Research Paper
Impact Factor: 3.996
Peer Reviewed & Indexed Journal

IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

WATER AND ENERGY EFFICIENCY FOR CLIMATE RESILIENCE

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Abstract
The process of economic development is essentially accompanied by urbanization, industrialization and greater stress on natural resources. The paper briefly deals with India's experience of urbanisation and current Green House Gases (GHG) emission scenario. It further discusses the status of two resources namely water and energy in the state of Rajasthan which is a water deficit and highly vulnerable from the point of view of human and ecosystem health but the arid and semi-arid regions are rich from the renewable energy(RE) point of view especially solar and wind energy. What role a "low growth, low urban and low carbon" state play in mitigating environmental issues in the emergence of economic super power, is the focus of the study. The study invokes harnessing huge potential for renewable energy for building "better growth, better climate". Energy being the largest contributor to climate change necessitates thorough efficiency from generation to consumers' end. It suggests a multisectoral approach to fresh and waste water management and GHG emission cut by 50 per cent by way of use of renewable energy in all the sectors of the economy.

Keywords: Urbanization, Greenhouse Gases Emission, Vulnerable, Renewable Energy, Climate Resilient.

Introduction

The notion of well-being extends much beyond the conventional notions of economic growth to include health, security, social harmony and freedom to make choices. Numerous services derived from ecosystems contribute in enriching and sustaining human well-being. However, in a race of being well off, cumulative and irreversible ecosystem damages are ignored. High growth rates together with high poverty levels increase the pressure on natural and socio-economic resources in turn contributing significantly to high sensitivity to climate change impacts. Evidence suggests that urban growth that is poorly managed by governments can lead to a range of economic, social and environmental costs, such as traffic congestion, inefficient public transport, air pollution with associated health impacts, and inadequate infrastructure for basic services such as energy, water and waste. There is growing evidence that India is currently on an urban and economic growth path that is increasingly carbon and energy intensive.

India experienced the most sustained period of rapid growth in its economic history during the 2000s – an average of close to 9 Per cent a year between 2003-04 and 2010-11, even taking into account a brief but sharp slowdown in 2008-09 during the global economic crisis. Thereafter growth slipped below 7 Per cent in 2011-12 and then to around 5 Per cent in 2012-13 and 2013-14. The rapid growth has certainly contributed to an unprecedented fall in poverty, yet much remains to be done. One third of the population continue to live below the US $1.25 a day poverty line – almost 400 million people, the largest number of absolute poor in any country.

Alongside these two central problems-sustaining rapid economic growth and also ensuring that it is broad based and inclusive – India is also grappling with a third, to ensure that growth is environmentally sustainable. India already ranked as one of the 10 largest economies in the world in 2010, and it is expected to continue to grow rapidly over the next two decades. Growth of this magnitude will bring tremendous benefits, but it also poses many challenges, particularly regarding sustainability.

The present study investigates the impact of urbanisation on water and energy sector and examines the deteriorating water quality in the wake of climate variability and effect thereof on Human Health. It seeks attention of policy makers towards the urgent need of holistic approach of sustainable development in a fragile State like Rajasthan.

Urbanisation, Emissions and Energy

India is at the cusp of a major urban transition. By 2031, the number of people living in Indian cities is expected increase from 377 million today (31 Per cent of the total population) to over 600 million (~40 Per cent). India's urban centres already account for two-thirds of the country's Gross Domestic Product (GDP), over 90 Per cent of the national tax base, and the majority of non-agricultural jobs (Census, 2011). By 2031, India's cities are expected to contribute 75 Per cent of its GDP and generate 70 Per cent of all net new jobs created (Ahluwalia, 2011; McKinsey, 2010). Estimates project that India will need new industrial towns, serviced land, jobs, and '700 to 800 million square miles of commercial and residential space over the next 20 years' to accommodate this growth, roughly equivalent to building a new Chicago every year (McKinsey, 2010; Balakrishnan, 2014). Analysts similarly suggest that much of India's freight and transport networks and buildings that will exist by 2050 are yet to be built (CSE 2011). The manner in which India manages this upcoming urban expansion will thus be critical in shaping its current and future growth paths.

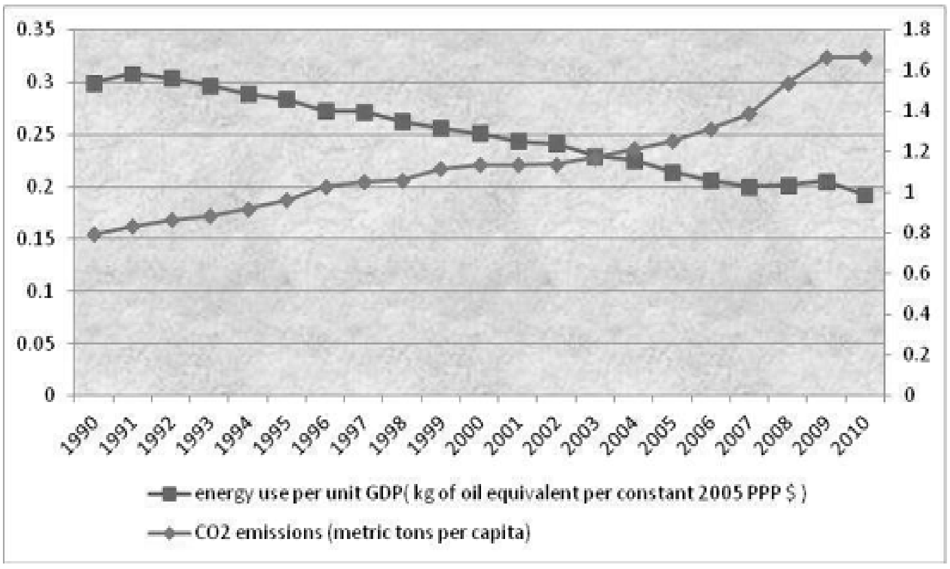
In 2007, India emitted 1,727.71 million tons of CO_2 eq. from energy, industrial processes, agriculture and waste (including emissions from land use, land use change and forestry, India's Second National Communication to the UNFCCC, MoEF 2012). This represented a 33 per cent increase over net greenhouse gas (GHG) emissions reported in 2000 (1,301.21 mt CO_2 eq.) and a 41 per cent increase over emissions reported in 1994 (1,228.54 mt CO_2 eq., MoEF, 2010). Current emissions stand approximately at 1.49 tons of CO_2 eq. per capita (MoEF, 2012). After a slight decline between 1994 and 2000, per capita emissions rose by 22 per cent between 2000 and 2007, while the total population grew by 11 per cent during the same period (Pahuja*et al*., 2014).

Although India's overall emissions are low by international norms (1.5 mt CO_2e per capita compared with China's ~9 mt CO_2e per capita), estimates show that India's environmental externalities already cost it 5.7 Per cent of GDP (Mani, 2013) and that urban pollution is the cause of an alarming number of premature deaths: 620,000 in 2010, up sixfold from 100,000 in 2001 (WHO, 2013).

India's primary energy consumption was an estimated 815 million tonnes of oil equivalent (mtoe) in 2013, about 6 Per cent of world energy consumption, compared for example, with the OECD and China's respective 40 per cent and 22 per cent shone. In per capita terms, energy consumption was 643 kg of oil equivalent, one third of the world per capita average, or 16 Per cent of the per capita level in OECD countries. Electricity consumptions is even more limited compared to international levels – 683 kwh per capita in 2011, a little more than 20 Per cent of the world average and only 8 Per cent of the OECD average.

Energy consumption is growing rapidly, at 4.6 Per cent per year in 2000–13, which represents a doubling in 15 years. This growth can be broken down into 6.8 Per cent annual GDP growth, minus a 2.2 Per cent annual decline in the energy intensity of GDP. Growth in energy demand in India is likely to remain robust, not only because of fast economic growth but also because of structural trends, such as increasing industrialisation and urbanisation, which tend to boost demand.

Figure 1: Energy Intensity and Emissions Per Capita Trends for India



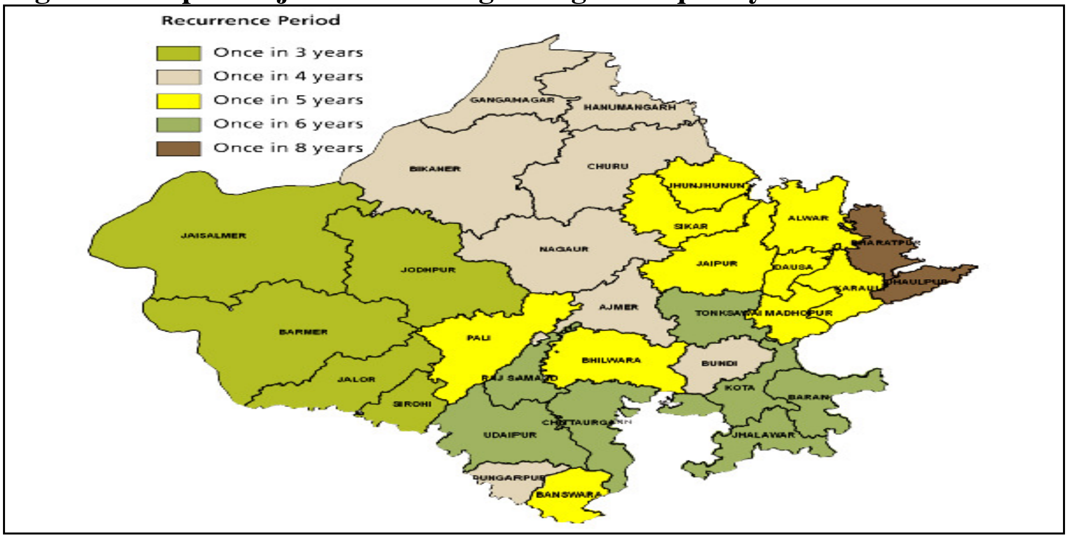
Source: Pahuja *et al*., 2014.

Rajasthan: Vulnerability, Status and Potential

The major climate related vulnerabilities for the state of Rajasthan are rise in overall temperature, reduction in mean annual rainfall, increase in frequency and intensity of extreme events, including droughts and floods. These vulnerabilities have associated impacts, like rise in overall temperature can lead to increased discomfort levels resulting in high cost for cooling and ventilation. Reduction in mean annual rainfall can be responsible for drinking water shortage, drought situations, failure of crops and food insecurity situation. Extreme rainfall/floods come with an array of problems like water logging, destruction of settlements around water bodies, spread of water borne diseases, etc.

IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

Figure 2: Map of Rajasthan showing Drought Frequency for Different Districts



Tiwari*et al*., (2015), classified 22 major states of India into six broad categories on the basis of linkage between economic growth, urban growth and emissions. Rajasthan, a traditionally, lagging state, has been categorized as "Low-growth, low urban, low – carbon state". It is the largest state in India (10.5 per cent of the country's geographical area), but sharing only 1.16 per cent of its water resources. It is the driest state with nearly 70 per cent (2/3rd) of the area classified as arid and semi-arid region. Rajasthan has always been a water deficit area. There have been 48 drought years of varied intensity in the period 1901-2002, which means that the chance of occurrence of a meteorological drought in the state is 47 per cent (Rathore, 2004). The state has the maximum probability of occurrence of droughts in India. Figure 2 presents the drought occurring frequency. These conditions may, however, deteriorate in terms of severity of droughts in a projected climatic scenario with enhanced greenhouse gas conditions.

Water availability is also fundamental to food security. Thus, impacts on water sector can be expected to have a cascading effect on food production thereby affecting food security and nutritional status of the population. Other than this, climate change may impact food production itself as has been projected in a range of simulation studies for various crops. A study conducted by O'Brien et al., (2003) assessed that the areas with high to very high climate sensitivity for agriculture are located in the semiarid regions of the country, including major parts of Rajasthan. Climate change can also be expected to reinforce the association between malnutrition and some infectious diseases.

Although the whole of Rajasthan state is categorized as water-scarce (having per capita water availability below 1000 m^3 year (Narain*et al*., 2006), the condition in western Rajasthan is more precarious. The west-central part of western Rajasthan is devoid of any drainage network and has meager surface water resources, which adds to the problem. The inherent surface water resources of the western Rajasthan are scarce and due to low and erratic rainfall, replenishment of these water resources is also very poor. Also, due to high atmospheric temperature and low humidity, a large part of the rainwater is lost as evaporation.

Climate change can impact surface water resources directly through changes in the major long-term climate variables such as air temperature, precipitation, and evapo-transpiration. The relationship between the changing climate variables and groundwater is more complicated. Greater variability in rainfall could result in frequent and prolonged periods of high or low groundwater levels, and saline intrusion in aquifers (Singh and Kumar, 2010).Thus groundwater resources are related to climate change through the direct interaction with surface water resources, such as lakes and rivers, and indirectly through the recharge process. The direct effect of climate change on groundwater resources depends upon the change in the volume and distribution of groundwater recharge.

Another major issue regarding the use of surface water resources in the state is that of water logging which is prominent in canal command areas like those of IGNP (Indira Gandhi Nahar Pariyojana).The major ecological changes associated with canal irrigation in the Thar Desert are understood to be playing an important role in accentuating the transmission of malaria. Dengue fever and Chickungunya (and more recently Swine Flu) are the other major Vector Borne Diseases (VBDs) in the State. The quality of ground water has also progressively deteriorated. Tremendous use of ground water has brought

IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

adverse changes in the geochemistry of water. Natural contaminates such as fluoride, nitrate, and chloride salts are increasing in ground water making it unfit for drinking and posing risk to health (Draft Document, 2005). Rajasthan accounts for 51 Per cent of fluoride and 42 Per cent of saline affected areas in the country (Reddy, 2010). Climate change will further increase ground water extraction due to less availability of surface water and rising demand which could further deteriorate ground water quality and have serious effects on health of people. The demand for increase in agricultural production has led to increased use of chemical /inorganic fertilizers, pesticides, high yielding varieties and mechanization of agriculture. The use of chemical fertilizers has been steadily increasing. In addition, Sewage water and industrial effluent are two major sources of water pollution. This has caused water quality problems having repercussions for human health (SEP, 2010).

Groundwater

The stage of ground water exploitation which was 35 Per cent in 1984 has reached a level of 138 Per cent in 2008 (State Water Policy, 2010). Also out of the 237 blocks only 30 are in safe category and the number of over-exploited blocks has increased from 140 to 164 from 2004 to 2008 (Table 1). According to NASA satellite data the ground water levels in northern states of India including Rajasthan have been declining at the rate of 33 cm per year over the past decade (SDC, 2009).

Table 1: Ground Water Status of Blocks

Category	1984	1988	1998	2001	2004	2008
Over-Exploited (>100%)	12	44	41	86	140	164
Critical (90 to 100%)	11	18	26	80	50	34
Semi Critical (70 to 90%)	10	42	34	21	14	8
Safe (<70%)	203	122	135	49	32	30

Source: State Water Policy, 2010

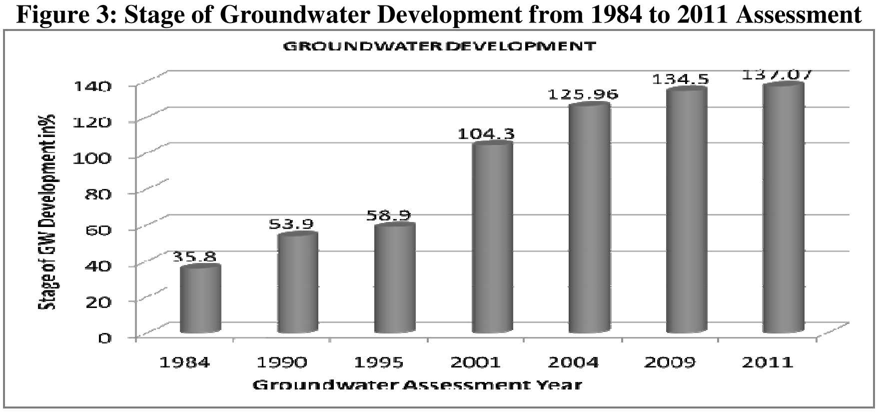
From the Fig.3, it can be observed that stage of groundwater development of Rajasthan was 35.8 per cent during 1984 assessment and it has increased to 137.07 per cent according to latest 2011 assessment. The stage of groundwater development has increased mainly due to overdraft. Irrigation draft which was 7038.817 mcm in 1984 assessment year has now increased to 13133.1818 mcm according to 2011 assessment.

Rajasthan is over-dependent on groundwater. The major problems associated with groundwater quality are fluoride, nitrate, and salinity.

Fluoride > 1.5 mm: Tonk, Churu, Barmer, Pali, Sirohi, Jalore, Rajasmand
Nitrate > 100 ppm: Churu, Nagaur, Jhunjhunu
TDS > 2000 ppm: Churu, Barmer, Bharatpur
Iron > 1ppm: Bhilwara, Jodhpur, Baran, Jaipur

In addition, many parts of the state encounter high levels of total dissolved solids (TDS) in drinking water, well above 1,000 mg/litre against the WHO standard of 500 mg/litre. Table 2 compares the magnitude of the problem with the rest of the country, and highlights the worst affected districts in the state.

Figure 3: Stage of Groundwater Development from 1984 to 2011 Assessment



Source: CGWB, 2015

IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

Table 2: Groundwater Quality in India and Rajasthan

Particulars	India	Rajasthan	Percentage of Country	Main Affected Districts in Rajasthan*
		Villages / Habitations		
Only Fluoride	17,986	7,130	39.64	Jaipur, Tonk, Nagaur, Ajmer, Bhilwara, Sirohi and Pali
Only Salinity	22,985	18,924	82.42	Churu Bharatpur, Barmer, Jhunjhunu, Nagaur and Ajmer
Only Nitrate	2,758	624	22.62	Jaipur, Nagaur, Barmer, Udaipur, Jodhpur, Churu, Alwar and Tonk
Only Iron	56,144	46	0.08	
Only Arsenic	4,314	5	0.12	
TOTAL	**104,160**	**26,729**	**25.6**	

Source: Draft Annual Plan (2013-14), Planning Department, Government of Rajasthan.
*From Environment Management and Action Plan of SWRPD Report, February 2013.

Changes in climate variables and associated impacts on natural and socio-economic systems are expected to pose additional stress on human health. Incidences of VBDs are widespread in the State. VBDs are probably the most sensitive to changes in climate parameters.

Inadequate availability of water, poor water quality at source, ill-maintained water lines, unsafe sanitation practices and lack of awareness about good sanitation practices, personal hygiene and primary health care are some of the key factors responsible for the common and widespread health risks associated with consumption of pathogen infested drinking water in rural habitations of Rajasthan.

Potential impacts of climate change can thus be expected to become an additional stressor for Rajasthan's heath sector which may increase the risk of exposure to vector, water- and food-borne diseases, aggravate malnutrition and increase mortality and morbidity associated with changes in intensity and frequency of extreme events.

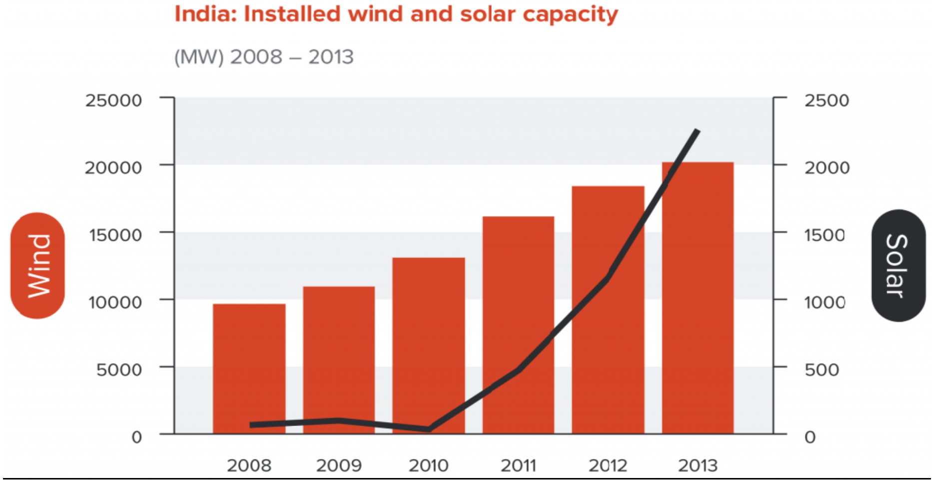
Renewable Energy

India is endowed with vast Renewable Energy (RE) potential of 8,89,508 MW. The Planning Commission in the 12th Five Year Plan document had stated that the supply from renewables is expected to increase rapidly from 24,503 MW by the end of the 11th Five Year Plan to 54,503 MW by the end of the 12th Five Year Plan, and underlined the need for investments in RE. Considering the significance of RE as an alternative to meet the ever growing energy demand of India, the Government of India, in pursuit of energy security and for minimizing impact on environment, has been prioritizing the development of RE sector through its policies and programmes. The exploitation of the two largest components i.e. solar energy and wind energy potential was only 0.35 and 21 per cent, respectively and varied significantly across States. The installed capacity of grid interactive solar power in the country at the beginning of the 11th Five Year Plan period was `Nil'. This rose to 2,656 MW by March 2014, which was 0.35 per cent of the country's solar energy potential of 7,48,990 MW.

Wind and solar generating capacity is still small but rising fast. Wind capacity doubled to 20 GW between 2009 and 2013, while solar, although much smaller, is rising much faster, increasing by almost five times in just two years, to reach 2.3 GW in 2013 (Figure 6).

India's Previous National Solar Mission targets of reaching 20 GW by 2022 have been increased to 100 GW in the same timeframe (Chadha, 2014).The physical potential for renewables generation in India is very large. A recent estimate by the Ministry of New and Renewable Energy puts India's potential solar capacity at 749 GW and total wind energy capacity at 2,000 GW or even higher (Ministry of New and Renewable Energy, 2014).

Figure 4: India: Installed Wind and Energy Capacity



Source: BP (2014)

Rajasthan has meagre resources of coal and petroleum but is richly endowed with renewable energy sources such as wind energy, solar energy, and biomass. The state receives maximum solar radiation intensity in India. In addition the average rainfall (hence number of overcast days in a year) is least in the state as compared to the rest of the country; hence it's best suited for solar power generation (Sukhatme and Nayak, 1997). It also has land available in abundance which is available at a very minimal cost. Therefore, Rajasthan is likely to emerge as the preferred destination for setting up installed capacity, which may eventually exceed 100,000 MW. In order to promote solar energy in the state, the government under it's 'Policy for promoting Generation of Electricity through Non- Conventional Energy Sources, 2004' has taken initiatives which includes giving incentives viz. exemption from electricity duty, special incentives for industries, single window clearance, allotment of land on concessional rates etc.

Rajasthan has an estimated potential of 1,42,310 Mega Watt (MW) but its installed capacity stands at 730.10 MW. In percentage terms, this is the second best in the top five high potential states which have 59 per cent of the national solar energy potential. Madhya Pradesh leads with 0.56 per cent and Rajasthan 0.51 per cent of its capacity installed. Gujarat and Rajasthan alone created more than 50 per cent of the capacity installed in the country but had exploited only 2.56 per cent and 0.51 per cent of their respective potentials. The Rajasthan state has wind energy potential of 4858 MW, which is around 10 Per cent of India's wind energy potential. At present, the state has harnessed only 850 MW of wind energy.

Table 3: Wind Potential, Target and Installed Capacity (In MW)

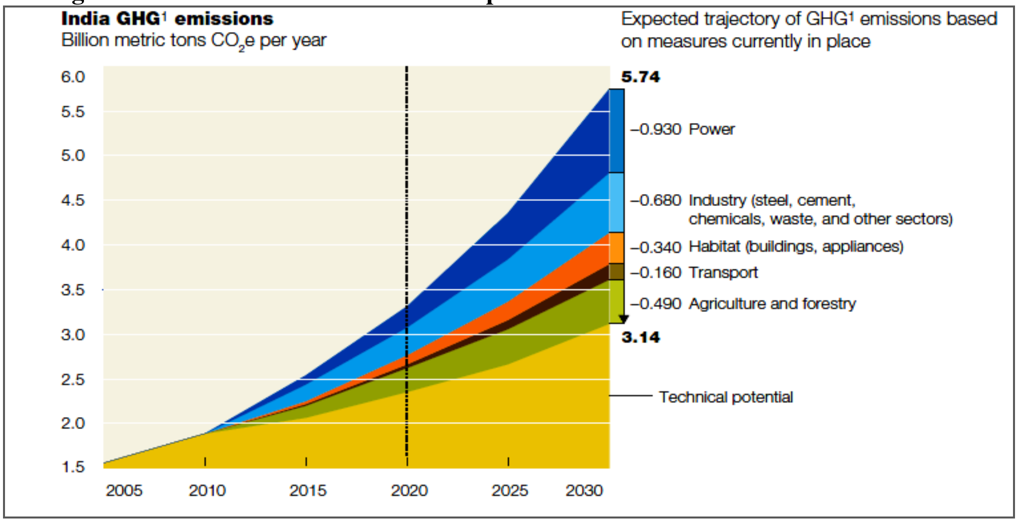
State	Estimated Potential		Targets fixed (2007-14)	Installed Capacity			Installed Capacity as a Percentage of Potential	
	at 50m	at 80m		Prior to 2007	2007-14	As on 31.3.14	50 m	80 m
India	49,130	1,02,788	12,205	7,091	14,046	21,137	43	**20**
Rajasthan	**5,005**	**5,050**	**1,400**	**470**	**2,316**	**2,786**	**56**	**46**

Source: MNRE

Discussion

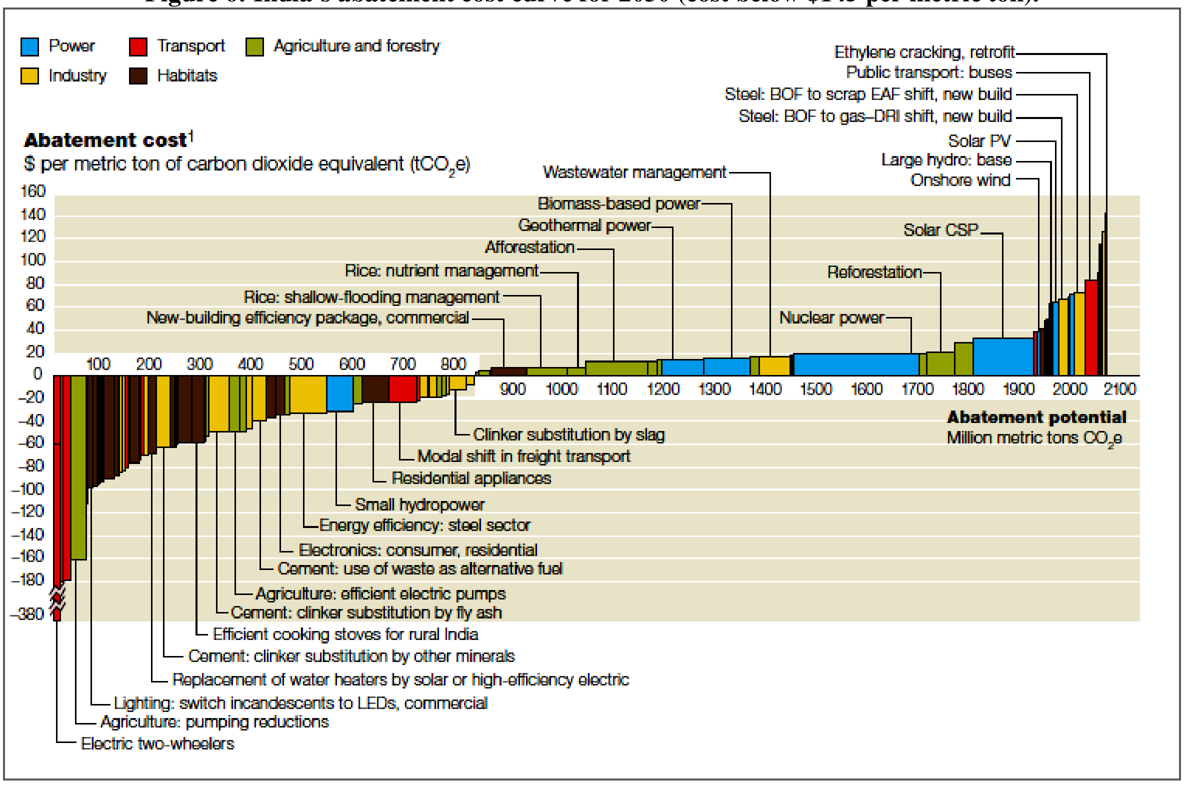
Climate change is a global challenge with diverse implications at the national and subnational levels, through impacts on various sectors such as agriculture, water resources, forestry and biodiversity, human health, energy and infrastructure. Such diverse impacts require a range of strategies to be deployed for an effective response and for better preparedness. India had formulated National Action Plan on Climate Change (NAPCC) in 2008. Its aim is to improve the understanding of climate science, adaptation, mitigation, energy efficiency and natural resource management and conservation. The NAPCC sets eight priority missions to respond to climate change; these include National Missions on Solar Energy, Enhanced Energy Efficiency, Sustainable Habitats, Water, Sustaining the Himalayan Ecosystem, Greening India, Sustainable Agriculture and Strategic Knowledge for Climate Change, covering a range of actions including adaptation and mitigation. Climate change anywhere on the scale predicted by the IPCC will have substantial to severe negative impacts on food and water resources, ecosystems, economic growth, population dynamics and health, undermining and often reversing gains made through development. The effects of climate change are already being felt, contributing to increasing heat waves and droughts, which in turn affect poverty, livelihoods and health.

Figure 5: India's Potential to Cut its Expected 2030 GHG Emissions Almost in Half



India's current efforts are impressive, but even if they were all implemented successfully, the country's total energy demand would be likely to increase to 1.8 billion metric tons of oil equivalent (btoe) by 2030, up from 0.5 btoe in 2005. This would make India the third-largest energy consumer in the world, after the United States and China. In 2020, energy and agriculture/forestry represent 60 per cent of abatement potential impact from nuclear and renewables starts by 2020 and triples by 2030 as more capacity is added.

Figure 6: India's abatement cost curve for 2030 (cost below $145 per metric ton).



IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

This curve estimates 2.1 billion metric tons of CO_2 e potential. Additional potential below $145 metric ton includes reduction in technical-transmission and distribution losses (190 million metric tons (mt) CO_2 e),auxiliary consumption (50 mt), efficiency improvement in other sector (200 mt), improved urban planning (30 mt), and distributed generation using combined heat and power (15 mt). Levers costing more than $ 145 per metric ton (not included in the cost curve) have a total abatement potential of 80 mt. Important levers are public-transport infrastructure in metropolitan regions (7 mt), electric vehicles, and full hybrids (6 mt). An 8 per cent discount rate was assumed for the cost-curve analysis, based on benchmark yield for long-term Indian government bonds.

Rajasthan State Climate Change Agenda (RCCA) was an important beginning given that Rajasthan is the largest state in the country and that there are unique vulnerabilities associated with the state, on exposure to climatic extremes and varying capabilities to be able to respond to the likely risks, and opportunities that can be tapped on like harnessing solar and wind energy. In an endeavour to cut GHG emissions by 50 per cent. Rajasthan can contribute enormously not only in India's growth but also its own transformation from "Low Growth, Low Urban, Low Carbon" to an unusual "High Growth, High Urban and Low Carbon" State. It is comparatively easy to adopt clean and green technologies at an early stage of development then to correct and mitigate an already worsened scenario. Each and every small step towards climate resilience would go a long way towards making 'a better world'. Energy is the single largest contributor to climate change; therefore, difficult climatic conditions of arid and semi-arid regions of Rajasthan must be utilized to generate RE which may prove blessing in disguise.

Enhanced water and energy efficiency has been identified as focus area in SAPCC. Initial cost of setting up required infrastructure is quite high but in comparison to the cost human race will have to pay in the form of climate change and externalities, it's meagre. Action plans framed meticulously must be implemented with full commitment so that the future generations benefit from timely and thoughtful strategies.

Concluding Remarks

If urban growth in India continues unabated as usual, it will certainly undermine quality of life of posterity. Accompanied by multiple externalities such growth is bound to be unsustainable. A number of studies have recently elicited the attention of policy makers to the link between urban growth and environmental externalities and also to potential gains of strategic development path in the diverse areas of health, employment, sustainability of natural resources, to name a few.

The paper brings out the rapid urban growth and its natural repercussion in the form of GHG emissions in India. What role a "low growth, low urban and low carbon" state play in mitigating environmental issues in the emergence of economic super power, is the focus of the study.

Precarious condition of scarce water resource of water deficit state "Rajasthan" is brought out in the form of its deteriorating quality and its dire consequences on human health. The study presents a blue print of large number of issues related with quality of water like fluoride, nitrate, salinity etc. With climate change the situation may only be expected to worsen. Potential impacts of climate change can thus be expected to become an additional stressor for Rajasthan's already dismal heath sector. Overdependence on groundwater is precipitating the impaired water scenario. Efficient use of surface and groundwater along with efficient waste water management is urgently called for. Water is one disadvantage of the state, compensated by huge potential for renewable energy especially solar and wind energy. The study invokes harnessing huge potential for renewable energy for building "better growth, better climate". The state can play a significant role in making climate resilient growth of the nation. Energy being the largest contributor to climate change necessitates thorough efficiency from generation to consumers' end. Broad strategies, which may include greater dependence on green energy and clean water and also water and energy efficiency in all spheres of the economy including agriculture and industry is the need of the hour.

Acknowledgement

Author gratefully acknowledges the UPE (University with Potential for Excellence) Study of "Study of Ecology and Economy of Rajasthan" for providing all the facilities and funding for undertaking the study. However, all views expressed are of author Alone.

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