DYNAMIC MODELLING AND SOCIO-SPATIAL TRANSFORMATION OF URBAN ARCHITECTURE: EVIDENCE FROM INDONESIAN COASTAL CITIES

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Abstract

This study relates the social, economic, and environmental aspects of sustainable development with urban architecture. The data were obtained by observation and using questionnaires, while the analysis approach uses Multidimensional Scaling method, combined with System Dynamic approach, in order to develop scenarios, policies and sustainability strategies. The results of the analysis highlight eight main levers for the sustainability of the socio-spatial transformation of urban architecture, namely: waste pollution, residential densification, income, hope for a new job that can be a permanent livelihood, social class, rooted culture, architectural type and style, and land use intensity. An optimistic scenario through interventions on eight leverage factors could raise the sustainability status from an the initial value of 46.81 (less sustainable) to 76.24 (sustainable).
Keywords: sustainable development; socio-spatial; urban architecture.

1. INTRODUCTION

Currently, more than half of the world's population live in dense coastal settlements, which make coastal areas a fast and productive urbanization destination for the development of new cities. Many reasearch illustrate that the potential for future urbanization is still occurring in the coastal areas (Brand, 2007; Day et al., 2021). Urban development interventions in coastal cities tend to confiscate land and the coastal environment that should be owned in a sustainable manner becomes threatened (Wessells, 2014). Development in coastal cities has an impact on environmental, socio-cultural, and socio-economic transformations, which result in changes in spatial structure and spatial patterns (Surya et al., 2020, 2019, 2018), adaptation of spatial functions, morphological diversity, and regeneration of urban spaces (Kazimierczak and Wrona, 2019; Panori et al., 2019; Surya et al., 2018).

Other important determinats also cause the transformation and evolution of coastal space (Waiyasusri and Chotpantarat, 2022): population growth, changes in socio-economic functions, increased economic productivity, socio-cultural transformation, social change, community segmentation, marginalization, and poor local communities (Surya et al., 2018). Numerous studies have highlighted that these transformations are threats to socio-cultural, economic and habitability traditions (Guerrero Valdebenito and Alarcón Rodríguez, 2018), influencing spatial behavior and making necessary the development of future urban policies (Al-Tal and Ahmad Ghanem, 2019; Yılmaz and Terzi, 2021). The above studies lead to the understanding that the development in a coastal city that is not well planned becomes a threat to the social, economic, and physical environment which disrupts the goals of a sustainable city.

The impact of various factors on the development of coastal cities greatly influences its sustainability. Coastal cities combine characteristics of sustainable development with the particularities of coastal environments, which on the one hand is a potential, but on the other hand is a serious threat to the expansion of cities in coastal areas. Meanwhile, this uniqueness should not be sacrificed and must be maintained to meet the needs of future generations (Keeble, 1988).

The expansion of the city into the coastal area causes socio-spatial transformation, and changes in the architectural elements of the coastal city. Zain et al. (2018) stated that a socio-spatial approach can transform urban spaces into a better community life. Therefore, the sustainability status of the socio-spatial transformation of urban architectural elements becomes an important subject of study.

2. LITERATURE REVIEW

Sustainable development (SD) is always associated with the Brundtland Report, which was published in 1987 by the World Commission on Environment and Development (Sinakou et al., 2018). Since then, researchers have begun to study sustainable infrastructure development in coastal areas. Studies conducted in the last years in Algeria (Bulakh, 2022), South Korea (Park et al., 2020), West Africa (Nlend et al., 2018), examine the impact of development in coastal cities. There is only a small amount of research that focuses on the development of coastal city infrastructure related to integrated sustainability. Shang and Liu (2021) conducted a study in China, analyzing the development of green infrastructure in coastal cities. Rahman and Rahman (2015) analyzed the threats that need to be taken into account for sustainable urban infrastructure planning in coastal areas. In the same context, Bagheri et al. (2021) propose for urban planners and decision-makers measures to mitigate the dangers that threaten coastal urban areas. There is a general consensus that the Integrated Coastal Management (ICM) approach can be an effective tool for local governments to promote overall sustainability in coastal governance, so that all types of risks to be minimized (Liu & Yang, 2020; Ye et al., 2015).

However, the studies mentioned above do not describe the initial status of sustainability, and do not explain much about the sustainability of socio-spatial transformation of urban architecture in a coastal city. The novelty of this research is a model of sustainable socio-spatial transformation of urban architecture in a coastal city by combining Multidimensional Scaling (MDS) and System Dynamic (SD) analysis to formulate sustainable policy strategy scenarios by prioritizing the simulation of each lever variable. This model differs from previous studies carried out by previous researchers. For this reason, this research can fill the gap in the literature that does not yet exist regarding the sustainability of the socio-spatial transformation of urban architecture in coastal cities. The study aims: to analyze the sustainability status of the socio-spatial transformation of urban architecture in coastal cities, determining leverage variables, and formulating measurable policy strategies for sustainable socio-spatial transformation of urban architecture.

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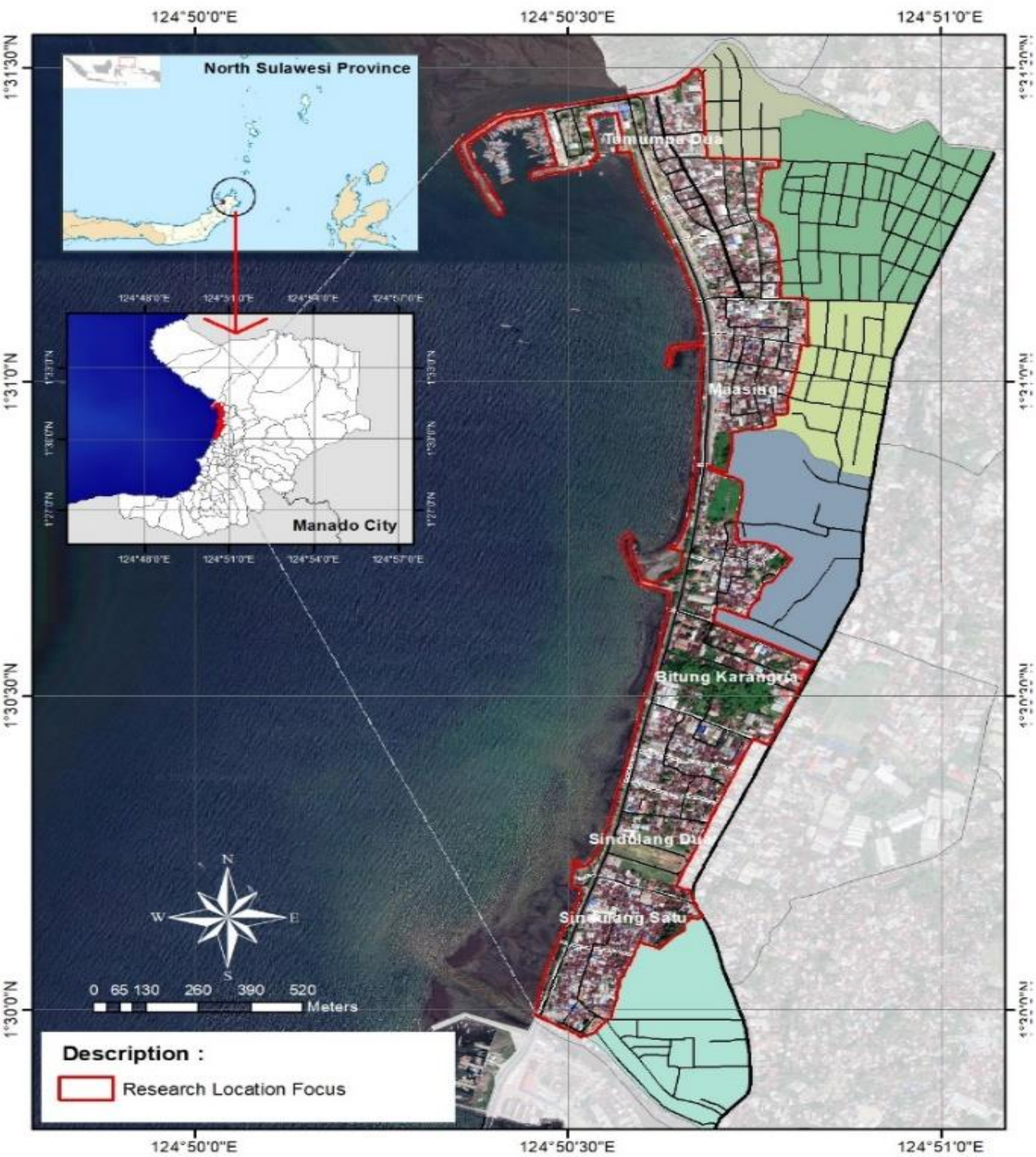

FIGURE 1 - LOCATION OF THE STUDY AREA
Source: UPTD Geospatial Data and Information Processing, Manado City

3. RESEARCH METHODOLOGY

3.1. STUDY AREA

The location of the study is at coordinates 1°29'59.66"--1°30'52.05" N and 124°50'27.24"--124°50'41.67" E, precisely in the five administrative areas of the village, namely: (1) Sindulang Satu village, (2) Sindulang Dua village, (3) Bitung Karangria village, (4) Maasing village, and (5) Tumumpa Dua village. Location map can be seen in Figure 1.

3.2. METHOD OF COLLECTING DATA

3.2.1. Observation

The observations in this study are used for data needs: (1) spatial changes and environmental quality, (2) socio-cultural changes, (3) economic changes; and (4) changes in the architectural elements of the city. The instruments used in the observation area were base map of the research site, field notes, documentation tools, and checklists.

3.2.2. Questionnaire

Questionnaires were distributed to obtain data on local community opinions and perceptions of the socio-spatial transformation of urban architecture in relation to environmental, socio-economic, socio-cultural and urban architectural conditions. Indicators are measured through questions in the questionnaire and are given a score of: 0 (bad), 1 (not good), 2 (poor), 3 (fairly good), and 4 (good). Closed questionnaire collected via google form media, from August to September 2022.

3.2.3. Sample Size

Respondent was selected using a purposive sampling technique of 200 respondents, aimed at the head of the village (5 people), academics (15 people), bureaucrats (4 people), practitioners (10 people), community leaders (10 people), fishermen's group (13 people), village government officials (13 people), and the community (130 people).

3.3. DATA ANALYSIS METHOD

3.3.1. Method

Application of Multidimensional Scale analysis to measure sustainability status through a rapid method (Appraisal). This appraisal method can quickly measure sustainability status through MDS (Multidimensional scaling) analysis, by including social, economic, environmental and architectural parameters or attributes of the city. Analysis of the sustainability of urban architectural transformation is carried out through several stages, namely the stage of determining the attributes of urban architectural transformation which includes four dimensions (Socio-cultural, Socio-economic, Environmental, and urban architectural dimensions). The coordination process stage uses MDS analysis, whereas the Rapid Sustainability Index called the Rapid Socio-Spatial Transformation of Urban Architecture (Rap-SSTUA) is used to asses the sustainability status. It is a modified program of the RAPFISH (Rapid Assessment Techniques for Fisheries) program developed by the Fisheries Center, University of British Columbia, Canada (Kavanagh & Pitcher, 2004). They recommend the stages and how to calculate and simulate the Rapid Sustainability Index, as follows:

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- Use the Rap-SSTUA template to start the Rap-SSTUA analysis;
- Determine the types of sustainability dimensions and attributes based on scoring rules;
- Determine the unit of analysis and preferably more than the attributes (minimum range of 6–12 attributes maximum);
- Create a score file in excel based on attribute dimensions;
- Conduct peer review scores to determine scoring consistency;
- Make reference points for good, bad and midpoints based on standardized scores;
- Create anchor points based on manual (all good scores minus worst scores for each step);
- Run Rap-SSTUA via Excel Add-ins;
- Enter "amount" and the position of the unit of analysis in the right cell;
- Do it for each different dimension by always checking the position of the attribute in the excel cell;
- Perform leveraging points for each dimension;
- Do flips-ordination to make the kite-diagrams for each dimension;
- Perform a Monte Carlo analysis.

Responses to the questionnaire are integrated into the model through the assessment of several respondents through the scores of each attribute and dimension. The value taken is the mode value of each respondent's response. The assessment is based on an ordinal scale that reflects bad and good values, where the range of scores ranges from 0-4 depending on the state of each variable which is defined as a "bad" value and a "good" value. The number 0 is a natural number, and is the default scale from the inventors of the Rapfish tool. "Bad" value is defined as the most unfavorable condition for the sustainability of urban architectural socio-spatial transformation. Conversely, a "good" value is defined as the most favorable condition for the sustainability of the city's architectural socio-spatial transformation.

After sustainability status with its leverage point obtained, scenarios, policies and sustainability strategies are formulated using a system dynamics approach (SD). System dynamic analysis begins with determining goals in the system (Sterman, 2000) then choose the system requirements to achieve the goal, and formulate the problem obtained from the results of the previous MDS study. Problems in the system are used as obstacles in the system's effectiveness. The next stage is to identify the system by making input and output diagrams. An illustration with a causal loop diagram is used to make it easier to see the relationship between variables, both input and output. The causal loop function is also used to limit the system to be studied (Muhammadi et al., 2001). Technical analysis is carried out by building a structure (Stock Flow Diagram) in order to carry out simulations, where the data grouping and data input are carried out in a model structure based on model scenarios to produce a systemic policy analysis (Firmansyah, 2016).

The discussion section compares the research findings with the findings of other research conclusions using different research approaches and methods (Salman et al., 2021).

3.3.2. Dimensions, variabel and scorps

Identification of dimensions and variables related to sustainable development departs from the categories and sub-categories found in research using Grounded Theory, as this research is a development of previous theoretical findings. Indicators are measured through questions in the questionnaire and are then given a score of 0 (bad) to 4 (good). The description of the dimensions and variables can be seen in Table 1.

TABEL 1 - SUSTAINABILITY DIMENSIONS AND VARIABLES

No	Dimension	Variable	
a	Environment	1	Safety from Waves and coastal climate vulnerability
		2	Safety from the dangers of vehicle traffic
		3	Noise Enhancement
		4	Temperature Increase
		5	Garbage Waste Pollution
		6	Shoreline Change
		7	Residential Densification
b	Socio-Economics	1	Profession Change
		2	Side job
		3	Hope for a new job that can become a permanent source of income
		4	Working Time
		5	Income
		6	Money Savings (Savings)
		7	Business Relations
c	Socio-Cultural	1	Lifestyle between immigrants and local communities
		2	Level of education
		3	Migrants Relations and Local Communities
		4	Kinship among Local Communities
		5	Community Organization
		6	Social class
		7	Dominant Tribes
		8	Traditions, Values and Norms
		9	Rooted culture
		10	Social conflict
d	Urban Architecture	1	Land Use Change
		2	Land values and prices
		3	Land Use Intensity
		4	Architectural Type and Style
		5	Circulation and Pedestrian Pathways
		6	Area Parking
		7	Public Open Space
		8	Local Wisdom Activity Room
		9	Utilization of Advertising Space and Regional Markings
		10	Historic Spaces and Buildings in the Area

Source: Field Data

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3.3.3. Categories Sustainability status and sensitive atributes

Rap-SSTUA ordination analysis with the MDS method is used to determine the position of sustainability status in each dimension, on the sustainability index scale. Sustainability index values for each dimension can be visualized in the form of a kite diagram and multidimensionally analyzed to determine points that reflect the position of sustainability of the socio-spatial transformation of urban architecture relative to reference points, both good (good) and bad (bad) points. The sustainability index scale has an interval of 0-100%. If the index value is more than 50%, it can be categorized as sustainable and if the index is less than 50%, then it is categorized as not or not yet sustainable. The sustainability score used refers to Firmansyah (2016), which divides the sustainable status into four categories, as presented in Table 2 below.

TABEL 2 - CATEGORIES SUSTAINABILITY STATUS

Index Values	Category
0 - <25	Not Sustainable
25 ≥ Index Values <50	Less Sustainable
50 ≥ Index Values <75	Sufficiently Sustainable
75 ≥ Index Values ≤ 100	Sustainable

Kavanagh & Pitcher (2004) states that sensitive variables are attributes that have influence and contribute to the sustainability index. The influence of each attribute is seen in the form of changes in the "root mean square" (RMS) ordination, especially on the X axis or the sustainability scale. The RMS value indicates the importance of the role of each attribute on the sensitivity of the sustainability index. The greater the value of the RMS change due to the loss of certain attributes, the greater the role of these attributes in the formation of the sustainability scale index value. Attributes that are categorized as sensitive are attributes that have an RMS value of ⩾ 50%.

4. RESULTS AND DISCUSSIONS

4.1. SUSTAINABILITY STATUS

4.1.1. Environmental Dimensions

The sustainability of the environmental dimension is included in the low criteria with a value of 47.59 (less sustainable). This dimension needs to be a concern because if there is no intervention, it will decrease. Factors that greatly influence the transformation of the environment are the residential densification with a value of 2.55 and waste pollution with a value of 2.43 on a scale of 3. Sustainability status and influencing variables on environmental dimensions can be seen in Figure 2.

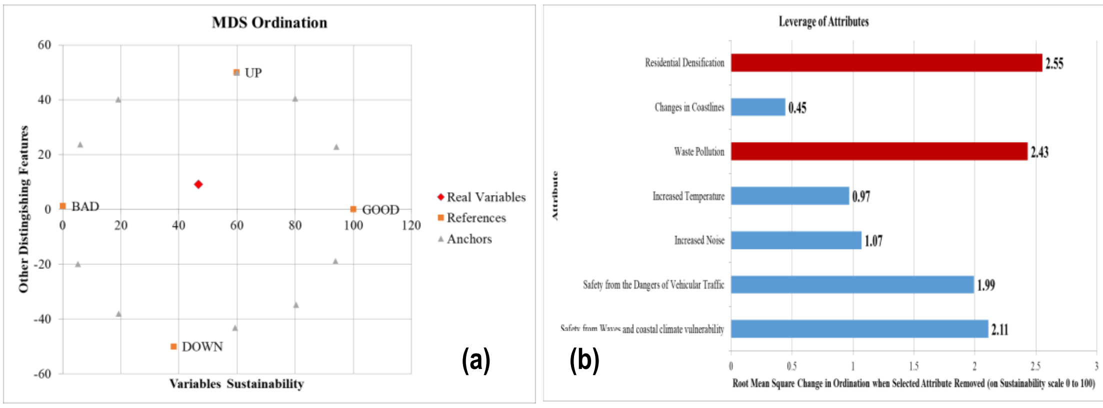

FIGURE 2 - THE STATUS OF THE ENVIRONMENTAL DIMENSION (a), LEVERAGE OF ATTRIBUTES ENVIRONMENTAL DIMENSIONS (b)

4.1.2. Socio-economic Dimensions

The sustainability status of the economic dimension can be seen in Figure 3 (a) below, including low with a value of 44.84 (less sustainable). This dimension is also a concern, because if left unchecked it will decrease. In the socio-economic dimension, the variables that greatly affect the income with a value of 2.32 and the expectation of a new job that could be a livelihood with a value of 2.18 on a scale of 2.5 can be seen in Figure 3 (b) below.

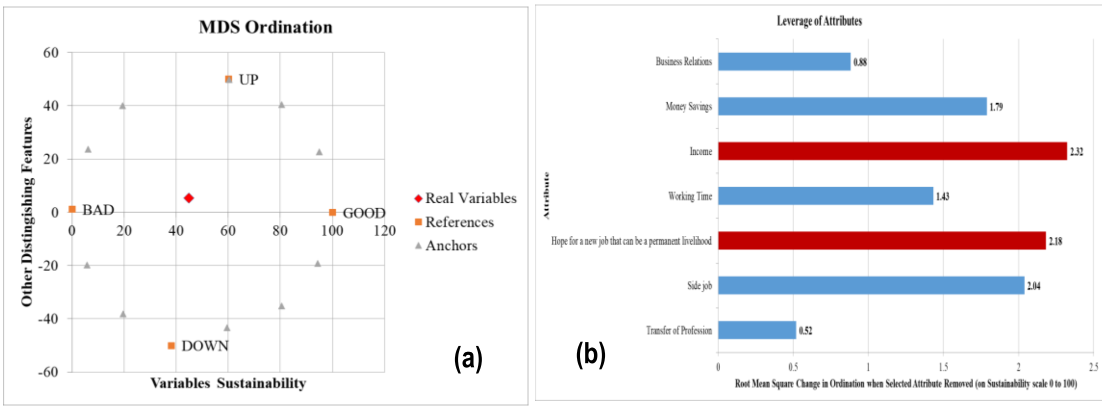

FIGURE 3 - THE STATUS OF SOCIO-ECONOMIC DIMENSION (a), LEVERAGE OF ATTRIBUTES SOCIO-ECONOMIC DIMENSION (b)

4.1.3. Socio-Cultural Dimensions

The sustainability of the socio-cultural dimension can be seen in Figure 4 (a) below, with a value of 59.58 (moderately sustainable). This dimension is strongly influenced by social class factors with a value of 1.79 and rooted culture with a value of 1.25 on a scale of 2. It means that these two factors need to be considered because they greatly determine the sustainability of this dimension in the future which can be seen in Figure 4 (b).

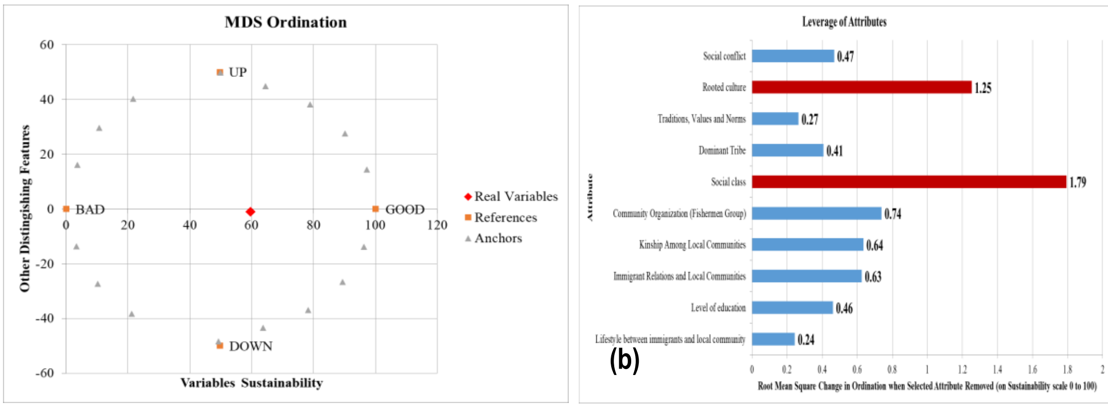

FIGURE 4 - THE STATUS OF SOCIO-CULTURAL DIMENSION (a), LEVERAGE OF ATTRIBUTES SOCIO- CULTURAL DIMENSION (b)

4.1.4. Urban Architecture Dimensions

The sustainability of the urban architectural dimensions that is 35.23 (less sustainable), including the very low criteria of all existing dimensions, can be seen in Figure 5 (a) below. If there is no intervention on this dimension, it will result in a decrease. The factors affecting the architectural dimensions of the city are the type and style of architecture with a value of 6.59 and land use intensity with a value of 5.77 on a scale of 7 which can be seen in Figure 5 (b).

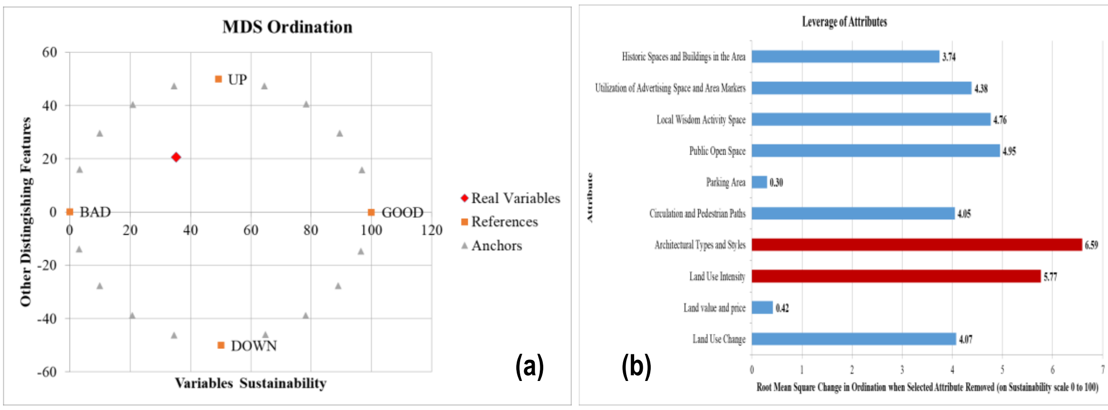

FIGURE 5 - THE STATUS OF URBAN ARCHITECTURAL DIMENSION (a), LEVERAGE OF ATTRIBUTES URBAN ARCHITECTURAL DIMENSION (b)

4.2. MDS ANALYSIS AND VALIDATION

In the dimension of the sustainability index of 47.59 (less sustainable), the socio-economic dimension value is 44.84 (less sustainable); in the socio-cultural dimension, the value is 59.58 (sustainable); and in the urban architecture dimension, the sustainability value is 35.23 (less sustainable). The average sustainability index of 46.81 falls into the category of less sustainable. From these results, it is necessary to carry out interventions in all dimensions so that they are included in the very sustainable category with a value of >75. Visualizations of sustainability status between dimensions and Baseline As Usual (BAU) are presented in Table 3 and Figure 6 below.

TABEL 3 - MULTIDIMENSIONAL SUSTAINABILITY BAU STATUS

Dimension	Dimension State	Description
Environment	47.59	Less Sustainable
Socio-economic	44.84	Less Sustainable
Socio-Cultural	59.58	Moderately Sustainable
Urban Architecture	35.23	Less Sustainable
Average	**46.81**	
Status	**Less Sustainable**	

Source: Analysis Results, 2022

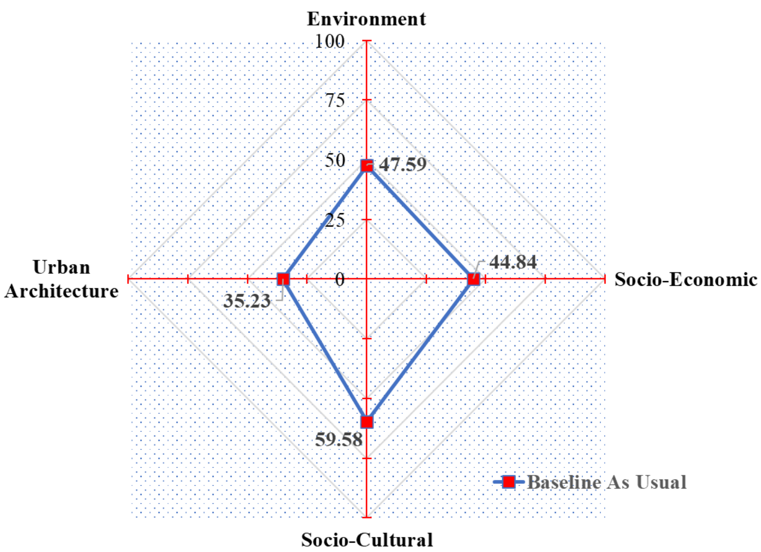

FIGURE 6 - MULTIDIMENSIONAL BAU INDEX

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The validity of the MDS analysis was performed using Montecarlo. The calculation of the sustainability index and its validation in detail are presented in Table 4 below.

TABEL 4 - SUSTAINABILITY INDEX VALIDATION

Dimension	Dimension State	Montecarlo	Delta	RSq	Stress
Environment	47.59	47.20	0.39	0.95	0.13
Socio-economic	44.84	44.66	0.18	0.95	0.14
Socio-Cultural	59.58	59.92	0.34	0.95	0.15
Urban Architecture	35.23	36.25	1.02	0.95	0.14

Source: Analysis Results, 2022

In Table 4 above, the difference in the results of the analysis using the MDS and Montecarlo methods is <5% or very small. This proves the level of confidence in the total index (multidimensional) and the confidence in the index value of each dimension.

According to Kavanagh & Pitcher (2004), this analysis is quite accurate and scientifically justifiable based on stress values less than 0.25 or 25%, and an RSq values close to 100%. Based on the results of the Rap-SSTUA analysis, the leverage attributes were obtained as presented in Table 5 below. The number of variables determined was not standard, the main one is the most dominant, and in this study the two most dominant variable attributes were determined and if further analysis is still less sensitive then it will be combined with the next variable according to the RMS value level. In this study, the two most dominant attribute modifiers were determined for further analysis using SD.

TABEL 5 - Leverage factor of Urban Architecture Socio-spatial transformation dimension

Dimension	Leverage Attributes	Value
Environment	Waste pollution Residential Densification	2.43 2.55
Socio-economic	Income Hope for a new job that can be a permanent livelihood	2.32 2.18
Socio-Cultural	Social class Rooted culture	1.79 1.25
Urban Architecture	Architectural Type and Style Land Use Intensity	6.59 5.77

Source: Analysis Results, 2022

4.3. MODEL SCENARIOS

Before the model simulation is carried out, variables affecting system performance are first described, which are outlined in a causal loop diagram in Figure 7 below.

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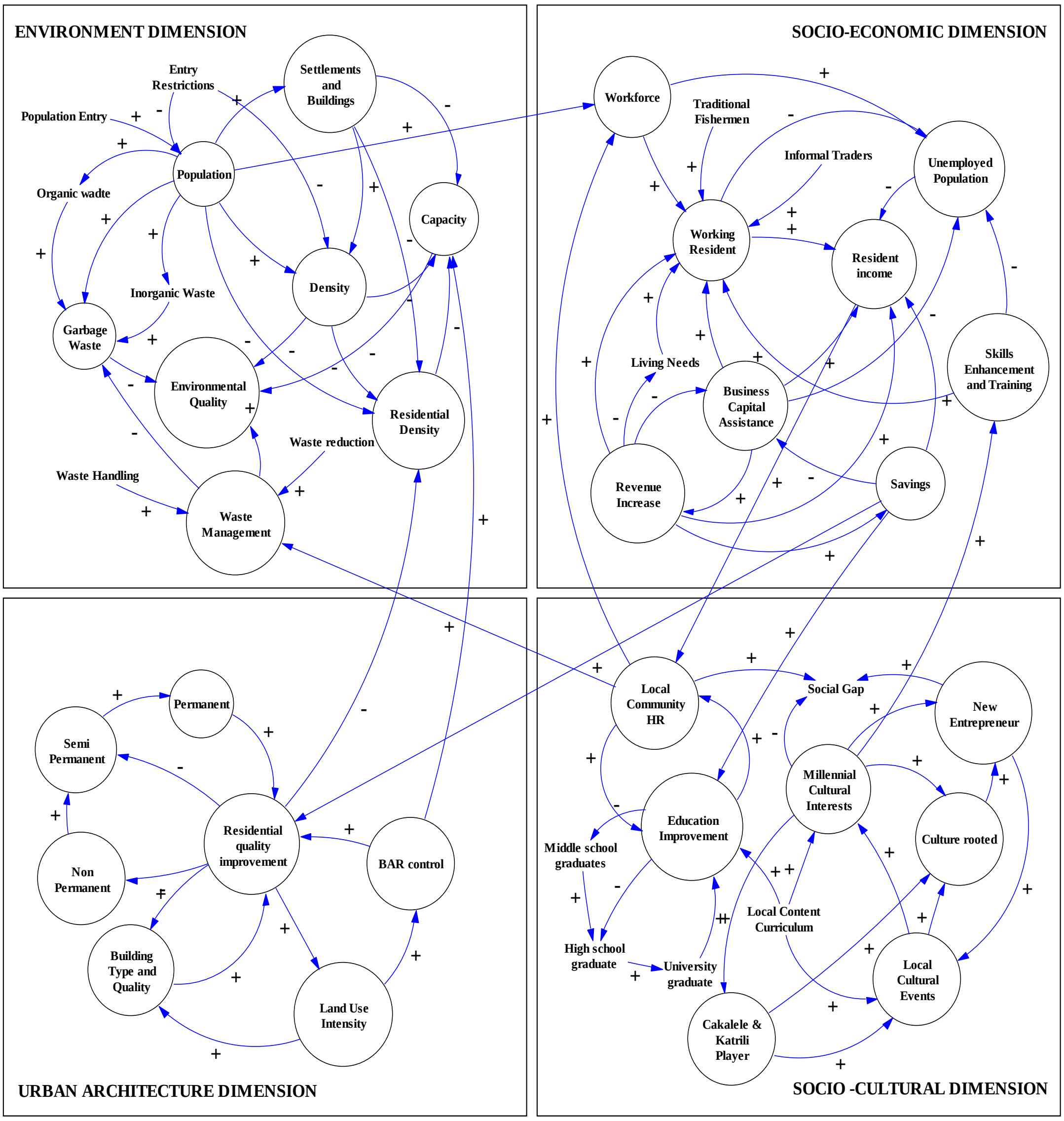

FIGURE 7 – CAUSAL LOOP DIAGRAM (CLD)

The Stock Flow Diagram (SFD) model scenario as shown in Figure 8 below is simulated from controlled inputs and interventions at eight leverage point factors. At this stage, several scenarios of changes were carried out at the leverage point in order to achieve an average sustainability status of >75. The scenarios compiled are: 1) Baseline As Usual (BAU), 2) moderate scenarios, and 3) optimistic scenarios.

Simulation using SD shows that with BAU sustainability status there will be a decrease in sustainability status in all transformed dimensions. The sequence of BAU sustainability scenario, moderate and optimistic scenario, can be seen in Table 6 and the sustainability graph in Figure 9

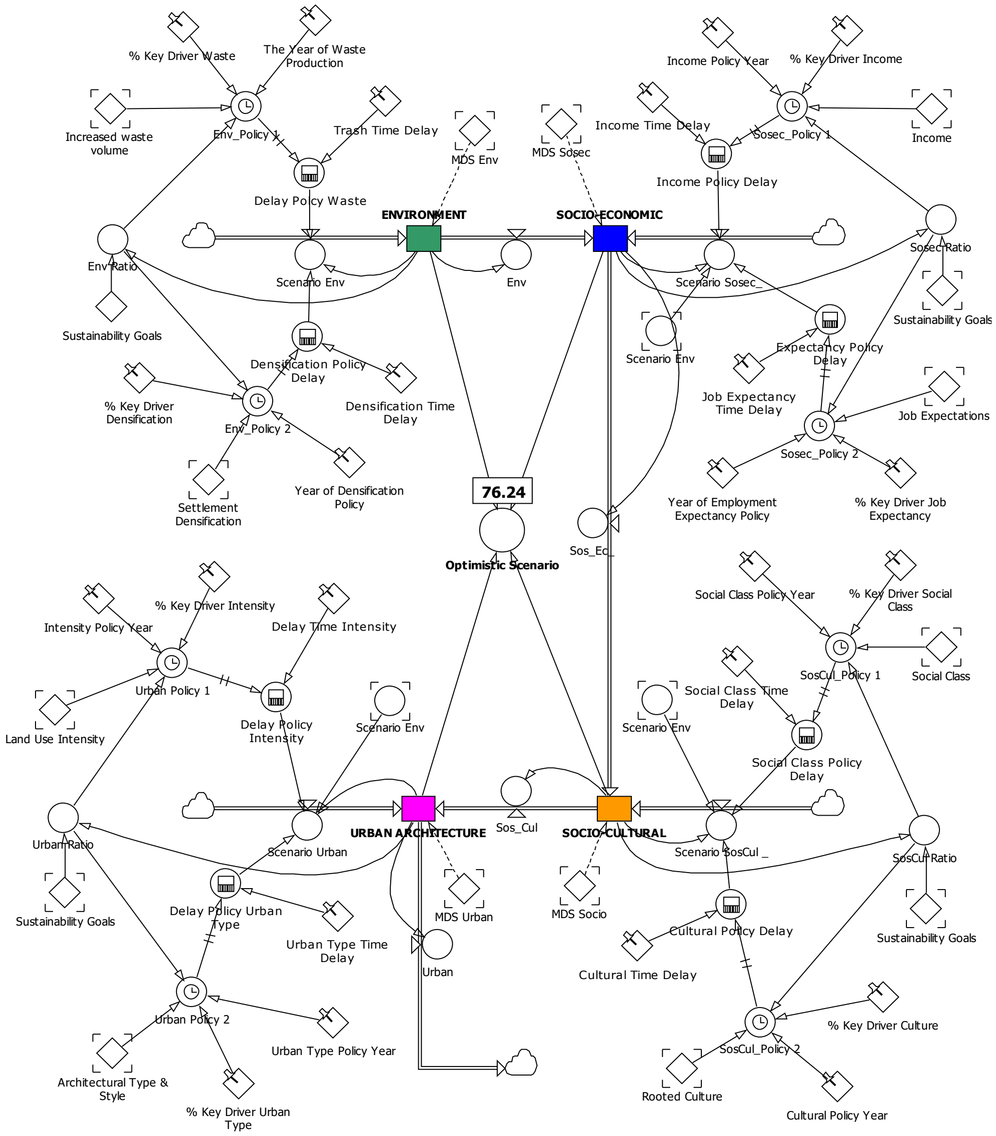

FIGURE 8 - STOCK FLOW DIAGRAM (SFD) SUSTAINABILITY SCENARIO

TABEL 6 - SUSTAINABILITY SCENARIOS

Policy	Sustainability Status		
	BAU	**Moderate**	**Optimistic**
Environment	47.59	59.63	82.58
Socio-economic	44.84	57.87	78.32
Socio-Cultural	59.58	56.21	74.13
Urban Architecture	35.23	54.54	69.91
Average	**46.81**	**57.06**	**76.24**
Status	Less Sustainable	Moderately Sustainable	Sustainable

Source: Analysis Results, 2022

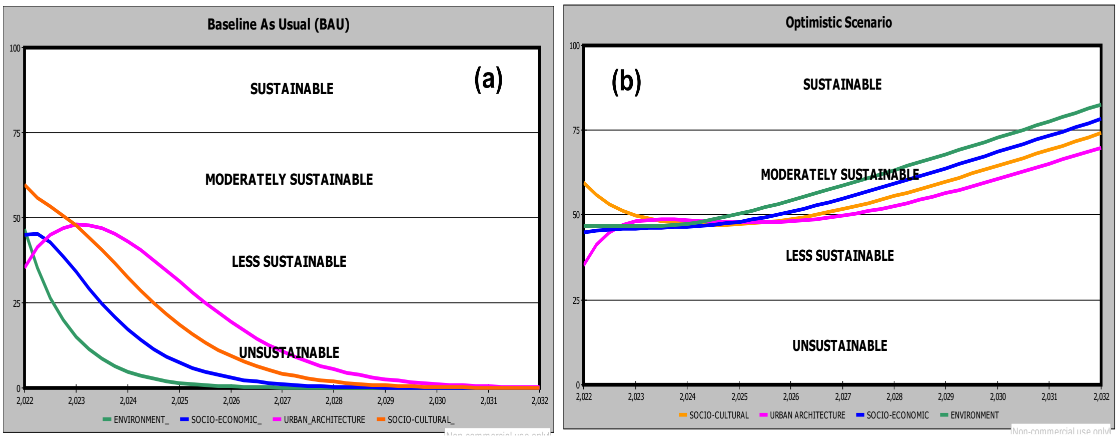

FIGURE 9 - SFD BAU GRAPH (a), SFD SCENARIO SUSTAINABILITY OPTIMISTIC (b)

The simulation results in Table 6 and Figure 10 above show that the BAU condition of the environmental dimension and the socio-cultural dimension will decrease to 2.63 and 5.64 until 2032. The architectural dimensions of the city will increase in 2023, but will begin to experience a downward trend entering 2024. Likewise, the socio-economic dimension will begin to decline from 2023.

Furthermore, the SFD model is built by changing the percentage change factor to achieve optimal sustainability status in the next ten years. Simulations using a moderate scenario were carried out with a percentage increase of fifty percent at the changer that had the highest RMS value and at the changer that had the second highest RMS value. The simulated environmental and architectural environment and architecture of the city begins in 2023, with a one year delay. Then the simulation of socio-economic and socio-cultural dimensions starts in 2024, and the time delay is 2 years. The achievement of environmental dimension sustainability status in 2032 is 62.93, the socio-economic dimension in 2032 is 61.04, the socio-cultural dimension is 59.20 in 2032, and the urban architecture dimension is 57.28 in 2032. The average sustainability status of the moderate scenario is 60.11 (moderately sustainable).

Simulations using an optimistic scenario were carried out with an increase in percentage of 75% at the changers with the first and second highest RMS values. Especially for the environmental dimensions, the densification of settlements is eighty percent. The simulated urban environmental and architectural dimensions begin in 2023, with a one year time delay. Then the simulation of socio-economic and socio-cultural dimensions starts in 2024, and the time delay is two years. The achievement of the sustainability status of the environmental dimension in 2032 is 82.58, the socio-economic dimension is 78.32 in 2032, the socio-cultural dimension is 74.13 in 2032, and the achievement of the sustainability status of the urban architectural dimension is 69.91 in 2032. The average sustainability status of the optimistic scenario is 76.24 (very sustainable). Through an optimistic scenario there will be an increase in the existing dimensions towards optimal sustainability status. At BAU position, the chart is trending downwards from 46.59 to 5.26. In the moderate scenario, the status increases from 46.59 to 57.09, and in the optimistic scenario, the sustainability status increases from 57.09 to 76.24 by the end of the simulation year.

This means that the reference parameters in optimistic scenarios such as how much the percentage of policy improvement is, what year this policy is started, and how long the policy delay is implemented are important parameters in the formulation of more measurable policies, strategies and programs. The final result of the change in sustainability status from BAU, moderate scenario and optimistic scenario is shown in the form of a sustainability index kite diagram which can be seen in Figure 10.

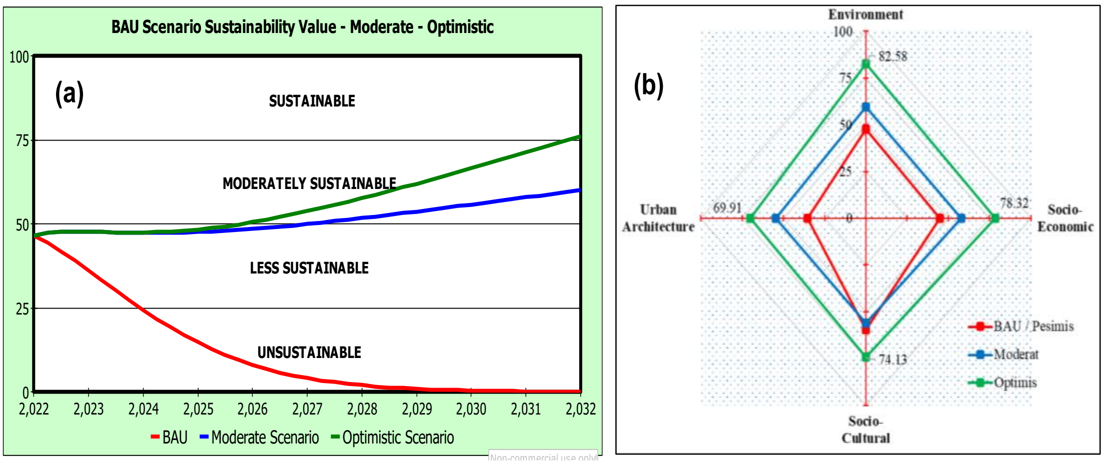

FIGURE 10 - SCENARIO SUSTAINABILITY STATUS (a), SUSTAINABILITY INDEX (b)

The simulation results for eight leverage points serve as a reference in the formulation of policy strategies, plans and programs, as shown in Table 7.

We know that, sustainable development is development that meets current needs without compromising the ability of future generations to meet their own needs (Keeble, 1988). This is followed up through the Sustainable Development Goals (SDGs), especially in goal 11: to make cities inclusive, safe, resilient, and sustainable (Bappenas, 2019), and ensuring that the policies made work as well as possible to support better and more sustainable cities (Klopp & Petretta, 2017).

So far, the above research findings pursue a compact and versatile urban design that is driving the shift in modes of transportation from private motor vehicles to walking, cycling, and public transport, to improve health and sustainability (Sallis et al., 2016). However, the concept of sustainable cities tends to focus primarily on infrastructure (Hilty & Aebischer, 2015). It is reinforced through the research of Moreno et al. (2021), which offering the concept of accessibility, especially through walking or cycling that shown to have many benefits on a social, economic, and environmental scale.

TABEL 7 - SUSTAINABILITY POLICIES STRATEGIES, PLANS AND PROGRAMS

Policy strategies	Plans	Programs
75% reduction in waste	• Waste reduction through reuse, recycling, and household-scale waste restrictions. • Improved waste handling through household-scale waste sorting, collection, and processing.	• Provision of waste facilities and infrastructure • Conscious program does not throw garbage into rivers and beaches. • Clean the beach once a week. • Provisioning of waste bank scale environment
Reduction of the population density by 80% within the region	• Reduction of the density level from 227 inhabitants/ha to 200 inhabitants/ha	• Restrictions on residents entering, especially in areas that are already densely populated. • Relocation of slum area
Increased income by 75% from the initial conditions in local communities engaged in the informal sector	• Increased income of residents who work as fishermen, traders, and stall businesses	• Provision of microenterprise assistance • Provision of business space for local communities on the waterfront • Providing boat and equipment assistance for traditional fishermen
75% reduction in the number of unemployed people	• Improvement of employment skills for the unemployed population	• Skills training in the field of construction (cooperation with related training institutions) • Microenterprise skills training for local communities
Reduction of the social gap between entrepreneurs and local communities through the improvement of human resources (HR)	• Increasing the human resources of local communities in the field of education, as many as 75% of junior high school graduates of productive age can continue their studies at least high school	• Providing educational scholarship assistance for underprivileged children • Cooperation with private campuses entering the village for a cheap and affordable financing scheme
Preservation of rooted culture	• Increased interest of 75% of millennials in rooted culture	• Culture rooted in the local content education curriculum. • Cultural preservation through the existence of interest and talent training facilities in each village • Hold *cakalele* (locally named for traditional culture) and *katrili* (locally named for traditional dance) competition events every year. • Establishment of regional-level customary and cultural councils
Improvement of the quality of housing and architectural style of the area	• Improving the quality of housing by 75% from non-permanent to semi-permanent conditions	• Repair of slum pockets • Surgical residential house of uninhabitable houses • Creation of a development guideline on the edge of the boulevard
The increase in the regularity of land use intensity reaches 75% in the area	• Building Approval (BAR) Regulation	• Control of dwellings that violate the boundary line of the building. • Providing Incentives for owners who take care of PBGs Councils

Source: Analysis Results, 2022

The relevance of this study is related to policies to reduce occupancy density, as studied by Dempsey et al. (2012). Their findings suggest that the higher the residential density, the lower the provision and use of public space and green space in the city. Other findings are also related to policies to reduce waste pollution, in line with the findings of Esmaeilian et al. (2018). They found that it requires four main strategies to become a sustainable zero waste city which are waste prevention, upstream waste segregation, timely waste collection, and proper value recovery from the collected waste. Such studies from Yang et al. (2020) found that the most significant factor of the location of traffic in coastal city, the construction of new roads which damaged many traditional houses in old cities, the attention of urban approaches and architecture that could adapt to local lifestyles and culture can indeed reinforce the findings in this study. However, the conceptualization is more descriptive and has not been measured.

Policies and strategies in the socio-spatial context found in this study are also in line with those described by Dakey et al. (2022). Their findings are through the role of community opinion in policy making for better coastal risk governance.

The explanation is in line with the MDS and SD approaches used in this study. The thing that differentiates it from the studies mentioned above is that it is not located in a coastal city, has not been measured, and does not describe the initial status of sustainability. However, most of their findings may also generally occur in coastal cities. It is clear that research on sustainability in more scalable coastal cities is very limited, and it is something completely new to research.

The results of the MDS analysis provide an overview of the index values for the environmental dimension, the socio-economic dimension, and the urban architectural dimension in the less sustainable category, and only the socio-cultural dimension which is classified as sustainable. Thus, it is found that the current status of the socio-spatial transformation of urban architecture is in the less sustainable category.

Then the SD simulation results focusing on the eight levers of sustainability which can be obtained by several policy strategies including reducing waste, reducing settlement density through controlling population density, increasing the intensity of land use, improving slum settlements through increasing the quality of building types from non-permanent to semi-permanent, and reducing disparities between migrant entrepreneurs and local communities through strategies to increase human resources that focus on improving education are some of the policy strategies that can be implemented.

It can be said that the findings of this study can provide support for the concept of better and more sustainable development policies, plans, and programs in coastal cities in the future.

5. CONCLUSIONS

This study concludes that the index and sustainability status of the socio-spatial transformation of urban architecture in BAU conditions are in the category of less sustainable with an index value of 46.81. The results of the MDS analysis show eight main lever factors for the sustainability of the socio-spatial transformation of urban architecture, namely: (1) waste pollution, (2) residential densification, (3) income, (4) hope for a new job that can be a permanent livelihood, (5) social class, (6) rooted culture, (7) architectural type and style, and (8) land use intensity.

The optimistic scenario model through intervention on eight lever factors through policy strategies to reduce waste, reduce population density, increase the income of local residents engaged in the informal sector, increase human resources through education, preserve deep-rooted culture, improve the quality of housing, and increase the regularity of use intensity land can improve the status of sustainability which currently has an index value of 46.81 (less sustainable), increasing its index value to 76.24 (very sustainable). The policy strategies, plans and programs in Table 7 above can be used as a reference for sustainable urban architectural development models.

Due to limitations in this study, policy strategies, plans and programs have not been described in detail in the form of a matrix which contains volume, estimated costs, stages of implementation, and responsible actors. In addition to related variables, further research requires additional dimensions such as infrastructure and technology, as well as legal and institutional dimensions. Therefore, it is possible to conduct further and more detailed research to build on these findings.

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