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Population Growth and Sustainable Development in India

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Introduction

The United Nations General Assembly adopted, in September 2015, the post-2015 development agenda named ' Transforming the World: The 2030 Agenda for Sustainable Development' as the plan of action for people, planet and prosperity (United Nations, 2015). The scope and the ambition of the Agenda are reflected in terms of its 17 Goals and 169 targets. Sustainable development may be defined as the development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. It is argued that it is crucial to harmonise three core elements - economic growth, social inclusion and environmental protection - to achieve sustainable development (United nations, 2015a). These elements are interconnected and all the three are crucial for the well–being of individuals and societies.

Surprisingly, the 2030 Agenda for Sustainable Development of the United Nations is silent about the fourth and the most important dimension of sustainable development - the population dimension. It is well known that pervasive poverty, environmental degradation and hazards, the use of natural resources, and economic and social development are closely linked to population growth, distribution and structure. It is also recognised that unsustainable patterns of consumption and production are depleting natural resources and causing environmental degradation, while reinforcing social inequity and poverty. The challenge of the sustainability of development processes is to meet the needs of the present generation and improve their quality of life in ways that do not compromise the ability of future generations to meet their own needs. It is therefore important to recognise the interrelationship between population, economic growth, social inclusion and environmental protection - the three dimensions of sustainable development. In the context of sustainable development, it is imperative that the population dimension is explicitly recognised in all strategies of economic growth, social inclusion and environmental protection. According to the latest medium variant of population projections prepared by the United Nations Population Division, the world population is the most likely to increase from an estimated 7349 million in 2015 to 8501 million in 2030 or an increase of 1151 million during the 15 years (United Nations, 2015). More than 97 per cent of this increase (1119 million) will be confined to the so-called developing or less developed countries of the world, although there will be substantial variation in the rate of population growth across countries. Along with the increase in population, there will also be changes in the age structure of the population because of the transition in fertility and mortality and movement of the population. All these changes in the population stock will undoubtedly have implications to the demand for natural resource and the impact on the environment in terms of the wastes generated out of the natural resources use. They will also influence the economic growth processes and prospects of human development including poverty eradication, unequal distribution of resources across countries and within countries. These concerns were recognised at the International Conference on Population and Development at Cairo in 1994 which emphasised the need of integrating population factors in development planning and programming (United Nations, 1994). The Conference also recommended that population considerations should be explicitly taken into consideration in economic and development strategies - planning, decision-making and resource allocation at all levels and in all regions - and argued that integration of population factors in development planning will contribute to both sustainable development and poverty alleviation and will lead to slowing down the population growth and improving the quality of life. However, the population dimension has surprisingly been ignored in the 2030 Sustainable Development Agenda.

The population dimension of sustainable development is not just about the implications of population growth on economic growth, social inclusion and environmental protection. It is also about the implications of the changes in population age structure resulting in demographic dividend and population ageing and mobility - urbanisation and migration. These dimensions are central to any development process and, therefore, have direct bearings on the realisation of Sustainable Development Goals and associated targets as identified in the 2030 Sustainable Development Agenda.

It is in the above context, this paper analyses how population growth impacts upon sustainable development in India. The United Nations Population Division has estimated that India's population in 2015 was around 1311 million (United Nations, 2015b). According to the medium variant of the projections prepared by the United Nations Population Division, India's population is the most likely to increase to 1528 million in 2030 (United Nations, 2015b). This means that during the 15 years between 2015 and 2030, India's population is the most likely to increase by around 217 million. It is obvious that this increase in the size of the population of the country will have important implications to the social and economic development processes of the country and will have substantial environmental impact.

On the other hand, sustainable development is characterised in terms of the dimension of environmental protection and focus on two aspects - primary energy use and associated carbon dioxide (CO_2) emission. An understanding of the contribution of the increase in the population to the increase in the primary energy use and the increase in CO_2 emission may be important to reflect the demographic dimensions of sustainable development in India.

The paper is organised as follows. The next section of the paper describes the methodology adopted for analysing the impact of population growth on sustainable development. The paper uses the widely used IPAT framework to analyse the contribution of the increase in population to the increase in primary energy use and CO_2 emission. The third section of the paper describes the data source. Results of the analysis are presented in section four of the paper while the fifth section discusses the policy implications of the findings of the analysis in the context of sustainable development. The last section summarises main conclusions of the analysis and emphasises the need of integrating demographic factors in sustainable development processes in India.

Methodology

The paper employs the well-known IPAT framework that assumes that the environmental impact is the combined effect of population, affluence and technology. This framework was first proposed in the early 1970s (Ehrlich, 1968; Commoner, 1972) but still used widely. The framework assumes that all anthropogenic changes in the environment are primarily due to (i) population, (ii) economic activity, (iii) technology, (iv) political and economic institutions, and (v) attitudes and beliefs (Stern, Yong and Druckman, 1992). The framework is simple, systematic, and robust. It is simple because it incorporates key anthropogenic driving forces with parsimony. It is systematic because it specifies the mathematical relationship between the driving forces and their impact. Moreover, it is robust because it is applicable to a wide variety of environmental impacts (Dietz and Rosa, 1997).

The IPAT framework requires measurement of the environmental impact and its three components - population, affluence and technology. In the present paper, we measure environmental impact in terms of primary use energy use and CO_2 emission. The primary energy use reflects the extent of the use of natural resources, whereas CO_2 emission reflects the technology involved in transforming natural resources into usable form. On the other hand, the most straightforward measure of population is the size of the population. Other things being equal, the larger the population, the larger the demand and use of natural resources and the larger is the waste generated out of the resource use, whereas affluence represents the average consumption of each person in the population - the higher is the average consumption, the larger is the use and hence the demand for natural resources and the larger is the waste generated out of resource use. A common proxy for measuring consumption is the GDP per capita. Finally, the technology component of the IPAT framework may be measured in terms of primary energy intensity of the gross domestic product which means the primary energy used in producing a unit gross domestic product. Many factors influence the energy intensity of the gross domestic product. These include, among others, general standards of living and weather conditions, structure of the social and economic production system and the efficiency of primary energy use by the system. In the context of the efficiency of primary energy use in the social and economic production system, energy intensity of the gross domestic product reflects the state of technology. When the energy intensity of the gross domestic product is low then, other things being equal, the state of technology may be termed as advanced as compared to when the energy intensity of the gross domestic product is high. It may be noticed that the energy intensity also reflects the use of natural resources.

If G denotes the total gross domestic product or the total output of the social and economic production system and P denotes the size of the population then the IPAT framework may be represented in terms of the total primary energy use (E) in the following manner:

$$E = P * \frac{G}{P} * \frac{E}{G} = P * A * R \qquad (1)$$

Here A is the gross domestic product per capita and R is the primary energy intensity of the gross domestic product. In this formulation, environmental impact is measured in terms of total primary energy use.

The equation (1) may be extended further in terms of total CO_2 emission (C) to what is known as the Kaya identity (1990):

$$C = P * \frac{G}{P} * \frac{E}{G} * \frac{C}{E} = P * A * R * W \tag{2}$$

Here W is the carbon intensity of energy use, which means CO_2 emitted in using one unit of primary energy. CO_2 is one of the greenhouse gases. Increased concentration of these gases in the atmosphere is attributed to disruptive changes in the climate, particularly, the increase in the atmospheric temperature. CO_2 is essentially a waste generated out of the primary energy use. The carbon intensity of the primary energy use also reflects the mix of the energy in the social and economic production system, in particular, the share of the energy from renewable or non-renewable sources, and - among the non-renewable sources - the share of highly carbon intensive sources such as coal and low carbon intensive sources such as natural gas (O'neill and Chen, 2002).

Following Kim and Strobino (1984), the change in the primary energy use (E) over a given period of time can be decomposed into the change in the size of the population, change in the gross domestic product per capita and the change in the energy intensity in the following manner:

$$\begin{aligned} E_2 - E_1 = {} & (P_2 - P_1) * A_1 * R_1 + (A_2 - A_1) * P_1 * R_1 + \\ & (R_2 - R_1) * P_1 * A_1 + (P_2 - P_1) * (A_2 - A_1) * R_1 + \\ & (P_2 - P_1) * A_1 * (R_2 - R_1) + P_1 * (A_2 - A_1) * (R_2 - R_1) + \\ & (P_2 - P_1) * (A_2 - A_1) * (R_2 - R_1) \\ = {} & P + A + T + PA + PT + AT + PAT \end{aligned} \tag{3}$$

The first three terms on the right-hand side of equation (3) represent the main effects, the next three terms represent two-way interactions while the last term represents three way interactions. For example, the first term on the right of equation (3) shows the contribution of the change in population size to the change in the primary energy use when the gross domestic product per capita and energy intensity of the gross domestic product are held constant at their initial values. Similarly, the fourth term on the right-hand side of the equation shows the contribution of the simultaneous change in the size of the population and the change in the gross domestic product per capita on the change in the primary energy use when the energy intensity of the gross domestic product is held constant at its initial value. Finally, the last term on the right-hand side of equation (3) represents the contribution of the simultaneous change in all the three components that ultimately determine the change in the total primary energy use - population size, gross domestic product per capita and energy intensity of the gross domestic product. Equation (3) thus helps in understanding the relative role of the change in population, affluence and technology to the change in the primary energy use. The change in the primary energy use reflects the impact of the change in the use and the demand of the natural resources on the environment. An increase in the primary energy used because of either increase in population or because of the increase in per capita gross domestic product or because of the increase in the primary energy intensity of the gross domestic product may be assumed to reflect the increased impact on the environment.

Following the same argument, the change in the CO_2 emission over time may be decomposed in the following manner:

$$\begin{aligned} C_2 - C_1 = {} & (P_2 - P_1)*A_1*R_1*W_1 + (A_2 - A_1)*P_1*R_1*W_1 + \\ & (R_2 - R_1)*P_1*A_1*W_1 + (W_2 - W_1)*P_1*A_1*R_1 + \\ & (P_2 - P_1)*(A_2 - A_1)*R_1*W_1 + (P_2 - P_1)*A_1*(R_2 - R_1)*W_1 + \\ & (P_2 - P_1)*A_1*R_1*(W_2 - W_1) + P_1*(A_2 - A_1)*(R_2 - R_1)*W_1 + \\ & P_1*(A_2 - A_1)*R_1*(W_2 - W_1) + P_1*A_1*(R_2 - R_1)*(W_2 - W_1) + \\ & (P_2 - P_1)*(A_2 - A_1)*(R_2 - R_1)*W_1 + \\ & (P_2 - P_1)*A_1*(R_2 - R_1)*(W_2 - W_1) + \\ & P_1*(A_2 - A_1)*(R_2 - R_1)*(W_2 - W_1) + \\ & (P_2 - P_1)*(A_2 - A_1)*(R_2 - R_1)*(W_2 - W_1) \\ = {} & P + A + R + W + PA + PR + PW + AR + AW + RW + PAR + PAW + ARW + PARW \end{aligned} \tag{4}$$

Application of equations (3) and (4) to India has been carried out for two time periods: 1990-2015 and 2015-2030. The period 1990-2015 is period of the Millennium Development Agenda of the United Nations (United Nations, 2000), while the period 2015-2030 is the period of the 2030 Sustainable Development Agenda also mooted by the United Nations (United Nations, 2015). The analysis for the period 1990-2015 reflects the historical perspective of the change in the size of the population, change in the per capita consumption or the change in the level of affluence and the change in the technology on the environment in terms of the change in the primary energy use and CO_2 emission. The analysis for the period 2015-2030, on the other hand, projects the future perspective of the projected change in the population size, projected change in the per capita consumption or the projected change in the level of affluence and the projected advancement in technology on the projected change in primary energy use and CO_2 emission. In other words, the analysis for the period 1990-2015 tells what has happened in the country in the past, whereas the analysis for the period 2015-2030 tells what is likely to happen in the near future. Three scenarios have been built up for the period 2015-2030. The first is the Business as Usual Scenario. This scenario is based on forecasting the change in the primary energy use and CO_2 emission, change in the size of the population and the change in the per capita consumption on the basis of the trend during 1990-2015 through the time series modelling. In the time series modelling, the past provides a model for the future. The Expert Modeller of the Forecasting module of the SPSS software package was used for building the forecasting model (IBM, *no date*). The Expert Modeller attempts to automatically identify and estimate the best-fitting ARIMA or exponential smoothing model thereby eliminating a great deal of the trial and error in modelling the time series. The second scenario is the New Policies Scenario (International Energy Agency, 2015). This scenario takes into account a number of policy initiatives that have been taken by India to influence the primary energy use and associated CO_2 emission. Finally, the third scenario may be termed as the Indian Vision Case, which takes into consideration an accelerated realisation of key policy targets notably the Make-in-India campaign, which is directed towards putting industry at the heart of India's growth model (International Energy Agency, 2015).

Data

The analysis is based primarily on the data on primary energy use and carbon dioxide emission in the country available through EnerData, which is an independent research and consulting organisation on the global oil, gas, coal, power, renewable and carbon markets. The organisation provides consistent estimates of total primary energy used, primary energy used per capita, energy intensity of the gross domestic product and total carbon dioxide emission for 186 countries of the world including India for different years of the period 1990 through 2015. These estimates have been used in the present analysis. In addition, estimates of population size are derived from the latest population prospects prepared by the United Nations Population Division (United Nations, 2015). The population enumerated at different population censuses in the country has not been used in the present analysis because of two counts. First, there is some under counting of the population at all population censuses. For example, the post enumeration survey carried out after the latest 2011 population census in India suggests that there was a net omission of 23 persons for every 1000 enumerated persons in the country (Government of India, 2014). Second, estimates of population are not available from the population census are available at an interval of 10 years only. On the other hand, the official population projections based on the 2011 are not yet available and the population projection based on 2001 population census is limited up to the year 2026 only.

Historical Perspective

It is estimated that during the 25 years between 1990-2015, the total CO_2 emission in India increased by more than four times from 517 million tones (Mt) in 1990 to 2166 Mt in 2015 or an increase of 1649 Mt (Table 1). During the same period, total primary energy use increased by 307 million tones of oil equivalent (Mtoe) in 1990 to 882 Mtoe in 2015 or an increase of 575 Mtoe. The increase in CO_2 emission and primary energy use has been associated with an increase in per capita income from US$1579 at 2005 US$ purchasing power parity in 1990 to 5134 in 2015, whereas the population of the country increased from 871 million in 1990 to 1311 million in 2015. As the result, per capita primary energy use increased from 352 Kilogram of oil equivalent (Koe) in 1990 to 673 Koe in 2015, while the carbon intensity of the primary energy use increased from 1.685 to 2.456. The energy intensity of the gross domestic product, however, decreased from 0.223 in 1990 to 0.131 in 2015.

Table 2 decomposes the increase in CO_2 emission during 1990-2015 into the increase attributed to the increase in population, per capita gross domestic product, carbon intensity of primary energy use and the decrease in the energy intensity of the gross domestic product. Similarly, the decomposition of the increase in the primary energy use during the period 1990-2015 has been decomposed into the increase in population, per capita per capita gross domestic product and the decrease in the energy intensity of the gross domestic product. The primary contributor to the increase in the primary energy use and associated CO_2 emission during the period under reference has been the increase in the gross domestic product per capita or the increase in the affluence.

However, the contribution of the increase in the population has also been quite significant. Moreover, the direct contribution of the decrease in the energy intensity of the gross domestic product to the increase in the primary energy use has been too small to compensate for the direct contribution of the increase in the gross domestic product per capita and the increase in population size. Similarly, the direct contribution of the decrease in the energy intensity of the gross domestic product to the increase in CO_2 emission has also been too small to compensate for the direct contribution of the increase in the per capita gross domestic product, population size and the carbon intensity of the primary energy use. This means that technological advancement in the country has not been large enough to compensate for the negative environmental effects of the increase in affluence and the increase in the size of the population.

One way to analyse the impact of population growth on primary energy use and CO_2 emission is to estimate the increase in the primary energy use and CO_2 emission under the condition that there is no population growth. If it is assumed that there had been no population growth in the country during the period 1990-2015, then, the table 2 suggests that the primary energy use would have increased by only 279 Mtoe, while the CO_2 emission would have increased by about 922 Mt. This means that population growth in India during 1990-2015 has been responsible for around 296 Mtoe of the increase in the primary energy use and 727 Mt of the increase in CO_2 emission during the 25 years between 1990 and 2015. The impact of population growth on the environment is obvious.

Future Prospects

Table 3 presents the future prospects of the increase in primary energy use and CO_2 emission and the components of the increase under three different scenarios as discussed above. Under the business as usual case, the primary energy use is forecasted to increase to 1665 Mtoe by 2030, whereas the CO_2 emission is forecasted to increase to 5138 Mt. In the New Policy Initiative case, the primary energy use is forecasted to increase to 3744 Mtoe, whereas the CO_2 emission is forecasted to increase to 3744 Mt. Finally, in the India Vision case, the primary energy use is forecasted to increase to 1482 Mtoe, whereas the CO_2 emission is forecasted to increase to 3865 Mt. On the other hand, the business as usual case suggests that the population of the country will increase to 1541 million by the year 2030 whereas the medium variant of population projection prepared by the United Nations Population Division suggests that India's population will increase to 1528 million by 2030. Finally, under the business as usual case, the gross domestic product of the country is likely to increase to US$ 13408 at 2005 purchasing power parity. This means that the energy intensity of the gross domestic product is likely to increase to 0.110 whereas the carbon intensity of the primary energy use is likely to increase to 3.1.

The decomposition of the increase in the primary energy use and CO_2 emission during the period 2015-2030 is presented in table 4. If it is assumed that there will be no increase in the population during the period 2015-2030 then the primary energy use will increase to 534 Mtoe, 354 Mtoe and 390 Mtoe respectively under the business as usual, New Policy Initiatives and India Vision scenario, while the CO_2 emission will increase to

2204 Mt, 1047 Mt and 1154 Mt respectively. This means that increase in population will account respectively for 249 Mtoe, 204 Mtoe and 210 Mtoe increase in the primary energy use and 768 Mt, 531 Mt and 548 Mt increase in the CO_2 emission in the country under the three scenarios.

Discussions and Conclusions

The analysis presented here highlights the impact of population growth on one of the three dimensions of sustainable development as defined by the United Nations in the 2030 Sustainable Development Agenda - the dimension of environmental protection - in India. The substantial impact of population growth on both the increase in primary energy use and the increase in CO_2 emission in the country in the past as well as the likely impact in the near future clearly emphasises the need of incorporating population concerns, while customising the 2030 Sustainable Development Agenda to the Indian context. The 2030 Sustainable Development Agenda is essentially a global development perspective which, as recommended by the United Nations, needs to be customised at the country level after incorporating development priorities and concerns specific to the country.

The analysis also suggests that although the direct contribution of the population growth to the increase in the primary energy use and CO_2 emission may not be large but the second order effects in conjunction with the change in the per capita gross domestic product or the change in the affluence is quite substantive. This means that a substantial proportion of the contribution of the increase in affluence to the increase in primary energy use and emission of greenhouse gases including CO_2 can be compensated by accelerating population transition. This observation is important as increase in affluence measured in terms of gross domestic product per capita is widely recognised as an indicator of development and improvement in the quality of life.

Finally, the analysis shows that technology advancement had and is likely to have only a limited impact on the environmental concerns in India. The decrease in the primary energy use and CO_2 emission as the result of improvements in the technology used in the social and economic production system has been too small to compensate for the increase in the primary energy use and CO_2 emission as the result of population growth and the increase in affluence. The prospects of rapid advancement in technology in India appear to be remote because of the heavy cost associated with technological innovations and technological research. As such, the case of accelerating population transition in the context of sustainable development in India becomes even stronger.

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Table 1
CO_2 emission, primary energy use, gross domestic product and population during 2015-2030 in India

Particulars	1990	2000	2010	2015
Population (million)	871	1053	1231	1311
Gross domestic product (Billion 2005 US$ ppp)	1375	2360	4878	6731
Gross domestic product per capita (2005 US$ ppp)	1579	2240	3963	5134
Primary energy use (Mtoe)	307	441	693	1649
Energy intensity of the gross domestic product	0.223	0.187	0.142	0.131
CO_2 emission (Mt)	517	899	1576	2166
Carbon intensity of energy use (Mt)	1.69	2.04	2.28	2.46

Source: Population estimates are from United Nations (2015b). Estimates of gross domestic product, primary energy use and CO2 emission are from EnerData. Rest are author's calculations.

Table 2

Decomposition of the increase in the primary energy use and CO_2 emission in India during 1990-2015

Contribution to the increase in primary energy increase and CO_2 emission	Primary energy use (Mtoe)	CO_2 emission (Mt)
Total increase	575	1649
Direct contribution	719	1448
Population (*P*)	155	261
Gross domestic product per capita (*A*)	690	1163
Energy intensity of gross domestic product ®	-126	-213
Carbon intensity of primary energy use (*W*)		237
Second order contribution	0	555
P and *A*	349	588
P and *R*	-64	-108
P and *W*		120
A and *R*	-285	-480
A and *W*		533
R and *W*		-98
Third order contribution	-144	-243
P and *A* and *R*	-144	-243
P and *A* and *W*		269
P and *R* and *W*		-49
A and *R* and *W*		-220
Fourth order contribution		-111
P and *A* and *R* and *W*		-111

Source: Author's calculations.

Table 3
Forecast of CO_2 emission, primary energy use, gross domestic product and population during 2015-2030 in India.

Particulars	2015	2030		
		Business as usual	New policy initiatives	India vision
Population (million)	1311	1541	1528	1528
Gross domestic product (Billion 2005 US$ ppp)	6731	13408	13408	13408
Gross domestic product per capita (2005 US$ ppp)	5134	8699	8777	8777
Primary energy use (Mtoe)	1649	1665	1440	1482
Energy intensity of the gross domestic product	0.131	0.124	0.107	0.124
CO_2 emission (Mt)	2166	5138	3744	3865
Carbon intensity of energy use (Mt)	2.46	3.09	2.6	2.61

Source: Author's calculations.

Table 4
Decomposition of the increase in the primary energy use and CO_2 emission in India during the period 1990-2015

Contribution to the increase in primary energy increase and CO_2 emission	Primary energy use (Mtoe)			CO_2 emission (Mt)		
	Business as usual	New policy initiative	India vision	Business as usual	New policy initiative	India vision
Total increase	783	558	600	2972	1578	1699
Direct contribution	721	613	634	2326	1632	1691
Population (*P*)	155	146	146	380	358	358
Gross domestic product per capita (*A*)	612	626	626	1504	1537	1537
Energy intensity of gross domestic product ®	-46	-159	-138	-113	-390	-338
Carbon intensity of primary energy use (*W*)				555	127	134
Second order contribution	68	-36	-18	619	1	54
P and *A*	108	103	103	264	254	254
P and *R*	-8	-26	-23	-20	-64	-56
P and *W*				97	21	22
A and *R*	-32	-113	-98	-78	-277	-240
A and *W*				385	90	95
R and *W*				-29	-23	-21
Third order contribution	-6	-19	-16	29	-51	-42
P and *A* and *R*	-6	-19	-16	-14	-46	-40
P and *A* and *W*				68	15	16
P and *R* and *W*				-5	-4	-3
A and *R* and *W*				-20	-16	-15
Fourth order contribution						
P and *A* and *R* and *W*				-4	-3	-2

Source: Author's calculations.