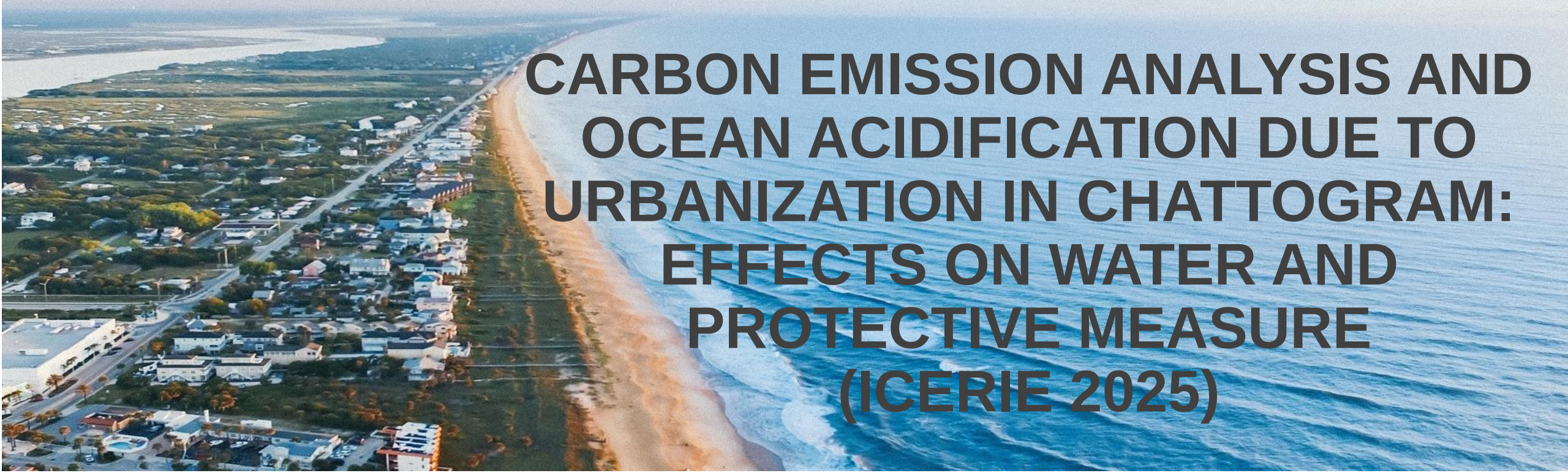

CARBON EMISSION ANALYSIS AND OCEAN ACIDIFICATION DUE TO URBANIZATION IN CHATTOGRAM: EFFECTS ON WATER AND PROTECTIVE MEASURE (ICERIE 2025)

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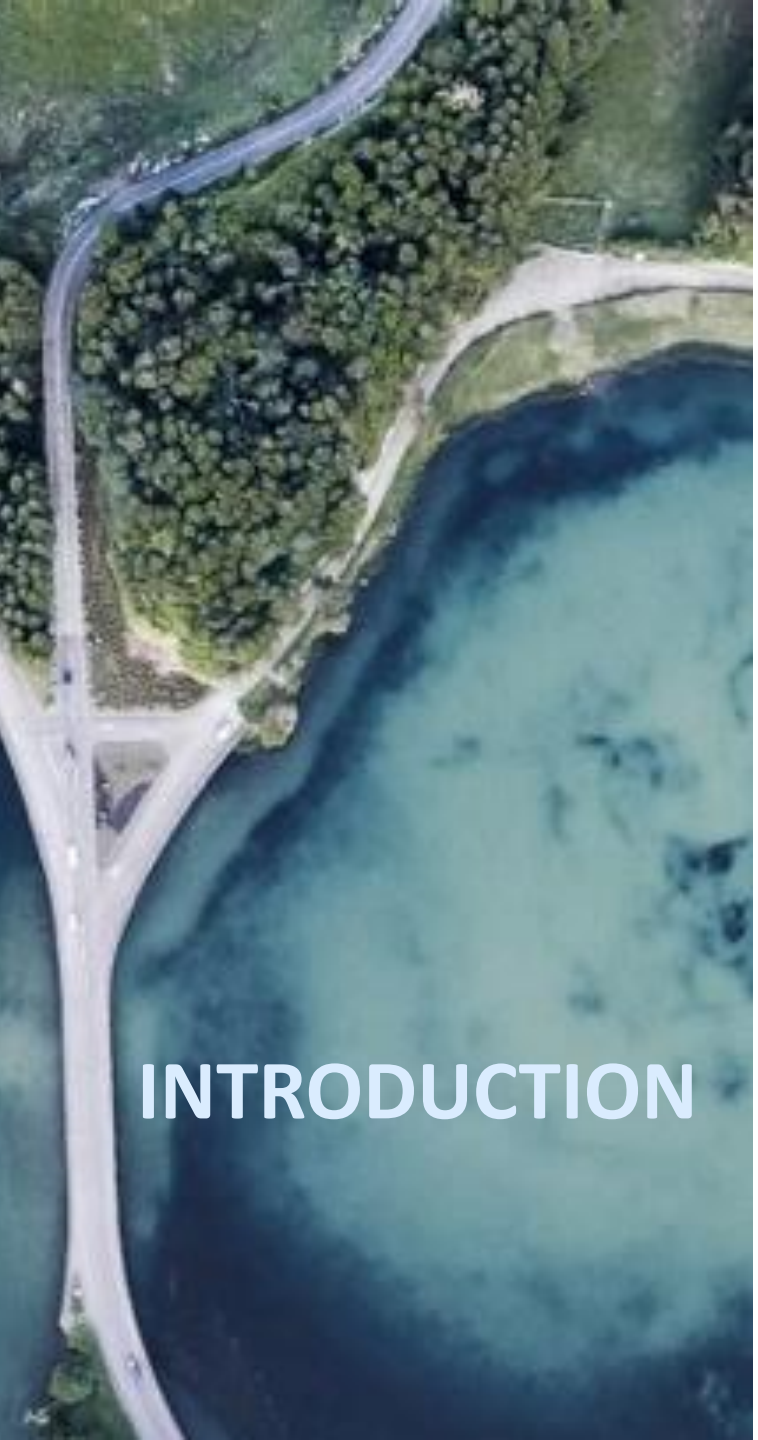


INTRODUCTION

- **Chattogram has experienced substantial urbanization** in recent decades as a rapidly expanding industrial and urban center (Samad, 2015).
- Growing energy use, industrial areas, and transportation networks have all resulted in a frequent rise in carbon emissions, which has raised atmospheric CO_2 levels.
- **Coastal waters eventually absorb this surplus CO_2**, which speeds up **ocean acidification** and changes the equilibrium of marine ecosystems (Emerson & Hamme, 2022).
- Environmental stress is exacerbated by the **unchecked growth of urban infrastructure**, which causes deforestation, increased runoff pollution, and altered land use patterns.
- This study highlights the pressing need for sustainable urban planning and emission control measures by examining how these urbanization-driven factors contribute to **the rising fCO_2 levels in Chattogram's coastal waters.**
- **Rising CO_2 levels in the atmosphere cause ocean acidification,** which threatens marine biodiversity and ecological services.

Background of the Study

- A research project conducted **in 2013** calculated that **29,926 tons** of carbon emissions were released annually in Bangladesh (Randall et al., 2015).

- **Human activities** including **industrialization**, **urbanization**, and **fossil fuel consumption** cause CO_2 levels to grow.

Bangladesh's consumption-based CO_2 emissions have consistently climbed over the past two decades **Fig 1**, indicating a rising reliance on carbon-intensive imports, according to Global Carbon Atlas (GCA).

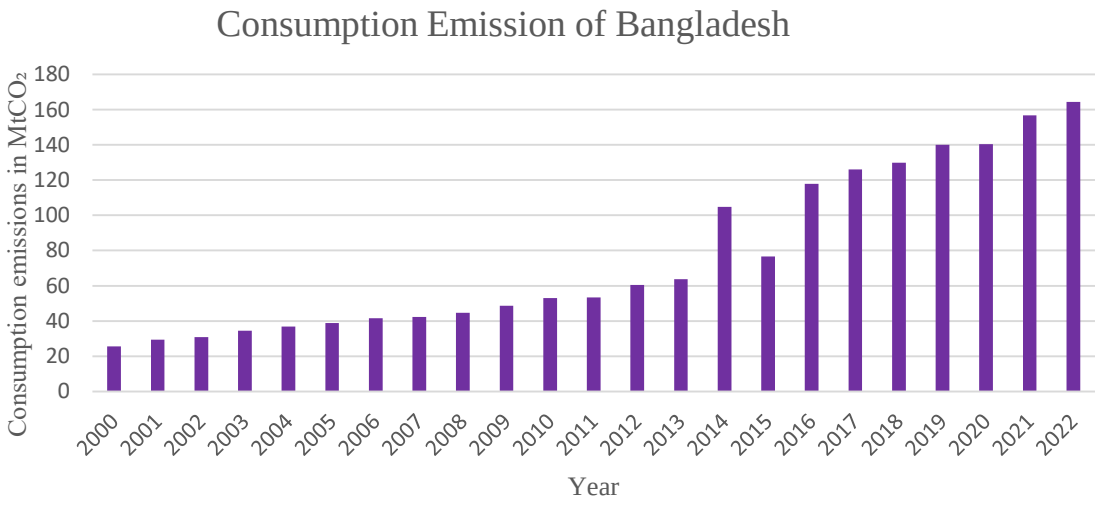


Fig 1: Consumption Emission of Bangladesh over years

- Ocean acidification is **the progressive reduction in pH** caused by the **absorption of excess CO_2** from the atmosphere.

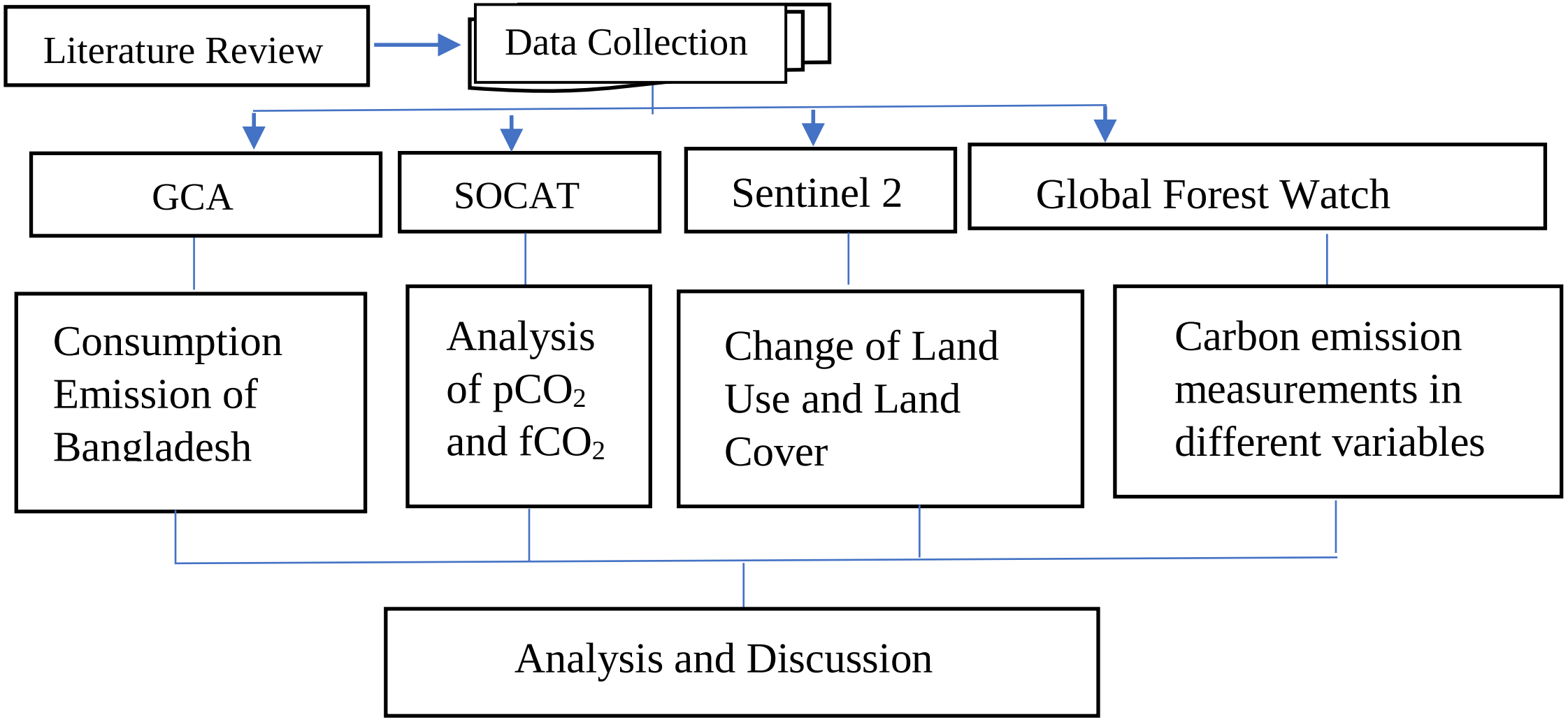
- This research intends to fill this gap by assessing the role of **urban CO_2 emissions in Chattogram to ocean acidification**.

SCOPE

This study assesses the role of **urban CO_2 emissions in Chattogram's coastal area** focusing on marine pH measurements, geospatial analysis, and satellite-based emission data.

The result analysis of Surface Ocean CO_2 Atlas (SOCAT) and its' future protective measures will help to **create focused actions for a sustainable future of Chattrogram**.

Adopted Methodology



EXPERIMENTAL

For Chattogram, Ocean acidification is a result of part of the **consumption of emissions** dissolving into the ocean after building up in the atmosphere. Fisheries, coastal resiliency, and biodiversity are all impacted by this occurrence, which upsets marine ecosystems. Emission for two decade of different variables are visible in fig 2 due to urbanization, shifting agricultural, forestry, commodity driven deforestation etc.

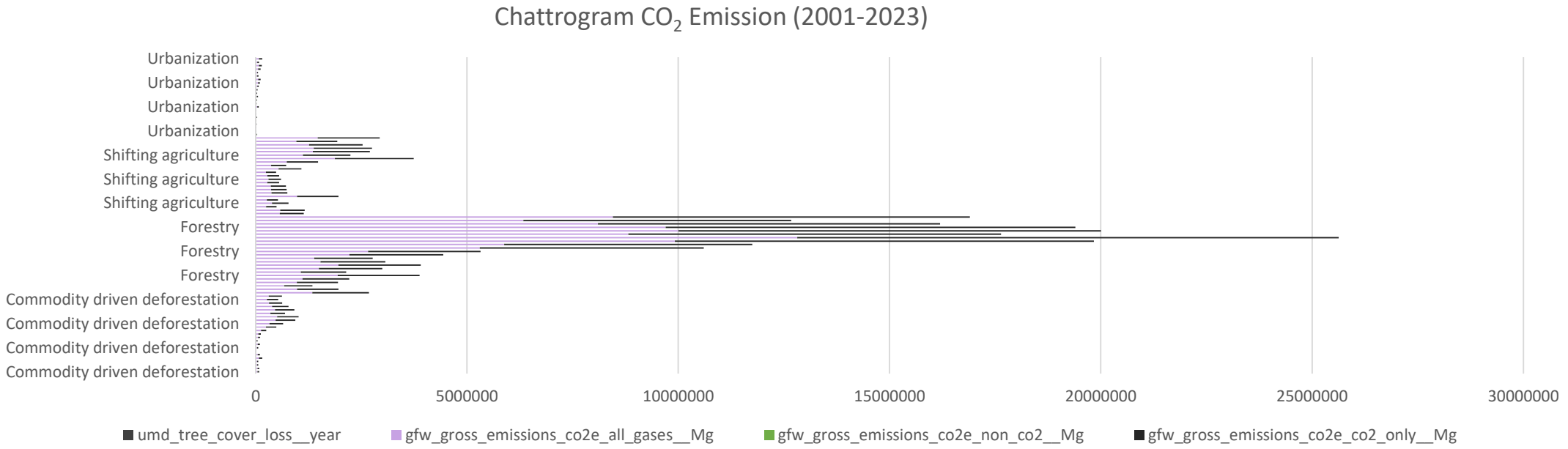
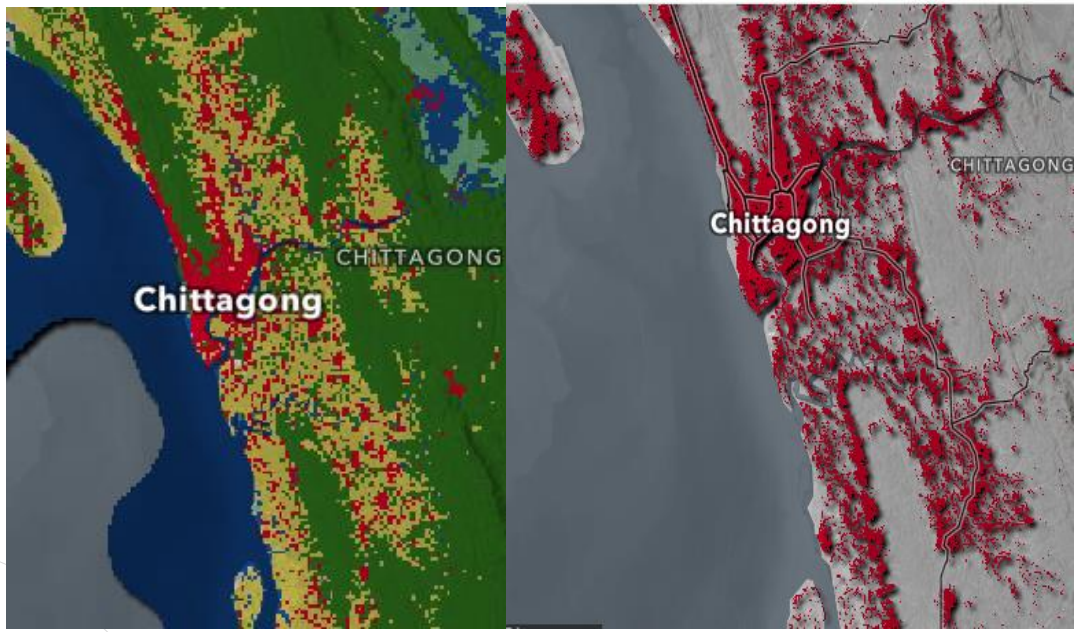


Fig 2: Chattrogram CO2 Emission for two decade of different variables

RESULT ANALYSIS

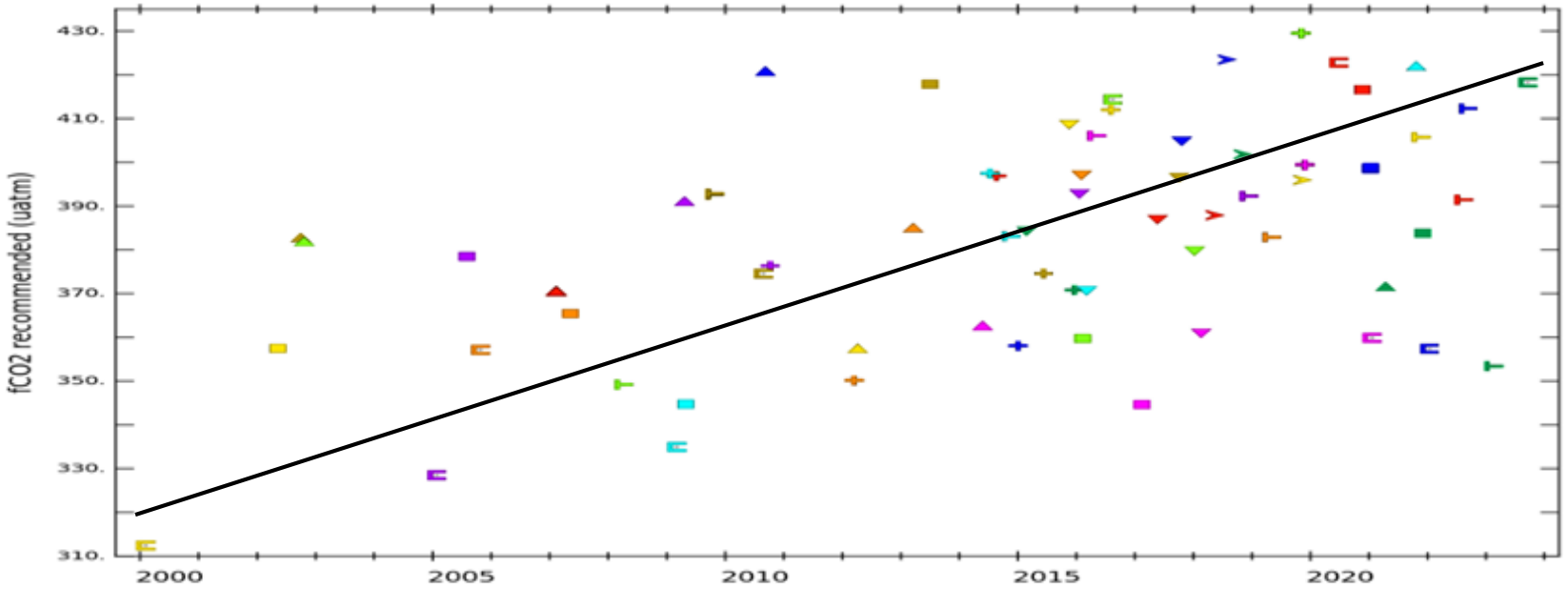
Chattogram's built-up areas increased from **5% in 2017** to **8% in 2023**, indicating the city's increasing urbanization **Fig 4.** The conversion of open spaces and vegetation into residential, commercial, and industrial zones is the result of this growth, which is fueled by **infrastructure developments**, **industrial development**, and **population growth**. Increased carbon emissions, changes in land use, and environmental stress on coastal ecosystems are all consequences of continuous **urbanization,** which is reflected in the growth of road networks, construction activities, and business centers.



- *Fig 4: Land Use Land Cover Analysis Sentinel 2 2023 (Built In Area of Chattrogram 8% increase among other changes)*

Result Analysis (Continued)

This study examines the function of CO_2 in ocean acidification using two essential parameters: fCO_2 and pCO_2. **fCO_2 is the effective partial pressure of CO_2 in saltwater**, which estimates the potential for CO_2 transfer between the ocean and the atmosphere. **pCO_2 is a direct measure of the concentration of CO_2 in the ocean.** Increased pCO_2 in saltwater causes higher quantities of carbonic acid, which dissociates into hydrogen ions (H^+) and lowers the pH of ocean water, contributing to acidification.



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Time >= 01-Jan-2000 00:00; Time <= 31-Dec-2023 00:00

The surface ocean pCO_2 (fCO_2) levels near Chattogram's coastline increased significantly between 2002 and 2023 , according to the SOCAT data study. In particular, **pCO_2 readings increased from 357.44 µatm in 2002 to 418.26 µatm in September 2023**. The value of 384.73 µatm in March 2013 represented a significant increase. Numerous important factors, most notably Chattogram's fast industrialization and urbanization, are responsible for this upward trend in pCO_2.

Result Analysis (Continued)

Chattogram carbon emission graph shows a trend of rising and falling CO_2 emissions over antiquity, followed by a notable increase in recent years. The measured CO_2 emissions in **2001** were **11.2 $ktCO_2$**, however in 2002, they sharply decreased to **3.56 $ktCO_2$**. This early variance points to irregularities in the patterns of energy use, urbanization, or industrial activity during that time.

Emissions fluctuated annually for the next few years, peaking at **9.39 $ktCO_2$ in 2010**, which was a moderate rise over the prior years. However, a more significant upward trend is observed from 2020 onwards, where emissions reached **26.7 $ktCO_2$**, reflecting the effects of urban expansion, industrial growth, and increased energy demands. Further Emissions of CO_2 increased to **76.1 $ktCO_2$ in 2023**, a significant increase over the preceding decades. This dramatic rise demonstrates the exacerbated effects of industrial emissions, urbanization, transportation expansion, and deforestation linked to Chattogram's quick development.

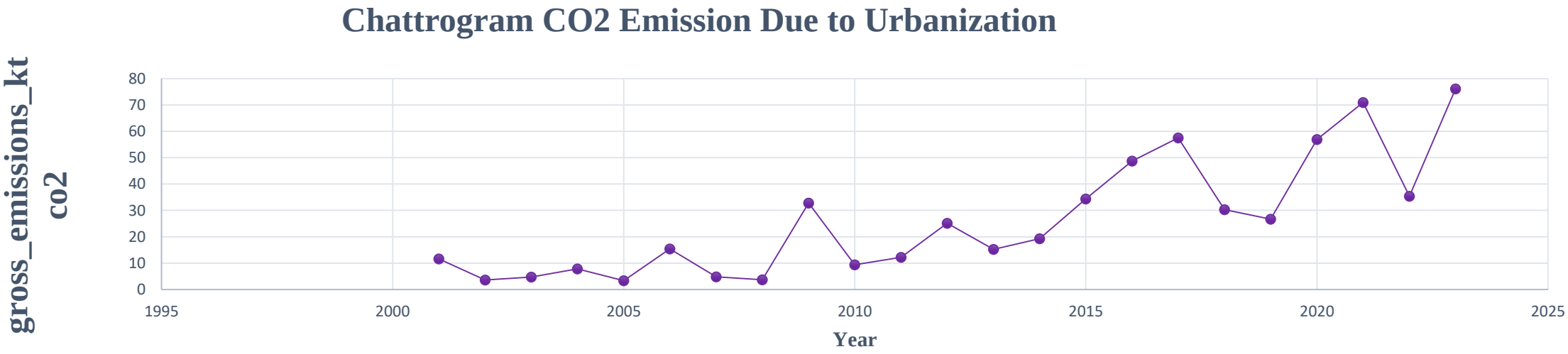
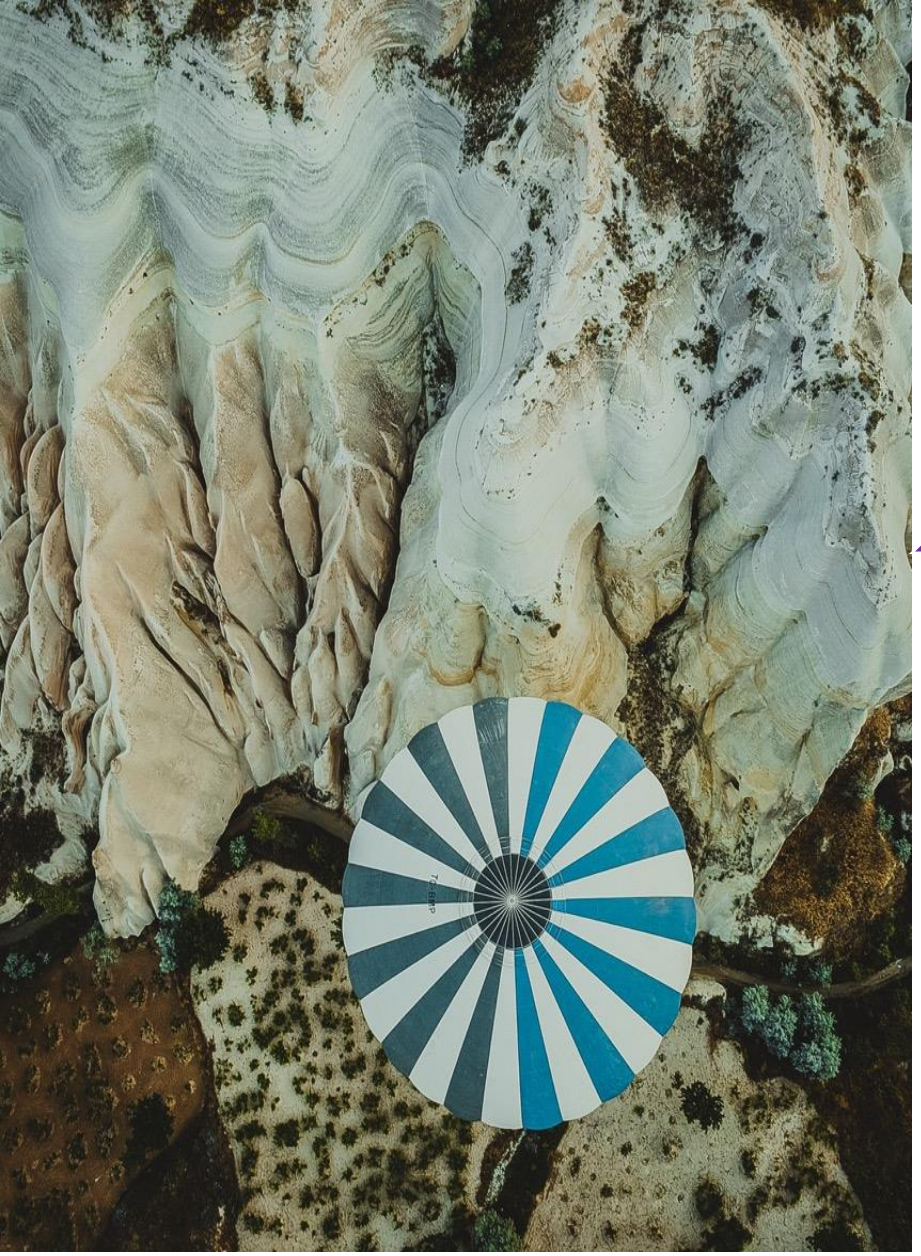


Fig 5: Chattogram's CO_2 emissions due to Urbanization over years

Conclusions

Ocean acidification and coastal environmental deterioration are the direct results of rising fCO_2 levels, which have been exacerbated by Chattogram's growing **urbanization** and **industrialization-related carbon emissions**. According to the study's findings, there is a direct link between **human activity** and **modifications in ocean chemistry**, which puts marine biodiversity and water quality at serious risk. Integrating nature-based solutions, such as artificial reefs, **sustainable drainage systems**, and **a balanced urbanization**, will be essential to ensuring sustainable coastal development. Advanced monitoring methods, **industrial emission management**, and **the enforcement of low-carbon policies** can also aid in striking a balance between environmental sustainability and economic growth. To protect coastal resilience in the face of climate change and growing urban demands, future studies should concentrate on **long-term carbon cycle monitoring** and adaptive measures



RESEARCH GAP

Although there is rising awareness of the link between **urban CO_2 emissions** and **ocean acidification**, there is still a major gap in knowing the localized implications, particularly in fast urbanizing places like Chattogram.

Future studies should concentrate on carbon cycle monitoring and adaptive measures to protect coastal resilience in the face of climate change.

REFERENCES

Adnan, M. (2023). *Oceanic Acidification : Causes and Consequence in the Bay of Bengal Oceanic Acidification : Causes and Consequence in the Bay of Bengal*. *December*, 1–5.

Emerson, S. R., & Hamme, R. C. (2022). The Role of the Ocean in the Global Carbon Cycle. *Chemical Oceanography*, 313–357. https://doi.org/10.1017/9781316841174.009

Randall, S., Sivertsen, B., & Salahuddin Ahammad, S. (2015). *Bangladesh Air Pollution Studies (BAPS): Task 5 (Industrial Emission Estimate)* (Issue May).

Sabine, C. L., Hankin, S., Koyuk, H., Bakker, D. C. E., Pfeil, B., Olsen, A., Metzl, N., Kozyr, A., Fassbender, A., Manke, A., Malczyk, J., Akl, J., Alin, S. R., Bellerby, R. G. J., Borges, A., Boutin, J., Brown, P. J., Cai, W. J., Chavez, F. P., … Yoshikawa-Inoue, H. (2013). Surface Ocean CO2 Atlas (SOCAT) gridded data products. *Earth System Science Data*, *5*(1), 145–153. https://doi.org/10.5194/essd-5-145-2013

Samad, R. B. (2015). Urbanization and Urban Growth Dynamics : A Study on Chittagong City. *Journal of Bangladesh Institute of Planners*, *8*(December), 167–174.

Talukder, B., Ganguli, N., Matthew, R., vanLoon, G. W., Hipel, K. W., & Orbinski, J. (2022). Climate change-accelerated ocean biodiversity loss & associated planetary health impacts. *Journal of Climate Change and Health*, *6*, 100114. https://doi.org/10.1016/j.joclim.2022.100114

THANKS