Not All Climate Benefits Are Created Equal: A Spatial Analysis of Climate Policy Co-Benefits and Deprivation

Intro

Climate mitigation policies generate co-benefits beyond carbon reduction, including improvements in air quality, public health, and transportation infrastructure. However, the distribution of these co-benefits across geographic areas and socioeconomic strata remains poorly understood. This study examines the spatial relationship between climate policy co-benefits and deprivation levels across Scottish local authorities, with particular focus on Glasgow.

Using data from the Scottish Index of Multiple Deprivation (SIMD) integrated with small-area co-benefit measures, we analysed the eleven distinct co-benefit categories identified in the Co-Benefit Atlas. Our analysis calculated per capita co-benefit values to account for population differences across small geographic areas. Observing an approximate positive correlation between per capita co-benefit and SIMD rank, we developed a normalized per capita co-benefit measure (RNIC) to understand co-benefits across regions while accounting for the variation due to socioeconomic status.

Initial findings reveal significant geographic heterogeneity in co-benefit distribution. Notably, more urbanised centres demonstrate substantially higher per capita co-benefits compared to rural and semi-urban areas, even after controlling for socioeconomic status through the described normalization against SIMD rankings.

This spatial analysis provides critical insights for equitable climate policy implementation, highlighting areas where targeted interventions could maximize both environmental and social welfare outcomes.

RNIC = log(per-capita co-benefit / SIMD rank)

"Relative Normalised Individual Co-benefit": a proposed measure to compare different small areas while accounting for the fact that co-benefits are not equally distributed across socio-economic levels.

Glasgow Case Study: Urban Co-Benefit Concentration

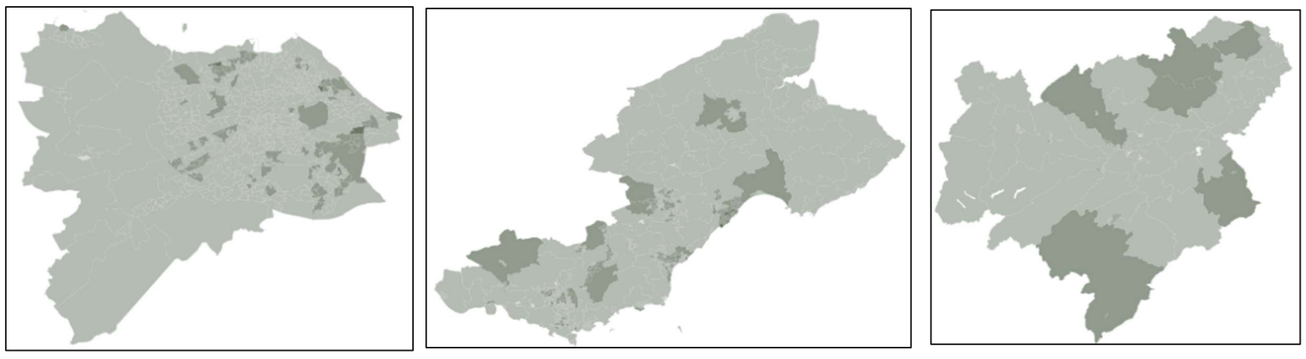
Glasgow emerges as a distinctive case in our analysis, demonstrating markedly elevated co-benefit values compared to other Scottish local authorities. Even after normalizing for socioeconomic deprivation through SIMD rankings, Glasgow exhibits substantially higher per capita co-benefits than other areas we researched (Edinburgh, Fife, and the Scottish Borders). This pattern is particularly pronounced in areas with the highest concentrations of deprivation: Glasgow's Northeast locality, where 56.8% of residents live in Scotland's 20% most deprived data zones (from https://www.glasgow.gov.uk/article/6499/Poverty-and-Deprivation), shows elevated co-benefit potential across multiple categories including air quality, congestion reduction, and active travel improvements. The concentration of co-benefits in Glasgow's most deprived neighbourhoods—areas such as Carntyne West and Haghill, North Barlanark and Easterhouse South—reflects underlying urban conditions that amplify the impact of climate interventions. These areas experience higher baseline levels of traffic congestion, poorer air quality from vehicular emissions, and limited access to green spaces, meaning that transport-focused climate policies yield disproportionately large health and environmental improvements. Research demonstrates that people experiencing deprivation are more likely to live close to sources of air pollution, such as major roads or industrial sources, and have less access to green and blue spaces, creating conditions where climate mitigation measures addressing transport emissions generate substantial co-benefits in air quality, noise reduction, and public health outcomes. The Glasgow findings underscore both the potential for urban-focused climate interventions to deliver amplified returns in deprived communities and the critical importance of ensuring these populations benefit equitably from climate policy implementation.

Figure 1: *Glasgow, darker areas show a higher RNIC*

Comparative Regional Patterns: Edinburgh, Fife, and the Borders

Beyond Glasgow, the three comparison regions reveal how urban form and industrial history shape co-benefit distribution. **Edinburgh** shows moderate normalized co-benefit values with improvements concentrated in specific deprived localities like Leith and Craigmillar, though income poverty is more dispersed across the city. **Fife** exhibits a distinctive coastal pattern with elevated co-benefit hotspots in former industrial areas along the south coast—particularly Levenmouth (Buckhaven, Methil) and Kirkcaldy—where post-industrial decline has created transport connectivity challenges and employment deprivation that climate policies addressing mobility can simultaneously ameliorate. The **Scottish Borders** demonstrates the lowest normalized values, reflecting both genuinely better baseline conditions (less congestion, better air quality, dispersed populations) and the limitations of urban-focused co-benefit measures in rural contexts, suggesting that rural areas require climate policy approaches centred on fuel poverty and service accessibility rather than congestion and air quality improvements that drive urban co-benefits.

Figure 2: *Edinburgh, Fife and Scottish borders - Darker areas show a higher RNIC*



Conclusion

This spatial analysis reveals that climate policy **co-benefits are not uniformly distributed across Scotland** but are instead mediated by urban density, deprivation levels, and historical development patterns. **Glasgow's** deprived urban neighbourhoods demonstrate the highest normalized co-benefit potential, while **Fife**'s post-industrial coastal communities show elevated returns despite lower absolute values, and rural areas like the **Scottish Borders** require fundamentally different policy approaches. The strong correlation between urban deprivation and co-benefit magnitude suggests that **transport-focused climate interventions can achieve dual objectives** : reducing carbon emissions while delivering substantial health, accessibility, and quality-of-life improvements to Scotland's most disadvantaged communities. However, realizing this potential requires **deliberate policy design that ensures vulnerable populations in high-benefit areas have meaningful access to climate interventions, while simultaneously developing rural-appropriate strategies that address the distinct needs of less densely populated regions**. Effective climate policy must therefore be spatially targeted and context-sensitive, recognizing that one-size-fits-all approaches will fail to optimize either environmental outcomes or social equity across Scotland's diverse geographic and socioeconomic landscape.

Bios

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