The Role of Data in Net Zero and Climate Change

"The keys to faster adaptation [to climate change] are information, incentives and effective government. Better information allows more rational decision-making."[1]

Context

Urbanisation is a worldwide phenomenon that has results in more than half of the world's population being categorised as urban citizens. This rapid growth of urbanisation resulted in a variety of advantages and obstacles. Although cities serve as economic hubs, supporting employment opportunities and driving innovation and prosperity, they also contribute to environmental issues such as air and noise pollution and global warming. Urban development and greenhouse gas emissions are positively correlated at the national, regional, and city levels. Urban growth can contribute to a huge positive impact on energy demand and energy consumption, which is identified as one of the key determinants of city greenhouse gases like CO_2, poses a threat to both humanity and the natural environment and is the main concern for governments and cities around the world.

An increase in public awareness of global warning in urban areas has contributed to global efforts and collaborations to reduce greenhouse gas emissions. As an example of the global effort towards this aim, in the Paris Agreement, all participating nations have committed to restricting the rise in global temperatures to below 2°C and striving to limit it even more, to below 1.5°C. Following the Paris Agreement, many global strategies have been established to reach a net zero balance in greenhouse gas emissions by 2025 or earlier. In parallel, the necessity of achieving zero emissions in cities has been extensively recognised and analysed in academic literature.

As the world continues to grapple with the escalating threat of climate change, data has emerged as a powerful tool in the efforts to understand, mitigate, and adapt to its impact. Data analytics – powered by advanced algorithms, machine learning, and artificial intelligence (AI) – has become central to tracking environmental changes, predicting future scenarios, and informing decision-makers about the best course of action.

From mapping carbon emissions to forecasting extreme weather events, data analytics is shaping the fight against climate change in profound ways. This section explores what data and data analytics could be used to monitor the planet, predict environmental trends, and drive actionable solutions to combat the climate crisis.

Data analytics in climate science involves collecting, processing, and analysing vast amounts of environmental data to identify trends, patterns, and potential solutions. This data comes a variety of sources, including satellite imagery, sensors, climate models, and historical records. With advanced computing power, machine learning, and AI, researchers and climate scientists are now able to process this data at unprecedented speeds and scale[2].

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[1] The Economist (2025), Smarter incentives would help India adapt to climate change, The Economist, 5 January. Available from: https://www.economist.com/leaders/2025/01/02/smarter-incentives-would-help-india-adapt-to-climate-change [Accessed 29 September 2025]

[2] El khirani S. E. (2024), The impact of data analytics on climate change, Medium, 7 September 2024. Available from: https://medium.com/data-science-clarity/the-impact-of-data-analytics-on-climate-change-5dd57b546496 [Accessed 29 September 2025]

The following section explores how data analytics has evolved as a tool for climate science and why they are important for tackling climate change, especially for cities such as Belfast.

Key areas for data analytics in climate research

Climate modelling – by analysing historical and real-time data, climate models simulate how the Earth's climate might change under different conditions, such as rising CO_2 levels or deforestation.

Predictive analytics for extreme weather – data analytics is used to predict the likelihood and severity of extreme weather events like hurricanes, floods, and droughts, enabling governments and communities to prepare better.

Carbon footprint monitoring – data analytics helps track carbon emissions from industrial activities, transportation, and agriculture, giving policymakers and industries real-time insights into their environmental impact.

Biodiversity tracking – by analysing ecological data, researchers can monitor species populations and their habitats, helping to preserve biodiversity and develop strategies for conservation in the face of climate change.

Satellite data and remote sensing

Monitoring deforestation and land use – satellite imagery analysed with data analytics tools helps track deforestation in real time, especially in regions like the Amazon Rainforest. By identifying illegal logging activities and habitat destruction, governments and environmental organisations can take immediate action to prevent further damage.

Ice melt and sea level rise – data analytics helps track changes in polar ice caps, glaciers, and sea levels. Satellite data from missions like NASA's GRACE (Gravity Recovery and Climate Experiment) allow scientists to monitor ice loss in Antarctica and Greenland, providing critical information about the rate of sea-level rise and its future impact on coastal communities.

Carbon emissions monitoring

Global CO_2 monitoring – data analytics tools are being used to monitor global carbon dioxide levels from space-based sensors and ground-based monitoring stations. Platforms like the CarbonTrackers Initiative utilise satellite data and machine learning models to estimate global CO_2 emissions from power plants, factories and transportation.

Real-time air quality data – cities around the world are using data analytics to monitor air quality in real-time. By tracking particulate matter, nitrogen dioxide, and other pollutants, cities can take swift action to reduce emissions, improve air quality, and protect public health.

Agricultural impact and food security

Agricultural monitoring – agriculture is both a contributor to and a victim of climate change. Data analytics is used to monitor agricultural practices, assess water usage, and predict crop yields. By analysing this data, farmers can make informed decisions that reduce environmental impact while ensuring food security.

Drought and water resources management – in areas prone to drought, data analytics helps manage water resources by predicting drought severity and optimising water usage. Tools like the Global Drought Information System (GDIS) use climate and hydrological data to provide real-time drought monitoring and forecast future water shortages.

Climate models and simulations

Predictive climate models – predictive analytics uses historical climate data and AI algorithms to model future climate scenarios. These models simulate the impact of various factors – such as greenhouse gas emissions, deforestation, and ocean temperatures – on future climate conditions. They help scientists predict rising temperatures, changing precipitation patterns, and the frequency of extreme weather events.

Scenario analysis – data analytics enables researchers to run multiple climate scenarios based on different policy decisions.

Predicting extreme weather events

Storms and flooding – data analytics models are being used to predict the likelihood of hurricanes and tropical storms, helping communities prepare for potential disasters. Machine learning algorithms analyse patterns in sea surface temperatures, wind speeds, and atmospheric pressure to predict when and where these storms will hit.

Heatwaves and droughts – predictive models help forecast heatwaves and droughts months in advance, giving governments time to plan responses, manage water resources, and protect vulnerable populations. This is especially important in regions already facing food and water insecurity due to climate change.

Predicting the impact ecosystems and species

Biodiversity forecasting – using ecological data and machine learning, researchers can predict how climate change will impact biodiversity. Predictive models analyse species distribution, migration patterns, and habitat loss to forecast the future health of ecosystems and guide conservation efforts.

Renewable energy optimisation

Solar and wind energy analytics – data analytics is being used to optimise the generation and distribution of renewable energy sources like solar and wind. By analysing weather patterns, energy demand, and grid performance, operators can improve the efficiency and reliability of renewable energy systems, reducing dependency on fossil fuels.

Energy forecasting – predictive analytics models can forecast energy production from renewable sources based on climate data.

Urban planning and climate resilience

Smart cities – cities are increasingly using data analytics to develop smart city initiatives that reduce carbon emissions and improve climate resilience. By analysing traffic patterns, energy usage, and air quality data, cities can implement policies that reduce pollution, optimise public transportation, and create greener urban environments.

Flood risk management – coastal cities and flood-prone areas use data analytics to predict rising sea levels and storm surges. With this information, city planners can build resilient infrastructure, such as sea walls and drainage systems, to protect against future flooding.

Carbon sequestration and forest conservation

Forest monitoring – data analytics is used to monitor carbon sequestration efforts, particularly in forests and wetlands, which act as carbon sinks. By tracking deforestation and reforestation efforts, governments and organisations can better manage their carbon reduction strategies.

Carbon markets – data analytics helps companies and countries participate in carbon trading markets by accurately tracking and reporting carbon emissions. This transparency is essential for ensuring compliance with global climate agreements and reducing overall emissions.

Key data sources

The influence of climate change on different aspects of society and ecology is too complex to comprehend from a singular lens, place or point in time[3]. Lahoud, for instance, highlights the omnipresence of climate change, stating how it occurs in the periphery of our vision and at the limits our sensorium and understanding[4]. Conceptualisations, speculations, and interventions around climate change have been consistently evolving. The understanding of climate change moves across different registers and scales – both spatially and temporally. Existing at different intersections of scales, issues and temporalities, recent research approaches attempt to make the impact of change more tangible.

As the conversation around climate action evolves, so do the approaches, which are becoming more complex and interpolating several different data sources and methods of analysis. It has become increasingly important to recognise the role data can play as well as what it is envisioned to do. The spatial-temporal nature of climate change is intertwined with the practices of data collection and deployment. As the academic Theodore Lim appositely put it, "different perspectives in time and space, with the help of data and information, can result in very different prioritisation of social and environmental outcomes".[5]

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[3] Bajaj, S. (2025), Conceptualising climate change and reconceptualising climate data: Understanding different interpretations and approaches to climate data, AAPTI Institute, 3 June 2025. Available from: https://aapti.in/blog/conceptualising-climate-change-and-reconceptualising-climate-data-understanding-different-interpretations-and-approaches-to-climate-data/ [Accessed 29 September 2025]

[4] Lahoud, A. (2016), Scale as problem: Architecture as trap, Climates: Architecture and the planetary imaginary, Columbia Books on Architecture and the City, 3 June 2016. Available from: https://averyreview.com/media/pages/issues/15/architecture-as-trap/2807d579b0-1663135360/averyreview-climates-10-lahoud.pdf [Accessed 29 September 2025]

[5] Lim, T. C. (2021), Patterns in environmental priorities revealed through government open data portals, Telematics and Informatics, 64, 101678

According to the Royal Statistical Society (RSS), there are approximately 1,000 official climate-related statistics available in the UK[6]. However, obviously, this figure does not take into account the myriad of unofficial climate-related datasets within local organisations such as Belfast City Council.

Moreover, a significant amount of this data is now being presented in various guises and forms through a growing number of climate-related dashboards[7,8,9]. These are usually interactive data visualisations that provide a snapshot of real-time climate-related activities across different stakeholder. They take a wide variety of data sources – for example, carbon emissions, energy usage, air quality, renewable energy production – and present in easy-to-interpret visualisations[10].

However, as investigated in this section, there aren't any particularly climate-related dataset that stands out as been most important. This is largely due to the sheer complexity of climate change and the unique characteristics associated with different cities and time periods[11].

Responsible data sustainability

As detailed above, data, data analytics and digital technologies play a pivotal role in tackling climate change, serving as catalysts towards achieving a wide range of climate-related objectives. As shown above, data-driven research and AI technologies are already being used to tackle different impacts of climate change. Furthermore, data stewardship is an important part of ensuring that data is available to support the fight against the climate crisis. Again, data enables more informed decision making and better targeted interventions, as well as improving and enriching scientific research.

However, too little is known about how data and technology contribute to the crisis. The internet creates 1.6 billion metric tons of greenhouse gas emissions per year. There is a growing recognition of the internet's cost to the climate, including the impact of online video streaming[12]. This is intrinsically linked to the way we collect, use and share data as individuals, as organisations and as society more broadly. Questions of environmental sustainability of data and technology, like energy-intensive AI models, are gaining traction in the public debate.

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[6] Royal Statistical Society (2025), Guide to UK official statistics on climate change, The Economist, 5 January 2025. Available from: https://www.economist.com/leaders/2025/01/02/smarter-incentives-would-help-india-adapt-to-climate-change [Accessed 29 September 2025]

[7] Climate Emergency UK (2025), Council Climate Action Scorecards, mySociety, 29 September 2025. Available from: https://councilclimatescorecards.uk/ [Accessed 29 September 2025]

[8] Department of Agriculture, Environment and Rural Affairs (2025), Northern Ireland Greenhouse Gas Inventory 1990-2022, Department of Agriculture, Environment and Rural Affairs, 30 June 2025. Available from: https://datavis.nisra.gov.uk/daera/northern-ireland-greenhouse-gas-inventory.html [Accessed 29 September 2025]

[9] Met Office (2025), Climate Dashboard, Met Office, 23 September 2022. Available from: https://climate.metoffice.cloud/ [Accessed 29 September 2025]

[10] Terrado, M. *et al* (2022), Towards more effective visualisations in climate services: good practices and recommendations, Climate Change, 172, 18. Available from: https://link.springer.com/content/pdf/10.1007/s10584-022-03365-4.pdf [Accessed 29 September 2025]

[11] Climate Service Center Germany (2015), Climate Focus Paper – Cities and Climate Change, Climate Service Center Germany, 1 November 2015. Available from: https://climate-adapt.eea.europa.eu/en/metadata/publications/climate-focus-paper-cities-and-climate-change/gerics_kfw_2015_climatefocuscities.pdf/@@download/filehttps://link.springer.com/content/pdf/10.1007/s10584-022-03365-4.pdf [Accessed 29 September 2025]

[12] Massey, J. and Moriniere, S. (2023), Why we need to be responsible about data and the environment, Open Data Institute. Available from: https://theodi.org/news-and-events/blog/why-we-need-to-be-responsible-about-data-and-the-environment/ [Accessed 29 September 2025]

As the reliance on data and technology increases, the environmental impacts of their use and development are likely to become more and more significant. Organisations, such as Belfast City Council, who are adopting these technologies and, as a result, stewarding large amounts of data will need to ensure that these risks are mitigated.

Conclusion

Data and data analytics has emerged as a critical tool in the fight against climate change, enabling researcher, policymakers, and industries to track environmental changes, predict future scenarios, and develop effective solutions. From monitoring deforestation and carbon emissions to optimising renewable energy systems and predicting extreme weather events, the role of data in climate action is undeniable.

This data also has the power to help debate with anti-green and climate-sceptic agendas and countering the scaling back of environmental action.

As climate change continues to pose an existential threat, the importance of data-driven decision-making will only grow. By harnessing the power of data analytics, we can better understand the challenges ahead and take meaningful action to protect our planet for future generations. The future of climate action depends on our ability to leverage data to make informed, impactful decisions.

As we move forward, data analytics will remain at the forefront of global efforts to combat climate change, offering hope that we can address this crisis with the precision, speed, and scale that it demands. However, it must be acknowledged that these data practices, paradoxically, generate carbon emissions.