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The integration of smart city planning policy with climate change adaptation and mitigation actions: a review of kathmandu

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ABSTRACT Many urban systems worldwide are projected to be affected by the consequences of climate change, such as increased rainfall intensity, storm surge, flooding, and the urban heat island effect. This will significantly impact the management of cities and their populations, and the services they provide. To overcome this effect, adaptation will likely be required. This article examines how climate change moderation and variation are combined with intelligent urban planning policies (strategies, legislation, and laws) in the Kathmandu district. The three governance sciences look at the two levels of governance (national and local) (intelligent urban planning, pollution management, and climate change). The assessment process is one of the few instruments to review the adequacy of climate change and strategic policies. The findings show that intelligent city planning documents should present climate change adaptation and mitigation actions. In addition, adaptation and mitigation measures still need to be well integrated. Significant prospects for greater policy coordination through guidelines and levels of government under the Paris Agreement priorities have been identified, ensuring implementation in land use and planning decisions. Innovative city development policies must be better able to design and implement climate resilience and mitigation measures.

1. INTRODUCTION

Cities play a crucial role in climate change. They are now home to the majority of human beings as well as they are a significant wellspring of greenhouse gas (GHG) pollution (Landauer et al, 2019). Severe weather disasters, bushfires, pollution, and storm flows, are all becoming more common in cities as an effect of climate change (Ireland et al, 2019), along with this trend, there will continue as climate change accelerates. Secondary effects on cities would include the affordability and reliability of smart city water and food sources, as well as the space and location of available tenable space. It is widely recognized that to avert devastating climate change impacts, GHG emissions must be quickly reduced to limit the global temperature boost to 1.5 degrees Celsius over pre-industrial levels by 2100. The Paris Agreement expects to reduce GHG emissions. However, according to the United Nations Environment Program (UNEP) yearly Emissions Gap information, there is a major gap between actual worldwide Green House Gases emanations and the measure of decrease required over a long time to meet the Paris Agreement's objectives. It is likewise recognized it is a prerequisite to respond to unavoidable changes.

Although several steps have been taken to combat climate change in the developed world, they have mostly been based on either adaptation or mitigation (Biesbroek et al, 2009; Reckien et al, 2018). Despite a clear need, there has been no progress in integrating adaptation and mitigation strategies Rosenzweig et al. The Paris Agreement and the IPCC's fifth appraisal study (Denton et al, 2015), as well as other academic contexts, have called for integration (Appiah, 2015; Reckien et al, 2018; Landauer et al, 2019). Integration of adaptation and prevention is critical for preventing the imposition of ineffective policies and facilities, as well as increasing resource efficiency (Appiah, 2015; Landauer et al, 2019; Reckien et al, 2018). Despite this, there has been limited research in Nepal into smart city planning strategies to see whether they discuss adaptation, prevention, or convergence.

Smart city planning aims to manage the activities and spatial form of communities by controlling the use and growth of the land. Smart city development is said to have a major impact on climate change mitigation (Carter et al, 2022; Rannow et al, 2010). However, most urban communities are not tackling climate change to the degree required to reduce environmental change risk, and the success of climate change adaptation plans remains unclear (Seto et al, 2014). With an emphasis on public and state scales, the possibility of climate change at the local level is often overlooked (Ireland et al, 2019). Although smart city development can lead to climate change adaptation and mitigation (Solecki et al, 2018), there is a discrepancy in our knowledge about how policy and regulation address this and what best practices could look like. Though there has been some study of climate change policies (Guyadeen

et al, 2019; Reckien et al, 2018), no reported analysis of the coverage of climate change measures of smart city development policy across all levels of government and through policy regulations has been made.

The study described and intended to reduce the gap. There is a need for the development of a series of standards for evaluating the coverage of climate change adaptation and mitigation, and the inclusion of smart city planning policies (corresponding to the Paris Agreement). Using these principles to assess the coverage of climate change activities in Kathmandu, Nepal's smart city development strategy since there are two levels of government and three disciplines (smart city planning, climate change, and pollution management). Thus, the study issues were addressed by observing the smart city policy fits the climate change mitigation in accordance to maintain worldwide temperature alteration to 1.5 degrees Celsius over pre-modern levels by 2100. Similarly, it also tried to focus smart city policy documents toward climate change adaptation.

This study's results are important in guiding future revisions and developments in smart city policies to conflict with climate change. This is more than ever critical regarding the documented challenges smart city planners face when dealing with climate change, such as complexity and instability in policy mechanisms for climate change adaptation (McClure & Baker, 2018).

2. METHOD

This research is based on a review of literature, reports, a case study, and government activities at the national, state, and municipal levels. The study is categorized as qualitative (Gil, 2008). The technical process employed was a bibliographic search using the Methodi Ordinatio methodology, as described by (Campos et al, 2018; da Silva et al, 2019; Zdepski et al, 2020). There are five steps in the approach. However, because the goal is to map out the state of the art in Smart city planning policy in terms of climate change adaptation and mitigation actions, only the first five steps were used for background information, Kathmandu land use and land cover management, and thus the evaluation criteria were reviewed.

Steps 1–3: Determine the purpose of the research, conduct a preliminary search, and define keywords: the goal was to investigate the policy developed for smart city planning in response to climate change adaptation and mitigation efforts. The search terms were "adaptation and mitigation, climate change, and smart city," with no time limit, and were found on Scopus' Title-Abstract Keywords (TAK).

Step 4: Conduct a final database search: information was gathered using Research Gate and Google Scholar. The search yielded roughly 50 results, which included all types of materials.

Step 5: Filtering procedures: All documents were used because there were no duplicates and they were all aligned with the theme. Excel was used for data processing, while the ArcMap application was used for mapping.

3. RESULTS AND DISSCUSION

3.1 Background Information on the Case Study – Kathmandu, Nepal

The district of Kathmandu is the capital of the country which is located in the central part of Nepal. It covers just 0.034% of the total land area and holds the home of 12.78% of the country's residents. The Kathmandu valley, which includes Kathmandu, Lalitpur, and Bhaktapur, is home to the majority of more than 3.7 million inhabitants by the year 2021. Kathmandu Metropolitan City (KMC) is one of the 11 local government levels in the district. Climate change is having a huge effect on Nepal. Temperatures have risen by over 1 degree Celsius since 1910 at the rate of 0.6□Cyr-1 (Ishtiaque et al, 2017) 0.04□Cyr-1 (Karki et al, 2022) and 0.03 □Cyr-1 (Baniya et al, 2018). Increased temperature has carried extreme heat events, as well as severe fire weather, which has become more frequent. Snow levels have also decreased in mountainous regions, increasing the risk of desertification, and rainfall has decreased from April to October (Biesbroek et al, 2009).

3.2 Land Use Management Policy Framework

Land use is an unavoidable part of land management that serves as a guide to successful land resource planning to realize regional and urban development goals. The land-use arrangement has remained a crucial implementation measure in land administration in Kathmandu, whether in land development plans or land reform policies. When we look at the history of land management in Kathmandu through periodic planning in the 1960s and 1970s national management reforms were implemented with a focus on rural efficiency from the beginning of intermittent planning in Kathmandu. Periodic plans, mainly for forestry and natural resource regeneration and maintenance, have clashed with local management processes since the 1970s and 1980s.

The Eighth Five Year Plan (1992/93-96/97) was a turning point in Kathmandu's land use planning, recognizing it as a long-term effort to address land use issues. The Ninth Five-Year Plan (1997/98-2001/02) was centered on long-term growth for the conservation and expansion of hill and valley ecological sectors by land and natural resource use. The Tenth Five Year Plan (2002/03-2006/07), had as its goal for the land-use region to develop a service-oriented and informative land administration through the implementation of sustainable land use management to increase The key objectives of the above-mentioned plans were to include land use planning dependent on maps arranged at different levels, as well as to define and classify land for horticulture, ranger service, industrialization, and city settlement expansion. Land-use strategy implementation, discouragement of the utilization of agricultural land for non-rural or useless practices, and the improvement of the National Geographic Information System were all included in the five-year plans. One particular agenda has often found its way into almost all subsequent fiscal plans of the Nepalese government: the formulation of effective land management or land use strategy to prevent the utilization of possibly arable land in inefficient city land. Although a National Land Use Policy (NLUP) was drafted in 2013, it was canceled in 2015 and replaced with another Land Use Policy (LUP) in 2016 (Kumar & Geneletti, 2015).

3.3 The Land Use Land Cover Practices of Kathmandu

When compared to previous years' findings, the cover of the built-up area has increased significantly, accompanied by a marginal rise in grassland cover. Water bodies, barren areas, and shrubland all declined dramatically, with water bodies, barren areas, and shrubland all nearly disappearing.

Even though these reductions, forest, and the farming area continued to dominate, covering 168.93 km2 (38.49%) and 165.16 km2 (47.63%) of the total area, respectively. However, the built area extended into agricultural and forest lands, accounting for 99.24 km2 or over 22% of the district's total land area. This reflects a nearly 8% rise since 1990, with long-term management implications such as land degradation and ecosystem services degradation. Rapid urbanization and lack of strict land transfer policies, according to (Ishtiaque et al, 2017)(; Khanal et al., 2019; Paudel et al., 2016) have resulted in the loss of agricultural and forest lands. (Appiah, 2015)(Khanal et al., 2019) further mentioned that after the civil war ended in 2006, Kathmandu's urbanization rate accelerated. The small increase in grassland is most likely due to deforestation and the depletion of agricultural land.

The land use and land cover class change pattern study suggests the course of land class changes based on their respective initial years as a guide (Appiah, 2015). Forest and agricultural coverage have both decreased by 17.28 km2 (9.28 percent) and 17.95 km2 (9.80 percent), according to the findings. Similar trends have been found in previous studies in (Paudel et al, 2016), such as the Kathmandu valley (Ishtiaque et al, 2017; Khanal et al, 2019), and elsewhere in the world (Hadi et al, 2014; Huang et al, 2008; Liping et al, 2018). Unsustainable forest resource use, drought (Appiah, 2015)(lack of irrigation water), land conversion to city and settlement centers, and climate change impacts all have the potential to degrade ecological services and increase food insecurity.

From 1990 (14.83%) to 2010 (22.61%), the built-up area increased by 52.47 percent, resulting in a substantial rise in the built-up area of 34.15 km2. This rapid expansion of the built-up region backs up a previous study by the United Nations Department of Economic and Social Affairs and subsequent studies by other researchers (Ishtiaque et al, 2017; Khanal et al, 2019; Paudel et al, 2016) who stated that Kathmandu, and Nepal in general, are experiencing uncontrolled and unplanned urbanization. By (Appiah, 2015), land use divisions such as forest and agriculture had transitioned into other land uses, as shown by the findings. Rapid urbanization is largely responsible for the transformation of rural and forest lands into developed areas. Population growth in neighboring cities and built-up areas along main roads has been exacerbated by the creation of new cores. Previous research in the Kathmandu Valley (Ishtiaque et al, 2017; **?**; Paudel et al, 2016) found that after the civil war ended in 2006, the rate of urbanization and its spread outwards from the urban core skyrocketed, followed by renewed development. Grassland coverage has risen by 62.36%, meaning that forest lands are being destroyed and grasslands are taking their place.

In the sense of Nepal, encroachment over cultivable lands, government and public lands, forests, and different natural resources is extensive nowadays, as a result of the rapidly increasing populace, domestic migration, and uncontrolled and hasty urbanization, among other factors, and the security thereof has now become a challenge (Kumar & Geneletti, 2015). Rural, private, industry, agricultural, mines and minerals, social and archaeological zones, river and lake-reservoir zones, forest zones, public use, and open space zones, excavation zone for building materials (sands, stone, concrete), and other zones are defined by LUP Policy No. 1. While the LUP promises to put an end to the practice of letting bare land rot, it also envisions a sanitary, lovely, well-facilitated, and prosperous human settlement, as well as planned and sustainable regional urbanization.

Numerous levels and fields of government strategy influence smart city planning for climate change mitigation and adaptation in Kathmandu. The Climate Change Act 2017 (hereinafter referred to as the CC Act) is the most important piece of climate legislation in the Kathmandu Valley. The Climate Change Act (CCA) and Kathmandu's Climate Change Framework (CCF) are two significant reports that outline the city's response to climate change. The Climate Change Adaptation Plan for Kathmandu 'spreads out a framework for the activity that will assist Kathmandu to face threats and respond on the opportunity of climate change,' according to the plan.

3.4 Climate Change Mitigation

When comparing mitigation through the twelve policy documents examined, seven of the twelve specifically reference mitigation. Five of the documents have goals aligned with the Paris Agreement. Planning for a Smart City and Pollution Guidelines are not addressed as well as mitigation. Three of the basic mitigation measures are not addressed at all.

The need to address climate change was noted in all but one of the planning documents designed to define sustainable energy management through frameworks such as a smart city development boundary (which could have a climate change benefit), but they do not justify it. While numerous studies undertaken over time have legislated the operation of the Planning Scheme, the specifics of how planning could or could be used to promote results are missing. Only the smart city planning of Kathmandu and its implementation activities position mitigation actions where the largest number of mitigating actions are outlined in the planning documents. To achieve the aim of reducing GHG emissions, a range of findings are used, such as increased energy productivity of green infrastructures and efforts to encourage the take-up of sustainable and low-emission energy technologies. Different alternatives for reducing emissions (regardless of being outlined for livability instead of climate benefits) incorporate moving future improvement in existing areas, dim fields, and key development halls, such as using a smart city development limit, the production of 20-minute neighborhoods via nonmotorized means of transportation, and making of walkable areas.

Two actions that can help reduce GHG emissions are a superior structure plan and the utilization of 'elective energy produced nearby.' Implicit reactions include increasing blended use and density, thereby promoting overall efficiencies, especially in transportation. The use of information technology technologies (ICTs) for smart city consolidation is not clear, as ICTs are often used to characterize regeneration that is concerned with current low-density communities in smart cities. Mixed-use designs are typically viewed favorably, with the implied advantage of improved energy, water, material, and transportation quality. Since this study guide is largely based on directing the introduction of Green Infrastructures, most of the work to accomplish pollution reduction comes under the Zero Net Emissions Framework (ZNEF). Nonetheless, several academics discuss the potential climate effects on en-

vironmental factors and emphasize the need to achieve climate neutrality where possible. Furthermore, the pollution guidelines imply that emissions should be minimized, but consumers of this plan are under no obligation to do so.

3.5 Adaptation to Climate Change

Climate change is accelerating at a faster pace in the high Himalayas than in numerous different pieces of the world, influencing both humans and natural systems]. Climate-related hazards including erratic rainfall, flash floods, drought, forest fires, and landslides are likely to become more common later on in Kathmandu. Due to factors such as high immigration and overexploitation of natural resources, Kathmandu is more vulnerable to climate change than many other cities. If action is not taken now to build resilience and adaptability, climate change would almost certainly be increased in the future.

Inferable from the absence of capacity and a weak economy, climate change adaptation is difficult. Human weakness to climate change is connected to poverty, isolation, dependence on rain-fed agriculture, a deficiency of social services, and insufficient alternative livelihoods. It's likewise connected to socioeconomic inequity, a lack of data and information, and prohibition from significant dynamic cycles. Biological systems and individual species are likewise in danger, and the temperatures and non-climate pressures in Nepal are likely to exacerbate this. The significance of adaptation in the worldwide response to climate change is now widely recognized. Development actors are gradually pursuing a community-based methodology that recognizes the specific dangers faced by poor people and burdened, as well as an environment-based methodology that has expanded to include biodiversity and biological system services as a feature of a broader transformation strategy to assist weak individuals in adapting. The Hariyo Ban Program, which is being piloted by WWF and CARE, has been pioneering a coordinating way to deal with the variation that incorporates both environment and community-based methodologies.

The Hariyo Ban Program will assist people, habitats, and wildlife in better understanding environmental change effects and adaptation goals, just as to create community-led adjustment mechanisms that are embedded in nearby bodies, define equitable, comprehensive, and practical activities for coordinated adaptation approaches, and investigate how to best connect the lowest level and highest level approaches to learning (LAPA).

Climate change adaptation was not tended to in the National Land Use Policy (NLUP) and was only addressed explicitly in planning documents in Kathmandu City Planning. Among the adaptation issues described in the NLUP are expanded evaporation, diminished precipitation, the heat-island impact, and extreme heat. Reduced rainfall, pollution/immersion, and bushfire, as well as expanded interest in fundamental services, increasing food costs, food shortages, infrastructure disruption, dust storms, stormwater quality, and poor air quality, are all concerns.

Climate change is stated many times in the National Land Use Policy (NLUP), with the policy's key objective emerging to be the preservation of the established nature of municipalities and landscape in the sense of a complex Kathmandu valley. While town boundaries are mentioned frequently, the main function of boundaries appears to be to maintain character, with only a couple of notices of their advantages for working with dynamic and maintainable transportation. The process for maintaining town boundaries by municipal planning systems and thus these lines genuine dynamic on this part of the policy is delegated to local government. The retreat is regarded as an opportunistic intrusion for human uses in which the city area is 'not needed' and 'no provision of help for city operation' is made. Protect isn't stated or implied, and accommodate isn't mentioned or implied, even when it's not suggested, because it keeps city vegetation communities from withdrawing. Despite the lack of land use planning or proper procedure, protection is often used with regard to safeguarding biodiversity and forest environments for their critical significance as 'blue carbon' sinks, meaning that forest ecosystem protection is a mitigation strategy.

The Smart City Planning Guidelines recognize NLUP as a critical approach for responding to climate change impacts. The strategy mentions several phenomena, such as "top streams," "pollution," "the heat island impacts," and "changing natural flow systems," many of which are related to climate change but aren't frequently disused explicitly in the Guidelines. With approaches that regard river, productive land, and deforestation impacts, the Pollution Guidelines recognized Kathmandu's "climate inconsistency" and "climate change." The Pollution Guidelines provide a wealth of information about how to respond to pollution caused by climate change, the majority of which is in the form of smart city planning, parts, and building configuration suggestions to cope with a "1% annual exceedance probability pollution level" (1 percent risk where significant emissions would occur in any given year). The shield is seen as untrustworthy, as shown by the fact that 'permanent or temporary pollution dividers, pollution hindrances, levees, or other pollution control systems are often proposed for new construction. They're not infallible, and they're just useful for protecting existing structures. They shouldn't be used to confirm green structures or green infrastructure in high-risk areas or to make up for green infrastructure floor-level requirements.

3.6 Integration of Climate Change Mitigation and Adaptation

The researchers should have looked at explicitly combining adaptation and mitigation strategies. On a few occasions, the Climate Change Adaptation Plan suggests convergence, such as adaptive results are noticeable to create a co-advantage for mitigation. For instance, improved energy proficiency is viewed as a way to minimize the release of GHGs while still ensuring supply protection. Similarly, the Climate Change Framework combines adaptation and mitigation but does not use "integration." Integrating mitigation and adaptation into a single system aims to push Kathmandu's energy and different processes into a new, radically diverse equilibrium. "Reducing pollution and building strength," "while reducing emissions will go some way toward mitigating climate change, we must prepare for the already unavoidable effects of climate change," and "speeding up the progress to a net-zero emission and climate-resilient Kathmandu," are just a few examples. Despite the Framework's commendable ability to meaningfully integrate mitigation and adaptation, the strength and potential that the concept of integration would have added to the Plan still need to be fully appreciated. Moreover, considering Kathmandu's track record of sustained policy ex-

ecution (Buxton et al, 2010), and potential contradictions with other strategic plans, progress remains to be determined.

The intelligent city planning policies studied should have addressed climate change mitigation and adaptation. The requirement for mitigation and adaptation is described as 'one of the main issues molding the strategy' for planning Kathmandu as a Smart City. However, the plan notes that "adapting to climate change is linked to taking purposeful steps to control and reduce possible impacts," meaning that "relieve" applies to a different choice than emissions reduction. This is also evident in Kathmandu's Planning Implementation, where "mitigation" is only used in the phrase "threat mitigation," with climate change phenomena seen as the primary means of mitigating dangers to property and lives. Despite its optimism, the plan's overriding focus is on growth and progress, which is unlikely to be compatible with the magnitude and nature of the energy transition that will almost certainly be needed. Regarding pollution regulation, there is a consensus that NLUP should be climate-susceptible, implying some integration.

4. CONCLUSION

This study shed light on Planning Kathmandu city as a smart city for climate change preparation, and how much the need is to reduce GHG emanations and adjust to climate change. By glancing through the sizes of government and authority, the results add to the limited studies focusing on a strategy to combat climate change (smart city planning; climate change, and pollution management). Generally, the study discovered Kathmandu has expressed clear goals for climate change mitigation that fit with the Paris Agreement point of preventive warming to 1.5 degrees Celsius above pre-industrial levels by 2100. These papers place a strong emphasis on the electro sector's potential for emissions reduction, with little attention paid to the variety of land use planning and strategy frameworks that could aid in planning the smart city with discharge reduction and adaptation activities.

Overall, the study found that there are substantial opportunities in Kathmandu, Nepal, for policies to be better aligned and implemented across disciplines and government levels in order to achieve climate change objectives and guarantee that they are enforced in land use and growth decisions. The study identifies the main areas in Kathmandu where climate change legislation, policy, and strategic strategy could be explored. The proposed framework could be extended to incorporate a more extensive scope of mitigation and adaptation measures, such as low-carbon development codes and design requirements, or blue and green carbon storage zoning. It can also be adjusted for use in a variety of different situations all over the world. More analysis into other contextual analyses and real decisions, as well as a comparative review of different situations, would contribute to this vital area of research to address climate change under global goals.

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