Analytical framework for integrating climate change mitigation and adaptation in local urban planning policy

Marco analítico para la integración de la mitigación y adaptación al cambio climático en la política de planificación urbana local

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Abstract

Climate change is a multidimensional observable fact and is regarded as one of the greatest challenge human societies is facing in the 21st century. Debates on climate change advocate that urban areas not only contribute to climate change by emitting huge amounts of carbon-dioxide gas into the atmosphere, but also play a vital role in addressing climate change. This research investigates whether local urban planning policies in master plans target climate change mitigation and adaptation. Accordingly, this research undertook a qualitative content analysis of the policy framework of master plans that are involved in the sample and developed climate change mitigation indexes for all the sampled master plans by assessing urban policies against climate change mitigation evaluation protocols. This research significantly contributes to the field of urban planning and public policy by developing empirical evidence that analyzes the relationship between urban planning policies and climate change mitigation and adaptation. This research supports the use of master plans as an effective tool in mitigating and adapting to climate change and has an implication for mainstreaming climate change mitigation and adaptation in urban planning.

Keywords: climate change mitigation, climate change adaptation, urban planning, policy framework, integration.

Resumen

El cambio climático es un hecho observable multidimensional y se considera uno de los mayores desafíos a los que deben enfrentarse las sociedades humanas en el siglo XXI. En los debates acerca del cambio climático, se aboga por que las áreas urbanas no solo contribuyen al cambio climático al emitir grandes cantidades de dióxido de carbono a la atmósfera, sino que también desempeñan un papel vital para abordar dicho cambio climático. En este artículo, se investiga si las políticas de planificación urbana local en los planes maestros apuntan a la mitigación y adaptación al cambio climático. En consecuencia, en esta investigación, se realizó un análisis de contenido cualitativo del marco de políticas de los planes maestros involucrados en la muestra y se desarrollaron índices de mitigación del cambio climático para todos los planes maestros de la muestra mediante la evaluación de las políticas urbanas, frente a los protocolos de evaluación de la mitigación del cambio climático. Tal investigación contribuye significativamente al campo de la planificación urbana y a las políticas públicas, al desarrollar evidencia empírica, pues se analiza la relación entre las políticas de planificación urbana y la mitigación y adaptación al cambio climático. Con esta investigación, se apoya también el uso de planes maestros como una herramienta eficaz para mitigar y adaptarse al cambio climático y posee una implicación para la integración de la mitigación y adaptación al cambio climático en la planificación urbana.

Palabras clave: mitigación del cambio climático, adaptación al cambio climático, planificación urbana, marco de políticas, integración.

1 Introduction

Global climate change is possibly one of the greatest threats human societies is facing in the 21st century and is a result of increased concentration of atmospheric greenhouse gases (GHGs) (IPCC 2021). Impacts of climate change are expected to adversely affect many developing countries in the world. Urban planning policies have been considered as a significant tool in promoting and regulating the development of cities (Kaiser & Godschalk 1995). Adequate research has been conducted in analyzing the role of urban planning policies in natural hazard reduction (Berke *et al.* 1996), environmental protection (Berke *et al.* 1999), promoting sustainability (Berke & Conroy 2000), promoting smart growth principles (Edwards 2007, Raparthi 2014a) and encouraging intergovernmental collaboration (Burby & May 1997).

Nevertheless, research focusing on analysing the impact of urban planning policies on climate change mitigation and adaptation is limited. Climate change researchers advocate those developing countries need to be priority targets for climate change mitigation action as they are the primary population and economic centres. Developing countries not only experience urban and economic growth but also significantly contribute to climate change, by emitting high levels of CO_2 emissions into the atmosphere, in comparison to many developed countries (Gasper *et al.* 1998, ICLEI 2005, IPCC 2007, ICLEI 2010, OECD 2010, IIR 2010, UN 2015, UN 2016).

India, being a developing country, poises rapid economic growth, which is mainly due to the service and industrial sectors. Research highlights that, as economies grow, rapid urbanization in India will drastically increase to nearly 60 % and the pattern of urbanization will tend to be mostly concentrated in cities (Ribeiro 2003, Ahmed *et al.* 2010). As such, it is projected that India's urban population would increase drastically from 288 million in 2011 to about 475 million in 2031 and 820 million by 2051 (Census of India 2011). As most of the economic activities tend to be located in urban areas, they are considered to significantly contribute to climate change, due to increased greenhouse gas emissions.

For all the above-mentioned reasons, India can be considered as a good platform to undertake climate change research by conducting an in-depth study of analysing the ability of urban planning policies in mitigating and adapting to climate change. The main purpose and aim of this research is to assess and evaluate the ability of urban planning policies on climate change mitigation and adaptation. The research questions this research tries to answer is whether master plans of Indian metropolitan regions include and promote urban planning policies that target climate change mitigation and adaptation. The article is divided in five sections. The second section focuses the

literature review on mainstreaming climate change concerns in local urban planning. In the third section, the study region is described. The research methodology is explained in the fourth section and, later, the results are discussed. Finally, the conclusions concerning the use of master plans as an effective tool in mitigating and adapting to climate change is highlighted.

2
Mainstreaming climate change concerns in local urban planning

Researchers focusing on mainstreaming climate change mitigation into urban planning have identified a set of planning actions that benefit in reducing CO_2 emissions. Such policies focus on promoting low building energy use, reducing vehicle miles, creating dense urban environments and green urban spaces; for example, adding green urban spaces is identified as an important step in reducing the urban heat island effect (Stern & Taylor 2007). Likewise, Cervero and Kockelman (1997) identified that density, diversity, and design have an ability to reduce carbon dioxide emissions. Later, Ewing *et al.* (2008) highlights that accessibility to destination, short distance between work and transit, increased density, increased diversity in land uses, and small block designs significantly reduce vehicle miles travelled and, eventually, reduces CO_2 emissions. Thereby, climate change is mitigated.

In addition to these aspects, the Climate Protection Agreement recommends a set of both short and long-term activities for mitigating climate change (ICLEI 2005). A set of short-term activities that is relevant to climate change mitigation are: planting shady street trees, maintaining urban forests, encouraging car-pooling and mass-transit, promoting usage of green energy, strict residential and commercial building codes, promoting reuse, and recycling programs and public education. Long-term actions include promote high-density; relocate facilities to reduce travel time; ordinances to limit sprawl, infill development and Brownfield redevelopment, and preserve open space and infill development.

Climate change researchers agree that, for policies to effectively mitigate climate change, it must constitute a mix of climate change mitigation and adaptation actions. Policies and actions that result in limiting or reducing the greenhouse gas emissions, along with measures that increase carbon sinks (green areas), will contribute to the global mitigation initiatives (Wheaton & Maciver 1999, Wheeler 2008, Wheeler & Hammer 2010). Besides, waste management practices such as landfills, thermal treatment, mechanical biological treatment, composting and anaerobic digestion (of source-separated organic wastes), recycling and waste prevention have a considerable impact on reducing greenhouse gas emissions

thereby mitigate climate change. Likewise, education programs also facilitate climate change mitigation actions, by creating awareness about climate change among the people and expedite plan implementation (UNEP 2010).

3
Study region

India is a rapidly developing country with high population and economic growth rates. India contributes to 18 % of the world population next to China which accounts for 19.4 % of world population. Since the last 10 decades, India has been progressively changing from a rural to an urban society. While only 10.86 % of the total population constituted city dwellers in 1901, this statistic stood at around 31.16 % in 2011 and, by 2030, it is expected that nearly 43 % of the country's population will live in urban areas. This means that rural population in 1901 was 89.14 % and has decreased in the last 11 decades to the current 68.84 %. On the other hand, urban population has increased almost threefold from 10.86 % in 1901 to 31.16 % in 2011. As such, it is projected that India's urban population would increase drastically from 288 million in 2011 to about 475 million in 2031 and 820 million by 2051 (Census of India 2011).

A close review at the pattern of urban growth across various cities in India highlights that urbanization is very prominent among million-plus cities. Share of the total urban population within the million plus cities has risen drastically from 32 to 38 % during 1991-2001 and, recently, to 54 % in 2011. It is estimated that, by 2030, the population within the million-plus cities will increase up to 68 %. Overall, these statistics affirm that India is catching up fast in the process of urbanization (Sudhira 2012, Raparthi 2014a).

Urbanization in India has led to rapid growth in car and motorcycle ownership and use (Ministry of Road Transport and Highways 1999, 2000, 2003, 2010; Raparthi 2014a). Transportation impacts include enormous problems for public transport. Increasingly congested roadways and increased average travel time slow down buses, increases bus operating costs, and further discourages public transport use (Mohan 2004, 2010; Ministry of Road Transport and Highways 1999, 2000, 2003, 2010; Tiwari 2001; Tiwari & Mohan 1999; Raparthi 2014a). As such increasing CO_2 emissions thereby, highlighting that urbanization contributes to climate change (Sibal & Sachdeva 2001, Lee & Choe 2011, Raparthi 2014a, 2015, 2016, 2021b).

India looks forward and participates in global negotiations on climate change because India believes that it is one of the many countries that were responsible for the climate change problem, due to increased urban and economic growth (Rattani 2018,

Raparthi 2018). As growth will continue to happen, it can be assumed that the total GHG emissions are bound to increase. In this regard, there is a need for developing countries, especially India, to manage the growth and respond to climate change by reducing their GHG emissions.

4
Research method

A mixed method was followed in this research. Keeping in view that regional levels play a major role in contributing to climate change, the sample-frame for this research comprises of all the 64 metropolitan regions/urban agglomerations in India, that consist of a densely populated urban area having population of one million (1,000,000) or more and represent a well-organized administrative, social, and political jurisdiction, were selected to develop the statistical analysis. Qualitative content analysis was used to conduct an in-depth analysis of policy framework of all the 64 regional master plans.

4.1. Calculating climate change mitigation and adaptation index

The climate change mitigation policy index and the climate change mitigation implementation index in this research were calculated by using the «Developing Index Method» and «Plan Implementation Evaluation (PIE) method», respectively. These methods were widely used by many researchers in evaluating the quality and the implementation success of plans (Berke *et al.* 2007, Portney 2003, Engel 2005). This research also tends to use the same technique.

Quantitative climate change mitigation and adaptation policy index identified the extent to which master plans developed climate change mitigation and adaptation policies and climate change mitigation, and adaptation implementation index highlights the extent to which the master plans implemented (put to practice) the climate change mitigation and adaptation policies are developed and theoretically conceptualized as the measure of the extent to which urban planning policies within the development plans promotes climate change mitigation (Raparthi 2021b).

Later, the 64 master plans are evaluated against two evaluation protocols (Table 1 and Table 2). Table 1 describes the protocol against which the master plans were evaluated for the presence of climate change mitigation and adaptation policies. Table 2 describes the protocol against which the master plans were evaluated for their implementation capacity. These protocols are developed based on the existing literature on environmental planning, climate change and plan implementation evaluation. Finally, a theory of planning ac-

tion is developed, which urban planners may tend to incorporate in their early stages of planning steps to address climate change. Planning policies related to land use, urban design, physical planning, building specifications, transportation, environment, incentive tools, educational tools, attainment tools and physical infrastructure of all the 64 master plans are analyzed.

4.1.1. Climate change mitigation and adaptation policy index

The climate change mitigation policy index was developed by evaluating the planning policies within the master plans against the policy evaluation protocol (Table 1). The development of the index includes five steps. Figure 1 highlights the steps undertaken in the research methodology.

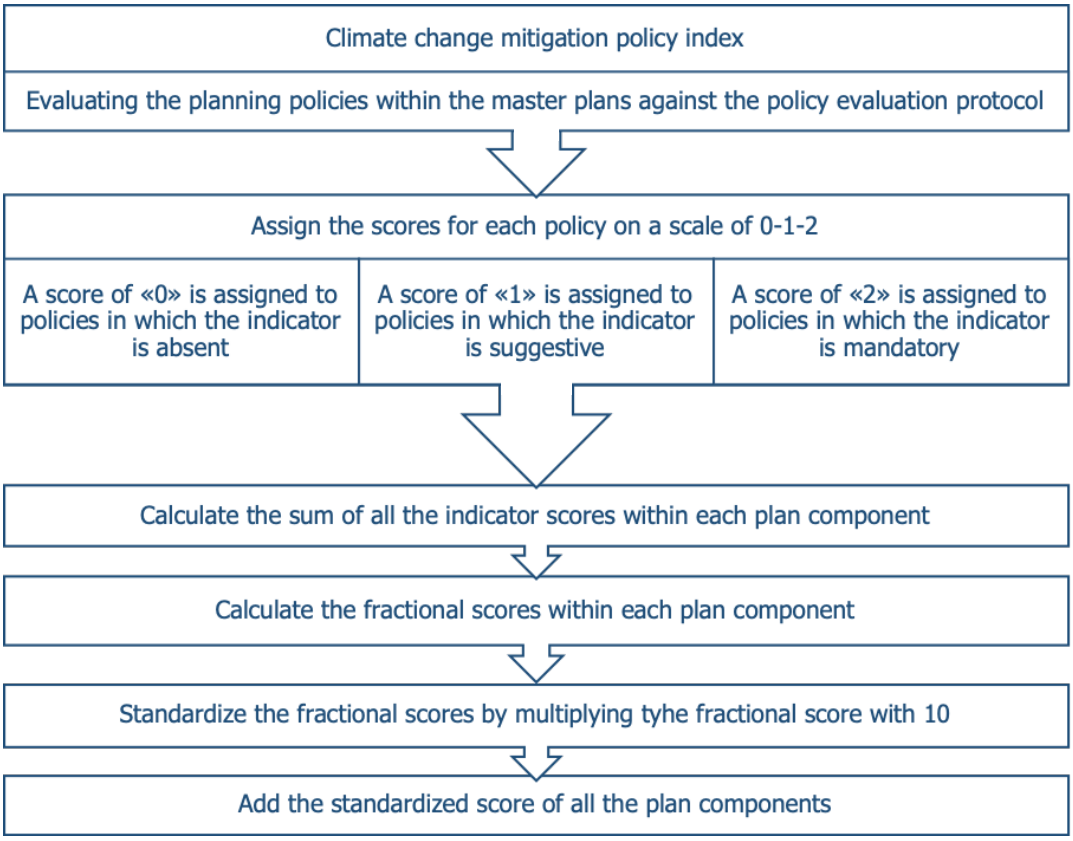

Figure 1
Research methodology

The first step was to assign the scores for each policy on a scale of 0-1-2. Scores will be assigned based on the presence of the indicators that are mentioned in the evaluation protocol (Table 1). If the indicator was absent within a policy, then, the score of the policy was «0». A score of «1» was assigned to policies which address the indicator but tend to be a suggestive policy. Words such as «may», «should», «prefer», «encourage», or «suggest» indicated the suggestive character of the policy. If the indicator was present in the policy and the policy was a mandatory policy, then, that policy receives a score of 2. Mandatory policies usually addressed keywords such as «shall», «mandated», «must», and

«will». The range of these scores was from 0 to 2 (Berke & Conroy 2000, Engel 2005).

The second step was to sum all the indicator scores within each plan component. The third step involves calculating the fractional scores of each plan component. This was achieved by dividing the total of assigned scores for each plan component by the maximum possible scores of the plan component (maximum possible scores imply that all the indicators are mandatory; for example, if there were 5 indicators in a plan component, then the maximum possible score of that plan component was 10).

In the fourth step, the fractional scores were standardized by multiplying the fractional score by 10. So that scores for each plan component can be scaled on a range between 0 and 10 (as shown in Equation 1):

$$SC_j = \frac{10}{2\,m_j} \sum_{i=1}^{m_j} \mathrm{I_i} \quad \text{(Equation 1)}$$

Where SC_j represents the j^{th} plan component standardized score; m_j represents the number of indicators within the j^{th} plan component (scale 0-10); I_i represents the i^{th} plan components' scores (scale 0-1-2).

The fifth step involved calculating, the mitigation policy score of a city's master plan. This was achieved by adding up the standardized score of all the plan components (as shown in Equation 2):

$$Policy\ Index_{City1} = SC_a + SC_b + SC_c + \cdots SC_j \ \text{(Equation 2)}$$

Where $Policy\ Index_{city1}$ represents the climate change mitigation policy index of region 1's master plan; SC_a, SC_b, SC_c... SC_j represent the standardized scores of the plan components in region 1's master plan. The climate change mitigation policy index ranges from 0 to 100.

Plan Component	Recommended Climate Change Mitigation Indicators
1. Land use	Promotes: 1. Mixed use development 2. Brownfield (or Greyfield) redevelopment 3. Infill development 4. Limiting use or limits use of hazardous areas/marginal areas (overlay zones/reduced densities)
2. Urban design	Promotes: 5. High density development 6. Urban landscape development 7. Has proposals/actions to decrease urban heat island effect 8. Has regulations on building height/orientation guidelines, street width to building height ratios
3. Physical planning	Requires: 9. Site plan review for land suitability assessment 10. Setbacks/buffers 11. Subdivision regulations

Plan Component	Recommended Climate Change Mitigation Indicators
4. Building specifications	Requires/promotes use of: 12. Solar PV panels and wind turbines on roofs 13. Storage, collection, and recycling of wastes 14. Water-efficient construction 15. Recycling of grey-water 16. Rainwater harvesting 17. On-site water treatment 18. Building standards/code for enhanced protection
5. Transportation	Requires/promotes use of: 19. Creating/implementing/enhancing public transportation systems 20. Transit oriented developments 21. Car sharing and car pooling 22. Increased public transportation stops/nodes 23. Creation/upgrading of bicycle paths 24. Creation/upgrading of pedestrian facilities 25. Management of no traffic zones
6. Environment	Promotes: 26. Environmentally sensitive area protection (national/state parks) 27. Conservation of forests, vegetation, and riparian areas 28. Creating wildlife corridors 29. Preventing habitat fragmentation 30. Sediment and erosion control regulation 31. Wetlands restoration
7. Incentive tools	32. Subsidized mass transit/incentives for car pooling 33. Impact fees for development in ecologically sensitive areas 34. Density bonuses
8. Educational tools	35. Education and outreach program during plan implementation 36. Training/technical assistance to developers or property owners
9. Attainment tools	37. Land and property acquisition 38. Transfer/purchase of development rights
10. Physical infrastructure	39. Maintenance of public Infrastructure 40. Capital improvements for developments

Table 1
Dimensions and parameters of the CCMI: Plan Evaluation Protocol

4.1.2. Climate change mitigation implementation index

In addition to the master plan's policy evaluation for climate change mitigation, the implementation potential of the master plan was also assessed using the plan implementation capacity evaluation protocol, that consists of ten implementation indicators (Table 2). Absence of the implementation indicator was coded as «0». A score of «1» was given if the implementation indicator was «mentioned but not in detail» (suggestive). Indicators that were «mentioned in detail» (mandatory) were assigned a score of «2».

The implementation index of a city was calculated as the ratio of the indicator capacity score received by each city's plan to the maximum possible score any city plan can achieve and multiplied

it by 100 (in this research, the maximum possible points any city can achieve is 20 points —10 × 2—, since there were 10 indicators against which the implementation capacity of a city was being evaluated):

$$Implementation\ Index_{City1} = \left(\frac{Indicator\ Capacity\ Score}{20}\right) \times 100 \text{ (Equation 3)}$$

The climate change mitigation implementation index ranges from 0 to 100. Assuming that for a city's plan all the 10 implementation indicators were «mentioned in detail», then the Implementation Score is (10 × 2) / 20 multiplied by 100, which is 100.

Accordingly, by calculating both (the climate change mitigation policy index and implementation index for each city master plan), it was able to deduce whether planning polices within the master plan had an ability to influence climate change mitigation within the city. Thereby address the research question: do master plans include and promote policies that target climate change mitigation? As such, climate change mitigation policies indexes were theoretically conceptualized as the measure of city master plans to include and promote urban planning policies that significantly promote climate change mitigation/adaptation.

	Implementation Indicators
1.	Initiation of Non-Governmental Organizations (NGOs), Community Development Centers (CDCs), Research Institution
2.	Designation of responsibility for implementation
3.	Funding for implementation
4.	Timetable for implementation
5.	Sanctions for failure to implement
6.	Regular update of the projects
7.	Provisions for technical assistance
8.	Monitoring of environmental and human impacts
9.	Public participation process in monitoring and review
10.	Provision of plan response to new information/data

Table 2
Dimensions and parameters of the CCMI: Plan Implementation Protocol

5
Results and discussion

5.1. Land use component

A detailed statistical summary of the four indicators that were included in the land use component is provided in Table 3. It was observed that most of the plans addressed the mixed-use development indicator in detail. Besides, the limiting use of marginal zones/hazardous areas indicator, though it was mentioned through reduced densities or overlay zones, it was not addressed in detail. Among all the plans that were evaluated, it was identified that the mixed-use development indicator and the limiting use of marginal zones and hazardous areas indicator was addressed in detail. The brown field development indicator was absent in 15 plans, and only 29 plans have addressed this indicator in detail. Infill development indicator was also not addressed by many metropolitan regions/ urban agglomerations.

Almost 12 plans did not have any planning policy that addressed this indicator. Amongst all the plans that addressed this indicator to some extent, nearly half of the plans addressed this indicator in detail. Thereby, highlighting that this policy is neutral. Regarding limiting use of marginal areas/hazardous areas with the exception for nine plans that were analyzed, the remaining plans had planning policies that addressed limiting use of marginal areas/hazardous areas with overlay zones or reduced densities. Detailed analysis of each indicator further reveals that the mixed land use development was addressed in detail. However, the other two indicators (Brownfield indicator and the infill development indicator) within the land use component were not mentioned in detail. Hence, it was analyzed that there is a need for metropolitan regions/urban agglomerations to develop policies related to limiting uses of marginal areas to address climate change effectively.

Indicators	Coded 0	Coded 1	Coded 2	% of plans coded (1)	% of plans coded (2)	Mean score (max. = 2)	Mean standardized score (SC)
Mixed use developments	0	9	55	14	86	1.86	6.26
Brownfield (or Greyfield) redevelopment	15	20	29	31.2	45.3	1.35	
Infill development	12	22	30	34.3	46.8	1.36	
Limiting use of marginal areas/ hazardous areas	9	44	11	86	17	0.44	

Table 3
Land Use Component

5.2. Urban design component

Regarding urban design component, there are four indicators that are included in the plan evaluation protocol. A detailed statistical summary of the four indicators is provided in Table 4. Among all the plans that were evaluated, it was observed that 45 master plans had policies that addressed the high-density development indicator, with only 2 plans that did not address the indicator. As such, it was identified that the high-density development indicator is addressed in detail by 70.3 % and the urban landscape development indicator was addressed in detail by 62.5 %. The urban heat island effect indicator was absent in 13 plans, and 30 plans had addressed this indicator in detail. The building height/orientation guidelines indicator was absent in 14 plans and was addressed in detail by 32 plans (50 %). This indicates that most of the development addressed this indicator in detail by focusing on higher density development. This was in accordance with the increased consideration and focus on sustainability since 2005. On the other hand, the urban landscape development has a mean indicator score of 1.52 points. Besides, the building height/orientation guidelines indicator received a very low detailed indicator score of 1.40 points. The urban heat island effect indicator has a detailed indicator score of 1.36 points. This overall indicator scores specify that most of the indicators are addressed in detail. Overall, detailed indicator scores of most of the indicators within this plan component indicate that this indicator was addressed in detail.

Indicators	0	1	2	% of (1)	% of (2)	Mean score (max. = 2)	Mean standardized score (SC)
High density development	2	17	45	26.5	70.3	1.70	
Urban landscape development	9	15	40	23.4	62.5	1.52	
Urban heat island effect (urban forests, and tree lined streets)	13	21	30	32.8	46.8	1.36	6.12
It has regulations on building height/orientation guidelines, and street width to building height ratios	14	18	32	28.1	50	1.40	

Table 4
Urban design component

5.3. Physical planning component

Regarding the physical planning component, there were three indicators that were included in the plan evaluation protocol. Table 5 shows a detailed summary of the three indicators that are included in site planning component. Detailed analysis of the indicators further reveals that among the three indicators, site plan review for land suitability assessment has high indicator scores of 1.58. The setbacks/buffer indicator have a low detailed indicator score of 1.46 points. However, the subdivision regulations indicator has a score of 1.38.

Indicators	0	1	2	% of (1)	% of (2)	Mean score (max. = 2)	Mean standardized score (SC)
Site plan review for land suitability assessment	8	12	44	18.75	68.75	1.58	
Setbacks/buffers	9	19	36	29.6	56.25	1.46	6.29
Subdivision regulations	12	21	31	32.8	48.4	1.38	

Table 5
Physical planning component

5.4. Building specifications component

A detailed statistical summary of the seven indicators that are included in the building design component is provided in Table 6. The solar Photo Voltaic (PV) panels and wind turbines on roofs indicator and building standards/code for enhanced protection indicator was almost addressed by all the 64 master plans. It was observed that the solar PV panels and wind turbines on roofs indicator and the building standards/code for enhanced protection indicator were almost addressed. This indicator was the most addressed indicator next to the storage, collection, and waste recycling indicator. Apart from the solar PV panels and wind turbines on roofs indicator, it was analyzed that the storage, collection, and waste recycling indicator was most addressed in the master plans. Building standards/code for enhanced protection indicator was addressed to some extent. However only 36 (56.25 %) of these plans had mandated compliance to this indicator. The water-efficient construction indicator was addressed by only 49 plans. Recycling grey-water indicator was not addressed by 14 plans. Very little consideration was given to the rainwater harvesting indicator

by the metropolitan regions/urban agglomerations. On the other hand, on-site water treatment indicator was addressed to some extent by 32 plans and only 22 plans addressed it in detail. The only indicator that has a relatively high detailed indicator score within this component is the storage, collection, and waste recycling indicator. Overall, most of the indicators in this component have low indicator scores thereby, indicating that this indicator was mainly regarded as a suggestive indicator.

Indicators	0	1	2	% of (1)	% of (2)	Mean score (max. = 2)	Mean standardized score (SC)
Solar PV panels and wind turbines on roofs	0	12	52	18.75	81.25	1.81	
Storage, collection, and waste recycling	10	13	41	20.3	64.06	1.54	
Water-efficient construction	5	49	10	76.5	15.6	0.54	
Recycling of grey-water	14	26	20	40.62	31.25	0.81	5.30
Rainwater harvesting	14	32	18	50	28.1	0.72	
On-site water treatment	10	32	22	50	34.6	1.24	
Building standards/ code for enhanced protection	0	28	36	43.75	56.25	1.46	

Table 6
Building specifications component

5.5. Transportation component

A detailed statistical summary of the seven indicators that are included in the transportation component is provided in Table 7. It was analyzed that almost all the master plans included policies that were related to reducing CO_2 emissions by improvising and enhancing public transportation systems within the metropolitan regions/urban agglomerations. However, only 40 plans (62.5 %) have addressed the increased public transportation stops/nodes indicator and the management of no traffic zones indicator this indicator in detail. Likewise, the creation/upgrading of pedestrian facilities indicators were addressed by 54 plans as a suggestive policy. It was analyzed that the creating/implementing/enhancing public transportation indicator received the highest mean indicator score and the creation/upgrading of pedestrian facilities indicator received a low mean indicator score. Thereby, indicating

that this policy was considered as only a suggestive policy. Overall, most of the indicators within this plan component received mean indicator scores between 1.4 and 1.8 points. This high indicator scores of 1.78 for creating/implementing public transportation systems and 1.73 for transit-oriented developments suggests that most of the plans have considered these indicators in detail.

Indicators	0	1	2	% of (1)	% of (2)	Mean score (max. = 2)	Mean standardized score (SC)
Creating/ implementing/ enhancing public transportation systems	0	14	50	21.8	78.1	1.78	
Transit oriented developments	5	12	47	18.7	73.4	1.73	
Car sharing and car pooling	11	18	35	28.1	54.6	1.44	
Increased public transportation stops/ nodes	4	20	40	31.2	62.5	1.52	8.36
Creation/upgrading of bicycle paths	8	16	40	25	62.5	1.52	
Creation/upgrading of pedestrian facilities	10	20	34	28.1	53.1	1.43	
Management of no traffic zones	6	22	36	34.3	56.25	1.46	

Table 7
Transportation component

5.6. Environment component

A detailed statistical summary of the six indicators that are included in the environment component is provided in Table 8. The conservation of forests, vegetation, and riparian areas indicator was included in detail. It was analyzed that the wetlands restoration indicator was addressed by 51 plans in detail. The sediment and erosion control regulation indicator were addressed in detail by only 18 plans. The preventing habitat fragmentation indicator was not addressed in detail. Thereby, they indicate lack of attention to environmental activities within the metropolitan regions/urban agglomerations. However, it was analyzed that regions were more focused in addressing environmentally sensitive area protection indicators and promoting forest conservation indicators within their environment component.

Indicators	0	1	2	% of (1)	% of (2)	Mean score (max. = 2)	Mean standardized score (SC)
Environmentally sensitive area protection (national/ state parks)	18	16	30	25	46.8	1.36	
Conservation of forests, vegetation, and riparian areas	14	12	38	18.7	59.3	1.49	
Creating wildlife corridors	20	16	28	25	43.7	1.33	6.10
Wetlands restoration	13	25	26	39	40.6	1.30	
Sediment and erosion control regulation	14	32	18	50	28.1	0.72	
Preventing habitat fragmentation	5	49	10	76.5	15.6	0.54	

Table 8
Environment component

5.7. Incentive tools component

A detailed statistical summary of the six indicators that are included in the incentive/disincentive tools component is provided in Table 9. It was analyzed that the subsidized mass transit and the use of density bonuses indicator were most addressed in the incentive tools component of most of the master plans. These two indicators were addressed by providing tax incentives for the companies that provided their employees with discounted passes for using mass transit. Besides, incentives were also provided to developers for expanding real estate near transit points and subsidized mass transit costs with an intention to increase ridership. On the other hand, it was observed that the impact fees for development in ecologically sensitive areas indicator by including provisions for imposing impact fees for new development received a comparatively low mean indicator score of 1.25 points meaning that this was not addressed in detail.

Indicators	0	1	2	% of (1)	% of (2)	Mean score (max. = 2)	Mean standardized score (SC)
Subsidized mass transit/incentives for car pooling	8	24	32	37.5	50	1.40	
Impact fees for development in ecologically sensitive areas	21	20	23	31.23	35.9	1.25	5.39
Density bonuses	18	22	24	34.3	37.5	1.27	

Table 9
Incentive tools component

5.8. Educational tools component

A detailed statistical summary of the two indicators that are included in the education component is provided in Table 10. It was analyzed that both the education and outreach programs during plan implementation indicator and the training/technical assistance to developers or property owner's indicator were addressed to some extent. Thereby suggesting that the master plans considered providing training/technical assistance to developers and property owners.

Indicators	0	1	2	% of (1)	% of (2)	Mean score (max. = 2)	Mean standardized score (SC)
Education and outreach program during plan implementation	0	24	40	37.5	62.5	1.52	5.68
Training/technical assistance to developers or property owners	0	28	36	43.75	56.25	1.46	

Table 10
Education tools component

5.9. Attainment tools component

A detailed statistical summary of the two indicators that are included in the acquisition component is provided in Table 11. It was analyzed that the land and property acquisition indicator and the transfer/purchase of development rights indicator was addressed in detail.

Indicators	0	1	2	% of (1)	% of (2)	Mean score (max. = 2)	Mean standardized score (SC)
Land and property acquisition	8	24	32	37.5	50	1.40	5.24
Transfer/purchase of development rights	10	32	22	50	34.6	1.24	

Table 11
Attainment tools component

5.10. Physical infrastructure component

A detailed summary of the two indicators that were included in the physical infrastructure and facilities component are provided in Table 12. It was analyzed that this component has a mean standardized score of 3.8. The capital improvements for developments indicator were addressed to some extent by 48 of the 64 plans. Twelve plans did not address this indicator at all in their master plans. Likewise, the maintenance of public infrastructure indicator was also addressed to some extent. Fourteen metropolitan regions/

urban agglomerations did not address this indicator in their master plans. It was further analyzed that the capital improvements for developments indicator and the maintenance of public infrastructure indicator was not addressed in detail.

Indicators	0	1	2	% of (1)	% of (2)	Mean score (max. = 2)	Mean standardized score (SC)
Capital improvements for developments	12	28	20	43.7	31.2	0.81	3.80
Maintenance of public infrastructure	14	32	18	50	28.1	0.72	

Table 12
Physical infrastructure component

5.11. Climate change mitigation and adaptation implementation index

To achieve the effect of the planning policies on climate change mitigation and adaptation, it was essential to evaluate the plans against an implementation protocol. All the sampled plans were evaluated against 10 implementation indicators. 1) initiation of NGOs and research institution, 2) designation of responsibility for implementation, 3) identification of costs/funding for implementation, 4) timetable for implementation, 5) sanctions for failure to implement, 6) provisions for technical assistance, 7) monitoring of environmental and human impacts, 8) public participation process in monitoring and review, 9) provision of plan response to new information/data, and 10) regular update procedures. These are the 10 important indicators that ultimately impact the overall implementation of the plan.

Table 13 displays the plan implementation evaluation results. The master plans received a mean implementation indicator capacity score of 13. This means that the mean implementation index is 65 %; accordingly, meaning that most of the plans have been implemented to some extent.

Indicators	0	1	2	% of (1)	% of (2)	Mean implementation capacity score (max. = 20)
Initiation of NGOs, research institution	3	0	61	0	95.3	13
Designation of responsibility for implementation	6	4	54	6.25	84.3	
Funding for implementation	5	22	37	34.3	57.8	

Indicators	0	1	2	% of (1)	% of (2)	Mean implementation capacity score (max. = 20)
Timetable for implementation	2	32	30	50	46.8	
Sanctions for failure to implement	58	2	4	3.1	6.25	
Regular update of the projects	7	18	39	28.1	60.9	
Provisions for technical assistance	0	20	41	31.2	64.1	13
Monitoring of environmental and human impacts	10	16	38	25	59.3	
Public participation process in monitoring and review	2	18	44	28.1	68.7	
Provision of plan response to new information/data	22	32	10	50	15.6	

Table 13
Policy implementation

Among all the policies that were evaluated with respect to plan implementation, it was analyzed that initiation of NGOs, research institution and designating responsibility for implementation were mostly addressed in all the master plans. With regards to initiation of NGOs, 93.75 % of the institution's research plans referenced NGOs, research institution and provided assessments of various past planning projects/initiatives within their city. Regarding the designating responsibility for implementation, a majority 84.3 % plan had designated specific agencies and departments for the implementation of specific schemes and programs.

It was analyzed that except for two master plans, all the plans have included a timetable for implementation and had public participation in monitoring and review. Amongst those plans that addressed the timeline for implementation guideline/indicator, 30 plans also provided in depth specific details for programs. Amongst those plans that addressed the public participation guideline/indicator, 44 plans mentioned this guideline in detail. 91.6 % of the plans addressed funding of various planning proposals for implementation. Among the plans that addressed this guideline/implementation, 37 plans identified funding for the proposed actions. Sixty-one plans also included provisions for technical assistance during the plan implementation process. It was also analyzed that 89.1 % of the plans addressed policies related to regular updating of the projects.

Surprisingly, 42 plans have policies that addressed the provision of planning response to new information/data. Provisions referred to the ability to adapt new projects in response to any sort of funding changes from the state government. However, only 10 plans addressed this guideline in detail. Among all the 64 plans that were evaluated, 54 plans addressed policies that related to monitoring of environmental impacts. Among these, only 38 master plans have mentioned this guideline in detail. Among all the implementation policies, it is analyzed that most of the plans did not mention sanctions for failure to implement.

5.12. Learning from local practice

Planning for climate change mitigation and adaptation within the cities generally undertook a bottom-up, action centered approach. Most of the reduce climate change mitigation and adaptation activities in these cities were mainly citizen led managed programs. These programs employed an action-oriented, radical approach towards planning. Thereby, it is highlighted that the main determinants for implementing their climate change mitigation and adaptation policies are appropriation of power by the people, political will, knowledge about the concern for the environment, educating residents about the climate change related programs and motivation among developers.

It was analyzed that these cities had environmental related works on their planning agenda. The city planning officials assigned the responsibility of climate change mitigation and adaptation within the city to the local neighborhood NGOs. These NGOs, set priorities for solving the problems as such; implementation was certainly a response to both the environmental problems and city official's pressure. The NGOs created implementation strategies for the climate change mitigation and adaptation projects that were identified in the pre-planning phase with collaboration from the research institutes, deadlines were specified to get them implemented, targets and indicators were set to get measure the plans, and deadlines to the pilot projects. Funding to carry out these projects usually was provided by the city government. However, as each city was distinct from another city in terms of its socio-economic, biophysical, and public policy contexts, it was identified that these two different cities had different climate change agenda and targets, as such responded differently in terms of reducing their CO_2 emissions.

Besides these NGOs reached out to the public create community and capacity building and collaborated with youth empowerment organizations. Accordingly, these NGOs created awareness-raising and mobilized the communities and citizens, encouraged them to get involved in development planning processes. They also promoted capacity building among local-level stakeholders to participate in these processes. These NGOs worked with the residents of the

neighbourhoods and research institutes within the city to provide technical assistance and expanded the process by developing consciousness of the environment among people and involving them in communicative, participatory action planning to find effective feasible solutions and implement them to effectively reduce CO_2 emissions within the city.

6
Analysis of climate change mitigation and adaptation policy index and implementation index

Descriptive statistics of the overall climate change mitigation policy scores and the total policy index are presented in Table 14. The maximum possible score an indicator can receive is 2 and this is possible only if the indicator is addressed to be mandatory in the master plan. For instance, maximum possible score of the transportation component will be 14, if all 7 indicators are addressed as mandatory policies (7 indicators multiplied by 2). Likewise, a minimum possible score of 0 indicates that the plan did not address any of the indicators that have been included in the plan component within the evaluation protocol.

The indicator score for each plan component is a measure of the extent to which that indicator is included in the planning component. The climate change mitigation policy index of a city's master plan is the measure of the extent to which climate change mitigation policies are promoted by that city. If all the 10 plan components of a city's master plan achieved a standardized score of 10, then the mitigation index of such a city will be 100.

Results show that each of the 64 master plans had at least one planning policy related to climate change mitigation (had a significant impact on CO_2 emissions) within their planning components.

As mentioned earlier, the climate change mitigation and adaptation policy index for a city's master plan ranges from 0-100 points. The mean climate change mitigation and adaptation index for all the plans (64 master plans) is 58.54 points, as such representing 60 % of the maximum climate change mitigation policy index. The mean maximum and minimum index ranges from 64 to 15 thereby suggesting that climate change mitigation and adaptation policies and its associated details vary within the communities.

Among the various components, transportation planning has the highest mean climate change mitigation standardized score 8.36 (83.6 %) of the possible maximum component score 10 (100). This means that the plans have made efforts to reduce climate change impacts, by addressing transportation related issues, thereby emphasizing more on transportation planning policies in their master

plans. Comparatively, the mean mitigation standardized score for physical infrastructure component is only 3.80 (38 %) of the possible maximum component score, indicating a lack of attention to these policies in the master plans.

Overall, the mean standardized scores for most of the plan components ranges from 4.0 to 6.0 (40-60 %) of their respective possible maximum component scores (10, 100 %). This suggests that a moderately fair amount of climate change mitigation and adaptation related urban planning policies are present in their master plans. Thereby, indicating that the master plans include policies that target climate change mitigation and adaptation.

Plan component	Number of indicators	Maximum possible score	Mean minimum score	Mean maximum score	Mean standardized score
Land use	4	8	2	7	6.26
Urban design	4	8	4	6	6.12
Physical planning	3	6	2	4	6.29
Building specifications	7	14	2	12	5.30
Transportation	7	14	2	12	8.36
Environment	6	12	2	10	6.10
Incentive tools	3	6	1	5	5.39
Education tools	2	4	1	3	5.68
Attainment tools	2	4	1	2	5.24
Physical infrastructure	2	4	2	3	3.80
Total policy index	40	80	15	64	58.54

Table 14
Climate change mitigation policy index scores

7
Conclusion

Currently, climate change mitigation is approached through national level. The national climate change action plan contains mainly strategies and activities that are relatively consistent in reducing carbon dioxide emissions but lack the regulatory framework and institutional capacity to achieve their goals and objectives. Research

highlights that there is a need to mainstream climate change mitigation and adaptation strategies into respective local land use, transportation, and environmental policies to effectively address climate change. In addition, it is essential to influence individual and organizational behavior to promote behavioral changes that lead to reduced emissions.

This research highlights that most master plans of Indian cities contain several planning policies that address climate change mitigation. However, to comprehend the potential of climate change mitigation policies in the master plans, it is essential to facilitate the implementation of the urban planning policies at the local level. The planning policies that are identified by using the climate change mitigation and adaptation protocol can be helpful in providing climate change mitigation benefits. Hence, as a first step, it is necessary to effectively implement climate change mitigation indicators at the local level.

Currently, Indian cities have very limited resources to achieve a sustainable development. However, there is an immense pressure from higher levels of governance to allocate resources towards climate change mitigation. Allocation of resources towards climate change mitigation is a unique opportunity to develop an integrated urban planning strategy at the local level wherein local master plans acts as a tool for implementing the climate change mitigation actions; for instance, a local planning policy that focuses on increasing the accessibility and availability of public transportation is mostly regarded as a local economic necessity. However, this research highlights that the same local development policy also tends to have climate change mitigation benefits. Hence, use of such policies that have an ability to serve the dual purpose of climate change mitigation as well as local development are most likely able to facilitate cities in accessing climate change mitigation funds thereby add to the local resources that are available for mitigating climate change at the local level. Convergence of urban planning policies will not only help in achieving an efficient utilization of resources but also facilitates a sustainable development.

The major implication of this research is the potential opportunity to develop and integrate climate change mitigation strategies in local urban planning to attain climate change mitigation benefits at the local level. Based on the overall results of this research, the final recommendation is to mainstream climate change mitigation in urban planning. This can be achieved by developing an integrated framework at the local level that bridges the gap between researchers, policy makers' and integrating climate change mitigation goals with the local developmental objectives. If local development policies are effective and are sensitive towards climate change mitigation then, it can be anticipated that the ensuing development would be sustainable.

8
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