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Public Perception of Green Infrastructure's Role in Urban Air Quality

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MSc Environmental Engineering

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Academic Year: 2024 - 2025

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Abstract

Urban green infrastructure (GI) is recognised for enhancing environmental quality and wellbeing, yet public perceptions of its air quality benefits remain underexplored. This study investigates how residents across two contrasting urban contexts (Bedford and Milton Keynes) view these benefits, and how socio-demographics, proximity, and use frequency shape perceptions.

A semi-structured survey of 51 participants combined closed- and open-ended questions. Descriptive statistics, t-tests, chi-square, and thematic coding identified key patterns. Findings show strong agreement (90.2%) that green spaces improve air quality, supported by a reliable attitudinal scale (Cronbach's $\alpha = 0.771$). Mature, evergreen, and mixed vegetation were rated higher than single-species or newly planted areas, indicating preference for diverse, stable planting. Visit frequency strongly correlated with belief in benefits ($p < 0.001$), and proximity influenced visitation ($p = 0.02$). Socioeconomic differences appeared: lower- and middle-income groups relied more on public green spaces, while some higher-income respondents were more sceptical. Despite concern over pollution, awareness and use of air quality indices were limited, with reliance on sensory cues. The study highlights the importance of context-sensitive, equitable, and communicatively effective GI planning to maximise ecological and social benefits.

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List of Abbreviations

AQI	Air Quality Index
BC	Black Carbon
BVOC	Biogenic Volatile Organic Compound
CFD	Computational Fluid Dynamics
DEFRA	Department for Environment, Food and Rural Affairs (UK Government)
DeFRAG	Defragmenting the Fragmented Urban Landscape
GI	Green Infrastructure
PM	Particulate Matter
PNC	Particle Number Concentrations
RMB	Renminbi (official currency of the People's Republic of China)
WHO	World Health Organization

1 Introduction

Urban air pollution represents one of the most pressing environmental health challenges of our time, with approximately 7.3 billion of the global population residing in locations where annual average PM_{2.5} concentrations exceed the World Health Organization's (WHO) threshold limit of 5 µg/m³ (Rentschler & Leonova, 2023). In 2021, this silent crisis was responsible for nearly 8.1 million deaths, ranking as the second-largest risk factor for premature death (UNICEF, 2024). Recent estimates reveal that 48,625 adults in the UK died prematurely in 2019 because of long-term exposure to PM_{2.5}, a figure notably higher than previous projections, largely due to improved modelling of health risks (Marais et al., 2023). The financial burden of air pollution in the UK was estimated at £157 million in 2017, and in the absence of intervention, this is expected to escalate to £18.6 billion by 2035 (Hamilton & Nicholson, 2024).

The prevailing challenge of urban air pollution has traditionally been countered by implementing conventional regulatory approaches such as stringent emission standards, zoning standards and fuel quality regulations and technological solutions like electrostatic precipitators, catalytic converters and industrial scrubbers (Jonidi Jafari et al., 2021; Peter Makinde et al., 2023). However, these interventions face limitations due to enforcement challenges, high implementation costs and significant energy consumption. In addition, rather than eliminating pollutants, these initiatives tend to transfer it from one area to another and they often concentrate on selected contaminants or specific sources overlooking the multifaceted nature of urban environmental issues (Gulia et al., 2015; Lin et al., 2024). This has prompted cities worldwide to explore nature-based alternatives, with green infrastructure (GI) emerging as a promising multifunctional solution that can simultaneously address air quality while delivering broader urban sustainability benefits (Y. Wang et al., 2025).

Green infrastructure (GI) consists of strategically deployed networks incorporating natural and semi-natural vegetated systems and engineered

spaces that are designed to support ecological health and deliver a range of environmental and social benefits in urban areas (Tzoulas et al., 2007), thereby promoting sustainability and ecosystem resilience (Pamukcu-Albers et al., 2021). Research demonstrates GI's capacity to reduce air pollutants significantly: establishing green zones within the urban environment can result in 16% reduction in PM10 and a 19% decrease in NOx (Rafael et al., 2018), while the annual removal of air pollution by urban trees in the US is estimated at 711,000 metric tons, representing an economic benefit of around \$3.8 billion (Nowak et al., 2006).

Despite mounting evidence of GI's technical effectiveness in improving air quality, a critical knowledge gap exists regarding public understanding and acceptance of these interventions (Zölch et al., 2016). The integration of GI into urban planning has gained momentum as cities seek multifunctional solutions to environmental challenges, yet the success of such initiatives depends critically on public acceptance and support (Frantzeskaki, 2019). While studies demonstrate clear air quality benefits, research exploring how communities perceive and value these functions remains limited, creating a disconnect between scientific evidence and social implementation (Suárez et al., 2025).

This disconnect is particularly concerning given that public perception shapes policy support, funding allocation, and long-term maintenance of GI initiatives. Current barriers to public understanding include the technical complexity of air quality science, limited awareness of GI functionality beyond aesthetic benefits, and insufficient communication strategies that translate scientific evidence into personally meaningful narratives (Nieuwenhuijsen, 2021). Furthermore, demographic factors, local environmental conditions, and previous experiences with green spaces all influence public attitudes toward GI interventions.

Limited studies have examined how public perceptions of GI air quality benefits vary across different urban contexts, particularly comparing established urban centres with planned new towns. To address this gap, this study aims to investigate public perceptions of green infrastructure's (GI) role in urban air

quality across two contrasting urban environments in England: Bedford (a historic market town) and Milton Keynes (a planned new town with extensive GI).

The objectives of this study include: (a) To assess public awareness, understanding and valuation of role of GI in urban air quality, including perceptions of both its benefits and potential drawbacks. (b) To identify demographic and socio-economic factors that shape public perception of GI's role in air quality. (c) To examine barriers to the acceptability of GI as an air quality management strategy and provide actionable recommendations for enhancing both its air quality benefits and social acceptability.

By assessing public awareness, attitudes, and demographic influences on GI perception, this research will provide evidence-based recommendations for enhancing social acceptability of GI interventions and inform more effective communication strategies for sustainable urban design. The findings will contribute to bridging the gap between technical assessments of GI effectiveness and community support, ultimately facilitating the successful implementation of nature-based solutions for urban air quality improvement.

2 Materials and Methods

2.1 Study Sites

This study examines Milton Keynes in Southeast England and Bedford in the East of England, purposively selected for their contrasting urban characteristics, GI provision, and socio-demographic diversity, providing a robust comparative framework. Milton Keynes, a post-war planned city with a grid road system and zoned industrial and commercial areas (Henderson, 2016), offers 59.7m² of green space per resident—among the highest nationally (Martin Guttrid-Hewitt, 2024)—with 6,000 acres of parks, linear corridors, and nature reserves, representing ~40% of its land area (Lepus Consulting Ltd, 2023; Milton Keynes City Profile, 2025). It is also highly diverse, with 37.8% of residents in 2021 identifying as Black, Asian or Minority Ethnic, above the 26.5% national figure. Bedford, by contrast, is a historic market town with a denser, organically developed environment, where GI is embedded within Victorian parks, ancient woodlands, and riverside corridors, and is similarly noted for ethnic and economic diversity (Office for National Statistics, 2023). Despite spatial fragmentation, 84.2% of Bedford households have access to a green space, exceeding regional averages (John Guinn, 2025). Both towns share similar oceanic climate, reducing climate as a confounding factor (Met Office, 2025). The availability of up-to-date socio-economic, health, air quality, and urban planning data enables a rigorous comparison of public perceptions of GI's contribution to urban air quality (Lumsden et al., 2024; Bedfordshire Council, 2023).

2.2 Questionnaire Development

The survey was administered online via Qualtrics XM (Provo, UT, USA), a widely used platform in environmental perception research (LaJoie et al., 2022; Rieves et al., 2024). It comprised 35 questions (Appendix B), including multiple-choice, five-point Likert scales, ranking, and open-ended items, with an average completion time of 10–15 minutes. Informed consent was obtained through an introductory page outlining the study's purpose, voluntary nature, anonymity, and GDPR compliance, with survey continuation indicating agreement.

A mandatory residency screening question ensured inclusion of participants from Milton Keynes or Bedford only. The questionnaire was divided into six sections: the first introduced the study and obtained consent; the second gathered residential details, including place and length of residence; the third focused on air quality and health, asking respondents to rate local air quality and express health concerns; the fourth explored awareness, access, and use of green spaces, including visit frequency and perceptions of their air quality benefits; the fifth examined attitudes towards GI, including perceived effectiveness, barriers, and community engagement; and the final section collected demographic and socio-economic data, with “Prefer not to say” options for sensitive items (Li et al., 2025). The questionnaire was piloted in two stages. First, it was reviewed by Cranfield University’s Decision Science Group, including social science researchers from the UKRI NERC-funded DEFRAG project, who provided feedback on wording, thematic alignment, and scaling, leading to refinements in structure and clarity. Second, informal pre-testing with a small group of local residents ($n \approx 10$) assessed clarity, navigation, and completion time, after which minor adjustments were made before launch.

2.3 Sampling Strategy

A non-probability sampling approach was employed, combining convenience and snowball sampling. Convenience sampling targeted accessible participants, including staff from the Environmental Sustainability Theme at Cranfield University and MSc and PhD students. Snowball sampling invited initial respondents to share the questionnaire with their personal and professional networks, reaching additional participants. This approach aimed to capture a range of perspectives within the study locations, including individuals with varying levels of academic involvement and environmental awareness.

2.4 Data Collection Procedures

Data were collected using an online questionnaire, open from 24 July to 10 August 2025. Staff participants were invited via email, sent to 178 individuals within the Environmental Sustainability Theme. MSc and PhD students were

recruited through the Cranfield student WhatsApp group, and additional participants were reached via LinkedIn and community-specific Facebook groups in Milton Keynes and Bedford. These channels enabled engagement from a diverse set of participants across the study locations.

2.5 Statistical Analysis

All survey responses were systematically recoded according to the codebook provided in 7Appendix C. To satisfy assumptions for categorical analyses, low-frequency categories (fewer than five observations) were merged with adjacent or conceptually similar categories. For instance, “Very poor” and “Poor” were combined into a single “Poor” category, and “Strongly agree” and “Agree” were merged into “Agree.” Similarly, rare response categories (e.g., “Never”/ “Rarely” or “Often”/ “Very often”) were collapsed, and concern levels were grouped to ensure sufficient counts. Descriptive statistics, including frequency distributions, measures of central tendency, and variability, were generated to characterise the dataset.

For inferential analysis, associations between categorical and ordinal variables were examined using cross-tabulations (Duan et al., 2018). Chi-square tests of independence were applied to contingency tables with all expected cell counts ≥ 5 , while Fisher’s exact test was performed for 2×2 tables. Ordinal and non-normally distributed variables were analysed using nonparametric tests: Mann–Whitney U tests for comparisons between two independent groups (Kim & Arik, 2025), and Kruskal–Wallis H tests for comparisons among multiple groups with ordinal data (J. Wang et al., 2023). Statistical significance was set at $\alpha = 0.05$. The analysis outputs included contingency tables with counts and percentages, test statistics (χ^2 , U, H values), and p-values, with significant results ($p < 0.05$) clearly indicated. A summary of all significant findings was also generated. All analyses were implemented using Python with a custom script.

3 Results

3.1 Sample Demographics

A total of 51 respondents completed the survey, with nearly equal representation from Milton Keynes (n= 25, 49%) and Bedford (n= 26, 51%). Appendix D depicts the socio-economic characteristics of the survey participants. Participants were predominantly aged 18–44 (70%), with more females (57%) than males (37%). Most held postgraduate qualifications (72%) and were employed (47%) or students (37%). Ethnic distribution was mainly White (39%) and Asian (37%), with incomes largely in the £0–50,270 range (58%), reflecting a younger, highly educated, and ethnically diverse sample.

3.2 Perceptions and Attitudes Toward Air Quality and Green Spaces

This section presents participants' perceptions of different green space characteristics in improving air quality. Respondents (n = 51) rated green space types on a 5-point scale (1 = "Not effective at all," 5 = "Extremely effective," 3 = "Moderately effective"). One-sample t-tests assessed whether mean ratings differed from the neutral midpoint, and Bonferroni-adjusted pairwise comparisons examined differences between characteristics.

Overall, participants perceived green spaces as beneficial for air quality, with mean scores above the neutral midpoint. Water features combined with vegetation received a mean rating of 4.02 (SD = 1.01). Table 1 shows clear preferences for vegetation types: mature trees (M = 3.84, SD = 0.88) were rated significantly more effective than single-species greenery (M = 3.00, SD = 0.98; $t(50) = 6.89$, $p < 0.0001$). Evergreen trees (M = 3.90, SD = 0.90) and mixed plantings (M = 3.80, SD = 0.94) were also rated higher ($t(50) = 7.21$, $p < 0.0001$; $t(50) = 6.57$, $p < 0.0001$). In contrast, recently planted trees (M = 2.94, SD = 0.97) and deciduous trees (M = 3.08, SD = 0.89) did not differ from single-species areas ($t(50) = -0.45$, $p = 0.655$; $t(50) = 0.66$, $p = 0.512$). Areas with closely spaced trees (M = 3.65, SD = 0.96) were rated higher than those with spread-out trees (M =

3.35, SD = 0.91; $t(50) = 5.30$, $p < 0.0001$), while spread-out trees still received significantly higher ratings than single-species greenery ($t(50) = 3.22$, $p = 0.0023$). These results highlight preferences for mature, evergreen, and mixed vegetation, with closer spacing perceived as most beneficial. Trends were consistent across Bedford and Milton Keynes.

Table 1: Perceived Effectiveness of Green Space Characteristics

Characteristics	Mean	SD
Areas with only one type of greenery	3.00	0.98
Areas with different types of plants mixed	3.80	0.94
Mature trees	3.84	0.88
Recently planted	2.94	0.97
Trees spread out	3.35	0.91
Trees close together	3.65	0.96
Evergreen trees	3.90	0.90
Deciduous trees	3.08	0.89

The findings demonstrated participants were highly supportive of green space initiatives (Q18.1; $M = 4.49$, $SD = 0.76$) and largely believed these areas help mitigate urban air pollution (Q18.2; $M = 4.47$, $SD = 0.76$). Clean air influenced their use of green spaces (Q18.3; $M = 4.24$, $SD = 0.95$), and there was broad support for roadside greenery improving air quality (Q18.4; $M = 4.25$, $SD = 0.80$). Responses were more mixed on visiting green spaces specifically for cleaner air ($M = 3.98$, $SD = 0.99$). One-sample t-tests confirmed all five items scored significantly above the neutral point of 3 (all $p < 0.001$). A composite index averaging these items captured overall attitudes toward green spaces and air quality benefits, justified theoretically as reflecting perceptions of

environmental and health benefits. Cronbach's alpha was $\alpha = 0.771$, indicating acceptable internal consistency. The composite mean was $M = 4.29$ ($SD = 0.78$). Repeated measures analysis showed significant differences between item means ($p < 0.05$), indicating that support for initiatives and pollution mitigation beliefs was rated higher than visiting for cleaner air. Overall, attitudes were positive and consistent, showing green spaces are widely perceived as beneficial for air quality.

3.3 Comparison of Environmental Perceptions between Milton Keynes and Bedford

A comparison of responses from residents in Milton Keynes and Bedford highlights how location may influence environmental perceptions and behaviours. As indicated in Figure 1, more respondents in Milton Keynes rated local air quality as "Good" (44%) or "Very good (16%)." Notably, neither city reported 'Very poor' ratings, while 42% in Bedford rated it 'Neutral' compared to 32% in Milton Keynes. 'Poor' ratings were higher in Bedford (15%) than Milton Keynes (8%). Perceptions of air quality and green space benefits were broadly similar, with no statistically significant differences ($\chi^2 (2) = 1.7368$, $p = 0.4196$; Mann–Whitney $U = 387.5000$, $p = 0.1955$).

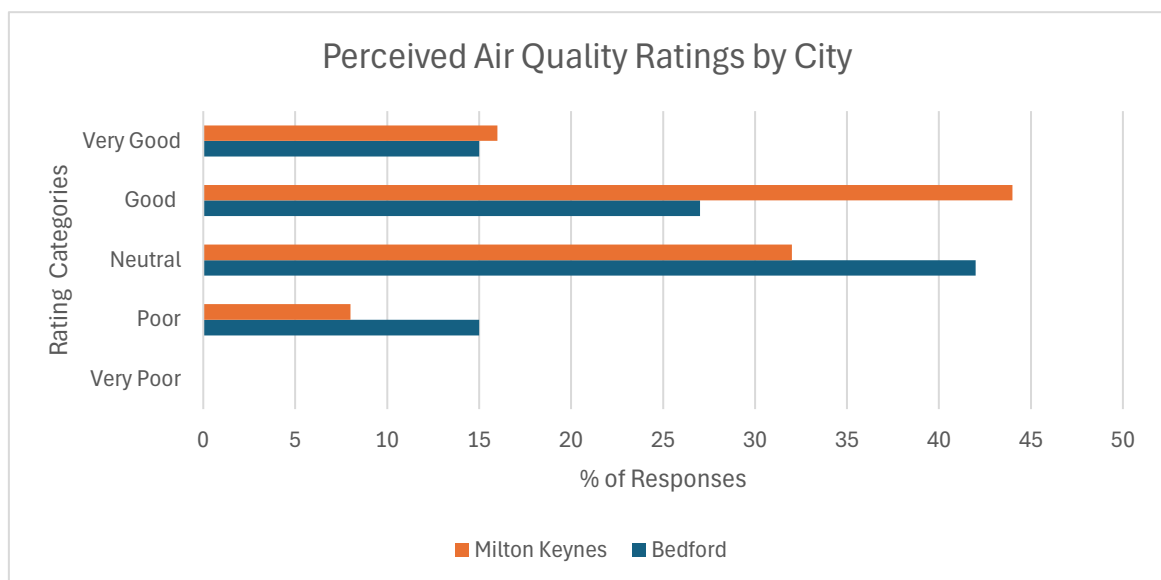


Figure 1: Perceived Air Quality Ratings by City

The survey results reveal a strong belief in the air-quality benefits of green spaces across both cities (Figure 2). Nearly all respondents in Bedford, about 95%, believe green spaces improve air quality. Milton Keynes also has a very high rate of agreement at around 85%. A small minority disagreed, with 10% of Milton Keynes residents and just 5% of Bedford residents responding 'No'. Perceptions of whether green spaces improve air quality did not differ significantly by city ($\chi^2(1) = 0.3156$, $p = 0.5743$; Fisher's exact $p = 0.3497$; Mann–Whitney $U = 351.5000$, $p = 0.2929$). No evidence was found for systematic differences in responses between cities.

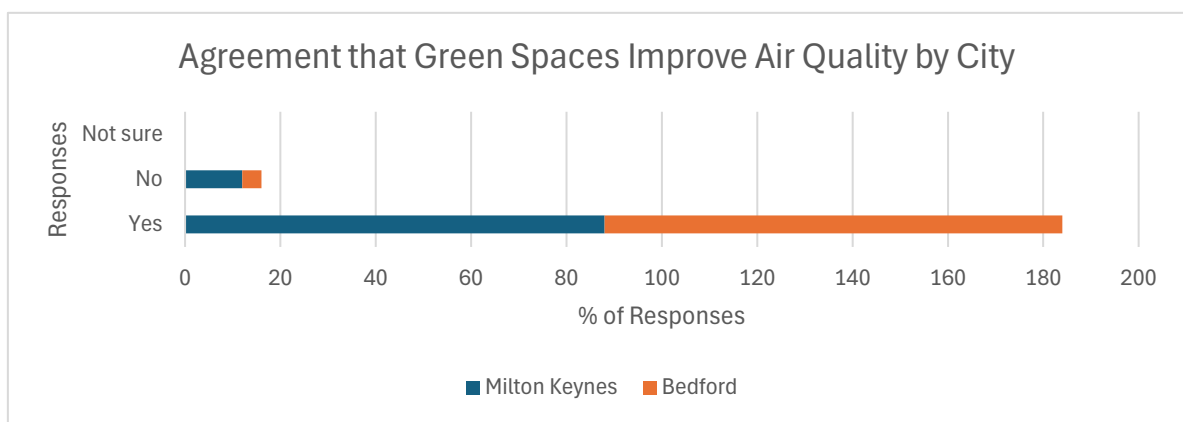


Figure 2: Perceived Air-Quality Benefits of Green Spaces by City

Figure 3 demonstrates perceived air quality issues reported by residents in Bedford ($n = 26$) and Milton Keynes ($n = 25$), with frequencies of responses; participants could select multiple issues. There were no significant differences between locations in the frequency of specific problems (all $p \geq 0.25$). The most common concerns were “bad smell” (Bedford: 10, Milton Keynes: 7; $\chi^2(1) = 0.46$, $p = 0.50$) and “dust on surfaces” (Bedford: 9, Milton Keynes: 6; $\chi^2(1) = 0.39$, $p = 0.53$). “Smoke or haze” was more frequent in Bedford (6 vs. 2; Fisher's exact $p = 0.25$), whereas “coughing or breathing problems” (1 vs. 2; $p = 1.00$) and “smell that makes it hard to sleep” (2 vs. 1; $p = 1.00$) were rare. Reports of no problems were similar (Bedford: 11, Milton Keynes: 12; $\chi^2(1) = 0.16$, $p = 0.69$).

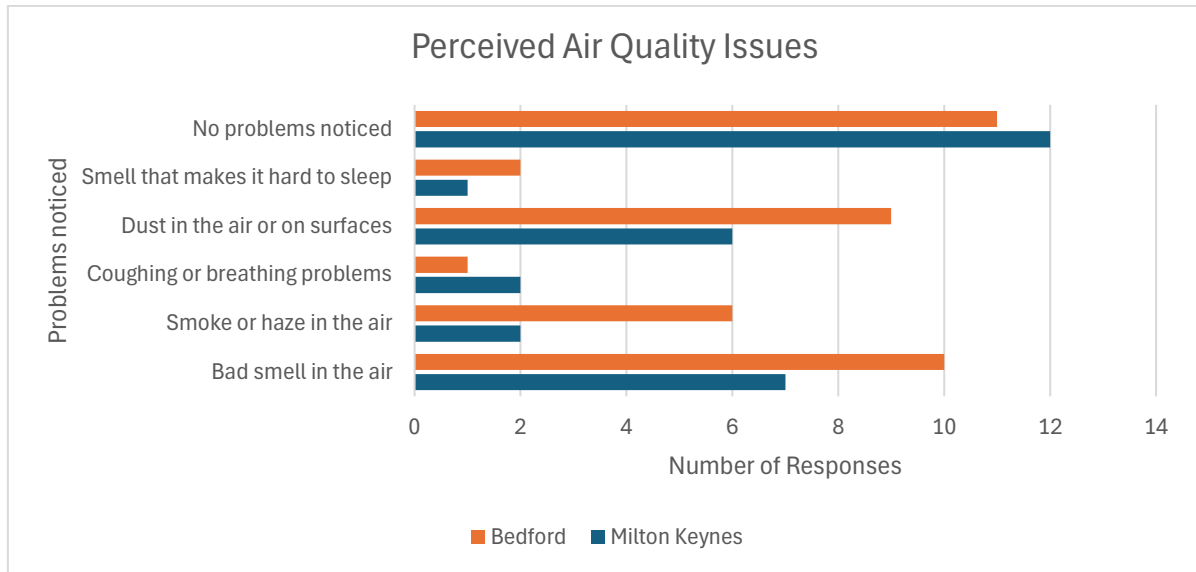


Figure 3: Air Quality Problems

Survey data show most respondents in Bedford (n = 26) and Milton Keynes (n = 25) identified various green spaces, with response rates from 19.2% to 96.2%. Fisher's exact tests revealed no significant differences between cities (all $p > 0.05$) (7Appendix E). Public parks/open spaces were identified by 25 Bedford (96.2%) and 19 Milton Keynes (76.0%) residents. Bedford respondents also noted riverbanks (50.0%), allotments (30.8%), and farmland (42.3%), while Milton Keynes respondents cited green roundabouts (60.0%), green paths/corridors (60.0%), and water-holding areas (32.0%). Street trees (76.9% vs. 80.0%), playgrounds/recreational spaces (69.2% vs. 72.0%), and urban forests/woodlands (50.0% vs. 52.0%) were reported at similar rates. Most residents (Bedford 69.2%; Milton Keynes 64.0%) reported the nearest green space is next to home or within a five-minute walk (7Appendix F). Fewer indicated walking times of 5–30 minutes, and none reported no green spaces. Chi-square tests found no significant difference in proximity distribution ($\chi^2 (4) = 0.76$, $p = 0.94$).

A strong and statistically significant association was found between the frequency of visiting green spaces and the perception that they improve air quality ($\chi^2 (2) = 13.94$, $p = 0.0009$; Kruskal–Wallis $H = 13.67$, $p = 0.0011$). The majority of participants visited green spaces more frequently (3–4 times per week and 5+ times per week) overwhelmingly believed these spaces contribute positively to air quality. Conversely, those who rarely or never visited green spaces were more likely to express uncertainty or disagreement with this perception (Figure 4). These findings suggest that greater exposure to green spaces may reinforce positive beliefs about their role in improving air quality.

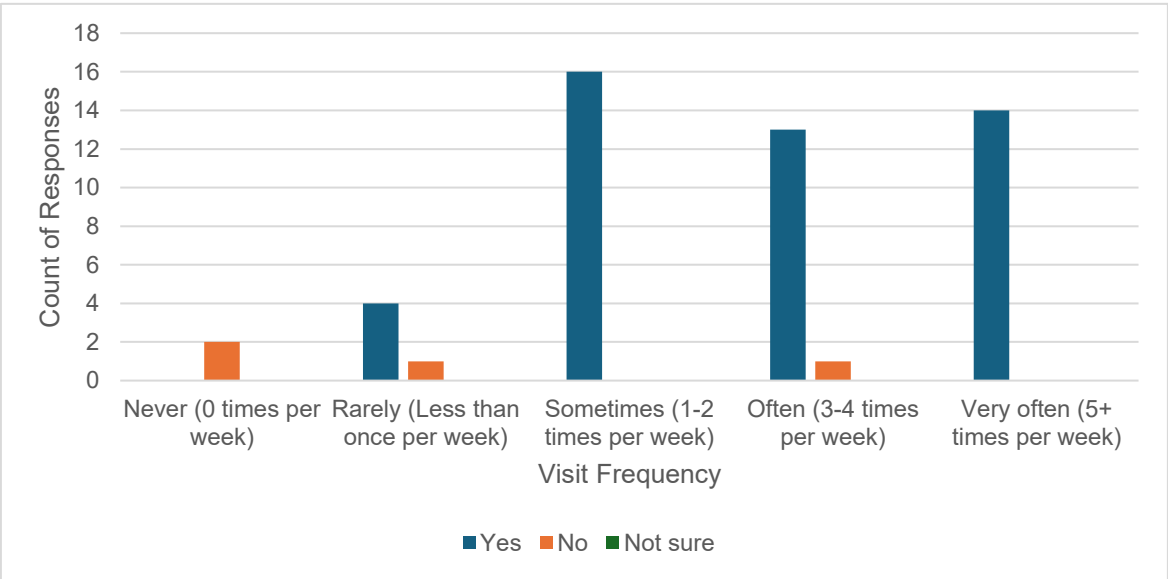


Figure 4: Relationship between frequency of green space visits and perceived benefits for air quality

Patterns of green space usage were broadly similar, although Milton Keynes residents reported a marginally higher (32%) frequency of visits (Appendix G). This could be attributed to differences in availability and accessibility. Visit frequency was not significantly associated with city ($\chi^2 (2) = 0.3734$, $p = 0.8297$; Mann–Whitney $U = 339.5000$, $p = 0.7682$), indicating similar patterns of green space use across locations.

Figure 5 clearly indicates that proximity to green spaces is strongly associated with visitation frequency. Respondents living right next to their homes reported

the highest mean frequency of visits ($M=4.70$, $SD=1.27$, $n=20$), followed by those within a 5 minutes' walk ($M=4.33$, $SD= 1.50$, $n=14$) and 5–15-minute walk ($M=3.60$, $SD=1.14$, $n=10$). Those at a distance of 15–30 minutes recorded the lowest frequency ($M=4.00$, $SD=1.07$, $n=7$). A chi-square test of independence was conducted to examine the relationship between proximity to green spaces and frequency of visits. The analysis revealed a significant association between these variables, $\chi^2 (2, N = 51) = 7.84$, $p = 0.02$, indicating that visit frequency varied by proximity category. Additionally, Cramér's V was 0.40, suggesting a medium to large effect size. These results suggest that individuals living closer to green spaces tend to visit more frequently, supporting the hypothesis that proximity influences visit behavior.

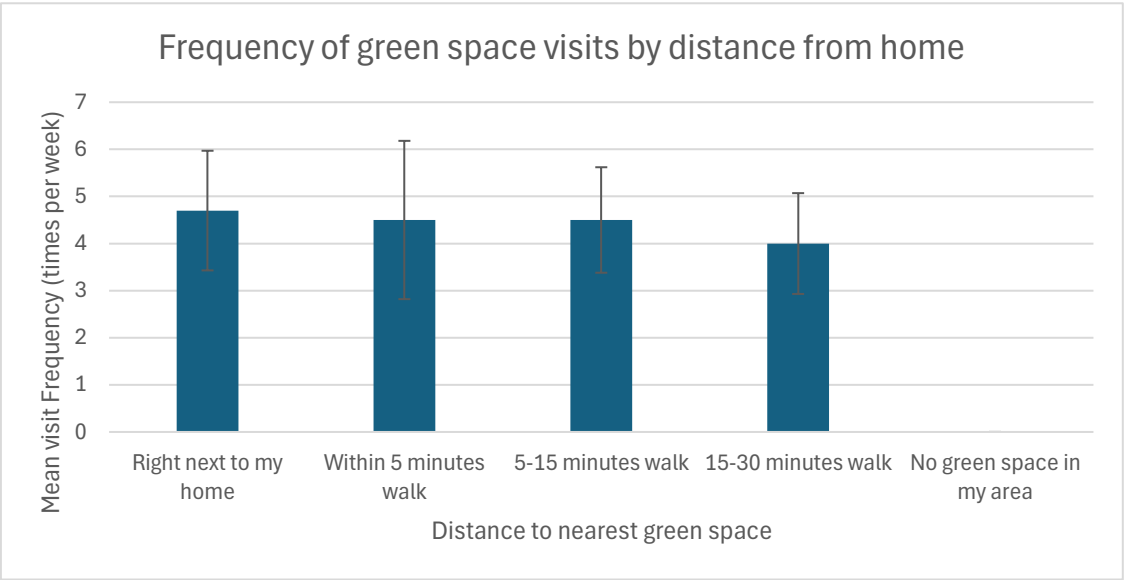


Figure 5: Frequency of Green Space Visits by Distance from Home

Participants' concern over air pollution shows mixed patterns across Bedford and Milton Keynes, with no consistent differences (7Appendix H). In Bedford, 31% were "concerned" and 19% "very concerned." Milton Keynes showed a more mixed response, with "concerned" slightly higher at 36% but only 4% "very concerned." Notably, Bedford had 0% "not concerned," while Milton Keynes had 8%, reflecting greater concern in Bedford overall. The relationship between city and concern over air pollution was not significant ($\chi^2 (4) = 8.7286$, $p = 0.0683$;

Mann–Whitney $U = 423.5000$, $p = 0.0567$). Participants' reported concern levels were comparable across cities.

Most age groups believe green spaces help improve air quality. Figure 6 shows the 18–24 and 35–44 groups with the highest average agreement, each scoring 1.14, based on 7 and 14 respondents respectively. The 25–34 group also shows strong agreement with a mean of 1.07 from 15 people. Older groups from 45–84 show full agreement with mean scores of 1.00, though they have fewer respondents (6 in 45–54, 5 in 55–64, and 1 each in 65–74 and 75–84). Perceptions of green spaces' air quality benefits were consistent across age groups, with no significant differences ($\chi^2(7) = 2.5112$, $p = 0.9262$; Kruskal–Wallis $H = 2.4620$, $p = 0.9299$).

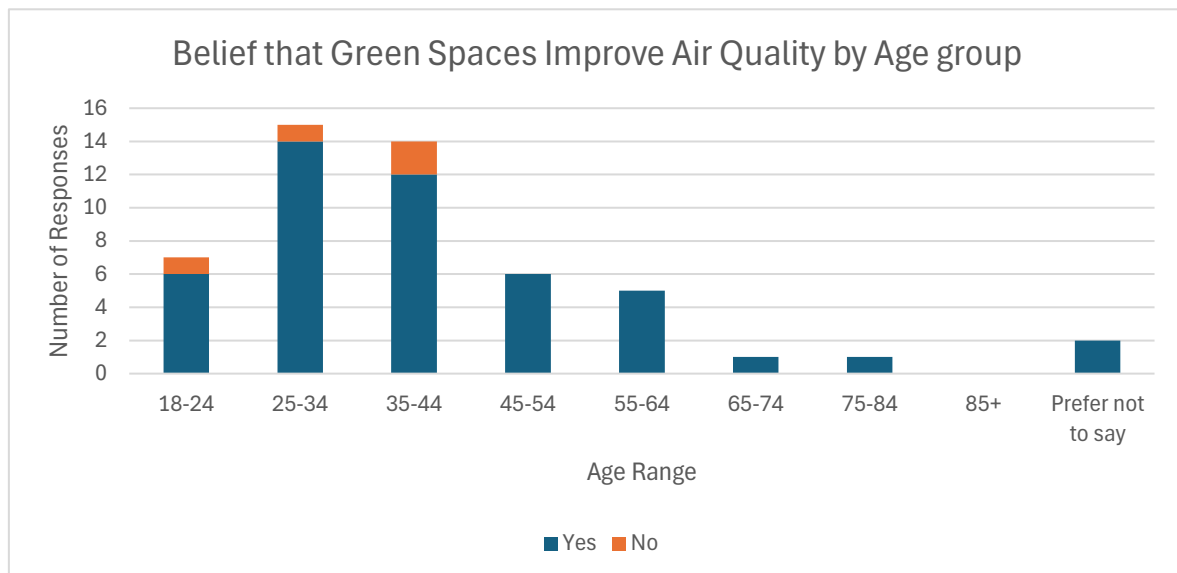


Figure 6: Belief that Green Spaces Improve Air Quality by Age group

Concern about health effects of air pollution varies by age: younger and middle-aged adults show neutral to high concern, while older adults express strong concern. This was not significant ($\chi^2(28) = 37.7156$, $p = 0.1039$; Kruskal–Wallis $H = 7.7194$, $p = 0.3580$), indicating broadly similar concern across age groups. Attention to air-quality information showed a different trend ($\chi^2(21) = 27.9897$, $p = 0.1404$; Kruskal–Wallis $H = 8.3020$, $p = 0.3067$): younger people checked occasionally, some middle-aged rarely, and a few older respondents more

regularly. Support for environmental initiatives was consistently high in both locations, with most respondents willing to endorse green space projects if shown to improve air quality. “Strongly agree” responses were slightly higher in Bedford, reflecting stronger commitment.

Figure 7 shows that most respondents earning £0–£12,570 (92.9%) and £12,571–£50,270 (93.8%) agreed that green spaces improve air quality, with only 7.1% in the lowest group disagreeing. Agreement declined in the £50,271–£125,140 bracket, where 81.8% agreed and 18.2% disagreed—the highest “No” rate. Respondents earning above £125,140 and those not disclosing income unanimously agreed (100%). Mean scores reflected this trend, with the £50,271–£125,140 group showing the highest average disagreement (1.18). No respondents selected “Not sure,” indicating generally definitive views. Overall, lower- and middle-income groups expressed consistently positive opinions, while a minority of higher middle-income participants were less convinced.

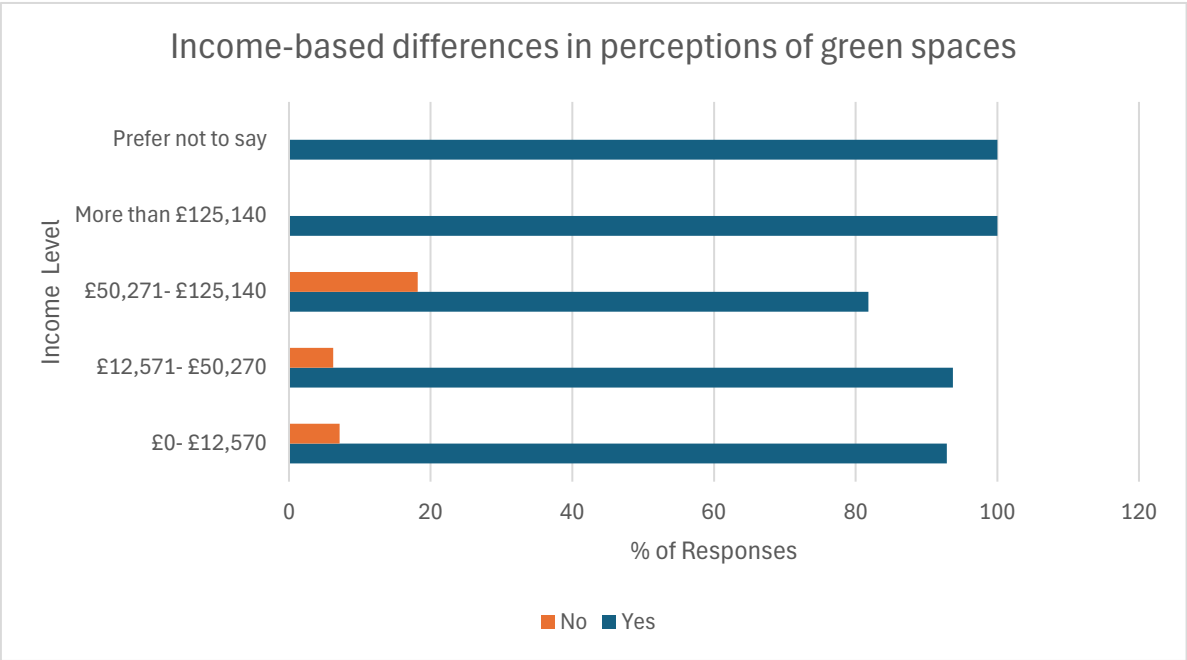


Figure 7: Belief that green spaces improve air quality by income level

Analysis of 51 survey responses revealed patterns in green space visitation across income groups (7Appendix I). In the middle-income group (£12,571–£50,270), 37.5% visited very frequently and 18.8% often, adding up to 56.3% at

least often. A similar trend appeared in the upper-middle group (£50,271–£125,140), where 36.4% visited very frequently and 36.4% often, nearly three-quarters frequent visitors. By contrast, the highest-income group (>£125,140) showed lower engagement, with the single respondent (100%) visiting only sometimes. At the lower-income level (£0–£12,570), half visited sometimes, 28.6% often, and 7.1% very often. Non-disclosers reported visiting often (33.3%) or very often (33.3%). Mean visitation scores ranged from 4.07 in the lowest-income group to 4.82 in the upper-middle group, with greater variability among middle-income respondents compared to more consistent patterns in the lowest and highest groups.

Responses to Q13, asking whether green spaces improve air quality, showed strong agreement—46 of 51 respondents (90.2%) answered “Yes.” A chi-square test found no significant association between education level and agreement, $\chi^2 (1, N = 51) = 1.55, p = 0.213$, indicating consensus across education groups. Notably, four postgraduate respondents (10.8%) expressed disagreement—the only dissent in the sample, highlighting variation by academic level, consistent with prior findings (Lingos et al., 2025). Further analysis revealed a significant association between education level and frequency of accessing air quality data, $\chi^2 (2, N = 51) = 8.04, p = 0.018$, showing postgraduates are more likely to monitor air quality regularly compared to those with lower education. These findings demonstrate general consensus on green spaces’ positive air-quality impact while highlighting education’s role in environmental data engagement.

3.4 Thematic Analysis of Open-Ended Questions

Question 1: Please specify the type of health issues you believe may be related to air pollution

As shown in Table 2, respondents most frequently associated air pollution with respiratory conditions (n=3), particularly asthma (n=2) and breathing difficulties (n=1). Allergic reactions were also common, with dust allergies mentioned

twice. Infections were identified less frequently, including lung and chest infections (n=1 each).

Table 2: Coded Themes and Frequencies of Health Issues Related to Air Pollution

Theme	Sub-theme (Node)	Frequency (n)	Example Response
Respiratory Conditions	Asthma	2	"Asthma"
	Breathing Problem	1	"Breathing problem and dust allergies"
Infections	Lung Infection	1	"Lung infection"
	Chest Infection	1	"Chest infection"
Allergic Reactions	Dust Allergy	2	"Dust allergy"

Question 2: Why green spaces help (or not) improve air quality?

Participants described multiple mechanisms through which green spaces improve air quality. The most frequent themes were carbon sequestration and oxygen provision (n=10) and pollutant removal (n=9). Fewer responses referred to photosynthesis (n=3) and cooling/shade effects (n=3). A single respondent expressed uncertainty about the mechanism but still believed in the benefits (Appendix J).

The word frequency analysis highlighted oxygen, carbon dioxide, pollution, photosynthesis, and filter as dominant terms (

Appendix L shows that the most frequently cited barriers were poor design and placement of greenery (n=5), followed by strong pollution sources (n=4) and maintenance challenges (n=4). Additional issues included human activities (n=3), limited space (n=2), and negative side-effects such as pollen release (n=2). One response highlighted safety concern (n=1).

Question 5: Do you associate any negative impacts of green spaces on air quality?

The most frequently cited negative impact was pollen and allergen release (n=5), followed by VOC emissions (n=4) and pollutant trapping due to dense vegetation (n=4). Less frequent concerns included human contributions (n=3), seasonal limitations (n=2), and ineffective planting choices (n=2).

4 Discussion

Table 1 illustrates that residents' perceptions of air-quality interventions are strongly influenced by visual and social cues, such as stability, continuity, and credibility, rather than solely by ecological outcomes. Interventions that appear stable and trustworthy are more likely to gain public support, while those perceived as temporary or less established may be undervalued socially (Pitt, n.d.). Local factors, such as environmental literacy, prior interactions with green spaces, and trust in public initiatives, further influence these perceptions (Andersson et al., 2015; Raymond et al., 2018). In addition, perceptions are shaped by overlapping social factors—such as gender, ethnicity, and socioeconomic status—while barriers like gentrification and exclusion restrict equitable access and long-term engagement (Calderón-Argelich et al., 2024). These findings highlight the need to align environmental goals with social dynamics to ensure inclusive and sustained community support.

The findings of this study reveal that the majority of respondents (90.2%) perceive vegetation as an effective means of improving air quality. This overwhelming level of support is consistent with DEFRA's (2017) national survey and international research from the US, China, and Europe, where urban greening is widely associated with air quality improvement (Islam et al., 2024; Diener & Mudu, 2021; Gong et al., 2023). Importantly, the composite scale used in this study demonstrated strong reliability (Cronbach's $\alpha = 0.771$), strengthening the validity of these attitudinal results.

The differences in air quality perceptions described in Figure 1 are supported by the spatial analysis performed using GIS and presented in Table 3 and **Error! Reference source not found.** Milton Keynes contains 921 mapped GI features compared to 577 in Bedford. **Error! Reference source not found.** illustrates the distribution of GI types in each area.

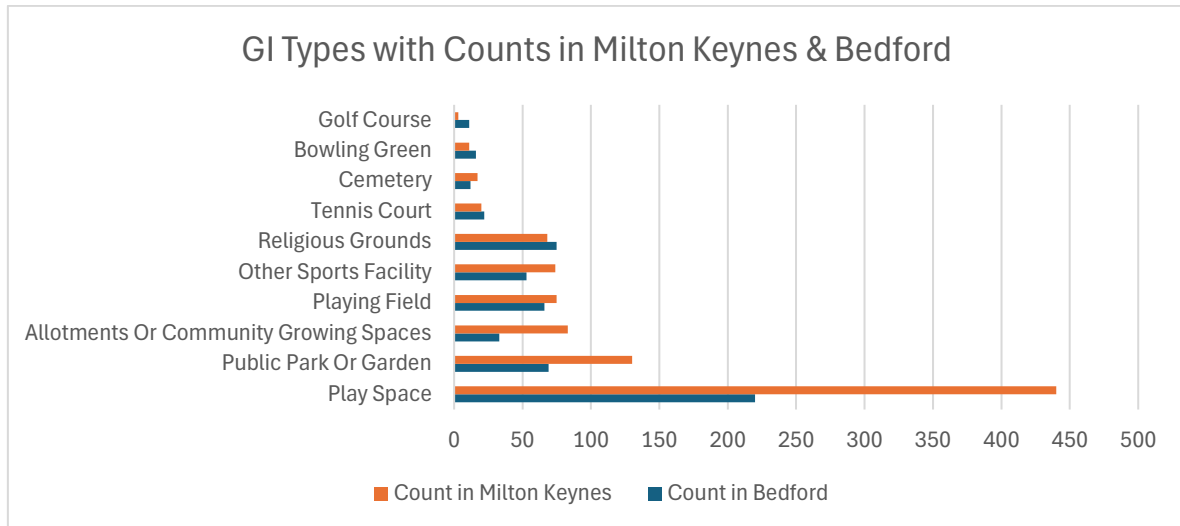


Figure 9: GI counts by function in study areas

Table 3 shows that the density of GI features is notably higher in Milton Keynes, with 2.98 sites per km² compared to 1.21 per km² in Bedford. Even though per capita access to GI is nearly equal in both cities, the higher urban density of Milton Keynes suggests its GI are more embedded in residents' immediate surroundings and this in turn improves air quality by filtering pollutants.

Table 3: Green Infrastructure Metrics for Milton Keynes and Bedford

Location	Population	Area (km ²)	GI count	GI per km ²	GI per 1,000 Residents
Milton Keynes	288,200	309	921	2.98	3.20
Bedford	194,976	476	577	1.21	2.96

In addition, 7Appendix H indicates that Bedford residents expressed comparatively more concern about air quality issues, while Milton Keynes residents were more likely to report no significant problems. This pattern reinforces the link between lower GI coverage and greater exposure to pollutants, suggesting that Bedford's lower extent of GI offers fewer natural buffers, potentially leading to greater pollution exposure and more frequent resident complaints.

As indicated in 7Appendix F, the reported ease of access to nearby green spaces aligns with the established urban planning approaches in both Milton Keynes and Bedford, where provision of accessible parks and open areas has been a consistent priority. This planning emphasis ensures that residents generally benefit from proximity to green spaces, supporting both recreational use and positive perceptions of the local environment. The variations observed in Figure 2 could reflect differences in local air quality, public awareness, and environmental conditions: Bedford, with more localised traffic congestion and fewer expansive green corridors than Milton Keynes, may prompt stronger concern, while Milton Keynes' extensive GI and urban design could lead some residents to perceive lower personal exposure to air pollution.

A significant and novel contribution of this study is the relationship between green space visitation and perceived benefits. Respondents who visited green spaces more frequently were more likely to believe in their role in improving air quality ($\chi^2 = 13.94$, $p < 0.001$). This finding supports theories from environmental psychology that repeated contact with nature reinforces positive attitudes and perceptions (Schertz et al., 2023; Hartig, 2021). Similarly, proximity was shown to influence use: those living nearer to green spaces reported more frequent visits ($\chi^2 = 7.84$, $p = 0.02$). These findings emphasize the importance of equitable access to green spaces within urban areas. They align with prior evidence (Fongar et al., 2019; Alderton et al., 2022; (Phillips et al., 2023; Shezi et al., 2024)that accessibility is a critical driver of engagement, particularly for those without access to private gardens (Poortinga et al., 2021).

The higher support for green spaces among postgraduates and undergraduates suggests that education level may influence environmental awareness and perceptions, a pattern consistent with real-world trends in urban sustainability advocacy (Kardan et al., 2015) ;Alam & Zakaria, 2013). As previously noted, engagement with air quality information was limited across all education levels among participants. These findings align with existing literature which found notable variations in air quality awareness by age, education and occupation,

and identified significant associations between education and awareness of indoor air pollution health risks (Al-Shidi et al., 2021 ;Al-Shidi et al., 2024;Kasirye et al., n.d.).However, the data also reveals that very few people (8), regardless of education, regularly check air quality data. This corresponds with existing literature which noted that most people are unaware of official air quality indexes (AQI) and instead tend to judge air quality based on their own senses (Ramírez et al., 2019). Similar patterns were observed globally (Oltra & Sala, 2018) ;Wen et al., 2009 ;Semenza et al., 2008).For instance, although in the US 49% were aware of alerts, only a minority changed their behaviour, and in Mexico City, 53% knew of the index but few actively used it (Mirabelli et al., 2018 ;Wells et al., 2012).Similarly, a survey in Luoyang China, found that while age, education, and occupation influenced awareness of air quality, this awareness rarely translated into concrete actions (Ge et al., 2024). Collectively, these findings suggest that while education significantly influences environmental health information-seeking behaviour, there remains a critical gap between awareness and the adoption of new behaviours. This highlights the necessity of effective public health communication strategies to bridge this gap and translate awareness into tangible action.

Despite strong concern about air quality, relatively few respondents reported checking AQIs. Postgraduates were more likely than undergraduates to use AQIs, but across the sample most participants relied on sensory cues such as visibility, odour, and dust levels to judge air quality. This gap between objective monitoring and subjective perception has also been identified in DEFRA's surveys and international studies (e.g., Luoyang, US, Mexico City). The results indicate an urgent need to improve communication strategies that make AQI data more accessible, interpretable, and relevant to the public.

Reflecting the patterns identified in income-based differences in perception of green space, people in lower-income areas often place greater importance on public green spaces due to limited access to private gardens and higher exposure to air pollution. This aligns with previous research indicating that

income and the type of housing significantly influenced general perceptions of GI, while particular aspects were perceived differently depending on one's age, gender, and local living conditions (Chukwu et al., 2022). Additionally, respondents with lower levels of education (junior high school or below) were more likely to hold low perceptions of GI's air purification functions. In contrast, those in the middle-income bracket (RMB 2000–5000/month) were much more likely to fall within the moderate to high perception categories (Jim et al., 2022). Some higher middle-income respondents disagreed likely because they recognise that green spaces alone cannot replace systemic pollution controls and that dense vegetation can sometimes trap pollutants or trigger allergies through pollen. Their typically higher education may contribute to a more informed and nuanced understanding of the benefits and limitations of GI. Together, these findings highlight that both income and education shape public perceptions of GI, emphasizing the need to address socioeconomic and demographic diversity in environmental strategies (Atiqul Haq et al., 2021; Tayouga & Gagné, 2016; Scarlett et al., 2021).

Socioeconomic differences were also evident. Lower- and middle-income groups were more likely to rely on and value public green spaces, while higher middle-income groups (£50,000–125,000) showed greater scepticism about their effectiveness. This reflects patterns of environmental justice, where those with fewer private resources demonstrate stronger dependence on shared public infrastructure. The findings highlight the need for urban planning that prioritises the equitable distribution of GI to avoid exacerbating inequalities in environmental and health outcomes (Venter et al., 2020; Hoffmann et al., 2017).

The visitation patterns reinforce the earlier finding that income shapes how people value and engage with green spaces as shown in 7Appendix I. The middle-income group's high usage likely occurs because they have better mobility than lower-income people but still depend on public green spaces more than wealthy people who may have private gardens. The highest income group shows the lowest frequent usage, possibly because they have access to private

outdoor spaces or can afford alternative recreational activities. The lowest income group shows moderate usage, which may be limited by transportation costs or time constraints from working multiple jobs. These findings are consistent with previous research showing that the presence of green spaces alone does not ensure equitable access or use; factors such as transportation, connectivity, socio-economic conditions, and individual perceptions play a critical role in shaping engagement (Deng et al., 2020).

Participants identified respiratory and allergic conditions as the primary health impacts of air pollution as demonstrated in Table 2. This emphasis corresponds with the well-documented association between particulate matter and respiratory illnesses, such as asthma and chronic bronchitis (WHO, 2023). While infections were mentioned less frequently, epidemiological studies indicate that exposure to fine particulate matter (PM_{2.5}) and nitrogen dioxide (NO₂) can increase vulnerability to respiratory infections (Yang et al., 2020). Notably, cardiovascular and systemic health impacts were rarely reported, suggesting that public understanding tends to focus on immediate, visible symptoms rather than long-term outcomes like heart disease or stroke. This finding highlights the importance of broadening public health initiatives to encompass chronic and systemic impacts. In addition, the prominence of day-to-day symptoms illustrates how personal experience influences risk perception, with direct exposure and immediate discomfort shaping awareness more strongly than abstract statistical information (Noël et al., 2021).

Open-ended responses reinforced the quantitative results, with respondents suggesting more trees, flowers, and natural landscaping as priority interventions, alongside calls for greener transport and urban design. The emphasis on natural elements illustrates strong trust in nature-based solutions. At the same time, the combination of quantitative and qualitative data reveals a clear tension: while the public strongly supports vegetation for air quality improvement, awareness of the mechanisms, trade-offs, and limits of vegetation remains partial.

The findings in **Error! Reference source not found.** indicated that respondents emphasised mechanisms such as trapping of dust and particulates, reduction of heat through shade and cooling, and air purification through the photosynthesis cycle as the major benefits of urban green spaces. These views align with existing literature that demonstrate vegetation contributes to local humidity and cooling through the process of evapotranspiration, where water vapor is released into the atmosphere (Wang, n.d.; Santamouris & Osmond, 2020). These benefits are often viewed as universally positive as indicated by Figure 2, with limited recognition of potential trade-offs such as VOC emissions or allergen production. This suggests that public understanding of GI may be partial, shaped by visible and immediately perceivable effects rather than nuanced ecological processes. Respondents' recognition of clean air as a key factor in their engagement with green spaces supports the idea that urban greenery can influence human behaviors and lifestyle choices. This illustrates an intuitive socio-ecological understanding of the connection between urban vegetation and healthier living. For planners and policymakers, this indicates that while public support for GI is strong, it can overstate certain outcomes, pointing to the importance of education on the full range of benefits and constraints of different planting approaches.

Error! Reference source not found. shows that participants recommended strategically placing vegetation near pollution hotspots, increasing plant species diversity, and expanding green coverage to enhance air quality. This aligns with studies such as Jayasooriya et al. (2017), which demonstrated that increasing tree density per hectare improved pollutant removal rates. Similar findings by (Chen et al., 2016) (Al-Dabbous & Kumar, 2014)(Klingberg et al., 2017) confirmed that GI effectiveness depends on wind direction and vegetation density, with maximum pollutant reduction during parallel winds when vegetation acts as a barrier limiting lateral dispersion. Particulate matter analysis revealed that hedges and mixed tree–hedge configurations reduced fine particles and vehicle-derived elements (iron, barium, chromium, manganese) behind vegetation compared to open areas. Literature further

notes that denser canopies act as solid barriers creating recirculation zones that trap pollutants, whereas in open urban settings like parks, well-spaced canopies enhance vertical dispersion and dilute plumes (Abhijith et al., 2017). In high-traffic zones, taller or more widely spaced trees aid dispersal, while in recreational areas, thicker cover improves deposition and limits downward flow of polluted air.

Abhijith & Kumar (2019) provided empirical evidence from Guildford, UK, showing that GI—including trees, hedges, and combinations—significantly ameliorates roadside air quality. Pollutants such as PM₁₀, PM_{2.5}, PM₁, black carbon (BC), and particle number concentrations (PNC) were consistently lower behind barriers. Hedges alone achieved the greatest BC reduction (63%), while tree–hedge combinations reduced BC by 52%, PM₁₀ by 15%, PM_{2.5} by 17%, PM₁ by 31%, and PNC by 30%. Field evidence from a co-designed school installation in Guildford also showed reductions in PM₁₀ (~32%) and noise (~5 dB(A)), with effectiveness varying by wind direction and particle size, emphasizing context-sensitive design and community involvement (Abhijith et al., 2025). Additionally, studies argue that green roofs and green walls are effective alternatives where space is limited (Berardi et al., 2014) (Ghasemian et al., 2017). Overall, strategic vegetation placement is crucial for maximising air pollutant reduction.

The barriers reported in **Error! Reference source not found.** correspond closely with those frequently cited in the GI literature. Vegetation positioned in street canyons or areas with high traffic flows can obstruct dispersion and even exacerbate pollution levels, confirming earlier studies on canyon ventilation and GI placement (Tomson et al., 2021). In parallel, inadequate maintenance—such as irregular watering, pruning, or replacement—reflect systemic governance gaps that continue to constrain the effectiveness of urban greening initiatives (Nobles & Moore, 2024). Poor maintenance often acts as triggers for vandalism and other antisocial behaviours, reducing both ecological function and social cohesion. These findings reinforce that GI strategies cannot rely solely on

technical interventions; success depends equally on fostering stewardship, accountability, and civic engagement (Heinze et al., 2018);Shepley et al., 2019).The fact that residents in this study recognised these complex barriers demonstrates a notable level of awareness, which could be channelled into participatory planning efforts to design locally meaningful and more sustainable interventions.

As shown in Table 1, respondents perceived mature, dense, diverse, and evergreen vegetation as the most effective in improving air quality. These preferences reflect intuitive recognition that larger canopies and denser vegetation provide greater shade, coverage, and aesthetic appeal. They also mirror findings from (Nowak et al., 2006), which stated that the extent of air pollutant removal varies considerably depending on several factors, including the extent of tree canopy coverage, pollutant concentrations, and local climatic conditions. Areas with the dense vegetation experience the highest levels of pollutant removal, whereas regions with shorter growing seasons or lower tree density tend to see less significant effects. Moreover, substantial literature affirms that key factors such as leaf area index, leaf morphology, and canopy roughness also enhance dry deposition of air pollutants, making GI a valuable tool for enhancing air quality (Baldauf, 2017) (Chen et al., 2017).

5 Conclusion

This study provides new insights into public perceptions of green infrastructure and its role in mitigating urban air pollution. Results confirm strong support for green space initiatives, with most respondents recognising their air quality benefits. Preferences for mature, evergreen, and diverse vegetation suggest that people intuitively associate long-established and resilient planting with greater effectiveness, though ecological outcomes may depend on factors beyond perception. Two socio-behavioural findings emerged. Firstly, frequent use of green spaces was linked to stronger belief in their air quality benefits, suggesting lived experience reinforces trust in GI. Secondly, proximity was a key determinant of visitation, with those living closest reporting the highest usage. These results support accessible urban greening as a pathway to environmental and social gain.

Equity considerations also emerged: lower- and middle-income groups relied more on public green spaces, reflecting inequalities in private garden access. Meanwhile, a minority of higher-income respondents expressed reservations, possibly reflecting awareness of ecological trade-offs such as allergen release or pollutant trapping. Despite widespread concern about air pollution, few respondents actively engaged with official air quality indices, relying instead on sensory observation, highlighting a challenge for public communication and health protection. Overall, the study shows that while public support for GI is robust, bridging the gap between perception and ecological evidence and ensuring equitable provision across socioeconomic groups remains necessary. Integrating community preferences with scientific understanding will be critical to designing resilient, context-appropriate, and socially inclusive GI that maximises its contribution to urban air quality management.

6 Recommendations

- **Strategic Placement in Pollution Hotspots:** Vegetation should be prioritised along Bedford's congested road corridors and near schools, where pollution exposure is highest. Piloting GI installations at schools and other high-exposure sites, combined with participatory design and monitoring, can protect vulnerable groups and build public trust. In Milton Keynes, roadside green buffers along wide grid roads and roundabouts can capture traffic emissions without impeding ventilation (Greenwald et al., 2024).
- **Context-Sensitive Design for Airflow:** In Bedford's denser streets, integrate well-spaced trees or hedges that promote airflow and prevent pollutants from being trapped in street canyons. In Milton Keynes, larger open green corridors allow for denser planting without compromising ventilation.
- **Species Selection:** Adopt mixed, mature, evergreen species preferred by residents in both cities to provide year-round benefits. Avoid high-pollen or high-VOC species to address allergen concerns, particularly in residential areas and near schools.
- **Expand Vertical and Rooftop Greening:** In Bedford, promote rooftop gardens, vertical green walls, and pocket parks to compensate for limited space. In Milton Keynes, green roofs can complement extensive ground-level GI, enhancing multifunctionality and biodiversity.
- **Long-Term Maintenance and Stewardship:** Address concerns regarding neglect and vandalism by allocating sustained funding for maintenance and developing resident-led stewardship groups, ensuring continued effectiveness and community ownership.
- **Inclusive Awareness Campaigns:** Tailor communication strategies for lower-income and less-educated groups, who reported weaker engagement with air quality data. Campaigns should emphasise both pollutant removal and longer-term health risks, such as cardiovascular impacts, which were under-recognised by participants.

- **Strengthening Trust through Transparency:** Implement visible monitoring (e.g., air quality sensors or public dashboards in parks) to help residents link GI interventions with measurable environmental improvements, addressing scepticism and fostering social acceptance.
- **Integrating Social Behaviour and Safety:** Consider barriers such as smoking, vandalism, and perceived safety issues. Design interventions with clear sightlines, adequate lighting, and community activity spaces to encourage positive use while minimising behaviours that compromise air quality benefits.
- **Holistic, Network-Based Planning:** Apply an ecosystem approach by connecting Bedford's smaller, fragmented green spaces into continuous corridors. In Milton Keynes, enhance existing linear parks to simultaneously support biodiversity, recreation, and air quality benefits.
- **Evidence-Based Modelling for Placement:** Use computational fluid dynamics (CFD) to guide planting layouts in Bedford's narrow streets, ensuring trees and hedges improve, rather than hinder, pollutant dispersion. In Milton Keynes, modelling can optimise large-scale roadside and water-linked vegetation projects (Gromke et al., 2008).
- **Accessibility and Equity in Green Space Provision:** Ensure GI is accessible within walking distance, particularly in Bedford's denser neighbourhoods, where residents rely heavily on public parks. Prioritise marginalised and high-exposure areas to address socio-economic disparities in access.
- **Cross-Sector Collaboration:** Coordinate efforts among planners, public health authorities, and local communities. In Bedford, collaboration is needed to retrofit GI into constrained spaces, whereas in Milton Keynes, it should focus on aligning extensive GI with ongoing climate resilience strategies.

7 Limitations of the Study and Future Research Directions

While this study provides valuable insights into public perceptions of GI, several limitations should be noted. The small sample size ($n=51$) limits statistical power and the ability to capture variation across demographic groups. Participants were recruited mainly through convenience and snowball sampling within academic and digital networks, skewing the sample toward younger, highly educated, and digitally connected residents, with older or less digitally active groups underrepresented. The exclusive use of an online survey also restricted participation to mobile and internet users. As the research was cross-sectional, it reflects perceptions at a single point in time and cannot account for seasonal differences in air quality or green space use. Reliance on self-reported perceptions introduces subjectivity, and the absence of qualitative methods such as interviews or focus groups limited understanding of cultural and behavioural dimensions of GI.

These limitations suggest several directions for future research. Larger and more representative studies using stratified sampling would help include diverse socio-economic, age, and ethnic groups. A participatory mixed-methods design with interviews and workshops could capture richer narratives of how lived experiences and social values shape perceptions. Longitudinal studies would trace attitudes across seasons and as vegetation matures, since findings here may not extend across time or other UK regions. Expanding research beyond Milton Keynes and Bedford to areas with contrasting urban forms, climates, and socio-economic conditions would further test generalisability. Future work should also examine how everyday behaviours in green spaces—such as smoking, barbecues, or recreation—interact with ecological processes, potentially influencing perceived and actual air quality. Postcode data could also be linked to objective indicators like greenspace distance, local green cover, and modelled pollution to compare perceived and actual conditions, and to examine how access to GI shapes visitation, perceptions of air quality, and equity, while ensuring

anonymity in spatial analysis. Finally, integrating computational modelling of pollutant dispersion with perception studies would provide a more comprehensive assessment of how public views align with measurable environmental performance. Together, these approaches would strengthen understanding of the social and ecological dimensions of GI and support.

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Appendices

Appendix A Ethical approval letter



18 June 2025

Dear Fariha

Reference: CURES/25662/2025

Project ID: 28981

Title: Public Perception of Green Infrastructure's Role in Urban Air Quality

Thank you for your application to the Cranfield University Research Ethics System (CURES).

We are pleased to inform you your CURES application, reference CURES/25662/2025 has been reviewed. You may now proceed with the research activities you have sought approval for.

If you have any queries, please contact CURES

Support. We wish you every success with your project.

Regards,

CURES

Team

Appendix B

Survey Questionnaire

Q1 Introduction

You are being invited to take part in a research study as part of a Master's thesis at Cranfield University. The research explores how the general public perceives the role of green spaces in improving urban air quality. Green Spaces includes natural elements like trees, parks, hedges or green roofs integrated urban planning. Before you decide whether to take part, it is important that you understand why the research is being done and what it will involve. Please take time to read the following information carefully. Feel free to contact the researcher if anything is unclear or if you would like more information.

What is the purpose of the research?

This study aims to learn about public awareness, understanding, and valuation of the role of green spaces in urban air quality by exploring residents' perceptions of both its potential benefits and possible drawbacks. In addition, the research seeks to find out the demographic and socio-economic factors that shape how members of the public perceive the effectiveness of green spaces in improving air quality. The study will investigate the barriers that may hinder the social acceptability of green spaces as an air quality management strategy, with the goal of providing actionable recommendations to enhance both the air quality benefits and the broader public acceptance of green space initiatives.

Why have I been invited to participate?

You have been invited because you are a resident of Milton Keynes or Bedford—two urban areas selected for this research because of their contrasting approaches to green spaces and air quality management. Your views will help build a more complete understanding of how green spaces are perceived in real communities.

What does participation involve?

You are invited to complete an online survey that takes around 10-15 minutes about your views on green spaces and its impact on air quality in your city. The survey will ask about your awareness, attitudes, and perceptions, as well as some basic demographic information (e.g., gender, occupation, area of residence/postcode). Participation is voluntary and you can withdraw at any time before submitting your responses.

Are there any risks or benefits?

There are no expected risks related to this study. The survey contains general demographic and socio-economic questions, such as age, ethnicity, employment status, and personal income. However, all responses are anonymous and entirely voluntary. Each of these questions includes a “Prefer not to say” option. While you will not receive any direct benefit from participating, your insights may help to better-informed urban planning and environmental policies.

Confidentiality and Data Handling

- All data collected will be handled confidentially and securely.
- You will not be asked to provide your name or contact details, unless you voluntarily give them to get study updates.
- Your responses will remain completely anonymous and cannot be linked back to you.
- Data will be stored on Cranfield University’s secure, password-protected servers.
- The researcher and supervisors will be the only people with access to the data.

Your consent:

By continuing with this survey, you tell us that:

1. You understand that your participation in this survey is voluntary and that you may withdraw at any time before submitting your response.
2. You consent to your survey responses being used for this research project.
3. You understand that your name or identifying information will not be used in any reports.
4. You are 18 years of age or older

End of Block:

Start of Block: Residential Information

Q2 In which area do you live?

- ☐ Bedford (1)
- ☐ Milton Keynes (2)

Q3 How long have you lived in your current area?

- ☐ Less than 1 year (1)
- ☐ 1-5 years (2)
- ☐ 6-10 years (3)
- ☐ 11- 20 years (4)
- ☐ More than 20 years (5)

End of Block: Residential Information

Start of Block: Air Quality and Health

Q4 How would you rate the air quality in your local area?

- ☐ Very poor (1)
- ☐ Poor (2)
- ☐ Neutral (3)

- o Good (4)
- o Very good (5)

Q5 What problems, if any, have you noticed with the air in your area?

- ☐ Bad smell in the air (1)
- ☐ Smoke or haze in the air (2)
- ☐ Coughing or breathing problems when outside (3)
- ☐ Dust in the air or on surfaces (4)
- ☐ Smell that makes it hard to sleep (5)
- ☐ No problems noticed (7)

Q6 How often do you check or pay attention to air quality information (e.g. on websites, apps, or news)?

- o Never (1)
- o Rarely (2)
- o Sometimes (3)
- o Often (4)
- o Always (5)

Q7 How concerned are you about the affect of air pollution on health?

- o Not concerned (1)
- o Somewhat concerned (2)
- o Neutral (3)
- o Concerned (4)
- o Very concerned (5)

Q8 Do you believe that you or a family member have experienced health issues that may be related to air pollution?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Not sure (3)

Display this question:

If Do you believe that you or a family member have experienced health issues that may be related to... = Yes

Q9 Please specify the type of health issues you believe may be related to air pollution.

End of Block: Air Quality and Health

Start of Block: Attitudes Towards Green Space

Q10 Green spaces mean outdoor areas in towns or cities that are covered with grass, trees, or plants- like public parks, community gardens, or natural areas- providing a place for people to enjoy fresh air and nature. Which of the following green spaces are present in your community? (Select all that apply)

- ☐ Public parks and open spaces (1)
- ☐ Street trees (2)
- ☐ Playgrounds and recreational green spaces (3)
- ☐ Urban forests and woodland areas (4)
- ☐ Green paths or corridors (e.g. between houses, along railways or roads) (5)

- ☐ Nature reserve and country parks (6)
 - ☐ Green roundabouts (7)
 - ☐ Riverbanks with public access (9)
 - ☐ Allotments (publicly provided for community use) (10)
 - ☐ Green verges (strips of grass next to roads or pavements) (11)
 - ☐ Green spaces that hold water temporarily (e.g. rain garden) (12)
 - ☐ Farmland (13)
 - ☐ Other (please specify): (8)
-

Q11 How far is the nearest green space from your home?

- ☐ Right next to my home (1)
- ☐ Within 5 minutes walk (2)
- ☐ 5-15 minutes walk (3)
- ☐ 15-30 minutes walk (4)
- ☐ No green space in my area (5)

Q12 How often do you visit green spaces?

- ☐ Never (0 times per week) (1)
- ☐ Rarely (Less than once per week) (2)
- ☐ Sometimes (1-2 times per week) (4)
- ☐ Often (3-4 times per week) (5)
- ☐ Very often (5+ times per week) (6)

Q13 Do you believe green spaces help improve air quality?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Not sure (3)

Q14 Why do you believe green spaces help or do not help improve air quality (Optional)?

Q15 Do you think air quality is better in areas where water features and green spaces are combined (such as parks with ponds, tree-lined rivers, or wetlands)?

- ☐ Strongly disagree (1)
- ☐ Disagree (2)
- ☐ Neutral (3)
- ☐ Agree (4)
- ☐ Strongly agree (5)

Q16 How effective do you think each of the following characteristics is at improving air quality? Select one option per row:

	Not effective at all (1)	Slightly effective (2)	Moderately effective (3)	Very effective (4)	Extremely effective (5)
Areas with only one type of greenery (like all grass or all trees) (1)					
Areas with different types of					

plants mixed together (2)					
Mature trees (old and big trees) (3)					
Recently planted (new and young trees) (4)					
Trees spread out (5)					
Trees close together (6)					
Evergreen trees (keep their leaves all year long) (7)					
Deciduous trees (lose their leaves in winter) (8)					

Q17 How do you think green spaces could be better designed or located in your area to improve air quality? (Optional)

End of Block: Attitudes Towards Green Space

Start of Block: Behaviour, Barriers, and Motivation

Q18 How much do you agree or disagree with the following statements?
(Please tick one box for each statement.)

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
I would support more green space projects in my area if they helped improve air quality. (1)					
I believe green spaces meaningfully reduce urban air pollution. (2)					
Cleaner air motivates me to spend time near green spaces. (3)					
Green spaces near roads and traffic areas improve air quality. (4)					
I spend time in green spaces because the air quality is better there. (6)					

Q19 Do you actively avoid areas with poor air quality?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Not sure (3)

Q20 What barriers might prevent green spaces from effectively improving air quality in your area? (Optional)

Q21 Do you associate any negative impacts of green spaces on air quality? Please specify if any (Optional).

Q22 Are you a member of any group or association that works on air quality?

- ☐ Yes (1)
- ☐ No (2)

Display this question:

If Are you a member of any group or association that works on air quality? = Yes

Q23 If yes, what is the name of the group(s) or association(s) you are a member of?

Display this question:

If Are you a member of any group or association that works on air quality? = No

Q24 If no, are you aware of any group or association that works to improve air quality?

End of Block: Behaviour, Barriers, and Motivation

Start of Block:

Q25 To help us understand how air quality varies by area, would you be willing to share your postcode? (Your postcode information will be kept confidential and used only to analyse air quality trends by location)

- ☐ Yes, the postcode is: (1)
-

- ☐ No, I don't want to share (2)

Q26 Please share any additional comments about air quality or green spaces in your community (Optional):

End of Block:

Start of Block: Demographic Information

Q27 What is your age range?

- ☐ 18–24 (1)
- ☐ 25–34 (2)
- ☐ 35–44 (3)
- ☐ 45–54 (4)
- ☐ 55–64 (5)
- ☐ 65- 74 (6)
- ☐ 75- 84 (8)
- ☐ 85+ (9)
- ☐ Prefer not to say (7)

Q28 What is your gender?

- ☐ Male (1)
 - ☐ Female (2)
 - ☐ Non-binary / third gender (3)
 - ☐ Prefer to self describe: (5)
-

- ☐ Prefer not to say (4)

Q29 Which ethnic group do you belong to?

- ☐ Asian, Asian British or Asian Welsh (Indian, Pakistani, Bangladeshi, Chinese, Any other Asian background) (1)
- ☐ Black, Black British, Black Welsh, Caribbean or African (2)
- ☐ Mixed or Multiple ethnic groups (3)
- ☐ White (English, Welsh, Scottish, Northern Irish, British, Irish, Gypsy or Irish Traveller, Roma, Any other White background) (4)
- ☐ Other ethnic group (Arab, Any other ethnic group) (5)
- ☐ Prefer not to say (6)

Q30 What is your highest level of education?

- ☐ No formal qualifications (1)
- ☐ GCSEs or equivalent (2)
- ☐ A-levels or equivalent (3)
- ☐ Apprenticeship or vocational qualification (4)
- ☐ Undergraduate degree (e.g. BA, BSc) (5)
- ☐ Postgraduate degree (e.g. MSc, PhD) (6)

- o Other (please specify- optional): (7)
-

- o Prefer not to say (8)

Q31 What is your employment status?

- o Employed (Full-time or part-time) (1)
- o Self-employed (2)
- o Student (3)
- o Unemployed/seeking work (4)
- o Looking after home or family (5)
- o Retired (6)
- o Unable to work due to illness/disability (7)
- o Prefer not to say (8)

Q32 What is your approximate personal income before tax?

- o £0- £12,570 (1)
- o £12,571- £50,270 (2)
- o £50,271- £125,140 (3)
- o More than £125,140 (4)
- o Prefer not to say (5)

Q33 Do you own or use an electric vehicle (EV)?

- o Yes (1)
- o No (2)
- o Not sure (3)

- ☐ Planning to (4)

Q34 Have you ever attended a class, workshop, or session about the environment or air pollution?

- ☐ Yes (1)
- ☐ No (2)

End of Block: Demographic Information

Start of Block: Consent to Participate

Q35 Optional Contact You may choose to provide your email address if you wish to: Receive a summary of findings Be contacted for follow-up questions related to the research Email Address:

Appendix C

Python Codebook

Variable Name	Survey Question Description	Data Type	Code	Meaning/Response Category
Area	In which area do you live? Q2	Categorical	1	Milton Keynes
			2	Bedford
Years_Lived	How long have you lived in your current area? Q3	Ordinal	1	≤ 5 years
			2	> 5 years
Air Quality Rating	How would you rate the air quality in your local area? Q4	Ordinal	1	Poor (Very Poor+ Poor)
			2	Neutral
			3	Good (Good+ Very good)
Air Info Check frequency	How often do you check air quality info? Q7	Ordinal	1	Low frequency (Never+ Rarely)
			2	Medium Frequency (Sometimes)
			3	High Frequency (Often+ Always)
Concern Level	How concerned about air pollution on health? Q8	Ordinal	1	Low concern (Not concerned+ somewhat concerned)
			2	Neutral
			3	High concern (Concerned+ Very concerned)
Visit Frequency	How often do you visit green spaces? Q13	Ordinal	1	Low frequency (Never+ Rarely)
			2	Medium Frequency (Sometimes)
			3	High Frequency (Often+ Always)
AirQuality_WaterGreen_Combined	Do you think air quality is better in areas where water features and green spaces are combined? Q16	Ordinal	1	Disagree (Strongly Disagree + Disagree)
			2	Neutral
			3	Agree (Agree + Strongly Agree)
Effectiveness_SingleTypeGreenery	How effective do you think each of the following characteristics is at	Ordinal	1	Low effectiveness (not effective at all+ slightly effective)
			2	Moderate Effectiveness

	improving air quality? Q17.1		3	High Effectiveness (Very effective+ Extremely effective)
Effectiveness_MultipleTypeGrennery	How effective do you think each of the following characteristics is at improving air quality? Q17.2	Ordinal	1	Low effectiveness (not effective at all+ slightly effective)
			2	Moderate Effectiveness
			3	High Effectiveness (Very effective+ Extremely effective)
Effectiveness_MatureTrees	How effective do you think each of the following characteristics is at improving air quality? Q17.3	Ordinal	1	Low effectiveness (not effective at all+ slightly effective)
			2	Moderate Effectiveness
			3	High Effectiveness (Very effective+ Extremely effective)
Effectiveness_RecentlyPlanted	How effective do you think each of the following characteristics is at improving air quality? Q17.4	Ordinal	1	Low effectiveness (not effective at all+ slightly effective)
			2	Moderate Effectiveness
			3	High Effectiveness (Very effective+ Extremely effective)
Effectiveness_TreesSpreadOut	How effective do you think each of the following characteristics is at improving air quality? Q17.5	Ordinal	1	Low effectiveness (not effective at all+ slightly effective)
			2	Moderate Effectiveness
			3	High Effectiveness (Very effective+ Extremely effective)
Effectiveness_TreesCloseTogether	How effective do you think each of the following characteristics is at improving air quality? Q17.6	Ordinal	1	Low effectiveness (not effective at all+ slightly effective)
			2	Moderate Effectiveness
			3	High Effectiveness (Very effective+ Extremely effective)
Effectiveness_EvergreenTrees	How effective do you think each of the following	Ordinal	1	Low effectiveness (not effective at all+ slightly effective)

	characteristics is at improving air quality? Q17.7		2	Moderate Effectiveness
			3	High Effectiveness (Very effective+ Extremely effective)
Effectiveness_DeciduousTrees	How effective do you think each of the following characteristics is at improving air quality? Q17.8	Ordinal	1	Low effectiveness (not effective at all+ slightly effective)
			2	Moderate Effectiveness
			3	High Effectiveness (Very effective+ Extremely effective)
Support_Projects	Support more green space projects if they help air? Q19.1	Ordinal	1	Disagree (Strongly Disagree + Disagree)
			2	Neutral/ Neither agree nor disagree
			3	Agree (Agree + Strongly Agree)
Age_Range	What is your age range? Q28	Ordinal	1	18-34
			2	35-54
			3	55+
			4	Prefer not to say

Appendix D

Sample Demographics of the Respondents

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	19	37
	Female	29	57
	Prefer to self-describe	1	2
	Prefer not to say	2	4
Ethnic Group	Asian	19	37
	Black	4	8
	Mixed	3	6
	White	20	39
	Other (Arab)	2	4

	Prefer not to say	3	6
Highest Level of Education	GCSE or equivalent	2	4
	A level	2	4
	Undergraduate	8	16
	Postgraduate (MSc/PhD)	37	72
	Other	1	2
	Prefer not to say	1	2
Employment Status	Employed	24	47
	Self-employed	3	6
	Student	19	37
	Unemployed/Seeking work	1	2
	Looking after home	1	2
	Retired	2	4
	Prefer not to say	1	2
Income after tax	£0–12,570	14	27
	£12,571–50,270	16	31
	£50,271–125,140	11	22
	More than £125,140	1	2
	Prefer not to say	9	18
Age Group	18-44	36	70
	45-64	11	22
	65+	2	4
	Prefer not to say	2	4

Appendix E

Percentages and statistical significance of green space types reported in Bedford and Milton Keynes

Green Space Type	Bedford (%)	Milton Keynes (%)	p-value (Fisher's Exact Test)
Public parks and open spaces	96.2%	76.0%	0.072
Street trees	76.9%	80.0%	1.00
Playgrounds and recreational green spaces	69.2%	72.0%	1.00
Urban forests and woodland areas	50.0%	52.0%	1.00
Green paths or corridors	53.8%	60.0%	0.80
Nature reserve and country parks	53.8%	44.0%	0.54
Green roundabouts	38.5%	60.0%	0.27
Riverbanks with public access	50.0%	28.0%	0.22
Allotments (publicly provided community use)	30.8%	28.0%	1.00
Green verges (strips of grass next to roads)	46.2%	44.0%	1.00
Green spaces that hold water temporarily	19.2%	32.0%	0.48
Farmland	42.3%	36.0%	0.77
Other	0%	4.0%	1.00

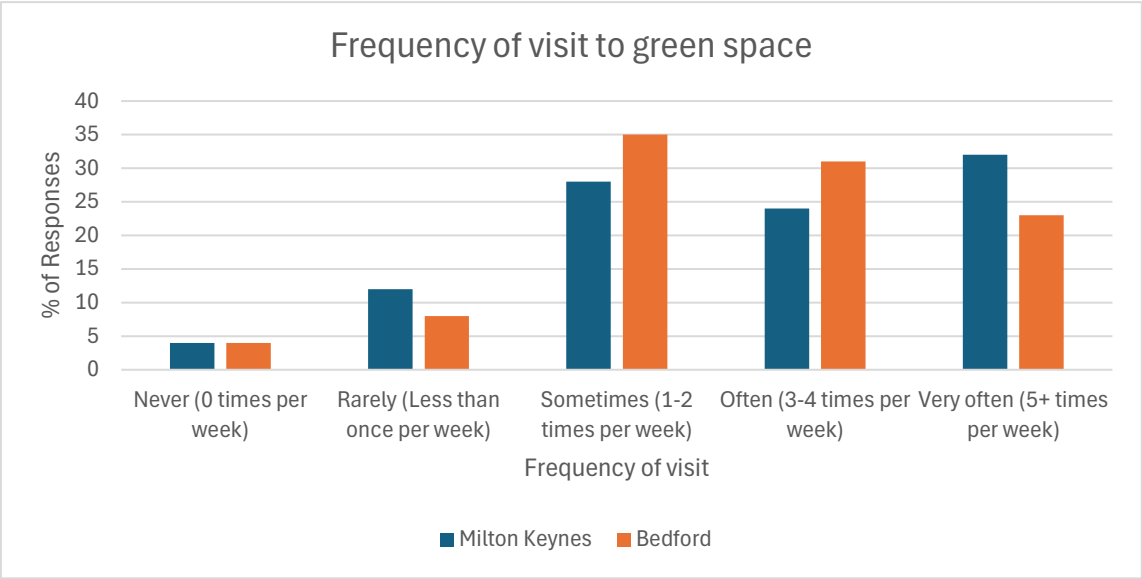
Appendix F

Proximity of Respondents' Homes to Green Spaces

Distance to nearest green space	Bedford	Milton Keynes
Right next to my home	11	9
Within 5 minutes' walk	7	7
5-15 minutes' walk	4	6
15-30 minutes' walk	4	3
No green space in my area	0	0

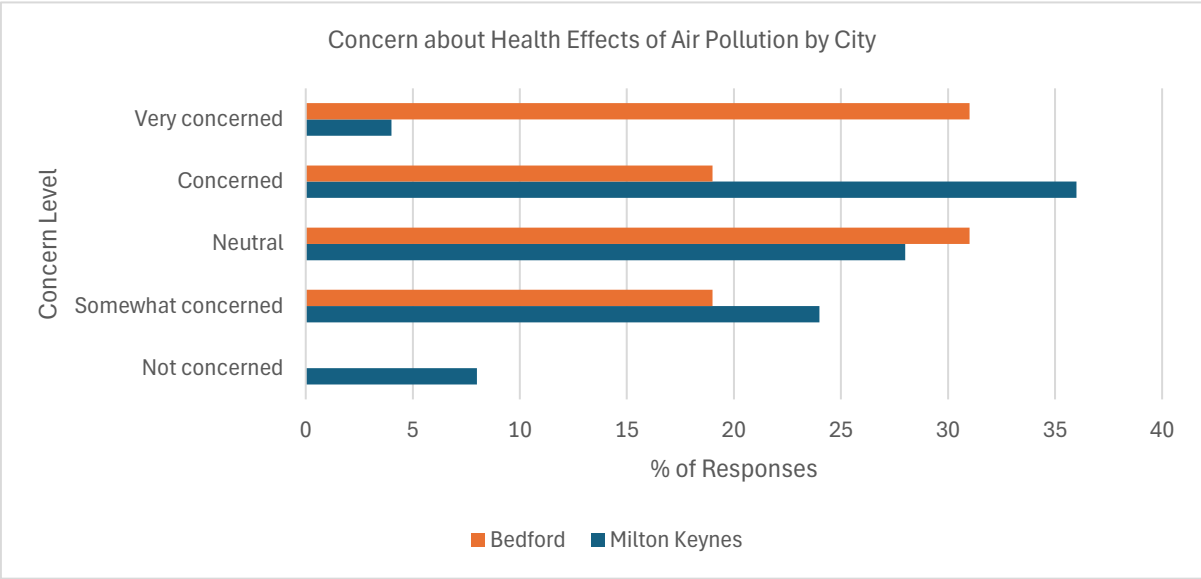
Appendix G

Frequency of green space visits in Milton Keynes vs. Bedford



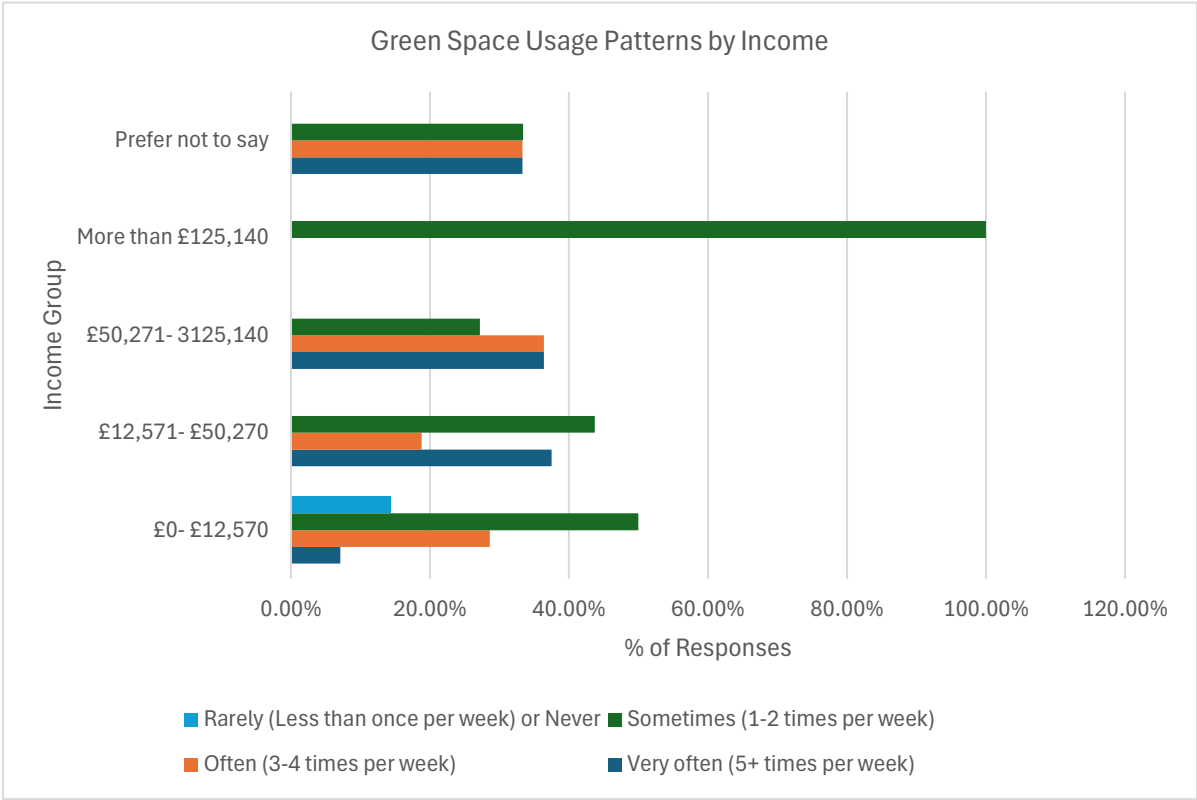
Appendix H

Levels of Concern About Air Pollution's Health Effects by City



Appendix I

Green space usage patterns by income



Appendix J

Coded Themes and Frequencies of Perceived Mechanisms by Which Green Spaces Influence Air Quality

Theme	Sub-theme (Node)	Frequency (n)	Example Response
Pollutant Removal	Filtering/trapping	9	“Trees trap dust, smoke and pollution on their leaves”
Carbon Sequestration & Oxygen	Absorb CO2 and release O2	10	“Green spaces produce oxygen and absorb CO ₂ ”

			which balance the airflow.”
Photosynthesis	Reference to photosynthesis	3	“It helps in photosynthesis.”
Cooling & Shade Benefits	Temperature regulation	3	“They provide shade and cool down cities, which helps reduce pollution.”
Scepticism/ Uncertainty	Not sure how it works	1	“Not sure exactly how... but I believe vegetation improves air quality.”

Appendix K

Suggested Improvements for Green Space Design and Location to Enhance Air Quality

Theme	Sub-theme (Node)	Frequency (n)	Example Response
Strategic Location & Planning	Near roads/schools, urban integration	6	“Green spaces should be placed near busy roads in Bedford to catch pollution.”
Diverse Vegetation & Design	Mix of plants, vertical greening	6	“Rooftop gardens and vertical green walls could be used in crowded places.”
Increased Planting & Expansion	More trees, hedges, planting	5	“Plant more wherever possible!”
Maintenance & Management	Regular care, upkeep	2	“More maintenance.”

Productive Planting	Fruit trees, multifunctional	1	"Pear and apple trees would be beneficial."
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Appendix L

Barriers Preventing Green Spaces from Effectively Improving Air Quality

Theme	Sub-theme (Node)	Frequency (n)	Example Response
Poor Design & Placement	Street canyons, airflow	5	"If vegetation is positioned without considering wind, it can trap pollutants."
Strong Pollution Sources	Traffic, factories	4	"Too much pollution from roads"
Maintenance Issues	Lack of funding, neglect	4	"If not well maintained, they lose value and effectiveness."
Human Activities	Smoking, vandalism, BBQs	3	"People smoking weeds and cigarettes... efficiency compromised."
Limited Space / Land Use	Urban density, competition	2	"Competition for land."
Negative Side Effects	Pollen, allergies	2	"Some trees release pollen that makes air quality worse"

Safety/Usability Concerns	Poor design, safety	1	“People might not use green spaces if unsafe”
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