Journal of Natural Resources and Environmental Management
http://dx.doi.org/10.29244/jpsl.14.1.160

RESEARCH ARTICLE

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Comparative Study of Indonesia and Denmark in Creating a Smart Environment

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Article History
Received 30 June 2023
Revised 09 August 2023
Accepted 25 August 2023

Keywords
smart city, smart environment, sustainable development goals

ABSTRACT

This study aims to compare the efforts of the Governments of Indonesia and Denmark in realizing a smart environment SDG's agenda. This urgency is motivated by the poor environmental conditions in Indonesia, and the government is targeting a reduction in emission production by 2030. This study uses a qualitative method. The results of this study indicate that Indonesia's pursuit of a smart environment is not optimal. This can be seen from the several indicators used in this study: (1) the attraction of natural condition indicators; the Indonesian Government has not enforced regulations or programs aimed at maintaining the balance of green open spaces. The Denmark Government launched a city greening program through the construction of green buildings. (2) Air Pollution Integrated Index indicator, the Indonesian government has not been able to minimize the number of vehicles through the use of electromobility-based vehicles as has been done by the Denmark government. (3) Indicators of Sustainable resource management: The Indonesian Government has not been able to optimize the development of technology for processing waste and waste into residues that can be reused. In Denmark, waste can be converted into a residue that can be reused.

Introduction

The problem of sustainable environmental management remains a context that needs to be addressed by various countries around the world. The United Nation Environment Program (UNEP) states that 6.5 million people die each year due to exposure to poor air quality. Fatally, 70% of these deaths occur in the Asia-Pacific region, with Indonesia being no exception. Indonesia is one of the countries with a poor environmental quality index. According to the results of the 2022 Environmental Performance Index (EPI), Indonesia ranks 164 out of 180 countries in the world with a score of 28.10 [1]. The EPI results also found that in the Asia-Pacific arena, Indonesia still ranks low, at 22nd out of 25 countries. Indonesia is also one of the countries with poor air quality by 2021, ranking 17th out of 118 countries [2]. Ninety one percent of Indonesia's 268 million people live in areas with high levels of pollution, exceeding the average pollution recommended by the WHO [2]. Indonesia was also included in the lowest category with a score of 3.68, indicating that Indonesia is still lacking in the development of a green and low-carbon environment [3].

Environmental sustainability is also related to waste management, which harms people's lives [4]. Meanwhile, Indonesia is still struggling with the waste problem, which annually produces 67.8 million tons of waste, consisting of 23 to 48 million tons of organic waste and 7.8 million tons of inorganic waste [5]. Jambeck in [5] states that Indonesia is the second country in the world to produce plastic waste in its waters. This condition is increasingly inflamed, along with the low quality and infrastructure of waste management and smart waste management systems [6,7]. However, the government's focus on highlighting environmental sustainability is still limited [8,9]. The Indonesian government needs to pursue a smart environment through the development of green transportation technology to minimize emissions, manage municipal waste, and cultivate sustainable energy [10–12].

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The smart environment is part of the smart city element, which discusses the contribution of digitalization to resource-efficient cities as a combination of smart city practices and sustainability [13]. His research explored urban nature using digital technology. The smart city itself is part of community collaboration with public administration in developing smart cities, using IT support to create smart and inclusive communities [14]. Smart environments use digital technology such as Artificial Intelligence (AI) to help human life [15]. Developing the Internet of Things (IoT) using sensors and computational devices to help environmental protection by monitoring water quality, air quality, pollution, etc [16]. Nagy et al. [17] stated the use of energy has consumes 60 to 80% energy. His research also mentions that a smart environment speaks about collection and management trash, which is the problem of rubbishing the more urgent along with an increase in the population of humans. Environmental monitoring systems and waste management require intelligent techniques to communicate and integrate information between big databases stored for easier and faster decision-making, especially to solve problems [18].

On the other hand, Denmark is one of countries in the world implementing smart environment to realize ambitious goals zero CO_2 in 2025 and 2030, many cities of Denmark have similar plans for sustainable developments and part of "Smart Cities" [19]. A smart environment consists of pollution prevention, sustainable resource management, and environmental protection, with digital technology adoption as a reference for the government in making policies. Denmark is one of the leading European nations in realizing smart city initiatives, developing "Copenhagen Connecting" and "Smart Aarhus" to create sustainable solutions in urban life. Copenhagen Connection is the best project in the world for collecting, integrating, and using data to realize higher quality citizens' lives, and greener cities use wireless data, sensors, and GPSs in buses to support the government toward a sustainable city with reduced pollution and emissions. Smart Aarhus is the link to inform the public and private sector about data and monitoring sensors, big data, drones, IoT, and AI about energy-efficient buildings, sustainable transportation, and intelligent traffic control to realize better lives for citizens. Smart Aarhus helps improve citizens' health and quality of life by making Aarhus greener and sustainable.

Because the Denmark government is attempting to implement a smart environment, Denmark achieves its first rank in the sustainable environmental performance index with a score of 77.9 [1]. Denmark also ranks second highest in the category of green and low-carbon environmental development [20]. This is also being replaced by Denmark's efforts to achieve the world's first projected carbon-free capital in the next three years [21]. Denmark is also ranked first in the category of the cleanest country in the world according to the 2020 EPI version with an index of 82.5 [22]. Denmark excels in several categories, namely marine waste management with a perfect score of 100, species maintenance index with a score of 100, and waste management with a score of 99.8. Denmark's best practice can serve as a reference for The Indonesian Government to manage greener and more sustainable environments, especially urban areas, using the smart environment concept. Based on this gap, the authors are interested in comparing the efforts of the Governments of Indonesia and Denmark to realize a smart environment. Denmark is used as a role model in implementing a Smart Environment is that Denmark is the number one country in the world in realizing smart cities and greener cities [23]. It is hoped that the author will be able to explore what the Indonesian government needs to do to implement a smart environment by learning from the steps taken by the Denmark government.

Research Methods

This study used a qualitative method with a case-study approach. Qualitative methods are believed to help writers understand a phenomenon well and deeply [24]. Qualitative methods try to understand an event as a whole without limitations, flexibly, oriented to careful cases, and through detailed processes [25]. Qualitative data sources consist of interview data, observations, literature studies, and supporting documents. This study is based on secondary data from previous research explorations and official government data collected using data collection techniques is documentation techniques.

Table 1. Mass media data resource.

Website data resource	Range date	Quantity
Official Government Website	June 2022 - June 2023	10
Kompas.com	June 2022 - June 2023	15
Detik.com	June 2022 - June 2023	10

Table 1 shows that the researcher used secondary data from the Official Government Website, Kompas.com, and Detik.com to improve data validation based on data resource triangulation proposed by Denzin et al. [26]. Official government data on website institutions and mass media were processed and analyzed using the Nvivo12 Plus Tools. In the first step, the author searches for official government data from their website. Data can be captured to save data into the research tool device and code the data based on the classified indicators, which is the reduction data. Visualize the data reduction to allow easier authors or readers to know the result through a crosstab query on Nvivo12 Plus tools. Visualization can help analyze the process and draw conclusions based on research.

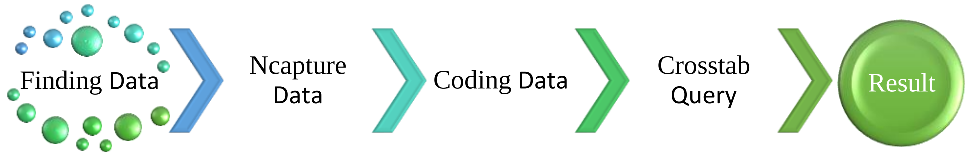

Figure 1. Data Processing using Nvivo12 Plus.

Figure 1 shows data processing in this study uses the interactive model initiated by Miles et al. [27], which consists of three stages: data reduction, data display, and conclusion. Data reduction was performed by selecting data according to the theory used in this study using Nvivo12 Plus. Therefore this study use Qualitative Data Analysist Software (QDAS). Official government data of website institutions are classified as indicators of theory and visualized as figures, graphics, or tables. Data display or visualization is the stage of presenting data that have been successfully selected, and concluding is the final stage in drawing conclusions based on the results found. The data analysis system was used to map the raw data to be grouped into several related indicators. The finding data were analyzed and combined with other data to strengthen the dissertation findings with visualization in the form of graphs, pictures, or tables to make it easier to understand the finding data. The results of the analysis are explained descriptively to form a conclusion as the final result of the study. In this discussion, the author will also provide an example of the progress of smart environment implementation in several cities in Denmark and Indonesia, especially big cities that have started planning smart city concepts as an explicit sample.

Results and Discussions

Smart Environment Concept

Smart cities integrate various dimensions of urban life with an efficient urban environment in accordance with digital technology adoption to improve citizens' quality of life [28]. Smart cities have 6 (six) indicators: smart government, smart people, smart economy, smart mobility, smart living, and a smart environment. Smart environment studies in the urban environment explore the natural sciences based on the use of digital technology and interpret changes in the lives of urban communities collectively and individually based on digital use [13]. The development of information technology and its application has stimulated the emergence of the smart city concept to form an intelligent society by collaborating between the community and the public administration sector, which has an impact on urban life innovations in a multi-dimensional manner [14].

Smart environments can focus on environmental management and urban growth and can be supported by smart applications to measure, control, create renewable energy innovation, and monitor environmental conditions [29]. Uses sensors and computational devices have been proven by the rapid progress of communication technologies, especially IoT, to support monitoring and protecting the environment via parameters such as air quality, water quality, environment quality, and wildlife conditions [30]. This concept is also derived from environmental issues, such as the sustainability of environmental vegetation, energy use, and waste management, especially in urban environments [31,32]. To overcome these problems, the government needs the help of digital technology to update data on environmental conditions in real time, assist in preparing future scenarios in environmental management, and increase public participation in supporting environmental sustainability programs by optimizing digital-based community literacy [33].

In analyzing the implementation of the smart environment, the authors based their analysis on the theory developed by Giffinger [34] which the authors then adapted with parameters from Nikoloudi et al. [35]. In the smart environment theory developed by Giffinger [34], there are three indicators chosen by the author as blades in studying the smart environment: the attraction of natural conditions, the integrated air pollution index, and sustainable resource management. To sharpen this indicator, the authors adopted the parameters used by Nikoloudi et al. [35] which consist of several parameters: green open land, emissions, air pollution, waste management, and smart resource management.

Table 2. Smart environment framework.

	Indicators	Parameters
Smart environment	Attraction of natural conditions	Green open space and buildings
	Air pollution integrated system	Emissions
		Air pollution integrated system
	Sustainable resource management	Smart waste management

This study applies smart environment theory to analyse the use of technology in maintaining the environment as implemented by the governments of Indonesia and Denmark. Table 2 presents indicators for measuring smart environment implementation, concluding of attraction of natural conditions, air pollution integrated systems, and sustainable resource management. Attraction of natural conditions concerning the government effort to balance infrastructure building and green open spaces to reduce environmental damage. Air pollution integrated systems discusses the production of emissions mainly caused by vehicle and industrial activities. The government is making efforts to monitor and manage through air pollution integrated systems. Meanwhile, sustainable resource management indicator, focuses on the use of technology to process waste and making waste management more eco-friendly.

Attraction of Natural Conditions

The attractiveness of natural conditions in a smart environment is related to the openness of green land and sustainable urban nature used digitally in a city [36]. Wireless sensor networks, artificial intelligence, Internet of things, data analytics support the government in managing and controlling their territory's environmental conditions more easily [37]. Denmark is ranked 2 out of 76 countries in 2021 and 2022 with an index score of 6.55 [38]. This index is based on several indicators: reducing carbon emissions, developing clean energy, and innovation in the greening sector. This success is the result of efforts by the Government of Denmark in December 2021 to raise bonds by 762 million dollar to fund its energy transformation program [39]. Denmark has achieved sustainable development through its government programs and environmental policies. Two years after the establishment of the Ministry of the Environment in 1971, Denmark became the first country to implement environmental legislation.

Denmark stimulates every building to use green buildings or buildings with green roofs and green infrastructure [40]. In the early 1980s, Denmark facilitated species conservation and built a network integrated into the spatial planning system and the spatial planning act in 2010. This policy is expected to maintain the greenness of the city even though building construction will continue. In 2014, green infrastructure development continued to be pursued through the Denmark Naturplan Policy, which is planned until 2020. This plan includes several aspects, including a 25,300 hectare optimization plan to build connected environments, carbon absorption areas, and public recreation areas. Green open spaces in Denmark are also aimed at reducing greenhouse gas emissions, improving the quality of the aquatic environment, and storing CO_2 and groundwater during extreme rainfall. Denmark also made the green map show the potential for regional connectivity, which will be included in the Naturplan in 2017, and will be implemented until 2050 [41].

The City of Copenhagen has been appointed by United Nations Educational, Scientific and Cultural Organization (UNESCO) as the world capital of architecture in 2023 because it can build architecture and culture that responds to environmental conditions. The city of Copenhagen designs a green building architecture by enforcing regulations for each building to provide green space by planting trees in the building. Green buildings are also realized through architectural designs with extensive lighting to illuminate the room using sunlight to efficiently minimize energy use. To maintain a stable room temperature, buildings in the City of Copenhagen have been facilitated with climate-friendly automatic heating and air-conditioning technology. Heating and cooling integration is realized by managing the excess heat from the building to create district heating. Conversely, district cooling water originating from seawater can be used to cool the heat pump.

This condition is in stark contrast to open land governance in Indonesia, whereas in 2019, only 13 out of 174 cities in Indonesia were implementing the Green City Program and had green open spaces [42]. The minimum portion of green open space in a city is 30 percent, as regulated in Law Number 26 of 2007 concerning Spatial Planning. Meanwhile, efforts made by Indonesia to restore green open spaces still use manual techniques, such as replanting trees in urban areas and providing socialization to increase public awareness regarding green open spaces [43,44]. Replacing open land with land used for settlements is also a city government strategy in Indonesia [45]. His research uses a land replacement mapping model that can still become a green open space to replace residential land, which reduces the percentage of green open land. A similar explanation was revealed by Wikantiyoso et al. [45], who used biodiversity development as an environmental balance and the provision of green open spaces in cities. One of the main challenges in providing green open land in Indonesia is the rapid development of housing needs, which have changed the allocation of green land to residential facilities. Meanwhile, efforts by the government to provide green open land are still limited. The government has not been firm in enforcing a program to provide green open land, which has recently been defeated by the provision of residential areas.

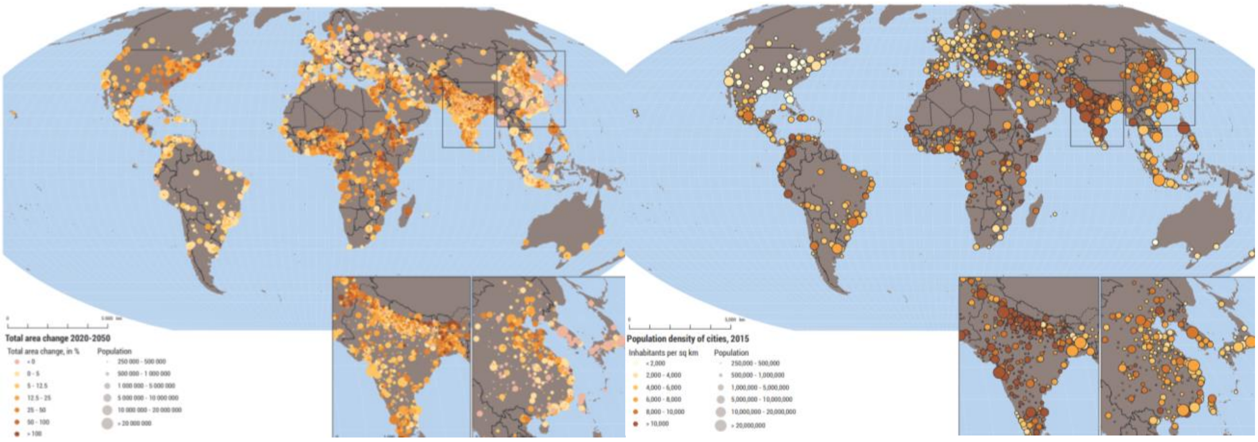

Figure 2. Deforestation caused by increase in world population 2020–2050 (sources: [46]).

Figure 2 shows estimates of infrastructure construction in many countries 30 years into the future. World population growth is one of the factors driving massive infrastructure building to meet the needs of settlement, industry and economic development activities that impact on deforestation. Indonesia is one of the countries experiencing rapid changes in land allocation. Most of the land change occurred on the islands of Sumatra and Java, where these conditions are closely related to an increase in population, which increases the need for housing and infrastructure to support economic activity. Inequality in economic growth between regions triggers people to migrate towards areas with rapid economic development, which affects the availability of land in migration destination areas. This condition sparked the government to expand residential areas to supply community housing needs, but on the other hand green open space is increasingly eroding and shows an imbalance in the ecosystem.

Meanwhile, the involvement of digital technology in monitoring green open lands is still limited to using satellite visual interpretation methods. Geospatial digitalization in Indonesia is achieved through a Geographic Information System (GIS), which does not contain monitoring data of green open spaces in Indonesia. The Indonesian Government still uses conventional methods to improve green open space by calculating the green open space condition percentage and comparing it with the green open space target on government regulation, which is 30% of the total area. Green open spaces comprise 10% of private green open spaces and 20% of public green open spaces. Private green open spaces, such as home pages, private institution pages, etc. Public green open spaces such as city gardens and grove spaces, in contrast to green open land management methods in other countries that involve technology to drive the existence of green open land, these data can be integrated into applications that can be accessed by the community. Therefore, indirectly, the community also participates in the management of open-land governance in urban areas and increases their awareness. Even now, the provision of open land in Indonesia is still limited to plans contained in the upcoming 2030 plan [47].

Air Pollution Integrated System

Agglomeration, which triggers an increase in the number of industries, has an impact on fuel consumption and pollution [48]. Increasing air pollution harms health, which has sparked various stakeholders to provide strategic management regulations for air pollution problems in recent decades [49,50]. Previously, Denmark also had problems with air pollution, as questioned by various countries worldwide. In response, the Denmark government collaborated with Google to measure and map air pollution in the city of Copenhagen. The mapping results show that there are many ultrafine particles on roads that are busy with transportation activities [51]. Even these particles are hazardous to health and sparked the Denmark Government to minimize emissions by increasing the cost of vehicle ownership tax by up to DKK 1,000 per year. The Denmark government limits the production of emissions from cars to below 5 µg of particulate matter per kilometer, which forces people to switch to using low-emission cars [51].

Denmark has become one of the top three eco-innovation countries through its efforts for environmental sustainability in Europe [52]. Various efforts have been made, such as installing Global Position System (GPS) on buses to monitor city conditions in real-time. This effort is also strengthened by commitments to be free of fossil fuels in 2050, carbon-neutral cities in 2025, and the use of sustainable transportation and reduction of greenhouse gas emissions [23]. The best practices of the smart environment in Denmark are the cities of Aarhus and Copenhagen. The city of Aarhus has created effective and efficient accessibility through IoT data integration to optimize traffic flow [53]. The delivery of short messages related to traffic condition predictions based on data is used as the basis for traffic management.

The integration of this information can help drivers choose the fastest traveling route, which has an impact on the efficiency of fuel use and vehicle emissions. Aarhus also uses drones as a tool to monitor surrounding conditions with a 360-degree camera that can record traffic data, overpasses, etc. The results of the drone recording show the condition of the air and environment. The operation of Aarhus SmartDrones approved by the Aarhus Transport Authority can also shoot emergency conditions and be integrated. The use of drones is an effort to increase public transparency regarding the surrounding environmental conditions. This can create a better level of public service by involving the public in participating in and knowing the public data.

The same is being done in the City of Copenhagen, which is building smart traffic at every intersection. Smart traffic is implied through online signals, which help drivers to be informed at every intersection. traffic lights can provide effective access to the way and efficient travel time owing to the integration of the signals contained in 380 intelligent traffic lights. Vehicles in the city of Copenhagen are equipped with GPS, which can capture information from intelligent traffic systems. The information obtained will help regulate traffic access to make it faster and more efficient, such as traffic congestion information conveyed to drivers to direct them through other routes, thereby reducing the level of congestion and emissions with other travel routes [54].

Denmark, a country with major maritime power, is developing emission-free sea transportation as a decarbonization effort. This effort is carried out by maximizing the shipping industry as an eco-innovation and contributing to the reduction of 70% CO_2 emissions in Denmark by 2030 [55]. Electrification is used to minimize energy consumption or convert fossil fuels to electrical energy. Denmark is also developing power-to-X to switch fuels to green fuels (ammonia and hydrogen) produced by electrolysis processes. This green fuel can be used to produce power planes, buses, and ships. The success of the Denmark Government in reducing carbon emissions has had a positive impact on reducing the death rate due to air pollution from 1990 to 2019. It can be seen from the figure above that the death rate in Denmark due to air pollution was quite high in 1990, reaching 3,770 people; in 1990, it decreased to 3,340 inhabitants, and in 2,000 there were 2,710 deaths in the population. The death rate gradually declined until 2019, and the death rate in Denmark due to air pollution was 1,470 [56].

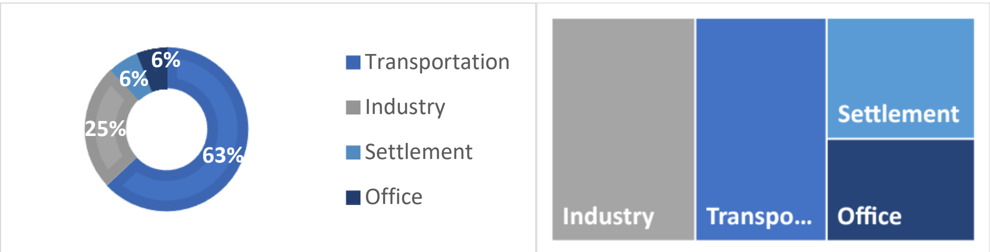

Figure 3. NO_2 and SO_2 production based on location classified (source: [57]).

Indonesia has also experienced air pollution problems, mostly caused by transportation and industrial activities. Figure 3 shows that transportation activities to support people's accommodation needs occupy the highest percentage of NO_2 concentrations, up to 63%. Other activities include industry (25%), residential activities (6%), and office activities, contributing at least 6%. Meanwhile, the SO_2 concentration was also generated by industrial and transportation activities as the highest sectors, with percentages of 34% and 31%, respectively. Other factors, such as residential and office activities, contributed 19% and 16% of the SO_2 respectively.

The Indonesian Government faces challenges in minimizing vehicle emissions, consisting of public policy in transportation management (60%), public engagement to promote public policy implementation (20%), and economic stability to support citizens implementing public policy in transportation management (20%). The high demand for mobility stimulates the Indonesian Government to organize public transportation regulated in Law Number 22 of 2009 concerning Road Traffic and Transportation, which the government is responsible for organizing public transportation; Government Regulation (PP) Number 30 of 2021 concerning Implementation of The Road Traffic and Transportation Sector. The Indonesian government has appealed to public transportation for their mobility; however, the quantities and capabilities of public transportation infrastructure are not optimal for supplying community mobility demand. The lack of integration of public transportation makes it difficult for people to access it. The imbalance between the intensity of public transportation provision and community mobility demand makes people switch to using private transportation and online public transportation, which increases the number of vehicles on the road.

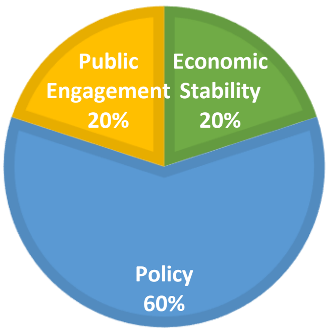

Figure 4. Challenge of Indonesian Government to reduce vehicle emission.

Figure 4 is result of data processing that author managed according to online mass media to map Indonesian government challenge to reduce vehicle emission. Indonesia facing any problems to minimise emission production especially from vehicle activities consists of the low of public engagement and awareness to maintain their vehicle, economy stability of Indonesian citizen to provide money allocation for maintaining their vehicle maccine to be eco-friendly and transport regulation to force and manage it. Public policy concerning emission vehicle assessment also needs to be reviewed through an analysis of community capacity. Indonesia still has many poor economic communities, which require a cost to maintain vehicle quality. The Indonesian government can review policies to provide subsidies or facilitate vehicle maintenance costs for the community. Therefore, economic stability (20%) and the welfare level of the community can be factored in to support public policy implementation. Moreover, successful implementation of public policy also was impacted by public engagement (20%) to realizing it in their life. Many people are aware of the urgency of climate change, and a sustainable environment, which is caused by one of the factors, is vehicle emissions. These factors are any challenges faced by the Indonesian Government in implementing a sustainable environment, besides the challenge of adopting digital technology for realizing a smart environment.

Figure 5 is the author's data processing result based on online mass media discussing the Indonesian government's efforts to reduce vehicle emissions. That figure shows the Indonesian Government has established strategy to minimize vehicle emissions and achieve sustainability goals. Some strategies consist of Vehicle Emission Assesment, the use of public transportation, developing the renewable energy and electrivity, also analyze data of monitoring results. Vehicle emission assessments (24%) have been implemented for several years, especially in metropolitan cities such as Yogyakarta, Surabaya, Jakarta, and surrounding areas. The vehicle emission assessment is the Ministry Environment and Forestry of the Indonesian strategy to ensure the machine performance and effectiveness of burning private vehicles. Vehicle emission assessment implementation based on Government Regulation (PP) Number 22 of 2021 concerning the Implementation of Protection and Management Environment. However, this regulation has not shown effective results in reducing vehicle emissions, which is proven by the environmental quality of some metropolitan cities in Indonesia that have not improved air quality, causing low public engagement and economic capabilities of the community to maintain their vehicle machines.

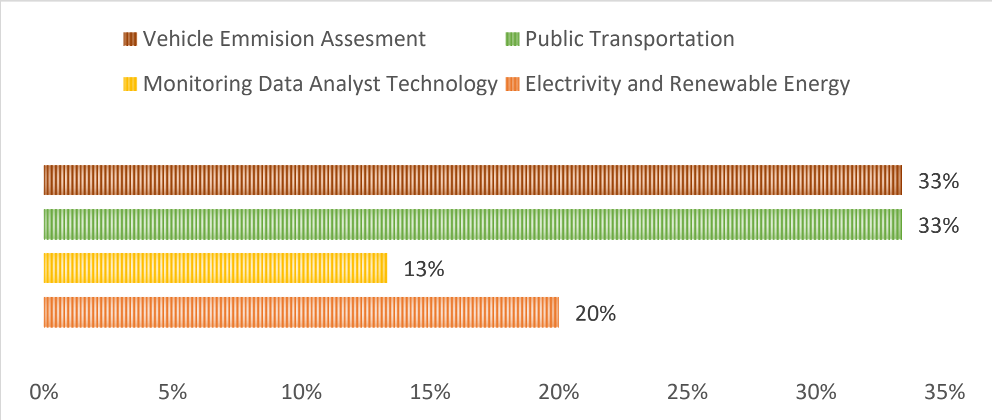

Figure 5. The Indonesian Government Strategy to minimize vehicle emissions.

In addition, The Indonesian Government uses public transportation to minimize transportation quantity on the road and reduce vehicle emissions (24%), which is implemented in any metropolitan city. However, this strategy does not provide a solution for urban transportation management. Public transportation is unable to fulfill community mobilization demands and a low level of public engagement concerning sustainability goals. Electivity and Renewable Energy of Public Transportation began to be used by the Indonesian Government in 2022 through the 3 (three) Buy the Service (BTS) Trans Semanggi Suroboyo electric bus inauguration. Electric public transportation was first implemented in Surabaya City because it has a high commitment to the Surabaya government and public awareness to reduce private vehicle use. In Jakarta, public transportation has grown through Mass Rapid Transit (MRT), Transjakarta, Light Rapid Transit (LRT), although it is not a solution for reducing vehicle emissions. However, the public transportation most cities in Indonesia still use petroleum fuel, which does not support the concept of sustainability.

Meanwhile, technology adoption to reduce vehicle emissions was also implemented through monitoring data analyst technology, although only implemented by the Jakarta and Yogyakarta City Governments. Jakarta has 7 (seven) air quality monitors, which are unable to fulfill the demand quantities, and the Jakarta Government still needs 43 to 45 air quality monitor devices to produce maximum result monitoring data. Yogyakarta City only has 1 (one) air quality monitor, which is the sensor ability that can record data up to 5 km in length, and most cities in Indonesia do not have a monitoring system to support their smart environment. The urgency of monitoring system devices to inform the community about the air quality in their areas. Monitoring systems are used to increase public awareness of the urgency of environmental problems; therefore, the Indonesian Government can increase the number of sensor devices to support air quality monitoring systems and realize smart environments by analyzing monitoring data.

Sustainable Resource Management

Sustainable resource management refers to sustainable resource management, including waste management and other resources. Sustainable resource management also involves technology in conserving resources and managing waste, considering that sustainable resource management is part of a smart environment. Denmark manages its waste with the help of software to manage sustainable resources. Automated waste management through online accessible software that helps recycle waste for reuse. This effort will indirectly reduce waste burning, which in turn will reduce CO_2 emissions. This software, called Recycle, also helps in pursuing SDGs goals, especially those related to waste management. Nearly 58% of the waste is recycled, and 40% goes to the manufacture of municipal fuel. This is a manifestation of the success of recycling and waste segregation campaigns, which have changed people's perceptions of waste as a resource [58].

Denmark is implementing smart waste management through an IoT-based trash that can be designed. Digitized trash bins can automatically sort waste according to its classification into organic and inorganic waste. Waste segregation is useful in facilitating the management stage. Smart bins in Denmark were also equipped with sensors to track the intensity of waste in the bins. The sensor informs the collection service provider. This information can provide convenience in estimating the time needed to collect waste, while saving up to 80% in management costs and up to 70% more efficient waste management time by employees. The collected waste will be managed using advanced technology to become a renewable energy source. Aarhus, Sonderborg, Copenhagen, and other cities in Denmark also manage waste as a source of fuel to replace coal. This effort was optimized in 2015 by converting renewable energy through the processing of non-fossil fuels, such as waste, wood, and straw.

The main fuel in urban areas comes from local straw, and half comes from wood chips. This is one of the solutions for dealing with waste from plants that fall in winter and supply more than 20% of the heat needs in Denmark urban areas [59]. In the management of water resources, households, and industrial activities in Denmark, consisting of 426 municipalities, produce 11.6 million wastewater per day. To maintain environmental sustainability, wastewater was treated in 337 factories prior to discharge. Wastewater treatment consists of biological treatment to remove phosphorus and nitrogen [60]. The Denmark Government also seeks to minimize water use through water consumption efficiency. This movement was successful, as indicated by the reduction in water consumption from 1976 to 2018. Denmark people also use rainwater to wash their clothes and flush toilets. Rainwater is operated through pipes connected to community houses with a separate system, and even if there is drought, the pipes will automatically be filled with water available in supply [55].

However, in Indonesia, waste management still uses manual systems. Although the Government of Indonesia has provided various waste management facilities in the form of Final Disposal Sites, Waste Recycling Technology, Compost Houses and Garbage Banks, waste problems in Indonesia cannot be resolved. This can be caused by the incompatibility of environmentally sound waste processing methods. To date, waste management in Indonesia still uses open dumping and landfill methods. This open dumping method was carried out by collecting waste in the Final Disposal Sites without further processing.

The landfill method is carried out by leveling the waste, then compacting and covering it with soil, therefore the waste is not processed but only buried. However, these two methods have the risk of causing soil, water, and air pollution if carried out in the long term. Final disposal sites also triggers the production of greenhouse gases, including CH_4, N_2O, and CO_2. However, the Government of Indonesia has been quite responsive in making a new breakthrough in the form of a Waste Power Plant (PLTSa). EGSA UGM [61] stated that waste power plant technology can convert waste waste into an energy source that is used as electricity through incineration, gasification, and pyrolysis techniques. However, some of these techniques also produce high emissions, which indirectly have an impact on environmental sustainability. Thus, Indonesia needs to develop new waste management techniques that do not impact the environment. Indonesia still faces problems in the management of sanitation and water resources. This is because of the careless disposal of wastewater without prior treatment [62].

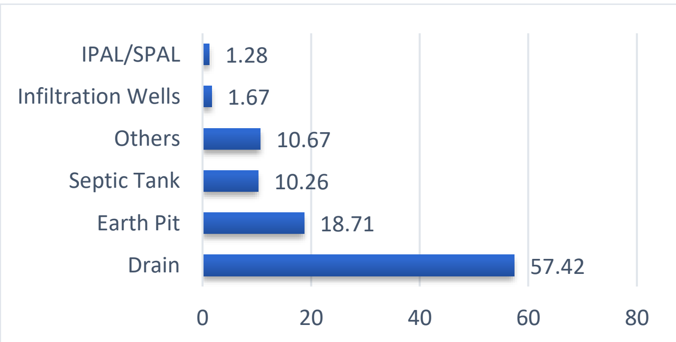

Figure 6. Household wastewater disposal sites in Indonesia (2021) (source: [62]).

Figure 6 show disposal site wastewater from household activities in Indonesia, consists of drain, earth pit, septictank, infiltration wells, IPAL/SPAL and others on percentage. The highest proportion of household wastewater is disposed of in ditches (57.42%), pits (18.71%), septic tanks (10.26%), and others (10.67%). Most household wastewater is disposed of in residential areas without being treated, and the distance is close to groundwater sources that are used to meet household operational water needs. Seepage of septic tank water can also infect groundwater which will cause germs and bacteria that are harmful to public health. Ironically, 70% of Indonesian drinking water is contaminated with feces, which indicates a poor sanitation system in Indonesia due to its low ability to manage water resources [63].

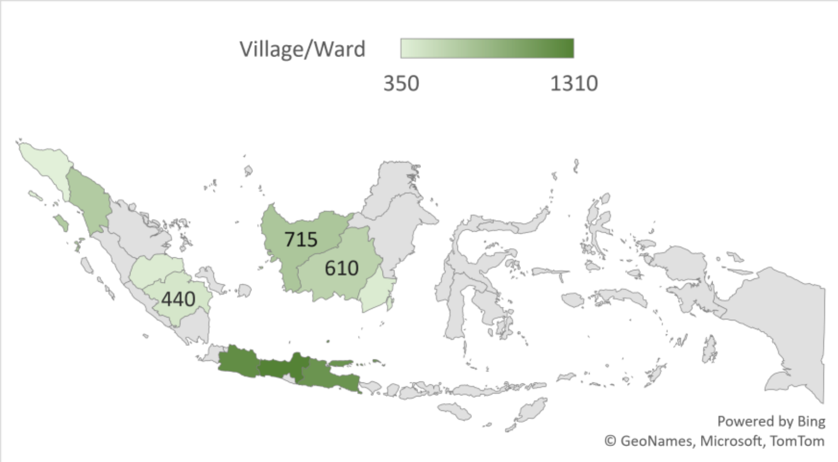

Figure 7. The highest province that wastewater pollution (source: [64]).

Figure 7 shows the province that the highest wastewater pollution in Indonesia especially from industry activities. Many industrial wastewater is not managed properly, which can be seen from the high-water pollution in the villages of various provinces in Indonesia. The provinces with the highest amount of industrial wastewater pollution are Central Java with 1,310 villages, West Java with 1,217 villages, East Java with 1,152 villages, West Kalimantan with 715 villages, North Sumatra with 673 villages, Central Kalimantan with 610 villages, South Sumatra with 440 villages, South Kalimantan with 396 villages, Jambi with 390 villages, and Aceh with 350 villages [64]. Industrial wastewater is discharged without treatment, which causes water pollution in Indonesia. Although the Ministry of Industry is developing an Adaptive Monitoring System (AiMS) technology, this technology can only monitor water and air quality that is integrated with a digital information system, not yet at the stage of treating wastewater [65]. Indonesia still has limited digital capabilities for developing technologies that can treat waste to achieve a sustainable environment. Moreover, the implementation of a smart environment, which is part of a smart city, has a wide complexity and many challenges that must be faced, including the government as a policymaker [66].

Conclusion

Based on the findings above, the authors conclude that the Government of Indonesia in pursuing a smart environment has not been optimal, in contrast to that sought by the Denmark Government. This can be seen from several indicators used in this study, namely, Attraction of Natural Conditions, Air Pollution Integrated Index, and Sustainable Resource Management. (1) The Attraction of Natural Conditions indicator shows that the Government of Indonesia has not enforced regulations or programs aimed at maintaining the balance of green open spaces. This failure can be seen in the decreasing percentage of green open spaces in Indonesia, especially in urban areas. Meanwhile, the Denmark Government launched a city greening program through both spatial planning and construction of green buildings. (2) Air Pollution Integrated Index indicator, the Government of Indonesia has also not succeeded in implementing it as indicated by the high production of vehicle emissions. Even the transportation sector is the highest sector in producing NO_2 and SO_2 concentrations which is contrary to the concept of sustainability. The use of fuel oil as a basic material for burning vehicles is a major factor in the production of vehicle emissions. The Indonesian government has not been able to minimize the number of vehicles through the use of electromobility-based vehicles as has been done by the Denmark government. (3) Indicators of Sustainable resource management, the Government of Indonesia, have not been able to optimize the development of technology for processing waste and waste into residues that can be reused. Unlike the waste management strategy in Denmark, which is able to turn waste into residue that can be reused. Therefore, the Government of Indonesia needs to maximize environmental preservation both in enforcement of regulations and in the use of technology to achieve a smart environment.

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