

Junk Maps: How Urban Mobility Apps (Re)Produce Digital Waste and Infrastructural Overload in Milan and Amsterdam

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Abstract

The article examines mobility app ecosystems in Milan and Amsterdam as digital infrastructures that organise practices of movement, waiting, and urban consumption, while producing specific forms of digital and material waste. Starting from a systematic mapping of mobility apps, the study focuses on applications that provide journey-planning solutions—such as Google Maps—and shows how forced choices, traffic concentration, technical malfunctions, delayed updates, service insufficiencies, and forms of passenger exclusivity contribute to making urban travel a more complex and uneven practice, while generating multiple forms of productive waste. Drawing on the walkthrough method, beginning from the app store search phase, the research compares interfaces, access logics, registration requirements, tracking systems, monetisation strategies, and communicative rhetorics. The analysis highlights how design choices produce different kinds of waste: digital waste, generated through data accumulation, advertising, and persistent notifications—often raising privacy concerns—and material waste, linked to physical infrastructures, urban congestion, and the intensive consumption of public space. Based on two years (2023–2025) of digital ethnography in the two cities, the study reveals that, despite the promise of service integration, institutional apps and private navigation platforms yield a fragmented user experience, accompanied by an increase in data extraction and a diffuse production of digital waste. In conclusion, it argues that mobility apps do not merely facilitate movement but actively reconfigure urban ecologies, participating in the production of urban space and, consequently, generating new forms of pollution, commercial opacity, and infrastructural overload.

Keywords

dark design; mobility; platform urbanism; political ecology

1. Introduction

Digital technologies have become constitutive of the mobility of people, goods, and information. As Schwanen (2019, p. 60) argues, everyday mobility—from walking to transit commuting—“is increasingly mediated by ubiquitous computing, software, digital interfaces, and environmental sensors as indicated by the proliferation of targeted smartphone apps.” Literature on platform urbanism (Barns, 2019) and digital geography (Ash et al., 2018) shows how platforms mediate physical movement through automation and the computational production of space (Leszczynski, 2015). Using qualitative methodologies, existing scholarship has investigated autonomous driving systems, smart mobility regimes, and e-cycling practices across diverse contexts (Behrendt, 2016; Brown & Laurier, 2017; Kent et al., 2017), highlighting their potential to exacerbate socio-spatial inequalities.

Yet it remains unclear how journey-planning apps (JPAs)—regularly framed as neutral instruments for urban optimisation and frictionless mobility-as-a-service (MaaS)—actively (re)produce infrastructural overload and digital waste in everyday life. Current scholarship risks overlooking the friction produced by platform mediation. In practice, the digital mediation of urban mobility is dictated by algorithmic governance (Lynch & Farrokhi, 2022) that alters both app functionality and the structural production of space—for instance, steering foot traffic toward monetised commercial corridors rather than efficient shortcuts (Leszczynski, 2015).

To address this gap, this article asks: How do JPAs in high-density European cities mediate daily spatial experiences, and through what digital and material mechanisms do they generate infrastructural overload and urban waste? Theoretically, this article is positioned at the intersection of urban political ecology and digital geography (Chiappini, 2020), operationalising urban mobility apps as active sites of metabolic transformation. Grounded in this framework, the article makes two primary contributions to the literature on platform urbanism, smart mobility, and digital geography: firstly, reconceptualising JPAs as metabolic infrastructures. It demonstrates that mobility apps are not passive tools for spatial navigation, but extractive platforms that generate digital waste—defined as the structural, non-functional residues (background data bloat, redundant notifications, unrevoked permissions, and “zombie” layers of outdated third-party service tiers) that impose attentional, energetic, and spatial costs. Secondly, it bridges digital mechanics and urban materiality by showing how extraction logics interface with clutter and dark design, which ultimately manifest as material congestion on city streets and in public transit gates.

Empirically, this study investigates these metabolic dynamics through a comparative case study of two high-density, highly digitised European transit environments: Milan and Amsterdam. Utilising a qualitative digital autoethnography and app-mapping methodology, the research tracks multi-app navigation routines (where trips routinely require three to five interconnected apps), conducting technical audits of background data tracking, dark pattern interface designs, consent flows, and their physical manifestations in transit spaces.

The remainder of this article is structured as follows. First, it presents a theoretical foundation in urban political ecology, establishing waste-making as an inherent outcome of spatial and platform production. Second, it conceptualises the relationship between physical mobility, digital mediation, and spatial consumption. Third, it outlines the app-mapping methodology and empirical case contexts in Milan and

Amsterdam, detailing the functional breakdown of JPAs. Fourth, the empirical findings are presented across five thematic sections, detailing how selected apps generate digital clutter, extractive data flows, interface dark design, service integration failures, and material spatial bottlenecks. Finally, the article concludes by discussing the theoretical implications for smart city governance, detailing study limitations, and offering avenues for future research.

2. Theoretical Framework

2.1. *Every Production Has Its Waste*

Urban political ecology emerged in the 1990s, refusing the distinction between the social and the natural. Scholars working in this tradition have understood cities as socio-ecological configurations—something actively produced through historically sedimented processes of accumulation, conflict, and institutional negotiation (Gandy, 2022).

Water networks, energy systems, transport corridors, green spaces, waste management devices—these are not neutral technical arrangements but material sedimentations of power, encoding social hierarchies into the urban fabric. As Lefebvre (1991, 2003) made clear, space is not a container but is produced through relations of power and exclusion. Every process of production is simultaneously a process of waste-making: Accumulation and disposal are two sides of the same metabolic cycle, and waste is not an accident of urban development but one of its constitutive by-products.

Infrastructures sit at the heart of this dynamic. The same networks that enable metabolic flows simultaneously channel their residues—effluents, emissions, discarded materials, exhausted energies—accumulating along existing social hierarchies, in communities with the least capacity to contest their presence (Harvey, 1996).

Infrastructures redesigned under the banner of sustainability tend to reproduce rather than resolve the contradictions of urban metabolism, displacing the geography of waste rather than dissolving it (Bahers & Rutherford, 2025). This is not simply a technical problem awaiting a technical fix. It is a political one—bound up with questions of who gets to decide how flows are organised, how new patterns of space consumption emerge, and which forms of waste are rendered visible within dominant urban imaginaries.

2.2. *Urban Mobility and Navigational Waste*

Transport infrastructures offer a particularly revealing vantage point from which to read these entanglements. Mobility systems make the inseparability of digital and material waste unusually legible, pulling together bodies, devices, platforms, and physical infrastructures into configurations that are at once fleeting and deeply sedimented. The new mobilities paradigm, as elaborated by Sheller and Urry (2006), equips us to follow these entanglements without reducing them to either their material or their digital dimension. Mobility systems are not simply physical networks overlaid with digital interfaces; they are sociotechnical formations in which the two are constitutively intertwined, each shaping the conditions under which the other operates and, eventually, deteriorates. The dockless model offers a clear example of this process: Designed to minimise infrastructure costs, it produces vehicles of relatively low quality—fragile, prone to damage, and difficult to maintain at scale (Nixon & Schwanen, 2019; Spinney & Lin, 2018)—and when the

market logic that sustains it collapses, the residues are physical and visible, as the bicycle graveyards that accumulated in Chinese cities between 2017 and 2019 made plain (Duran-Rodas et al., 2020).

Part of what makes this entanglement so difficult to grasp—and so easy to overlook—is a question of rhythm and speed. The rhythms of digital infrastructure operate at registers that are categorically different from those of human movement and perception. Digital systems do not simply support spatial practices but actively produce them, operating through logics that are largely inaccessible to the users whose movements they organise (Kitchin & Dodge, 2014). Greenfield (2017) pushes this further, arguing that the pace at which digital systems embed themselves in everyday life systematically outstrips the capacity for deliberate human response. The result is a structural asymmetry in which platforms act in the interval before the user has had time to think. This rhythmic disjuncture is particularly acute in the context of urban mobility. The conditions under which people typically engage with mobility apps—arriving in an unfamiliar city, running late, navigating a disruption to a planned route—are precisely the conditions that foreclose careful deliberation. And it is in these moments that the extractive architecture of mobility platforms operates most effectively, collecting permissions, harvesting data, and distributing residues at a pace and scale that the moving body has no practical means of tracking.

Yet, within this field, the question of waste remains curiously underexplored. Bissell's work on transit life (2018) attends with great care to the affective and atmospheric textures of everyday movement—to the vulnerabilities, rhythms, and minor socialities that infrastructures both enable and constrain. What it does not foreground, however, is the accumulation of digital residues that now accompanies these experiences as a matter of course. This gap becomes especially pronounced when attention turns to the navigational applications through which urban space is increasingly apprehended and traversed. Apps such as Google Maps, Citymapper, and the proprietary platforms embedded in ride-hailing and micro-mobility services have become, for many users, the primary interface through which they know and navigate the city. Design scholarship has shown how interfaces can be organised to work against the user's stated interest, through what Jensen (2018) terms dark design, and how freemium architectures convert basic functionality into a withheld good (Nieborg, 2016). We take these mechanisms as the point where the metabolic argument becomes empirically observable at the scale of the screen.

To summarise, the article contributes to platform studies and urban planning by reframing platform urbanism in terms of digital waste and metabolism; platforms actively produce urban friction, uneven spatial choices, and structural fragmentation. It builds on Stehlin et al. (2020) by showing how platforms function as a fragile “mobility fix” that externalises metabolic costs onto public infrastructure. Moreover, it expands the digital geography body of work by focusing on the “residual layers” of digital systems as waste. Ultimately, this article serves to challenge techno-optimist narratives of “frictionless” mobility-as-a-service (MaaS). It demonstrates empirically that multi-app requirements (three to five apps per journey) create a degraded, fragmented user experience.

3. Mapping Urban Mobility Apps

The selection of mobile applications was conducted through a multi-channel approach to simulate a standard user's app downloading in two cities. This included analysing pre-installed software ecosystems, organic peer-to-peer recommendations (word-of-mouth), and algorithmic search results via Google and

major digital marketplaces (Google Play Store and Apple App Store). The two authors lived in the same city. During the app store exploration phase, we identified significant instances of “digital waste”: search results dominated by “suggested” or “sponsored” applications that failed to align with the specific functional requirements of the query, but were market-visible.

Within the varied panorama of mobility apps, we have selected only apps that provide journey-planning solutions, namely apps which allow navigation from point A to point B on the map. In the JPA, we have included both apps with integrated GPS navigation (e.g., Google Maps, Uber, etc.) and those without (e.g., ATM, which stands for Azienda dei Trasporti Milanesi; GVB stands for Gemeentevervoerbedrijf, etc.). Ride-sharing platforms that include any form of navigation only after purchasing the service remain outside the selection for the sample, since they do not allow users to plan a journey but only offer a map or route once the ride has started.

Selected JPAs are not representative of the entire mobility app population but were chosen on the basis of their relevance in the two observed cities, the effective time spent using each app during the fieldwork, and the salience of the apps as a result of the app store search. In order to map the archipelago of JPAs we have selected, we can organise the apps as per Table 1.

Table 1. Overview of urban mobility apps and typologies.

App	Category	Description
1 Moovit	Private Journey Planning	Third-party aggregators that provide real-time transit data and routing.
2 9292		
3 Transit		
4 Citymapper		
5 City Transport Map Amsterdam		
6 Public Transport Map Milan		
7 ATM	Institutional Journey Planning	Official interfaces managed by public transit authorities.
8 GVB		
9 LimoLane	Taxi Service Apps	On-demand vehicular services with specific routing features.
10 Travel Electric		
11 Allround Mobility Service	Hybrid Platforms	Hybrid platforms integrating multiple transit modes and hailing services.
12 Uber		
13 Maps (Apple)	Navigational Apps	General-purpose geospatial platforms with turn-by-turn guidance.
14 Google Maps		

4. Methodology

By adopting the walkthrough method (Light et al., 2018), this research does not include an analysis of interfaces and specific affordances (i.e., screenshots of apps and functions or affordances are not included) but make visible their impact on the urban production in terms of digital waste and infrastructural overload. Moreover, digital ethnography was deployed (Caliandro, 2018) to capture the moments of friction, waste, and overload where the user’s lived experience diverges from the algorithm’s commercial logic and mere

affordances of the app. Both methods respond directly to the aim of the article. While the walkthrough makes visible the logics inscribed in the apps (registration, permissions, monetisation, notifications), digital ethnography captures how those logics are lived and accumulate over time. Following this approach, digital waste emerges precisely at the intersection between design and everyday use.

4.1. Fieldwork and Notes

The methodological framework for this study is grounded in a non-continuative but consistent approach in terms of reporting and tracking of a two-year digital auto-ethnography (2023–2025, see Supplementary File), during which the authors engaged in auto-ethnographic sessions during the deployment of the selected apps (see Table 1).

Each app was traversed following a similar sequence: store search and download; registration, consent, and permission; journey planning across recurring and casual routes; monetisation of ticketing and travel services; notification behaviour in the following weeks; and, where the app was not retained for personal use, uninstallation and data deletion. Walkthroughs were repeated over the observation period.

The auto-ethnographic component is grounded in everyday use of the apps over the 24-month period: Author I (Amsterdam) logged approximately 480 annual hours of app-mediated commuting across the GVB network and regional Sprinter trains, and author II (Milan) approximately 520, mainly through the ATM network; a further 150–200 hours per year each were devoted to leisure navigation, mostly via Uber. Fieldnotes were taken during and immediately after these journeys on paper notebooks and smartphones, and exchanged through shared drives. Each entry logged date, city, app, mode, and route, followed by a thick description of the friction encountered.

Each author coded their own corpus openly; the two sets were then compared and collapsed into types of waste and categories structuring the results. Comparison operated at the level of the single function performed in both cities, not between the two as wholes. Interpretations were validated by mutual re-coding, by cross-checking notes against walkthrough material, and by returning to the app where readings diverged.

4.2. Two Mobility Contexts: Milan and Amsterdam

Milan and Amsterdam were selected because their transport systems are, at once, historically parallel and culturally divergent. Both are European global cities that merged economic growth with global competition (Chiappini, 2020), running their transit through municipally owned but corporatised operators—ATM in Milan, GVB in Amsterdam—reshaped by the late-20th-century liberalisation of European public transport toward market-driven logics (Veeneman & van de Velde, 2014). Yet their mobility cultures diverge in parallel—cycling is Amsterdam's structuring mode, while in Milan an automobile legacy coexists with a transit system heavily invested with civic meaning. Across both, the local state acts not merely as regulator but as active promoter of platform-mediated mobility (Chiappini, 2020)—and it is this ambiguous institutional role that private JPAs exploit, extending and amplifying the externalising, referral-based logic that already fragments institutional provision (Barns, 2019; Kitchin & Dodge, 2014).

5. Results

5.1. A Systematic Waste-Production

Apps do not simply organise movement—they produce residue. This is not incidental to their operation but structural, inscribed in the very logics through which access to the service is granted and maintained. To open a JPA for the first time is already to enter a process of data accumulation that extends well beyond the immediate transaction of finding a route.

Registration is the first point of extraction. Consent screens recorded during the walkthrough declared 344 commercial partners for Citymapper, 297 for 9292, 220 for Moovit, and 47 for Uber. These figures, drawn from the consent screens that applications are legally required to display, give some measure of the scale of redistribution that accompanies registrations, though few users pause long enough to read them. As Table 2 below elucidates.

Table 2. Dot matrix of wastes. Practices in rows, apps in columns (numbered as per Table 1): ● = present; ○ = absent.

Practice \ App	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Uneven practices														
Passenger exclusivity	●	○	○	●	●	●	●	○	●	●	●	●	○	●
Service insufficiency	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Delayed updates	●	●	○	●	●	●	●	●	○	○	○	○	●	●
Technical malfunctioning	○	●	○	○	○	○	●	●	○	○	○	○	○	○
Forced choices	○	○	○	●	○	○	○	○	○	○	○	○	○	○
Wrong info	○	○	○	○	○	○	○	○	○	○	○	○	●	●
Digital waste														
Accumulation	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Notification	●	●	●	●	○	○	●	●	●	●	●	●	●	●
Data extraction	○	●	●	●	○	○	●	●	●	●	●	●	●	●
Advertising	●	○	○	●	○	○	○	○	○	○	○	●	○	●
Material waste														
Time	●	○	○	○	●	●	○	○	○	○	○	○	○	○
Urban congestion	●	○	●	●	○	○	●	○	●	●	●	●	●	●
CO2	○	○	○	○	○	○	○	○	●	○	●	○	○	○
Consumption of space	○	○	●	●	○	○	○	○	○	○	○	●	○	●

Some applications sidestep account creation altogether by allowing users to authenticate through Google or Apple ID. This appears, on the surface, to reduce accumulation. In practice, it concentrates it, linking the user's mobility data to profiles that are already aggregated across dozens of services:

I opened my Google account settings for the first time in months. The list of connected apps was longer than I expected—services I had used once, forgotten, and never disconnected. Citymapper was still there, active, with access to my location history. I revoked it. I wondered how long it had

been running in the background, and what it had collected in the meantime. (Author II, Milan, 10 October 2023)

These are data that do not simply vanish when a journey ends. They settle, and the infrastructure that holds them is not immaterial: The server farms that host these data occupy physical space distributed across the planet, drawing energy on a scale that makes the metaphor of the cloud deeply misleading (Google, 2023).

Beyond registration, applications conduct a further layer of activity that remains largely invisible to the ordinary user. Through external subdomains—ancillary addresses that applications contact autonomously, without explicit user action—content is hosted, images are served, and documents are stored. Ubers' own technical documentation describes how its subdomain `tb-static.uber.com` operates precisely as a hosting service for materials that the application accesses but does not store locally on the device (Uber, 2022). The arrangement is efficient from a technical standpoint; from the user's perspective, it is simply opaque.

Apps themselves accumulate. The journey-planning market has generated a proliferation of apps offering variants of the same service, many of them fragmentary, poorly maintained, and evidently not designed to meet a genuine user need. Two cases encountered during the research—Public Transport Map Milan and City Transport Map Amsterdam, both traceable to a single provider named Sklr, which operates dozens of near-identical apps across different cities—are instructive here. Both offer severely limited functionality: Neither handles journey planning across more than a single transit line, and neither even provides alternative routing when a transfer is required. Both advertise a paid version that promises to unlock unspecified restrictions. Neither appears to have attracted a meaningful user base—the Milan version carries no reviews at all; the Amsterdam version has a single, unfavourable one. These are not applications that emerged from a gap in the market. They are, in a fairly literal sense, junk maps—digital residue deposited by a market logic that rewards presence over function, accumulation over utility (Greenfield, 2017).

All the applications analysed—with the exception of the two near-inert Sklr products—request permission to send notifications on first opening, typically bundled with privacy terms in a single sequence, which we read as designed to be accepted quickly rather than read carefully. Some notifications are genuinely functional: a prompt that a train is departing (Transit), an alert that a driver is approaching (Uber). Others are promotional—discount offers, newsletter subscriptions (ATM), advertising (Moovit)—and accumulate in the notification centre in ways that we experienced less as useful information than as noise to be periodically cleared. The two modes are difficult to disentangle, which is precisely the point. To receive the service, the user must accept the clutter; to remove the clutter, the user must invest time in navigating settings that are rarely surfaced prominently and that most users, downloading an app in the urgency of an unfamiliar city, will not pause to configure. This dynamic was encountered directly during the fieldwork:

Late arrival at Amsterdam Schiphol. I opened Uber—hadn't used it in a while. Suddenly, a wall of permissions, notifications, and updated terms. I just tapped through all of it. I needed a ride. Today is the day after, and I only went back now to check what I had agreed to. It was more than I had realised. (Author I, Amsterdam, 7 March 2023)

What emerges from this account is not a series of discrete problems but a single structural condition. The digital infrastructure of urban mobility apps channels flows of data and attention in ways that

consistently benefit the service provider and impose energetic, attentional, and political costs on the user. These costs are not hidden exactly; consent screens display partner lists, notification preferences are technically adjustable, and privacy settings are nominally accessible. However, the architecture of these systems is designed to leverage precisely the inertia that urban movement produces (Kitchin & Dodge, 2014; Lefebvre, 2013): the distraction of arrival, the urgency of the unfamiliar, the friction of having to chase one's own data across a network whose full extent no single user can easily see.

5.2. Digital Delusion

How many apps does it take to complete a journey? One to plan the route, another to pay for the ticket, a third to navigate, and a fourth for real-time alerts. And yet each of these applications presents itself in the app store as a comprehensive solution. This is perhaps the most pervasive form of digital delusion encountered during the fieldwork: the promise of integration, systematically undelivered (Sheller & Urry, 2006).

From the earliest days of fieldwork, it became clear that every application used during the research period was, in some respect, disappointing. The disappointments took two forms: the betrayal of explicit promises, and the absence of features so basic that their omission means a failure of the service's own stated purpose. An exemplification of digital delusion can be traced in the following vignette:

It is an early grey morning in April in Amsterdam. The weather forecast indicates showers for the next few hours. I cannot take the bike. I have to cross the entire city to go to a seminar. Let me check on Google Maps how long it takes with public transport. How can it be? Forty-eight minutes by public transport and 15 minutes by bike? Or maybe 9292 is more reliable. Also, GVB might be useful since I will take a bus and a metro... I feel already stressed by the screen time to check the best route, and all these tabs open on my phone. (Author I, Amsterdam, 21 April 2025)

The first form was most visibly at work in the handling of shared mobility. Moovit, Transit, Citymapper, ATM, GVB, 9292, Google Maps, and Uber all allow users to incorporate bike or scooter hire into their journey planning, displaying available vehicles on the map with estimated prices and battery levels. But only Uber allows users to book and pay without leaving the app. Every other platform redirects the user to the provider's own app—Lime, Dott, Bird—which typically offers GPS navigation only after the service is purchased, and so is not useful for planning trips in advance, nor can users select their destination directly from the map, making it more convenient for users to return to the original app, or to a third one, to complete the journey. We read the redirect, following Kitchin and Dodge (2014), not as a technical glitch but as a designed spatial organisation of the user's movement through platforms: less a mobility solution than a chain of referrals, each app advertising a service it does not itself deliver. ATM opens an exceptional scenario:

You see them everywhere in Milan—the yellow BikeMi bikes, locked in rows at the docking stations. One afternoon, walking past a station near my place, I thought: Why not try? I opened ATM first—it seemed the obvious starting point. It told me to download the BikeMi app. I downloaded the app. It asked for a public transport subscription. I did not have one. It turned out I also needed a separate annual BikeMi membership, and to set that up, I had to navigate between two apps and a website. By the time I understood what was required, the impulse had passed. I took the metro. (Author I, Milan, 15 June 2025)

Unlike the private platforms, ATM redirects within its own institutional ecosystem, but still externalised, friction-heavy, and in practice accessible only to those already embedded in it. Both ATM and GVB redirect users to external—though official—websites for accessibility details and service updates, breaking the in-app experience at precisely the moments when continuity matters most. Ticket purchasing follows the same logic: Payment is processed through external services—WorldLine, PayPal, Satispay, Buckaroo, Tranzer—whose data-sharing implications are different from those of the app. Among private JPAs, the situation is in some ways worse: Moovit is the only app which allows you to buy a ticket in the app (after sharing email, telephone number, name, and surname); Citymapper and Uber display public transport fares, and none link directly to ticket purchase. We read this omission as disadvantaging the most affordable modal choice by rendering public transport comparatively invisible within the planning interface. Real-time crowding information—one of the most practically useful features a JPA could offer—is available through Google Maps, the Dutch institutional apps, and Transit, but is absent from every other private platform and from ATM entirely.

The sharpest paradox of the journey-planning ecosystem is that the applications which most consistently deliver on their promises are not multi-modal planners but taxi service apps: platforms whose function is simply to connect the user with a private hire vehicle. Limo Lane and Travel Electric in Amsterdam are clear examples. Their promise is narrow, and they keep it. But this reliability comes at a cost that is rarely acknowledged: Private hire is expensive, carbon-intensive, and inaccessible to those who cannot afford it.

Some platforms complicate even this. The walkthrough recorded how Allround Mobility Service in Amsterdam requires a phone call to complete a booking—a requirement we read as exclusionary for anyone unable to complete a voice transaction.

The conditions of urban movement—urgency, disorientation, the narrow window between deciding to travel and needing to depart—are not compatible with the deliberative pace that genuine service complexity demands. A journey requiring three to five applications, each with its own registration logic, notification permissions, and payment infrastructure, imposes a burden that accumulates invisibly across the experience of moving through the city. The technological advancement on offer turns out to be something closer to its opposite: a proliferation of partial services that replicate, in a more fragmented and data-extractive form, what a ticket office and a paper map once accomplished in a single transaction.

5.3. *Freemium Injustice*

Every application encountered in this research was free to download. This was not a methodological choice—no paid JPAs emerged from the fieldwork in either Milan or Amsterdam. And yet free, in this context, is a designation that requires some unpacking. The costs are real; they are simply displaced, distributed across revenue logics that are rarely visible at the moment of download.

Those logics take broadly three forms. The first, already examined in the preceding section, is data acquisition: the harvesting of personal information and usage patterns—including search queries entered into the app—which are stored and shared with commercial partners (Lee, 2010). The second is pay-per-use, where the app functions as an interface through which a discrete service is purchased: a transit ticket, a vehicle hire. Here, the commercial relationship is at least legible, even if its internal distribution—how much of a fare reaches

the driver, how much the platform—remains opaque. The third, and in many ways the most consequential for the argument developed here, is the freemium model (Nieborg, 2016): applications that are free in their basic form but withhold functionality behind a subscription or one-off payment.

The freemium model operates through two distinct strategies, both of which reproduce, at the level of the interface, the inequalities that already structure urban mobility more broadly. The first is the introduction of premium service tiers within taxi and ride-hailing platforms. Uber, Limo Lane, and comparable services offer a baseline option alongside more expensive alternatives—larger or more luxurious vehicles, additional passenger or luggage capacity, and reduced waiting time and unforeseen issues. The logic is familiar from other platform markets: The basic service is available to everyone, but comfort, reliability, and convenience are priced separately. The second strategy is more directly exclusionary. Apps such as Moovit, Transit, Citymapper, and the two Sklr products encountered earlier offer a degraded experience to non-paying users—interrupted by advertising pop-ups or stripped of essential features:

This morning, before setting off to the sociology department, I decided to finally try Moovit—people had been recommending it for months. I was not in a hurry, so I took the time to read through the permissions and agreements it asked me to accept before anything else. Then I entered my location and destination. Before the results loaded, a full-screen ad appeared. I closed it. I tapped the route again. Another ad. I closed it. I switched to another tab to explore the app. Another ad. I was genuinely frustrated—I kept thinking what this would be like in the middle of traffic, trying to navigate a city while closing advertisements between every tap. (Author II, Milan, 19 September 2024)

In Moovit, the premium subscription removes advertising and unlocks real-time vehicle tracking along transit lines—a function so essential that its absence from the free version is less a commercial decision than a structural penalty imposed on users unwilling or unable to pay. Transit similarly restricts the number of journey combinations available to free users and limits profile personalisation. What is sold as an upgrade is, in practice, the restoration of a service that was artificially degraded to begin with.

The consequences of this architecture extend beyond individual inconvenience. By conditioning access to functional journey planning on the ability to pay, freemium mobility apps reproduce and reinforce the spatial injustices already embedded in urban transport systems (Harvey, 1996). Those with the means to subscribe receive a more complete picture of the city's mobility options; those without receive a noisier, more restricted, and less reliable one. The paywall, in this sense, is not incidental to the service but constitutive of it—a form of dark design (Jensen, 2018) in which exclusion is not accidental but a structural feature, built into the revenue model. The promise of the free app, like the promise of the integrated service examined in the previous section, turns out on closer inspection to be organised around the needs of a particular kind of user: one with a high income, a current device, and enough time and digital literacy to navigate the gap between what the app offers and what it withholds.

5.4. Scrap Congestion

The consequences of JPAs in urban space are not limited to the energy costs of data accumulation. Digital infrastructures translate data flows into physical movement, channelling unsustainable vehicles and passenger flows into fragile urban environments.

Cars are sticky objects (Morton, 2013): Once embedded in the practices of the metropolis, they redefine those practices and redefine space itself, creating infrastructural dependencies that are extraordinarily difficult to undo. The analysis of JPAs conducted here makes clear that urban mobility platforms are themselves shaped by the sedimentation of this power relation. For over a century, the car has been positioned as the primary mode of urban transport, and the principal instrument in the production of urban space (Urry, 2004). This hierarchy is reproduced at the interface level: Google Maps and Apple Maps present private car navigation as the primary journey option; escaping from it requires repeated, deliberate effort, as one of the researchers noted during the Milan fieldwork.

Where the default is not the private car, it tends to be a car-adjacent service. Moovit and Citymapper consistently present ride-hailing as the primary solution for reaching any destination, effectively advertising Uber and comparable platforms within the journey-planning interface. The effect, aggregated across millions of daily queries, is a thickening of urban traffic. Ride-hailing services do not reduce congestion; they add vehicles to roads while minimising private car parking, producing a net increase in circulation rather than a redistribution of it (Erhardt et al., 2019).

A further dimension arises at the intersection of digital ticketing and physical infrastructure. Mobility practices unfold partly online and partly on-site, and when these two registers fail to communicate, the friction is felt physically. The ATM app allows users to purchase tickets in-app via QR code, but we observed that readers at metro gates frequently fail to scan them, creating queues at turnstiles during peak hours that the app cannot detect or address. A regular commuter described the experience to Author II:

The QR reader at the metro just doesn't work well. My colleague got stuck at Montenapoleone once—no operator, the reader wouldn't scan, and a queue of people behind her during rush hour. You've paid, you've done everything right, and you're still blocking everyone. So now I just print the ticket. Which is not exactly the paperless solution they were selling. (Commuter, Milan, 30 January 2023)

Two forms of material waste follow directly: the spatial congestion produced at the gates by the interface failure, and the commuter's return to printed tickets.

A third form of material residues is produced by the dockless sharing systems that many of these platforms promote and integrate. Scooters and bikes available through apps such as Lime, Dott (Milan), and Donkey Republic (Amsterdam) accumulate in the urban fabric in ways that their digital interfaces do not reflect. Damaged or non-functional vehicles are frequently abandoned around the city, particularly where reporting mechanisms are indirect: In Milan, for instance, Lime bikes booked through Uber cannot be reported as faulty from within the Uber interface, creating a gap between use and accountability that leaves broken vehicles scattered across the city.

In our research, more routinely, the dockless model is visible in Milan, which produces a spatial logic of concentration rather than distribution. Amsterdam has stricter regulations for bikes and scooters. In Milan, we observed that shared vehicles cluster around metro stations and major transit nodes—the points of highest demand—creating disorderly accumulations on pavements and cycle paths that obstruct pedestrian movement and generate their own forms of urban friction. This dynamic is shaped, to some extent, by the mobility culture of a given city. Amsterdam, with its dense network of cycle parking, absorbs some of this

pressure more effectively than Milan. However, the underlying problem persists: Once parked, the shared vehicle ceases to be the user's responsibility and becomes the city's problem—an object abandoned in public space, a scrap of the platform economy left for urban infrastructure to absorb. Transient populations, including tourists, further exacerbate spatial bottlenecking at key transit nodes due to app-guided routing practices. They use public space, with their long queues, to consume any last trendy products that Google or other platforms suggest:

Not again! The alley Heisteeg—in the core of the city centre of Amsterdam—is notoriously busy for a famous Dutch cookie shop. Google Maps attempted to force my trajectory through this narrow artery, which has been effectively privatised by the permanent hype queue. This is not smart optimisation! I changed route immediately, opting for a longer walk to bypass the congestion created by an app that no longer understands the concept of a shortcut, only the concept of consumption. (Author I, Amsterdam, 6 June 2023)

5.5. Waste-Washing

Alongside the forms of waste examined in the preceding sections, the JPAs analysed in this research deploy a further operation: the active reframing of their environmental costs as environmental contributions. Sustainability, in this context, functions as a rhetorical register that obscures the extractive logics underlying platform mobility while redistributing responsibility for ecological harm onto the individual user (Lynch & Farrokhi, 2022; Schwanen, 2019).

The gestures through which this reframing operates are varied but consistent in their direction. Moovit invites users to surrender their carbon credits to the platform. The mechanism works as follows: Moovit tracks user journeys and, where public transport, cycling, or scootering is chosen over the private car, calculates the CO₂ emissions avoided relative to an equivalent car trip. Moovit states that these savings are aggregated, annually audited, and converted into carbon credits (Moovit, 2025). Those credits are then sold to companies seeking to offset their own emissions, funding decarbonising projects (Moovit, 2025).

Citymapper and Uber display statistics on CO₂ saved, folding environmental accounting into the metrics of personal optimisation. One of the researchers encountered this panel during a routine fieldwork session and recorded the following:

One day, while browsing my personal profile on Uber, I noticed a section called “Estimated CO₂ Saved.” Below it, it listed how many eco-friendly trips I had made—electric cars, e-bikes, e-scooters—and then told me what my positive impact had been, comparing it to fuel savings, recycled waste, and square metres of CO₂ absorbed by forests. My immediate impression was that using Uber had somehow become an environmental duty—that I was saving the planet by opening the app. But then I paused. Saved compared to what, exactly? Compared to not moving at all? Compared to a combustion-engine car I don't own? Compared to cycling, which I do anyway? There was no baseline, no point of comparison, to make the figure meaningful. And I kept returning to the same question: Why is Uber making me feel responsible for the sustainability of my journeys, rather than accounting for the sustainability of the system it operates? (Author I, Amsterdam, 10 October 2024)

The question connects to a broader pattern that Gandy (2014, 2022) has identified in the relationship between urban infrastructure and environmental discourse: the tendency to present sustainability as compatible with—even produced by—existing extractive models, rather than in tension with them. What this research has documented across the preceding sections is precisely the opposite: a structural and functional production of waste that operates at every level of the platform—from data accumulation and notification overflow to material congestion and the abandonment of damaged vehicles in public space. The sustainability metrics displayed within these applications do not account for any of this. In the context of platform mobility, the greenwashing operation is particularly effective because it is personalised. The CO₂ panel does not ask the user to reflect on the energy costs of data centres, the labour conditions of gig-economy drivers, the material lifecycle of e-scooters, or the congestion effects examined in the previous section. It asks them to feel good about the trips they have already taken. Ecological harm is not denied; it is displaced—reattributed to a set of individual choices for which the platform claims partial credit, while the systemic conditions that make those choices necessary remain entirely outside the frame.

This is, in the most precise sense, depoliticisation. The conflict between platform capitalism and urban sustainability is resolved in advance, at the level of the interface, by rendering it a matter of personal carbon accounting. The app does not produce waste; it saves CO₂. The user is not subject to an extractive system; they are an eco-friendly traveller. What Gandy (2022) describes as the political stakes of urban metabolic organisation are quietly absorbed into the design language of individual empowerment, leaving the underlying contradictions not resolved but invisible (Barns, 2019; Lynch & Farrokhi, 2022).

6. Conclusive Remarks: Junk Maps—From “Smart” Optimisation to “Waste” Metabolism

The JPAs analysed in this research were not presented as tools for producing waste. They were offered, rather, as solutions to a practical problem: how to move through a city efficiently, with minimal friction and maximum information. What this article has documented is how the systematic gap between that promise and its material consequences is reproduced by design.

Junk maps, as a concept, means acknowledging that digital systems are as environmentally and spatially consequential as physical waste management systems. Drawing on urban political ecology and digital geography, this article has treated the app not as a neutral interface but as an infrastructure, a metabolic site, one in which inputs (i.e., user movement, public infrastructure, personal data) inevitably produce outputs of pollution that extend well beyond the journey itself. These outputs include data bloat, algorithmic residue, notification noise, physical congestion, abandoned vehicles, and queues at metro gates.

The service fragmentation—that requires three to five apps to complete a single journey—is the product of a platform economy in which each actor captures value from the user's movement without taking responsibility for the system as a whole. Monetisation operates through the same logic: Waste in the form of advertising interruptions, degraded functionality, and restricted information is not incidental to the revenue model but constitutive of it. Material waste, meanwhile, is generated by the failure of apps to register urban reality, and delayed updates and technical malfunctions produce physical queues, disorientation, and a congestion that no interface acknowledges.

What this research has insisted upon throughout is the invisibility of these processes to the user navigating the street. From data extraction to carbon credits sold to corporations without the commuter's knowledge, these are metabolic residues that accumulate precisely because JPAs are designed to keep them out of view.

A limitation of this article should be acknowledged. The analysis does not evaluate which app performs better, nor does it rank platforms by degree of harm. It aims to read critically the metabolic processes to which all these apps, both institutional and private, subject the city, and to make visible the forms of waste that users are systematically not positioned to see. The question of which platform is preferable or valuable is, in this sense, secondary to the prior question of what kind of system is being reproduced each time any of them is opened.

The industrial metabolism of 20th-century cities produced smog and toxic runoff that accumulated in the most vulnerable urban environments. The waste metabolism of the 21st century is producing its own residues—unevenly distributed, largely invisible, and systematically externalised onto users, cities, and the public infrastructures that platform capital depends on but does not maintain.

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Data Availability

Data available on request.

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