

'Beyond the Office: A Systematic Review of Changing Working Patterns and Their Urban Footprints

Abstract

Over the past decade, rapid advances in technology and socio-economic shifts have driven a profound increase in working flexibility, reshaping how and where people work. While numerous studies have examined the implications of these changes for urban environments, a comprehensive synthesis of the full range of impacts and their potential interrelationships remains lacking. This systematic review consolidates evidence from 213 studies to provide an integrated understanding of how changing working patterns affect urban development. We examine the direct impacts (activity-travel behavior, urban built environment) and secondary impacts (environmental impacts, social dynamics, economic performance, and urban form), revealing complex interdependencies and trade-offs across different domains. Using a temporal and spatial lens, we identify gaps including limited attention to long-term changes and insufficient cross-scale analyses. We also summarise data sources and analytical methods and identify challenges arising from data silos and methodological limitations. The review finds four priorities for future research: broaden the geographic, cultural, and economic diversity of study contexts, integrate cross-sectoral interactions for holistic urban policymaking, account for cross-temporal and -spatial scale effects, and advance urban data integration. This study provides an evidence base to support research and policy strategies that anticipate and manage the complex urban transformations driven by changing working patterns.

Keywords:

Working patterns; Remote work; Built environment; Urban development; Sustainable cities; Urban management; Systematic review

1. Introduction

The nature of work is undergoing profound transformation, reshaping the physical, economic, and social fabrics of cities worldwide (Bloom, 2020; Florida et al., 2023; Sassen, 2018). This transformation, driven by intersecting technological, economic, socio-cultural, and environmental forces (Kylili et al., 2025; Messenger & Gschwind, 2016; Reichenberger, 2018; Whyman & Petrescu, 2014), extends beyond the current dominant fixed-location and standardised-hour patterns (Kalleberg et al., 2000) to encompass a growing array of alternative working arrangements. These new arrangements are not only prevalent across global labor markets but are also poised for continued expansion. Evidence from North America indicates that remote opportunities accounted for more than 15% of the total job postings in 2021 (Ladders, 2021). From 2024 to 2030, the number of remote-capable jobs worldwide is expected to increase by approximately 25%, reaching around 92 million (World Economic Forum, 2024). Understanding these shifts in working patterns and their multifaceted impacts on urban development is essential for guiding the future trajectory of cities and strengthening long-term urban resilience.

Despite the proliferation of alternative working arrangements in recent years, a unified and widely accepted definition that captures their continuously evolving nature remains absent. Existing concepts, such as flexible working model (Yu et al., 2019a) and New Work (Bergmann, 2019), remain limited in capturing the full spectrum of practices currently transforming labor markets. This study conceptualized the term new working patterns, defined as a dynamic and evolving category that stand in contrast to traditional working patterns, and refers to any work arrangement that departs from the dominant working pattern within a given socio-historical context. New working patterns exhibits two unique characteristics. First, new is a relative concept. Any work arrangement differing from the prevailing baseline within a specific context qualifies as new. For example, compared with the once-prevalent six-day work week (Dickson, 1917), the contemporary five-day work week with a two-day weekend can be regarded as a new working pattern. Second, new is evolving. As societal and technological contexts shift, what constitutes new working patterns are subject to continual redefinition.

In relation to the prevailing 9-to-5 benchmark, the emergence of new working patterns can be categorised into four distinct types, each representing dimension of transformation within the contemporary work landscape (summarised in Table 1). The first category encompasses temporal changes that redefine fixed working hours or days, such as flexible working hours, part-time job, and other non-standard work schedules. The second category involves spatial changes, including the shift from centralised offices to decentralised or alternative workspaces (e.g., home-office, coworking spaces, third places). The third category captures spatial-temporal changes that simultaneously alter where and when work occurs, exemplified by flexible or hybrid working and workations. The fourth category reflects other relational or lifestyle-driven changes, encompassing new employment forms and life choices (e.g., gig work, creative work, self-employment, and digital nomad).

Table 1

Definition and description of new working patterns within the scope of this work.

Change dimension	New working patterns	Definition and description
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Temporal change	Flexible working hours	Flexible working hours refer to work arrangements that deviate from traditional 9-to-5 schedules, allowing employees to have autonomy over their work timing.
	Staggered work hours; Shift work	Staggered work hours refers to employees who have different start and finish times from their colleagues in the same workplace, though they usually have the same job duties or number of hours as other workers. Shift work typically involves working during non-standard hours, such as evenings, nights, or rotating shifts.
	Part-time job	Part-time job is a form of employment where individuals work fewer hours than those considered full-time, allowing for greater flexibility in the duration of their work.
Spatial change	Remote work; Telecommuting; Teleworking; Working from home (WFH)	Whilst previous literature recognises that there are differences between 'telecommuting' and 'remote work', for example that the latter may encompass a wider range of practice types, there is also a significant body of literature that treats them as synonymous. In this paper, we use 'telecommuting' interchangeably with 'working from home', 'remote work' and 'teleworking'. They refer primarily to having a portion of days or hours that do not require commuting to the workplace for work, with no particular emphasis on whether they are partially or fully remote.
	Flexible workplaces; Multi-local working	Flexible workplaces, or multi-local working, has similar meaning to the concept of working from anywhere (WFA) (Stoller, 2021), emphasizing employees' freedom to choose work locations, whether at home, in the office, or elsewhere.
	Home-office; Home-work	Home-office, or home-work emphasises that the workplace is based at home.
	Decentralised workspaces; Satellite offices	Decentralised workspaces, or satellite offices, refer to the redistribution of workplaces from the headquarters to other locations. It involves companies establishing multiple office sites, which means that workplaces are no longer concentrated in the Central Business District (CBD) but are instead situated closer to employees' residential areas (Burke et al., 2011; Kim & Choi, 2019).
	Coworking spaces	Coworking is typically defined as a practice where independent workers share a physical workspace and often engage in intentional cooperation (Waters-Lynch et al., 2016). The users of coworking spaces usually include freelancers, microbusinesses based in the coworking spaces, and employees or self-employed workers who operate on behalf of a company located outside the coworking spaces (Parrino, 2015).
	Third places	It refers to the use of third places such as cafes, tea rooms, bookstores, libraries, and community centers to accomplish work. While some research has categorised coworking spaces as third places as well, in this paper, third places mainly denote venues primarily serve other functions but also offering some workspace.
Spatial & temporal change	Flexible work; Flexible working arrangements	Flexible work, or flexible working arrangements, refers to the freedom to choose one's workplace as well as the freedom to organise one's working hours.
	Hybrid work	Hybrid work supports a blend of in-office, remote, and on-the-go workers. Employees can choose their location and working hours based on their priorities for the day.
	Workations	Workations refers to the practice of relocating one's home-office to vacation destinations. Workationers aim to integrate work with leisure, escaping the confines of their usual work environments (Bassyouny & Wilkesmann, 2023).
Other	Gig work	Gig work, as a non-traditional employment arrangement, features temporary and

relational or lifestyle-driven changes		project-oriented nature, work flexibility, and no formal organisational membership (D. Wu & Huang, 2024).
Creative industries; Creative workers		“Creative industries” was defined as “those industries which have their origin in individual creativity, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property” (DCMS, 2001). The intention of this paper is not to discuss the development of the industry, but rather to take the perspective of creative workers, who are often knowledge workers and have a high degree of flexibility in the way they work.
Self-employment; Freelance		Self-employment, or freelance, refers to a form of employment where a person works for themselves rather than being hired by someone else for payment. Self-employed people have autonomy in terms of workload, working hours, work location and business decisions (Shin, 2019). This paper concentrates on urban self-employment, defined as self-employed workers whose main activities are located in urban areas.
Digital nomad		Digital nomad denotes a lifestyle that combines long-term travel and work done remotely. Individuals can perform tasks from anywhere with the assistance of ICT technologies, representing a paradigm shift in the way of work (Aroles et al., 2023).

As new working patterns account for a growing share of the workforces (Guler et al., 2021; Matthews & Williams, 2005; Rostami et al., 2023), they shift where and when work happens and thereby generating broader impacts on cities. Previous studies have examined a range of urban implications of new working patterns, such as changes on travel behaviour (Balbontin et al., 2024; Elldér, 2015; Wang et al., 2022), housing demand (Nagarjun & Sridhar, 2023; Tayyaran et al., 2003), urban structure (Larson & Zhao, 2017; Muhammad et al., 2008), energy consumption (Carvalho et al., 2021; Kawanami & Tabata, 2023; Phoung et al., 2024), and carbon emissions (Badia et al., 2021; Shabanpour et al., 2018). These studies usually focus on the impact of a single domain, but working patterns represent a broader issue that simultaneously affects multiple domains (Sepanta & O’Brien, 2023). Therefore, it is necessary to undertake a comprehensive comparison of possible impacts and examine their potential interrelationships to quantify the impacts of new working patterns.

Existing review articles on this topic have made valuable contributions but also possess several limitations. First, most reviews focus on a single type of working pattern or on a single or limited aspects of their impacts, and therefore lack a comprehensive mapping of which urban domains are affected. For example, Halefom et al. (2025) focused on the impact of WFH on travel behaviour. Anik & Habib (2024) investigated the impact of telework on transport and land-use. Second, previous reviews emphasise what the impacts are but rarely summarise how these impacts differ across temporal and spatial scales, even though study scope can profoundly influence results (Helling & Mokhtarian, 2001). Third, there is also limited synthesis of datasets and research methods. For instance, O’Brien & Yazdani Aliabadi (2020) consider only quantitative energy-focused studies, while investigations exploring other impacts or employing other types of methodologies (e.g., qualitative approaches or emerging AI techniques) remain unsummarised. Fourth, there are timeliness issues with the included literature. For instance, Yu et al. (2019b) provided early insights (2007-2019) on flexible working patterns and their implications on urban environment, economy and planning. Since COVID-19, however, the rapid expansion of new working patterns has generated substantial new empirical evidence. To grasp the latest dynamics, it

is imperative to incorporate more recent literature into the analysis.

Therefore, this systematic review aims to provide a comprehensive and integrative analysis of the complex relationships between new working patterns and their urban effects, addressing the following research questions: (1) What aspects of cities might be affected by new working patterns? (2) How do these impacts vary across temporal and spatial scales? (3) What data sources and analytical methods are employed in existing studies to capture these impacts, and what are their key advantages and limitations? (4) What are the current challenges and the future directions for research and policy?

The remainder of this paper is structured as follows. Section 2 introduces the research methodology. Section 3 presents an overview of included studies, analyzing publication trends, geographical focus, and the distribution of new working patterns examined. Section 4 demonstrates the direct and secondary impacts that can be induced by changes in working patterns. Section 5 examines the temporal and spatial scales at which these impacts are studied. Section 6 presents the data types and analytical methods used for capturing the impacts in the included studies. Section 7 discusses the review findings, outlines research gaps, proposes future directions, and acknowledges the contributions and limitations of this review. Section 8 summarizes the work.

2. Methods

2.1 Search Strategy

This review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. We conducted keyword searches using Web of Science and Scopus, as they are the two most widely used databases known for their inclusion of high-quality research (Yuan & Chen, 2025). The search keywords were organized into four categories to correspond to the objectives of this review: working patterns, urban scale and location, urban effects, and changes and impacts, as shown in Table 2. The “AND” operator was used between each of the four search keyword categories, but the “OR” operator was used for keywords within each category. The search criteria also limited the writing language to English and the type to article, but there was no restriction on the publication time for included studies.

Table 2
Search keywords.

Categories of keywords	Search keywords
Working patterns	"remote work*" OR "hybrid work*" OR "telework*" OR "telecommut*" OR "work* from home" OR "flexible work*" OR "distributed work*" OR "co-working" OR "digital nomad*" OR "side hustle*" OR "side job*" OR "gig economy" OR "gig work*" OR "freelance work*" OR "self-employment" OR "portfolio career*" OR "multiple job holding" OR "location-independent entrepreneur*" OR "borderless work*" OR "workation" OR "flexible hour*" OR "asynchronous work*" OR "time-shifted work*" OR "compressed workweek*" OR "four-day *week*" OR "4-day work*" OR "location-independent work*" OR "distributed workplace*" OR "third place*" OR "third space*" OR "work mobility" OR "work intensity" OR "work-life balance" OR "part-time work*" OR "job sharing" OR "work* pattern*" OR "work* arrangement*" OR "knowledge work*" OR "creative industr*" OR "home-office" OR "multi-location* work*" OR "work schedule*" OR "work style*"

Urban scale and location	"urban" OR "region*" OR "city" OR "cities" OR "district*" OR "communit*" OR "neighbo\$rhood*" OR "metropolitan" OR "suburb*" OR "area*"
Urban effects	"urban planning" OR "urban mobility" OR "urban design" OR "15-minute city" OR "land use " OR "spatial planning" OR "regional planning" OR "zoning" OR "mixed-use development" OR "urban sprawl" OR "spatial redistribution" OR "urban densification" OR "urban revitalization" OR "commercial district*" OR "local economic impact*" OR "retail patterns" OR "local services" OR "real estate" OR "office market" OR "business district*" OR "industrial district*" OR "residential district*" OR "urban functional area*" OR "property values" OR "housing market" OR "amenities" OR "facilities" OR "community cohesion" OR "local social capital" OR "public space*" OR "community resilience" OR "urban resilience" OR "social infrastructure" OR "mobility patterns" OR "transportation demand" OR "traffic reduction" OR "commuting behavio\$r" OR "travel behavio\$r" OR "travel pattern*" OR "transit usage" OR "walkability" OR "accessibility" OR "proximity" OR "carbon emission*" OR "urban sustainability" OR "energy" OR "environmental footprint" OR "environmental impact*" OR "infrastructure demand" OR "urban governance" OR "urban management" OR "social equity" OR "spatial inequality"
Changes and impacts	"impact*" OR "effect*" OR "transform*" OR "chang*" OR "influenc*" OR "consequence*" OR "shift*" OR "adapt*" OR "response*" OR "trend*"

2.2 Inclusion and exclusion criteria

We performed the search in April 2025 and obtained a total of 2,772 articles from the two databases and removed 867 duplicates. We developed inclusion and exclusion criteria in terms of four dimensions: study topic, scale, content and type of literature, as shown in Table 3. For the remaining 1,905 articles, we utilised the Rayyan online platform (Johnson & and Phillips, 2018) for title and abstract screening and excluded 1,388 articles that obviously did not meet the inclusion criteria, leaving 517 articles. We further selected 209 articles by full-text screening. In addition, by searching before and after, we added 4 articles that met the inclusion criteria. The final inclusion was 213 articles, from which we extracted information and conducted analyses. The literature selection process is shown in Fig.1.

Table 3

Inclusion and exclusion criteria.

Dimensions	Inclusion criteria	Exclusion criteria
Study topic	Studies that explicitly investigate changes in human working patterns, i.e., adoption of new working patterns.	Uses of "working patterns" to describe non-human/system/process workflows (e.g., production lines, algorithms/IT workloads, clinical/educational procedures); Studies about work patterns that do not address change (only describe baseline or prevalence without shift); Studies not about working patterns.
Scale	Impacts of new working patterns at community/neighbourhood or above (e.g., community, city, regional level), focusing on aggregate outcomes.	Impacts confined to a single building, interior, or site-level micro-environment; Impacts solely at the individual/household level without aggregation to at least the community scale.

Content	Studies that explicitly link changes in human working patterns to urban outcomes at collective scales, and provide empirical evidence or modelling of such impacts.	Papers that discuss only determinants/adoption/attitudes/feasibility of new working patterns without evaluating their urban impacts; Speculative or conceptual discussions without data or validation; Analyses where working-pattern effects cannot be distinguished from major confounders (e.g., broad COVID policy shocks) due to design/measurement limits; Reverse-direction studies on how environment/infrastructure affects new working pattern adoption.
Type of literature	Empirical research.	Non-empirical research, e.g., theoretical models, review articles, editorials, policy briefs.

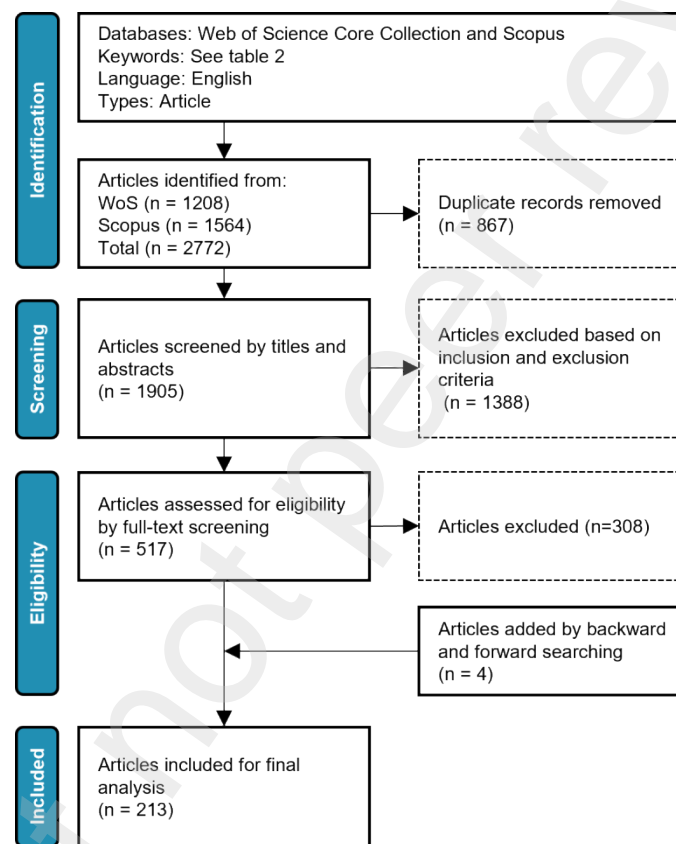


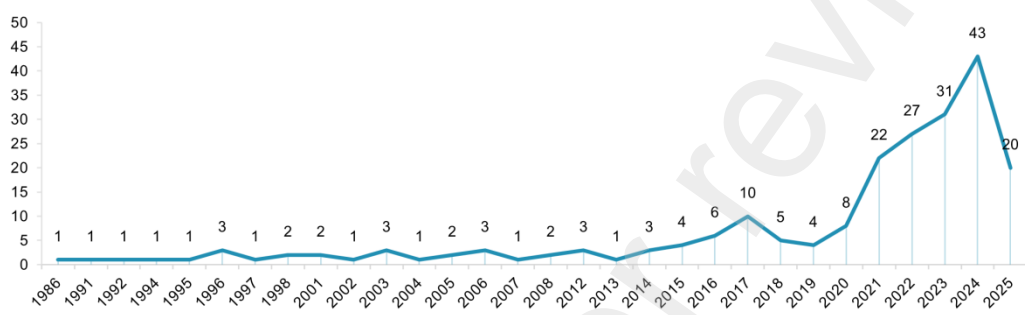
Fig.1. Literature selection process.

3. Overview

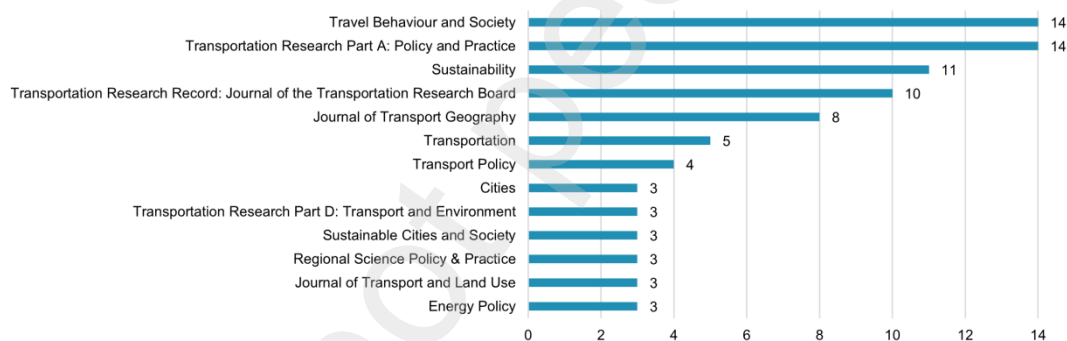
The 213 included papers were published between 1986 and April 2025. As shown in Fig. 2a, publications between 1986 and 2014 were relatively inactive, with no more than three papers per year. From 2015 to 2020, the field became more active, with annual outputs generally ranging from four to ten studies. Since 2021, however, the number of publications increased sharply, exceeding twenty papers per year, indicating a substantial surge in research interest in this topic. This surge was likely influenced and accelerated by COVID-19, which prompted the widespread adoption of new working patterns such as remote work.

Fig. 2b presents the top 13 journals publishing research on working patterns and their urban effects.

Travel Behaviour and Society and Transportation Research Part A: Policy and Practice are the most frequent published journals (each 6.6%, n=14), followed by Sustainability (5.2%, n=11). Overall, publications are concentrated in transportation journals, with urban studies journals ranking second. This distribution reflects academic recognition of the behavioural and transportation implications of new working patterns. Beyond those listed in Fig. 2b, relevant research also appeared in 111 other journals across diverse disciplines (e.g., Cities, Urban Studies, Applied Geography, Urban Climate, Energy and Buildings, Ecological Economics, Computers, Environment and Urban Systems), with 1–2 papers published in each journal. This demonstrates the topic's interdisciplinary nature and its broad impacts on urban development.



(a) Number of publications each year.



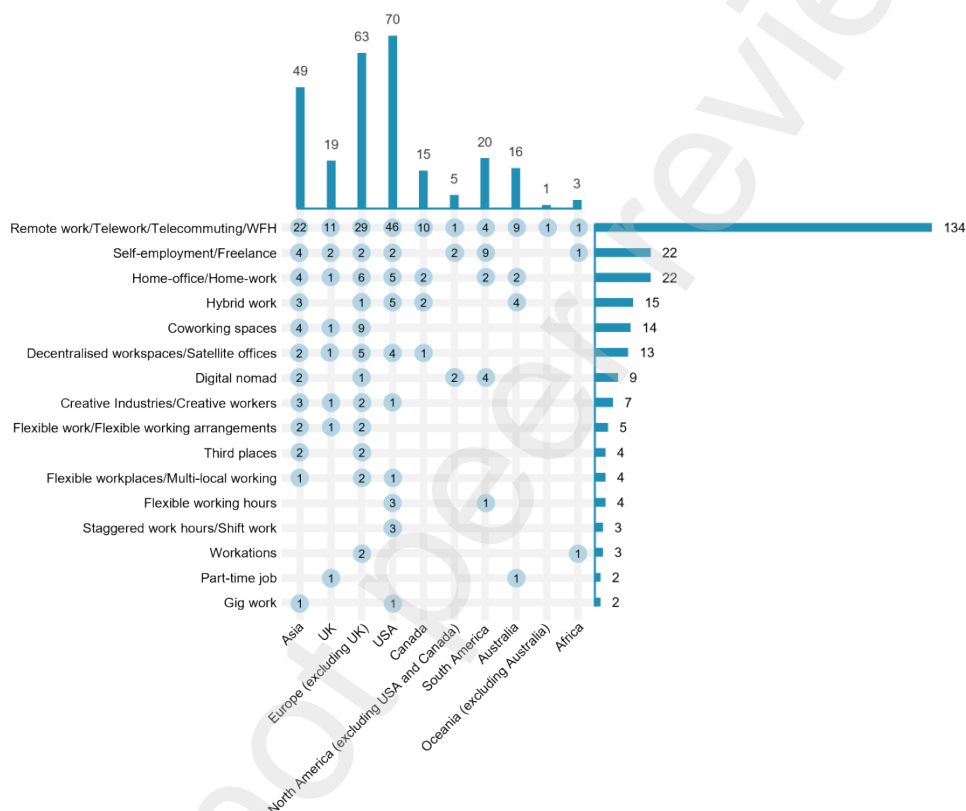
(b) Journals for publication of articles on related topics (Top 13).

Fig.2. Publication trends.

We further examined the intensity of discussion across different working patterns and geographical focus in the included studies, the result of which is shown in Fig.3. Remote work dominated the relevant studies (51%), with case studies distributed globally, reflecting its emergence as a universal pattern of work. The other topics that followed with relatively high levels of concern are self-employment (8.4%), home-based work (8.4%), hybrid work (5.7%), coworking spaces (5.3%), and decentralised workspaces (4.9%). Geographically, research concentration followed this order: North America (34.2%), Europe (31.2%), and Asia (18.6%), with remaining regions collectively comprising 16%.

Overall, discussion preferences for different types of working patterns show a degree of geographical variation. Asia and Europe showed a strong thematic alignment, emphasizing workplace flexibility and diversity through studies of creative industries, flexible work arrangements, coworking spaces, and third places. Canada, in addition to remote work, also focused on home-office, hybrid work, and decentralised workspaces, similarly showing an examination of

workplace variation. The United States cases addressed both temporal and spatial changes in working patterns, but demonstrated stronger interest in temporal adaptations (e.g., flexible working hours and hybrid work had a higher proportion of studies, reflecting a focus on daily or weekly time flexibility). The rest of North America, South America, and Africa were closer in their preferences, all focusing primarily on self-employment and mobile workstyles (digital nomad or workations). This may potentially be driven by economic conditions where self-employment fulfilling livelihood needs. Digital nomad and workation studies further appeared to be influenced by destination tourism appeal. Oceania had the smallest number of cases with only one study examining WFH.



Notes:

1. Within each continent, case studies from the UK, USA, Canada, and Australia account for a substantial share of publications. To enable finer-grained comparison, we report these four countries as stand-alone categories in this figure, while aggregating the remaining countries at the continental level.
2. When an article examined cases across multiple countries or multiple working patterns simultaneously, each country and working pattern was counted separately in our analysis. Consequently, the total number of observations represented in this figure exceeds the total number of articles reviewed.
3. Some studies include other working patterns such as self-employment within their remote work populations without further distinction, collectively categorising them as remote work. This approach is adopted in this study as well. However, where the reviewed literature explicitly distinguishes between different working patterns, each type is counted separately in our analysis.

4. Impacts of new working patterns on cities

Shifts in working patterns generate cascading effects across interconnected urban systems, which we categorise into direct impacts and secondary impacts. Direct impacts refer to primary and immediate responses to working pattern changes and comprise: (a) demand-side changes in activity-travel behaviour (e.g., commuting frequency, distance, time and mode choice, daily time-space allocation), as working pattern changes directly relate to travel demand and activity participation; and (b) supply-side adaptations in urban built environment (e.g., adjustments in office and facility utilisation, housing supply, service schedules and opening hours), whereby providers adjust capacity, provision or management in response to observed or anticipated demand.

Secondary impacts refer to second-order or derived outcomes arising from the interaction between human activities and built environment (e.g., the redistribution of activities between residential and office may trigger changes in energy consumption and carbon emissions across respective sectors), encompassing environmental impacts, social dynamics, economic performance, and urban form. In what follows, we map these impacts (Fig. 4) and list the detailed impact items under each category, together with the direction of each impact based on evidence from included studies (Table 4).

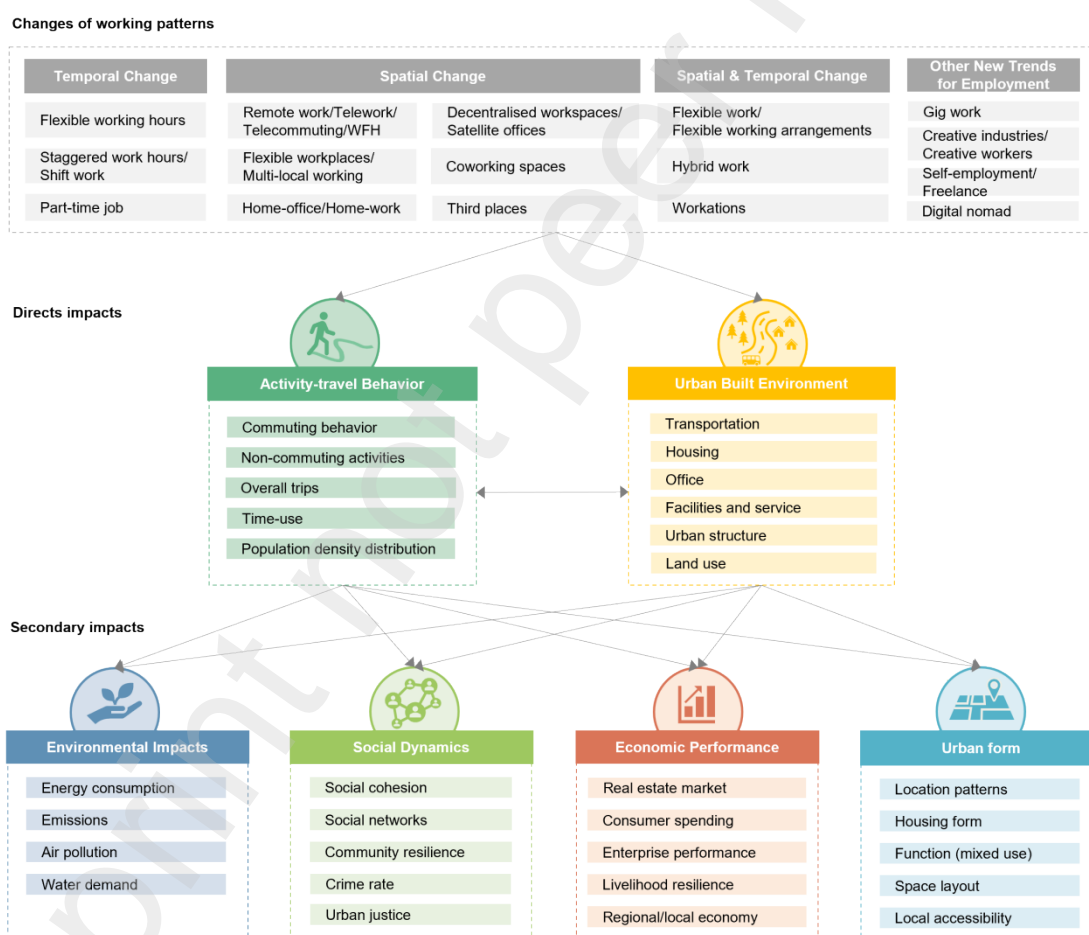


Fig.4. Changes of working patterns and their impacts.

4.1 Direct impacts

4.1.1 Activity-travel behaviour

Changes in working patterns most directly affect commuting by providing spatial and temporal flexibility. Spatial flexibility, with widespread application of digital infrastructure, enables

employees to work from multiple locations rather than having to go to the office (Bouncken & Reuschl, 2017). First, this flexibility leads to lower commuting frequency, shorter commuting time and distance, as confirmed by 43 articles (see Table 4). The higher the level of remote work and the longer the previous commuting route, the greater the reduction (Beck et al., 2020; Kim & Long, 2024; Stefaniec et al., 2024). Second, spatial flexibility has led to more complex commuting patterns than simply reducing it. For example, the rise of coworking spaces not only leads to shorter commuting due to spatial dispersion (Achariyaviriya et al., 2021), it also generates trips aside from home-office commutes such as home trips during lunch breaks. At the same time, temporal flexibility also reshapes commuting patterns. Working patterns such as flexible working hours, part-time job, self-employment, and hybrid work can allow for more flexible work schedules. This enables people to commute during off-peak hours (Chalabi & Dia, 2024a), resulting in changes in commute departure time (Asgari & Jin, 2018; Lizana et al., 2021; Ng, 2016; Saleh & Farrell, 2005) and reductions in peak-hour commuting time (Motte-Baumvol & Schwanen, 2024; Wang et al., 2021).

Changes in non-commuting activities cannot be ignored, as the benefits of reduced commuting may be offset by a rebound effect of non-commuting travel. This arises because adoption of new working patterns provides higher opportunities to access non-work activities (e.g., shopping, leisure, or family activities). These increased activity participation may lead to more non-commuting trips (Balbontin et al., 2024; Caldarola & Sorrell, 2024; Suzuki Goshima et al., 2023). However, the scale and direction of changes in non-commuting travel arrangements vary across contexts, making their net effect on total trips uncertain (Anik & Habib, 2025; Asgari et al., 2016). The influencing factors include travel attitudes (Soria et al., 2025), socioeconomic status (Tan et al., 2023), geographical factors (Balbontin et al., 2024), intra-household effects, and frequency of remote work (Caldarola & Sorrell, 2024), etc. Moreover, location choice for non-commuting travel is also a critical issue. Both full and partial remote workers exhibit a stronger preference for local activities at places such as neighbourhood parks or nearby shops, concentrating travel demand within shorter distances from home (Angel et al., 2023; Wang & De Vos, 2025). The difference between the two groups lies in the fact that full-time remote workers generally have higher overall local travel frequencies, while partial remote workers tend to concentrate daily errands on commuting days (Wells et al., 2001). Furthermore, in walkable neighbourhoods, full-time home-work demonstrates a more significant promotion of local consumption, leisure, and social interactions (Zenkeler et al., 2022).

New working patterns also influence travel mode choice. While increased remote work reduces public transit use, car trips for commuting remains largely unchanged (Edward et al., 2024; Stefaniec et al., 2024; Victoriano-Habit & El-Geneidy, 2024b). This persistence of car dependency is partly driven by the higher socioeconomic status and private vehicle ownership of teleworkers (Motte-Baumvol & Schwanen, 2024). Travel mode choices are also mediated by residential environment and commuting distance. Workers residing in suburban areas (especially >10 miles) exhibit increased car reliance (Hernandez-Tamurejo et al., 2023; Kikuchi et al., 2025; Tan et al., 2023), while those living in higher-density, transit-accessible urban areas shift toward active transport (walking/cycling) (Abe et al., 2023; Victoriano-Habit & El-Geneidy, 2024a; Wang & Ozbilen, 2020).

Overall, new working patterns do not simply reduce travel demand, but may have complex effects by changing activity patterns. Although commuting reduction represents the most direct and widely

recognized effect, changes in non-commuting travel, spatial and temporal distribution of activities, and modes of travel also need to be considered to fully grasp the potential implications.

4.1.2 Urban built environment

The adoption of new working patterns and associated activity changes significantly affect resource supply in urban built environment, encompassing transportation, housing, office space, facilities and services, urban structure, and land use.

The transport sector has received the most attention because of its close link with activity-travel behaviour. First, reduced commuting directly leads to decrease in traffic volume and commuting vehicle miles /kilometres travelled (VMT/VKT) (López Soler et al., 2021; Tian et al., 2025). These reductions contribute to lower congestion (Curtis et al., 2025) and fewer traffic accidents (Pirdavani et al., 2014). Second, new working patterns reshape the temporal and spatial patterns of mobility, redistributing demand throughout the day and consequently easing peak-hour congestion (Alonso et al., 2017; Chalabi & Dia, 2024a). As remote work increases, traffic flows shift away from CBDs and highways towards suburban areas, potentially easing central congestion (Shabanpour et al., 2018). Even non-teleworkers living near their offices benefit from shorter commute times due to reduced congestion (Hensher et al., 2023). However, local congestion may emerge around coworking spaces (Acharyaviriya et al., 2021). Third, changes in traffic volume varies across different transportation modes. Public transit ridership declines, while car ownership increases and car use remains steady or even grows in many cases (Currie et al., 2021; Kikuchi et al., 2025; Zheng et al., 2023). Moreover, non-commuting VMT may rise with increased non-commuting activities (Balepur et al., 1998), so total VMT outcome does not always decrease despite reduced commuting (De Abreu E Silva & Melo, 2018; Hernandez-Tamurejo et al., 2023).

The popularity of remote work reduces office demand, particularly in CBDs, driving up office vacancy rates (Bergeaud et al., 2023; Hensher et al., 2023). This decline reflects redistribution of population density between office and residential sector. With reduced commuting needs and increased residential usage, remote workers' housing preferences shift toward larger homes to hold home-office and properties with private yards (Larson & Zhao, 2017; Malik et al., 2023; Zhu et al., 2025), prompting relocation from city centers to suburbs. This phenomenon known as "donut effect" (Bloom & Ramani, 2021), reflecting the movement of activity out of city centers to the suburban ring, has been pronounced in tech and finance-intensive cities (Ramani et al., 2024). The donut effect illustrates how changing work patterns influence urban structure by redistributing population density and real estate values (Delventhal et al., 2023), leading to urban sprawl (Kikuchi et al., 2025; Marz & Şen, 2022; Muhammad et al., 2008) and polycentricity (concentration of consumption and services in suburban centers) (Schmahmann et al., 2022).

However, urban sprawl is not an exclusive outcome, as not all population groups participate in relocation. Essential and temporary workers remain bound to central locations because they are unable to achieve flexible work locations (Matson et al., 2023; Wächter & Kramer, 2025). Hybrid workers, needing to balance commuting frequency and accessibility, may potentially contribute to centralisation of cities (Sridhar & Sridhar, 2003). Distributed workplaces can reduce commuting distances and costs without necessitating relocation, potentially avoiding urban sprawl (Krozer, 2017).

Changes in activity patterns driven by new working patterns also interact with land use and the

provision of facilities and service. On one hand, changes in working patterns alter demand for different land types or facilities. For example, self-employed workers show increasing demand for public spaces, because they often lack fixed workplaces yet require accessible communal areas to seek networking opportunities and knowledge support (Uliarte et al., 2019). Remote workers exhibit stronger demand for blue-green space access and logistics services than office workers owing to more flexible daily schedule for recreation activities and to higher volumes of home deliveries (Astell-Burt & Feng, 2021; Pérez Pérez et al., 2004). Pressure for land-use change also stems from the locational preferences of co-working spaces and needs of flexible workers, who favour nodes offering transport accessibility, diverse amenities, and comprehensive community services, thereby reshaping local retail and service coverage (Di Marino & Lapintie, 2020; Fu & Wang, 2025; Hölzel et al., 2022). On the other hand, new working patterns alter facility provision. For instance, beyond demand for surrounding environment, flexible workspaces like coworking spaces can conversely serve as community facilities (e.g., providing meeting rooms, training services) (Di Marino et al., 2023; Mariotti et al., 2017). Such interactions underscore the need to consider these multifaceted impacts during urban planning and infrastructure investment.

4.2 Secondary impacts

4.2.1 Environmental impacts

Environmental impacts of new working patterns, encompassing energy consumption, emissions, air pollution and water demand, reveal complex trade-offs.

For the transport sector, commuting-related effects are the most immediate. Reduced commuting lowers traffic volume and commuting VMT/VKT, yielding declines in transport energy use and emissions (Badia et al., 2021; Roberto et al., 2023; Stefaniec et al., 2024; Tenailleau et al., 2021). These decline are more pronounced among high-frequency remote workers (≥ 3 days/week) and former long-distance commuters (Kitou & Horvath, 2006). However, rebound effects can partially offset the environmental benefits from reduced commuting. Additional non-work travel may weaken the overall reduction in transport emissions (Bañuelos-Gimeno et al., 2024; Li et al., 2023). The growth of e-commerce and home-deliveries driven by remote work can increase logistics activities and associated emissions (Pérez Pérez et al., 2004).

Sectoral reallocation of energy demand accompanies shifts in the location of activities. Moving work from offices to homes reduces office energy use (Deiss et al., 2021; Kawanami & Tabata, 2023; Krozer, 2017; Lier et al., 2014; Navaratnam et al., 2022; Rehmani et al., 2022) while raising residential consumption (Phoung et al., 2024; Wang et al., 2022). Over longer horizons, residential relocation to larger suburban dwellings, often undertaken to accommodate home-offices, can further increase energy consumption to meet heating or cooling needs (Saldanha & Beausoleil-Morrison, 2012).

Temporal load-shifting is a further consideration. Greater scheduling flexibility diversifies daily time-use patterns, altering energy-load profiles (Carvalho et al., 2021; Cicala, 2023; Debnath et al., 2022; Ku et al., 2022; Manjunath et al., 2021) and consequently influencing the time-varying characteristics of pollutant concentrations (Calafiore et al., 2022). Energy system operators and planners therefore need to not only estimate total demand but also predict its temporal and spatial distribution.

Taken together, the net environmental outcome remains context-dependent and uncertain. Influencing factors include transportation mode, commuting distance, remote work frequency, season and climate, building energy efficiency, renewable energy use (e.g., EV adoption), and the sustainability of human behavior (Achariyaviriya et al., 2021; Berkes & Keshav, 2024; Guerin, 2021; Larson & Zhao, 2017; Maipas & Chatzoglou, 2025; Marz & Şen, 2022; Noussan & Jarre, 2021; Shi et al., 2023; Zhang & Zhang, 2021). Overall, robust assessment requires an integrated, cross-sectoral lens linking transport, housing, and office energy systems rather than treating them in isolation.

4.2.2 Social dynamics

We categorised the social impacts of new working patterns by workers' community embeddedness into two groups: (1) those integrated into existing communities and (2) migrant or mobile workers joining new communities. We do so because embeddedness reflects how working pattern changes reshape daily interactions, local networks and place attachment, which explains why sometimes similar working arrangements can yield different community effects across contexts. This perspective helps clarify mechanisms of impacts in diverse situations and provides a basis for targeted interventions tailored to different groups.

For workers embedded in existing communities, including remote workers and users of coworking spaces, satellite offices, or third places near home, new working patterns tend to strengthen local ties through increased presence and participation. In Japan, remote workers reported higher neighborhood satisfaction because more local activities and amenity use (e.g., restaurants) accumulated day-to-day connections (Kim & Shimizu, 2022). Rising remote work rates have also been proven to correlate with lower crime rates and improved perceived safety (Díaz et al., 2022). Coworking spaces and other third places act as community hubs, fostering knowledge sharing, collective learning and informal peer support, thereby strengthening local networks and enhancing community cohesion (Bednár et al., 2023; Brown, 2017; Di Marino et al., 2023).

By contrast, migrant or mobile workers, including residential relocators, digital nomads, workation participants and autonomous entrepreneurs, affect host communities in more heterogeneous ways depending on socioeconomic background and willingness to integrate. Autonomous entrepreneurs and creative workers often seek suitable locations and flexible spaces, so they often actively engage with host communities, thereby stimulating local vitality and economic diversity (Bonello et al., 2020; Hanan & Hemanto, 2020). Digital nomads adopt a co-living lifestyle and integrate work-leisure-community events, which can build social networks and enhance belonging (Pacheco & Azevedo, 2023). Conversely, some workation participants and high-income elderly remote workers who relocate exhibit lower engagement, which can weaken social cohesion in destination neighborhoods (McCollum, 2025). This reveals that for populations with inherently lower integration willingness, policies and practices to assist new immigrants in settling down and integrating into local life are essential. Otherwise, their connections with the community will remain weak and may generate negative social impacts.

New working patterns also intersect with equity and inclusion issues across wage, employment, transport, and spatial dimensions, and the resulting effects are unevenly distributed. Telework capacity concentrates in high-income, well-serviced neighborhoods (Zenkter et al., 2022), whereas low-income groups face fewer telework options (Meredith-Karam et al., 2024; Zhang et al., 2023), higher time and cost burdens for commuting (Chen et al., 2025; Kar et al., 2022), and

more restricted transport mode choices (Paul & Taylor, 2024). Conversely, suburban relocation by highly educated and skilled workers can diffuse talent and economic opportunities and thereby reduce wage inequality and income or education segregation (Delventhal et al., 2023; Knuepling et al., 2025). Gig platforms can improve employment inclusion for marginalized groups, such as workers with disabilities, although income disparities still persist (Rechkemmer & Yin, 2022). Decentralised workspaces can shorten employees' average commutes, yet transport inequality may worsen if access is selectively granted to particular groups such as organisational leaders (Ge et al., 2018). Clustering of creative companies and workers can improve local social and economic conditions, although they may also contribute to gentrification pressures in host communities (Behrens et al., 2024; Kitsos et al., 2025).

4.2.3 Economic performance

New working patterns have generated diverse economic effects, most visibly in the real estate market and in local economic activities.

In the real estate market, the widespread adoption of remote and hybrid work has reduced the necessity to live near job centres and weakened the value of proximity to amenities. Consequently, housing demand has shifted from urban cores to suburban areas (Liu & Su, 2021; Schouten & Kawano, 2024). This is reflected in rising suburban housing prices and declining central housing prices (Brueckner et al., 2023; Delventhal et al., 2022; Nagarjun & Sridhar, 2023). Commercial real estate adjusts in parallel, with regions that have higher remote work potential experiencing surging vacancy rates and falling corporate and commercial property values (Bergeaud et al., 2023; Delventhal et al., 2023). The price and rent gradients flatten as the premium for central locations declines (Hensher et al., 2023; Kim & Long, 2024; Yiu et al., 2023). These changes may have profound implications for urban spatial and economic structure. As people relocate to suburbs, suburban commercial and service sectors gain development opportunities (Glackin & Moglia, 2022; Ramani et al., 2024). In addition to these urban-suburban structural changes, inter- and intra-city reallocations have also been observed. Liu & Su (2021) confirmed that housing demand was shifting from large cities to smaller cities, while Nagarjun & Sridhar (2023) found an intra-city price divergence around IT hubs that form a U-shaped pattern.

In local economic activities, new working patterns activate spaces and networks that can stimulate neighbourhood economies. Coworking spaces located in suburban areas help repurpose underused real estate resources and can generate spillover effects through daily customer flows and local purchases, thereby supporting nearby businesses (Fu & Wang, 2025). Informal and self-directed forms of employment (e.g., knowledge-intensive autonomous entrepreneurship, self-employment, cultural and creative industries) can boost innovation, enhance enterprise performance, and contribute to local industrial clustering and urban regeneration through knowledge sharing and social networks (Bonello et al., 2020; Hanan & Hemanto, 2020; Kalfas et al., 2024; Markusen & Schrock, 2006; Uliarte et al., 2019). These benefits are highly context dependent because in parts of the Global South informal employment primarily serves livelihood needs, which increases job diversity but offers limited economic resilience (Liu et al., 2024). Mobile working patterns such as digital nomadism and workations can raise local business performance via consumption, although these inflows may also trigger pressure on prices and reduce affordability for local residents (Jiwasiddi et al., 2024; Qosim et al., 2025; Wilkesmann & Bassyiouny, 2025).

4.2.4 Urban form

The impacts of new working patterns on urban form primarily manifest in how cities adjust their spatial configuration and functional organisation in response to the demands of emerging workplaces and lifestyles. These adaptations involve two key dimensions.

First, it concerns the location choices for work-related sites within cities, such as the location patterns of coworking spaces, third places, and freelancers. They typically exhibit preferences for features such as easy accessibility to public transport, abundant facilities, high density, multifunctionality, and richness in human capital (Fu et al., 2025; He et al., 2023; Hölzel et al., 2022; Li et al., 2024; Méndez-Ortega et al., 2024; Zenkteler et al., 2022).

Second, it relates to layout and function at the scale of districts, neighbourhoods, and buildings. As some remote workers relocate, they prefer housing with larger sizes in low-density areas, often with private green space, which may reshape residential layouts and garden provision (Larson & Zhao, 2017; Malik et al., 2023; Robbennolt et al., 2024; Shakib et al., 2024). More broadly, shifts in working patterns are reshaping demand for public space: self-employed street vendors and gig couriers often compete with residents for public space usage (Peng et al., 2022; Uliarte et al., 2019; Yasmeeen, 2001); those working in third places seek public space designed for social interaction and informal collaboration (Di Marino & Lapintie, 2020); and creative or knowledge-intensive entrepreneurs catalyse neighbourhood renewal through functional transformation of grey spaces and reuse of abandoned spaces (Bonello et al., 2020; Zeng et al., 2020). These evolving trends require urban planners re-examine the layout and function of public spaces to meet people's changing needs.

Table 4

Impact details summarized from included studies.

Impacts category	Impacts sub-category	Impacts details	References
Activity-travel behavior	Commuting behavior	Commuting frequency [↓] [--]	(Achariyaviriya et al., 2021; Adobati & Debernardi, 2022; Alonso et al., 2017; Anik & Habib, 2025; Badia et al., 2021; Berke et al., 2024; Caldarola & Sorrell, 2024; Chalabi & Dia, 2024b; Chen et al., 2025; Curtis et al., 2025; Delventhal et al., 2023; Eregowda et al., 2021; Erhardt et al., 2022; Gao et al., 2023; Gordon & Van Arsdale, 1986; Henderson et al., 1996; Henderson & Mokhtarian, 1996; Hernandez-Tamurejo et al., 2023; H. Hook et al., 2024; Huang et al., 2023; J. Kim & Long, 2024; S.-N. Kim, 2016; Kylili et al., 2025; Lake & Maidment, 2023; Larson & Zhao, 2017; Lier et al., 2014; Loo & Huang, 2022; López Soler et al., 2021; Matthews & Williams, 2005; McCollum, 2025; Melo, 2022; Nayak & Pandit, 2021; Nilles, 1991; Noussan & Jarre, 2021; Ohnmacht et al., 2020; Pérez Pérez et al., 2004; Rehmani et al., 2022; Saha & Fatmi, 2021; Shabanpour et al., 2018; Stefaniec et al., 2024; Suzuki Goshima et al., 2023; Tan et al., 2023; Zheng et al., 2023)
		Commuting distance [↓] [↑]	(Balepur et al., 1998; Berkes & Keshav, 2024; Bieser et al., 2021; Caldarola & Sorrell, 2022, 2024; De Abreu E Silva & Melo, 2018; Delventhal et al., 2022, 2023; Dissanayake, 2008; Ge et al., 2018; Gordon & Van Arsdale, 1986; Guerin, 2021; Höjer, 2002; H. Hook et al., 2024; Huang et al., 2023; Jahanshahi et al., 2015; L. C. Johnson, 2003; Krozer, 2017; Kylili et al., 2025; W. Li et al., 2023; Lier et al., 2014; Marz & Şen, 2022; McCollum, 2025; Nilles, 1991; Shin, 2019; Tenailleau et al., 2021; Zhu, 2012, 2013; Zupan, 1994)
		Commuting time [↓] [↑]	(Achariyaviriya et al., 2021; Berkes & Keshav, 2024; Bieser et al., 2021; Chia et al., 2016; Curtis et al., 2025; Delventhal et al., 2022, 2023; Eregowda et al., 2021; Ge et al., 2018; Giménez-Nadal et al., 2024; Giuliano, 1992; Gordon & Van Arsdale, 1986; Hensher et al., 2023; Huang et al., 2023; J. Kim & Long, 2024; Mohamed Tahir & Wong, 2022; Ohnmacht et al., 2020; Shin, 2019; Zhu, 2012, 2013)
		Peak-hour commuting time [↓]	(Motte-Baumvol & Schwanen, 2024; D. Wang et al., 2021)
		Non-peak commuting [↑]	(Chalabi & Dia, 2024a)
		Commute departure time	(Asgari & Jin, 2018; Lizana et al., 2021; Ng, 2016; Saleh & Farrell, 2005)
		Commuting mode	(Bieser et al., 2021; Eregowda et al., 2021; Lier et al., 2014; Ohnmacht et al., 2020; K. Wang et al., 2024)
		Temporal and spatial distribution	(Angel et al., 2023; Gorný, 2024; Lizana et al., 2021)
		Complexity of commute tours	(R. Wang, 2015; Wells et al., 2001)

	Peak hours motorcycle usage [↓]	(Akbari & Hopkins, 2019)
	Commuting trips by car/public transport [↓] [↑]	(Beck et al., 2020; Chalabi & Dia, 2024a; Lund et al., 2006; Paul & Taylor, 2024)
	Commuting trips [↓]	(Abe et al., 2023; Adobati & Debernardi, 2022; Akbari & Hopkins, 2019; Anik et al., 2024; Asif Hasan Anik & Ahsanul Habib, 2024; Balbontin et al., 2024; Bisen et al., 2014; Christidis et al., 2022; Currie et al., 2021; De Abreu E Silva & Melo, 2018; El Zein et al., 2022; M. Fu et al., 2012; Graizbord, 2015; Han et al., 2021; Henderson & Mokhtarian, 1996; Hensher et al., 2023; Kitou & Horvath, 2006; Lila & Anjaneyulu, 2017; Maipas & Chatzoglou, 2025; Marz & Şen, 2022; O’Keefe et al., 2016; Olszewski & Lam, 1996; Rachmawati et al., 2021; Roberto et al., 2023; Saxena & Mokhtarian, 1997; Tan et al., 2023; D. Wang et al., 2021; K. Wang et al., 2022, 2024; R. Zhang & Zhang, 2021)
	Long-distance work trips [↑]	(Kar et al., 2022)
Non-commuting activities	Non-commuting trips and other activities [↑] [↓]	(Anik & Habib, 2025; Asgari et al., 2016; Asgari & Jin, 2017; Astell-Burt & Feng, 2021; Balbontin et al., 2024; Balepur et al., 1998; Bieser et al., 2021; Caldarola & Sorrell, 2022, 2024; Curtis et al., 2025; Gorný, 2024; Hensher et al., 2023; S.-N. Kim, 2016; Kitou & Horvath, 2006; W. Li et al., 2023; Nayak & Pandit, 2021; Patwary & Khattak, 2024; Rachmawati et al., 2021; Rifat Hossain Bhuiyan & Ahsanul Habib, 2024; Shabanpour et al., 2018; Shah et al., 2024; Suzuki Goshima et al., 2023; Tan et al., 2023; K. Wang et al., 2022, 2024; K. Wang & De Vos, 2025; Wells et al., 2001)
	Local activity [↑]	(Angel et al., 2023; Kar et al., 2022; H. Kim & Shimizu, 2022; Suzuki Goshima et al., 2023; Wells et al., 2001; Zenkteler et al., 2022)
	Temporal and spatial distribution	(Alonso et al., 2017; Asgari et al., 2019; Hensher et al., 2024; Saxena & Mokhtarian, 1997)
	Non-commuting car trips [↑] [↓]	(Christidis et al., 2022; López Soler et al., 2021; Soria et al., 2025)
	Long-distance leisure travel [↑]	(López Soler et al., 2021)
	Non-work travel distance [↑] [--]	(Caldarola & Sorrell, 2024; Shin, 2019)
	Active non-work trips [↑] [↓]	(Abe et al., 2023; Gao et al., 2023; Victoriano-Habit & El-Genaidy, 2024a)
Overall trips	Car trips/car dependency [↓] [↑]	(Abe et al., 2023; Adobati & Debernardi, 2022; Asgari & Jin, 2023; Asif Hasan Anik & Ahsanul Habib, 2024; Balepur et al., 1998; Chalabi & Dia, 2024b; Currie et al., 2021; De Abreu E Silva & Melo, 2018; M. Fu et al., 2012; Hernandez-Tamurejo et al., 2023; H. Hook et al., 2024; L. C. Johnson, 2003; Kikuchi et al., 2025; Martínez-Jaramillo et al., 2017; Melo, 2022; Noussan & Jarre, 2021; Olszewski & Lam, 1996; Pedreira Junior & Pitombo, 2024; Pirdavani et al., 2014; Shin, 2019; Tan et al., 2023;

		Zenkteler et al., 2022)
	Public transport trips/dependency [↓] [↑]	(Chalabi & Dia, 2024b; Hensher et al., 2024; Kikuchi et al., 2025; Meredith-Karam et al., 2024; Pedreira Junior & Pitombo, 2024; Shin, 2019; Tan et al., 2023; K. Wang & Ozbilen, 2020; Zheng et al., 2023)
	Public transport adoption willingness [↑]	(Sekar Warangi Nurcahyati, 2025)
	Active transport (walking/biking) [↑] [↓]	(Asif Hasan Anik & Ahsanul Habib, 2024; Bieser et al., 2021; Hensher et al., 2024; Höjer, 2002; Huang et al., 2023; Melo, 2022; Tian et al., 2025; K. Wang & Ozbilen, 2020)
	Peak hour trips [↓] [↑]	(Anik & Habib, 2025; Giuliano, 1992; Huang et al., 2023; O'Keefe et al., 2016; D. Wang et al., 2021; K. Wang et al., 2022)
	Off-peak travel [↑]	(Anik & Habib, 2025)
	Trip frequency	(Jahanshahi et al., 2015)
	Total travel time [↓] [↑]	(Bieser et al., 2021; Motte-Baumvol & Schwanen, 2024)
	Total travel distance (daily/weekly) [↓] [↑]	(Caldarola & Sorrell, 2022; De Abreu E Silva & Melo, 2018; Long & Reuschke, 2021)
	Total travel (daily/weekly) [↓] [--] [↑]	(Anik & Habib, 2025; Asgari et al., 2016; Asgari & Jin, 2023; Caldarola & Sorrell, 2024; Kappler & De Abreu E Silva, 2025; Long & Reuschke, 2021; K. Wang et al., 2022; Zhu, 2012)
	Temporal and spatial distribution	(Elldér, 2015; Gao et al., 2023; Kar et al., 2022)
Time-use	Time use pattern	(Asgari et al., 2019; Cicala, 2023; Ku et al., 2022; Phoung et al., 2024; R. Wang, Ye, Hsu, et al., 2022; H. Wu et al., 2024)
Population density distribution	Population density distribution	(Bakchan et al., 2022; Carvalho et al., 2021; Debnath et al., 2022; Delventhal et al., 2023; Glackin & Moglia, 2022; Guerin, 2021; Kawanami & Tabata, 2023; Ling et al., 2020; Matthews & Williams, 2005; Pérez Pérez et al., 2004; Sridhar & Sridhar, 2003)
	Space occupancy (same community)	(Mosteiro-Romero et al., 2023, 2024; Shi et al., 2023)
	Neighborhood mobility [↓]	(Díaz et al., 2022)
Urban built environment	Transportation	Traffic volume/commuting VMT/VKT [↓]
		(Achariyaviriya et al., 2021; Alonso et al., 2017; Anik et al., 2024; Anik & Habib, 2025; Badia et al., 2021; Balepur et al., 1998; Bañuelos-Gimeno et al., 2024; Berke et al., 2024; Bisen et al., 2014; Chalabi & Dia, 2024b; Curtis et al., 2025; Delventhal et al., 2022; Dissanayake, 2008; Eregowda et al., 2021; Giovanis, 2018; Gordon & Van Arsdale, 1986; Graizbord, 2015; Guerin, 2021; Henderson et al., 1996; Henderson & Mokhtarian, 1996; Hensher et al., 2023; Hernandez-Tamurejo et al., 2023; Höjer, 2002; Jahanshahi et al., 2015; J. Kim & Long, 2024; S.-N. Kim, 2016; Kitou & Horvath, 2006; W. Li et al., 2023; Lier et al., 2014; Lila

		& Anjaneyulu, 2017; Loo & Huang, 2022; López Soler et al., 2021; Melo, 2022; Mokhtarian et al., 1995; Nilles, 1991; O’Keefe et al., 2016; Olszewski & Lam, 1996; Pérez Pérez et al., 2004; Pirdavani et al., 2014; Saha & Fatmi, 2021; Shabanpour et al., 2018; Stefaniec et al., 2024; Tenailleau et al., 2021; Tian et al., 2025; B. S. Wang et al., 2024; D. Wang et al., 2021; K. Wang et al., 2024; Zupan, 1994)
	Non-commuting VMT/VKT [↑]	(Balepur et al., 1998)
	Overall VMT/VKT [↑] [↓]	(Anik & Habib, 2025; De Abreu E Silva & Melo, 2018; S.-N. Kim, 2017; K. Wang & De Vos, 2025)
	Congestion level [↓] [↑] [--]	(Acharyaviriya et al., 2021; Adobati & Debernardi, 2022; Akbari & Hopkins, 2019; Bisen et al., 2014; Curtis et al., 2025; Giuliano, 1992; Hensher et al., 2023; Huang et al., 2023; J. Kim & Long, 2024; Lier et al., 2014; Lila & Anjaneyulu, 2017; Loo & Huang, 2022; Mohamed Tahir & Wong, 2022; Pérez Pérez et al., 2004; Rachmawati et al., 2021; D. Wang et al., 2021)
	Congestion hotspots shift	(Ge et al., 2018)
	Peak-hour congestion [↓]	(Alonso et al., 2017; Chalabi & Dia, 2024a; Wells et al., 2001)
	Peak-hour rail crowding [↓]	(Abe et al., 2023)
	Public transit ridership [↓]	(Adobati & Debernardi, 2022; Edward et al., 2024; El Zein et al., 2022; Erhardt et al., 2022; Han et al., 2021; Melo, 2022; Victoriano-Habit & El-Geneidy, 2024b)
	Car-ownership [↓] [↑]	(Sekar Warangi Nurcahyati, 2025; Zheng et al., 2023)
	Car-parking	(Ng, 2016)
	EV usage and charge	(Berkes & Keshav, 2024)
	Crash frequency, accidents [↓]	(Akbari & Hopkins, 2019; Pirdavani et al., 2014)
	Traffic violations	(Peng et al., 2022)
Housing	Relocation/ relocation willingness	(Adobati & Debernardi, 2022; Anik et al., 2024; Anik & Habib, 2025; Caldarella & Sorrell, 2024; Chalabi & Dia, 2024a; De Abreu E Silva & Melo, 2018; Delventhal et al., 2022, 2023; Hensher et al., 2023; H. Hook et al., 2024; Howard et al., 2023; Kikuchi et al., 2025; Knuepling et al., 2025; Larson & Zhao, 2017; S. Liu & Su, 2021; Marz & Şen, 2022; McCollum, 2025; Muhammad et al., 2008; Nagarjun & Sridhar, 2023; Nilles, 1991; Paköz & Kaya, 2024; Ramani et al., 2024; Robbennolt et al., 2024; Schmahmann et al., 2022; Tan et al., 2023; Tayyaran et al., 2003; Tayyaran & Khan, 2007; Wächter & Kramer, 2025; Zhu, 2013)
	Homeownership	(Zhu et al., 2025)
	Housing type choices	(Malik et al., 2023; Nagarjun & Sridhar, 2023; Robbennolt et al., 2024; Shakib et al., 2024; Ssemwanga et al., 2023; Tayyaran &

		Khan, 2007; Zhu et al., 2025)	
Office	Office demand	(Acharyaviriyi et al., 2021; S.-N. Kim, 2016; Ohnmacht et al., 2020)	
	CBD workplace concentration [↓]	(Delventhal et al., 2022; Hensher et al., 2023)	
	Office vacancy rates [↑]	(Bergeaud et al., 2023)	
Facilities and service	Need/provide for facilities/service	(Chandra et al., 2017; Di Marino et al., 2023; Di Marino & Lapintie, 2020; Ezeadichie, 2023; He et al., 2023; Mariotti et al., 2017; Peng et al., 2022; Pérez Pérez et al., 2004; Qosim et al., 2025)	
Urban structure	Urban structure	(Delventhal et al., 2023; Elldér, 2015)	
	Urban sprawl [↓] [↑]	(Kikuchi et al., 2025; Krozer, 2017; Larson & Zhao, 2017; Marz & Şen, 2022; Muhammad et al., 2008)	
	Centralization	(Sridhar & Sridhar, 2003)	
	Polycentricity [↑]	(Schmahmann et al., 2022)	
	Donut Effect	(Ramani et al., 2024)	
Land use	Land use/land use change	(Di Marino & Lapintie, 2020; L. Fu & Wang, 2025; Hanan & Hemanto, 2020; Hölzel et al., 2022; H. Liu et al., 2016)	
	Public space	(Peng et al., 2022; Uliarte et al., 2019)	
	Green/blue space	(Astell-Burt & Feng, 2021; Glackin & Moglia, 2022)	
Environmental impacts	Energy consumption	Transport energy use [↓]	(Deiss et al., 2021; Matthews & Williams, 2005; Mokhtarian et al., 1995; Navaratnam et al., 2022; Noussan & Jarre, 2021; Phoung et al., 2024; Roberto et al., 2023; R. Zhang & Zhang, 2021)
		Residential energy use/demand [↑] [↓]	(Deiss et al., 2021; Graizbord, 2015; Guerin, 2021; Kawanami & Tabata, 2023; Kitou & Horvath, 2006; W. Li et al., 2023; Lier et al., 2014; Matthews & Williams, 2005; Mokhtarian et al., 1995; Navaratnam et al., 2022; Phoung et al., 2024; Rehmani et al., 2022; Shi et al., 2023; R. Wang, Ye, Hsu, et al., 2022; R. Wang, Ye, Lu, et al., 2022; H. Wu et al., 2024)
		Residential energy use patterns	(Berkes & Keshav, 2024)
		Non-residential energy use [↓] [--]	(Deiss et al., 2021; Guerin, 2021; Kawanami & Tabata, 2023; Krozer, 2017; Lier et al., 2014; Matthews & Williams, 2005; Navaratnam et al., 2022; Phoung et al., 2024; Rehmani et al., 2022)
		Total/net energy use [↓] [↑] [--]	(Deiss et al., 2021; Guerin, 2021; Kawanami & Tabata, 2023; Larson & Zhao, 2017; Lier et al., 2014; Matthews & Williams, 2005; Mokhtarian et al., 1995)
		Fuel use [↓]	(Gordon & Van Arsdale, 1986; Graizbord, 2015; Kylili et al., 2025; Shabanpour et al., 2018)

	Space cooling energy demand [↓]	(Mosteiro-Romero et al., 2023, 2024)
	Electricity demand [↓]	(Manjunath et al., 2021)
	Residential electricity consumption [↑]	(Cicala, 2023; Ku et al., 2022; Rachmawati et al., 2021)
	Commercial and industrial electricity consumption [↓]	(Cicala, 2023)
	Electricity load profile pattern	(Carvalho et al., 2021; Cicala, 2023; Debnath et al., 2022; Ku et al., 2022; Manjunath et al., 2021)
Emissions	Emissions (no sector-specific)	(Anik et al., 2024; Chalabi & Dia, 2024a; Henderson & Mokhtarian, 1996; Ling et al., 2020; Mokhtarian et al., 1995; D. Wang et al., 2021)
	Carbon emission [↓]	(Graizbord, 2015; Guerin, 2021; Hensher et al., 2023; Krozer, 2017; Ohnmacht et al., 2020; O'Keefe et al., 2016; Shi et al., 2023; R. Zhang & Zhang, 2021; Y. Zhang et al., 2023)
	Greenhouse gas emissions [↓]	(Larson & Zhao, 2017; Navaratnam et al., 2022; Noussan & Jarre, 2021)
	Transport emissions [↑] [↓]	(Achariyaviriya et al., 2021; Badia et al., 2021; Berke et al., 2024; Bisen et al., 2014; Eregowda et al., 2021; Ge et al., 2018; Han et al., 2021; Henderson et al., 1996; Kitou & Horvath, 2006; Kylili et al., 2025; W. Li et al., 2023; Lier et al., 2014; Lila & Anjaneyulu, 2017; Maipas & Chatzoglou, 2025; Martínez-Jaramillo et al., 2017; Marz & Şen, 2022; Roberto et al., 2023; Saha & Fatmi, 2021; Shabanpour et al., 2018; Stefaniec et al., 2024; Tenailleau et al., 2021)
	Residential emissions [↑] [↓]	(Rehmani et al., 2022; H. Wu et al., 2024)
	Commercial emissions [↓]	(Rehmani et al., 2022)
	Non-transport emissions [↑]	(Kitou & Horvath, 2006)
	Net emissions [↓] [↑]	(Alonso et al., 2017; Graizbord, 2015; W. Li et al., 2023; Rehmani et al., 2022)
Air pollution	Air pollution [↓]	(Badia et al., 2021; Bañuelos-Gimeno et al., 2024; Dissanayake, 2008; Giovanis, 2018; Gordon & Van Arsdale, 1986; Kylili et al., 2025; Ling et al., 2020; Pérez Pérez et al., 2004; Rachmawati et al., 2021)
Water demand	Residential water demand [↑]	(Bakchan et al., 2022)
	Non-residential water demand [↓]	
	Total water demand [↓] [--]	
Social dynamics	Social cohesion	Social cohesion [↑] [↓] (Di Marino et al., 2023; L. C. Johnson, 2003; Kalfas et al., 2024; Mariotti et al., 2017; McCollum, 2025)

	Social networks	Local networks	(Sleutjes & Schutjens, 2012)
		Community engagement [↑]	(Brown, 2017; Di Marino et al., 2023; Kalfas et al., 2024)
		Social interactions [↑] [↓]	(Bednář et al., 2023; Bonello et al., 2020; Brown, 2017; Di Marino & Lapintie, 2020; Hanan & Hemanto, 2020; Jiwasiddi et al., 2024; L. C. Johnson, 2003; Mariotti et al., 2017; Markusen & Schrock, 2006; Pacheco & Azevedo, 2023; Wilkesmann & Bassyiouny, 2025)
	Community resilience	Community resilience	(Bednář et al., 2023; Pacheco & Azevedo, 2023)
		Neighborhood satisfaction [↑]	(H. Kim & Shimizu, 2022)
	Crime rate	Crime rate [↓]	(Díaz et al., 2022)
	Urban justice	Spatial inequality [↑] [↓]	(Knuepling et al., 2025; McCollum, 2025; Meredith-Karam et al., 2024; Shen, 1998; Zenkteler et al., 2022)
		Wage inequality [↓]	(Delventhal et al., 2023)
		Employment inequality	(Rechkemmer & Yin, 2022)
		Social inclusion and inequality	(Bonello et al., 2020; Lake & Maidment, 2023; Rechkemmer & Yin, 2022; Shen, 1998; Zenkteler et al., 2022; Zhang et al., 2023)
		Transport inequality [↑] [↓]	(Chen et al., 2025; Ge et al., 2018; Kar et al., 2022; Meredith-Karam et al., 2024; Paul & Taylor, 2024)
		Gentrification	(Behrens et al., 2024; Jiwasiddi et al., 2024; Kitsos et al., 2025)
Economic performance	Real estate market	Housing price gradients [--]	(Brueckner et al., 2023; Delventhal et al., 2022; Hensher et al., 2023; J. Kim & Long, 2024)
		Intra-city price divergence	(Nagarjun & Sridhar, 2023)
		Housing price [↑] [↓]	(Brueckner et al., 2023; Delventhal et al., 2022, 2023; S. Liu & Su, 2021; Miles & Zhu, 2024; Nagarjun & Sridhar, 2023; Schouten & Kawano, 2024)
		Housing rent [↑] [↓]	(Howard et al., 2023; Ramani et al., 2024)
		Rental gradient flattening	(Yiu et al., 2023)
		Commercial/office real estate value [↑] [↓]	(Bergeaud et al., 2023; Delventhal et al., 2023; L. Fu & Wang, 2025)
		Transaction volumes [↑] [↓]	(Ssemwanga et al., 2023)
	Consumer spending [↓] [↑]		(Glackin & Moglia, 2022; Jiwasiddi et al., 2024; Qosim et al., 2025; Ramani et al., 2024; Wilkesmann & Bassyiouny, 2025)

	Enterprise performance [↑]	(Bonello et al., 2020; Kalfas et al., 2024; Sleutjes & Schutjens, 2012)
	Livelihood resilience	Livelihood resilience [↓] [↑]
		(Bonello et al., 2020; Y. Liu et al., 2024)
		Unemployment [↓]
		(Ezeadichie, 2023; Jiwasiddi et al., 2024; Kalfas et al., 2024; Uliarte et al., 2019)
	Regional/local economy	Regional economy
		(Markusen & Schrock, 2006)
		Local economy
		(Ezeadichie, 2023; L. Fu & Wang, 2025; Hanan & Hemanto, 2020; Jiwasiddi et al., 2024; Kalfas et al., 2024; Mariotti et al., 2017; Markusen & Schrock, 2006; Qosim et al., 2025; Uliarte et al., 2019)
Urban form	Location patterns	(Di Marino & Lapintie, 2020; Y. Fu et al., 2025; He et al., 2023; Hölzel et al., 2022; W. Li et al., 2024; H. Liu et al., 2016; Méndez-Ortega et al., 2024; Zenkteler et al., 2022)
	Housing form	Housing size
		(Larson & Zhao, 2017; Nagarjun & Sridhar, 2023; Shakib et al., 2024)
		Housing density
		(Larson & Zhao, 2017; Robbennolt et al., 2024; Shakib et al., 2024)
		Properties with private green spaces (yards)
		(Malik et al., 2023)
	Function (mixed use)	(Di Marino & Lapintie, 2020; Peng et al., 2022)
	Space layout	(Bonello et al., 2020; Ezeadichie, 2023; Hanan & Hemanto, 2020; Peng et al., 2022; Wilkesmann & Bassyiouny, 2025; Zeng et al., 2020)
	Local accessibility	(Di Marino & Lapintie, 2020; Uliarte et al., 2019; Victoriano-Habit & El-Geneidy, 2024a; Yasmineen, 2001)

Note: [↑]: increase; [↓]: decrease; [--]: negligible change.

5. Temporal and spatial scales of different impacts

Wegener et al.'s (1986) Timescale of Urban Change Processes theory reveals that different components of urban systems respond to internal and external changes at different speeds with time: rapid behavioral shifts (e.g., mobility patterns), medium-speed functional adaptations (e.g., economic reconfiguration), and slow structural change (e.g., transportation construction). It highlights that urban systems are not only spatially interconnected but also temporally dynamic. With the rapid adoption of new working patterns after COVID-19, a considerable number of short-term changes has been observed (Jiang et al., 2021). However, as the impacts would evolve across timescales, understanding the longer-term consequences of changing working patterns remains a challenge. Using this lens, we analyze how new working patterns trigger multiscale impacts in both time and space, and examine the similarities and differences of these impacts across varying time horizons and spatial levels. Fig.5 maps the distribution of impacts by temporal and spatial scales in the included studies.

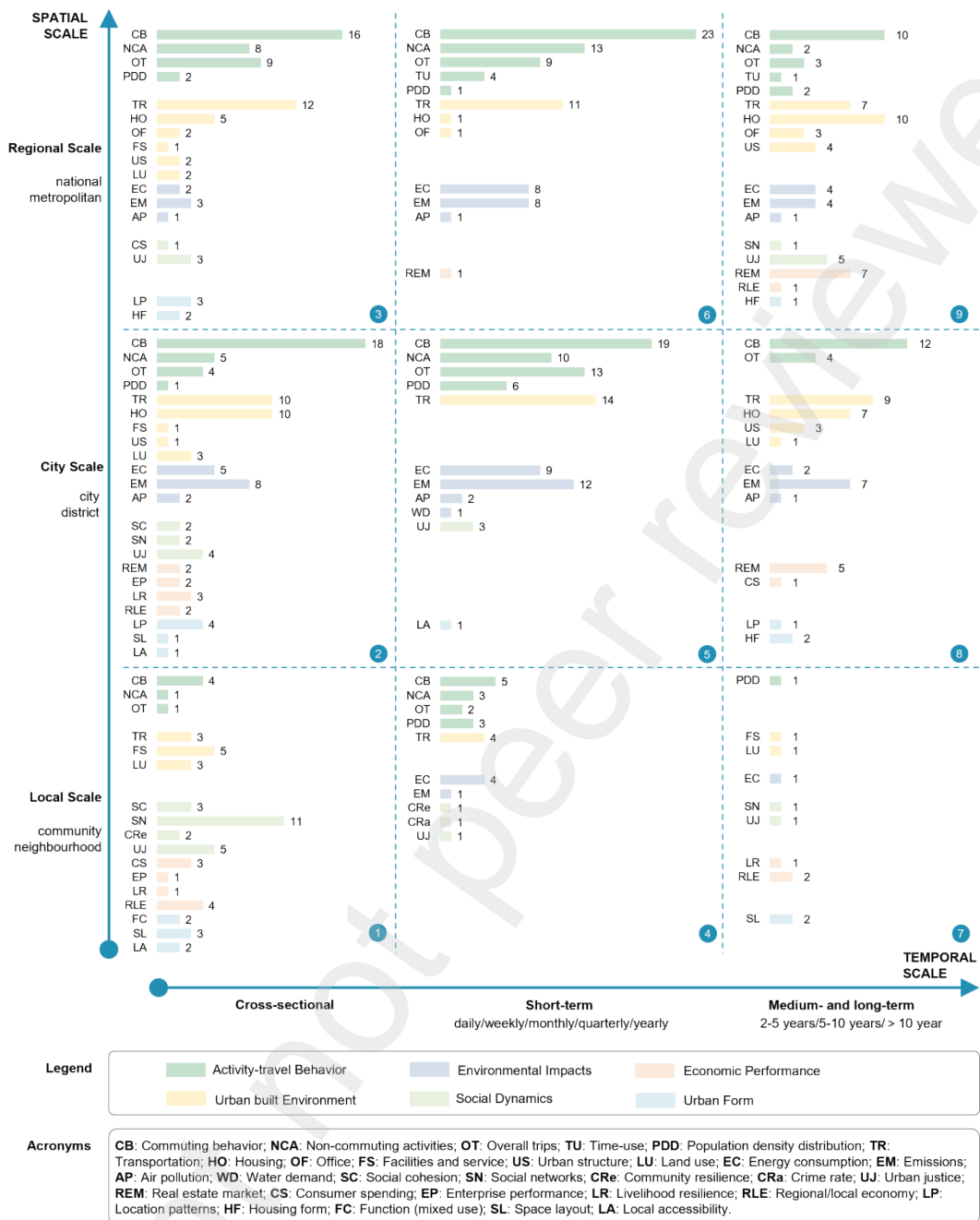


Fig.5. The number of impacts of working patterns changes across different temporal and spatial scales.

Notes: The total number of impact items represented in this figure exceeds the count of included articles, as multiple impacts were simultaneously examined within individual studies, with each distinct impact item counted separately.

5.1 Temporal dimension

We categorised the temporal scales of impacts into three types: cross-sectional ($n = 85$), short-term ($n = 81$), and medium-to-long-term ($n = 47$, of which n (mid-term) = 21 and n (long-term) = 26). The cross-sectional category includes studies using cross-sectional data or those where impact duration could not be effectively distinguished. Short-term impacts refer to those observed within one year, mid-term impacts span 2-5 years, and long-term impacts extend beyond 5 years. Only 22%

of included studies investigated medium-to-long-term effects, and just 12% explicitly focused on long-term outcomes. This imbalance motivates us to emphasise long-term findings to compare their differences from short-term effects, thereby providing a basis for more comprehensive assessments in future research.

We compared the frequency of impact items (Fig. 5) between short-term (quadrants 4,5,6) and medium-to-long-term studies (quadrants 7,8,9). Despite the smaller number of medium-to-long-term studies, several impacts appear almost exclusively in the long term, including housing, office, urban structure, land use, and real estate market. This distribution indicates that these impacts require longer duration to occur and be observed, which is consistent with Wegener et al.'s (1986) timescale framework and further validates the proposition the structural urban change emerges more slowly. The following paragraphs summarises insights from 26 studies addressing long-term effects, while recognising that short-term signals may not be reliable guides to the long-run net outcome.

With respect to housing and office demand, increased remote work adoption reduces the number of people working in central business areas (Hensher et al., 2023) and increases residential preferences for low-density areas (Liu & Su, 2021). Long term scenario projections suggest that sustained remote work trends may have a decentralizing and suburbanizing effect on urban structure (Delventhal et al., 2023; Larson & Zhao, 2017; Zhang & Zhang, 2021), with livable suburban areas at moderate distances from large cities facing the greatest sprawl pressures (Muhammad et al., 2008). At the same time, this long-run spatial shift is heterogeneous and depends on individual preferences and working pattern type. For instance, Anik et al. (2024) found that by 2031, fully-remote and non-remote workers in Halifax, Canada tend to cluster in similar locations, whereas hybrid workers may form two clusters, one near CBDs and another in the suburbs. Taken together, these findings indicate that short-term office and residential demand shifts can propagate into long-term structural change, but the direction and magnitude vary by worker group and therefore require cohort-sensitive tracking.

Conclusions regarding long-term transportation and environmental impacts remain uncertain (Hook et al., 2020; Stefaniec et al., 2024; Yu et al., 2019a). The initial implementation of remote work lead to reductions in commuting frequency, traffic volume, and carbon emissions (Graizbord, 2015; Guerin, 2021; O'Keefe et al., 2016). Holding other factors constant, long-term trends appear optimistic for reduced traffic congestion and transport emissions (Delventhal et al., 2022; Martínez-Jaramillo et al., 2017; Saha & Fatmi, 2021). However, changes in household vehicle choices and residential location over the long run may offset a large portion of the initial benefits (Marz & Şen, 2022). Estimates of the net effect on long-term energy consumption likewise vary, with some studies predicting decreases (Noussan & Jarre, 2021; Phoung et al., 2024) and others increases (Alonso et al., 2017; Larson & Zhao, 2017). These divergences likely reflect the complexity of cross-sector linkages, and the limited sectors and influencing factors incorporated in existing models, which implies that integrated, cross-sectoral approaches are needed to evaluate net outcomes.

In terms of economic impacts, remote work generated large short-term shocks where housing supply was inelastic. Corporate properties and downtown real estate prices declined sharply (Bergeaud et al., 2023) while suburban property prices rose (Nagarjun & Sridhar, 2023), flattening housing price gradients between high- and low-value areas (Brueckner et al., 2023; Kim & Long, 2024). Over time, as relocation gradually occur and supply adjusts, this gradient convergence is expected to

persist (Hensher et al., 2023; Miles & Zhu, 2024), although overall real estate prices may decline (Delventhal et al., 2022). As market elasticity increases, long-term effects on real prices are anticipated to be weaker than short-term shocks. For instance, Howard et al. (2023) estimated that long-term rent changes are roughly one-fifth of short-term effects. The shock to downtown areas may also be less severe than initially projected (Delventhal et al., 2023; Liu & Su, 2021). These trajectories imply that price dynamics evolve with migration timing and supply responses, so long-term evaluation must incorporate adjustment lags.

Other potential long-term impacts identified include profitability challenges for coworking spaces (Mariotti et al., 2017), the evolving social interactions between flexible and creative workers and their host districts or neighbourhoods (Hanan & Hemanto, 2020; Markusen & Schrock, 2006), the dynamic interplay between creative workers' location choices and land-use change (Liu et al., 2016), and gentrification risks (Behrens et al., 2024; Kitsos et al., 2025). These findings emphasise that policies should be adaptive and staged, aligning short-term measures with longer-term social and spatial objectives.

To summarise, the temporal evidence exhibits three gaps. First, there is a predominant focus on short-term effects, while research on long-term impacts still needs to be further supplemented. Second, there is enough observational data to support short-term impacts, while long-term impacts rely heavily on simulation because longitudinal data are scarce, which limits validation of modelled pathways. Third, models often assume steady long-term growth in remote work prevalence or specific long-term adoption levels. Given that the large-scale shift towards remote work is relatively recent, its longer-term direction remains uncertain (Brueckner et al., 2023; Phoung et al., 2024). Differences in assumed adoption rates across studies also reduce comparability. Addressing these gaps requires cross-temporal research designs that follow adaptation cycles, integrate sectors, and explicitly test for offsetting mechanisms.

5.2 Spatial dimension

We categorised spatial scales into three levels based on the scope of analysis in the included studies: (1) regional scale (national, metropolitan level), (2) city scale (city, district level), and (3) local scale (community, neighbourhood level). Fig. 5 shows that most studies were conducted at the regional (40.4%) and city (43.1%) scales, with fewer at the local scale (16.5%).

Impacts diverge across scales in two ways. First, some impacts are only observed at regional and city scales and rarely at local scales (e.g., housing), or vice versa (e.g., social cohesion). Second, other impacts are studied at different scales but with divergent foci, methods, or conclusions. These differences reinforce the need to interpret findings cross-scalarly rather than in isolation. Below we summarise the spatial variations across these impacts.

Activity-travel behavior occupies an important share of studies across all scales and functions as a bridge between regional, city, and local systems. For instance, reductions in commuting are related to both regional and city scale VMT reductions (Badia et al., 2021; Stefaniec et al., 2024), as well as neighborhood-level non-work trip increases (Zenkteler et al., 2022). Flexible work schedules alter regional traffic peaks (Alonso et al., 2017), while also changing localised congestion hotspots distribution (Acharyaviriya et al., 2021; Wells et al., 2001) and reshaping local parking preferences near workplaces (Ng, 2016). These findings illustrate that a change in working patterns

simultaneously generates impacts across different scales, while activity-travel behaviour can serve as a key integrative link connecting these multi-scale effects.

Built environment impacts exhibit pronounced scale differences. Impacts on housing, office, and urban structure are mainly regional and city level phenomena, such as relocation trends or willingness (McCollum, 2025; Wächter & Kramer, 2025), housing type choices (Zhu et al., 2025), and office demand change (Hensher et al., 2023). Facilities and service demand manifests primarily at the local scale. For example, coworking spaces and third places can drive amenity provision (Di Marino et al., 2023; Mariotti et al., 2017), while digital nomads, self-employed workers, and gig workers reshape space use through different amenity needs (Ezeadichie, 2023; Peng et al., 2022; Qosim et al., 2025). In contrast, transportation and land use impacts are studied at all scales, but the emphasis varies. Transportation studies at regional and city scales focus on aggregate metrics like traffic volume, congestion, and transit ridership (Curtis et al., 2025; Tian et al., 2025; Zheng et al., 2023), while local-scale research address niche dimensions such as EV charging behaviors (Berkes & Keshav, 2024), hyperlocal VMT redistribution (Balepur et al., 1998), and traffic violations linked to the gig economy (Peng et al., 2022). For land-use, regional and city analyses examine green space visitation and area regeneration (Astell-Burt & Feng, 2021; Glackin & Moglia, 2022), whereas local analyses prioritize public space demand (Di Marino & Lapintie, 2020; Uliarte et al., 2019). These differences highlight the cross-scale nature of built environment impacts, suggesting that indicators and methodologies must align with the research scale. Additionally, resolution and boundary effects should be explicitly addressed to enhance cross-scale comparability.

Environmental impacts display scale-dependent approaches. Energy consumption is studied across all scales but relies on distinct tools: simulation or calculation at regional and city scales (e.g., LEAP (Martínez-Jaramillo et al., 2017); Standard Urban Model and energy calculation (Larson & Zhao, 2017)), while sensor-based or microsimulation approaches at the local scale (e.g., agent-based model (Wang et al., 2022); CEA (Mosteiro-Romero et al., 2023)). Emission and air pollution research are mostly at regional or city scales because they rely more on city-scale monitoring networks whose resolutions rarely align with neighborhood-level analysis. This methodological stratification underscores that valid cross-scale inference must reconcile differences in measurement resolution and geographic units.

Social impacts concentrated at the local scale (74%), reflecting the place-based feature of social processes. These studies often employ community-embedded methods such as ethnography (Uliarte et al., 2019) and participatory mapping (Hanan & Hemanto, 2020) to capture granular interactions such as peer support in coworking spaces (Mariotti et al., 2017) or informal networks among self-employed workers (Sleutjes & Schutjens, 2012). Such phenomena are difficult to aggregate at broader scales. The sole regional-scale case examined cross-sector innovation networks among self-employed artists (Markusen & Schrock, 2006). Although city scale analyses sometimes explore cohesion issues induced by relocation (McCollum, 2025) or creative industry inclusion (Bonello et al., 2020; Kalfas et al., 2024), these phenomena still essentially occur at the community level. Urban justice impacts contrastingly maintain multi-scalar balance (regional 42%, city 32%, local 26%), as disparities coexist at different scales and are measurable through both regional statistics and local surveys. These distribution indicate that social evidence is scale-sensitive and that inference should avoid extrapolating local mechanisms to regional conclusions without an intermediate link.

For economic impacts, real estate market analyses appear only at regional and city levels because they are closely related to housing and office demand and because price-gradient estimation requires large-scale data. Other economic impacts (consumer spending, enterprise performance, livelihood resilience, and regional/local economy) are more evenly distributed across scales. Economic impacts operate through both market-wide price formation and neighbourhood-level demand, implying that cross-scale assessments may benefit from linked datasets.

Urban form impacts also exhibit scale differences. Location patterns and housing form are exclusively examined at regional or city levels, whereas function, spatial layout, and local accessibility are analysed solely at local scales. Future cross-scale frameworks should consider how to connect macro siting with micro design to understand full system effects.

The spatial-scale analyses reveal two limitations. First, most studies focus on examining impacts at a single scale without tracking feedbacks across scales. For example, regional suburbanisation is rarely associated with increased local amenity demand, obscuring how metropolitan trends are linked to neighbourhood changes. Second, studies at different scales often adopt different data and methods. This methodological mismatch may hinder the comparability of evidence. These limitations point to the need for cross-scale analytics and approaches that integrate temporal and spatial dynamics to comprehensively assess the diverse impacts of changing working patterns.

6. Data and methods for capturing the impacts

6.1 Data types

Measuring the urban implications of changing working patterns relies on various data sources, each with distinct strengths and limitations. As summarised in Table 5, these data can be categorized into seven types: (1) survey-based data, (2) mobile big data, (3) government and public urban data, (4) passive crowdsourced data, (5) geo-information data, (6) parameters for calculation, and (7) experimental and simulation data. Figure 6 shows the number of different data types or subtypes in included articles.

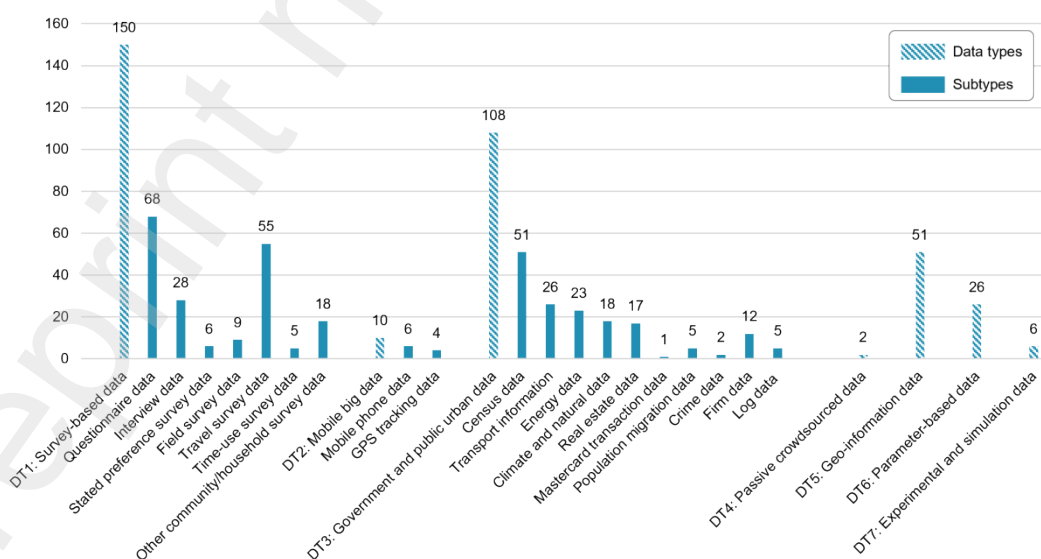


Fig.6. Number of different data types/subtypes in included articles.

Used together, these data sources can connect different urban systems and enable us to better understand the relationships and interactions between them. In practice, however, most studies still rely on short-term, readily available datasets and struggle to integrate heterogeneous sources because of misaligned spatial or temporal resolutions, fragmented ownership, and inconsistent formats, which limits holistic assessment.

6.1.1 Survey-based data

Survey-based data remains foundational for observing working patterns, activity-travel behaviours, and socio-demographics at the individual level, and they are highly adaptable to different research questions. Surveys can provide nuanced insights into behavioral motives, preferences, detailed activity patterns (activity types, timing, and locations), work status, and socioeconomic attributes. Despite their strengths of high granularity, survey data collection is time-consuming and labor-intensive, and faces challenges such as recall bias and sample representativeness. Combining survey data with other datasets (such as passive sensing, administrative data or other public urban data) helps validate self-reports and link demographic characteristics to impact outcomes. However, it may be constrained by the resolution of survey data and the design of questionnaire variables.

6.1.2 Mobile big data

Mobile big data (mobile phone data, GPS tracking data) provide high spatiotemporal resolution on revealed mobility and activity patterns, enabling analyses over specific periods or continuous panels and across multiple scales. For example, Huang et al. (2023) examined the impacts of WFH on travel behaviors and activities by comparing three time periods based on a set of GPS tracking data in Switzerland. The use of such data often faces the problems of limited data access, high costs, lack of broad socio-economic attributes, and representativeness concerns tied to device coverage. They are most powerful when linked to survey data (to recover attributes) and to public urban data (to anchor movements in land use, facilities, and markets), but this linkage also faces resolution mismatch issues.

6.1.3 Government and public urban data

Government and public urban data provide rich information for assessing multidimensional impacts of new working patterns. This category encompasses census, transport information, energy, climate and natural, real estate, master-card transaction, population migration, crime, firm, and log data. Their credibility and breadth make them ideal backbones for multi-sector outcomes. Constraints include inconsistent spatial units and temporal coverage across sources, access barriers for some datasets, and fragmented ownership (e.g., venue Wi-Fi logs or tele-centre sign-ins), which limit cross-locational comparability and integration.

6.1.4 Other data types

Other data types employed in reviewed studies include geo-information, passive crowdsourced, parameter-based, and experimental and simulation data. Geo-information data (e.g., POIs, land-use, building footprints) support granular spatial analysis of built environment interactions with working patterns and other factors. Update frequency and classification consistency remain common issues. Passive crowdsourced data (e.g., Bluetooth sensors, smartwatch apps) is another complementary data source for capturing micro-scale or indoor activity patterns and user feedback with low installation cost (Angel et al., 2023; Mosteiro-Romero et al., 2024), but samples skew toward device users. Parameter-based data provide technical coefficients and behavioral parameters for quantify

and estimate impacts when empirical data are not available, but transferring coefficients across contexts introduces uncertainty. Experimental and simulation data provide assumptions related to travel and activity patterns through APIs or model outputs, enabling modelers to overcome observational data gaps, particularly when conducting scenario predictions.

Table 5
Data used in included studies.

Data types	Subtypes	Sources	Impact domains	Advantages	Limitations
Survey-based data (small sample)	Questionnaire data	Self-collected by researcher; public departments or authorities	Activity-travel behavior; Environmental; Social; Economic; Urban	More personal& detail information, motive interpretation	Small samples, recalling bias, low representation
	Interview data				
	Stated preference survey data				
	Field survey data				
(large sample)	Travel survey data	Public departments or authorities; collected via panel company	inequalities; Urban form	Large sample size, high resolution	Time consuming, resolution constrained by survey accuracy and typically lacks geocoding
	Time-use survey data	Public departments			
	Other community/household survey data				
Mobile big data	Mobile phone data	Mobile operators	Activity-travel behavior	High spatiotemporal resolution, large-scale coverage	Limited data access, high costs, lack of broad socioeconomic information, variable spatial accuracy
	GPS tracking data	Third-party companies; Self-collected by researcher through mobile apps			
Government and public urban data	Census data	Government; public departments; open database	Activity-travel behavior	Authority & universal coverage, rich socioeconomic information	Limited data years and spatial granularity
	Transport information	Transport operators; public departments or transport authorities; sensors managed by public departments	Built environment	Reliability; diversity and sectoral breadth	Inconsistent spatial units and temporal coverage across data sources,
	Energy data	Government report; public departments; public system operators;	Environmental		access barriers for certain

		reports from utility providers; public database			datasets
	Climate and natural data	Public departments; local authorities; sensors managed by public departments; open database; social media; archival docs	Environmental		
	Real estate data	Third-party platforms; public departments or authorities; public database	Economic		
	Mastercard transaction data	Financial institutions	Economic		
	Crime data	Public departments or authorities	Social		
	Population migration data	Public database; public departments; map operator platform	Activity-travel behavior; Built environment		
	Firm data (including coworking spaces, industry, employment information)	Public departments; third-party platforms; public database; social media	Built environment; Economic; Urban form		
	Log data (tele-center sign-in logs, Wi-Fi connection logs)	Business operators	Activity-travel behavior	Objective behavioral capture, high spatiotemporal resolution, longitudinal, monitoring capacity	Fragmented ownership, inconsistent coverage
Passive crowdsourced data	Bluetooth sensor network records, Smartwatch app	Users	Activity-travel behavior	Ease of sensor installation, user feedbacks	Lack of personal information, micro scale only, sample restricted to device users
Geo-information data	POIs, rail and road networks, land use, building geometry, administrative boundaries	OSM; public departments; public database; local authorities; map operator platform; third-party companies	Built environment; Urban form	High spatial accuracy	Update frequency issues

Parameters for calculation	Vehicle parameters, PV parameters, air pollution parameters, emission factors, commute time matrices, telework parameters; energy efficiency; fuel properties data; empirical relations for speed-congestion dynamics	Vehicle companies; literatures; public database; guidebook or standards from public authorities or agencies	Activity-travel behavior; Built environment; Environmental	Standardized, compensation for data scarcity, ability in supporting scenario projection	Uncertainty across diverse urban contexts
Experimental and simulation data	Google Maps API travel time data, model outputs data (e.g., trip tables, OD matrix, zone distances), activity assumptions	Google Maps API; model outputs; literatures	Activity-travel behavior; Built environment	Filling observational gaps	Validity threats

6.2 Analytical methods

Despite the richness of data described in Section 6.1, integration is rare in existing studies because of the data silo problem. As a result, researchers default to methods that work within one sector (e.g., transport or housing) rather than cross-sectors, which prevents capturing of their complex interactions. Based on the 213 included studies, eight categories of analytical methods for capturing impacts of new working patterns on cities were identified (Table 6, Fig.7). For clarity, we tag them as typical methods and emerging methods. Typical methods are widely used and strong within a single sector, they include: (1) Basic quantitative analysis, (2) Statistical and econometric models, (3) Engineering and accounting models, (4) Geospatial analysis and statistics, (5) Qualitative analysis, and (6) Mixed-methods. Emerging methods have the potential or ability to deal with multi-source data integration and cross-scale coupling, they comprise: (1) Simulation and computational models, and (2) Machine learning.

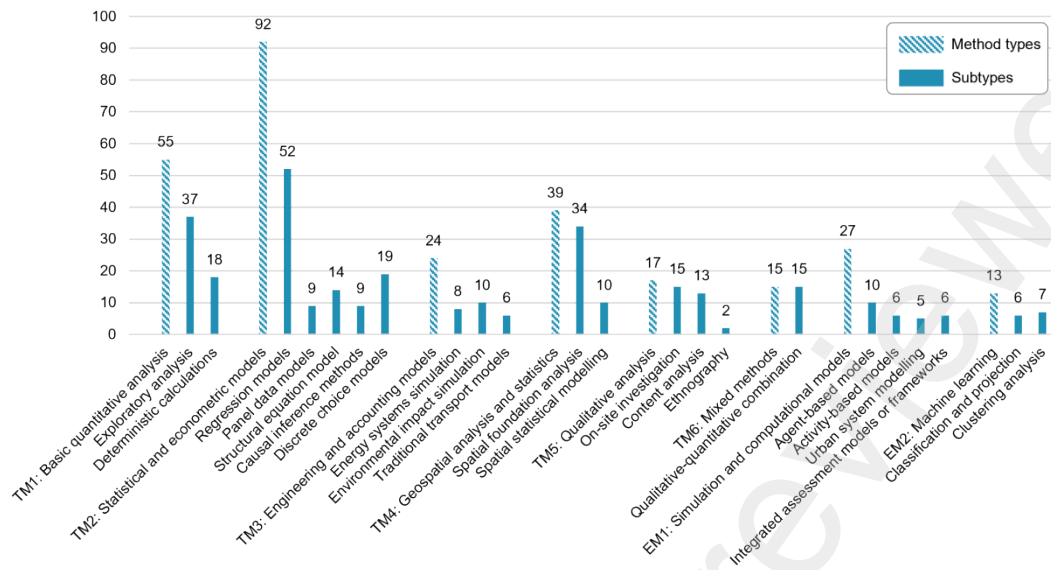


Fig.7. Number of different analytical methods in included articles.

6.2.1 Typical methods

(1) Basic quantitative analysis

Basic quantitative analysis (n=55, 26%) remain common, encompassing exploratory summaries and deterministic calculations. Exploratory analysis provides descriptive statistics to identify trends or correlations, such as changes in activity-travel patterns (Huang et al., 2023; Tian et al., 2025), traffic volume (Akbari & Hopkins, 2019; Melo, 2022), housing price (Miles & Zhu, 2024), and correlations between remote work and air pollution (Bañuelos-Gimeno et al., 2024). However, the inability to establish causality limits its use to preliminary analysis and to complement statistical or simulation models. Deterministic approaches (emission coefficients, GDP scaling, life cycle assessment (LCA)) enable impact estimation with sparse observations (Deiss et al., 2021; Guerin, 2021; Han et al., 2021; Kitou & Horvath, 2006; Kylili et al., 2025; Pérez Pérez et al., 2004), though parameter assumptions may introduce uncertainty.

(2) Statistical and econometric models

Statistical and econometric approaches were the most frequently applied (n=92, 43%). Regression models (OLS, Logistic, Tobit, etc.), panel data models (fixed/random effects), and structural equation models are widely used to estimate associations between working-pattern variables and urban outcomes such as travel behaviour, housing demand, property prices, or energy consumption (Asgari & Jin, 2023; Bergeaud et al., 2023; Carvalho et al., 2021; Kim & Long, 2024; Tian et al., 2025). Causal inference methods (e.g., IV, DID) can address endogeneity and have applications such as identifying net effects of remote work on air pollution or crime (Giovannis, 2018; Yiu et al., 2023). Discrete choice models are used to capture individual preference heterogeneity for residential, travel mode, departure time, trip purpose and work-arrangement choices (Balbontin et al., 2024; Hensher et al., 2024; Lizana et al., 2021; Saleh & Farrell, 2005; Shakib et al., 2024; Tayyaran et al., 2003; Zheng et al., 2023). These models typically rely on single-stream outcomes and stable units, and remain sensitive to unresolved endogeneity or measurement error issues, thereby limiting their ability to integrate heterogeneous data or convey cross-sector feedbacks.

(3) Engineering and accounting models

Engineering and accounting models (n=24) are domain-specific tools widely used for quantifying single sector impacts, including energy systems simulation (n=8), environmental impact simulation (n=10), traditional transport models (n=6). They can convert behavioural inputs into physical outputs. For example, models such as LEAP (Long Range Energy Alternatives Planning), CEA (City Energy Analyst), and EnergyPlus are used for regional- or city-scale energy demand simulation (Martínez-Jaramillo et al., 2017; Mosteiro-Romero et al., 2023; Wang et al., 2022); environmental simulation tools such as WRF-Chem, MOVES, COPERT are used to estimate emissions (Badia et al., 2021; Stefaniec et al., 2024; Wang et al., 2021); traditional four-stage transport models can project transport demand and congestion patterns under different working pattern scenarios (Lila & Anjaneyulu, 2017). They are transparent and easy to scenario-test, but they typically treat other sectors as exogenous and thus hard to track feedbacks (e.g., residential relocation influencing travel patterns, which in turn affects energy consumption).

(4) Geospatial analysis and statistics

Geospatial methods (n=39) allow for capturing the spatial characteristics and dependence. Spatial foundation analysis was mainly used for analysis of morphological indicators and visualization of geospatial distribution. Popular techniques include kernel density and hotspot analysis (Fu & Wang, 2025; Ge et al., 2018), accessibility analysis (Chandra et al., 2017; Elldér, 2015; Zeng et al., 2020), spatial correlation test (He et al., 2023; Méndez-Ortega et al., 2024). Spatial statistical models (e.g., GWR, hedonic, spatial error models) were employed to reveal spatial heterogeneity or dependence for impacts on traffic safety (Pirdavani et al., 2014), real estate values (Brueckner et al., 2023; Ssemwanga et al., 2023), transit ridership (Meredith-Karam et al., 2024), and travel demand (Kar et al., 2022). These methods are well suited for place-based analysis and city/regional questions, but they often operate on aggregated units that are not directly linkable to micro-behavioural datasets, which weakens cross-scale inference ability.

(5) Qualitative analysis

Qualitative analysis (n=17) exhibit strong topical preferences and focus on informal or less-studied working patterns (e.g., digital nomads, gig work, self-employment, workations, and flexible workplaces). At the same time, these studies investigate impacts centered on social consequences and local economies. Examples include the community engagement of digital nomads (Jiwasiddi et al., 2024), the social network characteristics of coworking spaces (Bednár et al., 2023), and the role of self-employment in local economic resilience (Uliarte et al., 2019). Qualitative exploration excel at capturing social processes (e.g., motivations, experiences and adaptations) that are difficult to quantify (Wilkesmann & Bassyouny, 2025), and can provide contextual depth and theoretically integrated insights to complement what may have been overlooked in quantitative research.

(6) TM6: Mixed methods

Mixed-methods research (n=15) combine qualitative and quantitative approaches to provide a more comprehensive understanding of the possible impacts of new working patterns. For instance, interviews and surveys are commonly used to explain or extend statistical findings (El Zein et al., 2022; Rachmawati et al., 2021; Wells et al., 2001). Another example is the application of Q-methodology, which examined the motivations and perceived benefits for coworking space usage

(Brown, 2017).

6.2.2 Emerging methods

(1) Simulation and computational models

Simulation and computational models (n=27) prioritize system dynamics and interactions and are particularly suited to predicting impacts that are difficult to assess through observational data. They include four subtypes, namely activity-based models (n=6), agent-based models (n=10), urban system modelling (n=5), and integrated assessment models or frameworks (n=6). Activity-based models can capture individual heterogeneity and daily activity realism beyond trip-based assumptions. Frameworks such as CUSTOM and POLARIS simulate how different working patterns reshape daily activity chains, travel patterns, and transport demand (Shabanpour et al., 2018; Wang et al., 2024). They also enable high policy sensitivity (Arentze & Timmermans, 2005), for instance, FEATHERS was used to compare traffic outcomes under remote work and baseline scenarios (Pirdavani et al., 2014).

Agent-based models (ABM) are capable of portraying individual-level decision-making and modelling individual-environment interactions. For example, MATSim was used to model how travel mode shifts affect network congestion (Wang et al., 2021), and CID-USST-GIS was employed to explore how creative industry practitioners form industrial clusters and interact with land use planning (Liu et al., 2016).

Urban system models (e.g., LUTI) integrate land use and transport to predict long-term spatial evolution. For example, Hensher et al. (2023) utilised the MetroScan-TI system to assess how changes in WFH probability affect travel behaviour, transport network performance, and residential or workplace relocation. Larson & Zhao (2017) employed the Standard Urban Model (SUM) to simulate telework-induced urban sprawl and energy consumption.

Integrated assessment models or frameworks evaluate cross-sectoral trade-offs of policy interventions by coupling modules such as economic, social, and environmental systems. For example, Bisen et al. (2014) assessed the role of remote work policies in reducing emissions using a system dynamics model with four modules (vehicle population, congestion, emissions, policy evaluation). Zhang & Zhang (2021) applied a spatially computable general equilibrium (CGE) model to project WFH impacts on energy use and CO₂ emissions by integrating population distribution, land use, and transport demand.

Although the sectors incorporated remain limited, these models have made some progress in capturing interactions across sectors and scales. They also face challenges such as calibration data needs and computational cost. Future research may benefit from more integrated models or frameworks capable of dynamically capturing spatial and temporal variations.

(2) Machine learning

Machine learning methods are less frequently used in reviewed studies (n=13), likely due to interpretability challenges and the black-box nature of some algorithms. Applications focused on classification, clustering, and nonlinear prediction. For example, clustering methods were applied to classify energy profiles (Debnath et al., 2022; Manjunath et al., 2021; Mosteiro-Romero et al., 2023) and trip patterns (Gao et al., 2023; Rifat Hossain Bhuiyan & Ahsanul Habib, 2024), while

classification prediction algorithms such as random forests and XGBoost were employed to identify location patterns for coworking and third places (Li et al., 2024) and to quantify impacts of remote work on travel and transport demand (Edward et al., 2024; Wang & Ozbilen, 2020). Although machine learning holds potential in data processing and integration, its application scenarios in current research remain highly limited. Future efforts could explore combining them with other tools to overcome the limitations of single approaches.

To sum, typical methods still dominant the literature, and emerging methods are growing but remain sparsely used. The key unresolved issues are data silos, misaligned space-time resolutions, limited cross-sector coupling, and weak dynamic analysis capabilities. Future progress can be achieved by combining typical and emerging approaches and borrowing mature practices from adjacent fields.

Table 6

Analytical methods used in included studies.

Method types	Subtypes	Techniques	Applications/Purpose	Representative references
Basic quantitative analysis	Exploratory analysis	Descriptive statistics/Pearson/Spearman correlation, t-test/ANOVA/...	Comparison of simulated data with empirical data; Temporal change of bike trips/traffic congestion; new working patterns and activity-travel behavior, built environment, economic impacts	(Akbari & Hopkins, 2019; Bañuelos-Gimeno et al., 2024; Chalabi & Dia, 2024b; Eregowda et al., 2021; Huang et al., 2023; Melo, 2022; Miles & Zhu, 2024; Nayak & Pandit, 2021; Tian et al., 2025; Wächter & Kramer, 2025)
	Other quantitative analysis	Deterministic scenario analysis/emissions coefficient method/GDP scaling method/Life Cycle Assessment/ Calculation/...	activity patterns change; transport impact assessment; energy and emission calculation; self-employment and economic impacts	(Deiss et al., 2021; Guerin, 2021; Han et al., 2021; Kitou & Horvath, 2006; Kylili et al., 2025; Pérez Pérez et al., 2004; Y. Zhang et al., 2023)
Statistical and econometric models	Regression models	OLS/Tobit/Joinpoint/NBR/GLMM/MVPLN/LCR/...	Widely applicable to new working patterns and impacts on activity-travel behavior, built environment, social, economic, environmental, inequalities and urban form	(Brueckner et al., 2023; Carvalho et al., 2021; Malik et al., 2023; Tian et al., 2025; Wächter & Kramer, 2025)
	Panel data models	Fixed-effects/random effects	Energy consumption patterns; activity-travel behavior; air pollution; corporate real estate market; controlling for individual differences	(Bergeaud et al., 2023; Cicala, 2023)
	Structural equation models	SEM/path analysis	Activity-travel behavior, transport, land-use patterns, and environmental impacts	(Asgari & Jin, 2023; Motte-Baumvol & Schwanen, 2024)
	Causal inference methods	Instrumental Variable model/ Difference-in-Differences, Conditional Mixed Process model	Activity-travel behavior; housing choice; transportation; air pollution; social impacts; real estate market; address endogeneity and selection bias	(Giovanis, 2018; Yiu et al., 2023)
	Discrete choice models	Logit/LCCM/LCOLM/MDCEV/Generalized heterogeneous data model (GHDM) framework/...	Behavioral choices in heterogeneous groups; residential choices; travel mode choice; departure time choice; work-arrangement choice	(Balbontin et al., 2024; Beck et al., 2020; Hensher et al., 2023, 2024; Lizana et al., 2021; Saleh & Farrell, 2005; Shakib et al., 2024;

				Shin, 2019; Tayyaran et al., 2003; Tayyaran & Khan, 2007; Zheng et al., 2023)
Engineering and accounting models	Energy systems simulation	Macro-scale: LEAP/IPAT; Urban-scale: City Energy Analyst (CEA)/EnergyPlus/...	Energy demand simulation	(Martinez-Jaramillo et al., 2017; Mosteiro-Romero et al., 2023, 2024; R. Wang, Ye, Hsu, et al., 2022)
	Environmental impact simulation	WRF-Chem/COPERT/ MOVES/ EMFAC/BURDEN/...	Emission estimation	(Badia et al., 2021; Stefaniec et al., 2024; D. Wang et al., 2021)
	Traditional transport models	NTA's Regional Modelling System/Four-stage Urban Transport Model/Strategic Transport Evaluation Model (STEM)/Stratified travel demand model/...	Transport demand impacts	(Lila & Anjaneyulu, 2017)
Geospatial analysis and statistics	Spatial foundation analysis	Kernel density/mapping/Getis-Ord Gi* hotspot analysis/non-linear programming optimization/accessibility analysis/spatial configuration/proximity gradients/Moran's I/...	Exploratory spatial pattern identification & data preprocessing	(Chandra et al., 2017; Elldér, 2015; L. Fu & Wang, 2025; Ge et al., 2018; He et al., 2023; Méndez-Ortega et al., 2024; Ssemwanga et al., 2023; Zeng et al., 2020)
	Spatial statistical modelling	Hedonic Pricing Model/Spatial error model/Spatial lag model/ GWR/GWGLM/GWPR/ Spatially weighted interaction model/...	Modeling spatial dependence/heterogeneity & interaction mechanisms	(Brueckner et al., 2023; Kar et al., 2022; Malik et al., 2023; Meredith-Karam et al., 2024; Pirdavani et al., 2014; Ssemwanga et al., 2023; Yiu et al., 2023)
Qualitative analysis	On-site investigation	Interviews/in-person workshops/ field observation/mapping	Flexible workplaces, decentralized workspaces, coworking spaces, cultural entrepreneurs, creative industries, self-employment, digital nomad, workations and their impacts on built environment, social, economic, urban inequalities, urban form	(Bednář et al., 2023; Jiwasiddi et al., 2024; Peng et al., 2022; Uliarte et al., 2019; Wilkesmann & Bassiouny, 2025)
	Content analysis	Thematic analysis/SWOT/POE/case study analysis/...		

	Ethnography		Self-employment and impacts on built environment, economic, and urban form; Digital nomad and social impacts	(Uliarte et al., 2019)
Mixed-methods	Qualitative-quantitative combination	Qualitative + quantitative/Q methodology	Activity-travel behavior, built environment, social impacts	(Brown, 2017; El Zein et al., 2022; Rachmawati et al., 2021; Wells et al., 2001)
Simulation and computational models	Agent-based models	MATSim/MobiSim-MQ/CID-USST-GIS/Integrated Urban Modelling Framework (IUMF)/ITLE/...	Activity-travel behavior, transportation, energy consumption, emission, land use impacts	(H. Liu et al., 2016; D. Wang et al., 2021)
	Activity-based models	POLARIS/CUSTOM/FEATHERS/...	Activity-travel behavior, transportation, emissions	(Pirdavani et al., 2014; Shabanpour et al., 2018; K. Wang et al., 2024)
	Urban system modelling	Standard Urban Model (SUM)/LUTI/MARS/MetroScan-TI/...	Integrated transport/land use model system	(Hensher et al., 2023; Larson & Zhao, 2017)
	Integrated assessment models or frameworks	System Dynamics/Spatial equilibrium model/Urban Spatial Computable General Equilibrium (CGE) Model	Interactions of behavior, economic, social, and environmental impacts	(Bisen et al., 2014; R. Zhang & Zhang, 2021)
Machine learning	Classification and projection	Random forest/XGBoost + SHAP/GBDT	Travel and transport demand; locations patterns of remote work in third places	(Edward et al., 2024; W. Li et al., 2024; López Soler et al., 2021; K. Wang & Ozbilen, 2020)
	Clustering analysis	k-means/k-medoids/K-prototypes/Gaussian mixture models	Wi-Fi profile; electricity load profile derivation; pseudo-panel dataset construction; trip clustering; define gentrifying neighborhoods	(Debnath et al., 2022; Gao et al., 2023; Manjunath et al., 2021; Mosteiro-Romero et al., 2023; Rifat Hossain Bhuiyan & Ahsanul Habib, 2024)

7. Discussion and future directions

7.1 Future directions

This review analyzed evidence from 213 studies to unveil the complex relationships between new working patterns and urban development. While significant progress has been made by existing research in exploring the urban effects of diverse working patterns that are emerging, we find important knowledge gaps remain in four critical areas that require priority attention in future research.

(1) Broadening geographic, cultural, and economic diversity of study contexts.

The regional preferences observed in current studies illustrate the profound influence of local contexts on the adoption of new working patterns. However, research remains heavily concentrated in Europe and North America (65%), with less than 20% originating from Asia, and regions of the Global South remaining critically underrepresented. This limited geographic focus risks generating findings lacking external validity, limiting their applicability across diverse cultural and economic backgrounds. Working pattern choices and impacts are deeply rooted in local realities. On one hand, flexibility and work-life balance often drive adoption in high-income regions, while livelihood-oriented adaptation is crucial in lower-income areas. On the other hand, studies confirm heterogeneity in the directionality and magnitude of impacts across different cities and regions (Maipas & Chatzoglou, 2025; Malik et al., 2023; Nayak & Pandit, 2021; Ramani et al., 2024; Shi et al., 2023).

The literature also disproportionately centers on remote work (51% of the selected studies), leaving other emerging working patterns such as multi-local working, part-time job, and digital nomadism significantly under-explored. The salience of these emerging working patterns in practice is not matched by proportional scholarly coverage. Taking the digital nomad groups as an example, recent estimates suggest its global scale reached 35 million by 2024 (Bahri, 2024), yet literature exploring its impact on cities remains sparse. To address these gaps, future research should actively incorporate evidence from a wider array of regions, compare the impacts of working patterns across varying contexts, and prioritise investigating understudied working patterns. Adopting such inclusive and comparative approaches is essential for developing a truly global understanding of how new working patterns reshape diverse urban fabrics. The insights will be invaluable in selecting locally appropriate implementation strategies when considering shifts in working patterns as part of policy interventions.

(2) Integrating cross-sectoral interactions for holistic urban policymaking.

A key limitation of current literature is the predominant use of isolated perspectives for impact assessment. Most studies focus narrowly on single sectors (e.g., transport emissions, office vacancy, residential energy use), with only a limited number addressing interactions across sectors. This fragmented perspective fails to reflect the interconnected nature of urban systems and impedes evidence-based policymaking. Our review provides a strong indication of the existence of these cross-sectoral links by summarising the impacts of different aspects. For instance, shifts in activity-travel behaviour among hybrid workers (e.g., commuting to office 2-3 days per week while working from home or local coworking spaces on other days) may reshape land use demands (e.g., decreased

demand for office space and increased demand for coworking spaces and local amenities within residential communities). These altered land use patterns can subsequently influence energy consumption patterns (changes across transportation, offices, residential buildings, and community-based commercial establishments) and social equity outcomes (e.g., accessibility of employment opportunities).

Most importantly, although single-sector findings are often clear and consistent (e.g., reduced commuting generally lowers transport volumes and associated transport emissions), evaluating the net cross-sectoral effect (e.g., combining transport, residential and non-residential buildings' energy use and emissions) is far more complex. This complexity stems from frequent trade-offs and even reversals of initial benefits due to rebound effects and mutual offsets. Academic studies tend to deepen one effect at a time, whereas policy must weigh all material effects together. Because cities function as highly complex systems, the gap between research focus and policy needs can be especially large. The current urban challenges we face such as congestion, climate change, and equitable development are rarely isolated, and involve multiple stakeholders whose priorities may compete. It suggests the need for a holistic and cross-sectoral perspective in both future research and policy making. Effective solutions require policies that consciously recognise the complex interdependencies, actively seek synergies (e.g., combining remote work policies, EV infrastructure, and building energy retrofits), and manage trade-offs to avoid unintended negative consequences where benefits in one sector are offset by losses in another.

(3) Accounting for cross-temporal and -spatial scale effects.

The interplay between shifting working patterns and urban systems unfolds across various temporal and spatial scales, yet current research often fails to capture this complexity. As found in Section 5, most studies focus on short-term effects. Only 12% of studies examine long-term impacts (more than five years), and rely heavily on simulation due to the lack of longitudinal data tracking the evolution of impacts over long-run adaptation cycles. These temporal limitations may lead to misleading conclusions. For instance, the initial reductions in commuting VMT and traffic congestion (Graizbord, 2015; Guerin, 2021; Pérez Pérez et al., 2004) may be partially or fully offset in the long term by residential relocation, suburbanisation, or increased non-commuting travel (Balbontin et al., 2024; Liu & Su, 2021). Although long-term tracking may be limited by data availability or has not been observed because changes in working patterns have occurred over a relatively short period of time, future research must recognise the need for evaluating long-term impacts to fill current gaps.

Spatially, impacts manifest differently across scales. Regional or city scale studies reveal structural shifts such as urban sprawl and real estate market changes (Delventhal et al., 2023; Ramani et al., 2024; Schmahmann et al., 2022), while local scales capture community-level reorganisation such as intensified local activities (Zenkteler et al., 2022), demand for amenities (Di Marino & Lapintie, 2020), and social effects (Mariotti et al., 2017). What needs to be noticed is that a single change in working patterns can simultaneously trigger impacts across scales. For example, the relocation of high-skilled remote workers influences regional housing markets while also potentially driving local gentrification. Despite this, current research largely examines impacts at single scale using disparate methods and data resolutions, making cross-scale comparisons difficult. Future work should therefore develop cross-scale analytical frameworks that integrate temporal and spatial dynamics,

enabling policymakers to anticipate lag effects and align short-term interventions with long-term development goals.

(4) Advancing data integration and innovative methodological applications.

Due to the complexity of urban systems, measuring urban impacts of new working patterns relies on multi-source data for more integrated insights. However, data silos remain a major challenge to our understanding of cross-sectoral interactions. For instance, assessing the net environmental impact of remote work requires integrating data on commuting reduction, induced non-work travel, residential relocation, changes in office and residential energy use, and potential shifts in logistics patterns. This may involve survey data, transport data, energy consumption records, land-use data, and socioeconomic indicators, etc. These data are often held by different entities and have incompatible spatial and temporal resolutions and formats. Existing models are typically powerful for identifying associations within sectors (e.g., transport models, energy models) or limited integration (typically integrated transport and land use), frequently lack the capacity to incorporate cross-sectoral feedback loops essential for capturing interactions of complex systems. Studies attempting integrated assessment suggest that isolated interventions (e.g., promoting remote work alone) are insufficient to achieve long-term sustainability goals such as deep decarbonisation. Greater long-term benefits emerge only when combined with complementary policies in other sectors (e.g., accelerating EV adoption, and enhancing building energy efficiency) (Zhang & Zhang, 2021).

To address these gaps, future research should prioritise data integration and innovative methodological applications. For example, semantic web technologies, which have the ability to facilitate the integration of heterogeneous data, enhance data interpretability, and enable logical inference (Donkers et al., 2022; Li et al., 2022; Pauwels et al., 2017), can be used to standardise and integrate diverse data types. Ontological frameworks could be developed to formalise the concepts and relationships within and across urban systems, supporting interoperability and cross-domain reasoning. Future research and policies will also benefit from the development and application of hybrid modeling approaches that can dynamically couple various models (e.g., behavioural models, land use and economic models, transport models, energy and emission models, social impact models). The ultimate goal is to build accessible decision-support systems that allow policymakers to evaluate the cross-sectoral, cross-scale, and long-term scenarios for sustainable urban adaptation under evolving working patterns.

7.2 Contributions and limitations of this review

This review provides an innovative and comprehensive perspective of emerging new working patterns and their impacts on cities. The key contributions are as following. First, moving beyond the prevalent, often narrow focus on remote work, this review establishes a dynamic and evolving concept for "new working patterns" by defining them as any work arrangement that differs from the mainstream working pattern within a given socio-historical context. This definition, on the one hand, more clearly captures the dynamic nature of working pattern changes and their impacts. On the other hand, this unified concept better reflects the common core characteristic shared by various new work patterns, namely altering where and when work occurs by providing varying degrees of spatiotemporal flexibility, thereby transforming human-environment interactions and simultaneously impacting different aspects of cities. Second, this review presents, to our knowledge,

the first comprehensive synthesis of the multi-dimensional urban impacts of new working patterns across the interconnected urban systems. It highlights the importance of holistic and cross-sectoral policy that recognise interdependencies and potential trade-offs, a perspective largely missing from prior research. Third, it advances the field by systematically analysing the temporal and spatial scales at which these impacts manifest and are studied, as well as the diverse data sources and analytical methods employed. These summaries and analyses provide the robust basis and strategies for researchers and policymakers grappling with the urban effects of changing working patterns. Fourth, the review identifies critical research gaps and proposes actionable future directions.

Despite these contributions, several limitations should be acknowledged. First, the inclusion criteria focused on impacts at the community/city/regional level and aggregate outcomes, excluding those at individual or household level (e.g., well-being, productivity, mental health). While these are important, they largely represent different areas of research, often psychological or management, and are beyond the focus of this review on urban systems. We also did not assess global-scale effects such as international talent mobility and the global redistribution of economic activity, energy use and emissions. Given the global nature of shifts in working patterns, these topics merit attention in future research. Second, this review focuses only on behavioural shifts and their impacts, without discussing the underlying psychological, social, or economic drivers influencing adoption of new working patterns or behavioural changes. Understanding these drivers is essential for predicting adoption rates and developing targeted interventions. Finally, the search was restricted to English-language articles from Scopus and Web of Science. Although the core international literature is covered, relevant studies published in other languages or gray literature sources may be missed.

8. Conclusion

Changes in working patterns are reshaping urban systems in profound and interconnected ways. This paper defines “new working patterns” and points out their dynamic and evolving nature in response to social, cultural and technological trends. We also summarises different types of new working patterns in terms of four dimensions: temporal change, spatial change, spatial & temporal change, and other relational or lifestyle-driven changes.

Through a systematic review of 213 articles, this paper provides a comprehensive overview of the direct impacts (activity-travel behavior, urban built environment) and secondary impacts (environmental impacts, social dynamics, economic performance, urban form) that may result from working pattern changes. Evidence from diverse contexts reveals that such shifts can generate both opportunities and challenges for cities: reduced commuting, lower congestion, and redistributed economic activities, alongside rebound effects, spatial inequalities, and cross-sector trade-offs. These findings reveal the complexity and interconnectedness of urban systems in response to working pattern changes and underscores the necessity for holistic and cross-sectoral policy integration.

This paper also examines the temporal and spatial scales at which these impacts are studied, as well as data types and analytical methods used for capturing the impacts. It identifies critical research gaps, such as the imbalance of research focus, the lack of understanding on cross-sectoral dynamics and long-term effects, and challenges of data silos and methodological limitations. These gaps may limit the ability of policymakers to develop integrated interventions that align with broader goals of

sustainability, equity, and resilience. Addressing these gaps requires an expanded geographic and thematic scope, improved integration of multi-source datasets, and methodological innovations that enable cross-scale, cross-sectoral, and longitudinal analyses.

We advocate holistic and dynamic perspectives and approaches to understand and navigate the urban effects of changing working patterns. The insights from this study provide a strategic knowledge base to inform future research and policies, enabling urban decision-making and management to coordinate both with the way people work and live, and with the different systems across the city.

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Beyond the Office: A Systematic Review of Changing Working Patterns and Their Urban Footprints

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