Spirit Publik
Jurnal Administrasi Publik

Spirit Publik Volume 20, Nomor 2, 2025, Halaman 291-307
P-ISSN. 1907-0489 E-ISSN 2580-3875
URL : https://jurnal.uns.ac.id/spirit-publik/article/view/116294
DOI : https://doi.org/10.20961/sp.v20i2.116294

Pentahelix Collaboration as An Attempt to Optimize Sustainable Waste Management Services in Banyumas Regency

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Abstract
The Zero Waste policy in Banyumas Regency has been implemented through the development of an innovative program called Sumpah Beruang (Sulap Sampah Berubah Menjadi Uang), which utilizes digital technology, such as the Salinmas (Sampah Online Banyumas) and Jeknyong (Ojeke Inyong) applications. Through this program, Banyumas Regency has won an award as the best waste management region in Indonesia. However, the effectiveness of the program has declined each year, as indicated by a decrease in the number of application users, while the volume of waste continues to increase. This study aims to identify the factors that influence the success and failure of the sustainability of an effective digital waste management system. This study uses a descriptive qualitative method with a literature review approach. The data obtained was analyzed using the Collaborative Governance theory by Ansell and Gash (2008) with a pentahelix collaboration model involving the government, academics, the community, the media, and the private sector. This approach is aimed at realizing a circular economy that supports the achievement of the Sustainable Development Goals (SDGs), particularly goal 12 on responsible consumption and production. The main idea of the research emphasizes the importance of inclusive and collaborative governance to optimize the performance of the Salinmas and Jeknyong applications, while strengthening the role of stakeholders and the community in reducing waste generation. The results of the study show that the decline in the effectiveness of the Salinmas and Jeknyong applications is due to two main factors, namely the lack of collaboration between stakeholders in system maintenance and the low level of community participation in waste sorting. In addition, to encourage the sustainability of the Salinmas and Jeknyong programs, there is a need to increase collaboration between stakeholders and active community participation so that waste management in Banyumas Regency can be carried out effectively and sustainably.
Keywords: Governance, Pentahelix, Digital Technology, Zero Waste

INTRODUCTION

The increasing rate of urbanization and economic growth in various regions has significantly changed people's consumption patterns, which directly implies an increase in the volume of waste generated (Jovanca & Shara, 2025; Pratomo et al., 2023). These conditions have a significant impact on the environment, including soil, water, and air pollution, as well as threatening the health, quality of life, and welfare of the community (Aunal et al., 2023; Wu et al., 2023). To address these challenges, the Zero Waste concept has emerged as an innovative solution that reduces waste generation comprehensively through cleaner consumption and production patterns based on sustainable products (Achmad, 2024; Valenzuela-Fernández & Escobar-Farfán, 2022). This approach not only encourages the creation of a circular economy system that maximizes resource reuse, but

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also supports the achievement of Sustainable Development Goals (SDGs) target 12.5, which emphasizes substantial waste reduction by 2030 through prevention, reduction, recycling, and reuse (Valenzuela-Fernández & Escobar-Farfán, 2022; Verawati, 2022; Widiatmoko et al., 2024).

In Indonesia, the Zero Waste principle is implemented through policies outlined in the Operational Plan document "Zero Waste Zero Emission 2050" published by the Ministry of Environment and Forestry (KLHK) (Alyka & Boedi Andari, 2025). This document sets a target of achieving "zero waste" by 2040 as a first step towards achieving "zero emissions" by 2050 (Hendra et al., 2024). In line with this, the Zero Waste policy emphasizes the principle of inclusiveness through the active participation of various parties, including the central government, local governments, the private sector, and the community (Widiatmoko et al., 2024). This is in accordance with Law No. 18 of 2008 on Waste Management, which authorizes local governments to collaborate with other regions, partner with business entities, and encourage community participation in waste management (Hendra et al., 2024). Thus, waste management is a shared responsibility that requires cross-sector coordination and collaboration (Koiwanit & Filimonau, 2023; Wandira et al., 2025).

As the fourth most populous country in the world, with a population of around 277.7 million, Indonesia faces serious challenges in waste management (Sinambela et al., 2024). According to data from the National Waste Management Information System (SIPSN) in 2024, out of 323 districts/cities, the total national waste generation reached approximately 35 million tons per year. Of this amount, waste reduction efforts have only been able to reduce approximately 1.11% or only 390 thousand tons per year, while waste management through various processing facilities has only been able to reach 37.53% or around 13 million tons per year. As a result, the total waste that has been successfully managed only reaches 38.63%, while the remaining 61.37%, or 21 million tons per year, has not been properly handled and has the potential to cause increasingly complex environmental problems (SIPSN, 2025).

A similar challenge was also experienced by Banyumas Regency, which faced a waste emergency crisis in 2018 due to suboptimal waste management from upstream. (Utama *et al.,* 2024). To follow up on this issue, the Banyumas Regency Government released Circular Letter (SE) Number 660.1/7776/2018 concerning Waste Management, which refers to Banyumas Regency Regulation (Perbup) Number 45 of 2018 concerning Banyumas Regency Policies and Strategies in the Management of Household Waste and Household-like Waste (Pradana & Yuwono, 2023). This policy is reinforced by the innovative SUMPAH BERUANG (Sulap Sampah Berubah Menjadi Uang) program through the Salinmas (Sampah Online Banyumas) and Jeknyong (Ojeke Inyong) digital applications to strengthen the integrated management system from source to final stage towards zero waste to landfill (Rosyidah, 2024; Siagian, 2025). Through the Salinmas and Jeknyong applications, the waste management service system in Banyumas has

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transformed from a passive manual method, which involved waiting for the community to come to the waste processing site, to an active service with a direct pick-up system from residents' homes (Pradana & Yuwono, 2023; Rosyidah, 2024).

These transformation efforts have successfully earned the Banyumas Regency government an award as the region with the best waste management in Indonesia (Galuh & Sunarno, 2024). This recognition was evidenced by Banyumas being selected as the host of the Smart Green ASEAN Cities (SGAC) Program's 2nd City Windows Series in 2023, an ASEAN forum that brings cities together to share environmentally friendly practices with the Ministry of Environment and Forestry and the ASEAN Secretariat (Pratami et al., 2025). In addition, in 2025 Banyumas was awarded the 6th ASEAN Environmentally Sustainable Cities (ESC) Award along with the 5th Certificate of Recognition (COR) in Malaysia as a form of appreciation for the successful implementation of sustainable environmental management with the main indicators of air quality, clean water availability, and land management (Kompas, 2025). Thus, environmental governance in Banyumas not only has an administrative impact but also generates substantive recognition at the national and regional levels as a model of good practice in sustainable environmental management.

However, despite these achievements, waste management in Banyumas Regency still faces a number of challenges, one of which is low community participation and minimal collaboration between stakeholders (Marlina et al., 2021). This situation has led to a decline in the use of Salinmas digital services and the suspension of Jeknyong operations, indicating sustainability issues in the implementation of waste management technology (Fahlevi, 2025; Ramadhani & Adnan, 2023). Furthermore, these challenges are worsened by the continuous growth in population, along with the increasing volume of waste generated. According to data from the Banyumas Regency Communication and Information Agency (Diskominfo) in 2025, the population increased from 1,789,630 in 2021 to 1,842,582 in 2022, reaching 1,857,211 in 2023. Along with this, waste generation has also increased every year. The following is data on the amount of waste generated in Banyumas Regency.

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Figure 1. Diagram of waste volume data for Banyumas Regency
Sumber: National Waste Management Information System (SIPSN) 2025

According to SIPSN data in 2022, waste generation in Banyumas Regency was estimated at 195,357.75 tons, increasing to 197,758.42 tons in 2023, and reaching 200,228.74 tons in 2024. This upward trend indicates that existing waste management services are not yet fully capable of keeping pace with the growth in waste generation, necessitating a sustainable improvement in waste processing services in Banyumas Regency.

Previous studies have highlighted the issue of waste management in Banyumas Regency, such as that conducted by Oktaviani et al., (2023), which shows that public education and infrastructure development play an important role in increasing public awareness of waste management in Banyumas Regency. The study also emphasizes the importance of providing adequate facilities and the role of local government in encouraging behavioral change among the community. In line with these findings, Ramadhani and Adnan (2023) conducted research on the implementation of the Salinmas digital service and found that this innovative program has not been running optimally. Problems that have arisen include a decline in the number of application users, a lack of continuous socialization, and limited human resources and budgets that affect program implementation. In addition, the Salinmas application also faces technical obstacles, preventing it from functioning optimally on the various devices used by the community. These issues show that the challenges faced are not only technical in nature but also relate to how policies are implemented and managed at the bureaucratic level. Therefore, Ramadhani's research emphasizes the dimensions of policy implementation and bureaucratic governance in public service innovation.

Responding to the lack of research and the urgency of solving waste problems in Banyumas, this study explores community-based waste management and circular economy principles within an inclusive governance framework through a penta helix approach analyzed using Ansell and Gash's (2008) Collaborative Governance theory, focusing on the Salinmas and Jeknyong digital services. This approach is expected to strengthen community participation in waste sorting, improve the effectiveness of digital

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programs, and support the implementation of the zero waste concept towards a circular economy in line with the achievement of the Sustainable Development Goals, particularly goal 12 on responsible consumption and production. Thus, this research is important for formulating more inclusive and collaborative governance strategies, which not only improve the performance of waste transportation and processing systems but also strengthen the role of non-governmental actors in supporting equitable and sustainable waste management practices.

METHODS

The method used in this study was descriptive qualitative with a literature study approach. The descriptive qualitative method was chosen because it allows researchers to explore in depth the complexity of policy phenomena through an understanding of the context, process, and meaning behind its implementation (Hariawan et al., 2025). Literature study is understood as a systematic effort to collect, review, and analyze various sources relevant to the issue being studied (Febrianto et al., 2024). This approach was used because the research focused on interpreting meaning, analyzing policies, and interpreting data from various sources to build a conceptual understanding of the dynamics of digital-based waste management in a collaborative framework (Saádi, 2023). Data collection was carried out through a review of policy documents, program reports, official publications of the Banyumas Regency Government, regional regulations related to waste management, academic papers, and relevant previous studies (Thamrin et al., 2022).

The analysis began with an assessment of the implementation of the Zero Waste policy in Banyumas Regency through the Sumpah Beruang program, which utilizes the Salinmas and Jeknyong applications as instruments for service digitization. This was followed by an examination of the existing conditions of digital waste management services in Banyumas Regency to determine the compatibility between policy design and implementation reality. Next, the analysis is deepened using Ansell and Gash's (2008) collaborative governance theory with a pentahelix collaboration model involving the government, academics, community, media, and private sector. This framework is used to explain the dynamics of stakeholder relations, role distribution, and structural and institutional factors that influence the sustainability of the Zero Waste policy and the phenomenon of declining effectiveness of digital waste management in Banyumas Regency.

RESULTS AND DISCUSSION

Waste management from a governance theory perspective is understood as a management process that is not only centered on the government as the main actor, but also involves various other actors who have significant roles (Abatan et al., 2025). Governance theory emphasizes the importance of the participation of non-governmental

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DOI : https://doi.org/10.20961/sp.v20i2.116294

organizations, the private sector, and society in formulating and implementing public policies through collaborative collective action (Smith & Osborn, 2006; Noor et al., 2022). By involving the community as waste producers, together with managers and formal and informal institutions in policy formulation to implementation, a sense of ownership and shared commitment to waste management will be created (Gachoki et al., 2022; Lingga et al., 2024). This sense of ownership then encourages each actor to be more responsible for their actions, creating a harmony of behavior that ultimately supports the achievement of Sustainable Development Goal (SDG) 12 on responsible consumption and production (Gachoki et al., 2022; Hendra et al., 2024).

The current orientation of waste management is no longer focused on final disposal, but rather directed at reducing waste generation at source through changes in consumption patterns, sorting, and initial processing at the household and community levels (Apaydın, 2025). The zero-waste policy requires a change in perspective, viewing waste not merely as residue that must be disposed of, but as a resource that still has economic and social value if managed according to the principles of sustainability and the circular economy (Dada et al., 2024; Mohajan, 2025). Within this framework, the circular economy emphasizes waste reduction, reuse, and recycling of materials throughout the entire production, distribution, and consumption cycle (Kirchherr et al., 2017). Operationally, this principle is realized through three main strategies, namely material reuse, product life extension, and the development of more efficient and value-added production processes (Bocken et al., 2016). The implementation of this policy requires inclusive governance, as zero waste can only be achieved through the active involvement of all actors in an integrated system (Valentina et al., 2025). In line with these needs, the collaborative governance approach emphasizes deliberation, trust building, and cross-actor cooperation in policy formulation, implementation, and evaluation, so that development programs are not only technically effective, but also inclusive and sustainable (Noor et al., 2022; Setiawandari & Kriswibowo, 2023).

Ansell and Gash (2008) assert that collaborative governance is an extension of the concept of governance that emphasizes the resolution of complex public issues through consensus built in deliberative forums between the government and non-governmental actors. This model places the process of dialogue and trust building as the main foundation for achieving legitimate and mutually acceptable decisions (Bilqis et al., 2025). This thinking is in line with Stoker (2008), who states that the collaborative governance model centers on the formulation of public policies that are decided jointly through interaction and agreement between actors in a participatory governance process. In the face of technological developments and increasingly complex human resource dynamics, the government no longer has sufficient capacity to act unilaterally, thus requiring the involvement of various actors in the policy implementation process so that the resulting policies are more adaptive and effective (Prabowo & Lukman, 2026). This concept is increasingly relevant in the digital era, when public waste management

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governance is also beginning to be realized through technology-based services (Rittl et al., 2025).

The use of technology in public waste management not only speeds up the service process and improves efficiency, but also expands access to information for the community and encourages more active public participation (Mansyur et al., 2025). In Banyumas, waste management is promoted through two innovative applications that collaborate with Community Self-Help Groups (KSM), namely Salinmas and Jeknyong (BRIN, 2024). KSM was formed to facilitate digital-based waste collection services through the Salinmas application, so that residents do not need to bring their waste to a specific location (Pradana & Yuwono, 2023; Putranto et al., 2022). Through Salinmas, the community can sell sorted organic waste to KSM at a price of IDR 400 per kilogram, which is then managed through transportation, sorting, and processing into economically valuable products such as compost and Refuse-Derived Fuel (RDF) (Siagian, 2025; Utama et al., 2024). Meanwhile, Jeknyong connects the community with more than 100 three-wheeled motorcycle driver partners to pick up household waste (Widyastuti, 2025). Sorted inorganic waste is picked up by motorcycle driver partners through the Jeknyong application, then handed over to KSM for further processing (Manurung et al., 2023). Through this app, the community can sell sorted waste, and officers weigh and purchase the waste according to type and weight, with varying prices, for example, IDR 1,500 per kilogram for plastic bottles (Widyastuti, 2025).

Over time, the use of the Salinmas and Jeknyong applications has faced a number of challenges that have affected the effectiveness of waste management in Banyumas (Utami, 2024). Salinmas has experienced a decline in the number of users over the last few periods, while Jeknyong is no longer operational (Fahlevi, 2025; Ramadhani & Adnan, 2023). One of the main problems is low community participation, as many residents are still unfamiliar with or unmotivated to sort waste from their households (Fahlevi, 2025). In fact, active community involvement is crucial to the success of these applications, both in ensuring the smooth transportation, sorting, and processing of waste, and in supporting the creation of sustainable waste management practices (Marlina et al., 2021; Putra, 2025). This challenge is worsened by technical problems, such as network disruptions that hinder data transmission, unstable servers, and limited device compatibility, resulting in a less than pleasant user experience and a significant decline in the number of active users (Aulia et al., 2024; Pradana & Yuwono, 2023; Ramadhani & Adnan, 2023).

In addition, public awareness and education regarding 3R-based waste management through the Salinmas and Jeknyong applications is still uneven (Utami, 2024). Information conveyed through face-to-face meetings and social media is often limited by the lack of assistants and human resources, so that some residents still do not understand how to sort waste properly and use the application optimally (Fahlevi, 2025; Ramadhani & Adnan, 2023). The operational capacity of KSM is also a limiting factor,

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as sometimes KSM is unable to accommodate or process the collected waste optimally, resulting in temporary accumulation that disrupts the smooth management process (Ilhami, 2024). On the Jeknyong side, coordination between driver partners, the community, and KSM is also not always smooth, so that inorganic waste is not always picked up on time, causing uncertainty in the management process (Utami, 2024). These various challenges indicate that waste management in Banyumas requires a more structured and inclusive cooperation mechanism between actors so that existing programs can run effectively.

The effort to strengthen the waste management system in Banyumas can be done through the Pentahelix approach as a collaborative strategy that brings together the government, private sector, academics, community, and media, within an integrated governance framework, so that waste management practices based on the Salinmas and Jeknyong applications are not only technically effective but also socially, economically, and environmentally sustainable (Hendra et al., 2024; Nafi'ah et al., 2024). This approach requires a clear division of roles between actors and a coordination mechanism that can synergize the capacities and resources of each party. The Salinmas application needs to be encouraged to expand its service coverage through improved digital infrastructure and more intensive socialization strategies so that community participation increases. Meanwhile, Jeknyong requires operational revitalization through improved coordination between driver partners, KSM, and residents, as well as adequate technical support so that inorganic waste collection services can run consistently and on time. The strengthening of these two applications needs to be followed by data integration and a transparent reporting system to support responsive decision-making.

This Pentahelix approach is analyzed with regard to six parameters formulated by Ansell and Gash (2008). First, there is a forum, part of whose authority lies with public institutions (Ansell & Gash, 2008). This forum is strengthened through the leadership of the Banyumas Regency Government, particularly the Environmental Agency (DLH), which acts as a regulator and policy facilitator. The DLH has a strategic role in designing programs, allocating budgets, and building waste treatment infrastructure connected to the Salinmas and Jeknyong services (Hertati & Nurhadi, 2023; Siagian, 2025). This public leadership needs to ensure that cross-actor coordination runs effectively so that the collaboration forum not only functions administratively but is also able to overcome technical obstacles (Nurhayati et al., 2024; Widyastuti, 2025). In this case, the position of the DLH is not merely as a policy implementer, but as a director of the collaboration agenda that ensures the integration of the roles of the government, private sector, academics, community, and media within a structured governance framework.

Second, the existence of policy actors outside the government (Ansell & Gash, 2008). The involvement of policy actors outside the government is key to supporting the sustainability of Salinmas and the revitalization of Jeknyong. The private sector can strengthen logistical and technological support, for example by providing additional

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vehicles, improving transportation infrastructure, and developing digital systems that facilitate the tracking and coordination of waste transportation, so that Jeknyong's operations can run more smoothly and on time, while Salinmas can expand its service coverage and improve accessibility for the community (Hertati & Nurhadi, 2023; Pratami et al., 2025). Academics play a role in providing data-based research to evaluate the performance of both programs, designing waste management innovations that are appropriate to the local context, and organizing training for managers so that their technical and managerial capacities continue to improve (Artiar & Triyono, 2024). Community members are the main drivers in the field by increasing public participation in sorting waste from households, ensuring that organic and inorganic waste flows can be managed effectively through Salinmas and Jeknyong, and maintaining the sustainability of these services (Artiar & Triyono, 2024; Asnaini et al., 2022; Hertati & Nurhadi, 2023). The media plays a strategic role in disseminating educational information about the use of Salinmas and Jeknyong, while also running awareness campaigns to encourage the public to continue participating in and supporting the sustainability of these two digital-based services (Widyastuti, 2025).

Third, the direct involvement of non-governmental actors in the policy process is not merely a formality or consultation, but is realized through concrete communicative actions (Ansell & Gash, 2008). In the context of Salinmas, effective communication between actors is important to strengthen community participation, disseminate information about services, and ensure the operational sustainability of the application. Meanwhile, in Jeknyong, interaction between actors is necessary to coordinate service revitalization, improve the transportation system, and harmonize the roles of driver partners, KSM, and the community (Ade, 2024; Harlyandra & Kafaa, 2021; Silaningrum, 2022). Fourth, collaboration must be clearly scheduled so that program implementation can be measurable and consistent (Ansell & Gash, 2008). For Salinmas, a structured agenda is needed to expand service coverage, database integration, and education and incentive programs that encourage active community participation. Meanwhile, for Jeknyong, collaborative scheduling focuses on operational revitalization, including fleet maintenance, driver partner coordination, and monitoring of inorganic waste flow. A structured agenda allows for periodic evaluation, continuous improvement, and ensures that both applications support a more effective waste management system (Pekasih, 2022; Sianturi et al., 2024).

Fifth, the agreed policy is based on consensus among all key actors (Ansell & Gash, 2008). The resulting policy decisions emphasize mutual agreement, particularly in formulating behavior-based incentives for environmentally friendly practices and the allocation of budgetary support (Islamiati, 2024). Consensus-based policies will promote the sustainability of both services while ensuring that programs run effectively and on target (Destiani et al., 2025). Sixth, collaboration focuses on public policies and programs to ensure that the results achieved are in line with the needs and expectations of the

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community (Ansell & Gash, 2008). This focus is realized through joint efforts to strengthen the Salinmas application and revitalize Jeknyong, improve public education on waste management, and create a circular economy that supports waste reduction and sustainable reuse of materials (Hertati & Nurhadi, 2023; Islamiati, 2024).

With the continuation of Salinmas and the revitalization of Jeknyong through the Pentahelix approach, the second scheme of these two applications not only provides economic value to the community but also builds collective awareness to manage waste independently (Pradana & Yuwono, 2023). By encouraging active participation, this system increases environmental responsibility, minimizes the volume of waste entering landfills, and supports the creation of sustainable waste management practices while supporting the achievement of zero waste targets in Banyumas Regency (Utama et al., 2024; Widyastuti, 2025a). Additionally, when processed by KSM, organic waste, such as food scraps and agricultural waste, is converted into compost and maggots, while inorganic waste is processed into paving or plastic roof tiles and RDF, which is an alternative fuel to replace coal (Utama et al., 2024). This processing creates a circular economy, where waste that was initially worthless is converted into reusable products, resulting in a more efficient resource use cycle, providing additional economic benefits to the community, and at the same time supporting environmental sustainability (Djuniardi et al., 2025; Ritzkal et al., 2025).

CONCLUSION

Waste management in Banyumas Regency shows that the implementation of Salinmas and Jeknyong digital services has great potential in supporting the principles of zero waste and circular economy, but its sustainability still faces significant challenges, particularly related to low community participation, limited capacity of community-based organizations (KSM), and technical issues with the applications. The Pentahelix approach is a relevant strategy for strengthening collaboration between the government, private sector, community, academia, and media, so that each actor can contribute optimally in expanding service coverage, increasing community involvement, and ensuring effective application operations. With good coordination, Salinmas can continue to actively collect waste, while Jeknyong can be restored to be able to collect inorganic waste on time, while also building collective awareness and environmental responsibility in the community.

Based on these findings and analysis, the recommended strategic steps include technical improvements to the application, integration of digital systems between services, increasing the capacity of KSM as the operational implementer, and strengthening community-based education and socialization to build sustainable environmentally friendly behavior. Support from academics and the private sector through applied research, technological innovation, and investment in digital infrastructure is needed to strengthen the effectiveness and sustainability of Salinmas and Jeknyong, while the role of the media is an important instrument in expanding

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information dissemination and increasing public participation. The success of digital-based waste management in Banyumas Regency is highly dependent on the collective commitment of all stakeholders to maintain regulatory consistency, strengthen collaborative governance, and ensure the continuity of a pentahelix ecosystem that is adaptive to local social and cultural dynamics. Through the integrated implementation of these recommendations, Salinmas and Jeknyong not only contribute to enhancing the economic and social value of the community but also establish an innovative, inclusive, and long-term oriented waste management system to support the achievement of the zero-waste target in Banyumas Regency.

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