

Perspective

Multi-Vector Approach to Cities' Transition to Low-Carbon Emission Developments

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Abstract: Globally, cities have made efforts to shift to low-carbon emission development (LED), amidst air pollution, greenhouse gas (GHG) emissions, and high temperature anomalies. However, the emphasis on cities to help shift the global economy to LED has been on a single individual sector approach operating in silos rather than the inter and intra-specific outcomes of multiple sectors. Thus, there are uncertainties of adopting suitable pathways for cities' transition to LED, due largely to data paucity and policy incoherence, constrained further by barriers to integrating science, policy, and practice. Hence, the need for cities to take advantage of the benefits of multi-directional perspectives of multiple sectors acting together—the “multi-vector” approach, to confront key questions of climate compatible development (CCD) that support LED. Therefore, the paper extends the development narratives of the CCD approach to an “enhanced” climate compatible development (EnCCD) pathway with in-built questions and determinants to scope cities' transition to LED. The EnCCD suggests that the standalone intersection between mitigation and development to deliver LED will not result in cities' resilience unless (i) co-benefits, which are outcomes of mitigation and adaptation, and (ii) climate-resilient development, the product of adaptation and development, coevolved. Therefore, the EnCCD transforms the development policy focus of cities on separate, single-purpose sectors, such as energy or transport, into multi-sector portfolios having synergistic benefits of mitigation, adaptation, and development strategies.

Keywords: adaptation; climate change; climate resilience; co-benefits; greenhouse gas emissions; enhanced climate compatible development (EnCCD); policy mainstreaming; mitigation

1. Introduction

The global focus on cities to shift towards low-carbon emission development (LED) to help avoid a global mean temperature change of greater than 2 °C and climate change's worst effects has accelerated [1,2]. However, recent analysis suggests lack of clarity in the direction [3]. The complex social-ecological-linkages of cities call for frameworks to implement LED to be sector-interdependent, such as the climate compatible development (CCD) approach (Figure 1) [4]. Hence, the understandings of the synergies and trade-offs of mitigation, adaptation, and development strategies in multiple sectors, the “multi-vector” approach rather than single standalone sectors to implement LED is emerging [2]. Thus, a multi-vector approach refers to how the interactions and interdependences of the elements

of multiple sectors compensate for the shift in the attributes of the individual sectors making up the combined sectors, including reducing the inter- and intra-specific weaknesses and residual effects whilst harnessing strengths and benefits of the individual standalone sectors (single-vector). However, studies that engage the CCD approach, use single sectors (single-vector approach), such as energy or transportation, without analyzing the outcomes of their interdependencies, which would require having to address key research questions at the various intersections of the CCD strategies [4]. It is the research questions overlaid on the CCD approach across its three strategies and the intersections (Figure 1), to enhance the interpretation of the CCD in addressing LED from a multi-vector perspective that this paper explores in an “enhanced” CCD approach, the “EnCCD”. LED constitutes one of the intersections of the three CCD strategies, between development and mitigation strategies (Figure 1), analyzed in this paper on how holistic enhancement of the CCD supports cities’ transition to LED. Therefore, the EnCCD is scaled to leverage how climate-resilient development and co-benefits strengthen opportunities for LED transitions using clearly defined questions and related determinants of multiple sectors. Thus, defining carbon neutrality for cities and managing residual emissions is key for cities [5], and supportive of human security and environmental sustainability. Therefore, the paper takes a “Perspective” look of low-carbon emission development of cities, defining philosophical understandings of recent developments of the significance of LED, and intended to discuss models and ideas from authors’ viewpoint to highlight future directions that stimulate discussion and new approaches.

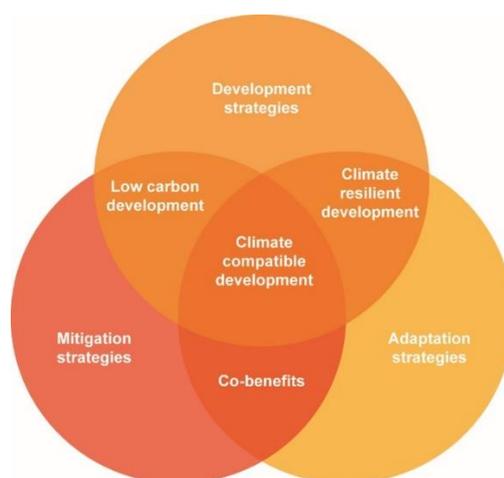


Figure 1. The Venn diagram of the climate compatible development approach. Source: [4].

The pressure on cities to act on LED initiatives was made more evident in the wake of the recent heat waves across some cities. Historically, in absolute terms, July 2019 virtually tied with August 2016 as Earth’s hottest month on record of any month (Figure 2a [6,7], Figure 2b [8]). The UN-Habitat has consistently, since 2011, reported that cities were getting hotter from global warming and will become the future battleground for climate change [9,10], following earlier concerns [11,12]. Recent discussions on cities suggest that overarching frameworks are being sought to track the progress of cities towards the multiple societal outcomes related to sustainability goals rather than addressing the goals of individual sectors [13]. This is because urban landscapes and associated cities constitute complex socio-ecological systems facing multiple risks of climate change and climate variability [14–16]. Cities contribute close to 70% of the global greenhouse gas emissions [9], raising concerns over the fate of fast-growing small and medium sized cities [17,18], yet, as acclaimed future of the world’s development [1,19], cities mostly find themselves on the peripheries of the climate change debate. This is because, more frequently, those in charge of urban and city affairs hardly made provisions in the planning process to reduce climatic risks that confront them [20,21], but can be minimized to favor LED initiative by bridging gaps between national and city-level policy-making [22].

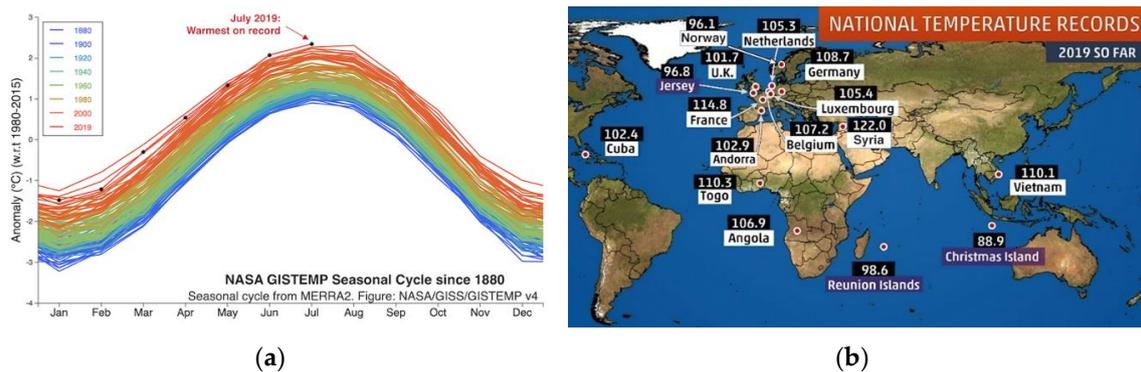


Figure 2. (a): The departure from average (compared to temperatures from 1980–2015) of Earth’s surface temperature from 1880 through July 2019, with the seasonal cycle. Source: [6,7]. (b): Nations (white labels) and territories (purple labels) that set all-time record temperature highs by 13 August 2019. Source: [8].

Cities globally continuously incur significant annual losses and damages to major infrastructure in the energy and transport sectors, and critical ecosystem services, attributed to climate change-related events [23,24], with population growth remaining an attendant problem of loss and damage [25]. Thus, the effects of urbanization in cities globally are increasingly burdened by climate change [26–28]. However, cities face challenges to pursue strategic reforms for building climate-resilient infrastructure, blamed mainly on limited capacity and resistance to change, characterized by political sensitivity and ensuing volatility when it comes to climate change mitigation decisions [29,30]. Thus, culturally inappropriate policies on economic and technological applications frustrate adoption of limited strategic niche management and niche creation [31,32]. The need to catalyze the generation of new research areas and data for cities to build low-carbon, climate-resilient, and sustainable societies has arisen [33–35], as some recent studies predefine how this unfolds (e.g., [33,36,37]). There is rich literature on low-carbon emission development, but the focus has been on individual sectors, acting in disciplinary silos (e.g., energy, transport, waste) and not cross-cutting. The EnCCD pathway, however, supports harmonization of sectors using determinants of the total environment. The LED-driven determinants also capture human security issues, imposed on the traditional CCD approach (Figure 1) to harness sector synergies, and optimize benefits from their trade-off’s as part of the multi-vector effects to also reduce redundancy, and enforce co-creation and co-evolution of knowledge which are not typical of the traditional CCD approach in Figure 1.

2. The EnCCD Pathway

The challenges of LED call for new learning approaches which the EnCCD pathway supports to guide LED transition across multiple sectors and heterogeneity in the interests of stakeholders, culminating in the multi-vector character of the EnCCD. The addition of cross-cutting themes to the CCD approach based on three research questions to mainstream the development, adaptation, and mitigation strategies and the accompanying intersections (i.e., low-carbon emission development, climate-resilient development, and co-benefits) drive the EnCCD pathway. The cross-cutting themes of the EnCCD are on:

- (i) resource transformation,
- (ii) the physical and biological environment, and
- (iii) human security.

The three themes thus define the cross-sector and multiple science and policy dimensions of the individual components of the CCD and addressing the synergies and trade-offs of the intersections of the CCD. Using the crosscutting themes to set priorities for the intersection between mitigation

and adaptation produces co-benefits, such as green infrastructure, distributed energy, resilient transportation, low input agriculture, etc.

For the climate-resilient development intersection of development and adaptation strategies, applying the cross-cutting themes enables transformative learning and change characterized by flexibility, adaptability, and reorganization of development and adaptation, as well as enhancing the capacity of a system to regenerate, recover and stabilize whether in a human or the biophysical environment. The implications of the combined effects of the crosscutting themes on the co-benefits and climate-resilient development intersections, for the LED intersection for development and mitigation are that:

- Technology will be enhanced to drive the reduction in greenhouse gas emissions, including carbon neutrality of cities,
- The efficiencies in operations of various sectors, such as energy, transport, water, etc. will be improved due to minimization of redundancies and wastage in management,
- Infrastructure across all sectors will be improved in terms of provisioning and delivery, informed by reduced consumption of sources of GHG emissions, and
- There is a need for improving economic measures, which include job and wealth creation, poverty reduction, and resilient communities of cities.

Harnessing co-benefits of cities [38–40] has emerged as a major concept for future cities—climate change research to support the transition towards LED [41]. The EnCCD pathway thus mainstreams the research priorities and benefits of their intersections. The co-benefits comprise outcomes of the synergy between mitigation and adaptation, which includes green infrastructure, resilient urban transport, distributed energy, water and energy conservation, and building weatherization [41]. An analysis of five strategic sectors shows how co-benefits provide a number of cross-cutting benefits for cities that do not compromise quality of life because they already constituted core strategic development planning areas for many cities [42]. The strategic sectors, which are health, mobility, resources, buildings, and economy would require coordination across several government departments, yet, with one city authority leading the implementation [42], which supports the EnCCD multi-vector approach whilst responding to increased citizenry demand [43]. Therefore, LED transition will not automatically translate into resilient cities unless the principles and goals interlock with development. The EnCCD's questions and underlying determinants are a source of convergence to reduce complex planning of multiple sectors and policy misalignments that address increasing consumption-based emissions. It is adding value to CCD initiative in providing a specific and targeted outcome-based guide as it focuses on intersecting determinants to mainstream research findings into cities' planning and priority setting.

Subsequently, defining research priorities [33] will enable the cities-climate change nexus to capture opportunities for knowledge co-creation and co-evolution, linking cities' development, and Earth system processes, which are enshrined in the EnCCD pathway (Figure 3). The need for science to have a stronger role in urban policy and practice, that helps cities share information and learn from one another is on the rise [33]. Accordingly, some areas that need the attention of science are (i) researchers and city authorities expanding the scope of protocols for urban data, (ii) appreciate and comprehend the complexity of how climate interacts with local factors, (iii) informal settlements because they are unapproved and mostly unplanned, such as slums with greater exposures, (iv) technological change, (v) transformative strategies for achieving low-carbon, resilient cities, (vi) thinking globally and acting locally in a complex dynamic system [33]. The climate-resilient development intersection represents the degree to which climate change adaptation and risk management are mainstreamed into governance and for cities, sustainable management of space and resources is key. This is because the reason to act or not to act on climate change depends on socio-technological change and the long-term economics of mitigating climate change and the estimated net economic impact. The heightened level of case for cities to pursue low-carbon is multi-faceted because apart from the socio-demographic, urbanization,

and industrialization issues, cities provide networks that allow the flow of information and capital for informed commodity and resource management.

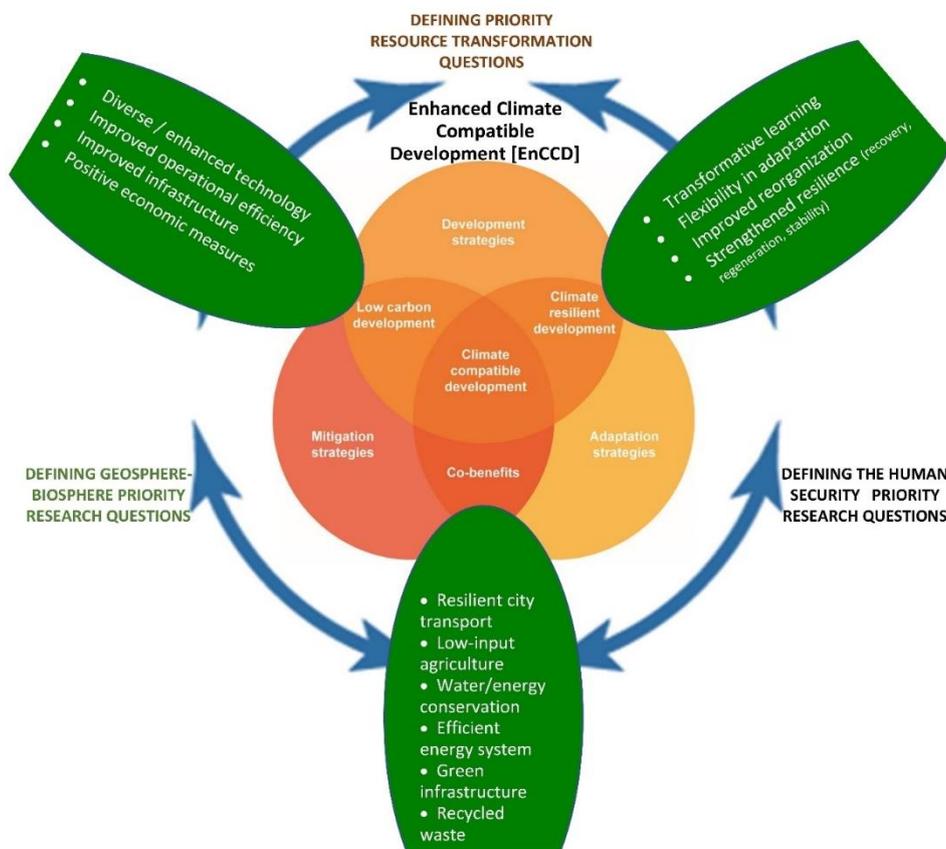


Figure 3. Evolution of an enhanced climate compatible development (EnCCD) planetary pathway for analyzing emerging research priorities on the cities—climate change nexus in synergizing strategies for development, mitigation, and adaptation as an opportunity for mainstreaming LED for cities. Source: This paper (adopted and modified from [4]).

3. Junctures of Climate Compatible Development and Urban Policy

The Sustainable Development Goal (SDG), Target 1.5 seeks the resilience interests of the poor and those in vulnerable situations in reducing exposure to climate-related extreme events and socio-economic shocks [44]. The SDG 11 is specific to building resilient cities and combining it with SDG 13 to combat climate change, which is consistent with climate-friendly policies and development. The priorities 2, 3, and 4 of the Sendai Framework for Disaster Risk Reduction (SFDRR) on strengthening and investing in disaster risk governance and resilience are significant elements of sustainability [45]. It has taken the world three decades to fully put the cities' climate change intersection into development perspective since the Brundtland Report placed environmental issues firmly on the world's political agenda on environment and development as one single issue [46–50]. The CCD approach to LED espouses the extent to which climate change adaptation, mitigation, and development can build synergies [51,52], creating junctures for innovation in multi-layered dimensions, including private sector inputs and relevance for governance and equity measures in cities [53]. The emergence of the CCD approach, with the potential to help shift development towards a low-carbon economy, has catalyzed ascendancy in national green growth agenda in urban landscapes with cities as the foci [19,54,55]. Many indicators related to consumption-based emissions have emerged over low-carbon cities, low-carbon technologies, industries, and infrastructure in individual economic sectors [56–59]. The major factors that influence the total and per capita CO₂ emissions of consumption-based emissions

of cities include (i) geographic situation, in predetermining energy expenditures for heating, cooling, and lighting, (ii) the demography, defining population size, and how demand for space and services is influenced, (iii) the form and density of settlement, as sprawling cities are known to have higher per capita emissions than more compact ones, (iv) types of economic activities and links to the quantum of greenhouse gases emitted, and (vi) wealth and consumption patterns of residents [9].

There are also multi-sector integration of low-carbon emission development indicators and strategies from local to national levels [57,60–62], which fit the EnCCD's multi-vector principles, responding to operational gaps in the cities–climate change nexus [63]. A successful climate-compatible development that promotes LED also builds into its actions the governance of risks and knowledge transformation [64,65]. Cities are centers of power and innovation for knowledge brokering and having frameworks that balance human development and climate actions constitute an important precursor for national growth and development. This is also because there is an immense presence of state-level development and policy apparatus in cities to support climate actions. Most collaboration between public and private sectors, which are essential ingredients to deliver economic growth and LED, is found in cities. Therefore, there is a sizeable opportunity for cities globally to identify the potential to develop new businesses and industry sectors linked to climate change and LED [66]. Cities are also showing interest in climate change-related interventions by collaborating with companies to enable them to cut emissions and attracting private sector finance for development [67]. However, the transition to LED faces challenges, with 75% of them preventing future climate action in cities because the challenges cannot be resolved unilaterally by cities unless they worked with partners in the private sector, national government, and civil society [68]. It has been observed that cities collaborating on climate action will have more ambitious emission reduction targets, and that 74% out of 190 cities that have a city-wide emission reduction target collaborated with businesses [66,68]. The extent of autonomy of cities, unlike other state and government agencies, is such that decisions on actions are often reached quickly with drastically reduced bureaucracies and making them better positioned to implement their own actions on shift to low-carbon. Knowing the resources that cities have, and given their resources, cities are capacitated to use shorter time periods to reduce barriers to intersectoral collaboration, technocratic approaches, and use of scientific evidence and data in decision making on LED.

4. Mainstreaming Climate Change Policy Actions and Cities' Priorities

In the face of rapid urbanization, cities still control major resources to enable them to respond to climate change in ways that support national level low-carbon growth [54,60] and generate the largest co-benefits of mitigation and adaptation for economic growth, employment, and increased well-being [24]. However, the resources available to cities may be finite or difficult to access due to increased citizenry demand and political economy challenges hence would require a targeted and guided approach which the EnCCD questions and determines as useful, which the emerging Urban NEXUS approach aligns with (Figure 4) [60]. “The approach guides stakeholders to identify and pursue possible synergies between sectors, jurisdictions, and technical domains, so as to increase institutional performance, optimize resource management, and service quality” [60]. Solar energy conversion, fossil fuel, and materials for energy systems, including biofuels and biorefineries, present opportunities for carbon capture, storage, and sequestration, towards LED but the knowledge of their interdependence has eluded scientific scrutiny. The EnCCD thus provides a framework to facilitate the design of resilient solutions for cities to resolve LED challenges, and serving as an information hub for integrating climate change response measures into development. Notwithstanding, there is a need to understand why city authorities rarely deliberated and engaged businesses and residents in climate change risks, although it affects the wider communities [69]. Therefore, strong local citizenry engagement and acceptance, local leadership, public and private sector inputs into EnCCD will trigger an increased rate of adoption and transfer of local carbon technology to stimulate green growth and resilience of cities [70,71]. The presence of businesses, strong and diverse populations in cities means

that large pools of biophysical and human assets provide urgency for multilevel low-carbon growth and climate-resilient governance [71,72]. Analyzing and understanding these and related negative impacts and burdens from health influences on society and ecosystems by city planners who are generally often unwilling to embrace change will be monumental. This is mostly because cities want to realize immediate profits and will, therefore, encourage investments with quick turnovers than to mitigate climate change that come with delayed returns. The IPCC estimates the turn-over of benefits from mitigating climate change as between 50 and 100 years [73], which disincentivizes cities because of a lack of understanding of what CCD brings and what guides its implementation, which the EnCCD pathways add to the CCD approach.

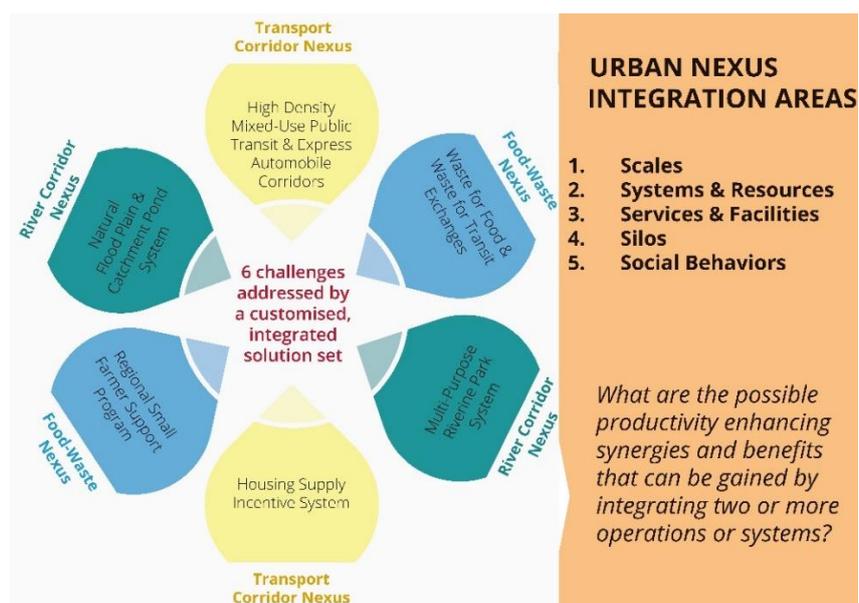


Figure 4. The urban NEXUS development cycle addressing multiple urban policy aims through each integrated solution and investment. Source: Adopted and modified from [60].

5. Examples of LED Initiatives of Cities

There are varying levels of success of LED programs that target municipal facilities and operations [71], and their understandings would help resolve individual interests of researchers, which is mostly data, policymakers on institutions, practitioners for implementation and other city actors and agencies. The Brazilian city experience of LED compared to the Indonesian cities amplifies how cities will likely commit to a multi-vector approach (Table 1). This is because the Brazilian strategy is enshrined in broad climate change policy framework whilst that of Indonesia offers no clear climate policies that identify with the national development plans, and therefore, not necessarily operating a multi-vector response of the EnCCD. Under the 2015 PaCA Brazil committed to cutting 37 percent of its carbon emissions by 2025, and 43 percent by 2030 but experts suggest that recent anti-environmental, climate change and deforestation policies of the government were jeopardizing those goals, with supposedly 80% funding cut to the environment sector [74]. However, there are commitments and interventions to help offset the gaps in funding to the PaCA, such as the European small and medium enterprises (SMEs) partnership agreements, Cooperation and Partnership Agreements (CPA) between European and Brazilian SMEs, the urban buses and bus rapid transit (BRT) buses and the Financing Energy for Low-carbon Investment, Cities Advisory Facility (FELICITY) [67,75–77].

The strategies of Indian and South African cities, however, are mitigation-restricted, operating entirely outside of a broader strategy on climate change contrary to a multi-vector approach (Table 1), and isolating political economy factors inevitable for successful climate policy regime. Addressing the EnCCD's questions (Figure 3) will guide transforming climate governance and political economy

constraints into enablers of low-carbon economy actions [58,78] observed for the transport sector with an integrated policy and governance approach that built on coalitions and the endurance of political change [29]. A recent study of ten southern African countries demonstrates partial alignment to the multi-vector approach with South Africa's policy approaches being the most aligned in the context of development only, and Malawi's the least as sector policies failed to capitalize on synergies between different sectors [61]. LED raises questions about how much of GHGs such as carbon dioxide (CO₂) can be removed from the atmosphere, including criteria for safe levels, and by which method to stabilize atmospheric GHG levels [79]. Lessons from over 100 case studies, intended to make cities and urban areas more resource-efficient and integrated [60], have provided major lessons, which, if aligned to the multi-vector approach, would engage the relevant metrics. The EnCCD embodiment of development requires strong structures and political institutions to implement LED trade-offs, yet the interactions have been largely obscured in research [55], calling for new forms of climate policy infrastructure to enable cities to respond to climate change continuously transform to foster social, economic, and technological change [55,70].

Table 1. Models of city-level Low-Emission Development (LED) Strategies as either a standalone document, city legislation or as part of the city development plan Source: [10].

CITY	STRATEGY FORM	COMMENTS
Fortaleza, Brazil	Legislation: Climate Change Bill including low emissions development policy	Mayor signed the Climate Change Bill, which includes the city's LED policy, commitments and actions in December 2015—to be approved by the City Council.
Recife, Brazil	Legislation: Municipal Climate Change and Sustainability Bill	Decree enacting the City's Action Plan and Target, This Decree, N°29.219 as approved by the Council was published in the Diário Oficial 12 November 2015.
Rajkot, India	Stand alone document: Low Emission Development Strategy (2019–2020)	Approved by the Commissioner (March 2016) approved by the City Council August 12 2016.
Panaji, India	Standalone document: Low Emissions Development Strategy	This is a Satellite City that has prepared its Strategy as input to the Integrated Development Plan 2016–2021—ratified and adopted the Panaji Low Emission Development Strategy in June 2016
Thane, India	Standalone document: Low Emission Development Strategy	LED Strategy with the Smart Cities Proposal for the city is not yet approved—submitted in April 2016 for approval (decision pending)
Balikpapan, Indonesia	City 5-Year Development Plan: includes a Low Emission Development Strategy	LED Strategy City Action Plan for Emissions Reductions approved and imbedded in National Action Plan and The Provincial Action Plan (City's 5-Year Mid-Term Development Plan for Balikpapan (RPJMD 2016–2020).
Bogor, Indonesia	City 5-Year Development Plan (RPJMD) including LED Strategy	Adopted in November 2014 recognizes climate change mitigation, adaptation and disaster risk reduction as strategic priorities for the period 2014-2019.
KwaDukuza, South Africa	Low Emission Development Strategic Framework and Action Plan	The Municipality approved the Development Strategic Framework and Action Plan (part of the Integrated Development Plan (IDP) in January 2016
Steve Tshwete, South Africa	Low Emission Position Statement	An LED Position Statement was prepared for approval by the Municipality not a full Strategy, to be embedded in the city IDP

6. Knowledge Co-Creation for Cities and the EnCCD

Cities require culturally appropriate transformation to promote collaboration for improved appreciation of climatic risks in physical and development planning [80]. It means engagements of city actors by research scientists in a sustained public-private inclusion and dialogues to engender creative and practical outcomes [81,82], complemented with dissemination of research findings by the science community, such as the IPCC [82]. The EnCCD pathway raises specific questions that incorporate strong capacity building, technology, and innovation opportunities to guide adaptation and mitigation, including promoting usable knowledge and efficient institutions. The EnCCD pathway, therefore, supports local co-creation of knowledge from higher policy scales and informed citizenry responsibility and participation for enhanced accountability, monitoring, verification, and reporting procedures of climate change indicators [80,83,84] are key for multi-sector integration. This is because research outcomes, climatic policy frameworks, and goals will not automatically translate into cities' resilience unless multi-vector approaches dependent on scenario-based multi-stakeholder engagements are engaged. Knowledge co-creation and co-evolution is a costly venture and would require the investment of cities in strengthening basic research on climate change and cities' transformation, whilst setting up new data infrastructure, including those for long term transdisciplinary research and knowledge incubation of LED models. Therefore, financing will be required across the design and planning scales (Table 2) [85], and financing attention paid to scientific research. Therefore, choosing the best climate financing design that informs LED investment is a matter of concern providing the best solution for mitigation and adaptation of a multi-vector approach.

Table 2. Recommendations for financing urban transformation at three levels (global, national, local) (Source: [85]).

Goals	Important Measures and Approaches
Global level	
> Coordinate the international financing of development and climate mitigation and gear it more closely to sustainable urban development	> Gear international collaborations to already agreed objectives on sustainable urban development > Direct international financial resources to the municipalities as appropriate > Clarify the rules on accounting with regard to the Green Climate Fund (GCF) to avoid double counting between development and climate financing
> Mobilize private capital for urban infrastructure	> Take local factors into account when linking the financial sector with sustainable development objectives > Have existing criteria and standards reviewed by external evaluators > Develop binding criteria and standards for sustainable investment and extend them by adding city-specific criteria > Introduce a global insurance mechanism for urban infrastructure and further develop innovative financing instruments
National Level	
> Strengthen municipal administration and financial base	> Ensure solid financing of cities through adequate transfer payments > Use transfer payments to strengthen the endogenous financing potential and support existing development potential > Consider making it easier for cities to use the financial markets
> Mobilize private capital for urban infrastructure	> Work out a long-term and binding national transformation strategy > Create inclusive financial institutions
Local Level	
> Strengthen municipal administration and financial base	> Make better use of the potential of existing financial instruments > Create transparency with respect to municipal revenue and services > Coordinate policies above and beyond local jurisdictions and, wherever possible, harmonize administrative and functional borders
> Mobilize private capital for urban infrastructure	> Develop community forms of financing

7. Conclusions

7.1. Synthesis

First, current scientific knowledge, questions, and research pathways to support cities to lead the transition of the global economy to LED are inconclusive and mostly limited to single-vector sector approaches, questions and operations rather than multiple-vector sectors (e.g., for energy, transport). Second, to support and enhance cities' transition to low-carbon emission development, pathways that build synergies between mitigation and adaptation strategies (co-benefits), and development and adaptation strategies (climate-resilient development) will be required in a multi-vector approach. Third, the Enhanced Climate Compatible Development (EnCCD) pathway provides a transformative agenda for building synergies within the CCD approach, using the targeted research question and the synergy determinants (Figure 3). Lastly, the EnCCD pathway provides a basis for the three communities of development (science, policy, practice) to leverage knowledge on climate resilience of cities and related synergies and trade-offs. Thus, a low-carbon emission development pathway in no way compromises human security and existing environmental challenges.

7.2. Limitations and Future Work

- The drivers of the nexus approach to development in the urban space and landscape, which generally enforce development of cities in ensuring that LED actions in cities do not undermine resource allocation and distribution, will delay strategies to enforce a multi-vector approach. Amongst these drivers are the effects of sustainability, equity, and feedback mechanisms on emissions, which are yet to be understood at scale. Subsequently, research that focuses on LED and accompanying policy decisions which is broad, integrative, and demand-driven across multiple sectors within relevant policy coherence will result in inclusive green growth and carbon neutrality of cities [5,35,86].
- Strong national level transformative agenda that strategically recognizes the multifaceted sector-based approach to LED in ensuring that horizontal integration of LED policies meets the development needs of local government will help drive city-level decisions that affect LED exemplified in the EnCCD on defining the resource transformation priority research question (Figure 3).
- Whilst LED will likely pressurize urban resources because it involves a radical economic shift, there is a need for intense knowledge brokering on resource transformation, human security, and the biogeophysical environment across multiple sectors to remediate potential residual impacts.
- Undertaking exploratory efforts on how to harmonize the resources of cities and human security questions such as demand for services, will be key for efficient transitions of cities to LED, based on healthy compromise and conflict minimization across multiple sectors.

7.3. Way Forward and Recommended Steps for Action

The EnCCD pathway is a catalyst for coherence building between the global climate policy ambition of low-carbon, national development, and local climate policy actions with questions and determinants that enable climate change science to lock into guiding the building cities' resilience. Thus:

- There is a need for sustained climate actions on CCD to support LED strategies for cities and ensuring that science, policy and practice work together across the scale.
- The cities' climate change nexus priority engages broad level national development planning, such as in achieving GDP per capita, analyzed from climate-resilient perspective based on the fostered shared vision of transformative actions of cities, and low-carbon initiatives.
- Cities decide which value addition to development targets become the key entry point for LED in ensuring that social, economic, and environmental issues reflect in all LED strategies (Figure 3).

- Social learning that is culturally appropriate and acceptable to promote climate change awareness [87,88] is an inherent part of coevolving knowledge and policy orientation across scale [86] to strengthen cities' approach to sustainability strategies using a multi-vector approach.

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