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Authors: Ellie Nelson & Jiaxin Liu

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A Rapid Evidence Synthesis of Policy Mechanisms To Reduce Greenhouse Gases from Transport In Rural Areas

Ellie Nelson
University of York
York, United Kingdom
ellie.nelson@york.ac.uk

Jiaxin Liu
University of York
York, United Kingdom
jiaxin.liu@york.ac.uk

Abstract

The transport sector in the United Kingdom represents a significant contributor to national greenhouse gas emissions, necessitating focused climate change mitigation strategies. While urban areas have seen the successful implementation of policies targeting vehicle emissions over the last two decades, such as Ultra Low Emission Zones and Clean Air Zones in cities, the reduction of greenhouse gas emissions from rural transport has received comparatively less scholarly attention. To address this disparity, a rapid review was conducted following the PRISMA protocol to evaluate the current state of research. The screening process of 565 potentially relevant publications yielded only 11 eligible studies for inclusion in the review. The limited volume of existing articles containing primary data suggests that further empirical research is needed to assess effective policy interventions for rural transport emission mitigation. Nevertheless, preliminary syntheses from this review suggest that enhancements in public transport provision, including responsive transport services, alongside the promotion of active travel and shared transport initiatives, offer potential avenues for greenhouse gas emission reduction in rural areas.

Keywords: Greenhouse gas emissions, rural transport, transport policies, PRISMA rapid review, evidence synthesis

Synthèse rapide des données probantes sur les mécanismes politiques visant à réduire les gaz à effet de serre liés aux transports en milieu rural

Ellie Nelson
University of York
York, United Kingdom
ellie.nelson@york.ac.uk

Jiaxin Liu
University of York
York, United Kingdom
jiaxin.liu@york.ac.uk

Résumé

Au Royaume-Uni, le secteur des transports est l'un des principaux responsables des émissions nationales de gaz à effet de serre, ce qui rend indispensables des stratégies ciblées d'atténuation du changement climatique. Si les zones urbaines ont bénéficié, au cours des deux dernières décennies, de la mise en œuvre réussie de politiques visant à réduire les émissions des véhicules, telles que les zones à très faibles émissions et les zones d'air propre dans les villes, la réduction des émissions de gaz à effet de serre liées aux transports ruraux a, comparativement, suscité moins d'intérêt de la part des chercheurs. Afin de remédier à cette disparité, une revue rapide a été menée selon le protocole PRISMA pour évaluer l'état actuel de la recherche. Le processus de sélection de 565 publications potentiellement pertinentes n'a permis de retenir que 11 études pouvant être incluses dans la revue. Le nombre limité d'articles existants contenant des données primaires suggère que des recherches empiriques supplémentaires sont nécessaires pour évaluer l'efficacité des interventions politiques visant à réduire les émissions liées aux transports ruraux. Néanmoins, les synthèses préliminaires de cette revue suggèrent que l'amélioration de l'offre de transports publics, notamment par la mise en place de services de transport adaptés, ainsi que la promotion des modes de déplacements actifs et des initiatives de transport partagé, constituent des pistes prometteuses pour la réduction des émissions de gaz à effet de serre en milieu rural.

Mots-clés : émissions de gaz à effet de serre, transport rural, politiques de transport, revue rapide PRISMA, synthèse des données probantes

1.0 Introduction

The 2008 Climate Change Act committed the United Kingdom (UK) to reducing its greenhouse gas (GHG) emissions to 80% of 1990 emissions by 2050 (HM Government, 2008). This target was strengthened in 2019 to achieve net zero GHG emissions by 2050 (HM Government, 2019). The Act sets legally-binding limits on the total amount of GHGs the UK can emit over sequential five-year accounting periods, with each of the UK's national administrations coordinating targets under their own Acts. Transport is the highest emitting sector, producing 26% of UK GHG emissions; road transport accounts for a significant proportion, contributing 91% of transport emissions (Department for Transport, 2023a). Therefore, this sector is a major focus for GHG reduction policies.

The sources of emissions are unevenly distributed throughout the country. On average, CO_2 emissions per capita from transport are 1.4 tonnes for individuals living in UK cities compared to 2.5 tonnes for the rest of the UK (Department for Business, Energy & Industrial Strategy [BEIS], 2020; Centre for Cities, 2024). This is due to many factors. Firstly, many successful policy strategies have been targeted at urban areas to reduce GHG emissions from transport, such as the Ultra Low Emission Zone (ULEZ) (Greater London Authority, 2018), clean air zones in other cities (Department for Environment, Food & Rural Affairs [DEFRA], 2024; Low Emissions Zones Scotland, 2024), and improvements to urban bicycle networks (DEFRA, 2024). However, limited efforts have been made to reduce GHG emissions from smaller towns and rural areas despite transport emissions from such regions being some of the highest in the country. The majority of local authorities in the UK with the highest CO_2 footprints from road transport are largely rural areas, with Rutland and Perth and Kinross having the highest emissions per capita in 2022 (Department for Energy Security and Net Zero, 2024). The challenges to reducing transport emissions in these regions differ from those in urban settings. There is a greater reliance on individual car ownership for day-to-day transport, often due to the need to make longer journeys (Quino & Rodrigues, 2021). Public transport is often scarce and infrequent; stops can be some distance from people's homes, making them inaccessible (Department for Transport, 2023b). This is in part due to closures of many railway routes as part of the so-called "Beeching Closures" of the 1960s (Beeching, 1963), and a decline in rural bus services (Friends of the Earth [FoE], 2023), which further reduces public transport provision for rural areas. Rural areas are also diverse, with each area possessing its own specific needs and challenges (Department for Transport, 2023a).

Policy strategies to target emissions from these regions usually come from nationwide plans. However, policy translation from national and central actors to the local level is likely to fail without consideration of the local realities (Sausman et al., 2016). For instance, national policy guidelines include the decarbonisation of road transport through the increase of electric vehicles for private, public, and heavy goods vehicles (Department for Energy Security & Net Zero, 2023; Department for Transport, 2021). Yet, few policy mechanisms are proposed to target GHG emissions in rural areas specifically, leading to a clear policy and knowledge gap, especially given the unique geographic and socio-demographic challenges faced by these areas (as discussed earlier). Emerging research calls for small cities and towns to develop sustainable transport indicator frameworks tailored to their specific needs, as existing frameworks for larger cities may not be applicable (Rasca & Høgli Major, 2021). Small towns and rural areas should select sustainable development indicators and develop policy strategies based on their unique development priorities, policy objectives, community input, evidence-based decision-making, and

anticipated future challenges (Visvaldis et al., 2013). Therefore, there is an urgent need for research on effective policy mechanisms in rural areas to decrease GHG emissions from transportation.

To address this policy gap and contribute to its evidence-based policy making, the UK Government has recently issued a call for evidence in 2020 and subsequently developed a policy paper for its rural strategy to improve the availability of sustainable transport in rural areas as part of the Department for Transport's Future for Mobility work (Department for Transport, 2023a). This paper included findings from the Government's public consultation on how emerging technologies could improve rural transport, highlighting how demand-responsive, autonomous vehicles and shared mobility schemes could provide more diversity for transport options for rural communities and support the reduction of greenhouse gas emissions (Department for Transport, 2023b). Furthermore, organisations such as the Confederation of Public Transport are putting pressure on the Government for more targeted action on transport emissions in rural areas (Confederation of Passenger Transport, 2023). These recent developments create a timely policy window for setting the policy agenda and exploring policy solutions. Demonstrating the urgent need to compile evidence of viable policy mechanisms and options appropriate to aid rural areas in reducing their GHG emissions.

In light of this policy window, our study contributes to the policy development by offering timely evidence via a Rapid Evidence Assessment (REA, also known as rapid review) of effective policy mechanisms to reduce GHG emissions from transport in rural areas. To ensure transparency and methodological rigour throughout the study, we used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses approach for rapid reviews (PRISMA-RR; Stevens et al., 2018) to report and synthesise existing research into this issue. As an accelerated and streamlined version of a full systematic review, REAs have gained increasing popularity in policy research for their ability to provide comprehensive evidence within a constrained timeframe to answer a specific research question (Breckon et al., 2023). The method is explained and discussed in more detail later.

Our rapid review synthesises the current research available addressing possible policy mechanisms to reduce GHG emissions from transport in rural areas. This synthesis reveals the quantity of robust studies available and the policy areas that have been explored. The effectiveness of these policy areas is tentatively evaluated. Policies from Organization for Economic Cooperation and Development (OECD) countries have been targeted as they will more likely apply to the challenges facing rural areas in the UK. Policy mechanisms that have been successfully employed will be identified. In addition, the availability of robust studies on policy mechanisms targeting GHG emissions in rural areas will be assessed.

2.0 Methods

2.1 Justification and Note on REAs

As a method that brings information, knowledge, and evidence from a wide range of sources and disciplines to inform debates and policy discussions, evidence synthesis has gained significant popularity in policy review and evaluation (The Royal Society and the Academy of Medical Sciences, 2018). Within this landscape, REAs stand out for their ability to deliver high-quality evidence in a timely and cost-effective manner (Breckon et al., 2023). While REAs are less resource-intensive than full systematic reviews, they maintain a

high degree of rigour and transparency in that the use of a strict protocol ensures that the process remains systematic, therefore minimising potential bias (Collins et al., 2015). To further strengthen the rigour of the present study, the research team consulted with key policy actors during the framing of the research questions and integrated a formal quality appraisal process into the evidence searching and data collection phases.

REAs play a critical role throughout the policy cycle, from priority setting and identifying policy agenda to assessing policy options and informing implementation strategies (Tricco et al., 2017). As time is of the essence in the policymaking of GHG emissions in rural areas, the streamlined yet robust evidence synthesis method of the REA is its greatest asset. While rapid reviews may carry a slightly higher risk of bias than exhaustive full systematic reviews, a mostly completed synthesis delivered before a policy decision is made is far more valuable than a comprehensive version that arrives after the policy window closes, provided the limitations of the accelerated timeframe are clear (The Royal Society and the Academy of Medical Sciences, 2018). In this sense, the present rapid review serves as a vital, actionable tool for evidence-informed decision-making.

2.2 Summary of PRISMA Method

This rapid research synthesis was guided by the methodological framework proposed by the PRISMA rapid review protocol (Stevens et al., 2018). PRISMA has been used in this study to provide transparency in the review process, maintain a clear and organised approach, and reduce bias. An accelerated version of the PRISMA systematic review protocol was used, which enables a review of the current research into a policy area in a timeframe that can accommodate certain decision-making situations. The abbreviated methodology has been detailed below. The rapid review synthesis was carried out between December 2023 and March 2024.

2.2.1 Eligibility criteria. Only studies carried out within countries that are members of the OECD were included in this meta-analysis to ensure comparability of GHG with the UK, so that findings could be useful to generate policy recommendations in the UK context. Studies were included if they assessed policy mechanisms applied in rural areas or small towns when access to public transport was limited.

Unpublished studies, non-English papers, opinion pieces, abstracts, letters, editorials, and studies without empirical data, were excluded. In addition, studies that did not include the research methods or design were also excluded as part of the quality appraisal process. We have excluded studies that were published before 2008, as this year marked the start of the first commitment period under the Kyoto Protocol (UNFCCC, 1998), where member countries committed to reducing their GHG emissions by a pledged amount between 2008 and 2012. Therefore, an increased focus on meeting such targets was expected to be reflected in the literature.

2.2.2 Search strategy. Google Scholar, Scopus, and Science Direct databases were used to identify all published full-text articles available on policy mechanisms to reduce GHG emissions in rural areas.

Keywords were altered to accommodate the search functionality within each database. The following combinations of keywords were used in each database:

- Scopus: "Sustainable transport OR transport emissions" AND "Policy" AND "Small towns OR rural"
- Google Scholar: "Policy" AND "transport emissions" AND "sustainable transport" AND "small towns OR rural" AND "OECD"
- Science Direct: "Policy" AND "transport emissions" AND "sustainable transport" AND "small towns OR rural" AND "OECD"

2.2.3 Study selection. Both authors and an additional researcher independently screened the titles and abstracts of the studies identified in the electronic search. Duplicate studies were excluded. Discrepancies between the reviewers were resolved by a selection of studies being scanned by more than one researcher to confirm similar results.

Following the initial scan, the full text of all remaining studies was independently scanned by the team to remove any studies that did not meet the selection criteria.

2.2.4 Data extraction. The following parameters were extracted from each study by all researchers independently: name of the first author; year of publication; study design; the policy mechanism assessed; the policy effectiveness reported in the study; location of study; and a summary of the main findings.

Regarding policy mechanisms, this study specifically categorised the nature of incentives as either positive ("carrot" policies) or negative ("stick" policies). This distinction is particularly relevant given the ongoing debates within policy and climate change mitigation research concerning the effectiveness of these mechanisms in driving individual behaviour change (e.g. Xiao et al., 2022; Ling et al., 2024). While acknowledging that the "carrot and stick" dichotomy remains a contested framework in transport policy research (see Dyson, 2023), the classification used here is based on an assessment of an intervention's intended influence on individual behaviours. This approach is informed by established evaluative frameworks in the field, specifically the behaviour-influence categories outlined by Xiao et al. (2022, pp. e860-e861, see Table 1).

To evaluate the impact of the policy mechanism on GHG emission reduction within the studied region, a summary of key findings has been provided. It is worth noting that this review does not aim to provide a single, unified measurement for policy effectiveness in reducing GHG emissions from rural transportation, given the wide range of policy initiatives and research designs included in the reviewed studies. To reflect this methodological heterogeneity, we have instead broadly approached “effectiveness” as whether a policy intervention achieves its intended emissions reduction or modal shift goals, as reported by the original study authors (Higgins et al., 2024). Four policy themes, public transport, active transport, responsive transport, and carpooling, emerged from the synthesis of the studies. The overall effectiveness of each policy theme has been assessed to provide recommendations for effective policy mechanisms to address GHG emissions in rural areas of the UK.

3.0 Results

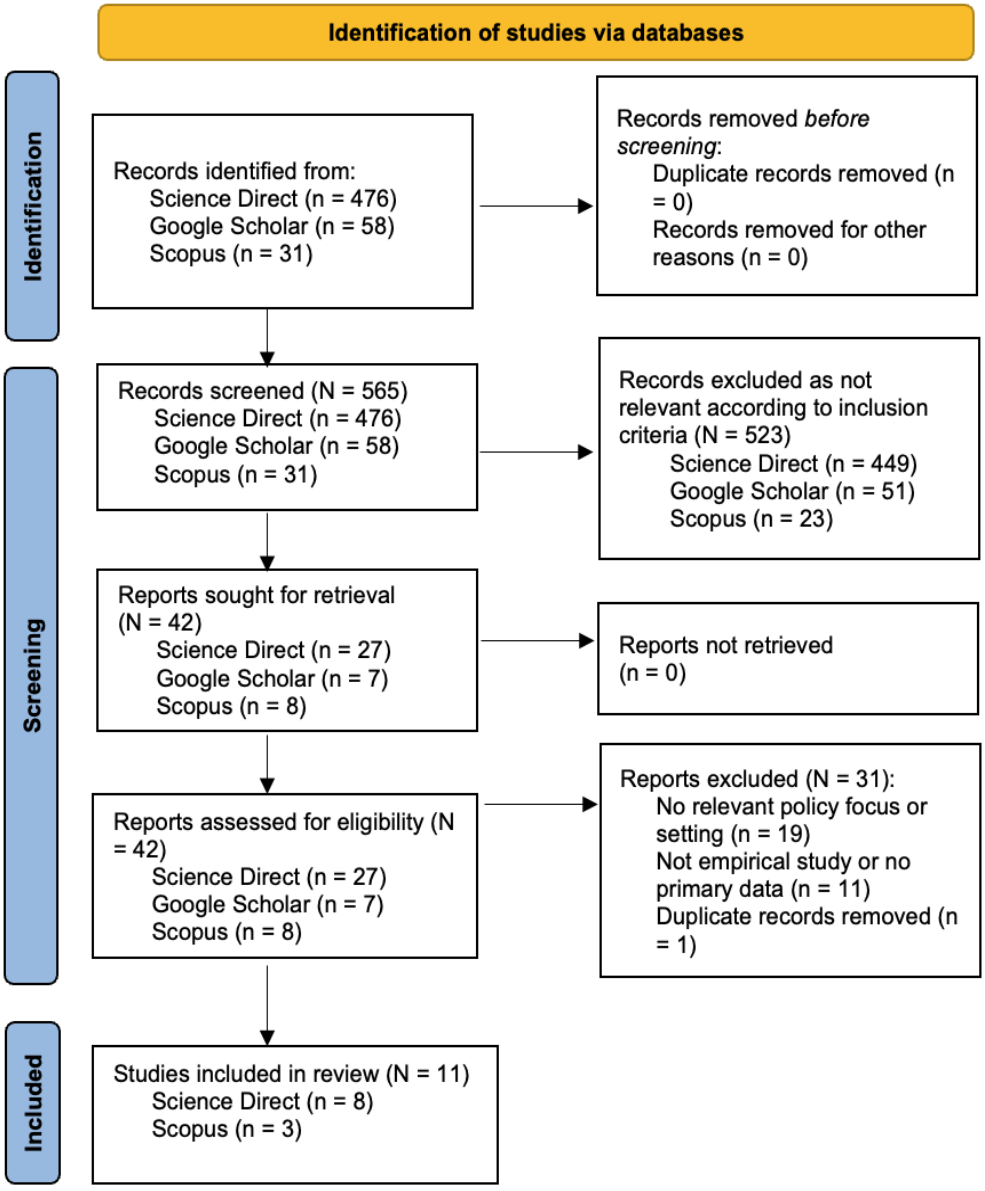
3.1 Quantitative Summary

This rapid evidence review began in December 2023 with discussions on searching strategies and inclusion/exclusion criteria. The initial search started in late January 2024. Between February 5 and February 19, 2024, 565 results were identified from Science Direct, Google Scholar, and Scopus. These results were then assessed for eligibility, applying inclusion and exclusion criteria, reducing

the pool to 11 relevant results between February 19 and March 18, 2024 (see Figure 1). The discussion of the findings and synthesis of the results took place from March 18 to May 2, 2024.

The most common reason for exclusion during the screening stage was the lack of a relevant policy focus or applicability to rural or small-town settings. This suggests that most empirical studies on GHG emissions from transportation concentrate on urban areas, confirming the gap in research on policy mechanisms in rural contexts.

Figure 1: PRISMA flow diagram for Rapid Evidence Review of policy mechanisms to reduce GHG emissions in rural areas (from Page et al., 2021).



3.2 Thematic Summary

Table 1. *Summary of Selected Studies*

No	Authors	Location	Research method and data	Main findings/focuses
1	Phillips et al., 2024	Lake District, United Kingdom	Sequential mixed-method approaches using survey data and participation observation	E-bike use in rural and tourist areas has considerable potential to replace car journeys (34%-57% resident e-bike owners stated they replaced one or more car trips with an e-bike trip), thus reducing GHG emissions and other negative impacts of car use (carrot - improving e-bike infrastructure). There is overall support for car restraint measures, but no empirical evidence on the effectiveness of GHG reduction (stick - restrain car use).
2	Bauchinger et al., 2021	Metropolitan area of Styria (Austria), Ljubljana urban region (Slovenia) and rural Wales	Qualitative case study with documentary analysis and semi-structured interviews	Demand-responsive transport services enhance public transport connectivity in rural areas, improve regional accessibility, and reduce average journey times (carrot - provide accessible transport options). However, there are challenges with service availability, accessibility to booking, and technology.
3	Farrell et al., 2010	A small town in Ireland	Logistic Model Regression using census data Scenario simulation	The use of a combination of soft transport measures (walking, cycling, carpooling) would "substantially" reduce CO2 emissions (e.g., CO2 emissions [tonnes] annual savings are estimated to be 2.67 to 8.89 for people to shift from driving to walking, 10.39 to 34.64 for driving to cycling, and 8.96 to 29.97 for driving to rideshare). Results are based on scenario simulations; no specific information on the nature of the policy incentive is provided.
4	Bueno, 2012	Basque Country, Spain	Scenario modelling analysis	Promoting public transport considerably reduces energy consumption in transport. Increasing the loading factors of small vehicles is as important as the change from private small vehicles to public transport (e.g., 85% loading cars would consume 64% less energy [MJ/pkm] compared to 30% loading cars in the studied scenario). Results are based on scenario simulations; no specific information on the nature of the policy incentive.
5	Rasca & Saeed, 2022	Agder, Norway	Ordered Logit Regression with secondary survey data	Frequent bus services, shorter bus times, and shorter walking distances between bus stops and homes will increase the probability of frequent bus use (carrot - provide more accessible and frequent bus services).
6	Soliz et al., 2023	Canada, United States, and Mexico	Comparative policy content analysis	Integrated planning, infrastructure investment, and supportive policies will help promote active transportation modes like walking and cycling (carrot - promoting active and multimodal transport instruments and the benefits of active transportation modes). Traffic calming strategies (stick - e.g., community safety zones and speed limits).

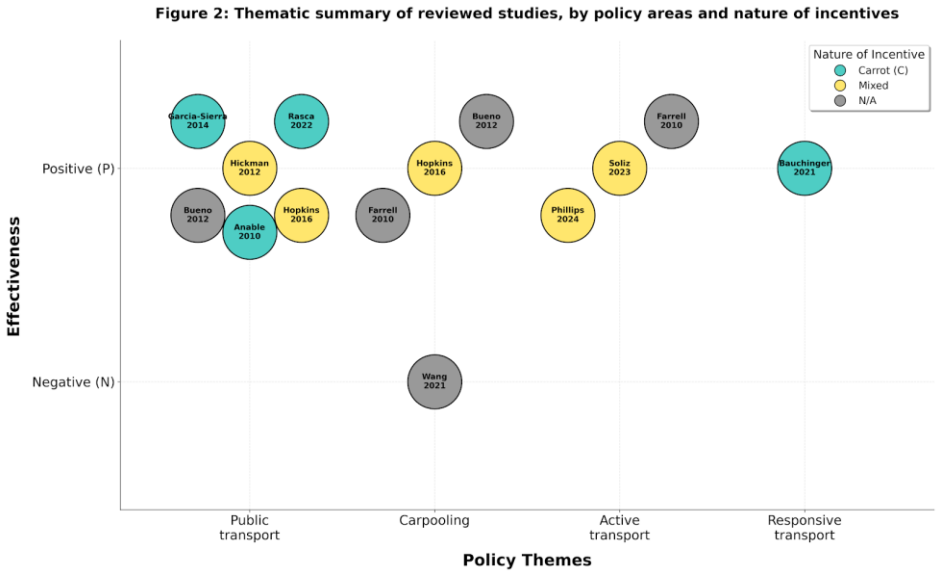
Table 1 continued				
7	Hickman et al., 2012	Oxfordshire, United Kingdom	Case study, scenario analysis	An integrated approach to transport policymaking is important to achieve sustainable travel behaviours. These policy options include carrot policies such as better local rail links, tram-train services, extensive bus services in rural areas, and stick policies such as fare level changes, higher road and parking prices, etc.
8	Garcia-Sierra & van den Bergh, 2014	Barcelona, Spain	Case study	Limiting spatial dispersion (i.e., restraining low-density building projects) and providing adequately designed public transport services (accessibility, cost, quality, reliability, etc.) will reduce GHG emissions from commuting. (carrot - improving public transport services).
9	Wang et al., 2021	America	National Household Travel Survey	Carsharing services and lift services such as Uber and Lyft may increase a person's CO2 emissions. Shared transport can help to reduce weekend emissions but does not reduce emissions on weekdays. Results are based on modelled behaviour based on participant survey; no specific information on the nature of policy incentives.
10	Hopkins & Stephenson, 2016	New Zealand	Semi-structured interviews	Factors that decrease car dependence include diverse and reliable public transport options, available lift sharing, petrol prices, and shorter distances between amenities and homes (mixed: carrot - improving transport choice and accessibility to amenities; stick: petrol prices).
11	Anable et al., 2010	United Kingdom	Scenario modelling	Multi-modal travelling, including buses, cycling and walking, reduces car travel distance by 74% (carrot - improving transport choice and accessibility to amenities).

Table 2. *Thematic Summary of Selected Studies, by Policy Areas*

Policy areas	**What is included**	**No**	**Studies cited**	**Effectiveness (positive - negative/mixed evidence)**
Public transport	Increase the use of public transport, such as buses, trains, and trams	6	Bueno, 2012 Rasca & Saeed, 2022 Hickman et al., 2012 Garcia-Sierra & van den Bergh, 2014 Hopkins & Stephenson, 2016 Anable et al., 2010	Positive evidence
Carpooling	Car sharing, carpooling, lift sharing	4	Farrell et al., 2010 Bueno, 2012 Wang et al., 2021 Hopkins & Stephenson, 2016	Mixed evidence
Active transport	Walking and cycling (including the use of e-bikes)	3	Phillips et al., 2024 Farrell et al., 2010 Soliz et al., 2023	Positive evidence
Responsive Transport	Demand-responsive transport	1	Bauchinger et al., 2021	Positive evidence

Most studies included in this Rapid Evidence Review focus on public transport (6 out of 11), followed by carpooling (4 out of 11) (see Table 2 and Figure 2). The theme of active transport was mentioned in three studies. Only one study addressed demand-responsive transport options. The majority of the interventions discussed in the reviewed studies (8 of 11) can be characterised as "carrot" policies, relying on positive incentives such as improvements to public transport services or the development of active transport infrastructure. Four of these studies also briefly consider policy measures based on negative incentives, including restrictions on car use, speed limits, road and parking pricing, and fuel prices. In addition, three studies employ scenario simulation modelling methods and therefore do not provide detailed information regarding the nature of the policy incentives considered. Overall, four key themes emerge from the literature and are reported in the following sections.

Figure 2: Thematic summary of reviewed studies, by policy areas and nature of incentives.



3.2.1 Public transport. Increasing the use of public transportation options such as buses, trains, and trams has been shown to positively impact the reduction of GHG emissions in rural areas (Bueno, 2012; Hopkins & Stephenson, 2016; Anable et al., 2010).

In addition to a stronger commitment to public transportation usage, increasing the loading factors of these modes of transport also contributes to lower energy intensity (energy consumed per kilometre). For example, raising bus occupancy from 20% to 30% can result in approximately a 34% decrease in energy consumption per kilometre (Bueno, 2012).

Several factors can help boost the use of public transport, thereby reducing GHG emissions. These factors include the accessibility, cost, quality, and reliability of public transport services. Specifically, frequent services, diverse and dependable transport options, reduced travel times, and shorter walking distances between bus stops and homes are crucial (Rasca & Saeed, 2022; Garcia-Sierra & van den Bergh, 2014; Hopkins & Stephenson, 2016).

Furthermore, an integrated approach to public transport is vital for promoting sustainable travel behaviours. This includes strengthening local rail links, promoting tram-train services, and expanding bus services in rural areas (Hickman et al., 2012).

3.2.2 Carpooling. Carpooling, also known as car sharing or lift sharing, has garnered increasing attention from scholars. Although evidence is mixed, most studies in this review indicate that carpooling has a positive impact on reducing GHG emissions. For instance, a qualitative study with young people in New Zealand found that lift-sharing reduced car dependence (Hopkins & Stephenson, 2016). Farrel et al. (2010) estimated that in areas with high concentrations of individuals who drove alone to work in the town centre, if 5% of them shifted to carpooling, CO_2 emissions would decrease by up to 14.94 tonnes per year. Additionally, Bueno (2012) suggested that a fully loaded efficient car consumes less energy per passenger-kilometre than a bus or train with average occupancy (30-40%). This highlights the importance of increasing loading factors in small vehicles alongside transitioning from private small vehicles to larger ones, indicating a significant role for carsharing and carpooling schemes.

However, analysis of the 2017 [USA] National Household Travel Survey by Wang et al. (2021) revealed that carsharing services and ride-hailing services like Uber and Lyft might increase a person's emissions, as they provide car access to individuals who previously did not have it.

3.2.3 Active transport. Promoting active transportation, such as cycling and walking, has a positive impact not only on reducing GHG emissions from transport but also on improving physical and mental health. This also includes multi-modal travel options - buses, cycling, and walking - which can reduce the travel distance by car trips by 74% (Anable et al., 2010).

For example, Phillips et al. (2024) found that e-bike use in rural and tourist areas had significant potential to replace car journeys, thereby reducing GHG emissions and other negative impacts of car use. E-bikes substituted car trips more effectively than public transport and conventional bicycles. In 2020, 57% of local resident e-bike owners substituted one or more car trips, and this figure was 34% in 2021. E-bike users also perceived e-bikes as enhancing road safety, accessibility, and physical and mental health. The study supports secure e-bike parking, e-bike share schemes, and integration with public transport through Mobility as a Service (MaaS) scheme.

Farrell et al.'s (2010) scenario modelling revealed that in a small town, if 5% of individuals with a commuting distance of less than 2 km shifted from driving alone to walking to work, it would reduce up to 4.44 tonnes of CO2 emissions per year. Similarly, if 5% of individuals with a commuting distance of 2-6 km shifted from driving alone to cycling to work, it would reduce up to 17.32 tonnes of CO_2 emissions per year.

To better promote active transportation modes such as walking and cycling, integrated planning, infrastructure investment, and supportive policies are required, as demonstrated by comparative case studies in Canada, the United States, and Mexico (Soliz et al., 2023). The United States, while offering a broad set of funding options, risks deprioritising active travel without dedicated support for active transport. Mexico has developed various soft policy instruments related to active transport at the federal level, but physical instruments are yet to be fully developed. Canada's policies show promise for improving active transport infrastructure but raise questions about equity in road safety and the ability of smaller municipalities to access competitive programs.

3.2.4 Responsive transport. The demand-responsive transport services Bwcabus and Grass Routes were introduced to address the limitations of traditional public transport in Welsh rural areas. By dynamically planning daily routes based on users' needs and leveraging mapping, routing, and GPS technologies, these services enable journeys that would otherwise be impossible by car. Users book in advance and are picked up at their nearest bus stop. This model aims to reduce costs and emissions by operating only when and where needed, enhancing service access, and fostering social connections.

Bwcabus and Grass Routes serve as critical adaptations for maintaining public transport connectivity in rural regions where fixed timetables are impractical. They also complement existing public transport by providing first and last-mile solutions, linking users to bus and rail interchanges for extended travel. An evaluation indicated that Bwcabus considerably reduced average journey times to the nearest employment centre from 52 to 27 minutes, thereby substantially improving regional accessibility (Bauchinger et al., 2021).

Despite these benefits, the study identified limitations and opportunities for improvement. Service availability is a key challenge, as fleet capacity and operating hours may not fully meet demand, especially during peak times or in remote areas. Improving the booking process is crucial; the current reliance on phone lines can hinder accessibility. Transitioning to digital platforms could streamline bookings and enhance user experience, offering real-time tracking and easier modifications. Further development could focus on expanding the fleet and extending operational hours to better match user needs. Increasing community awareness about these services could also drive higher utilisation. Addressing these areas would enhance the effectiveness of demand-responsive transport arrangements, paving the way for more sustainable and accessible rural transport solutions.

4.0 Discussion

4.1 Main Findings

This rapid evidence review suggests that most policy mechanisms addressing GHG emissions from transport in small towns and rural areas focus on encouraging a modal shift towards more efficient travel options, including public transport, carpooling, and demand-responsive transport services. At the same time, some interventions aim to reduce the need for travel by promoting active transport modes. These approaches correspond broadly to the "shift" and "avoid" strategies described by Gota et al. (2019). In particular, the emphasis on these strategies differs from many national decarbonisation frameworks, which often prioritise technological improvements that increase the energy and carbon efficiency of vehicles, often described as the "improve" strategy (e.g., see Gota et al., 2019).

This divergence highlights an important contextual difference between rural and urban transport decarbonisation pathways. In rural settings, structural characteristics such as dispersed populations, longer travel distances, and limited transport alternatives often constrain the effectiveness of technology-focused approaches alone. As a result, policies that encourage behavioural shifts or reduce the need for travel may play a comparatively greater role in emissions reduction strategies. These findings therefore reinforce the importance of understanding the specific transport challenges faced by rural areas and the potential for shift and avoid strategies to contribute to rural decarbonisation efforts. Increasing the use of public transportation options, such as buses, trains, and trams, in rural areas can significantly reduce GHG emissions, especially when combined with higher occupancy rates to decrease energy consumption per kilometre. This finding is particularly relevant within the UK rural policy context, where public transport provision remains limited due in part to the legacy of previous service reductions (as discussed in the Introduction). In such contexts, improving the availability and reliability of services may be a more immediate priority than technological upgrades to vehicle fleets. The findings, therefore, highlight the importance of considering local conditions when translating or transferring policy approaches developed in national or urban settings. Policies that focus on decarbonising public transport fleets, such as railway or bus electrification, may be less immediately impactful in rural areas where the fundamental challenge is often the limited availability of services. Factors such as accessibility, affordability, service quality, and reliability appear crucial in encouraging greater public transport use. Integrated approaches that strengthen local rail connectivity and expand bus networks may therefore play an important role in promoting more sustainable travel behaviour.

The review also highlights the potential of alternative shift strategies, particularly demand-responsive transport. By optimising routes based on user needs, demand-responsive transport reduces costs and emissions while improving accessibility in rural areas. However, the effectiveness of these services depends on several factors, including service availability, booking processes, and technological integration. Improving digital platforms and increasing community awareness may therefore enhance these services' effectiveness. Similarly, carpooling represents another promising strategy for reducing GHG emissions by shifting individuals from single-occupancy vehicles to shared journeys. While studies report substantial potential reductions in CO_2 emissions, the evidence also suggests that some ride-hailing services, such as Uber and Lyft, might increase emissions by providing car access to individuals who might otherwise rely on non-car modes of transport.

In addition to modal shift strategies, the review identifies several "avoid strategies," particularly those promoting active transport modes such as cycling and walking. These strategies offer multiple co-benefits beyond emissions reduction, including improvements in physical and mental health. The increasing adoption of e-bikes is particularly noteworthy, as they have demonstrated considerable potential to replace car trips in rural and tourist areas while improving accessibility and road safety. However, the successful implementation of active transport strategies requires coordinated planning, infrastructure investment, and supportive policy environments.

Another important observation emerging from the review concerns the nature of policy incentives. Although the specific incentives of policy mechanisms are not always clearly described, most interventions appear to rely on positive incentives, such as improved services or infrastructure, rather than restrictive measures aimed at discouraging car use. This pattern is consistent with existing research on population-level interventions, which suggests that "carrot" policies tend to be more commonly implemented than "stick" policies (e.g., Xiao et al., 2022). However, the available evidence does not clearly indicate whether positive or negative incentives are more effective in promoting rural transport decarbonisation. In several cases, the reviewed studies rely on scenario-based simulation modelling, making it difficult to identify the specific policy incentives involved.

Taken together, these limitations highlight the relatively limited empirical evidence base on rural transport decarbonisation. The reliance on modelling approaches and the lack of detailed descriptions of policy mechanisms suggest that many proposed interventions remain conceptual rather than widely implemented. This gap in the literature underscores the need for more empirical research and policy experimentation focusing specifically on rural transport contexts. In this regard, the present review contributes to an emerging body of research by synthesising the available evidence and highlighting areas where further investigation is required.

4.2 Why is This Evidence so Limited?

In this review synthesis, we have discovered that currently, there are very few studies evaluating policy mechanisms targeting GHG emissions in rural areas. This is likely due to the challenging nature of decarbonising surface transport in rural areas. Key issues include the density of demand in rural areas being limited for infrastructure improvements, such as EV charging stations or public transport, making such investments unattractive. Often, everyday journeys are much longer than those in urban settings, meaning that low-carbon transport options such as EVs or active transport are less appealing to rural commuters (Rural England, 2021). In addition, studies have shown that rural dwellers tend

to be older and are much less likely to be receptive to non-car travel modes (Department for Transport, 2021). Finally, the reduction in local services such as General Practicioners, shops, schools, post offices, connectivity and transport networks means that rural dwellers often have to travel some distance for basic amenities (Rural Services Network, 2021). Therefore, policy strategies targeting rural communities require a more joined-up policy approach than is required in urban areas, where access to such amenities is already present at a local level.

There is clearly a need to address transport emissions in rural areas, but studies that have produced primary data are still lacking in the literature. In summary, more research is required to evaluate what policies are most effective to target GHG emissions in rural areas. Such policies will likely need to go beyond the assessment of policies targeting solely transport and look into how improvements in local infrastructure and services can help to reduce the quantity and duration of journeys taken by car to reduce emissions from rural areas.

4.3 Policy Recommendations

To provide more robust policy recommendations for rural areas to reduce GHG emissions from transportation, more research evidence will be required. However, based on this rapid evidence review, there are several tentative recommendations for UK rural transport policy.

Enhancing public transport in rural areas is crucial to reducing GHG emissions from transportation in these areas, as suggested by the evidence. This could be achieved by increasing the accessibility and reliability of public transport services. For instance, developing integrated transport systems that combine local rail, tram-train, and expanded bus services can provide seamless access and travel options.

Promoting active transport through infrastructure investments, such as safe cycling and walking paths, secure e-bike parking, and e-bike share schemes, along with supportive policies for funding and integrated planning, will further enhance the use of active travel modes. This has not only been proven to reduce GHG emissions but also to improve physical and mental health.

Responsive transport services like Bwcabus and Grass Routes have the potential to reduce GHG emissions from transportation in rural areas and also enhance accessibility in rural areas. To further explore and develop such options, more focus should be on fleet capacity, operational efficiency, the development of booking platforms, and increasing community awareness of these services.

Lastly, encouraging carpooling through incentives and promoting car-sharing schemes, especially in areas with high single-occupancy vehicle use, can help reduce GHG emissions from excessive car usage and improve the occupancy rates of smaller vehicles. The latter has been proven to be as effective in reducing GHG emissions from transportation as switching from private small vehicles to bigger public transport options such as buses and trains.

Rural communities are more diverse than their urban counterparts, and each community will have a unique set of challenges and needs regarding policy mechanisms to reduce transport emissions. Therefore, it is likely that a mixture of policy mechanisms will be required to tackle this issue.

5.0 Conclusions

Given the urgent need to develop policies to reduce GHG emissions in rural areas and the lack of existing research on this topic, this Rapid Evidence Review aimed to address the question of which policy mechanisms are effective in reducing GHG emissions from transportation in rural areas. By applying the

established PRISMA rapid review protocol, we assessed 11 studies and identified four key policy areas for reducing GHG emissions in rural areas: public transport, carpooling, active transport, and responsive transport. Acknowledging the relatively small number of studies evaluated in this rapid review, we provided several tentative policy recommendations based on our findings. Although targeted at UK policy, the findings and recommendations are likely to be relevant more broadly across OECD countries.

The scarcity of existing studies evaluating policy mechanisms targeting GHG emissions in rural areas highlights the policy and research gap. Policy mechanisms and strategies designed for larger cities, such as the ULEZ in London, are unlikely to be applicable or effective in small towns or rural areas. This discrepancy highlights the necessity for small towns and rural areas to explore and develop policies tailored to their unique needs, development priorities, policy objectives, community input, and anticipated future challenges.

Given the limited literature on this subject, it is evident that there is a critical research gap that must be addressed. Further research is required to identify and evaluate effective policy mechanisms for reducing GHG emissions in rural areas. This research should consider the distinct characteristics of rural settings, including lower population densities, greater travel distances, and limited access to public transport infrastructure.

For policymakers aiming to advance policies in this area, it is imperative to commission additional research and place calls for evidence to fill this gap. Engaging with rural communities, local governments, and other relevant groups will be essential in developing and implementing effective GHG reduction strategies. By fostering a collaborative approach and investing in targeted research, policymakers can develop tailored solutions that address the specific challenges and opportunities in rural areas, ultimately contributing to broader environmental and sustainability goals.

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