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Examining the Role of Principal Contributors to 'Sectoral Carbon Emissions': In the Indian Context

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Abstract

In the light of impending global climatic risk due to different anthropogenic activities, the current article studies the sectoral carbon footprint of third generational alterations along with new emerging determinants like Information and Communication Technology (ICT), innovation and other related factors with a special reference to the Indian economy. The article concludes with the inclusion of possible way forwards that could contain the deleterious prospective influence with the help of the appropriate policies and programmes.

Key Words

Sectoral Carbon Emissions, Urbanization, Smart Cities, Infrastructure, Inequalities, IT & Innovation

The warning professed by global warming undisputedly has crafted climate policy as the key stream to be acted at. Worldwide rising trend of emissions substantiates the immediate demand to move and act differently from the existing reliance on fossil fuel-based energy trend. The concern is so grave that seven out of the top nine risks, recently identified in the *Global Risk Report* (World Economic Forum [WEF], 2018) reserves the place for climate change and its related turbulence. Vulnerability to climate change will mainly depend on the economic position and infrastructure capacity of a nation. Bucking a worldwide trend of slowing carbon emissions, India's emissions grew quicker in 2018 than they had ever done before.

Evidently, 'Transportation' has remained the fundamental element to drive the manufacturing sector's growth rate by enabling the distribution of goods and services. On the other hand, looking at the global platform, extensive and efficient infrastructure is critical for ensuring the competitiveness of an economy by reducing the effect of distance between regions, integrating the national market and connecting it at low cost to markets in other countries and regions. The improved competitiveness score (4.90 out of 7) and deteriorating ranking (25th place) of transport infrastructure for India in 2017–2018 substantiates the relevance and potential of this sector (WEF, 2018).[1] Unfortunately, the transport sector is primarily dependent on fossil fuel (Coal, Oil and Gas) energy resources. These are limited and responsible for carbon (Carbon dioxide, CO_2) emissions, which in turn is considered to be the principal contributor to 'Global Warming', Greenhouse effect (Figure 1). As per recent IEA report (World Energy Investments [WEI], 2019), the global energy investments[2] in the year 2018, over 2017 have witnessed a decline by 1 per cent in the renewables for transport and heat. Also, despite ascending electric vehicles sales, the transport sector has witnessed stagnation for its efficiency. The underlying question is—who will ensure 'sustainable-equitable-inclusive mobility'. It is often debated widely that technologically advanced countries are prepared well for responding to climate change. They have developed and established suitable sustainable policy, institutional and socially capable systems for dealing with the consequences of global warming. However, how the future will unfold for developing/emerging nations like India, remains dubious.

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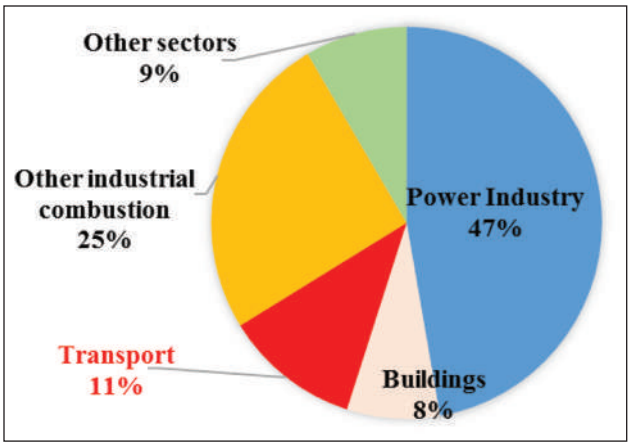

Figure 1. India's Sectoral CO2 Emissions

Source: IEA Database, India (2018).

Sectoral Carbon Footprint

The base mode of transport is the 'vehicle'. Vehicular emission is one of the core stimulators of air pollution in India (Figure 2). In 2016, in not less than 40 per cent of the nations' globally, the transport sector is reported to be one of the largest energy utilizing sectors while in rest of the world economies, it is ranked the 2nd largest energy utilizing sector. Current urban transport arrangements together account for more than 11 per cent of the total worldwide energy consumption, which is comparable to almost twice the complete energy utilization of Africa, and around 18 per cent of international carbon emissions (WRI, New Climate Economy [NCE], 2018). As per one of the recent prognoses, CO_2 emissions from energy sources are likely to intensify by about 40 per cent from the year 2013 to 2040. Jointly, this sector adds 23 per cent of worldwide energy linked greenhouse gas emissions (GHG) with 18 per cent of anthropogenic emissions globally (Global Mobility Report [GMR], 2017). Needless to mention that rising prosperity, increasing per capita energy consumption, urbanization and pace and mode of economic growth have broadened energy access in the country, more pronouncedly since the Kyoto Protocol. Undoubtedly, the universe of the transport sector is altering fast, and therefore its future track remains indecisive. Imminent future mobility is expected to further grow since towns and entire globe witness greater movement of people and goods. Annual passenger traffic is projected to surpass 80 trillion passenger kilometers, nearly 50 per cent surge over 2015 with international freight volumes by 70 per cent over 2015, and added 1.2 billion vehicles on the road, which is almost double of today's overall by the year 2030 (GMR, 2017).[3] The fundamental invigorators of atmosphere infectivity are commercial emissions, domestic fuel usage like cooking, vehicular emissions and possibly sizable miscellaneous class. By the year 2017, India was among the 10 countries with the highest exhaust pollutants from the 'Transportation' wherein road fuel consumption has doubled every 10 years since 1980 (IEA, 2019). Additionally, the expanding global mobility poses an impending risk by engendering combined inequalities (disparities) in social and economic development, promoting fossil fuel-based usage, degrading the environment and adding to the transport-allied mishaps and the deaths from air pollution (GMR, 2017). In the light of the above, it becomes morally and socially elementary for each one of us to know the prime direct carriers of 'sectoral emissions from transport'.

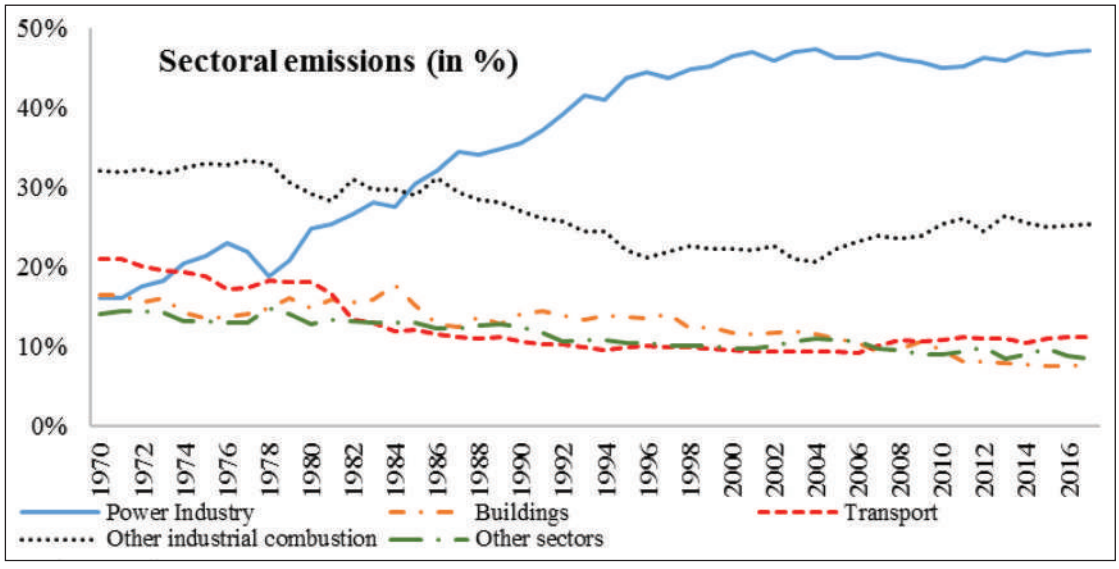

Figure 2. India's CO2 Sectoral Emissions (in % of fuel combustion)

Source: IEA Database, India (2018).

Identifying the Key Determinants

So far popular chief contributors of vehicular/transport carbon emissions in India comprise of economic growth, industrial value added, financial development and of course, fuel efficiency norms. But one of the prime inextricable links in the list is urbanization (by induced energy usage through connectivity) and consequent emerging income and geographical inequality as the strategic game changers to determine the environmental health of a nation like India. Let us explore the association in greater details.

Urbanization is one of the most significant factors of productivity and development in the global economy. The recent report on 'New Climate Economy on India's urbanization potential' mentioned that superior and niftier urban development could prove to be an economic prospect for India worth up to 6 per cent of GDP by 2050 (LSE, NCE Cities, 2014, Paper 01). Standalone, the production of infrastructure resources would produce about 470 gigatonnes of CO_2 emissions if developing countries enlarge their infrastructure to current global mean levels (Pachauri, Meyer, Plattner, & Stocker, 2014). And unfortunately, much of this would be concentrated in sprawling city centres. It is imperative to clearly understand the underlying relationship among these key contributors.

Urbanization, Inequality and Associated Climate Depletion

Urban lifestyles inflict three discernible types of energy usage (Figure 3) that can eventually result in the kind of emissions (that may lead to global warming or 'greenhouse' effect): energy transition from one form to another, indirect energy utilization in goods-producing (energy supply infrastructure) and transporting activities, and direct energy consumption in final uses like transportation, preference of household for energy goods consumed. As living standards rise and the urban population continues to grow, so do energy use and carbon emissions in urbanized areas especially (Fong, Matsumoto, Lun, & Kimura, 2007). Predictably, the time plots of urbanization, energy consumption (per capita) and carbon emissions (per capita) signal the complementarity of the co-movement of later two due incessant urban sprawl (World Bank, 2018; IEA Database, 2018). As per one of the recent report documents, especially Indian urban cities are considered to be worse in terms of particulate pollution and therefore it is most likely to have equivalent urban air pollution per capita mortality here as in the USA (Environmental Protection Agency [EPA], 2018). Surprisingly, the majority of these cities have outdone the standards given by National Ambient Air Quality (NAAQ). India is witnessing air pollution to be one of the chief reasons for death. Fostering urbanization and population surge together have led large cities to grow at an unprecedented level that in turn have caused a sudden leap in travel demand. As a result, India has become one of the biggest emitters of atmospheric pollutants from *transportation* globally. The pace at which urbanization is progressing, it is discussed in one of the recent summits that the same is bound to bring in discrimination as an inevitable segment (Shanmugam, 2015). This certainly would require matching cultural shifts (inequalities due to rising shift towards urban growth centres) that will require greater dependence on resources (transport emissions due to increased movement between the city centres), which indirectly would be exerting strenuous impact on sectoral climate sustainability (Figure 4).

Additionally, it is commonly realized that the recent structural transformations in the Indian economy could worsen the rapid shifts during the process of development from primary employment to secondary urban-centric sectors, industry and services. Such shifts clearly hint towards increasing urban–rural subdivide geographically, respective rate of growth and their income levels (World Bank, 2009). As per Kuznets' hypothesis, in the early stage of growth, the urban sector develops due to a quick improvement in urban labour efficiency. This further broadens the urban–rural income inequality because of a sluggish rise in rural efficiency.

Another crucial aspect that remains largely missing is the emergence of economic risk due to direct causality linkages among trade, rural–urban subdivide and climate change. A conspicuous dawdler as the division of climatic

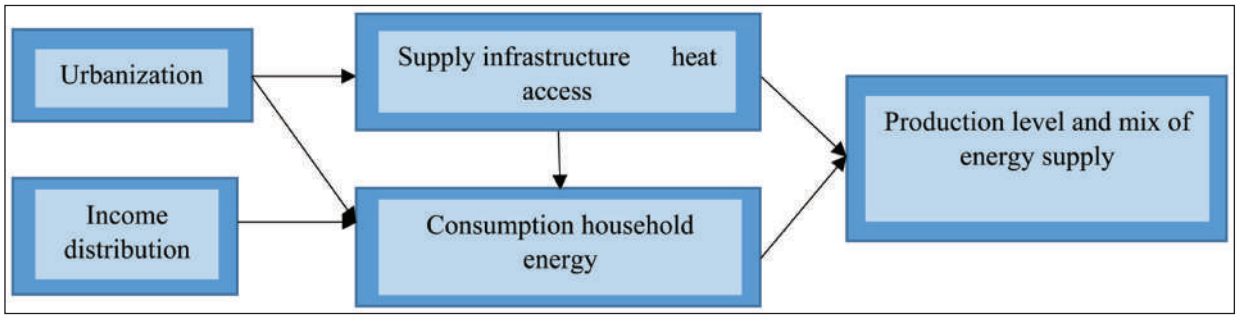

Figure 3. Urbanization Sectoral Linkages

Source: Krey et al. (2012).

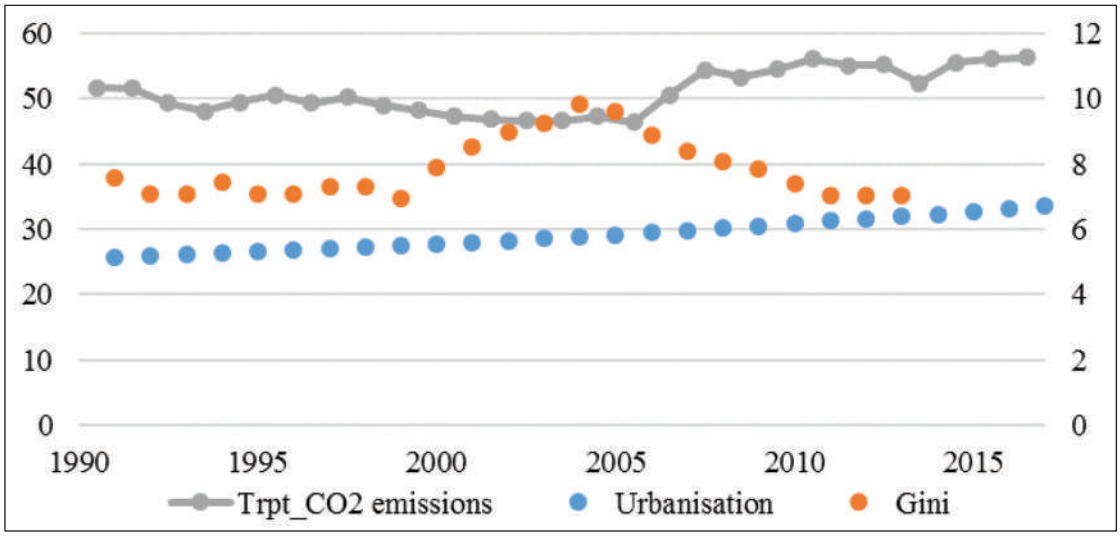

Figure 4. Relationship Among Indian Transport Emissions (%), Gini,[14] and Urbanization (%) (between 1991 and 2017)

Source: Author's depiction from WDI and SWIID databases. Gini (proxy to measure inequality) and Urbanization (in %) are on the primary axis and transport CO2 emissions (in %) is on the secondary axis.

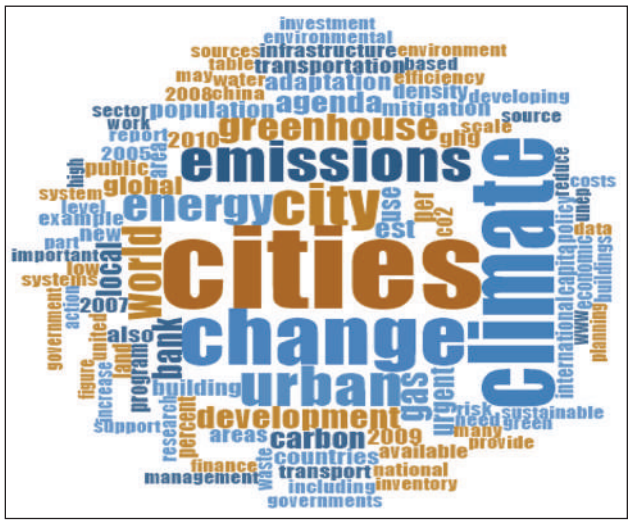

Figure 5. Word Cloud on World Development Report, World Bank Report on Cities and Climate Change 2010

Source: Author's depiction using NVIVO 12 Pro on WDR 2010.

solution is trade policy that questions actual trade transactions in clean know-how. In general, trade lifts comprise of containment of tariffs and non-tariff barriers (NTBs), which could obstruct trade of eco-friendly goods and services, fining subsidies that may encourage fossil fuels or additional climatic hazardous goods, and other related areas. A year ago, the Canadian and EU trade agreement (ETA) provides a noteworthy example that supports the idea of converting all tariffs on the low carbon makes as zero (CETA provisions). This hints towards the potential prospects for developing nations like India to explore and subsequent much-needed action-oriented policies.

New Emerging Determinants

It is now possible to explore the prospects of emerging usage of *IT & ITeS (Information and Communication Technology, ICT)* and *Innovation (R&D)* in the area of smart cities planning and financial policies that has the potential to alter the existing dependence on carbon-intensive processes to shift towards 'climate friendly' techniques in almost all the spheres (OECD, 2019). As per the recent Global e-Sustainability Initiative (2018, WRI),[4] 20 per cent of the total emissions (at the year 2015 levels) could be lowered just by alone ICT itself by better awareness (knowledge economy) among corporates and end users to use and save energy more judiciously. International organizations like FAO and UNFCCC are taking forward steps to ensure its implementation. And fortunately, the same could be possible without compromising on economic growth. Since, both production and consumption practices are the sources of emissions, therefore generation of products with fewer emissions, lesser use of emission-intensive inputs (by employing renewable energy sources), diminution in pollution intensity of the input, cutback in input used per unit of output and curative steps; all could be tackled in one strand, by involvement of ICT in the broader framework. The strength of the innovation creation and adoption incentive both have a bearing on the emission reduction possibility.

As per the report by LSE[5] (New Climate Economy, 2014), digitization and materials science are the two crucial fields that could determine the systemic transformation to obtain a low-carbon resource efficient resilient economy. The recent innovations in materials have eased greater advances in the areas of appliances and illumination

together with the swift beginning of the usage of LEDs.[6] These have facilitated a wide range of tools and techniques that have marked recurrent step ups in vehicles' fuel efficiency. R&D on innovation in the stream of better urban governance by shifting to electric and hybrid vehicles could prove to mark the desired dent in order to capture urban emissions. In this area, digital e-apps are considered to be an aid to car ride-sharing plans, by putting emphasis on public transit use, and support motorists escape jammed roads and locate parking speedily; facilities like e-shopping and net banking, abridged the travel requirements (LSE, NCE Report, 2016).[7] Future techniques like cloud computing, reverse logistics, etc., (recycle and remanufacture circular industrial models) can really prove to be game changers in order to increase efficiency by reducing overhead costs and energy usage by corporates to decarbonize industrial activities (LSE, NCE Report, 2018).

Changing Urban Ecology

As per one of the recent reports (UN DESA, 2014), India is going to witness the highest rates of urban population growth. The urban population of India has risen from 217 million to 377 million, lifting the urban segment to 31 per cent in 2018 over 26 per cent in 1991 (World Bank Report) in the last two decades. Indian cities not only face stark infrastructure bottlenecks and urban service deficits that hamper urban productivity and economic performance, but they are also currently on an economic growth path that is progressively carbon and energy intensive that definitely is not a healthy sign of climate resilient pathway.

There are different urbanization linked factors that are responsible for expanding carbon-intensive economic growth in India. The factors are energy-intensive industrial structure in urban areas, paucity of adequate public non-motorized transport systems joined with a high degree of reliance on private vehicular polluting mode of transport, deficient well-functioning land markets; and an absence of transparent regulations for developing and redeveloping land or property more strategically (Tewari, Salamanca, Martilli, Treinish, & Mahalov, 2017). As per recent WHO estimates, a doubling of population density is accompanied by a 24.2 per cent increase in particulate air pollution in a developing country's cities outside South Asia. Whereas in the South Asian cities, the increase is estimated to be as high as 34.8 per cent. As per a recent report by Stanford University (USA), the reliance on fossil fuel-based energy is the prime reason behind the rising global temperatures that eventually is widening the gap between the colder and affluent countries like Norway and Sweden, and hotter and poorer countries like India and Nigeria. The same corroborates to recent index rating by Global Climate Risk Index (2019 report). As per the report, 8 out of 10 countries are developing nations that are the most impacted due to erratic climate conditions between 1998 and 2017. It is projected to devise a new type of *disparity* among rich (developed) and poor (developing) nations due to substantial variance, premised upon their difference in living standards, health and weather conditions and per capita income.

Misperceived Notion

Urbanization, on the one hand, apportions internal economies in production, but on the other hand, necessitates emerging transportation obligations (translating into increased energy usage). While this transformation has positive effect on economic development, these bring additional negative externalities (impacts) for both individuals and societies, namely traffic congestion, accidents, noise, land take, energy use, air pollution and carbon dioxide emissions (Rodrigue, 2006). A major dissimilarity in domestic pursuit between rural and urban areas is in transportation. While farmers may devote a quarter to a third of their entire labour hours travelling to and fro to the fields, they almost prefer to walk or use an animal power source. In cities, however, fuel-intensive transportation is more prevalent, even among lower strata. The last four decades have endorsed a strong growth in urbanization in the world. Based on the World Development Indicators (World Bank, 2018), the urbanization rate rose from 36 per cent in 1970 to over 50 per cent in 2014. Meaning, thereby, that more than 50 per cent of the world population lives in urban areas where the level of emission increases to high levels posing a serious concern.

> If urbanization endures a significant impact on carbon emissions then this shall have implications for sustainable development and climate change policies in terms of financial and welfare costs. (Kamal-Chaoui & Robert, 2009).

Urban capitals are usually considered to be contributing the most to the climatic deterioration and hence exert enormous ecological burdens. In parallel, these could in a way set contemporary exemplary of climatic efficiency with their best practices like good density,[8] better management (by reducing the service delivery cost), innovation without jeopardizing wealth creation via economic expansion (World Bank, 2010; WRI NCE, 2018). Clean and efficient transport practices are mandatory in order to ensure good density. Urban capitals have to minimize their dependence on motor-based transport systems and also indulge in shared and active transport arrangements. In lower and smaller income towns, convenient and safe 'cycling and walking' should be a collective primacy. It is believed that urban capitals encompass the exclusive potential to react to a global concern like domestic climate change at a more noticeable level. It is validated by now that urban cities carry the potential of prospective co-benefits of climate change mitigation and adaptation policies. Ironically, current growth paths of most of the Asian cities seem to lock in more emissions.

Way Forward

Both transport system and urban arrangement must change for urban capitals to encounter challenges of the twenty-first century (NCE Report, 2018). By and large, the present urban planning seems to be reactive. It calls for an immediate need to shift to more radical and transformative actions. Sustainable advancement can only be possible if erected on sustainable cities (alternative ways of land management). Therefore, the standard policy shall be the one that pursues the environmental 'bad' precisely and provides reformers tractability to ascertain the best ways of achieving assumed climate goals. Structuring the inclusive, green and sustainable cities shall be the basis of national and local climate change schedule. It calls for better city management, mobilization of respective participants, strengthened alliances and supplementary financing along with sector-specific reforms like policies of urban transport management, enriching city resilience, energy efficiency, complete urban renewal with sustainable city planning. The prospects of many cities would be locked by the choices opted-in today. Although we are laying down the foundation of the infrastructure of the year 2050 today, still the set-up of the year 2050 is expected to differ substantially as of today (World Bank, 2010) (see Figure 5).[9] Further, the transport sector electrification contains a huge untapped potential to curtail local pollutants and GHG emissions (NCE, 2018). Additionally, urban cities especially would require to modify their respective current energy sources, correct energy efficiency and expand city density in order to endorse growth with favourable climate change. In building and transportation systems, spatial structure and urban density are going to be critical components to exert impact on energy usage. Dense cities will possibly have a reduced per capita emission due to greater dependence on public transportation (like Bangalore BRT corridors) that facilitate the containment of sectoral (transport-related) emissions. There is an emergent need of global impetus to make 'Sustainable Mobility for All' (SuM4All)[10] initiative relevant by transforming the transport sector on the grounds of equitable, safe, efficient and green mobility (GMR, 2017). More initiatives like RE 100 (EV 100) could really prove beneficial in the area of accelerating the transition to electric vehicles (EVs) and making electric transport the new normal by 2030 for better urban governance (Climate Disclosure Project [CDP], 2019).[11] Governments' reliance on no-regrets[12] techniques could play the desired part in the shift to low-carbon transport (NCE Report, 2018). Additionally, there is an urgent need to fix market failures so as to allow innovation in order to lead it towards a low-carbon nation. These could prove to be a real game changer to revamp the entire urban set-up that is a prerequisite to a sustainable economy. Further, in the words of Gaigne, Riou, and Thisse (2012), density propels emissions due to increased traffic congestion and elongated work trips, sufficient enough to wipe away the benefit due to improved efficiency via intercity transport. It calls for a planned urgent action to combat increasing temperatures and to shape infrastructure which is climate-resilient. Further, Multilateral Environmental Agreements (MEAs) for their successful address of the global climatic issue with other neighbouring nations could really prove helpful. Also, building energy usage might double or even triple by the year 2050 because of urbanization, population growth and rising incomes without sizeable advancements in materials and energy efficiency. But instead, if economical best practices and technologies are broadly embraced, energy consumption could remain constant or even decline.[13] Urbanization could be leveraged for transformation, inclusion and integration via critical areas like ICT, collaborations, empowerment and governance reforms. Last but certainly not the least, shift to the universal digital platform by nations could accelerate and provide the desired scale, essential to push wider connectivity and evolution of new, disruptive business models.

> The need of the hour is to act now, together, and differently by constructing the climate-smart policies that combine the economies of scaled development with zero-carbon growth paths. (World Bank, 2010)

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Notes

1. World Economic Forum (WEF), World Bank Report on Global Competitiveness Report 2018 to rank and score a nation globally out of 144 nations, based upon prevailing macroeconomic conditions to determine their competitiveness (Schwab, 2018).
2. Investment is measured as the ongoing capital spending in energy supply capacity and incremental spending on more efficient equipment and goods (in energy efficiency). Renewables for transport and heat comprise of solar thermal heating and biofuels for transport.
3. The Global Mobility Report 2017 (GMR) is a novel effort to observe functioning of the transport sector worldwide, and its ability to assist the goods and people mobility in a sustainable way.
4. World Resources Institute.
5. London School of Economics (LSE), see http://static.newclimateeconomy.report/wp-content/uploads/2014/08/NCE_GlobalReport.pdf
6. Light-emitting diodes.

7. See https://newclimateeconomy.report/2016/wp-content/uploads/sites/2/2014/08/NCE-cities-web.pdf
8. Good density means functionally and socially mixed neighbourhoods with access to green spaces, comfortable, affordable and climate-smart housing for all, and high-quality public transport networks (NCE, 2018).
9. From the report, 'Cities and Climate Change: an Urgent Agenda' by World Development Report, World Bank 2010.
10. SuM4All is a global multi-stakeholder partnership that speaks with one voice, and acts collectively to help transform the transport sector.
11. Climate Disclosure Project Group in collaboration of Climate Bonds Initiative (CBI).
12. Key 'no-regrets' technologies includes fuel cells, batteries, green hydrogen production, sustainable biofuels based on biomass and algae, and electric charging infrastructure.
13. Both business-as-usual and technology impact projections are from the IPCC, as outlined in Lucon et al. (2014, Chapter 9: Buildings).
14. Proxy to measure inequality where greater value means rising inequality and vice-versa.

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