Urbanization in India: Revisiting the energy aspect and policy issues

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URBANIZATION IN INDIA: REVISITING THE ENERGY-ASPECT AND POLICY ISSUES

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ABSTRACT

Given the indisputable fact that urbanization has long become the cornerstone of industrialization and development efforts in India, this paper specifically takes up the issues of urbanization as related to energy usage and sustainability issues. We find that urbanization has followed a model that is neither energy-efficient, nor, for the very same reasons, sustainable on a long-term planning horizon. The empirical relationship between urbanization and energy use is examined, with strong evidence of urbanization having led the continual increase in energy use per capita in India. The pattern of urbanization and some of its other salient characteristics are also examined and their energy and environment-related consequences discussed. Some important data and empirical evidence are highlighted and policy inferences drawn. Finally, some tentative policy suggestions have been offered as to the course along which future urbanization efforts should be directed.

Keywords: Urbanization, Energy prices, Energy use, India, Sustainable Development

JEL Code: O13, O18, Q3, Q4

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INTRODUCTION

With technological and communication transformation as the New Revolutions ushered in by the Millenium, the model of development we have embraced globally marks a sea-change and a paradigm shift in the history of human development.

Indeed, much longer ago, even before this Millenial Revolution, industrialization and urbanization had been recognised as the twin pillars of that development paradigm. As social and economic life has been becoming increasingly complex day-by-day— the leading development model, principally a product of the Advanced Capitalist regime, with its supreme emphasis on industrialization, urbanization and ever-increasing consumption has been causing widespread dismay among concerned observers and commentators. The voice of conscientious criticism has gained increasing vehemence, arguing that development along such lines has not, and indeed can neither be equitable nor sustainable, as we have been taking more and more out of our natural environment, degrading and diminishing it irrevocably beyond repair or redemption. Not only have cities become "highly unequal spaces - economically, spatially, socially and culturally", as the Conference Theme so eloquently points out, but increasingly, the very core issue of sustainability has been threatening to become endangered.

While the questionable consequences for the pattern of urban development the world over as well as in India are being more and more researched, the present paper focuses on one specific aspect of urbanization in the Indian context that is directly related to sustainability considerations, viz., the energy issues. The paper briefly examines some salient features of the pattern of urbanization in India, focussing particularly on the pattern of energy usage consequent upon such urbanization, and some of the immediate concerns that are a direct fall-out of the same.

PARADOXES

At the outset, we begin by pointing out a few paradoxes observed in everyday economic life—and yet, perhaps commanding rather less attention than it merits.

We are concerned here with the co-existence of three phenomena together in conjunction. First, the well-known relentless increase in crude oil prices globally (in dollar terms), that has

been continuing over the last couple of decades. The second is the continual slide of the Indian currency against the dollar, particularly dramatic over the last few years, which is equally well-known. And finally, we have the seemingly inexplicable fact that, notwithstanding the above, oil imports by India both in physical volume as well as in money terms, have all along continued to increase exponentially.

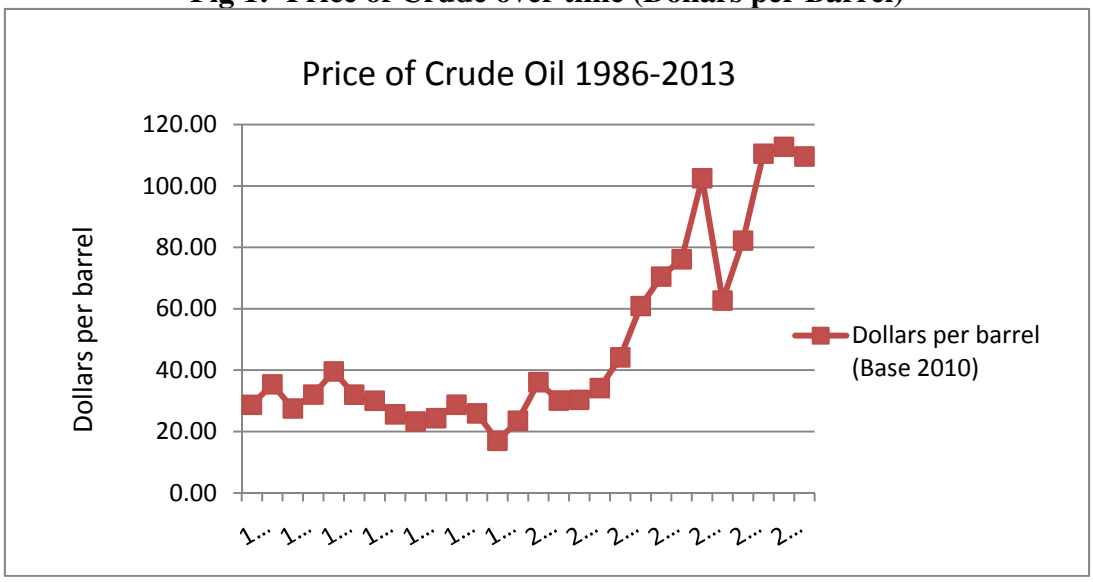
Taken together, these three simultaneous facts present an interesting scenario which is contrary to what normal expectations would suggest according to economic logic. The following data tables bring out the starkly paradoxical yet co-existing observations.

Table 1: Price of Crude Oil 1986-- 2013

Year	Dollars per barrel (*Base 2010*)	Year	Dollars per barrel (*Base 2010*)
1986	28.71	2000	36.08
1987	35.39	2001	30.10
1988	27.51	2002	30.33
1989	32.05	2003	34.17
1990	39.58	2004	44.17
1991	32.03	2005	60.87
1992	30.03	2006	70.46
1993	25.61	2007	76.13
1994	23.27	2008	102.50
1995	24.35	2009	62.68
1996	28.72	2010	82.20
1997	25.94	2011	110.50
1998	17.01	2012	112.75
1999	23.52	2013	109.58

Source: *www.tradingeconomics.com (2013), www.infomine.com/ investment (2013)*

Fig 1: Price of Crude over time (Dollars per Barrel)

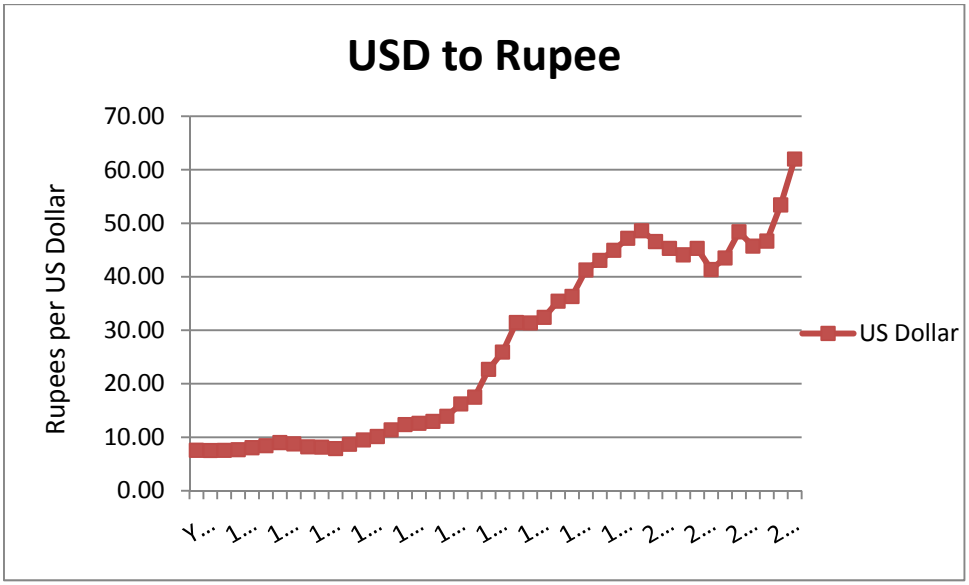


Source: *As Above*

Table 2: Dollar vs. Rupee Exchange Rate over time

Year	Rupees per US Dollar	Year	Rupees per US Dollar
1986	12.61	**2000**	44.94
1987	12.96	**2001**	47.19
1988	13.91	**2002**	48.60
1989	16.22	**2003**	46.58
1990	17.50	**2004**	45.32
1991	22.69	**2005**	44.10
1992	25.92	**2006**	45.31
1993	31.44	**2007**	41.35
1994	31.37	**2008**	43.50
1995	32.42	**2009**	48.40
1996	35.43	**2010**	45.73
1997	36.32	**2011**	46.67
1998	41.27	**2012**	53.44
1999	43.06	**2013**	62.00

Source: *RBI Handbook of Statistics (2013)*



Source: *As above*

The above shows the exchange rate between the Indian Rupee and the US Dollar over the period 1986 to 2013. Clearly, the Rupee has continually undergone depreciation against the latter currency barring the period 2002-2004. The purpose of presenting this data is to showcase the fact that even in the face of the increasingly adverse exchange rate position Crude Oil imports, even in Dollar terms, has been increasing unabated, a fact presented in the next set of tables and figures below.

Table 3: Crude Import over time in Dollar Terms: India *(Dollar Mn)*

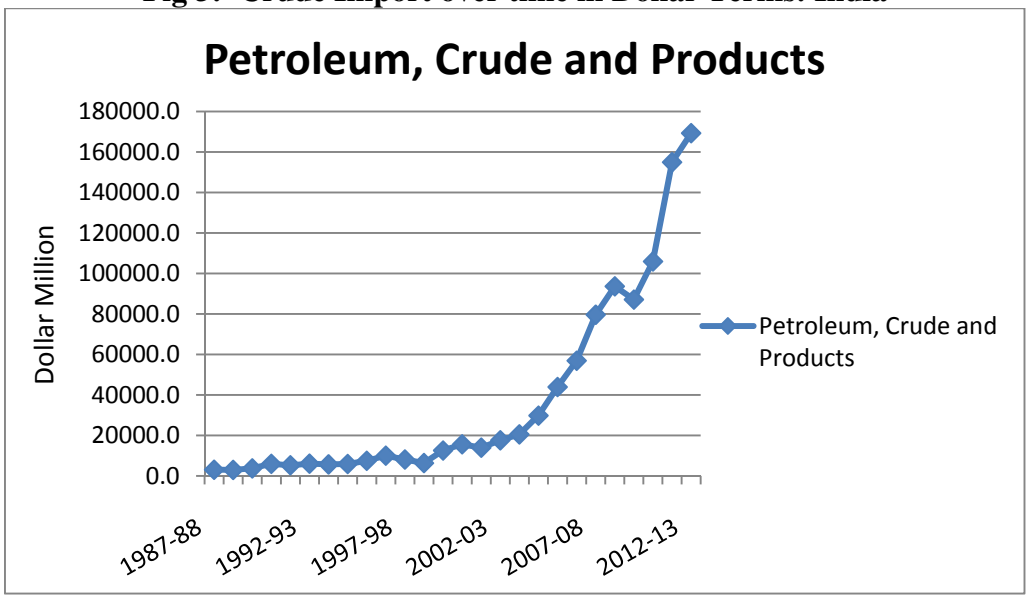
Year	Petroleum, Crude and Products	Year	Petroleum, Crude and Products
1987-88	3118.1	**2000-01**	15650.1
1988-89	3009.0	**2001-02**	14000.3
1989-90	3767.5	**2002-03**	17639.5
1990-91	6028.1	**2003-04**	20569.5
1991-92	5324.8	**2004-05**	29844.1
1992-93	6100.0	**2005-06**	43963.1
1993-94	5753.5	**2006-07**	56945.3
1994-95	5927.8	**2007-08**	79644.5
1995-96	7525.8	**2008-09**	93671.7
1996-97	10036.2	**2009-10**	87135.9
1997-98	8164.0	**2010-11**	105964.4
1998-99	6398.6	**2011-12**	154967.6
1999-00	12611.4	**2012-13**	169319.3

Source: Reserve Bank of India (2013)

Thus, despite the deterioration in the Rupee-Dollar exchange rate, import of crude oil has increased exponentially over time not only in Rupee terms but in dollar terms as well, a fact

that applies for the actual physical volume of imports as well. The dramatic increase in imports in dollar terms is brought out sharply in figure 3 below.

Fig 3: Crude Import over time in Dollar Terms: India



Source: As Above

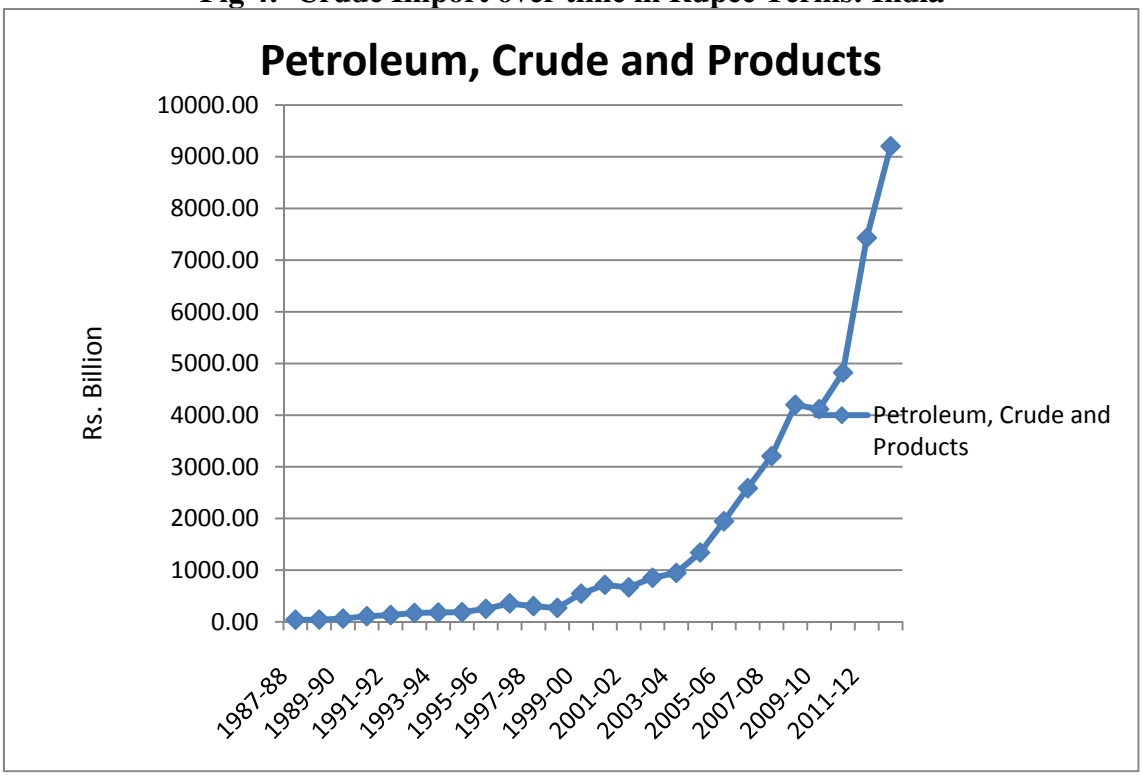
In the following, the same information is presented for imports in Rupee terms, where the essential conclusions remain the same.

Table 4: Crude Import over time in Rupee Terms: India
(Rs. Billion)

Year/ Commodity	Petroleum, Crude and Products	Year/ Commodity	Petroleum, Crude and Products
1987-88	40.43	**2000-01**	714.97
1988-89	43.58	**2001-02**	667.70
1989-90	62.73	**2002-03**	853.67
1990-91	108.16	**2003-04**	945.20
1991-92	131.27	**2004-05**	1340.94
1992-93	171.42	**2005-06**	1946.40
1993-94	180.46	**2006-07**	2585.72
1994-95	186.13	**2007-08**	3206.55
1995-96	251.74	**2008-09**	4199.68
1996-97	356.29	**2009-10**	4116.49
1997-98	303.41	**2010-11**	4822.82
1998-99	269.19	**2011-12**	7430.75
1999-00	546.49	**2012-13**	9204.56

Source: Reserve Bank of India (2013)

Fig 4: Crude Import over time in Rupee Terms: India



Source: As Above

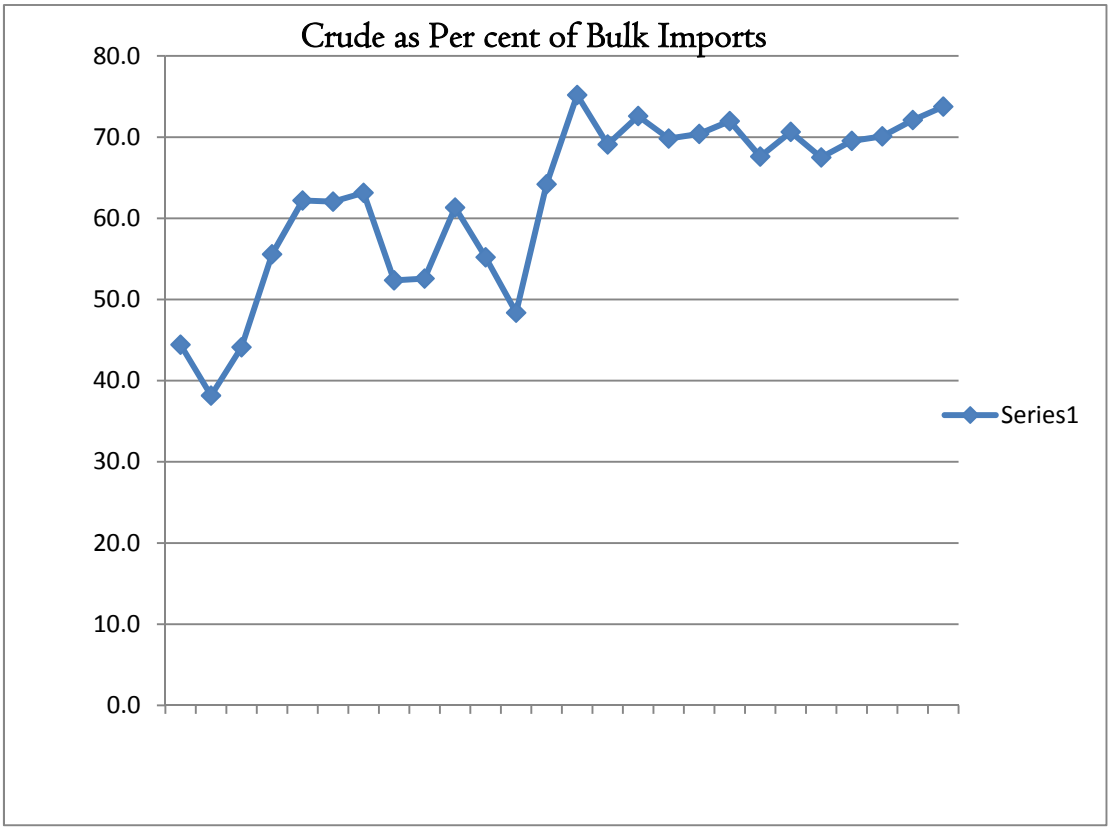
Finally, as a further indicator of India's dependence on oil imports, the historical data on weightage of crude imports in India's bulk import is presented below.

Table 5: Crude Import as Per cent of Bulk Import over time: India

Year	Crude as % of Bulk Imports		Year	Crude as % of Bulk Imports	
	In Dollar Terms	In Rupee Terms		In Dollar Terms	In Rupee Terms
1987-88	44.4	44.42	**2000-01**	75.2	75.18
1988-89	38.2	38.16	**2001-02**	69.1	69.09
1989-90	44.1	44.12	**2002-03**	72.6	72.59
1990-91	55.6	55.57	**2003-04**	69.8	69.82
1991-92	62.2	62.19	**2004-05**	70.4	70.39
1992-93	62.1	61.34	**2005-06**	72.0	71.97
1993-94	63.1	63.14	**2006-07**	67.6	67.68
1994-95	52.4	52.36	**2007-08**	70.6	70.64
1995-96	52.6	52.58	**2008-09**	67.5	66.93
1996-97	61.3	61.33	**2009-10**	69.5	69.44
1997-98	55.2	55.20	**2010-11**	70.1	70.07
1998-99	48.4	48.36	**2011-12**	72.1	72.11
1999-00	64.2	64.19	**2012-13**	73.8	73.74

Source: Reserve Bank of India (2013)

Fig. 5 Crude Import as Per cent of Bulk Import over time: India



Source: As Above

Now, the legitimate question, what is the point of these extensive discussions on the Indian economy's dependence on oil imports?

The point is that dependence on crude imports on such immense scale is a direct fallout of industrialization on one hand and urbanization on the other. Urbanization means increased usage of crude oil products, basically in the form of energy. As industrialization as well as urbanization has proceeded, oil imports, as well as consumption within the domestic economy, have been increasing unabated by either adverse exchange rates or extreme price increases.

The explanation behind the seeming anomaly is not hard to seek, of course, as oil-pricing in India has in actual fact been long known to be largely determined not by market forces but by a highly complex system of subsidies geared towards import and production. However, it is not our main focus here to analyze the workings of the enormous subsidy regime or its implications, as done by Srivastava et al (2003). However, we move on by noting various various authors and commentators have established, that the economic inefficiencies

subsidies generate are too large to ignore, as also the fact that such subsidy regimes are, in the ultimate analysis, unsustainable.

URBANIZATION—ITS CO-INCIDENT FEATURES

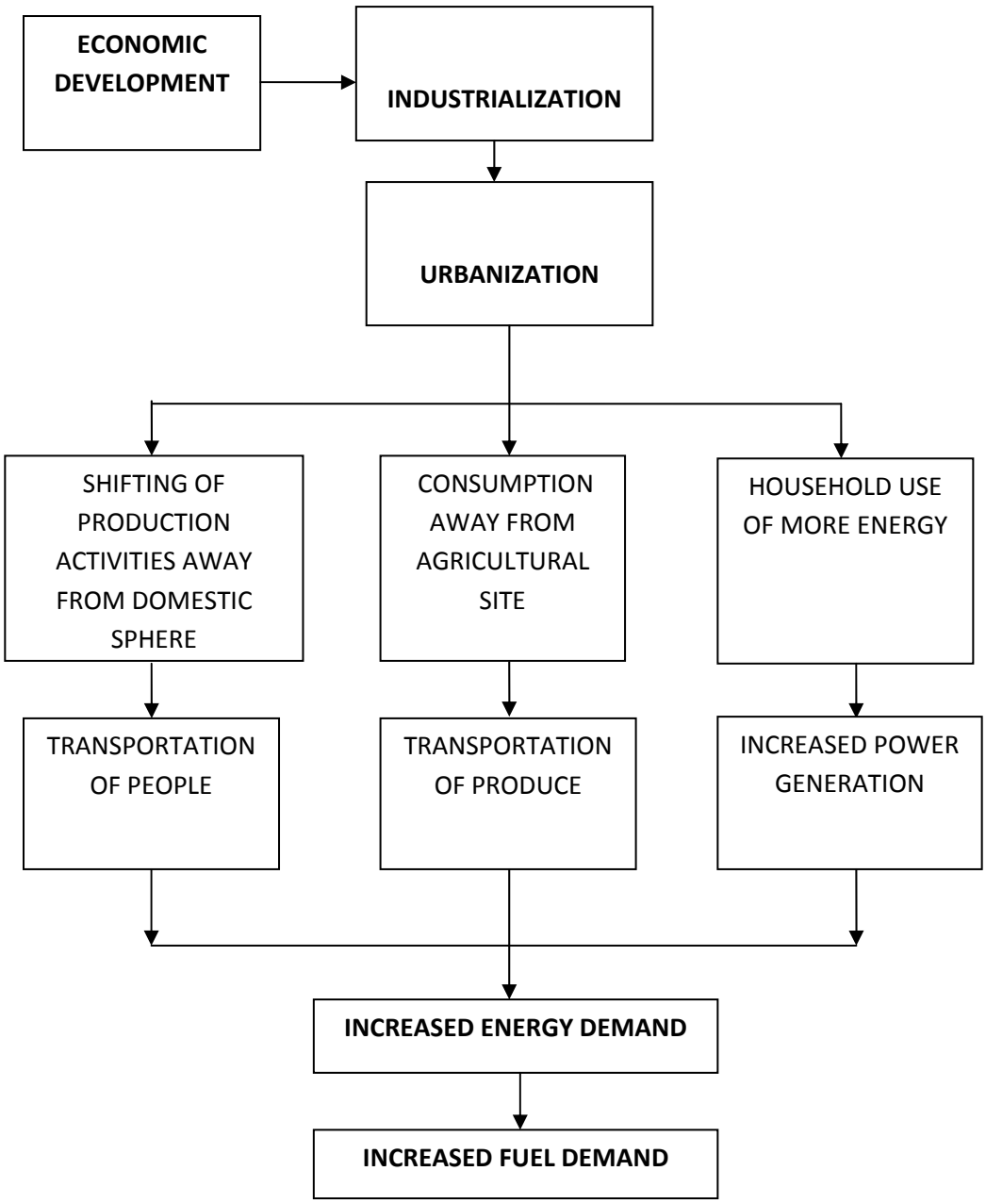
Granted that urbanization is a key fact of life in the current development scenario, we now turn to the question: What does the process of urbanization imply, specifically, what are the ways in which the process impacts the economic environment and, as a direct fall-out, leads to increased energy needs?

As Jones (1989) observed "... Urbanization and industrialization are the most prominent features of economic development. The energy use changes brought about by industrialization are well known, but urbanization also imposes major, if subtle, changes in energy use. Urbanization shifts production activities formerly undertaken in the home with little or no energy to outside producers who do use energy. One of the largest changes is the daily travel of urban residents, primarily if not exclusively, to work. Personal transportation in rural areas generally entails little or no fuel use, while urban transportation does, particularly as income increases. Higher density living also induces substitutions of modern for traditional energy forms. Finally, food must be transported longer distances to urban consumers than to rural, agricultural consumers." (Jones 1989).

Some such major possible inter-linkages are enumerated in the Basic Flow-chart (Fig. 1) below. As economic development proceeds, it leads to industrialization, and simultaneously, to urbanization. Production activities that traditionally took place within the domestic sphere are now shifted outside home, and consumption of agricultural produce now increasingly occurs *away* from the site of actual production. A third aspect is the increasingly greater use of energy at the household level as urbanization occurs.

Thus, transportation of people to the sites of productive activity, and transportation of produce away from the production site to the market, all involve increased usage of energy. Added to this is the increased use and demand for energy at the gradually evolving household sector. Taken together, all this combines to lead to increased demand for power generation, increased energy demand, and consequently, increased demand for fuel use. And this is exactly where the twin questions of environmental impact coupled with sustainability considerations, come into the picture.

FIG 6: URBANIZATION AND ENERGY USE: SOME BASIC INTERLINKAGES



In the present context of the paper we are mainly focussing on the aspects of power generation, and transport.

Where, we have the somehow cyclic scenario of

A. An economy dependent on fuel imports, and

B. Fuel use dependent on urbanization

For one, urbanization immediately leads to increased fuel uses for both transport sector and power sector. This in turn, would lead to increased environmental strain in an already strained environmental circumstance through additional increase in environmental pollutants, viz.

- Generation of more greenhouse gases.
- Increase in SPM
- NOX SOX etc.
- Finally, urbanization with its almost automatic concomitant of rapid increase in car use, adds to vehicular pollution.

These have all been the salient features of urbanization typical in rapidly urbanizing areas like India, barring a few notable exceptions like Singapore, Hong Kong etc where the efforts have been much more environmental-conscious and actively aware of the need to mitigate pollution (UNESCAP 2013).

As for the overall scenario in Metro cities, when we look at the total chunk (pie-chart) of different fuel types in this ever-increasing energy usage pattern, the share of coal and gas in overall power generation completely dominates vis-a-vis renewable/ nuclear/ hydel which are much less polluting.[1] Our concern in the present context, therefore, has two essential aspects: On one hand, reducing the dependence on and requirement of imports, and simultaneously, improving the environmental impact of the pattern of energy usage associated with the current urbanization pattern.

The "**Economics**" of the issues discussed above, then, boils down to:

- The economy's dependence on fuel imports and an ever-rising import bill
- Costs of environmental degradation
    - Medical
    - Other associated Concerns

[1] It is worth mentioning here that in actual fact, no energy source can claim to be 100% pollution free, since even with the "clean" source like wind there are noise & other environmental effects involved. Similarly, the huge land requirements by solar power, and the dubious environmental impacts of nuclear power have been debated at length. So the question is, rather, one of achieving relatively lower pollution "energy-mix" rather than a "zero-pollution" goal.

- Costs of mitigating adverse environmental effects like anti-pollution measures by industries etc.

The present paper seeks to clearly bring out the inter-linkages between the diverse issues of urbanization and the way it impacts energy usage pattern and the consequent environmental implications. From the extremely rich resource base on the issues, some representative literature and associated empirical data is discussed to clearly enunciate some relevant empirical results.

In an early pioneering work, Jones (1989) conducted an aggregate cross-sectional regression analysis for 59 developing countries for 1980. "Aggregate energy use per capita and per dollar of gross domestic product is regressed on per capita income (adjusted for PPP), the percent of GDP coming from industry, the percent of the population urbanized, arable population density, and several product-specific fuel prices. Holding constant per capita income, industrialization, population density and fuel prices, the elasticity of energy consumption w.r.t. a 1% increase in urbanization is between 0.35 and 0.48. The implication is that, although increasing per capita income and industrialization are important sources of increase in energy consumption, urbanization alone is also an important source of increased consumption and could be a major factor in world energy demand over the next generation."

The essential structure in Jones (1989) was essentially as follows:

Energy use /per head, per dollar of GDP → **f** (income, degree of industrialization, urbanization, agricultural population, fuel prices) … … 1)
Where all the other variables like income, agricultural population and fuel prices were controlled for to yield a robust relationship between urbanization and energy use per capita per dollar (Jones 1989).

Moving on from this cross-section analytical framework, we consider in turn a somewhat analogous analysis on time-series basis in the Indian context, albeit using a much simpler framework to be further developed and expanded using additional variables. We investigate the formal relationship between urbanization and energy consumption per capita as evidenced in India since 1985—using the latest data that has been made available by the World Bank (2013). The relevant variables of our focus here are first presented first in some detail below.

Energy Use per capita: Indian Economy

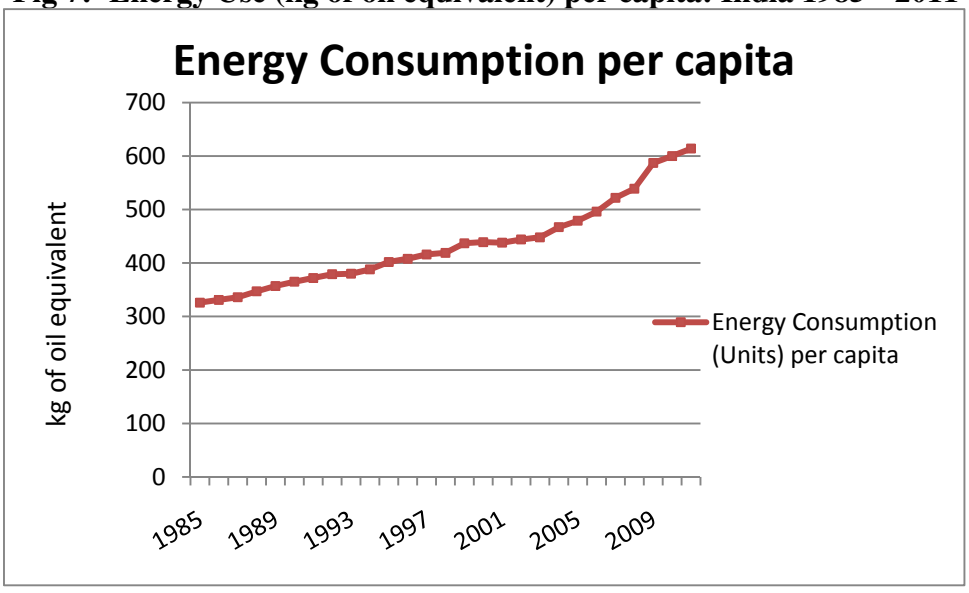
Data for Energy use per capita (kg of oil equivalent), as per the latest World Bank release, are available as comprehensive time series for all countries over the period 1982-2012. For India however, this data is available only upto 2011, and hence for this part of the analysis we restrict our time period to 2011. The relevant data (World Bank 2013) has been presented below.

Table 6: India: Energy Use (kg of oil equivalent) per capita

Year	Energy Consumption (Units) per capita	Year	Energy Consumption (Units) per capita
1985	326	1999	437
1986	331	2000	439
1987	336	2001	438
1988	347	2002	444
1989	357	2003	448
1990	365	2004	467
1991	372	2005	479
1992	379	2006	496
1993	380	2007	522
1994	388	2008	539
1995	402	2009	587
1996	408	2010	600
1997	416	2011	614
1998	419		

Source: As per latest available data from World Bank (updated September 2013)

Fig 7: Energy Use (kg of oil equivalent) per capita: India 1985-- 2011



Source: As Above

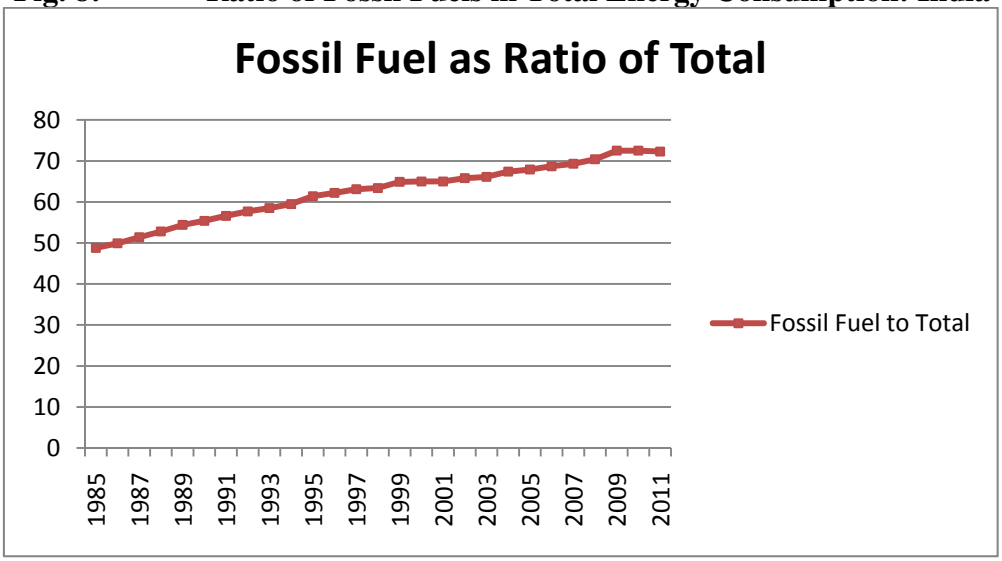
Clearly, energy use per capita has been increasing steadily over our study period. Of greater concern to us, however, is the pattern of this energy use. Specifically, what has been the predominant source of energy in this increasing energy usage? To understand this, we look at the use of fossil fuel as a proportion of total energy consumption in India. The relevant data and charts are presented in the Table 7 and Figure 8 below. As before, we report data made available by the latest World Bank estimates.

Table 7: India: Fossil Fuel in Total Energy Consumption

Year	Fossil Fuel to Total	Year	Fossil Fuel to Total
1985	48.8	1999	64.9
1986	49.9	2000	65
1987	51.4	2001	65
1988	52.8	2002	65.8
1989	54.4	2003	66.1
1990	55.4	2004	67.4
1991	56.6	2005	67.9
1992	57.7	2006	68.7
1993	58.5	2007	69.3
1994	59.5	2008	70.4
1995	61.4	2009	72.5
1996	62.2	2010	72.5
1997	63.1	2011	72.3
1998	63.4		

Source: World Bank (2013)

Fig. 8: Ratio of Fossil Fuels in Total Energy Consumption: India



Source: As Above

Urbanization and Energy Use per capita: A Simple Analysis

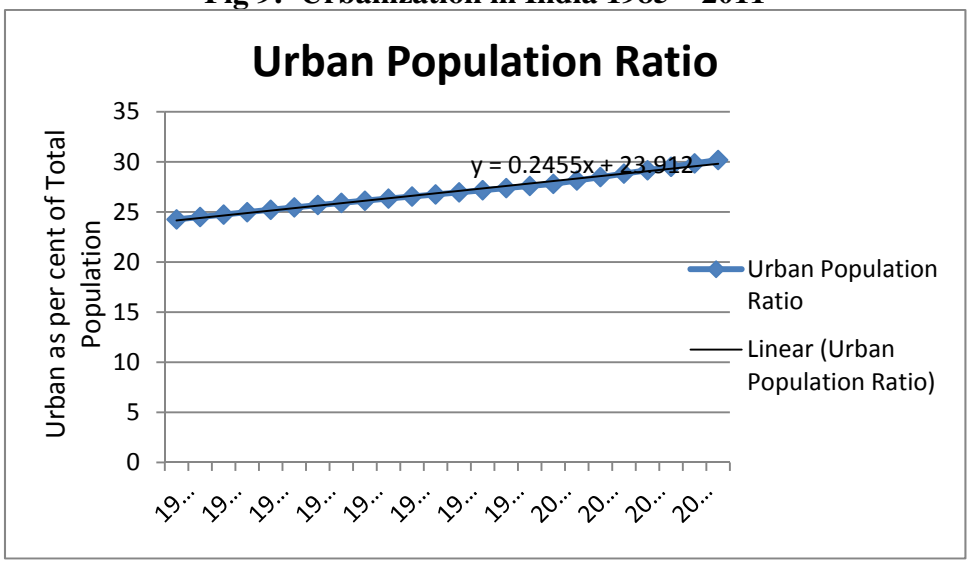
We now come to the part of our analysis where we discuss, at a very basic level, the empirical evidence on the relationship between urbanization on one hand and energy use per capita on the other, as observed in India over the period 1985-2011. Table 8 and Fig 9 below present the data on urbanization in India as computed through interpolation of decadal Census data (Census 2011), restricting the period of our analysis up to the year 2011, since that is the year till which World Bank energy use data for India has been made available.

Table 8: Proportion of Urban in Total Population: India: 1985-- 2011

Year	URBAN	Year	URBAN
1985	24.26	1999	27.38
1986	24.5	2000	27.59
1987	24.74	2001	27.8
1988	24.98	2002	28.14
1989	25.22	2003	28.48
1990	25.46	2004	28.82
1991	25.7	2005	29.16
1992	25.91	2006	29.5
1993	26.12	2007	29.84
1994	26.33	2008	30.18
1995	26.54	2009	30.295
1996	26.75	2010	30.54
1997	26.96	2011	30.79
1998	27.17		

Source: Based on Interpolation from Census data, GOI (2011)

Fig 9: Urbanization in India 1985—2011



Source: As Above

The data on urbanization, being extrapolated from the decadal Census data on the assumption of a constant trend rate of growth, is clearly a linear series (Table 8 and Fig 9 above). In spite of the unavoidable approximation involved here, urbanization in India between the period 1985 to 2011can safely be assumed to have grown continually. In addition, it is also clear from the relevant Tables and Figures as above that energy use per capita on one hand, and urbanization on the other, have moved in close correspondence.

In the following, we run a very basic regression of energy use per capita in India over the study period (1985—2011) on urbanization over the same period, whose results are discussed below.

Regression of Energy Consumption per capita on Urbanization: Results

Regressing the Log of Energy use per capita on log of urbanization, we obtain the following results as detailed below:

Estimated Regression:

$$\text{Ln}(\text{ENERGY}_{pc}) = \underset{(-7.157)}{-.884} + \underset{(28.460)}{2.448}\ \text{Ln}(\text{URBAN}) \quad \ldots \quad \ldots \quad \ldots \quad 2)$$

$$\overline{R}^2 = .969$$

Where, ENERGY_{pc} = Energy use (/consumption) per capita (kg of oil equivalent)

And URBAN = Proportion of Population living in Urban areas

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.985[a]	.970	.969	.0138606	.369

a. Predictors: (Constant), URBAN

b.Dependent Variable: ENERGYpc

Model Summary[b]

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Clearly, the results are robust with a quite high adjusted R^2 and significantly high t-values. However, the low DW-statistic definitely points to the presence of high serial autocorrelation, a fact that is naturally expected given the strong time trend element involved in either series. Secondly, this very much basic-level regression also suffers from the omitted variables bias as there are a number of concurrent factors or variables that theory and common sense suggests as having considerable impact on energy usage, an aspect which is reserved for a further, fuller analysis. However, even this very elementary exercise definitely reinforces the strong relationship existing between per capita energy use in an economy and the level of urbanization.

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.156	1	.156	809.962	.000[a]
	Residual	.005	25	.000		
	Total	.160	26			

a. Predictors: (Constant), URBAN

b. Dependent Variable: ENERGYpc

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-.884	.124		-7.157	.000	-1.139	-.630
	URBAN	2.448	.086	.985	28.460	.000	2.270	2.625

a. Dependent Variable: ENERGYpc

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.505415	2.758788	2.631152	.0773622	27
Residual	-.0246108	.0293800	.0000000	.0135915	27
Std. Predicted Value	-1.625	1.650	.000	1.000	27
Std. Residual	-1.776	2.120	.000	.981	27

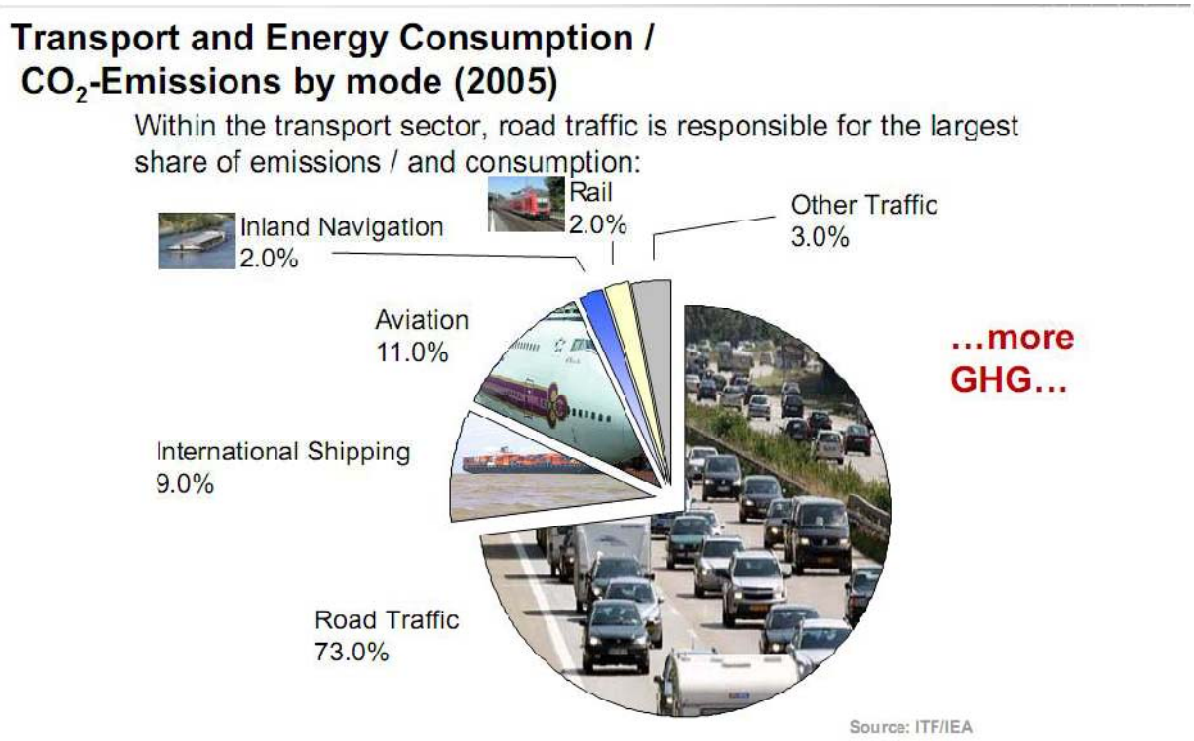
a. Dependent Variable: ENERGYpc

India's Pattern of Industrialization and Urbanization: Some Further Paradoxes

Another interesting aspect of India's urbanization experience has been its pattern of transport expansion, which has been massive by any scale. The increase in power generation in the country has gone up more than threefold between 1983 to 2012 (GOI, MOSPI 2013). Laying of railway lines in the same period has increased from 50000 kms to a mere 60000 kms., implying a huge contrast between energy use growth and increase in relatively environmental-friendly modes of transport.

Both these issues indicate that, for its rapid urbanization, India has encouraged growth of Road transport, which is much more environmentally adverse, rather than growth in rail transport which is relatively environment-friendly. A further, extremely perplexing feature is the addition of enormous road lengths, as compared to the extremely meagre addition to rail length in India over the period post-Independence. This , despite the fact that, within transport mediums, roads are the most energy-consuming while Railways are among the most energy-saving, as the following chart from UNDP shows.

Figure 10: Mode of Transportation and Related Energy Usage



Source: UNDP (2013)

CONCLUDING REMARKS, POLICY SUGGESTIONS & FURTHER RESEARCH:

Having discussed in some detail some aspects of India's urbanization experience, specifically, the aspect of energy usage and sustainability, we are now in a position to conclude this discussion. The empirical evidence as well as the general research consensus point to the strong and inevitable linkages between urbanization and increasing energy use. While for India, the per capita energy use figures, despite continued increase, are comparatively much more modest than its peer countries (World Bank 2013), the worrying feature is the continued increase in dependence on fossil fuel and associated imports which are causing unmistakable strain on the economy's finances, not to mention the all too apparent and potential environmental hazards. The dependence on fossil fuels is a problem that many of India's peers have already been able to reduce since some time (World Bank 2013). India, therefore, needs to take a leaf out of the books of such countries and increasingly work towards a more favourable renewables vs. non-renewables energy mix.

What then are the options open to us with the current ongoing process of rapid urbanization so that the future is not completely compromised? Plans for urbanization should consider the following points:

1. Encouraging increased rail transport of goods between various urban centres
2. Increased Use of Rapid Mass Transport Systems (MTS) within urban areas
3. Encouraging the usage of renewable sources of energy like solar power, including solar heaters / cookers

Urbanization should consider the following points:

- Mandatory usage of solar panels for street lighting
- Incentivising Usage of solar heaters / solar cookers at homes
- Mandatory installation of solar panels on roofs above a particular minimum area

Clearly, these are concern areas that need concerted efforts and participation both at the government as well as the corporate levels. While government could focus on the design of suitable incentives and efficient subsidization of innovative and alternative energy source usage and their active adoption at the urban metropolitan and household level, the private sector would do well to recognize its own responsibilities in coming forward to participate in a future-looking sustainable urbanization programme.

Our future research interests in this regard include the following:

- Exploring and capturing more fully the interrelationships between urbanization ad energy usage pattern in a more comprehensive analytical framework
- As urban areas expand more and more in the future, exploring the potentials for solid waste management in the form of waste-to-power generation, since solid wastes are an inevitable by-product (a “necessary evil” as it were) as long as India adheres to the current dominant development model, which indeed seems an irreversible fact of life at least in the foreseeable future.

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