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A model for sustainable city and community development based on local potential and wisdom towards Blue Villages in Indonesia

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CITATION

Kunyati SA, Setiawan A, Santri T, et al. (2024). A model for sustainable city and community development based on local potential and wisdom towards Blue Villages in Indonesia. *Journal of Infrastructure, Policy and Development*. 8(16): 9526. <https://doi.org/10.24294/jipd9526>

ARTICLE INFO

Received: 9 October 2024

Accepted: 5 December 2024

Available online: 31 December 2024

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Abstract: Indonesia, as a maritime country, has many coastal areas with fishing villages that have significant potential, especially in sociological, economic, and environmental aspects, to be developed as models for sustainable development. Indonesia, with its long-standing fishing traditions, showcases the abundant potential and traditional that could help address global challenges such as climate change, rapid urbanization, and environmental and economic issues. This study aims to develop a conceptual model for sustainable cities and communities based on local potential and Wisdom towards the establishment of a Blue Village in the fishing village of Mundu Pesisir, Cirebon, Indonesia. The urgency of this study lies in the importance of developing sustainable strategies to address these challenges in coastal towns. This study involves an interdisciplinary team, including experts in sociology, social welfare, architecture, law, economics, and information technology. Through the identification of local natural and sociocultural resources, as well as the formulation of sustainable development strategies, this study develops a conceptual Blue Village model that can be applied to other coastal villages. The method employed in this study is qualitative descriptive, involving the steps of conducting a literature review, analyzing local potential, organizing focus group discussions, conducting interviews, and finalizing the conceptual model. The study employed a purposive sampling technique, involving 110 participants. The results of the study include the modeling of a sustainable city and community development based on local potential and Wisdom aimed at creating Blue Villages in Indonesia, and It is expected to make a significant contribution to the creation of competitive and sustainable coastal areas capable of addressing the challenges of climate change and socioeconomic dynamics in the future.

Keywords: communities; sustainable cities; Blue Villages; local potential; development; process innovation

1. Introduction

Sustainable development is now a critical global priority, especially in tackling issues like climate change, rapid urbanization, and environmental degradation. Indonesia which has the world's second-longest coastline, boasts coastal areas that are vital to its economy and environmental sustainability. The fishing villages along Indonesia's coastline offer immense potential in their natural resources and

sociocultural heritage (Kovačić et al., 2024). However, these areas often lag in terms of infrastructure development, technology, and community welfare. Sociologically, communities usually exhibit a low work ethic, organizational structures, and institutional management lack professionalism, and they remain primarily oriented towards paternalistic and traditional practices.

The concept of Sustainable Cities and Communities, as part of the Sustainable Development Goals (SDGs), is highly relevant for implementation in coastal villages (McMichael and Katonivualiku, 2020). This concept focuses on achieving a balance in the utilization of natural resources. (Ahmed et al., 2020) while improving quality of life without compromising long-term sustainability. Data indicates that the poverty rate in Cirebon Regency is approximately 11.20% of the total population or around 249,180 people. The Human Development Index (HDI) is 70.95, a figure still below the national average in Indonesia. A development model should aim to improve the welfare of its people by managing village potential as a form of local Wisdom. Previous studies have revealed that management based on local Wisdom (Cahyono et al., 2022) plays a crucial role in preserving ecosystems and improving the welfare of coastal communities (Foale et al., 2013; Sui et al., 2020). Local traditions, such as the Nadran ceremony in Cirebon, which represents the fishermen's gratitude for their catch, can be optimized as a foundation for developing sustainable creative economies (Duffy and Meisner, 2023). However, coastal villages in Indonesia still face significant challenges, such as poverty, limited access to technology, and agrarian conflicts related to coastal land (Jia et al., 2021). Agrarian conflicts often occur in coastal areas related to newly formed land, as high sedimentation in these regions can expand the shoreline. However, its ownership usually becomes a source of conflict among residents.

To address these challenges, a development model is needed that integrates local potential, traditional Wisdom, and modern technology sustainably. (Gain et al., 2021; Ichsan et al., 2024) The proposed "Blue Village" model aims to preserve coastal ecosystems while simultaneously improving the economic welfare of the community. Krsak (2020) through sustainable resource management and the use of technologies such as the Internet of Things (IoT) and e-commerce. This model is highly relevant to supporting the achievement of the SDGs, particularly those related to marine ecosystem preservation and poverty alleviation (Phelan et al., 2020; Tarigan, 2023).

Indonesia, as an archipelagic country with a coastline of 95,181 km, is home to coastal communities that heavily rely on marine resources for their daily livelihoods (MacLeod et al., 2010). Indonesia is the largest archipelago in the world, consisting of 17,504 islands, including 9634 unnamed islands and 6000 uninhabited ones. Indonesia has the highest ethnic diversity globally, encompassing over 740 ethnic groups and 583 regional languages. Although this diversity offers immense potential to enhance welfare, it poses significant risks of societal vulnerability and potential national disintegration, potentially impoverishing citizens both economically and socially. This could stall the development process, leaving the nation increasingly fragile.

With the rapid population growth, threats such as climate change, pollution, and overfishing have increasingly deteriorated marine ecosystems, which in turn affect the livelihoods of coastal populations. (Kusumawati et al., 2020; Qadarisma et al., 2021). This condition is exacerbated by the decline of mangrove forests, which should serve

as natural barriers against coastal erosion and as critical habitats for various marine species (Phelan et al., 2020). One of the villages in Cirebon Regency, Mundu Pesisir, continues to preserve its mangrove forest habitat, with plans to expand it to 7 hectares, while it currently spans 5 hectares. Indonesia holds 23% (3,489,140.68 hectares) of the world's mangrove ecosystems, making it the largest globally. The total global mangrove area is 16,530,000 hectares, of which 1,817,999.93 hectares are degraded. Thus, its management must be community-based.

Through community-based management and the adoption of modern technology, efforts to preserve the environment and empower socioeconomic activities in coastal areas can be significantly enhanced. This study aims to develop a sustainable development model that integrates local potential and traditional Wisdom with digital technology, using Mundu Pesisir Village in Cirebon as a case study. This model is expected to serve as a practical solution that can be replicated in various coastal villages across Indonesia that are facing similar challenges.

2. Material and methods

This study employs a qualitative descriptive method to develop the Blue Village model based on local wisdom and modern technology in Mundu Pesisir Village, Cirebon. The descriptive method is used to uncover facts with accurate interpretation related to a group of people, an object, a set of conditions, a system of thought, or a class of events in the present (D'Alessandro et al., 2022). The data collected include both primary and secondary data relevant to natural resources, local Wisdom, and the use of technology in managing coastal resources.

The primary data were collected using in-depth interviews involving 110 respondents representing diverse community groups. These comprised 15 fishermen, 25 traders, seven village officials, five community leaders, seven civil servants (PNS), and 51 general community members. Focus group discussions (FGDs) were also held involving traditional leaders and village officials to examine customary practices, socioeconomic conditions, and the challenges faced by coastal communities.

Secondary data were collected through a literature review focused on resource management grounded in local wisdom, the integration of Internet of Things (IoT) technologies, and strategies for blue economy development (Adnan, 2023; Airawati, 2023). IoT technology is employed to monitor critical parameters such as water quality, temperature, and environmental conditions, particularly in the fisheries and maritime tourism sectors. Additionally, e-commerce platforms are utilized to enhance the marketing of local products, including fishery goods and handicrafts (Gao and Liu, 2020; Mack et al., 2020).

Qualitative data were collected through in-depth interviews to explore resource management practices, technology adoption, and community participation in environmental conservation efforts (Adnan, 2023). These data offer valuable insights into the interplay between traditional practices and technological innovations within coastal communities. Supplementary data delve into the marketing of local products via e-commerce platforms, with a particular focus on enhancing market access for fishermen and local artisans in coastal villages. Collected data include metrics such as transaction volumes, income growth, and enhanced logistical efficiency stemming

from e-commerce utilization (Gao et al., 2023). These findings can inform the development of training programs on IoT technology and e-commerce utilization, alongside initiatives to strengthen local-value-based institutions to enhance their roles in coastal resource management (Foale et al., 2013; Phelan et al., 2020; Tarigan, 2023). Such an approach aims to bolster community capacity to adopt modern technologies, improving resource management efficiency and broadening market access for local products. Support from local institutions rooted in established wisdom practices will ensure the sustainability of Blue Village development initiatives.

Several parameters are used to measure the success of the Blue Village model, including environmental, social, and economic aspects. The ecological aspect is measured by monitoring water quality, clean water quantity, and coastal temperature using IoT sensors (Adnan, 2023; Mack et al., 2020).

The social dimension was evaluated by analyzing community participation in environmental management, technology adoption, and involvement in safeguarding traditions and local wisdom practices, exemplified by the Nadran ceremony. Data were gathered through in-depth interviews with residents to explore their perceptions of modern technology and its role in supporting environmental conservation (Foale et al., 2013; Tarigan, 2023).

The economic aspect is measured by tracking changes in community income. Nugraha (2021) Before and after interventions, the number of e-commerce transactions, and the contribution of maritime tourism to the local economy. This evaluation examines the impact of technology adoption on improving the economic welfare of coastal communities (Gao and Liu, 2020). In addition, this study analyzes shifts in natural resource management and their effects on the local fisheries and ecotourism sectors (Phelan et al., 2020).

Data related to social and economic aspects were analyzed using qualitative analysis techniques to formulate the desired model in this study. In-depth interviews and FGDs were employed to analyze community participation in institutional strengthening, environmental conservation, and technology utilization, as well as their impacts on social welfare (Foale et al., 2013; Gao et al., 2023).

The results of the qualitative analysis were used to describe the Blue Village model. The evaluation included a comparison of initial conditions with outcomes achieved after the intervention and assessed its impacts on economic welfare, social participation, and environmental sustainability in Mundu Pesisir Village (Airawati, 2023; Gao et al., 2023).

The success of the Blue Village model is subsequently measured through an analysis of the socioeconomic impacts resulting from the adoption of modern technologies such as IoT and e-commerce. Data collected on income growth, the number of transactions via e-commerce platforms, and the contribution of maritime tourism to the local economy are analyzed using regression analysis techniques to understand the relationship between technology adoption and economic growth (Phelan et al., 2020). In-depth interviews were also conducted to identify challenges in technology adoption and the efforts made to overcome them.

For the environmental aspect, data from IoT sensors monitoring water quality and coastal temperatures were used to evaluate how residents adapt to ecological changes, including rising air temperatures, and to determine the impact of technology

interventions on marine ecosystem sustainability (Adnan, 2023; Mack et al., 2020). Through real-time monitoring, this data provides an accurate depiction of environmental changes in Mundu Pesisir Village, which can be used to evaluate the effectiveness of the Blue Village model.

In the final stage, the qualitative analysis results offered a detailed overview of the model co-developed by the research team and the community through FGDs. The findings of this study aim to benefit not only Mundu Pesisir Village but also other coastal regions in Indonesia facing comparable challenges.

The study underscores the critical role of active community participation in achieving sustainable development. Community members actively participated in all stages of the research, including data collection and results evaluation.

By integrating local wisdom with modern technology, the model provides an innovative approach applicable to other coastal communities in Indonesia. Moreover, this model aims to contribute to the achievement of the Sustainable Development Goals (SDGs), particularly those focused on environmental conservation (SDG 14) and poverty alleviation (SDG 1) (Airawati, 2023; Apriliana, 2024)

3. Results and discussion

The study explores the Blue Village model, comprising five core pillars: 1) Mapping Local Potential and Wisdom; 2) Strengthening Institutional Capacity and Enhancing Community Participation; 3) Infrastructure and Technology Development; 4) Environmental Management; and 5) Monitoring and Evaluation. Each of these pillars is essential for fostering sustainable coastal village development.

3.1. Mapping local potential and wisdom

The mapping of Mundu Pesisir Village's local potential highlights that traditional practices, such as the Nadran ceremony, offer considerable creative economic opportunities. Despite being an annual event, the ceremony generates substantial social benefits for the community, such as fostering creativity—especially among fishermen groups—enhancing social cohesion, and strengthening community solidarity. Fishermen work collaboratively, promoting mutual support and organizing fundraising activities for the celebration. The sea festival provides a platform for developing, showcasing, and celebrating the coastal community's cultural traditions, which are highly valued by residents and visitors alike. Furthermore, local wisdom in marine resource management has been shown to preserve ecosystem balance while enhancing the economic welfare of the coastal community. Residents work together in Gotong Royong (cooperation) to plant and care for mangroves, which has brought tangible benefits to the community both locally and beyond. The mangrove forest has become a tourist attraction that increases income while providing cooler air and reducing the heat intensity typical of coastal areas (Herningtyas, 2023), this analysis also highlights that the fisheries and maritime tourism sectors are the village's primary economic sources. These sectors can be further strengthened through sustainable economic diversification strategies (Lindsay et al., 2020; Sui et al., 2020). Diversification efforts identified through focus group discussions (FGDs) include not only selling raw fish catches but also processing them into various products, such as

fish jerky/steak and a variety of *Pindang* (steamed fish). The community has utilized the availability of traditional markets to sell these products, which often stem from skills gained during local training sessions. On the social aspect, the community demonstrates potential in cooperation, participatory action, and volunteering, all of which serve as critical forms of social capital that can be further developed as foundations for sustainable development. Social capital is vital for fostering welfare (Podgorskaya and Schitov, 2021).

3.2. Development of infrastructure and technology

Modern technology-driven infrastructure development is essential for promoting sustainability in coastal villages. The integration of Internet of Things (IoT) technology is critical for monitoring water quality and overcoming water resource limitations. State of Infrastructure Provided by the Government and Community.

A. State of infrastructure provided by the government and community.

The available infrastructure in Mundu Pesisir Village and other coastal areas in Indonesia still requires significant improvement. One major issue is access to clean water. Most villagers must purchase water from private providers because clean water distribution has not yet reached their homes. This disparity occurs because priority is given to large companies located along main roads, while villagers rely on manual distribution using pushcarts. Despite the significant potential of the fisheries and maritime tourism sectors, supporting facilities such as small harbors, local markets, and storage facilities for marine products remain inadequate.

B. Support from modern technology beyond IoT.

Modern technology offers significant potential to advance sustainable development in coastal villages. In addition to IoT, renewable energy technologies like solar panels can deliver reliable and environmentally friendly energy solutions. However, these technologies remain underutilized by the residents and businesses in Mundu Pesisir. Solar energy could address the electricity needs of fishermen and the local community, including lighting docks, powering cooling systems for fish storage, and operating tourism facilities. For instance, the mangrove tourism site currently lacks electricity. Furthermore, big data analytics could be applied to assess fish catch patterns, weather trends, and marine conditions, enabling improved decision-making in natural resource management, particularly for fishermen. E-commerce also represents a vital alternative, facilitating the broader market reach of local products, including aquatic goods and handicrafts, thereby boosting community income.

C. Specific role of the internet of things (IoT)

The Internet of Things (IoT) plays a vital role in real-time monitoring of environmental conditions and enhancing economic efficiency in coastal areas. In environmental management, IoT sensors monitor key water quality parameters, such as dissolved oxygen levels and temperature, which are crucial for maintaining marine ecosystem sustainability. From an economic perspective, IoT sensors enable fishermen to locate fish colonies directly, minimizing search time, conserving fuel, and boosting catch yields. In the tourism sector, IoT technology can track visitor numbers and assess facility conditions, allowing managers to implement timely improvements.

Integrating technologies like blockchain can improve transparency in the seafood supply chain, guaranteeing product quality for consumers and enhancing product value. IoT technology can also integrate with smart home devices to optimize energy efficiency, supporting environmental sustainability and boosting the economic welfare of coastal communities.

At present, the use of IoT in commerce remains limited. However, fishermen and coastal communities have significant potential to utilize IoT for more efficient natural resource management. For example, IoT sensors have been shown to enhance coastal water quality, thereby supporting the sustainability of the fisheries sector (Gao and Liu, 2020; Mack et al., 2020). Additionally, e-commerce technology helps fishermen and local artisans expand market access, increasing income by utilizing digital platforms to sell their products more widely (Gao and Liu, 2020). Interviews with traders revealed that they rarely use e-commerce for marketing, as most sales are conducted manually and in person. Mobile phones are used mainly for social interactions with relatives rather than for productive purposes, with heavy reliance on WhatsApp and YouTube, while other social media platforms are seldom used.

3.3. Environmental management

Environmental management in Mundu Pesisir Village focuses on mangrove ecosystem rehabilitation and reducing plastic pollution through community-based initiatives. Mangrove planting has proven effective in reducing coastal erosion and improving the quality of coastal environments (Kusumawati et al., 2020; Qadarisma et al., 2021). In the northern coastal region of Cirebon, mangroves have increased land area due to sedimentation trapped by mangrove roots, preventing it from being washed into the sea. Mangrove management is entrusted to community institutions known as the Village Tourism Monitoring Group, which trains cadres to manage the environment, including mangroves. These institutions collaborate with village officials and Village-Owned Enterprises (BUMDES). These groups also manage assistance from private entities (CSR), the public, state-owned enterprises, and government agencies. Access to clean water continues to pose a major challenge, with unequal distribution worsening the problem. Many residents rely on water purchased from regional water companies (PDAM), often delivered by pushcarts. This unequal access benefits companies operating along main roads while marginalizing villagers. Future efforts should prioritize advocacy to guarantee fair and equitable access to clean water for all community members.

3.4. Strengthening institutional capacity and community participation

Active community participation plays a pivotal role in ensuring the successful implementation of the Blue Village model. Training programs involving IoT and e-commerce technology have enhanced community skills and capacity for resource management and economic development (Foale et al., 2013; Kurniawan et al., 2023; Tarigan, 2023). However, follow-up in the form of sustained mentoring and support for these programs remains minimal, limiting their impact on social and economic institutions. Development efforts without community participation often fail to empower residents, leaving them dependent, unskilled, and excluded, perpetuating

poverty (Vokoun and Píchová, 2020). Findings from FGDs and interviews reveal that paternalistic relationships still dominate rural areas, where village heads hold significant authority in appointing community leaders. Strengthening democracy and providing opportunities for public participation in problem identification, planning, implementation, and monitoring are essential. A democratic approach ensures fair treatment and institutional capacity-building across community and government segments (Salim and Wibowo, 2024). Communities have shown a growing demand for democratization, and village governments must create opportunities for public participation at all stages, including problem identification, planning, implementation, and monitoring. A strong democratic approach fosters the development of institutional capacity across multiple sectors, within both communities and governments, promoting equity and prosperity.

Institutional sustainability is supported by collaboration that is not merely short-term, temporary, or sporadic but is mutually beneficial, equitable, and empowering (Tarigan, 2023). Collaboration should be built openly using the penthaleid approach, involving government, academia, the private sector, and media to strengthen institutional capacity and expand cooperative networks.

Partnerships have been established with state-owned enterprises, including *Permodalan Nasional Mandiri*, *Perusahaan Listrik Nasional* (PLN), and Cirebon Electric Power; public and private universities; local and national media; and community organizations. Collaborations with government entities have involved the Ministry of Marine Affairs and Fisheries, along with various district-level government organizations. However, research indicates that these partnerships are frequently short-lived and lack sustainability. Consequently, development progress becomes sporadic, particularly when relying solely on community initiatives and village budget allocations without optimizing collaborative efforts.

3.5. Monitoring and evaluation

Monitoring and evaluation activities in community development should be carried out collaboratively by program managers and community members. The community must actively participate in analyzing successes, identifying failures, and proposing solutions. Such involvement enhances the community's capacity to design more effective programs in the future. Unfortunately, monitoring and evaluation processes are frequently conducted haphazardly. Program managers often neglect the rigor required for comprehensive monitoring and evaluation, resulting in repetitive, formulaic program designs year after year. These practices impede institutional progress, stifle modernization, and lead to regression and stagnation due to poor adaptability. Technological advancements, such as IoT sensors for environmental monitoring, can significantly enhance monitoring and evaluation by enabling precise assessments of the Blue Village model's impact. Real-time data from IoT sensors reveal improvements in water quality and marine ecosystem health, which directly support better outcomes in fisheries and tourism (Adnan, 2023). Economic evaluations also show that the adoption of e-commerce technology has increased community incomes by expanding market access (Gao and Liu, 2020). The monitoring results indicate that few significant changes are made from year to year, and many data

updates remain unaddressed, leading to discrepancies with field conditions. For instance, discrepancies exist in data on poverty rates, the number of fishermen, and small and medium enterprises. Outcome and process evaluations of implemented programs are often inadequate, resulting in slight improvement to program designs in subsequent years. Evaluations are frequently concentrated among village elites. As a result, they fail to respond to community aspirations and tend to focus primarily on physical development while neglecting social and economic aspects. Problem-solving for community welfare should adopt a strengthening perspective, focusing on untapped potential and employing an Asset-Based Community Development (ABCD) approach (Nainggolan et al., 2020).

3.6. Modelling

The success of the model lies not only in improving environmental and economic quality but also in enhancing community participation in managing their natural resources (Sayogi and Suhardono, 2023). Community involvement in traditional practices and environmental conservation efforts through modern technology strengthens social identity while supporting both economic and ecological sustainability (Phelan et al., 2020).

Based on **Figure 1**, it is evident that the development of a city and community based on local potential and Wisdom towards a “Blue Village” in the fishing community is influenced by:

- 1) Infrastructure and technology, combined with local wisdom, serve as fundamental pillars supporting community participation.
- 2) Community participation is central to fostering economic and environmental sustainability, which together contribute to building an empowered community.
- 3) This model embodies a holistic approach in which social, economic, and environmental dimensions are integrated to foster a sustainable and self-reliant community.
- 4) Local Wisdom is a critical element in ensuring that development remains relevant to the local cultural context, while Infrastructure and Technology provide the means for modernization and improvement.

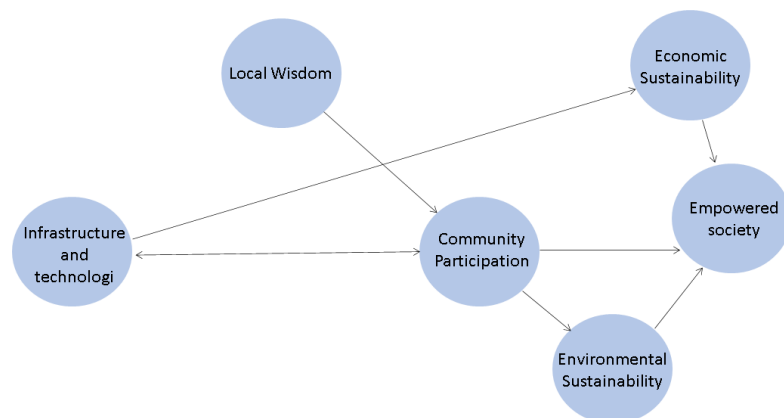


Figure 1. Sustainable city and community development model based on local potential and wisdom towards a “Blue Village” in a fishing community.

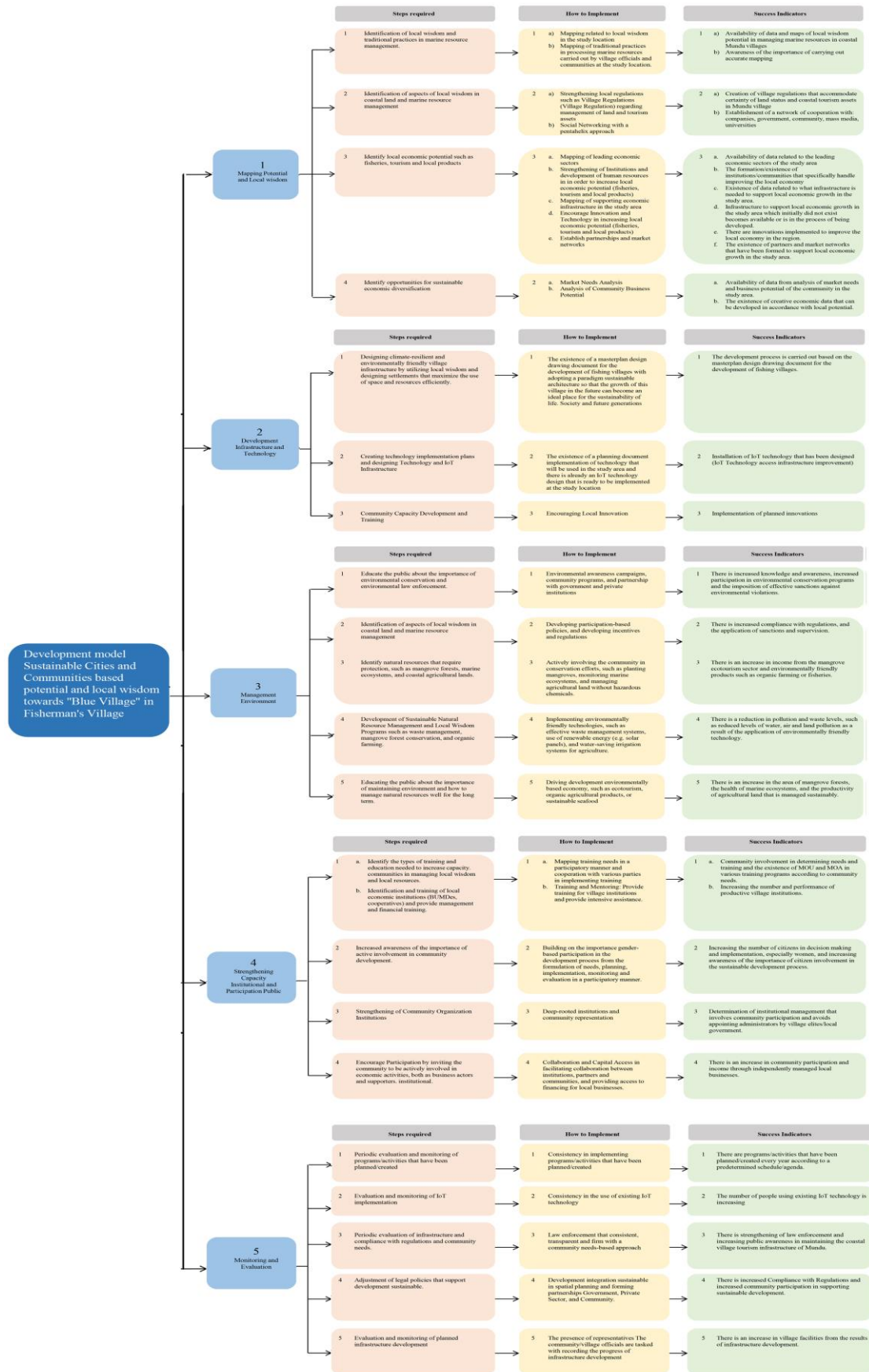


Figure 2. Framework for sustainable city and community development based on local potential and wisdom towards a “Blue Village” in a fishing community.

Drawing on the collected primary and secondary data, the development of Sustainable Cities and Communities rooted in local potential and wisdom, aligned with the “Blue Village” concept in Mundu Pesisir Village, can be examined through multiple dimensions: economic, social, cultural, legal, architectural, and informatics/IoT. These dimensions are integrated into initiatives aimed at leveraging natural potential and addressing local challenges. **Figure 2** presents a comprehensive discussion of the development framework, which can serve as a foundation for further development.

Based on **Figure 2**, there are five critical points in the development process: **Figure 2** outlines five essential elements in the development process: 1) Mapping local potential and wisdom includes identifying and understanding the diverse potentials of Mundu Pesisir Village, such as its physical, economic, social, and cultural assets; 2) Developing infrastructure and technology focuses on constructing and upgrading physical and technological systems to facilitate natural resource management and bolster the economic activities of the Mundu Pesisir community; 3) Environmental management encompasses initiatives to conserve nature and ensure the sustainable use of natural resources, safeguarding them for future generations; 4) Strengthening community capacity and participation aims to improve the community’s skills and knowledge in resource management while fostering active engagement in village development; 5) Monitoring and evaluation focus on measuring and analyzing the impact of village programs and policies. This ongoing process ensures that development goals are met and adjustments are made when necessary. Collectively, these elements play a crucial role in creating a sustainable coastal village.

4. Conclusion

The implementation of the Blue Village model, integrating local wisdom with modern technology, has demonstrated effectiveness in enhancing economic welfare and promoting environmental sustainability in Mundu Pesisir Village. The model successfully combines five main pillars: Mapping Local Potential and Wisdom, Developing Infrastructure and Technology, Environmental Management, Strengthening Institutional Capacity and Community Participation, and Monitoring and Evaluation. Each pillar contributes significantly to achieving the Sustainable Development Goals (SDGs), particularly in preserving marine ecosystems (SDG 14) and fostering community development and poverty alleviation (SDG 1).

Mapping local potential and Wisdom in coastal villages demonstrates that traditions like the Nadran ceremony not only support environmental conservation. However, it can also be leveraged for creative economic development, such as cultural tourism. The integration of Internet of Things (IoT) technology and e-commerce into environmental management and market access has improved resource management efficiency and broadened local product marketing networks, thereby directly increasing community income.

Moreover, active community involvement in diverse training programs focused on technology and environmental management enhances institutional capacity and fosters greater awareness of the critical importance of coastal ecosystem conservation. Evaluation results indicate that technology-based environmental monitoring and

stakeholder collaboration through a Penta helix approach can lead to more sustainable and adaptive resource management in response to environmental changes.

With the success of the Blue Village model in Mundu Pesisir Village, this model has significant potential to be replicated in other coastal areas across Indonesia. The integration of modern technology with local Wisdom not only helps maintain ecosystem balance but also enhances the economic competitiveness of coastal communities in the context of globalization. Through this holistic approach, the Blue Village model offers sustainable solutions to the economic, social, and environmental challenges faced by coastal communities in Indonesia.

Author contributions: Conceptualization, SAK and AS; methodology, TS; software, RS; validation, SAK, AS and SNW; formal analysis, DAD; investigation, VV; resources, SK; data curation, DAD; writing—original draft preparation, SAK; writing—review and editing, AS; visualization, RS; supervision, SNW; project administration, DAD; funding acquisition, SK. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

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