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Monetizing Smart ADT Systems: A Digital Business Model for Traffic-as-a-Service (TaaS)

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ABSTRACT

Traffic congestion remains a persistent problem in mid-sized Indonesian cities, including Kediri, where several key intersections experience recurrent bottlenecks. Average Daily Traffic (ADT) monitoring has traditionally relied on manual counts, which are prone to inaccuracies and lack sustainability. This study examines the integration of Smart ADT systems with Internet of Things (IoT) sensors, edge computing, and cloud-based analytics to develop a Traffic-as-a-Service (TaaS) model for Kediri. Using a traffic-survey model derived from municipal planning discussions, this research highlights the technical and business feasibility of TaaS. Findings from the Kediri pilot indicate recurring congestion during peak commuting hours, with IoT-enabled monitoring providing real-time data to support predictive traffic management. Monetization opportunities include government subscriptions, shared-use platforms for multi-agency data, and integration with logistics and mobility services. The study underlines that sustainable financing and robust data governance are prerequisites for scaling TaaS in Indonesian secondary cities.

Keywords: data monetization; IoT; Kediri; smart city; traffic-as-a-service; traffic survey model

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ABSTRAK

Kemacetan lalu lintas tetap menjadi masalah yang persisten di kota-kota menengah di Indonesia, termasuk Kediri, yang beberapa persimpangan utamanya mengalami kemacetan berulang. Pemantauan Lalu Lintas Harian Rata-Rata (ADT) secara tradisional bergantung pada penghitungan manual yang kurang akurat dan berkelanjutan. Studi ini mengeksplorasi penerapan sistem ADT cerdas yang terintegrasi dengan sensor Internet of Things (IoT), komputasi tepi, dan analitik berbasis awan untuk mengembangkan model Traffic-as-a-Service (TaaS) di Kediri. Menggunakan desain model survei lalu lintas yang dihasilkan dari diskusi perencanaan kota, penelitian ini menyoroti kelayakan teknis dan bisnis dari TaaS. Temuan dari uji coba di Kediri menunjukkan pola kemacetan berulang selama jam sibuk. Pemantauan berbasis IoT menyediakan data real-time yang dapat mendukung manajemen lalu lintas prediktif. Peluang monetisasi meliputi langganan pemerintah, platform berbagi data antar-lembaga, serta integrasi dengan layanan logistik dan mobilitas. Studi ini menekankan bahwa pembiayaan berkelanjutan dan tata kelola data yang kuat merupakan prasyarat untuk skala TaaS di kota-kota sekunder Indonesia.

Keywords: *traffic-as-a-service; kota pintar; IoT; Kediri; monetisasi data; model survei lalu lintas*

INTRODUCTION

Rapid urbanization in Indonesia has intensified traffic congestion, particularly in secondary cities such as Kediri, where road infrastructure development often lags behind population growth and increasing vehicle ownership. Several major intersections in Kediri experience recurrent congestion during peak commuting and school hours, resulting in travel delays, fuel inefficiency, and higher emissions. Effective congestion management in such contexts requires reliable and continuous traffic data as an empirical basis for planning, control, and evaluation. However, many local governments still rely on conventional traffic surveys that are limited in frequency, accuracy, and long-term sustainability.

Average Daily Traffic (ADT) data constitute a fundamental input for traffic engineering and urban transport planning. These data are used to assess road performance, identify congestion-prone locations, evaluate the level of service, and support decisions on traffic management, infrastructure investment, and policy formulation. For public agencies, continuous ADT data enable evidence-based interventions such as signal timing optimization, congestion mitigation strategies, and monitoring of environmental impacts. Moreover, ADT data are essential for academic research, feasibility studies, and inter-agency coordination, particularly in cities where traffic problems are localized but recurrent. Previous studies on smart mobility in Indonesian secondary cities indicate that traffic-related challenges differ significantly from those in metropolitan areas. Wahyudi and Hidayat highlight that cities outside major urban centers face constraints related to limited budgets, fragmented institutional coordination, and uneven technological readiness, despite experiencing recurring congestion at specific locations [1]. Similarly, Kurniawan and Prasetyo identify regulatory uncertainty, capacity gaps within local governments, and weak integration between technology providers and public agencies as persistent barriers to the implementation of smart mobility in Indonesian cities [2]. These findings suggest that technological solutions alone are insufficient unless they are aligned with local governance capacity and sustainable operational models.

Despite their importance, ADT data collection in many Indonesian cities remains dominated by manual counting methods. Such approaches are labor-intensive, episodic, and prone to human error, making them unsuitable for capturing dynamic traffic patterns. Recent advances in Smart Average Daily Traffic (ADT) systems, integrating Internet of Things (IoT) sensors, artificial intelligence (AI), and edge computing, provide opportunities for real-time traffic monitoring, predictive analytics, and adaptive traffic management [3], [4], [5]. Empirical studies demonstrate that IoT-driven Intelligent Transportation Systems (ITS) can improve traffic efficiency, reduce delays, and mitigate environmental impacts [6]. Nevertheless, the deployment of these technologies often encounters non-technical barriers related to governance, data ownership, and financing.

Governance and funding challenges have been widely identified as critical obstacles to the long-term Sustainability of smart city initiatives. The Organization for Economic Co-operation and Development (OECD) highlights that unclear data governance arrangements and fragmented institutional responsibilities frequently undermine the continuity of digital urban services [7]. In Indonesia, Public–Private Partnership (PPP) schemes have been promoted to address fiscal constraints and distribute risks between public authorities and private actors [8], [9], [10]. While such arrangements have shown promise in large metropolitan projects and the development of Indonesia's new capital city [11], their applicability and effectiveness in secondary cities remain underexplored.

Within this context, Traffic-as-a-Service (TaaS) offers a conceptual shift in how traffic management systems are designed and financed. Rather than treating smart traffic infrastructure as a one-time capital investment, TaaS frames traffic monitoring and analytics as a continuous digital service delivered through subscription-based or performance-linked models. This approach aligns technological innovation with sustainable financing, enabling municipalities to access real-time traffic intelligence without bearing high upfront investment costs. For cities such as Kediri, where fiscal capacity is limited and congestion is concentrated in specific locations, TaaS offers a potentially viable pathway to sustain Smart ADT systems while maintaining public accountability.

Based on these considerations, the problem addressed in this study is the lack of sustainable, accurate, and institutionally viable traffic data systems in Indonesian secondary cities. This research aims to examine the technical and business feasibility of implementing Smart ADT systems combined with a Traffic-as-a-Service (TaaS) model in Kediri. The study contributes by (i)

demonstrating how IoT-based traffic surveys can generate actionable ADT data to support congestion management, (ii) proposing a service-oriented monetization framework suitable for secondary cities, and (iii) highlighting governance and financing implications for scaling Smart ADT solutions in the Indonesian urban context.

Smart ADT and IoT-Enabled Traffic Survey Systems

Traffic data collection has traditionally relied on manual traffic counts, which remain widely used in many developing countries, including Indonesia. While manual surveys provide basic traffic volume data, they are episodic, resource-intensive, and unable to capture temporal variations in traffic flow. As urban traffic becomes increasingly dynamic, such limitations reduce the effectiveness of traffic management and long-term planning. Consequently, recent studies have shifted toward Smart Average Daily Traffic (ADT) systems that integrate Internet of Things (IoT) sensors, computer vision, and edge computing to enable continuous and real-time traffic monitoring [3], [5].

IoT-enabled traffic systems allow automatic vehicle detection, classification, and flow measurement with higher accuracy and temporal resolution than conventional methods. Empirical evidence shows that Intelligent Transportation Systems (ITS) leveraging IoT technologies can reduce travel time, improve intersection performance, and lower emissions through adaptive control and predictive analytics [6], [12]. Advances in computer vision have further enhanced Smart ADT capabilities by enabling vehicle classification based on size and type, which is essential for performance evaluation and capacity analysis [13]. Bosch IoT Lab also emphasizes that high-resolution data generated by IoT sensors is critical for real-time decision-making in urban mobility systems [14]. Acceptance studies confirm that edge-computing–based sensors are increasingly viable and socially acceptable in smart city environments [15]. Advances in communication technologies further enhance the effectiveness of Smart ADT systems. A systematic mapping study by Yang et al. demonstrates that 5G connectivity significantly improves the reliability, latency, and scalability of smart city applications, including real-time traffic monitoring and analytics [16]. Although full-scale 5G deployment remains uneven across Indonesian secondary cities, these findings highlight the future readiness of Smart ADT architectures to integrate higher-bandwidth communication as infrastructure becomes available.

In the Indonesian context, traffic data requirements are formally defined in the Panduan Kapasitas Jalan Indonesia (PKJI) 2023, which establishes standards for road capacity analysis, level-of-service evaluation, and traffic performance assessment [17]. PKJI 2023 explicitly identifies Lalu Lintas Harian Rata-Rata (ADT) as a core dataset required for capacity calculations, congestion analysis, and infrastructure planning. The guideline also specifies the need for vehicle classification data, including motorcycles, light vehicles, heavy vehicles, and non-motorized traffic, reflecting Indonesia's heterogeneous traffic composition. However, PKJI 2023 does not prescribe a specific technological approach for continuous data collection, leaving local governments largely reliant on manual or short-term surveys. This gap highlights the relevance of Smart ADT systems as a technological complement to existing regulatory frameworks.

Despite technological progress, prior studies predominantly focus on system performance and technical feasibility. While Smart ADT solutions have demonstrated their ability to generate accurate, granular traffic data, limited attention has been paid to how these systems can be sustained financially after pilot funding or project-based budgets expire. This unresolved issue is particularly critical for secondary cities, where fiscal capacity is constrained, and long-term maintenance of digital infrastructure is often overlooked.

Data Monetization and Business Models for Smart Mobility

The sustainability of smart mobility initiatives depends not only on technical performance but also on viable business and financing models. Existing literature on smart cities increasingly recognizes data as a strategic asset that can be monetized through service-based models [18], [19]. Rather than treating traffic data systems as cost centers, data monetization frameworks propose transforming them into revenue-generating services that support long-term operation and

continuous improvement [20]. Recent developments in several developing countries further illustrate the practical relevance of urban data monetization for municipal finance. A report by *The Times of India* describes how the Ahmedabad Municipal Corporation has explored monetizing smart city data, including traffic and property information, as a strategy to generate additional revenue and reduce reliance on conventional public funding [21]. Although this initiative originates from a different institutional context, it demonstrates a growing recognition of urban data as an economic asset rather than merely an administrative resource. Such international experiences provide contextual support for exploring service-based traffic data models, while also highlighting the importance of governance mechanisms to safeguard public interest and data sovereignty.

"As-a-service" models have gained traction across various urban domains, including Software-as-a-Service (SaaS), Infrastructure-as-a-Service (IaaS), and Mobility-as-a-Service (MaaS). Service-oriented approaches to urban mobility have often been discussed within the Mobility-as-a-Service (MaaS) framework. Zhang and Zeng argue that MaaS development faces challenges related to institutional coordination, data integration, and long-term financial viability, particularly when public authorities retain primary responsibility for traffic management [22]. While MaaS emphasizes user-facing mobility services and modal integration, its reliance on behavioral change and consumer adoption limits its applicability in secondary cities. This distinction reinforces the relevance of Traffic-as-a-Service (TaaS) as an institution-centered model that prioritizes traffic data generation, analytics, and decision support for public agencies. MaaS primarily focuses on integrating transport modes and user-facing mobility services, whereas Traffic-as-a-Service (TaaS) specifically targets traffic data generation, analytics, and decision support as a digital service for governments and enterprises. Unlike MaaS, which depends heavily on consumer adoption and behavioral change, TaaS is institutionally oriented, making it better suited to secondary cities where public agencies remain the primary actors in traffic management.

Several studies highlight that Smart ADT systems often fail to scale beyond pilot phases due to the absence of sustainable revenue mechanisms [18], [23]. In many cases, systems are deployed using grant-based or project-based funding without clear plans for operational cost recovery. Research from India demonstrates that smart city initiatives that adopted data monetization and subscription-based models were better able to sustain ICT investments over time [23]. However, comparative studies indicate that these models must be adapted to local institutional and economic conditions, as approaches suitable for metropolitan areas may not translate effectively to smaller cities.

For secondary cities such as Kediri, TaaS offers a pragmatic alternative by allowing municipalities to access traffic intelligence through operational expenditure rather than capital-intensive ownership. This model reduces upfront financial burdens while enabling continuous service delivery. Nevertheless, existing literature lacks empirical case studies demonstrating how TaaS can be operationalized in Indonesian secondary cities, particularly in alignment with national traffic guidelines such as PKJI 2023.

Governance and Public–Private Partnerships in Smart Traffic Systems

Governance plays a central role in determining the success of Smart ADT deployment and monetization. Prior research emphasizes that data governance frameworks, including data ownership, access rights, and privacy protection, are essential for building trust among stakeholders [24], [25]. In smart city contexts, weak governance structures often lead to fragmented systems, limited data sharing, and institutional resistance. At the regional level, the ASEAN Smart Cities Network Action Framework emphasizes the importance of interoperable data platforms, inclusive governance, and sustainable financing mechanisms for smart city development [26]. The framework encourages member cities to adopt collaborative models that balance innovation with public accountability. Aligning Smart ADT and TaaS initiatives with ASEAN-level principles strengthens policy coherence and enhances the legitimacy of service-based traffic data systems in Indonesian cities.

Public-Private Partnerships (PPP) have been widely promoted in Indonesia as a mechanism to address financing and capacity gaps in infrastructure development [8], [9], [10]. Studies on Indonesian smart mobility projects highlight that PPP arrangements can distribute risks and

leverage private-sector expertise, but their effectiveness depends on clear contractual frameworks and regulatory certainty [24], [27]. Emerging models such as Public–Private–People Partnerships (4P) further emphasize citizen engagement and social acceptance as critical success factors [20], [28]. Recent studies in the Indonesian context further emphasize the strategic role of Public–Private Partnerships (PPP) in the development of Intelligent Transportation Systems (ITS). Putri et al. provide a comprehensive literature review of PPP schemes implemented for ITS development in Indonesia's new capital city, highlighting how collaborative financing, risk-sharing mechanisms, and private-sector expertise can accelerate smart mobility deployment under fiscal constraints [24]. Their findings indicate that PPP models are particularly relevant for large-scale, technology-intensive transportation systems, while underscoring the importance of clear contractual arrangements and institutional coordination. These insights are directly relevant to secondary cities such as Kediri, where similar fiscal and capacity constraints necessitate adaptable, scalable PPP-based approaches for Smart ADT and Traffic-as-a-Service implementation.

Governance theory also stresses that smart city initiatives must be embedded within local institutional contexts rather than relying solely on imported technological solutions [29]. For secondary cities like Kediri, governance challenges include limited administrative capacity, budget constraints, and public concerns over surveillance and data privacy. While global cases such as adaptive traffic control systems in the United States and open-data mobility platforms in Europe demonstrate the potential of data-driven traffic governance [30], [31], these models often assume strong institutional capacity and stable funding streams that may not be present in smaller Indonesian cities.

Research Gap and Relevance for Kediri

This study demonstrates that Smart ADT systems are technically capable of generating high-quality traffic data aligned with national guidelines such as PKJI 2023. Studies also suggest that service-based and monetization models can enhance the Sustainability of smart mobility initiatives. However, three critical gaps remain unresolved. First, there is limited integration between Smart ADT technologies and regulatory frameworks governing traffic data requirements in Indonesia. Second, existing studies rarely examine sustainable business models tailored to secondary cities, where financial and institutional constraints differ significantly from metropolitan areas. Third, empirical evidence linking governance arrangements, monetization strategies, and technical deployment within a single case study remains scarce.

Addressing these gaps, this study positions Kediri as a representative secondary city to explore how Smart ADT systems can be combined with a Traffic-as-a-Service (TaaS) framework under realistic governance and fiscal conditions. By integrating IoT-based traffic surveys, service-oriented monetization, and public–private collaboration, the research seeks to contribute to both the academic literature and practical policy discourse on sustainable traffic data systems in Indonesia.

METHOD

This study adopted a qualitative case study approach to examine the feasibility of implementing Smart Average Daily Traffic (ADT) systems combined with a Traffic-as-a-Service (TaaS) business model in Kediri, Indonesia. A qualitative case study was selected because the research focuses on technical performance as well as institutional arrangements, governance structures, and financing mechanisms shaping smart traffic system sustainability. These dimensions are context-dependent and cannot be captured through purely quantitative methods. Kediri was chosen as a representative secondary city with recurrent traffic congestion, limited fiscal capacity, and smart mobility initiatives still in early stages.

Case Selection and Context

Kediri is a mid-sized Indonesian city with congestion concentrated at several critical intersections rather than network-wide gridlock. This characteristic makes it an appropriate case for examining Smart ADT deployment at a limited scale while assessing its potential for incremental

expansion. The city's institutional structure, which involves multiple municipal agencies responsible for transport, environment, and public safety, also provides a relevant context for analyzing inter-agency data use and Public–Private Partnership (PPP) arrangements within a TaaS framework.

Data Sources and Collection

This study relied on two primary data sources. The primary data were derived from a pilot traffic survey model in Kediri, which included planning discussions conducted in July 2025 with local stakeholders such as municipal planners and transport-related agencies, the identification of critical intersections experiencing recurrent congestion during peak commuting and school hours, and the selection of representative urban corridors affected by mixed traffic flows comprising motorcycles, private vehicles, and commercial traffic. The secondary data were obtained from a literature and policy review consisting of peer-reviewed journal articles published between 2020 and 2024 on IoT-based traffic systems, Intelligent Transportation Systems (ITS), and smart mobility; policy and institutional documents including OECD frameworks on smart city data governance and Indonesian Public–Private Partnership (PPP) regulations; and industry and technology reports such as those from Bosch IoT Lab and Deloitte addressing IoT deployment, data monetization, and service-based digital infrastructure. These sources provided the theoretical foundation for the study and informed the development of the conceptual and analytical framework.

Smart ADT Pilot Framework and Data Validation

The Smart ADT pilot integrated IoT-based traffic monitoring with an edge and cloud computing architecture. Computer vision-enabled cameras and traffic sensors were installed at selected intersections to capture vehicle counts, flow rates, and average speeds in real time. Data pre-processing was conducted at the edge level to filter noise and synchronize sensor outputs, after which the data were transmitted to a cloud platform for storage and advanced analytics.

Data validation was conducted through triangulation. Automated traffic counts generated by the Smart ADT system were periodically compared with short-duration manual counts conducted during peak periods to verify consistency and detect anomalies. Additionally, the system-identified temporal traffic patterns were cross-checked against known congestion periods reported by local stakeholders. This approach ensured that the pilot data were sufficiently reliable for analytical and exploratory purposes, while acknowledging that the system was not intended to replace full-scale regulatory traffic surveys at this stage.

Analytical Strategy

The analysis employed the Business Model Canvas (BMC) as an interpretive framework to examine the monetization potential of Smart ADT systems under a TaaS model. Rather than applying all nine BMC components, the study focused on five elements most relevant to service-based traffic data provision: customer segments, value propositions, revenue streams, key partnerships, and cost structure. This selective approach allowed the analysis to concentrate on financial Sustainability and governance implications without overextending the scope of the case study.

In addition, comparative benchmarking was conducted against selected international cases, including adaptive traffic signal systems in the United States and open-data traffic platforms in Europe. These cases were used as reference points to contextualize the Kediri experience and identify transferable lessons, while recognizing differences in institutional capacity and scale.

Limitations and Scope

This study has several limitations. First, as a qualitative case study focused on a single secondary city, the findings are exploratory and indicative rather than statistically generalizable. Second, the pilot implementation was limited to selected intersections and a relatively short observation period, which constrains the assessment of long-term performance and scalability.

Third, institutional and financial conditions in Kediri may differ from those in larger metropolitan areas or rural regions, limiting direct transferability.

Nevertheless, the qualitative case study approach provides in-depth insights into how Smart ADT systems, monetization strategies, and governance arrangements interact in practice. The findings offer a conceptual and empirical foundation for future studies that may employ larger samples, quantitative performance evaluations, or comparative multi-city analyses.

RESULTS AND DISCUSSION

Traffic Conditions and Congestion Patterns in Kediri

The Smart ADT pilot in Kediri shows that traffic congestion is spatially concentrated at a limited number of critical intersections rather than evenly distributed across the road network. IoT-based monitoring identified three recurring peak periods. The morning peak occurs between 06.30 and 08.00 and is dominated by school-related trips and commuter flows, leading to sharp increases in traffic volume and queue lengths. The afternoon peak between 15.30 and 17.00 reflects the convergence of school dismissal traffic and commercial activity, resulting in prolonged congestion. A moderate evening peak between 18.00 and 19.30 is associated with returning commuters and mixed vehicle flows, including motorcycles, private cars, and public transport.

Compared with conventional manual traffic surveys, the Smart ADT system demonstrates greater sensitivity to temporal variations in traffic flow. Manual counts conducted within limited observation windows are less effective at identifying recurring, time-specific congestion patterns. Continuous monitoring enables a more detailed understanding of traffic dynamics at the intersection level, particularly in urban areas where congestion is localized but repetitive.

Performance of the Smart Survey Architecture

The three-tier Smart Survey architecture, consisting of schematic data capture, cloud computing, and application services, proved effective in supporting continuous traffic monitoring and analysis. At the data capture layer, computer vision-based sensors successfully detected and classified heterogeneous vehicle types, which is critical in Indonesian traffic conditions dominated by motorcycles. Edge computing enabled preliminary data filtering and synchronization, thereby reducing latency and minimizing data loss during data transmission.

At the cloud layer, real-time analytics and structured storage supported both operational monitoring and historical traffic analysis. Predictive algorithms applied to the collected data were able to anticipate congestion patterns during peak periods, enabling more proactive traffic management measures. The application server layer provided secure data access via role-based dashboards and application programming interfaces, enabling municipal agencies to visualize congestion levels and retrieve analytical reports for planning. This layered architecture supports scalable and reliable monitoring of urban traffic dynamics.

Implications for Urban Traffic Management

The results indicate that Smart ADT systems can generate actionable traffic intelligence for municipal decision-making. In the Kediri context, real-time traffic data enable transport authorities to identify congestion-prone intersections, evaluate the effectiveness of operational interventions, and prioritize low-cost measures before considering large-scale infrastructure expansion. This capability is particularly relevant for secondary cities with limited fiscal capacity.

The availability of continuous traffic data also supports cross-sectoral applications. Beyond traffic management, these datasets can also inform environmental monitoring, enforcement planning, and urban development strategies. This multi-purpose use enhances the overall value of Smart ADT systems and supports more integrated urban governance practices.

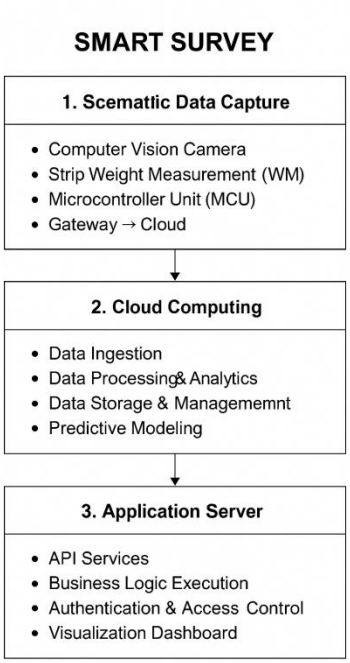


Figure 1. Smart Survey system architecture.

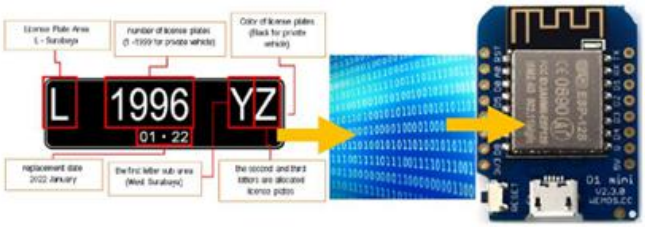


Figure 2. License plate recognition and data capture.

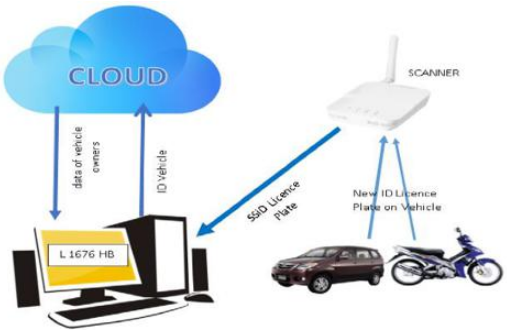


Figure 3. Vehicle ID integration with cloud system.

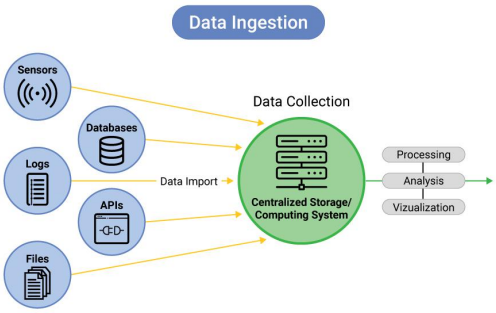


Figure 4. Data ingestion framework for Smart Survey.

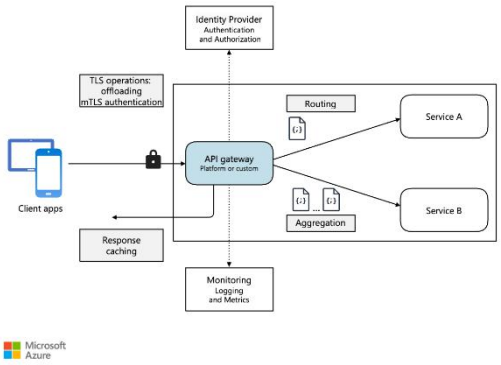


Figure 5. API gateway architecture pattern.

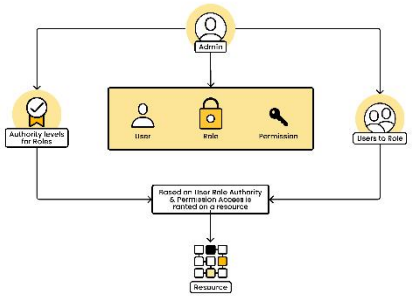


Figure 6. Role-based access control (RBAC) dashboard.

Business Model Opportunities

The findings were mapped using the Business Model Canvas (BMC). Rather than presenting all nine traditional BMC blocks, the analysis focused on five dimensions most relevant to this study: customer segments, value propositions, revenue streams, key partnerships, and cost structure.

Table 1. Business Model Canvas (BMC) elements for Traffic-as-a-Service (TaaS) in Indonesia.

BMC Element	Key Insights for TaaS in Indonesia
Customer Segments	Governments, commuters, logistics providers, and ride-hailing platforms
Value Propositions	Real-time traffic intelligence, congestion reduction, predictive analytics
Channels	Digital dashboards for governments, mobile apps for commuters, APIs for enterprises
Customer Relationships	Subscription contracts, data-sharing agreements, performance-linked service guarantees
Revenue Streams	Service subscriptions, platform licensing, performance-based payments, and data marketplace fees
Key Resources	IoT sensors, edge-computing infrastructure, AI algorithms, skilled technical teams
Key Activities	Data collection, analytics, system maintenance, API service delivery
Key Partnerships	Telecoms, IoT vendors, municipalities, ride-hailing firms, cloud providers
Cost Structure	High upfront IoT deployment, ongoing O&M costs, mitigated by PPP and shared-use platforms

Source: Processed by the authors (2025)

This shows that monetization is feasible, but requires regulation, transparent governance, and strong private-sector participation. Similar perspectives are emphasized in Indonesian PPP studies, which highlight that sustainable infrastructure depends on effective collaboration between government, private firms, and the community.

Financial Sustainability of TaaS for Kediri

In the Indonesian context, monetization of Smart ADT systems should be seen as a pathway to sustainable financing rather than profit-making. The aim is to ensure continuous system operation while delivering long-term public benefits. Four mechanisms can support this:

1. *Operational Cost Recovery*
   Kediri typically relies on yearly municipal budgets for road and traffic projects. This model creates sustainability risks once the budget cycle ends. Under a TaaS framework, the city could subscribe to traffic intelligence services rather than owning the infrastructure fully. For example, IoT sensors installed at high-congestion intersections would be maintained by providers, while the government pays monthly or quarterly fees. This allows Kediri to spread costs as operational expenditure, thereby avoiding heavy upfront investments that would strain the city's finances.
2. *Shared-Use Platforms*
   Traffic data in Kediri is valuable not only to the Transport Agency. The same information could support the Environmental Agency in monitoring emissions, the Police in mapping accident-prone areas, and city planners in designing future road expansions. By integrating Smart ADT data into a unified digital platform, costs can be shared across agencies. This multi-agency approach reduces duplication, maximizes return on investment, and ensures that the benefits of traffic intelligence are extended across public services.
3. *Public-Private Collaboration*
   Given Kediri's limited fiscal capacity, PPP arrangements can play a central role. Local telecom operators or IoT firms could provide the hardware and connectivity infrastructure, while the municipality guarantees payment for the service. This reduces the need for upfront capital and encourages local innovation. Unlike larger metropolitan cities, Kediri's PPP schemes must be modest and tailored to local economic realities, ensuring cost recovery for private firms while maintaining the town's affordability.

Business Model and Sustainability Implications

From a sustainability perspective, the findings suggest that technical feasibility alone is insufficient to ensure long-term operation of Smart ADT systems. While the pilot demonstrates functional performance, ongoing operational and maintenance requirements create financial pressure if systems rely solely on project-based funding. A service-oriented approach allows traffic monitoring costs to be distributed over time and shared across multiple users.

In the Kediri case, a service-based model enables the municipality to access traffic intelligence without owning the infrastructure. Shared platforms across agencies and subscription-based arrangements reduce investment duplication and improve financial predictability. Compared with traditional government-owned systems, this approach provides greater flexibility and supports continuous system operation.

Governance Considerations and Scope of Findings

The implementation experience highlights the importance of clear governance arrangements, particularly regarding data access, privacy protection, and institutional coordination. Effective collaboration between public agencies and technology providers is necessary to ensure system reliability and public trust. In secondary cities such as Kediri, governance models must be adapted to local administrative capacity and community expectations.

The findings of this study are exploratory and indicative. The analysis is based on a limited scale pilot implementation in a single city context. As such, the results are not intended to be statistically generalizable but provide context specific insights into the interaction between technology, governance, and service-based business models in Smart ADT deployment.

Global Benchmarking

International cases illustrate different models of traffic data monetization. In the United States, the SURTRAC system uses real-time adaptive traffic control, leading to measurable reductions in congestion and demonstrating the potential for government-led service contracting. In Europe, cities such as Helsinki and Barcelona have fostered innovation through open data platforms by publishing traffic data openly, enabling startups and enterprises to build services while the government maintains regulatory oversight. In the private-led model, global technology firms such as Google and TomTom monetize traffic data by offering premium APIs to navigation apps, insurers, and logistics companies. These models are highly profitable and technologically advanced, but they create dependency on foreign providers and raise concerns about digital sovereignty. For Indonesia, this pathway risks limiting local innovation and could undermine long-term national control over critical mobility data.

For Kediri, a hybrid model is most suitable: the government should retain regulatory control and data governance, while private firms provide technical innovation and service delivery.

Value Flow of TaaS in Kediri

The framework in Table 2 illustrates how value is created, exchanged, and sustained within a Traffic-as-a-Service (TaaS) ecosystem tailored for Kediri as a mid-sized Indonesian city.

Table 2. Actor and value exchange in the Traffic-as-a-Service (TaaS) ecosystem in Indonesia.

Actor	Provides	Receives	Value Exchange
Government (Municipality of Kediri)	Road infrastructure, regulatory framework, and coordination across agencies	Traffic intelligence, efficiency gains, predictable OPEX model	Ensures governance, pays subscription/service fees, and integrates into urban planning
Private Technology Providers (IoT vendors, telecoms, developers)	IoT devices, connectivity, data analytics platforms	Service contracts, limited access to non-sensitive datasets	Supply innovation and infrastructure while sharing investment risks
Commuters and Citizens	Mobility data via mobile apps, sensors, and participation in pilot schemes	Reduced congestion, shorter travel times, cleaner air	Provide anonymized mobility data, benefit from improved public services (no direct revenue exchange)
Logistics & Ride-hailing Firms	Fleet movement data, co-investment in platform development	API access, route optimization, operational cost savings	Subscribe to premium analytics and contribute data
Cross-sector Municipal Agencies (Environment, Police, Urban Planning)	Utilize traffic data for enforcement, emission monitoring, and city planning	Shared platform access, reduced duplication of costs	Participate in the co-financing and contribute to sectoral requirements

Source: Processed by the authors (2025)

This flow highlights the hybrid governance model. The Kediri government acts as the orchestrator, maintaining equity, accountability, and sovereignty over mobility data. Private providers bring essential technological capabilities, rapid innovation cycles, and partial infrastructure investment. Citizens and firms benefit from efficiency gains and improved urban services, while also contributing data. Cross-sectoral integration ensures that the traffic data ecosystem generates value beyond mobility, extending to environmental management and urban safety.

Such a multi-actor value flow creates a virtuous cycle in which technology providers innovate, governments secure Sustainability, and society benefits through enhanced service delivery. For Kediri, embedding this framework ensures that Smart ADT monetization evolves not only as a financial model but also as a broader ecosystem of public value.

Comparative Perspective with Traditional Government Owned Systems

Compared with traditional government-owned traffic systems, the TaaS framework introduces several structural advantages. Conventional systems often depend on annual budget allocations, which can lead to interruptions in maintenance and system upgrades. Ownership-based models also place technical and operational risks entirely on public agencies, which may lack specialized expertise.

In contrast, the TaaS approach distributes risks between public and private actors. Private providers are incentivized to maintain system performance because service continuity is linked to revenue. Municipalities benefit from reduced technical complexity and improved service reliability. This shift from asset ownership to service outcomes enhances flexibility and supports long-term sustainability.

CONCLUSION

The case study in Kediri confirms that Smart ADT systems offer a viable solution for addressing recurring congestion in secondary Indonesian cities. By integrating IoT-based monitoring with a structured traffic survey model, the city can obtain accurate, real-time data to enhance decision-making and support more adaptive mobility planning. Compared with conventional manual surveys, these systems deliver greater precision and predictive power, making them more effective at guiding policy and infrastructure interventions.

Traffic-as-a-Service (TaaS) emerges as a promising framework to ensure the financial Sustainability of such initiatives. Rather than being seen as a profit-making venture, TaaS allows Kediri to secure continuous operation through manageable operational costs, shared use across municipal agencies, and carefully designed performance-linked contracts. This model not only ensures that investments remain sustainable but also creates added value for commuters, logistics firms, and public institutions.

The broader implication is that Kediri's approach can serve as a reference for other mid-sized cities in Indonesia. By adopting a hybrid governance structure that safeguards the public interest and sovereignty over traffic data. At the same time, private providers contribute technological expertise, and the city can achieve both Sustainability and innovation. If complemented by clear regulatory frameworks and citizen trust, TaaS has the potential to transform traffic data into a sustainable digital service that supports more efficient, equitable, and environmentally conscious urban mobility.

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