

DEVELOPMENT OF AN ADAPTIVE DIGITAL ECOSYSTEM MODEL TOWARDS A SUSTAINABLE SMART CITY IN BANYUWANGI REGENCY

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ABSTRACT. This research is conducted to create an adaptive and sustainable Smart City ecosystem model for Banyuwangi Regency in response to challenges of digitalization and sustainable development in the region. The study emphasizes three pillars: building digital infrastructure, improving stakeholder cooperation, and formulating regulations conducive to technological innovation. Employing an exploratory qualitative method, the research was conducted through 18 in-depth interviews, direct observation, document analysis, and FGDs with diverse stakeholders. The collected data were analyzed using a paradigmatic model to construct a "Smart Sustainable City Ecosystem" tailored to Banyuwangi's characteristics and challenges. This study yields a digital ecosystem model incorporating policies to advance digital infrastructure, community digital literacy, and the regulation of technological innovation, adaptable across contexts. This development model would enable the continuity of Smart City development in Banyuwangi through an all-encompassing, adaptive strategy for environmental change. This study is only focused on the Banyuwangi area, and the data are collected from several stakeholders. It is suggested that future research, using multiple longitudinal studies, assess the model's effectiveness.

Keywords: smart city, digital ecosystem, digital infrastructure, digital literacy, adaptive regulation.

INTRODUCTION

The evolution of digital technology has transformed the operation of cities globally, enabling more diverse, effective, and sustainable transformations (Bokolo Anthony Jr., 2021). Developments such as the IoT, artificial intelligence (AI), and blockchain technology have further enhanced the smart city concept by enabling real-time data use to increase efficiency, safety, and comfort for citizens (Scuotto, Ferraris, & Bresciani, 2016; Shilpi & Ahad, 2020). This digitalization not only challenges the way to enhance the quality of life and competitiveness of cities but also demands a profound understanding of how technology can be inclusive across areas with widely different features (Sharifi et al., 2021). The use of IoT and AI technologies in city infrastructure can reduce operating costs and increase investment attractiveness, resulting in substantial economic benefits over the long term (Bokolo Anthony Jnr, 2021).

Applying the smart city concept at the regional level offers many advantages, but data integration, strategic design, and stakeholder collaboration are often challenging (Daniyar Mukhametov, 2019). Senior and Suharto (2021) Note That Local Governments, particularly in Indonesia, face a significant challenge in making smart cities inclusive and sustainable. An ideal smart city, according to research by Svitek and Kozhevnikov (2023), is one with mechanized, effective city governance that involves various stakeholders to deliver more effective cross-sector solutions. "These challenges are more acute in the rural district, because digital infrastructure is not uniformly distributed and the community's digital literacy is yet to be enhanced" (Sari, 2022).

Banyuwangi Regency in Indonesia is a fascinating case of a 'smart city' concept developed in a rural setting through the 'smart village' scheme. It is, in fact, in the more rural areas of the regency that have become model practitioners of community-based smart cities. In the "smart village" scheme, Banyuwangi focuses on improving public service quality, enhancing digital infrastructure, and promoting public participation in the digital transformation. The creative approach Banyuwangi has taken has won numerous national and international awards, demonstrating that the smart city concept can be adapted for rural use (Widiyastuti et al., 2021).

Nonetheless, this paper's evidence from observations, interviews, and document analysis shows that

Banyuwangi is still confronted with several significant challenges in building a sustainable medium-sized smart city. Difficult access to the internet and technological gadgets in a few villages is one of the hurdles that, percentage-wise, widens access to information and digital services. The community's digital literacy is also challenging, as the majority of the rural population is still not fully exposed to or accustomed to using digital technology in their lives (Sari, 2022; Jang & Gim, 2022). Finally, the collaboration among various stakeholders, such as local government, the private sector, academia, and communities, needs to be more synergistic to bring together pre-existing efforts (Emerson & Nabatchi, 2015; Etzkowitz & Leydesdorff, 2000).

Adaptive regulation is also an important factor that remains to be strengthened in the Banyuwangi Smart City ecosystem. Flexible and innovative supporting policies are needed to foster dynamic technological development (Kociuba et al., 2023). According to the work of Kociuba et al. (2023), the model of an innovative city ecosystem is a collaborative framework that develops the technology innovation system and ensures protection and access to all sides of the innovation process. To stimulate Banyuwangi's ability to nurture a culture of sustainable innovation, particularly within industries that feature cross-sectoralities, comprehensive and responsive regulation will be needed (Carayannis & Campbell, 2019; Carayannis, Barth, & Campbell, 2012). The answers to these calls should also help formulate an adaptive, inclusive digital ecosystem model. In essence, it should adjust to the local settings (Gor Yainova, 2020; Carmen et al., 2019). In the digital ecosystem model, all aspects of the innovative city's digital ecosystem should be covered (Bayraktar et al., 2021; Gorelova et al., 2021).

It is an exodus, with an adaptive model of good practice in smart city development, Banyuwangi will not only have the chance to carry on its tradition but also gain inspiration to encourage many other rural regions in Indonesia to follow the same path (Widodo & Rahman, 2021; Tura & Ojanen, 2022). Drawing on the Pentahelix model of innovation (Carayannis & Campbell, 2019) and agile governance (Kociuba et al., 2023), this paper proposes an adaptive digital ecosystem model to enable sustainable smart city development in Banyuwangi.

The framework is based on three generic pillars, conceptually derived from the imaginative city governance literature and Indonesia's national digital transformation policy. In the case of Banyuwangi, these are found to be aligned with the local realities: First, the enhancement of digital infrastructure is in line with the regency government's streak in increasing accessibility in the Electronic-Based Government System (SPBE) Index and its effort for extending internet in the rural and urban areas, despite the gap in infrastructure in rural areas still existing. The second pillar, enhancing stakeholder engagement, corresponds with Banyuwangi's tradition of multi-actor involvement in its smart village initiatives. However, resonance between the Pentahelix components (government, business, academia, community, and media) is somewhat lacking. Third, creating adaptive regulations is related to local demand for policies that can respond immediately to fast-paced technological development and ensure sustainability and inclusiveness. These three pillars are also instrumental in providing an analytical framework for evaluating Banyuwangi's existing ecosystem and in developing a contextual digital model that builds on its strengths and addresses its weaknesses. With such a model, it is hoped that a more holistic solution can be achieved to address various challenges and harness Banyuwangi's potential as a digital transformation pioneer in rural areas.

RESEARCH FRAMEWORK

This study is intended to be a smart city development model that is adaptive and sustainable in Banyuwangi Regency. As excellent region that has been investing in transforming itself into a digital one via the "smart village" scheme, real challenge in "smartifying" that Banyuwangi now must face is how to handle the gaps in access to digital infrastructure, the low digital literacy of rural communities, the weak synergy among stakeholders, and the limited (and not yet responsive to technology development) regulations. To confront these issues, this study proposes a conceptual model that incorporates various critical factors in building an adaptive digital ecosystem. Starting from the problem's background and context, based on the Pentahelix theory

(Carayannis & Campbell, 2019) and agile governance (Kociuba et al., 2023), the conceptual framework ends with the proposal of an adaptive and sustainable digital ecosystem model. Figure 1 shows schematically this conceptual framework.

The conceptual framework of this study is the resulting comprehensive philosophical base is designed to steer the overall study descriptions, from stating the research problem to creating a model.

1. Background and context

This part illustrates the worldwide trend of urban digital transformation and the issues of regional smart city realization. Banyuwangi was selected as a one-of-a-kind case study given its successful adoption of the smart city approach in rural settings in the form of "smart village".

2. Problem Identification

Four major issues were raised as barriers to forming a digital ecosystem in Banyuwangi: (1) the disparity in availability to the internet and technology devices, (2) the low digital literacy of the people, (3) the absence of synergistic collaboration among stakeholders, and (4) the inadequate regulations accommodating technology.

3. Theoretical Foundation

This framework draws on five theoretical underpinnings: the Pentahelix Model (government-business-academia-society-media) as a model for collaborative engagement, Agile Governance as a theory of policy agility, Collaborative Governance Theory for governance management, Triple Helix Innovation as an innovation model, and the Smart City Ecosystem Model as a smart city ecosystem.

4. Conceptual Framework

The three pillars as the foundation of the Adaptive- Digital Ecosystem model are: (1) building inclusive digital infrastructure, (2) enhancing stakeholder collaboration, and (3) designing adaptive regulations. The three pillars are connected and work collectively to the dynamic and sustainable digital ecosystem.

5. Ultimate Goal

The fitting end to this framework is a sustainable Smart City in the Banyuwangi Regency, one that is not only technologically advanced but also inclusive, participatory and resilient to change, which is figured as an ideal smart city model."

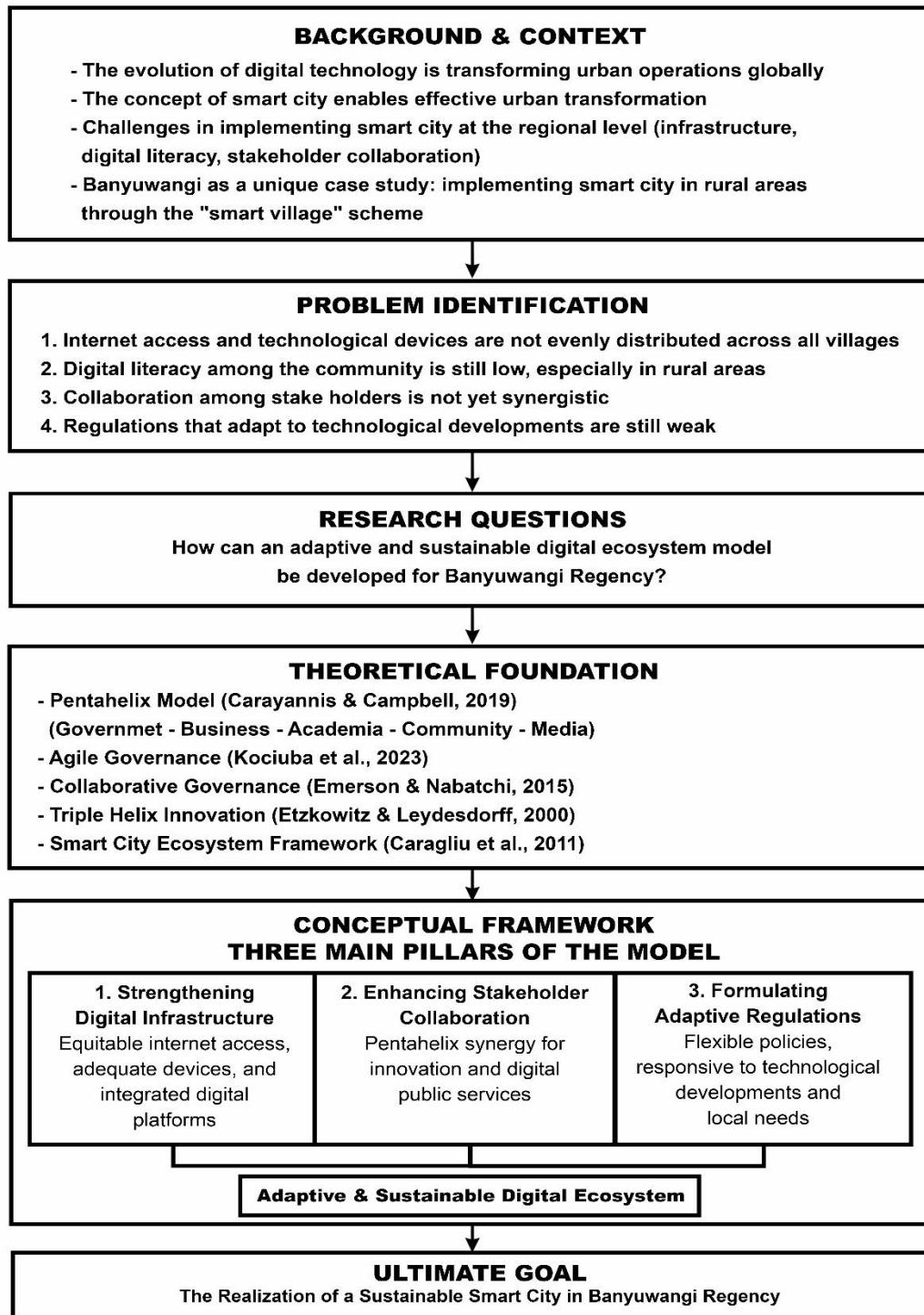


Figure 1. Research Conceptual Framework

METHOD

The current research uses an exploratory qualitative method to provide a comprehensive perspective on how a sustainable Smart City environment can be developed in Banyuwangi Regency (Creswell, 2015). The

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exploratory method is preferred because it has special utility for discovering new phenomena and developing models, as noted in Mudjiyanto's 2018 view of exploratory communication research. The framework approach is used in this study as an analytical tool to examine descriptive data across different facets of the phenomenon (Smith & Firth, 2011). Various methods were used to collect the data, ensuring richness and accuracy, such as in-depth interviews with different stakeholders (Phadermrod, Crowder & Wills, 2019), fieldwork observations to sight digital infrastructure, document review and secondary data from government agencies such as Bappeda and Diskominfo, as well as Focus Group Discussions (FGD) consisting of elements of the Pentahelix (government, educators, business, community and media). These FGDs focused on each party's visions, priorities, strategies, and roles and responsibilities in developing the Smart City ecosystem.

The qualitative data were analyzed systematically in NVivo to identify paradoxes and emergent patterns. The analytical steps are data coding, categorization, and thematic analysis. Moreover, visualization is used in the form of word clouds and tree map diagrams to depict dominant topics from the perspective of stakeholders (Miles, Huberman, & Saldana, 2014). A brief analysis of the interactions among factors such as leadership, collaboration, and strategy, the crucial nodes in the digital transformation arena, has been conducted (Wahyuddin & Wibowo, 2021; Moreira & Macke, 2023). All of these things have laid the foundation for the strategic recommendations needed to develop an adaptive, sustainable digital ecosystem.

RESULT AND DISCUSSION

Banyuwangi Regency has shown significant progress in implementing the Electronic-Based Government System (SPBE) from 2018 to 2021. The value of the SPBE Index gradually improved from 3.43 in 2018 to 3.53 in 2021, indicating the strong momentum of the regional government in embracing digital services and good governance. The digital change in this case involves enhancing the supporting infrastructure and digital apps for public services, as well as improving the capabilities of human resources. Through the use of SPBE, the regional tasks of developing economic resilience, building a high-quality human resources pool, accelerating infrastructure development, and developing a flexible and responsive administration are now based on this digital concept.

However, Banyuwangi faces actual challenges, such as budgetary constraints, as it transforms. In the above synopsis, public-private partnerships between government, business, and members of society seem to be becoming even more important than before. Such partnerships ensure a flow of innovations that help public services to become even more efficient.

Banyuwangi has built more inclusive and sustainable communities through its many digital projects and enabling internal policies, and has been recognized nationally for its innovativeness in government management. NVivo software was used to analyze data from Focus Group Discussions (FGDs) with key actors, including the local government, the community, and the private sector, to elicit the critical ingredients for the success of digital transformation in Banyuwangi.



Figure 1. Word Cloud Results of FGD among stakeholders in Banyuwangi Regency

Figure 1 is a word cloud from the FGD analysis, revealing that the focal words communication, community, and leadership dominated the discussion. Good communication at all levels – from government to the public, and from government to government – was identified as crucial. This demonstrates that the commitment to ensuring everyone involved understands the goals, benefits, and activities of digital transformation is vital. The community is a pivotal user group for the developed digital services, and the firm's top management is considered a critical driver of digital transformation success. Communication is the keystone in the foundation of establishing a comprehensive and efficient digital transformation system.

Communication at the right level allows all stakeholders to properly understand the vision, benefits, and processes of digital initiatives such as those in the case of Banyuwangi, which also consists of government agencies (Diskominfo, Bappeda, OPD teknis), business and industry groups, schools, community leaders and village councils, media organizations, as well as the general public in both urban and rural areas. It connects technical realisation with societal integration, addressing misinformation and institutional inertia. In an ideal smart city, advancement depends on open communication among many parties. Consider: town meetings, social networks, community radio, local television stations, printed newsletters, as well as service applications with feedback mechanisms. The purpose here is to offer two-way communication – not only dissemination but also listening to the residents. This requires collaboration for shared ownership as they navigate the digital transformation to suit residents' needs.

Community engagement is not something that happens; it is the key to the success of technology. The community cannot simply be presented with a new technology solution from above. They must be considered collaborators and active players. This means more than simply seeking feedback. To fully involve the community in the process means bringing

them into the design, prototyping, and testing of new digital services. Involving the community at every stage of the process will make it more likely that the community will embrace the result and help it develop the skills for a more successful digital world. Leadership is crucial to the pace and direction of digital transformation.

Strong leaders at the political and administrative levels (vision and political support) are needed to advance the smart city agenda, secure the necessary resources, and overcome institutional inertia. They provide an overarching Strategy, establish the context for innovation, and permit civil servants to take informed chances. More than championing, good leadership must orchestrate and enable cross-cutting coordination within and across the complex, multi-stakeholder matrix of diverse government agencies, private-sector collaborators, and academic institutions to develop the synergies and coherence needed to successfully evolve and deliver an integrated, anticipatory national digital policy.

In addition, Figure 2 Tree Map shows the topic distribution based on the number of coding references retrieved for the NVivo analysis. Keywords like the Strategy for the Smart City, leadership, SKPD (S) relationship, and development of the State Civil Apparatus (ASN).

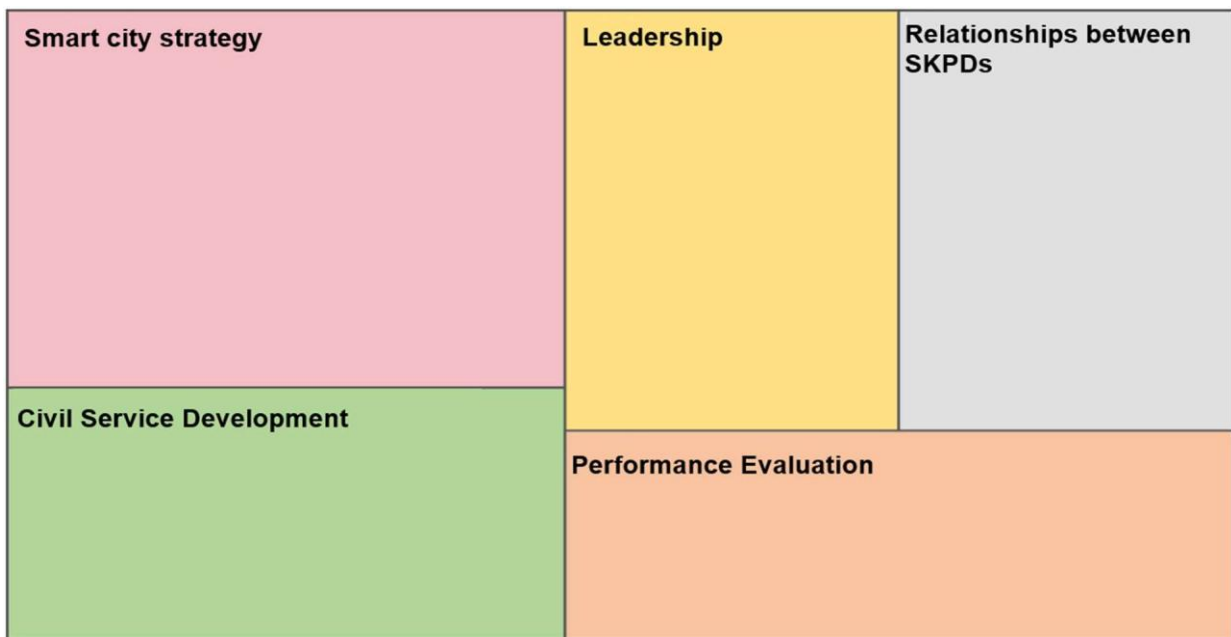


Figure 2. Tree map Diagram of FGD Results among Stakeholders in Banyuwangi Regency

The above explanation of several subsystems and categories describes intricate dynamics of the digital transformation in Banyuwangi. The Smart City policy in Banyuwangi is a leading umbrella policy that includes specific digital infrastructure development, the installation of fiber-optic cables in sub-district centers, the expansion of public WiFi at village offices and schools, and the facilitation of digital access for the community at community learning centers. The development of technology-based public services includes Lapor Banyuwangi (a citizen reporting platform), SIPANDU (an integrated village information system), and e-SIK (an electronic health information system), transforming manual systems into digital ones. These digital solutions have delivered demonstrable results in improving citizens' living standards, such as shortening permit processing time from 5-7

days to 48 hours; enabling farmers to access real-time market prices via mobile applications; and providing digital literacy education to students in remote areas to address educational gaps.

Discussion among stakeholder groups emphasize the importance of integrating this approach with sustainable strategic planning and partnership between the private sector and society. The basis for this Strategy is a leader with sufficient power to move it forward. The leaders of the Regency and the Regional Apparatus Organizations (OPD) play an important role in implementing the digital transformation strategy, as evidenced by the Regent's instruction to allocate 15% of the regional ICT budget to rural digital infrastructure and the creation of the Digital Transformation Task Force. The leader requires vision and the ability to make strategic decisions in a digital innovation environment.

Furthermore, the quality of Inter-SKPD Relations is a significant factor in the successful implementation of the Strategy. The issue of synergistic cooperation between government agencies in Banyuwangi Regency is related to this Strategy. Cooperation and proximity between SKPDs are also essential to ensuring that any digital program is implemented in a coordinated and effective manner, without disrupting one another in the process of building a digital ecosystem. The growth of the State Civil Apparatus (ASN) is a requirement for operationalizing these digital programs and cannot be overlooked. It is crucial that the ASN's skill development, including training and digital skills upgrading, is supported to ensure that public officials are better equipped and prepared to manage digital change. In conclusion, the entire process must be accompanied by a functional system of public performance appraisal. The quality appraisal of the digital program's performance is supported by a set of KPIs that measure all targets, providing helpful feedback for ongoing assessment and policy development.

The relationships among nodes are also crucial for understanding the dynamics of Banyuwangi Regency's digital transformation. All these essential factors involved in transformation, such as leadership, cooperation between SKPDs, cooperation in ASN development, and innovative city strategies, are interlinked, meaning they will NOT occur in isolation but as a robust system.

The model described above is based on data from Focus Group Discussions (FGDs). These connections, revealed through NVivo analysis of stakeholders' narratives, materialized in governance as local practice in Banyuwangi. Strong leadership, such as the Regent's order to accelerate digital transformation, has led to greater cooperation between agencies, as demonstrated by a cross-OPD Digital Transformation Task Force mandated to meet monthly for program coordination. This also involves support for human resource capacity building in digital competencies as part of compulsory training for ASN, with 500+ officials trained in data literacy and e-service management thus far in 2023.

It is also the result of leadership that supports a more effective implementation of the new city concept, as witnessed in the speedy adoption of the SIPANDU (village information system) by 189 villages through joint SKPD budgeting and technical assistance. Likewise, good coordination between SKPDs — that is, between Diskominfo and Dinas Pendidikan — yields synergy in digital patterns, one of which is the smart school scheme, which now also utilizes the same broadband infrastructure funded by the office communications, thereby avoiding duplication of costs. Diagram 5: Relationship between concept, element, and principles in sustainable ITCR. This relationship diagram transforms abstract node-linkages into tangible, actionable ones, in which operational synergies are observable and can be coalesced to build a strong core that can sustain digital transformation in Banyuwangi Regency.

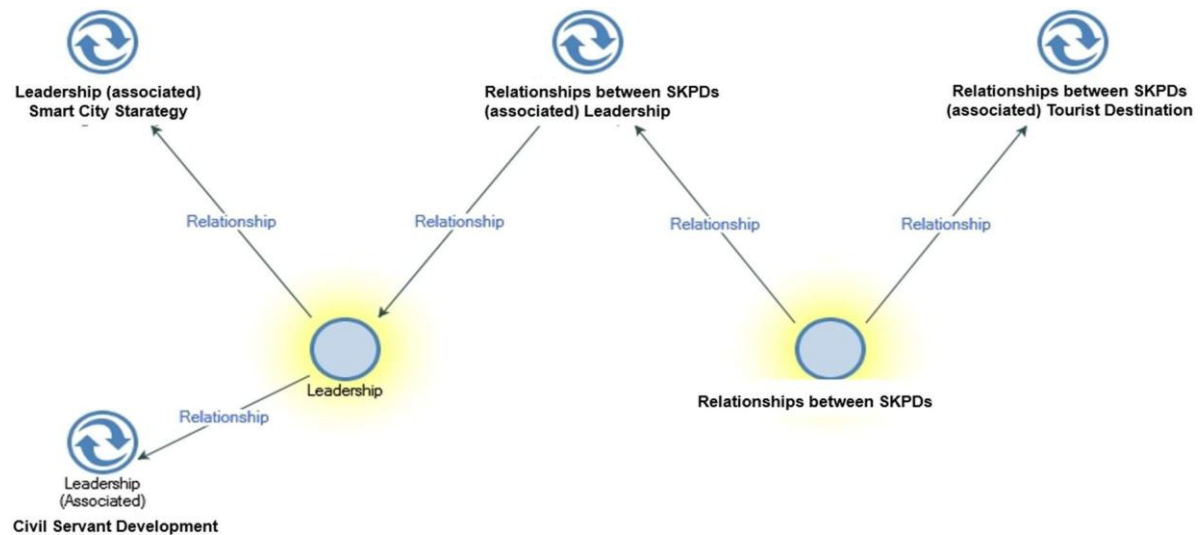


Figure 3. Diagram of the Relationship between Nodes (Key Elements) in Digital Transformation in Banyuwangi Regency

Based on field visits and interviews with stakeholders, this analysis shows that success in digital transformation in Banyuwangi depends not only on technology but also on leadership, multi-stakeholder collaboration, and human resource (HR) capacity. For example, our lines of inquiry show that leadership commitment has led to a regency-level digital roadmap and budget prioritization, resulting in increased private-sector participation in cofinancing village internet access points. Cross-sector cooperation is evident in the co-creation of the Lapor Banyuwangi application, which involves university students, local universities, and community representatives who together help ensure the application's usability for rural citizens. Village officials tailored capacity-building to energize new HR development; 40% uptake of e-gov services supports progress over the past two years. In this regard, the relations between nodes offer a conceptual map and substantiate the perception that interaction and collaboration across different hierarchical levels of government and community sectors can materialize a more inclusive and creative smart city vision.

Figure 3 is a graphical representation of nodes that provides a general understanding and includes several aspects that contribute to the success of digital transformation in Banyuwangi Regency. Each relationship suggests that various factors, such as leadership, inter-SKPD relations, ASN development, and an innovative city strategy, are at play and affect one another.

Strong leadership is the primary driver of the digital transformation ecosystem as a whole. The leader is not only accountable for developing efficient and creative city strategies but also for ensuring that civil servants (ASNs) have the capacity to run diverse digital programs.

Moreover, the type of leadership in the region is decisive for the tightness of cooperation among SKPDs and its synergy with the successful implementation of the programs. Inter-agency coordination between SKPDs is the foundation of integration, ensuring the digital movement does not become isolated. To achieve this, a competent leader would work to create conditions that foster communication and to break down the bureaucratic walls that routinely block interdepartmental collaboration. Good leadership will enable civil servants to receive proper, relevant training, thereby continually enhancing their competence in line with the needs of digitalization. The development of human resources is, in and of itself, the basis for supporting and facilitating future digital programs. Based on the results of the cloud, tree map, and node relationship analysis, the following findings were obtained in Banyuwangi Regency concerning digital transformation success:

- The results of the word cloud analysis suggest that words such as 'communication,' 'community,' and 'leadership' were at the forefront of stakeholder conversations, suggesting their central importance in the context of the change process.
- Tree map analysis revealed the most dominant thematic clusters were "smart city strategy" (with the most coded passages), "leadership," "inter-SKPD relations," "ASN development," and "performance evaluation," indicating the focal areas of intervention.
- Node relationship analysis also revealed strong two-way relationships between leadership and other nodes; for example, leadership directly influenced collaboration among SKPDs, which, in turn, influenced the delivery of digital services and the development of ASN competencies.

Overall, the extent of the digital transformation in Banyuwangi depends on interrelated key factors rather than a single factor. This result is consistent with the study by Caragliu et al. (2011), which affirms that smart cities are not only about technology but also about enhancing synergies among innovation, governance, and citizen involvement. Communication between the government, the public, and agencies needs to be facilitated to develop a digital-friendly environment.

Leadership can help to lead the organization towards a successful, sustainable city strategy, and SKPD collaboration is indispensable to the process of programmed coordination. This multi-stakeholder collaboration is essentially the core of the collaborative governance regime framework literature (Emerson & Nabatchi, 2015) and involves building collaborative structures to attain shared public goals. Further, the performance evaluation of ASN and the improvement of ASN competency are critical factors supporting the success of digital transformation.

The model development of the Smart City for Banyuwangi Regency is an answer to detailed local needs, grounded in the uniqueness of regional potentials and supported by empirical results, including field research, observation, electronic interviews, and document analysis. The model also needs to ensure equal digital access in rural areas—35% of villages still face connectivity issues—through targeted infrastructure investment. It also builds on Banyuwangi's tourism and agricultural prowess with IoT solutions for innovative tourism management and precision farming, which had emerged as a community in each community consultation session.

The model is also built around existing local initiatives, such as the Lapor Banyuwangi citizen reporting platform and the SIPANDU village information system, which have been operating in pilot villages and helping villages improve their services and community engagement. Introducing a whole-of-society approach, the model seeks to foster synergy among government, the private sector, academia, the community, and the media to forge an adaptive, sustainable digital ecosystem that enhances community life.

The Pentahelix framework in this model aligns with the perspectives of Carayannis et al. (2012), affirming that a system of interaction among five knowledge helices, which considers the environment as the fifth pillar, holds that innovation and sustainable development are linked. Led by its outstanding achievements, Banyuwangi Regency is working to bring regencies and cities across Indonesia to level up, particularly in building smart cities that reflect local wisdom and characteristics.

The Banyuwangi Smart City/Smart Village System Model and Philosophy adopt a holistic approach and emphasize multi-stakeholder partnership, visionary leadership, and community vocation as essential to the success model. The importance of public participation in the model of a smart city is its relevance to an inclusive model, where citizens are part of the development process (Hollands, 2008). With the synergy between the Pentahelix elements, this model is capable not only of effectively driving technological innovation but also of increasing social and economic quality of life and a friendly environment, which aligns with the focus on sustainability-oriented innovations (Tura & Ojanen, 2022). Through its Connect, Collaborate, and Celebrate initiatives, Banyuwangi can continue building an adaptive Smart City ecosystem and inspire other regions in Indonesia to do the same.

In this ecosystem model, the local government serves as the leader and coordinator, first inviting stakeholders to play an active role. Regional Apparatus Organizations (OPD) actors play the roles of regulator, policy maker, and provider of infrastructure. At the same time, the business sector is a technology investor and enabler in the implementation of digital infrastructure. Academia contributes its research and solutions for the future; the community aligns, provides feedback, and ensures that the public is an active participant. The media had also had a role in informing and educating the public about the advantages of digitalization. All of these components are linked and work synergistically to realize Banyuwangi's smart City agenda: the establishment of a Digitally Inclusive and Resilient ecosystem (Figure 8). Based on the pentahelix model of collaboration, this framework also defines clear roles for each stakeholder, contributing to an adaptive and sustainable Smart City.

In the Banyuwangi Smart City Ecosystem Model, the actual process of digital transformation and innovation is characterized by collaboration and the inclusion of the most incredible possible diversity of players and approaches in building and developing the solution and the system itself (Caragliu et al., 2011). Banyuwangi plans and integrates all elements of the solution, including enhancing human capital and improving governance processes, rather than merely improving technology.

Its solution-focused, iterative planning strategy reflects the model's understanding of grassroots realities while maintaining a global perspective. The eight-step implementation process of the Smart Kampung model progresses in the following manner: (1) assessing the online literacy of the area, (2) installing basic online infrastructure, (3) developing online e-governance platforms, (4) testing IoT integration within key sectors, (5) solidifying online stakeholder networks, (6) interlinking the whole ecosystem, and (7) adjusting policies through continuous learning to ensure long-term viability.

Banyuwangi has taken a deliberate approach in Stage 4 by adopting global IoT trends but addressing local agriculture issues with soil moisture sensors and precision irrigation in drought-prone regions — a technology that cuts water consumption by as much as 30% without compromising crop yields, as witnessed in pilot villages. Stage 3 While developing mobile apps with vernacular user interfaces and offline modes to meet rural users' needs for reachable public services, directly tackles place-based digital divide Meanwhile, Stage 3 addresses local demand for accessible public services by creating mobile apps with vernacular user interfaces and offline modes to meet rural users' needs for reachable public services, directly tackling place- based digital divides. No mere importing of global technological trends, but rather a careful contextualization for particular local problems, working in and through local culture, building on existing local community structures.

Moreover, the emerging city ecosystem and community participation, with community thinking and acting, emphasize the role of the public in the involvement in development planning and management of Smart Kampung, in accordance with Hollands' (2008) suggestion that Smart Cities need to be inclusive, and citizens have to take part in the development process.

The Banyuwangi Smart City/Smart Village ecosystem prototype is an integrated model, with cooperation among all stakeholders, good governance, and community empowerment as the primary keys. With the convergence of the Penta helix, this paradigm transcends technological innovation to social and economic innovation, yielding a more sustainable and inclusive society. Through the three strategies Connect, Collaborate, and Celebrate, Banyuwangi may continue to build its dynamic Smart City ecosystem and be a model for other parts of Indonesia.

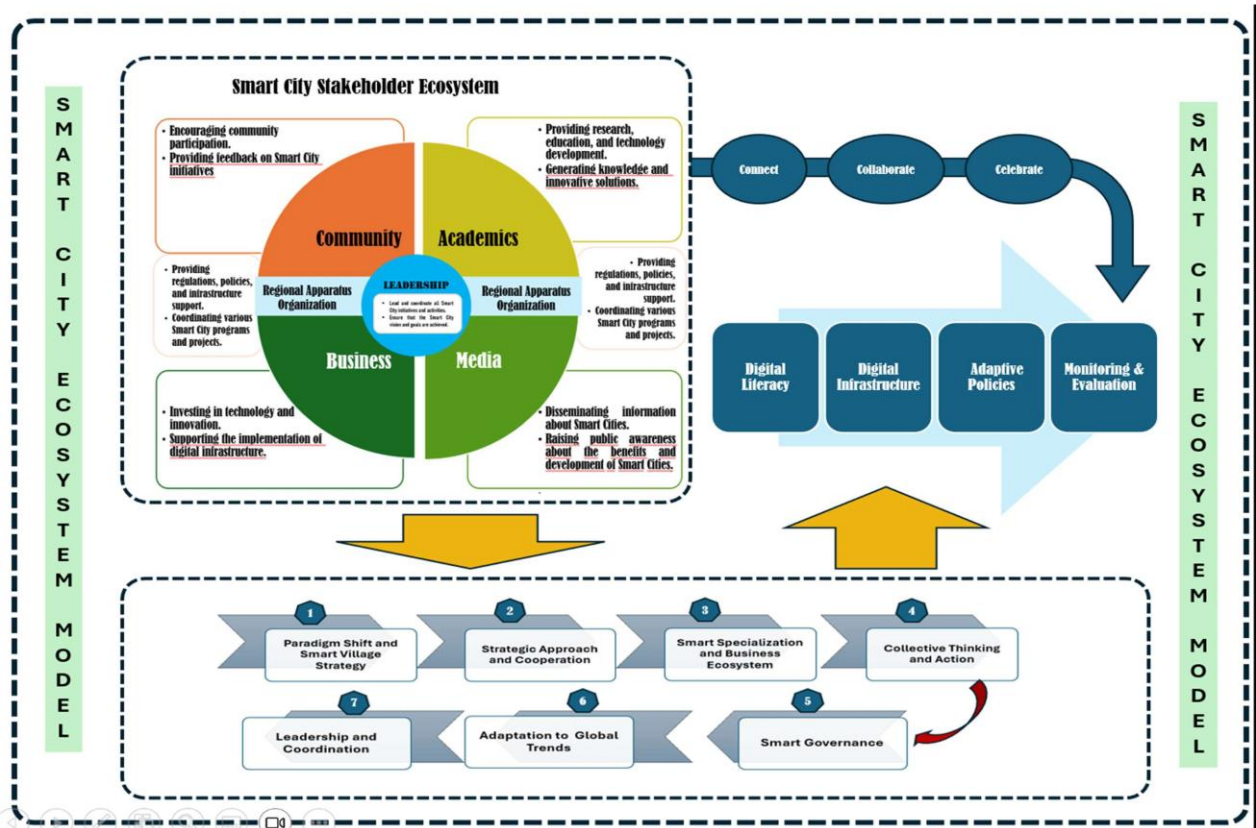


Figure 4. Banyuwangi Smart City Ecosystem Model, adapted from the Pentahelix framework, with each component implemented through the following programs and policies

Banyuwangi has institutionalized each element of this ecosystem model with computable programs and policies. The digital infrastructure materialized through the extension of the fiber-optic cable network to reach 70% of villages and the provision of public WiFi access at 25 strategic service points, with investments from teleco operators such as Telkomsel and Indosat in the expression of the role of business/media. Adaptive policies are pursued through Regent Regulation No. 12/2022 on digital innovation and a regulatory sandbox scheme that permits the testing of IoT technology in agriculture, resulting in a 30-percent reduction in water use in five pilot villages.

Community participation gets a boost through the Digital Ambassador campaign, which has trained 250 youth to serve as digital literacy agents, and the SIPANDU platform, which has boosted citizen participation in village deliberations by 40%. By working with Banyuwangi State Polytechnic, scholars help develop innovative solutions, such as intelligent tourism algorithms. While the new Digital Transformation Task Force, led by the regional secretary, has the overarching responsibility for leadership and coordination, including 15 regional apparatus organizations, it meets monthly to discuss digital initiatives. Therefore, this model not only serves as a conceptual lens for viewing but has also been explored in the governance of Banyuwangi to provide a more inclusive and sustainable nature-based digital transformation.

The following section presents a concise explanation of three key components of an adaptive digital ecosystem model developed within this study. These elements form the core of smart city development in Banyuwangi. These three dimensions – i.e., bolstering digital infrastructure, fostering multi-stakeholder engagement, and formulating adaptive policies – not only emerged as dominant themes in the data analysis but also constitute interrelated, mutually supportive, and operational frameworks. This section is exempt to ensure that

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all observations remain organized while still proving that the entire image is important—the three or four parts work together in harmony. Through fieldwork observations, in-depth interviews, and focus groups, this is how all aspects unfold in Banyuwangi and contribute to building an inclusive, resilient, and sustainable digital ecosystem.

In the model above, having a solid digital foundation enables the "city system" to be "both resilient and innovative." Banyuwangi's vision is to bridge the digital divide by providing fast connectivity to remote villages and building data platforms that enable real-time public service delivery. Nevertheless, what the study unequivocally shows is that merely having digital infrastructure will not be sufficient. What needs to be done is the implementation of digital literacy education for the local populace in the provinces, and the provision of more reliable telecommunications operators with better infrastructure. Technology is not the ultimate goal but rather the multiplier of human talent. The paper calls attention to the importance of the continuous collaboration among the players of the Penta-helix model: government, private sector, academic institution, community, and media. This is implemented in Banyuwangi through partnership forums, co-creation activities, and shared financing. This is exemplified by the development of the Smart Kampung application, intended to integrate multiple interfaces. Universities, telecommunications companies for network deployment, and village heads for collecting feedback. This shared governance model enabled digital solutions tailored to local needs, adopted on a large scale, and financially sustainable.

This article promotes regulatory structures that can accommodate change along with technological development. In the region of Banyuwangi, the approach to regulation is becoming more adaptable, ranging from the development of sandboxes for the Internet of Things applied to Agri farming to public procurement regulations refocused on scalable, open-source digital platforms. Such factors make it easier to pursue innovation and to maintain a focus on holding individuals accountable for their actions to avoid adverse outcomes. Lessons from vision-oriented authorities on adapting to change, to some extent, have contributed to the development of space for technological experimentation for the public good.

In short, the model presented here is based on three key pillars: improved infrastructure, shared governance, and dynamic regulations, led by leadership that is brave, collective, professional, as well as diverse." When you combine motivated talent and technology, strong yet collective, professional, and diverse leadership is a key factor for adequate progress in this mix. Thus, we have to understand the success of digital transformation as resulting from system integration rather than a collection of isolated elements. The practical implication is that future smart city planning answers and solutions should not be based on "isolated" technology-based investments, but rather on whole-system, balanced investments that consider investment in the non-technical portion at par with investment in technological infrastructure. Hence, the Banyuwangi ecosystem model is a strategic, humanistic approach to developing sustainable smart cities in Indonesia.

CONCLUSIONS

Firm and fair digital infrastructure today is a fundamental enabler of sustainable smart city development in Banyuwangi, as this study concludes. Despite some progress, disparities in rural internet access and the availability of digital devices continue to be obstacles to an inclusive transformation. This infrastructure must have a physical dimension but should also parallel investments in digital literacy and the ability to maintain technical systems locally. Hence, it will be necessary for the government of the regency to spur the rollout of the high-speed internet network, particularly in remote and isolated villages, through innovative financing schemes, including Public-Private Partnerships (PPP). At the same time, result-driven digital literacy programs for rural citizens and technical training for local operators need to be expanded to achieve sustainable establishment and utilization.

DEVELOPMENT OF AN ADAPTIVE DIGITAL ECOSYSTEM MODEL TOWARDS
A SUSTAINABLE SMART CITY IN BANYUWANGI REGENCY

Ismail Nurdin, Etin Indrayani, Eem Nurnawaty, Dedhy Guntoro, Ikra Novar Rizqi, M. Rahimi Hasan

The results also highlight that successful Penta helix (government, private sector, academia, community, and media) cooperation is indispensable for developing digital solutions that are both contextual and widely applicable. In Banyuwangi, although some collaborative practices exist, they are scattered and unstable. It was thus proposed that regular multi-stakeholder collaboration forums be institutionalized as co-creation platforms. These should encourage joint planning, the sharing of resources, and equitable feedback. The local government should urge the formation of partnerships that clearly lay out what everyone does, who benefits, and why it is important.

A reading of this literature suggests that adaptive regulatory frameworks are most conducive to innovation while taking public accountability and sustainability into account. A reading of the current situation in Banyuwangi reveals a more reactive policymaking system, making it difficult for investors and innovators to gain clarity. It can be advised in this regard that the regency should encourage a more conducive regulatory environment, relaxing the conditions of visits with the assistance of policy sandboxes, testing new technology in the domain of agricultural tourism with IoT, for example, as well as simplifying public procurement procedures for scalable open-source technology in the digital domain. Moreover, innovation in the region might also derive from innovators focusing on local startups developing new technologies in the digital domain, thereby making a more profound social impact. Any modifications to the regulations, in other words, have to incorporate agility, equity, and sustainability in the environmental domain.

REFERENCES

- Arfiansyah, D., & Han, H. (2021). Bandung smart city: The digital revolution for a sustainable future. In J. C. Augusto (Ed.), *Handbook of smart cities*. Springer. https://doi.org/10.1007/978-3-030-15145-4_92-1
- Bayraktar, H., Bayar, D. Y., & Bilgin, G. (2021). Making cities interoperable in Turkey. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLVI-4/W5-2021, 91–96. <https://doi.org/10.5194/isprs-archives-XLVI-4-W5-2021-91-2021>
- Bokolo Anthony Jnr. (2021). Managing digital transformation of smart cities through enterprise architecture – A review and research agenda. *Enterprise Information Systems*, 15(3), 299–331. <https://doi.org/10.1080/17517575.2020.1812006>
- Carayannis, E. G., Barth, T. D., & Campbell, D. F. (2012). The quintuple helix innovation model: Addressing global warming as both a challenge and a driver for innovation. *Journal of Innovation and Entrepreneurship*, 1(1), 2. <https://doi.org/10.1186/2192-5372-1-2>
- Carayannis, E. G., & Campbell, D. F. J. (2019). *Smart quintuple helix innovation systems: How social ecology and environmental protection are driving innovation, sustainable development, and economic growth*. Springer. <https://doi.org/10.1007/978-3-030-01517-6>
- Carayannis, E. G., Campbell, D. F. J., & Grigoroudis, E. (2021). Helix trilogy: The triple, quadruple, and quintuple innovation helices from a theory, policy, and practice perspective. *Journal of the Knowledge Economy*, 13, 2272–2301. <https://doi.org/10.1007/s13132-021-00813-x>
- Chotary, V., & Stroker, G. (2009). *Governance theory and practice: A cross-disciplinary approach*. Palgrave Macmillan.
- Creswell, J. W. (2015). *Research design: Pendekatan kualitatif, kuantitatif, dan mixed*. Pustaka Pelajar.
- Emerson, K., & Nabatchi, T. (2015). *Collaborative governance regimes*. Georgetown University Press.
- Etzkowitz, H., & Leydesdorff, L. (1997). Universities and the global knowledge economy: The triple helix of university–industry–government relations. *SSRN*.

- Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From national systems and “Mode 2” to a triple helix of university–industry–government relations. *Research Policy*, 29(2), 109–123. [https://doi.org/10.1016/S0048-7333\(99\)00055-4](https://doi.org/10.1016/S0048-7333(99)00055-4)
- Gorelova, I., Dmitrieva, D., Dedova, M., & Savastano, M. (2021). Antecedents and consequences of digital entrepreneurial ecosystems in the smart city development process. *Administrative Sciences*, 11(3), 94. <https://doi.org/10.3390/admsci11030094>
- Goryainova, L. V. (2020). Smart city ecosystem: Elements of concept, coordination challenges, and funding mechanisms in Russia. *Revista Turismo Estudos e Práticas (RTEP/UERN)*, 2020(4), 1–15. <https://geplat.com/rtep/index.php/tourism/article/view/753>
- Helms, M. M., & Nixon, J. (2010). Exploring SWOT analysis – Where are we now? A review of academic research from the last decade. *Journal of Strategy and Management*, 3(3), 215–251. <https://doi.org/10.1108/17554251011064837>
- Horshkov, M. A., & Lozovskyi, O. M. (2021). Trends in the introduction of smart city technologies in urban community development strategy. *Innovative Economy*, 2021(5–6), 87–91. <https://doi.org/10.37332/2309-1533.2021.5-6.12>
- Huertas, J. I., Mahlknecht, J., Lozoya-Santos, J. de J., Uribe, S., López-Guajardo, E. A., & Ramirez-Mendoza, R. A. (2021). Campus city project: Challenge living lab for smart cities. *Applied Sciences*, 11(23), 11085. <https://doi.org/10.3390/app112311085>
- Jang, S., & Gim, T.-H. T. (2022). Considerations for Encouraging Citizen Participation by Information-Disadvantaged Groups in Smart Cities. *Sustainable Cities and Society*, 76, 103437. <https://doi.org/10.1016/j.scs.2021.103437>
- Jo, S., & Lee, S. (2022). Development and application of smart SPIN model: Measuring the spectrum, penetration, impact, and network of smart city industries in South Korea. *Buildings*, 12(7), 973. <https://doi.org/10.3390/buildings12070973>
- Kiliç, A. S. (2022). Smart city as an ecosystem of innovation and entrepreneurship: What open innovation means for cities. *İzmir Democracy University Social Sciences Journal*, 5(1), 79–95.
- Kociuba, D., Sagan, M., & Kociuba, W. (2023). Toward the smart city ecosystem model. *Energies*, 16(6), 2795. <https://doi.org/10.3390/en16062795>
- Kollarova, M., Granak, T., Strelcova, S., & Ristvej, J. (2023). Conceptual model of key aspects of security and privacy protection in a smart city in Slovakia. *Sustainability*, 15(8), 6926. <https://doi.org/10.3390/su15086926>
- Moreira, L. F., & Macke, J. (2023). Proposal of a conceptual framework based on the triple helix of innovation for smart cities: A study in southern Brazil.
- Mudjiyanto, B. (2018). Tipe penelitian eksploratif komunikasi. *Jurnal Studi Komunikasi dan Media*, 22(1), 65–78. <https://doi.org/10.31445/jskm.2018.220105>
- Mukhametov, D. (2019). Smart city: From the metaphor of urban development to innovative city management. *TEM Journal*, 8(4), 1247–1251. <https://doi.org/10.18421/TEM84-20>
- Phadermrod, B., Crowder, R. M., & Wills, G. B. (2019). Importance-performance analysis based on SWOT analysis. *International Journal of Information Management*, 44, 194–203. <https://doi.org/10.1016/j.ijinfomgt.2016.03.009>
- Rotuna, C., Gheorghita, A., Zamfiroiu, A., & Smada, D.-M. (2019). Smart city ecosystem using blockchain technology. *Informatică Economică*, 23(4), 41–50. <https://doi.org/10.12948/issn14531305/23.4.2019.04>

- Santoso, A. S., An, C. M., & Juwono, R. (2022). Jababeka smart township super-app case-study: Hackathon as a mechanism for open innovation. *JIE Scientific Journal on Research and Application of Industrial System*, 7(2), 101–109.
- Sari, A. M. P. (2022). Digital literacy and smart city development: A literature review. *Jurnal Ilmiah Ilmu Komunikasi*, 17(2), 179–192.
- Scuotto, V., Ferraris, A., & Bresciani, S. (2016). Internet of things: Applications and challenges in smart cities: A case study of IBM smart city projects. *Business Process Management Journal*, 22(2), 357–367. <https://doi.org/10.1108/bpmj-05-2015-0074>
- Sharifi, A., Allam, Z., Feizizadeh, B., & Ghamari, H. (2021). Three decades of research on smart cities: Mapping knowledge structure and trends. *Sustainability*, 13(13), 7140. <https://doi.org/10.3390/su13137140>
- Shilpi, S., & Ahad, M. (2020). Blockchain technology and smart cities: A review. *EAI Endorsed Transactions on Smart Cities*, 4(10). <https://doi.org/10.4108/eai.13-7-2018.163846>
- Shvetsova, O., Bialevich, A., Kim, J., & Voronina, M. (2022). Behavioral model deployment for the transportation projects within a smart city ecosystem: Cases of Germany and South Korea. *Processes*, 11(1), 48. <https://doi.org/10.3390/pr11010048>
- Smith, J., & Firth, J. (2011). Qualitative data analysis: The framework approach. *Nurse Researcher*, 18(2), 52–62.
- Suharto, R. A. (2021). The role of government in building smart cities: A case study of Banyuwangi, Indonesia. *International Journal of Public Administration and Management*, 3(2), 123–132.
- Svitek, M., & Kozhevnikov, S. (2023). Smart city 5.0 as digital ecosystem of smart services: Basic concept. In M. D. Lytras, A. A. Housawi, & B. S. Alsaywid (Eds.), *Smart cities and digital transformation: Empowering communities, limitless innovation, sustainable development and the next generation* (pp. 35–57). Emerald Publishing. <https://doi.org/10.1108/978-1-80455-994-920231003>
- Tura, N., & Ojanen, V. (2022). Sustainability-oriented innovations in smart cities: A systematic review and emerging themes. *Cities*, 126, 103716. <https://doi.org/10.1016/j.cities.2022.103716>
- Wahyuddin, Y., & Wibowo, M. (2021). The socio-technical governance of smart city to scaffold city energy transition policy. *Civil Engineering and Architecture*, 9(5), 1409–1420. <https://hal.archives-ouvertes.fr/hal-03311415>
- Widiyastuti, I., Nupikso, D., Putra, N. A., & Intannya, V. A. (2021). Smart sustainable city framework: Usulan model kota cerdas yang berkelanjutan dan integratif. *Jurnal PIKOM (Penelitian Komunikasi dan Pembangunan)*, 22(1), 13–30. <https://doi.org/10.31346/jpikom.v22i1.3297>
- Widodo, B., & Rahman, A. (2021). Analysis of the smart tourism model in South Tangerang City. *Journal of Industrial Tourism*, 4(1), 1–12. <https://doi.org/10.36441/Pariwisata.V4i1>