram of HDI and EFpI* for 135 countries are as per Fig 1.

Fig 1 SCATTER DIAGRAM HDI AND EFpI



* *EFpI is calculated by dividing EFp of a particular country by maximum EFp of all the countries.*

Going through the scatter diagram it is found that for less developed countries (HDI less than 0.5) EFpI increase is very meagre compared to HDI achievements. However, for medium developed countries (HDI value between 0.5 and 0.7) HDI achievements and EFpI are getting correlated. For highly developed countries (HDI value is greater than 0.7) EFpI increase is far greater than HDI increase.

This may be attributed to the following reasons[3]:

- Inadequacy of human development quantification in the case of developed countries as it is felt that basic human development only is evaluated in UNDP's HDI calculations. Educational achievement index is to be modified to suit the overall human skills achievements. Also health index is to be modified to accommodate the wellness of the people.
- Human development deviated and wasteful consumption patterns of developed countries.

World countries EE map and CC map are as per figure 2 and figure 3..

fig 2 - WORLD COUNTRIES' EE

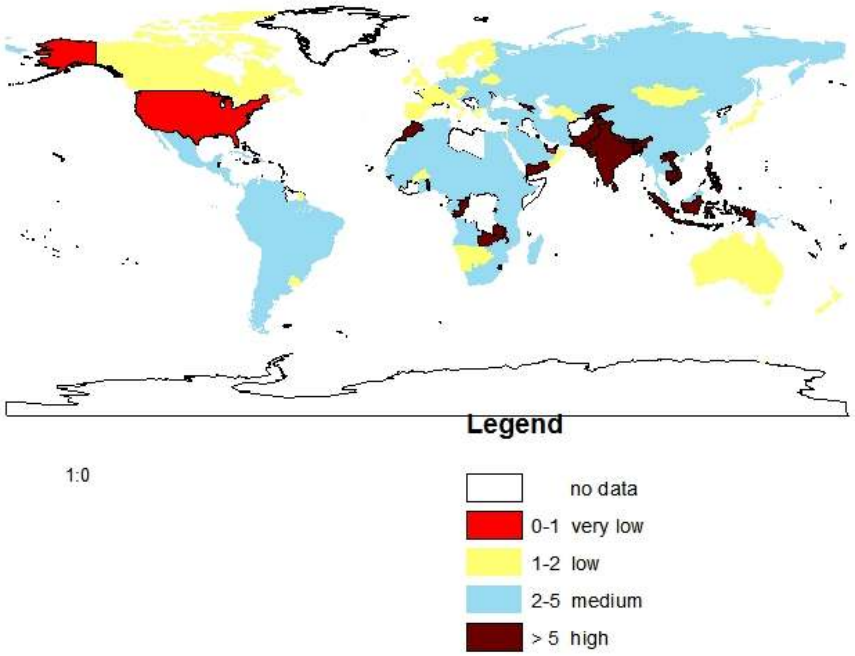
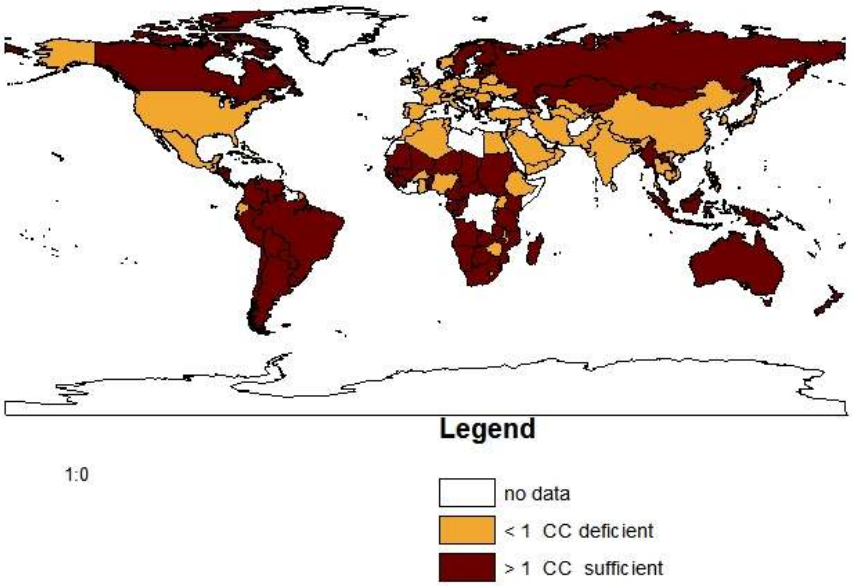


fig 3 - WORLD COUNTRIES' CC



Based on HD, EE and CC values different types of countries are identified. Some of the high HD countries are having very low EE and CC values. Those countries should introspect themselves to improve their EE and CC values on sustainability considerations. Also there are countries with very low HD values but having very good EE and CC values. Some countries and their sustainability status are as per table 2.

Table 2 SOME COUNTRIES AND THEIR SUSTAINABILITY STATUS

Name	HDI	EE	CC
high HD, high EE, CC sufficient			
Georgia	0.75	6.63	1.63
Indonesia	0.73	7.26	1.47
high HD, very low EE and CC deficient			
Kuwait	0.89	0.95	0.06
United Arab Emirates	0.87	0.87	0.11
United States	0.95	0.95	0.53
low HD, CC surplus			
Zambia	0.43	5.33	3.72
Angola	0.45	4.65	3.57
Central African Republic	0.38	2.29	5.92
Mozambique	0.38	3.9	3.67
high HD, CC very low			
Sri Lanka	0.74	6.86	0.37
Egypt	0.71	4.02	0.22
Jordan	0.77	4.29	0.16
Korea, Republic of	0.92	2.33	0.19
Lebanon	0.77	2.37	0.14
Netherlands	0.95	2.05	0.26
Singapore	0.92	2.1	0.01
Belgium	0.95	1.74	0.22
Greece	0.93	1.49	0.29
Israel	0.93	1.82	0.08
Italy	0.94	1.87	0.26
Japan	0.95	1.84	0.12
Portugal	0.9	1.91	0.28
Spain	0.95	1.56	0.23
Switzerland	0.95	1.81	0.25
United Kingdom	0.95	1.68	0.31

3.4 GLOBAL SUSTAINABILITY THROUGH EE AND CC ATTAINMENT AND SHARING

As per the living planet report of WWF the ecological footprint is 30% more than the bio-capacity of the bio-sphere. This ecological overshoot is mostly resulting as international environmental problems such as global warming which is a threat to the sustainability

and prosperity of cities/ states/nations/globe. EE and CC of nations are two strong sustainability indicators which should be included by UNDP and WWF in their research publications to make the nations aware of their sustainability status. Nations should aim to improve their EE and CC values by policy revisit and use of appropriate strategies and technologies to reduce their ecological footprint and increase the biocapacity while focusing on their human development. Instead of carbon trading, ***biocapacity-trading*** between resource-rich underdeveloped nations and resource-deficient developed nations is a possible option as it ensures both inter-generational and intra-generational equity which are inevitable components of global sustainability

3.5 EE AND CC EVALUATION OF HUMAN SETTLEMENTS

The methodology introduced by UNDP and WWF for human development index and ecological footprint can be applied at national, sub-national, district and human settlement level. UN-Habitat, in its Urban Indicators Tool Kit[7], explains the methodology of finding out the 'city product' (indicator 21) which would be useful for the calculation of Human Development Index at city level.

Health achievements and educational achievements can be calculated at city level, by incorporating wellness of the society and overall human skills achievements. EFp calculations at city level are also possible. City of Santa Monica calculated its Ecological Footprint from 1990 to 2000 and reduced the footprint from 2914 sq. miles to 2747 sq. miles through policy revisit, energy conservation and alternate energy measures[8].

All metropolitan areas are supported by a region to provide natural resources and energy for city input. CC of the supporting region is also very important for attaining EE. of the city/ metropolitan area.

Encouraging planned, compact, high density development coupled with green building techniques can contribute substantially to EE enhancement at city level. Apart from achieving lesser ecological footprint, CC enhancement is possible through ecosystem conservation by curbing urban sprawl on the consideration of sound externalities and spillovers as 'ecosystems don't obey the rules of private property'(MA 2005).

EE and CC evaluation and monitoring can be spearheaded by Global Urban Observatory Programme of UN HABITAT through their national, state and local urban observatories across the world. Policy formulation and investment prioritization can be done based on the EE and CC performance of different states/cities within the nations.

EE and CC based development planning and management can be evolved at metropolitan area level using remote sensing GIS possibilities by identifying proxy indicators. This can also be developed as a Strategic Environmental Impact Assessment tool at city/metropolitan region level.

4. CONCLUSIONS

EE and CC based development planning and management of nations, states and metropolitan areas definitely reduces the gap between output and input. The gap is either hidden as spare capacity of infrastructure / resources or losses like fossil fuel wastage, distribution losses of power transmission etc. Reducing of this gap increases the profitability of the business establishments and enables efficient administration of the governments. As the profitability increases job opportunities also increase. This enables balanced urban and regional development and urbanization of a higher percentage of people. A fewer percentage of people will be depending on primary sector activities causing bulk production with high mechanization and automation so that productivity of primary sector activities also multiplies.

LIST OF TABLES

LIST OF FIGURES

REFERENCES

1. United Nations.2010. *World Urbanisation Prospects The 2009 Revision*. Department of Economic and Social Affairs. New York.
2. UN Habitat. 2011. *Cities and Climate Change: Policy Directions. Global Report on Human Settlements 2011. Abridged Edition*. Earthscan. London.
3. May Mathew. 2009. *Environmentally-Efficient development management system for Greater Kochi in Kerala State.* The Thesis Report, School of Management Studies, Cochin University of Science and Technology, Kochi.
4. United Nations Development Program (UNDP). 1990. *Human Development Report.* www.undp.org
5. United Nations Development Program (UNDP). 2008. *Human Development Report.* www.undp.org
6. World Wide Fund for Nature (WWF). *Living Planet Report* 2008. www.panda.org
7. UN Habitat. *Urban Indicators Toolkit Guide*. ww2.unhabitat.org/programmes/guo/guo_guide-asp
8. Redefining Progress. Sustainable Indicators Program. 2004. *Reducing a City's Ecological Footprint: The case of Santha Monica (1990-2000).* www.rprogress.org/publications/2004/santha_monica2004.pdf
9. World Resources Institute. Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being: Biodiversity Synthesis*. Washington, DC.