Co-benefits from opportunities: The Built Environment, Climate Change and Health.

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***Abstract*— The earth's climate is changing day by day since decades due to largely done air pollution, greenhouse gas emissions due to unstoppable and unmanageable human activities. These gases are generated from different aspects of the built environment such as transportation systems, infrastructure, building construction and operation and land use planning. All these aspects influence climate change though their contribution such transportation end use consumer of energy affecting human health i.e., respiratory effects directly through air pollution and indirectly through physical activity behavior; building contribute in climate change which influence transportation and affect health through material utilization, on site decisions, electricity, water usage and landscape surroundings. Land use, forestry and agriculture also increases the carbon dioxide levels in the atmosphere through the shaping of the structure and thereby affecting access to green spaces. Because of Development in transportation, Buildings and land use, vulnerable population gets affected be experiencing the effects on climate change. By incorporating a health promoting approach in the design and development of built environment through working in the different sectors may help in achieving reduction in climate change, promotion in adaptation and improvement in public health.**

Keywords—**climate change, Greenhouse gas emissions, Land use, forestry and agriculture, Buildings, Transportation.**

I. INTRODUCTION

The proof shows that the climate is globally changing indicating, rising sea level, elevated temperatures, heavier precipitation events, heatwaves and droughts. (1. Intergovernmental Panel on Climate Change. Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Solomon S, Qin D, Manning M, et al., eds. Camb) Due to heat, extreme weather events, vector borne and waterborne infections, mental stress, food and water shortages, respiratory diseases, international conflict, and air pollution ends up to possible ailments like morbidity and mortality. (Patz JA, McGeehin MA, Bernard SM, et al. The potential health impacts of climate variability and change for the United States: executive summary of the report of the health sector of the U.S. national assessment. Environ Health Perspex 2000;108:367–76.) Despite being among the first countries to join in the Paris Climate accord in 2015, India is currently the world's third largest emitter of greenhouse gases after China and the US. Greenhouse gas (GHG) emissions, composed mainly of carbon dioxide, methane, nitrous oxide, and fluorinated gases. (Ewing R, Kreutzer R. Understanding the relationship between public health and the built environment. A Report Prepared for the LEED-ND Core Committee. Design, Community & Environment, Lawrence Frank and Company, Inc., 2006. www.usgbc.org/ShowFile.aspx?) In 2018, India's emission level was 2307.78 MtCO2e, an increase of 335.33% from 1990. 5 These are largely a resultant of human activity. Reduction in GHG emissions, climate change and adverse health can be achieved incorporating changes in policies and behaviors. Built environment influences human choices, affecting health and the global climate. This built environment comprises of small-scale settings e.g., Offices, houses, hospitals, shopping malls and schools to large scale e.g., Neighborhoods, communities and cities as well as roads, sidewalks, greenspaces & connecting transit systems. It involves many areas including urban planning, architecture, engineering, local & regional governments, transportation design and land conservation. Not only neighborhood design influences health but also communities design practice

adversely. (https://www.epw.in/journal/2020/15/special-articles/key-drivers-indian-greenhouse-gas-emissions.html)
The correlation between the elements of the built environment and climate change have largely affected the global GHG emissions due to the following areas such as energy supply, transportation, industry, land use and forestry, agriculture and building acclaimed by the UN intergovernmental panel on Climate Change. (Emissions inventory for road transport in India in 2020: Framework and post facto policy impact assessment). Action plan aims at reducing atmospheric CO2 by decreasing use of motor vehicles and deforestation and thereby increasing energy efficiency in the buildings. On the basis of this action plan the current study focuses on three built environment areas; Transportation, Buildings and Land use (which includes forestry and agriculture). These areas of the built environment may unreasonably affect vulnerable populations such as children, the elderly people, people with disabilities, racial with ethnic minorities, people of low SES especially when effect on health are not considered into the built environment decision making. (https://rmi.org/indias-buildings-sector-moonshot-corporate-climate-commitments-can-forge-the-path/) In this paper the affected vulnerable population on the basis of health issues are featured. As the built environment. Since the built environment comprises an important determinant to climate change and health outcomes, different practices provided window both for improved health and reduced climate change. This paper presents the evidence and potential co benefits of different practices and elaborate built environment schemes that lessen the effects of climate change and improve health. Also, opportunistic partnership for both health and non-health sectors are also scrutinized. Lastly, how further research should be carried out are also proposed.

II. Proposed Algorithm

A. **Transportation–**

Transportation, a key feature of the built environment, encompasses roads, highways, airports, railroads, public transit, ports, and bicycle trails, as well as the interaction of these systems with cities and communities. Globally the transport sector is responsible for 25% of total carbon dioxide (CO2) emissions from fuel combustion in 2018 (IEA, 2020). It is the fastest growing sector and is a major contributor of global greenhouse gas emissions. In India, it is the third most CO2 emitting sector, and within the transport sector, road transport contributed more than 90% of total CO2 emissions (IEA, 2020; Ministry of Environment Forest and Climate Change, 2018). The greenhouse gas (GHG) emissions in India consisted of 70% CO2 and 30% non-CO2 (methane, nitrous oxide, F-gas) emissions. Climate change and air quality have an interactive relationship. Climate change affects air quality by altering local weather patterns, such as temperature and wind speed, which affect the distribution of air pollution. Anthropogenic sources of air pollution (e.g., motor vehicles) promote climate change through their emission of CO2, volatile organic compounds (VOCs), and nitrous oxide. The combination of VOCs, nitrous oxide, and sunlight form ozone and smog, which are harmful to health. Although no direct health effects are attributed to increased ambient levels of CO2, high concentrations of indoor CO2 are associated with drowsiness, headaches, poor concentration, and increased heart rate; and extremely high concentrations of CO2 (5000 parts per million [ppm]) potentially lead to oxygen deprivation and serious health effects. Other byproducts of fossil fuel combustion (e.g., ozone and fine particulate matter) contribute to air pollution and associated respiratory illnesses. Exposure to air pollutants is linked to chronic obstructive pulmonary disease hospitalizations, respiratory and cardiovascular morbidity and mortality, acute asthma care events, diabetes mellitus prevalence, lung cancer risk, birth defects, lung impairment, fatigue, headaches, respiratory infections, and eye irritation. Air pollution health effects are particularly associated with SES and age. Asthmatic children living in areas with low SES were found to be more affected by air pollution than asthmatic children in high- SES regions. Emergency room visits for air pollution– related asthma was highest among young children and the elderly. With economic development in India, the vehicle ownership level has increased with a growth rate of 10.4% for two-wheelers and 11% for cars from 2001 to 2015 leading to an increase in emission levels on the road. An increase in vehicle population also contributed significantly to India's air pollution. Serious health issues are observed due to high exposure to air pollution (PM and NOx) in India. Hence, various transport policies were introduced in the past, which impacted the vehicle exhaust emission and influenced the characteristics of the vehicles present in the fleet and their activity levels. Most of the transport policies were first introduced in metropolitan cities and later in other parts of India. The auto-fuel norms were introduced before 2000 (in 1999), giving a clear-cut road map for passenger vehicle technology changes and corresponding fuel quality for the country. Under this policy, vehicles follow the strict emission standard norms introduced as Bharat Stage (BS) norms, equivalent to the Euro norms implemented in Europe. According to the timeline, the BS-IV was implemented entirely in India by 2017. The Ministry of Road Transport & Highways issued a draft notification for the BS-VI emission standards, which would apply to the vehicles manufactured in the year 2020. Significant policy initiatives were introduced in India to control vehicular emissions, such as a shift in technology, a shift to alternate fuel, and advancement in emission norms from 2000 to 2020. The share of electric vehicles increased from 0.04% in 2011 to 0.8% in 2020 in India. Simultaneously, other alternate fuels such as biofuels, liquified natural gas, and hybrid vehicles grew their share to 1.2% in 2020 in India. CNG is the third most significant road transport fuel in India after gasoline and diesel. However, their share in vehicles remained the same in India's total mix from 2011 to 2020. (International Energy Agency (IEA).)

B. **Buildings–**

Global CO2 emissions from energy use in buildings grew approximately 3% per year between 1999 and 2004. Buildings affect GHG emissions through various aspects of their design, location, orientation, and use, such as their relationship to each other and the neighboring landscape, the material composition and design elements of their interiors and exteriors, and the energy and water resources used by their occupants. A building's energy use is also affected by features of its surrounding environment (e.g., sunlight, wind, trees, and water), which in turn affects its GHG emissions. Various building aspects influence the health of users. For example, design characteristics of hospitals, such as better lighting, layout, and ventilation, have resulted in reduced stress and fatigue in patients and staff, as well as improvement in overall health. Similarly, building placement relative to residential and commercial areas influences whether occupants must depend on automobiles or are able to walk, bicycle, and use public transit to other destinations, and has been shown to have a considerable impact on BMI. The conditions of a building affect the health of its occupants. Mold, pests, lack of safe drinking water, and inadequate heating or cooling, waste disposal, and ventilation systems result in adverse health effects, including respiratory illnesses, asthma, infectious diseases, injuries, and mental health disorders. These conditions, which are characteristic of substandard housing, predominantly affect vulnerable populations, specifically people of low SES and racial minorities. Moreover, susceptibility of poor and minority populations to hazards may be increased due to underlying health conditions, such as asthma and cardiovascular disease. Therefore, maintaining the conditions of a building improves the health of its occupants. Decisions to use sustainable building materials and operation practices can promote health and protect the environment by mitigating the urban heat island effect (higher temperatures in metropolitan areas than in surrounding areas), conserving resources, and allowing safe disposal of contaminated or hazardous waste products. Environmentally friendly supplies (e.g., recycled materials) can be substituted for products that use nonrenewable resources. Buildings constructed with locally produced materials support local economies and reduce transportation-related air pollution. In addition, building and landscape designs can encourage routine physical activity by providing accessible, attractive stairwells with clear signage and outdoor walking paths. Carbon dioxide emissions from buildings are primarily caused by the use of electricity to provide heating, cooling, lighting, water, information management, and entertainment systems. Because of their long-life expectancies, buildings affect the environment and public health for many years. In India's fight against climate change, the buildings sector provides huge opportunities for emissions reductions. Progressive and forward-looking real estate players are increasingly backing the move toward net zero with ambitious sustainability commitments. As companies set voluntary targets for reducing greenhouse gas (GHG) emissions, the use of science-based targets is becoming a mainstream business practice. Numerous real estate companies globally have announced sustainability commitments using frameworks such as the Science-Based Targets initiative (SBTi), World Green Building Council's Net Zero Commitment, the Better Buildings Partnership (BBP), the Architecture 2030 Challenge, the RIBA 2030 Climate Challenge, and The Climate Pledge.

Recently, the Lodha Group also announced its ambitious commitment to be a carbon-neutral company by 2035. The buildings sector likely provides the single largest opportunity for reductions in energy consumption and GHG emissions. Currently, India's buildings account for around one-fifth of total CO2 emissions and nearly 33 percent of the nation's energy use. The buildings sector is also one of the largest consumers of natural resources. In the absence of peremptory energy efficiency improvements and policy measures, the buildings sector is projected to emit seven times more CO2 by 2050, as compared with 2005 levels. Meanwhile, the residential sector's overall energy use could increase eightfold. India's real carbon savings potential lies in the buildings that are yet to be built. Estimates suggest that about 70 percent of India's 2030 urban infrastructure is yet to be built, signaling huge opportunities to save embodied carbon emissions—the emissions from the full life cycle of building materials or other products. In India, real estate is the sector responsible for the most job creation and GDP multiplication driving the economic growth in the country. About 250 ancillary industries, including cement, steel, brick, timber, and building materials, depend on the real estate industry. Therefore, decarbonizing the buildings sector's portfolio also drives sustainability in the industries upstream and downstream in the value chain. Eliminating these embodied carbon emissions, along with the operational carbon emissions generated by a building's ongoing use, is the key to addressing climate change and meeting Paris Climate Agreement targets. Real estate developers can explore various pathways to achieve their targeted sustainable development goals. However, a powerful vision and roadmap are necessary to lay the foundations for future scaling and to achieve significant GHG emissions reductions. (International Energy Agency (IEA).)

C. **Land Use, Forestry, and Agriculture–**

Carbon accumulation is important because forests "sequester" CO2 by absorbing it from the atmosphere, therefore reducing the amount contributing to the overall levels of GHG emissions. Deforestation increases the levels of atmospheric CO2 and promotes climate change. 22 According to the World Resources Institute Climate Analysis Indicators Tool (WRI-CAT), India's 2014 GHG profile was dominated by emissions from the energy sector, which accounted .1 for 68.7% of total emissions. (AFOLU) Within the energy sector, 49% of emissions were due to electricity and heat generation, followed by 24% from manufacturing and construction.

Agriculture was the second highest source (19.6% of total emissions), with enteric fermentation contributing 14 45% of agriculture emissions.2 Industrial processes (IP), land use change and forestry (LUCF), and waste contributed 6.0%, 3.8% and 1.9% of 2014 total emissions, respectively. India's First Biennial Update Report (BUR) to the UNFCCC, submitted in 2015, includes a GHG inventory for 2010 and GHG trends from 2000 to 2010. The BUR shows land use, land use change and forestry (LULUCF) to have been a net carbon MtCO2e sink in 2010, absorbing 252.53 more than 3 what was emitted that year. (International Energy Agency (IEA).) From 2000 to 2010, WRI CAIT also shows LUCF as a net sink, but from 2011 until the most recent year for which data are available, 2014, CAIT shows LUCF to have become an emissions source. The BUR does not present data from 2011 onwards. However, the GHG Platform – India has published GHG emission estimates for 2005 to 2013, Subsector including for agriculture, forestry and other land use (AFOLU).16 It shows the land have been an increasing carbon sink from 2005 to 2013, with removals increasing from 134.0 MtCO2e in 2005 to 177.7 MtCO2e in 2013.17 Direct comparison of findings from multiple sources can be difficult due to the use of different estimation methodologies and data sources. The BUR and WRI CAIT show energy to be the highest GHG emitting sector in India, followed by agriculture. WRI CAIT data show that agriculture emissions increased 25% from 1990 to 2014, driven by emissions from synthetic fertilizers (47%) and enteric fermentation from livestock (30%). FAO data show that from 2002 to 2014, use of nitrogen fertilizers (total N) increased 62%, potash (K2O) 59%, and phosphates (P2O5) 51%. The BUR 17 notes that growth in total fertilizer consumption has been significant over the 2002-2012 decade and contributed (along with irrigation and availability of seeds) substantially to increased food grain productivity. It also notes that several technologies to reduce GHG emissions with sustainable crop and livestock management have been developed under the National Initiative on Climate Resilient Agriculture. The government has also proposed complementary actions to reduce methane emissions from ruminants, including modifications of diet, and from rice paddies. Between 1990 and 2014, FAO data show that the number of cattle decreased 8%, but buffaloes, sheep, and goats increased 37%, 29% and 17% respectively Emissions from enteric fermentation grew 30% during this time frame. The overall contribution of 18 the livestock sector to total GDP was nearly 4.11% during 2012-2013, while the agriculture sector share of GDP was 17.6% in 2014. (International Energy Agency (IEA).) In a traditional urban setting, residential and commercial land uses are mixed, allowing for proximity of home, work, school, and other destinations. Workplace proximity is a major influence on the commuting decision to walk, particularly for women. Similarly, situating schools near residential areas encourages students to walk or bike to school, thereby yielding the co-benefits of physical activity and reduced GHG emissions. Parents who walk their children to school accrue the health benefits of physical activity, as well as the advantages of interacting with other parents and strengthening community ties. In general, walkable communities are associated with higher physical activity levels, lower obesity prevalence, lower car dependency, and higher levels of social capital. The location of community resources is particularly relevant for vulnerable populations. A disparity often exists because poor people and ethnic minorities live far from high-quality schools, employment opportunities, resulting in a cycle of poverty that is difficult to escape. Situating community facilities, such as libraries, parks, health centers, and fire and police departments, near residential and commercial areas can have a positive effect on the health of all residents. Unlike traditional neighborhoods, sprawling developments outside of city centers feature low-density land use, extensive road systems, a lack of centralized community centers, and a greater distance between destinations such as home and work. These factors contribute to increased automobile dependence and decreased ability to walk, bike, or use mass transit, as well as loss of farmland and forests. Highways, which link suburbs to downtown areas, are often routed through low-income neighborhoods, thereby creating a physical barrier that interferes with community cohesion. Poor people and people of color are disproportionately affected because they often live near highways, which are major sources of air pollution. Urban sprawl affects air and water quality, physical activity level, mental health, and social capital, resulting in elevated risk of respiratory, cardiovascular, and chronic diseases, cancer, psychological and emotional disorders, and injuries. In addition, the increased driving time typical of urban sprawl contributes to climate change. Increasing density in urban areas is only part of the solution to urban sprawl. Although most urban environments offer sidewalks, mixed-land use, public transportation options, and connectivity, these aspects may be undermined by factors that pose health threats, such as crime, waste or industrial sites, and inadequate infrastructure maintenance. Neighborhood indicators characteristic of underprivileged communities (e.g., the lack of nearby walkable destinations, or sidewalks in disrepair) are significantly associated with obesity. Living in disadvantaged neighborhoods is linked to higher rates of cardiovascular and stroke mortality. When these areas are redeveloped, gentrification often occurs, causing property values to rise and forcing lower-income residents to move out. Involvement by health professionals and adequate representation of vulnerable populations in zoning and planning decisions represent important opportunities to benefit public health and climate change. Improved urban green space planning and management can help mitigate climate change while offering considerable co-benefits for human health. Urban green spaces reduce atmospheric CO2 levels through direct sequestration and accumulation of carbon by trees and shrubs. In addition, urban green spaces decrease building heating and cooling needs, thus reducing fossil fuel consumption. Lack of contact

with nature can influence the mental, physical, and emotional health of the public, particularly children. supermarkets, and Urban green spaces such as parks and trails provide access to nature and encourage physical activity, thereby helping combat obesity and its co-morbidities, such as hypertension, osteoarthritis, sleep apnea, and stroke. Access to green space decreases aggression and violence, improves mental fatigue, and increases social capital and community building. Finally, exposure to nature reduces pain in patients undergoing bronchoscopy, improves attention among children with attention deficit disorder (ADD), and increases the life span of the elderly. Improved land-use planning can be a cost-effective way to mitigate climate change and promote public health. Specific approaches for reducing GHG emissions include creating new green spaces (e.g., on roofs and along streets and railroad lines), maintaining existing green spaces, conserving natural lands through controlled development, and planting trees with high growth rates for additional green cover. Land-use planning is particularly relevant for cities. Dark, impervious surfaces on buildings and roads and the lack of shade and vegetation cause urban areas to have higher average temperatures than rural areas, resulting in the urban heat island effect. This effect decreases the relief available from nighttime cooling and amplifies the susceptibility of urban residents to heat-related illnesses,
including those anticipated to occur more frequently under climate change scenarios. Reuse of previously developed land such as greyfields and brownfields is also an important method for mitigating climate change and its health implications. Greyfield sites, such as underutilized shopping centers, can be redeveloped into valuable real estate assets because they are usually located along well-traveled areas with good infrastructure. Similarly, brownfield sites, which are properties contaminated with hazardous substances, can be decontaminated and redeveloped into healthy communities that feature mixed-land use and connectivity. In addition to economic benefits, such projects help preserve existing agricultural and forest lands.

IV.DISCUSSION

The built environment offers opportunities to improve health and livability while reducing the GHG emissions that underlie climate change. This article contributes to a growing dialogue addressing the impacts of climate change on human health, by highlighting built environment strategies that minimize the effects of climate change and concurrently improve health. Research on these relationships, although needed, is difficult because built environment data are infrequently collected and usually local in nature. By contrast, climate change indicators such as temperature, weather, wind, and precipitation trends are often measured on a macro-scale level. Although work is underway to identify key indicators for the built environment and climate change, using these divergent data to describe and understand the relationships among the built environment, climate change, and human health is a complex challenge for researchers.Adaptation strategies, although not the focus here, merit attention because they can help prepare the built environment to better withstand the effects of climate change. An example of an adaptation strategy is a policy that limits situating buildings in flood plains or low-lying coastal regions because of the increased risk of flooding from heavy precipitation and rising sea levels.119 Some adaptation strategies may have a negative impact on climate change. For example, although air conditioning in buildings is an important adaptation strategy to reduce heat-related illnesses caused by higher temperatures, the energy used to cool a building contributes to GHG emissions and climate change. Although some literature discusses adaptation strategies for various built environment components to address climate change effects, more research on this interplay is needed, especially in relation to health impacts. Future research could include cost–benefit analyses of the impact of built environment interventions on GHG emissions and public health. For instance, a light-rail transit line in Charlotte NC with 15 stations covering 9.6 miles averaged 14,000 daily riders in its first year (2007), exceeding projections by 55%.125 Estimates suggest this transit line will save $12.6 million dollars in total healthcare costs over 9 years. Possible research projects from this transit system include climate change–impact assessments by measuring transit users' vehicle miles traveled, the health outcomes for residents and transit riders, and social cohesion and economic impacts on the city. Similar monitoring and evaluation research may be conducted for GHG emissions associated with larger projects such as new buildings, transportation systems, land-use patterns, and major infrastructure changes, as well as for smaller projects such as new sidewalks, bicycle lanes, and parks. Research that examines how built environment interventions both affect the health of vulnerable populations and reduce climate change is encouraged. Because health systems will need to address the effects of climate change on public health, it is important for healthcare providers to become leaders in the built environment discussion. Co-benefits from promoting these changes will directly improve health. CDC scientists have described how ten public health functions can help alleviate and respond to the health effects of climate change.8 As part of this response, individual physicians can be models for behaviors that promote sustainability. It has been shown that physicians with healthier personal habits are more likely to encourage patients to adopt similar habits. This effect may hold true for behaviors related to sustainability through transportation choices, energy use, and involvement in local policies affecting land use and community design. Healthcare providers can collectively and individually influence the built environment and climate change through their actions and leadership. Decisions about the built environment are routinely made by city planners, architects, political leaders, financiers, and public service officials. Because the built environment affects health, public

health professionals should be included in land use and transportation decision-making processes. Health Impact Assessment is a tool that can be used by public health practitioners to assist planners and developers in understanding the health impacts of the decisions they make about land use and transportation planning. Fostering such multidisciplinary collaboration can help maximize the positive health impacts of infrastructure changes and reduce their negative effects. Potential for collaboration exists among scientists, politicians, urban and transportation planners, healthcare providers, and concerned individuals across numerous agencies and organizations. These partnerships can promote the concept that built environment interventions will yield the co-benefits of mitigating climate change and promoting public health. Although some of the impacts of climate change cannot be predicted or fully understood today, the precautionary principle suggests there is enough evidence to justify proceeding with known mitigation strategies to counter the effects of climate change. Through careful planning of transportation systems, buildings, and land uses, built environment programs can support climate change mitigation and enhance human health.

V.CONCLUSION

The built environment, climate change, and public health are closely connected. Built environment strategies that promote climate change mitigation through transportation infrastructure, building construction, and land-use planning provide opportunities both to improve health and reduce climate change. By combining various built environment strategies through complimentary policies and programs, multiple co-benefits emerge. Encouraging leadership and collaboration among various professions within the built environment, climate change, and public health fields is an important step toward reducing GHG emissions, thereby mitigating climate change effects and promoting healthier living.

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