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A GEOSPATIAL FRAMEWORK FOR SELF-SUSTAINING URBAN METABOLISM IN SOUTH TANJUNG DUREN AREA, WEST JAKARTA

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ABSTRACT

Urban metabolism plays a crucial role in shaping the sustainable development of regions since it relates to how resources are consumed, transformed, and disposed of dynamically. In an increasingly urbanized world, effective regional planning is essential to address challenges such as resource depletion, environmental degradation, and socio-economic issues. This study aims to create an implementation framework for urban metabolism in South Tanjung Duren, West Jakarta, selected as part of a larger urban metabolism model. The research introduces a practical approach for urban designers, architects, and local authorities to establish self-sustaining urban areas. The methodology consists of two stages. In the first stage, the study thoroughly assesses the object of the study. This includes profiling the essential aspects of the object study, environmental impact assessments, mapping material and energy flows, and categorizing groups to optimize urban metabolism. Findings from this stage shape the second stage, which uses urban infill strategies via four approaches: Collecting Resources, Creating Biotopes, Channeling Energy, and Catalyzing. These strategies are simulated on the study site to analyze flows of goods, people, waste, biota, energy, food, water, sand, clay, and air, creating a geospatial framework for self-sustaining urban metabolism. The findings underscore that South Tanjung Duren has strong potential for implementing an urban metabolism framework, with simulations revealing increased resource efficiency, effective waste reduction, improved green space, and minimized environmental impact. This framework not only enhances resource optimization and environmental protection but also fosters sustainable development, positioning South Tanjung Duren as a replicable model for resilient, self-sustaining urban neighborhoods.

Keywords: urban metabolism, urban infill, geospatial framework, self-sustaining

1.0 INTRODUCTION

Human populations have increased from two and a half billion in 1950 to seven points eight billion in 2020. It almost tripled with almost five billion people added up within eight decades (Kotkin, 2012) (Hesketh, Lu, & Xing, 2005) (Fischer, 2006). Even though several researchers predicted that the growth would slow down between 2020 and 2050, humankind has already faced global issues related to their needs in energy, food, waste and living qualities. In the realm of urban planning and architecture, one of the most significant implications is the ability to create a self-sustaining environment on a smaller scale of living ecosystems.

Changes from rural to urban are inevitable and would loosen the ability to have a self-sustaining environment. Slowly but surely, the rural areas which have always become a buffer zone to fulfil the urban needs will become more fragile and lose their ability to support their greater areas. Several aspects that are known as Land Use Intensification led to the development of land for commercial properties, transportation, and residential buildings, which can lead to deforestation, fragmentation, or other disruptions of much larger areas per household (Meyer, 2013). Along with it, poor air and water degradation quality are also increasing; biodiversity loss is also part of urbanization where land-use change, climate change, nitrogen deposition, and the introduction of invasive species, affect the ecosystems that animals and plants need; climate change is developed and eventually water scarcity happened.

Both the rate of ecosystem degradation and the cost of establishing engineered infrastructure are major drivers in determining the dearth of services in peri-urban areas. For example, when the cost of supplying the service is high for the environment, then nature could support only low population densities. Similarly, when the cost of building infrastructure is also high, then it is only economically viable at high population densities (Costanza, 2020). In such a situation, the green-loop system is likely to degrade before the red-loop system is fully established.

Thus, the idea of urban metabolism was introduced to help urban designers, architects, and local authorities to establish self-sustaining urban areas. With a global pandemic issue in mind, this framework would also provide a more practical implementation that solves an urban metabolism issue on a neighbourhood scale at the same time. In case another isolation ever happens again to a region, the population in a self-sustaining neighbourhood could still support their lives.

Since the earlier studies about urban metabolism have been focusing on a larger scale, an implementation framework using several architectural approaches such as urban infill development in one smaller urban fragment is challenging. This research introduces an innovative approach using urban metabolism to shape regional planning in the South Tanjung Duren area in West Jakarta through an experimental strategy. Although the geospatial framework proposed in this research is highly experimental, it surely could provide views on how people should act and how local authorities should start preparing a region to be resilient and self-sustaining.

By observation, Jakarta has almost everything to run the urban metabolism framework such as natural resources, biodiversity, demographic bonuses, landbanks owned by the government, and the awareness and eagerness of the society. In fact, the guidance in implementing this framework was still limited and needs to be studied further on a smaller scale in neighbourhoods and districts. This research conducted together with the students was not mainly talking about numbers and the impact of implementing the Urban Metabolism framework but rather discusses the built environment spatiality of the district that might be interfered with by the ideas themselves.

2.0 LITERATURE REVIEW

The Urban Metabolism idea was developed by Wolman in early 1965. It refers to the flow of materials and energy through urban systems, including the consumption of resources, the production of waste, and the impact of urbanization on the environment (Wolman, 1965). The first idea of urban metabolism was to understand the relationship between industrial

systems and the environment, which was initiated by Rapoport's ecological industries and Karl Marx's economic theory. Urban metabolism studies the flow of materials and energy through urban systems, including the consumption of resources, the production of waste, and the impact of urbanization on the environment (Lederer & Kral, 2015). The concept of urban metabolism has evolved over time, with researchers expanding its scope to include social and economic factors, and climate change's impact on urban systems (Céspedes Restrepo & Morales-Pinzón, 2018). Now, the urban metabolism framework has been used to inform urban planning and design, as well as to evaluate the sustainability of urban systems.

Urban metabolism was enhanced by Kennedy in 2007 by adding several indicators and measurement aspects such as carbon footprint calculations that subtracted from the flow of materials and energy through urban systems, including the consumption of resources, the production of waste and social and economic factors, as well as the impact of climate change on urban systems (Kennedy, Cuddihy, & Engel-Yan, 2007).

The principle of urban metabolism is a view of seeing a city as an organism, which has a metabolic process to live daily, which conceptually can be seen in Figure 1. When seeing as an organism, therefore it is important to see the big picture of the cycle of elements that are required in order to live. This may involve the quantifications of inputs, outputs, and storage of energy, water, nutrients, materials, and waste for an urban area. Thus, urban metabolism may be understood as a technical and socio-economic process that occurs in one city, causing many growths, energy production, and waste disposal. It plays a crucial role in shaping the sustainable development of regions since it relates to how resources are consumed, transformed, and disposed of dynamically (Stewart, Kennedy, & Facchini, n.d.; Wolman, 1965). As the world becomes increasingly urbanized, effective regional planning becomes important to address challenges, such as resource depletion, environmental degradation, and socio-economic issues.

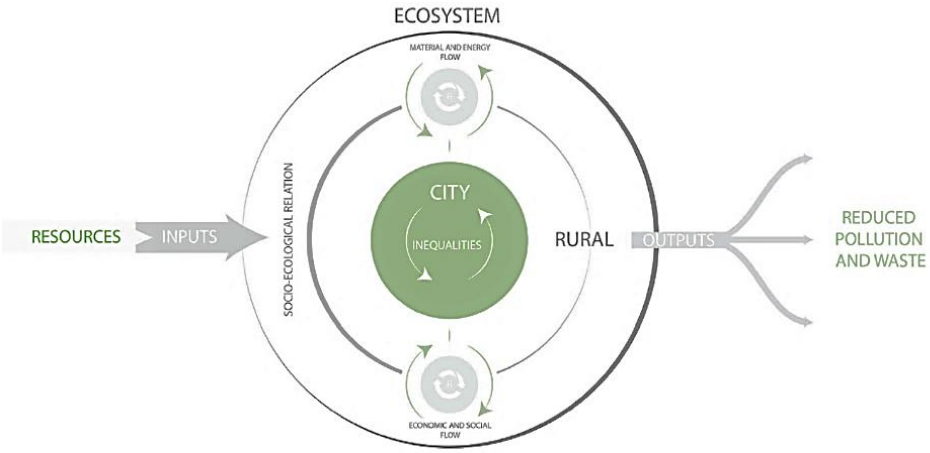

Fig. 1: Concept of Urban Metabolism (Lucertini & Musco, 2020)

As an organism, then another importance other than things that are related to economic-impact movements lies in understanding the socio-ecological relationships within an urban area. However, the process of looking at this needs to go through the metaphor that a city is an ecosystem, where urban elements interact with each other, both biotic and abiotic, and humans as inhabitants are equal components. All of them play a role in the flow of materials and energy (Grove, Cadenasso, Pickett, & Machlis, 2015).

Implementing urban metabolism study in urban planning would contribute to sustainable urban development since it promotes the city to optimize resource efficiency, waste reduction and recycling, improve environmental quality, enhance urban resilience, and gain better-informed decision-making, which supports the sustainable development goals to create the social and economic benefit for the city.

The study of urban metabolism now is more considered an interdisciplinary study, different from the earliest study of it that dominated as accounting exercises. This may be caused by the aspects of the city process varying, not to mention the political and historical aspects that affect the decision-making process in governing the city (Stewart et al., n.d.). Regardless of the complexity, there is a key connection between urban metabolism and the sustainable development of cities that needs to be found contextually and designed uniquely to simplify the implementation on a smaller scale. This approach was suggested because most of the cities that need to be self-sustaining have experienced stagnant development, with a high density of population, and complex demography and socio-economic situation. Any progressive or intimidating development might lead to community rejection and result in failure.

However, there are also challenges to studying urban metabolism, such as the lack of data on resource flows in many cities. It is important to continue to research and develop this concept to create more liveable and resilient cities for the future. This challenge brings up the urban metabolism into a utopian framework that is hard to apply in existing conditions that involve people on smaller scale regions.

3.0 METHODOLOGY

This study is divided into two stages, in which each stage has several steps to be done. The first stage is more towards an academic process, which is applied to the case study as an object selected with the consideration of its bigger context as the background of the study. The second stage is an experimental stage to apply the urban metabolism framework using the result of the first stage. As the South Tanjung Duren area is a small fragment in West Jakarta municipality, then Jakarta can be considered as a background of the study.

3.1 First stage: Complete assessment the Object

The first stage consists of several steps implemented in the object of study to gain subjective aspects as variables for the second stage. They are:

3.2 Profiling the object

Looking for implementation possibilities of urban metabolism framework in Jakarta requires geospatial information of the region itself. Jakarta is the capital and largest city of Indonesia, located on the northwest coast of Java. The city has a long and rich history, with evidence of human habitation dating back to the fourth or fifth centuries.
The government has implemented various strategies to make Jakarta self-sustaining, including the 2014 smart city concept, the sustainable urban development framework during Governor Fauzi Bowo's tenure, community-driven incrementalism under Governor Anies Baswedan, and the 2020 urban environmental management system. These initiatives aimed to improve environmental quality by tackling issues such as poverty, pollution, and flooding

but have not effectively enhanced the city's material, resource, energy, and waste management.

Despite these efforts, Jakarta has yet to adopt an urban metabolism framework, which could be more appropriate given the growing public awareness. South Tanjung Duren area is identified as an ideal pilot location due to its complexity and availability of resources, materials, energy, food, and waste management infrastructure, as indicated by remote sensing data. This area features Kampong Kota, commercial zones, diverse housing, rivers, government land, and an engaged community that actively supports cleanliness and waste management programs.

A vital aspect of urban metabolism is the urban food system, essential for achieving self-sufficiency. Analyzed GIS data shown in Figure 2 reveals that 80% of South Tanjung Duren consists of residential areas, including houses and apartments, predominantly on the eastern side. In 2019, the total population was 32,839 (15,847 males and 16,992 females) (Kantor Walikota Jakarta Barat, n.d.)., resulting in high food demand. Thus, ensuring food security and developing a self-sustaining regional plan is crucial for this community.

Fig. 2: Zoning of South Tanjung Duren, West Jakarta

South Tanjung Duren has various untapped local resources, while the community continues to rely on external sources. However, these resources hold significant potential for local processing to bolster the urban food system. Initiating an urban metabolism process within the region could foster self-sustaining regional planning. To achieve greater sustainability, the prevalent linear metabolism model common in most cities must transition to a circular metabolism approach. Although the scale of metabolism may differ, integrating circular systems across urban regions can enhance a city's overall sustainability.

This research will experiment with strategic regional planning that incorporates circular metabolism principles such as resource collection, biotope creation, energy channelling, and system catalysis. By applying these strategies, the study aims to simulate a self-sustaining regional plan that ultimately supports the development of a circular economy in South Tanjung Duren.

3.3 Environmental Assessment

This step uses the environmental assessment method by Rapoport. They consist of sustainability aspect (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007), interregional exchange (Blanc & Friot, 2010) (Kissinger & Rees, 2010), territorial impacts (Loiseau, Junqua, Roux, & Bellon-Maurel, 2012), and urban metabolism (Sun et al., 2016) (Zhang, Yang, & Yu, 2015). The purpose of this environmental assessment is to identify the critical issues that may be impacted by the proposed project or development. This involves scoping, defining environmental impact statements, assessing the historical aspects, identifying the stakeholders involved, predicting the impact using magnitude, reversibility or irreversibility, duration, and zone, and proposing an environmental management plan that also talks about mitigation. Defining impact statements and predicting the potential impacts also involve air quality, water quality, soil quality, wildlife, and other environmental factors that would interfere with the urban metabolism framework.

Since the spatiality of the built environment and neighbourhood become the emphasis of this research, assessing the historical aspects and rethinking the context should implement several guidelines from the urban infills framework. Urban infill strategies aim to increase housing availability while minimizing city boundary expansion. This approach is considered a smart growth strategy to address the lack of space in densely populated areas and curb uncontrolled urban expansion. Urban infill involves developing vacant or underutilized land within existing urban spaces, enabling cities to expand housing without extending their boundaries. Additionally, urban infill contributes to neighbourhood revitalization and helps mitigate urban sprawl (Jones & Williamson, n.d.) (Talen, 2015).

Key strategies for urban infill development include adaptive reuse (Al Shamarti & Al Shammari, 2020), mixed-use development, transit-oriented development, small-scale projects, and green space preservation (Abedini & Khalili, 2019). However, challenges such as limited land availability, zoning regulations, community resistance, and higher costs must be considered. In high-density cities, available land for infill development is often scarce, making large-scale implementation difficult. Zoning regulations can further hinder urban infill by limiting the types of development permitted on potential sites.

Despite these challenges, integrating urban infill development into the study area remains a viable approach. The process is intricate and may face community resistance due to concerns over increased density, traffic, and noise. Additionally, urban infill development can be costlier than building on greenfield sites because of the need for extensive site preparation and infrastructure enhancements (Jones & Williamson, n.d.). Understanding these complexities is essential for effective planning and execution of urban infill projects.

3.4 Resources and materials mapping

To implement the urban metabolism framework that has a good flow of material, resources, energy and waste, the processing facilities should be accepted by the context first. The initial step to be conducted is mapping the resource, material and possible place to be injected. Resources and materials were divided into natural resources and waste. It is not only the types of resources and material, but also the zones and amount they had. The possible place to put the processing facilities should be using the existing government buildings, public facilities, and land banks owned by local authorities.

Each place was measured using the key factors of urban infill developments such as Community Acceptance and Engagement, Density and Scale Appropriateness, Socio-Economic and Environmental Impact, Design Quality and Built Environment Integration. The community resistance can be viewed from the impact aspects. The bigger impact they have, the bigger possibilities would be accepted. The impact itself should not only be related to socio-economic, but also the built environment qualities that can widely use by the whole communities (Papangelou, Bahers, & Aissani, 2023).

3.5 Categorization and grouping

The next step that is needed after resource, material and place mapping, is creating a categorization and grouping. This categorization can help the urban metabolism flow goes more effective and efficient. The proposed type is: (1) good position or zones, easy infill strategies, high impact to communities; (2) Good position or zones, easy infill strategies, low impact to communities; (3) Good position or zones, complex infill strategies, low impact to communities; (4) Bad position, complex infill strategies, low impact to communities.

This step will also provide information how good the metabolism within an area can be achieved. If the first categories dominate the possible places, it can be more ideal to the metabolism itself. But otherwise, if the fourth category dominate the places, the metabolism can also be achieved but not in ideal conditions.

3.6 Second stage: Simulation of the Urban metabolism in the object

This stage is the action that implements the urban metabolism framework in the object, using results from the previous assessment. Urban metabolism is a combination of morphological and physiological that can be used in the prolonged process of reconstructing the city. (Oswald, 2003) This research introduces an innovative approach using an urban infill strategy to shape an urban metabolism in the South Tanjung Duren neighbourhood through four strategies, such as Collecting Resources, Creating Biotopes, Channeling Energy and Catalyzing. These different strategies are simulated by analyzing the flow of urban metabolism elements, which are goods, people, waste, biota, energy, food, fresh water, sand and clay, and air.

In the concept of urban metabolism, what becomes an issue is the boundaries of that urban area because the flows occur within the city's spaces. Therefore, it is important to define the physical boundaries and urban spaces before assessing and analyzing the various flows. As a base thought, a remote sense of how the South Tanjung Duren area is divided into commercial zones, housing and dwelling zones, public facilities zones and educational zones is presented. Figure 3 below shows the profile of the South Tanjung Duren area as an object of study.

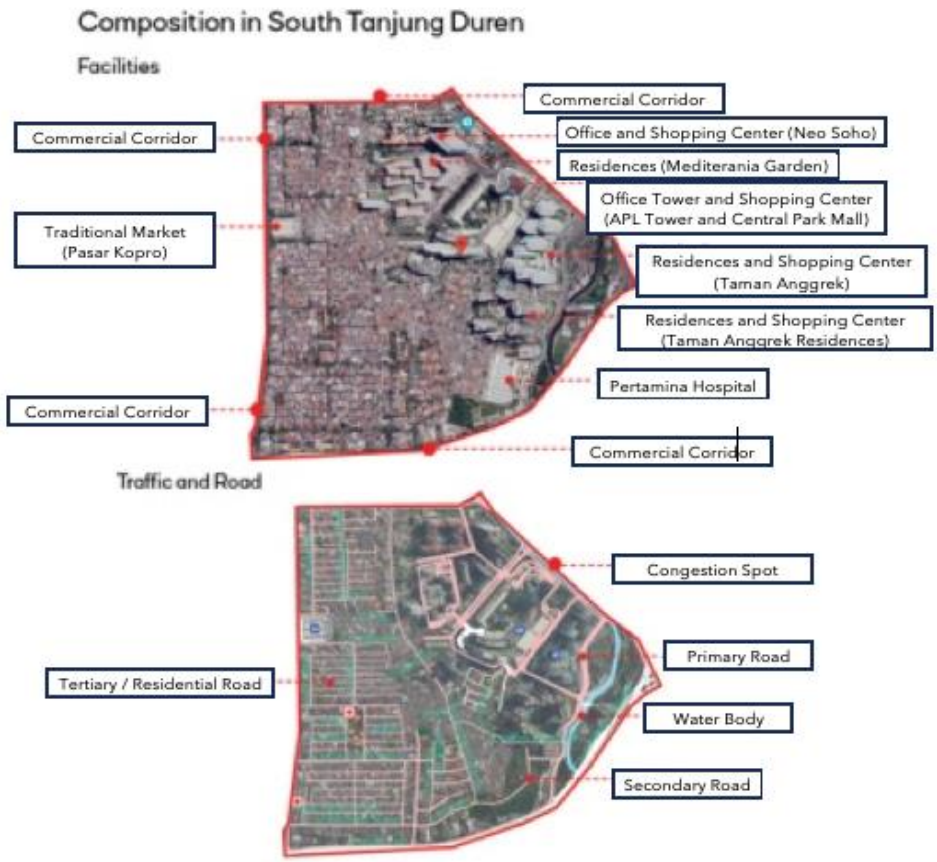

Fig. 3: Physical Boundaries of South Tanjung Duren

The first strategy is collecting resources in South Tanjung Duren by extracting raw materials from waste and food, such as plastics, cans, maggots and organic waste. Then, the second strategy is creating biotopes by improving existing urban nature including waterway aqueducts, hydroponics, catfish farms and carbon dioxide. The third strategy is channelling energy by using dry steam power plants, solar panels, and biogas energy. Lastly, the fourth strategy is catalyzing all earlier strategies into suppliers, food courts, laboratories and distribution centres, which will contribute to the collecting resources strategy again showing a circular metabolism system. These strategies simulate a unique network that shows various resource flows creating complex interdependencies and environmental impacts of various urban activities in the South Tanjung Duren area of the neighbourhood, which is accommodated by implementing the urban infill strategies as shown in the conceptual framework in Figure 4.

Various strategies could contribute to an urban metabolism that has more positive effects on the quality of life. These strategies will also improve the efficiency of their material flows while decreasing the negative effects on sustainability. This strategy is unique because it is based on local resources which will be simulated to a potential cycle to create a sustainable system.

Fig. 4: Conceptual framework of Urban Metabolism in Neighbourhood Scale

Re-using, redesigning, innovation and substitution are generally seen as being guiding principles for improving the sustainability of the use of materials in production and consumption chains. In this case, experimental simulation looks at the synergy between the various flows by linking them to each other at the regional level. Another strategy is to set up material flows in the production-consumption chains that are part of the urban metabolism. These chains cannot be seen separated from each other, but they could be perfected individually. Eventually, this strategy becomes a transition to a circular economy in the region.

4.0 ANALYSES AND RESULTS

These are strategies implemented in object of study as analyses of the simulation of the urban metabolism framework. Each strategy is analysed and gained the decision-making inputs of the urban spatial planning.

4.1 Collecting Resources

This first strategy, Collecting Resources, is how raw materials from waste and food in the region are obtained. South Tanjung Duren area produced a lot of plastic waste, organic waste, and recycled cans which have not been disposed of properly. Maggots are also found because of organic waste. These elements could be potential resources if developed well instead of throwing them away as waste.

South Tanjung Duren produces various types of waste, including household, organic (e.g., vegetables and fruits), and problematic plastic waste, accumulating up to 110 kg over two days (Muhammad Al Faruq Abdullah, 2021). Plastic waste, difficult to decompose, can be processed into polypropylene pellets for resale and durable by-products through a process of collection, sorting, chopping, melting at 650°C, cleansing, and drying, which conceptually is shown in Figure 5 below. This method yields compounds like Ethylene, Hydrogen, and Methane, which can fuel power plants after pyrolysis.

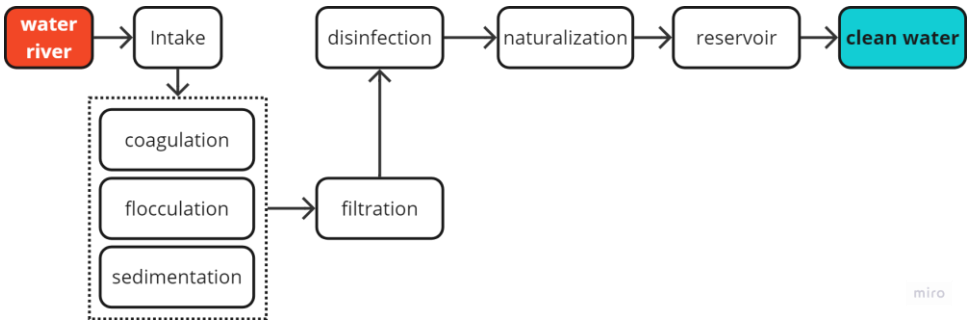

Fig. 5: Plastic Waste Subtraction Process

Additionally, recyclable inorganic waste such as cans, containing metals, can be melted and repurposed into new products. Due to the many residential areas and the Kopro Market, organic waste is also prevalent. Black Soldier Fly (BSF) larvae, derived from such waste, offer a promising maggot farming opportunity that could benefit South Tanjung Duren area economically and environmentally.

In simulating first strategy in this area, so, there should be some spaces that can be injected as facilities for resources and material collector. Looking to the object of study profile and the process of collecting resources, there are some criteria of places that can be categorized as suitable for these facilities, such as: the simplicity of implementing the infill development, less negative impact on community, good accessibility and achievability for the collector.

Fig. 6: Collecting Resources in South Tanjung Duren

By assessing the potential points and spaces for each resource and material collection from the spatial composition map of South Tanjung Duren area and using the variables of subject analysis gained from the first stage, the site of each facility to accommodate the first strategy can be decided.

Figure 6 above and Table 1 below is showing the location of spaces elected for facilities to be injected for collecting resources and material, and the surrounding context and typical proposed infill design.

Table 1. Designated spaces for location of resources and material collectors

No	Place	Existing and Propose Design	Argumentation
1	Kopro Market backyard. Suitable for waste and plastic recycle facilities	 	Good location and close to sources of waste. Simple strategies of infill development Good impact on communities
2	Public space near the river and The Empty space in between central park mall and Taman Anggrek Mall. Suitable for placing catfish farm	  	Good position Simple strategies of infill development Good impact on communities
3	Community Center. Suitable for placing maggots farm	 	Position is not close enough to the resources and material and it needs a small vehicular transportation to collect resources. Simple strategies of infill development Good impact on communities

4.2 Creating Biotopes

The second strategy, Creating Biotopes, focuses on enhancing urban nature using local resources like freshwater, sand, and clay. This involves developing waterway aqueducts, hydroponics, catfish farms, and carbon dioxide management. The principle behind this strategy is that harmonious coexistence with nature supports safe living and economic growth through food production. Maximizing urban nature would thus be highly beneficial. The approach requires simulating methods to produce food from local resources and biotopes.

South Tanjung Duren area is bypassed by a river, Grogol River. However, the water in this river is not clean. Thus, one of issues in South Tanjung Duren is the limitation of clean water. Clean water services in Jakarta have only reached about 20,000 liters per second out of 26,000 liters per second requirement(Arsito Hidayatullah, 2024). West Jakarta, where South Tanjung Duren is located, is one of the two regions in Jakarta which is still struggling with the clean water availability. Water security in West Jakarta has only reached 60,2%. (Bima Setiyadi, 2018) This condition needs to be improved by doing clean water treatment from the river so we can maximize the potential. Clean water treatment can be done using Reverse Osmosis, or simply using simple water treatment plant to gain preferred BOD and COD demands for the water to be able to be used for growing foods or planting freshwater fish. The scheme of simple water treatment plan and proposed design facilities by simulate the urban infill strategies can be seen in Figure 7 and Figure 8 below.

Fig. 7: Clean Water Treatment

Fig. 8: Water Purification

The Grogol River also had indigenous fish biota that could be found easily many years ago. However, with the clean water crisis in this area, this fish has not got a proper ecosystem. In fact, if this biotope condition is improved, it could be a potential resource. Fish farming could support good quality food and later has a strong impact in the local economy. Some endemic fish species that were found in West Jakarta rivers are Catfish, Uceng Fish, Beunteur Fish, Baung Fish, Bogo Fish and Julung Fish.

Another existing problem in South Tanjung Duren is traffic which causes a lot of carbon dioxide pollution. However, carbon dioxide actually could be processed into water by removing toxic compounds. This water function will be used as cool water to support a cooling tower.

South Tanjung Duren area could also have a potential in urban farming. Urban farming using hydroponic system can be applied by every household, or to any public facilities with certain management system by the community. This program could be inserted in the area to support quality of organic food and supply fresh products to the local Kopro Market. The scheme of relationship of this potential with other elements to create biotopes is shown in Figure 9. This shows that urban farming is also need the involvement of water supply, organic fertilizer, and local market in order to develop. Even so, the involvement of other party such as the scientific research is needed to maximize this strategy.

Fig. 9: Urban Farming Potential

The relationships among those mentioned elements are interdependent to create the biotopes within this object of study. The connection among those can be simulated in spatial planning shown in Figure 10 below.

Fig. 10: Creating Biotopes in South Tanjung Duren

4.3 Channeling Energy

The next strategy is Channeling Energy which means using by-products of energy extraction to get energy. In South Tanjung Duren, it is potential to make a channeling energy using solar panel and biogas energy.

Solar panel system is a potential in the Channeling Energy strategy. Placement of solar panel locations must be in a place that gets minimum of 80% light exposure before the sunset. Solar panel placement can be carried out in these four locations below. These locations are considered based on existing lighting simulations. Energy that comes out from solar panels in those specific locations will be allocated mainly for the public area such as street lighting and traffic light. The placement of solar panel installations in this area at least are on the public building such as local market, public school, and government office. The greenery area can also be placed by these installations since it will provide electricity for lighting and others in specific public spaces. The distribution of those is shown in Figure 11 below.

Fig. 11: Solar Panel Systems

The natural energy stated above will not be sufficient especially natural energy depletion is becoming another issue nowadays. Alternative energy is needed to support the sustainability of a sustainable urban metabolism. One of the alternative energy sources that has potential in South Tanjung Duren is biogas energy. Biogas energy is made from organic waste such as livestock manure, or kitchen waste like vegetables. These wastes will go through a decomposition process called anaerobic digester in an airtight room. The main components of biogas energy are methane gas (CH4) and carbon dioxide (CO2). Both gases can be burned or oxidized and release energy, which then could be used by humans for daily needs. In a day, the volume of waste produced in South Tanjung Duren area reached 11,120 kilograms of combined organic and inorganic wastes. Inorganic type waste collected reached around 110 kilograms (H. Ahmad Mujahid, 2022). These numbers are very potential to support us as an alternative energy source. Figure 12 is showing the scheme of biogas energy supply for community scale.

Fig. 12: Biogas Energy as Alternative Energy

The placement of these biogas energy installations should be planned to be able to distribute the energy resulted to the households in the area. Therefore, the location and the scale of the space to be infilled with these facilities should be sufficient and complementing each other with the source of energy. In this object of study are the organic waste and animal

waste. Table 2 below shows the argumentation of the location selected of biogas energy facilities.

Table 2. Location and argumentation of selected biogas facilities

No	Place	Argumentation
1	 Slums area near the river	Good position Simple strategies of infill development Bad impact on communities Scores: Medium
2	 Public space near the river	Good position Simple strategies of infill development Good impact on communities Scores: high
3	 Sports facilities	200 meters from the nearest river Simple strategies of infill development Bad impact on communities Scores: Medium
4	 Empty space in between Central Park Mall and Taman Anggrek Mall	Good position Simple strategies of infill development Good impact on communities Score: High

Therefore, channelling energy within this object of study by connecting these alternative sources of energy with other facilities from other strategies can be seen in this Figure 13.

Fig. 13: Channeling Energy in South Tanjung Duren

4.4 Catalyzing

The fourth step of the strategy is Catalyzing where the quality of flows of goods, people and air are boosted. This last strategy catalyzes all earlier strategies into suppliers, food courts, laboratories and distribution centers, which in the end will contribute to the collecting resources strategy again.

Food court as a public space is important to have in the catalyzing strategy because it allows goods contribution to the community. A food court would be a space to distribute the results of products which then could be consumed by the community.

Fertilizer Supplier would also be a helpful element in catalyzing strategy. The solution offered is a supplier shop that provides equipment for farming along with planting media, especially fertilizer. This shop could also be used for holding workshops on making compost from organic waste, which is expected to initiate an urban farming movement in the community.
South Tanjung Duren already has a local market, Kopro Market. This local market could be a perfect Hydroponic Laboratory and Distribution for Food Security. Smart hydroponic laboratory is also needed in this catalyzing strategy to expose the community to eco-technology and sustainability. This laboratory is needed to accommodate research about food resource quality.

The network of this strategy with other facilities resulted from other strategies can be simulate in the map of South Tanjung Duren area, shown in Figure 14 below.

Fig. 14: Catalyzing in South Tanjung Duren

5.0 DISCUSSIONS

The main goal of urban metabolism is to contribute in reducing the circulation of materials and resource consumption within cities. In the context of aiming for urban sustainability, what needs to be achieved is a balanced cycle between mass and energy. In this research, four strategies stated above are simulated in unusual ways to support each element to sustain the regional growth. Thus, these four strategies Collecting Resources, Channeling Energy, Creating Biotopes and Catalyzing, are interconnected to sustain the local condition in South Tanjung Duren as shown in the diagram in Figure 15 below.

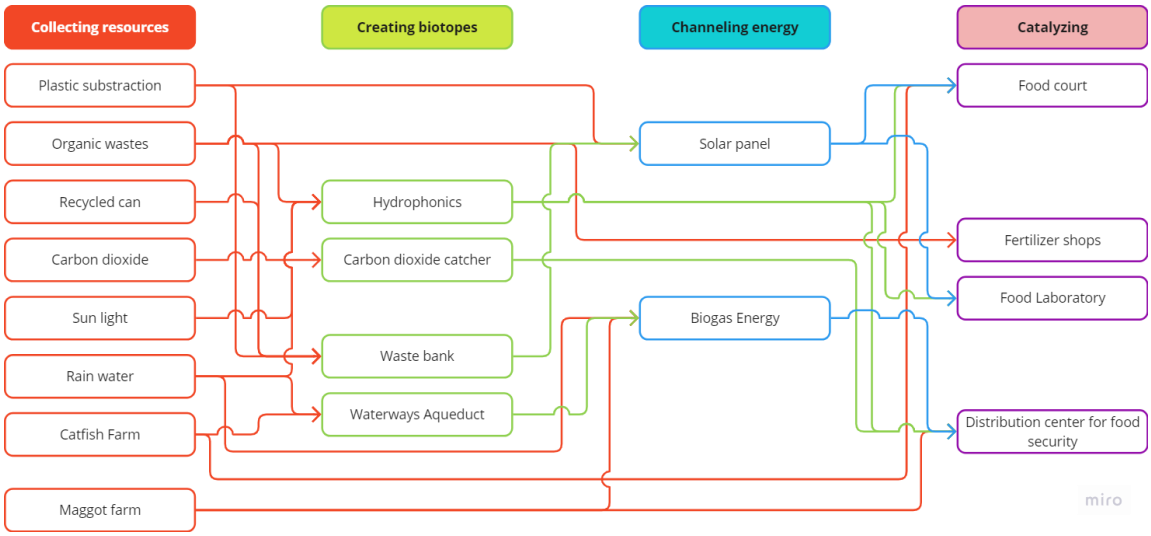

Fig. 15: Collecting Resources, Creating Biotopes, Channeling Energy, and Catalyzing Strategies

The implementation aspect has always been an issue regarding how complexes the existing context has become. Implementing this idea to a district as case studies might be able to help simulate the idea in Jakarta. One of the most important things is context understanding and data resources to correctly put the system in a neighbourhood. South Tanjung Duren area as the chosen sub-district has all the resources and it consists of residential, commercial, social and cultural facilities to accommodate and increase community involvement. Community involvement has become one of the important aspects to guarantee the system's sustainability since this idea needs several years before the impact can be quite useful to the community. Thus, as part of the implementing strategies, the build systems should avoid disturbing locals living qualities such as increased noise and smell pollution, alienated architectural forms, or other side effects that can reduce the community's sense of belonging. Collecting all the resource data in South Tanjung Duren is essential when simulating this framework. This sub-district has several natural resources that are needed, such as all-day sunlight in dry seasons and 121,3 mm3 rainfall in wet seasons, 1,3 km of riverbanks to cultivate protein, and 1,7 hectares of green area to cultivate fibre and vegetables. This district also has commercial resources such as 1,8 million square meters of commercial area and housing resources such as 2,3 million square meters of vertical housing, and 115,5-kilometer squares of landed houses (Kantor Walikota Jakarta Barat, n.d.).

Dry seasons supply adequate sun and heat energy that is potential enough to be captured by solar panels. Wet seasons supply enough water to be conserved and can be used to minimize the use of groundwater anthesis well during dry seasons. Housing supplies almost 12 tons of organic waste each week, nearly 4 tons of plastic waste each week and almost 2 tons of steel waste each year. The commercial area consumes almost 133 tons of vegetation and protein each week and the whole area needs almost 8 tons of steel for building renovation each month(Kantor Walikota Jakarta Barat, n.d.).

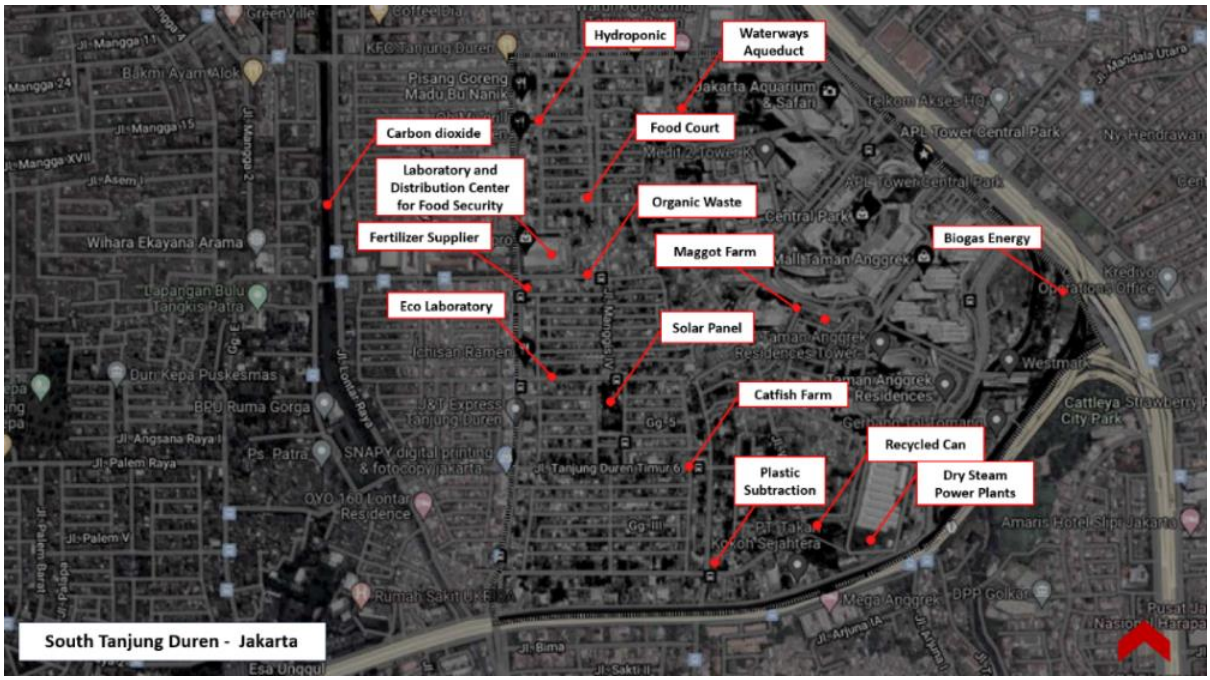

Fig. 16: Collecting Resources in South Tanjung Duren

Mapping the resources and mapping the processing plants in South Tanjung Duren are the crucial steps. Since this area has grown maturely, several social and economic segregations affect the resource and processing plant mapping. For example, even though the area has plenty of organic waste, plastic waste and steel waste, the processing plants cannot be implemented near the area because it consists of high-end communities that are quite sensitive to smell and noise. Another example that should be put in mind is the road width (ROW) that is unable to be expanded even more. Building the catalyzing facilities can increase the mobilization of people and might worsen the traffic jams.

Overall, this district can be separated into 6 zones such as commercial zones in Jl. Tanjung Duren Raya, river front zones in Jl. Tanjung Duren Barat and Jl. S. Parman, small housing zones behind Kopro Market and the south side of South Tanjung Duren, Real estate zones throughout Jl. Way Seputih. Podomoro City zones on the east side of the district, Taman Anggrek zones on the southeast side of the district, school, public library and sports zones west side of the district.

Injecting the processing plants, energy plants and catalyzers into the neighbourhood is done by choosing the building owned by the government that can be renovated using the adaptive reuse strategies. Adding a new building storey, infilling a new infrastructure on the existing yard, reprogramming the building function, and integrating the facilities into other zones of resources, are the strategies that can be implemented. Therefore, detailed building structures and their contextual settings are required to ensure the metabolism works properly.

Several government buildings that can be injected by collecting resources programs are district offices, postal offices, markets and sports facilities. These facilities were selected because their role in communities is quite important and able to gather people. The biotope plants will be placed near the public library and public school as part of their educational program to involve youngsters at an early stage. Channelling energy plants should be placed near organic waste collecting resources but should have a 50-meter distance to avoid smell and explosion possibilities. The catalysator facilities should be placed near the market, health facilities, school, RPTRA (community centre), Masjid or Church, so it can increase the commercial aspect and produce revenue to enhance the metabolism.

Other than those resources, more protein alternatives to replace the consumption of chicken and red meat are introduced. One of the protein alternatives chosen is maggot farming. Maggots were widely used in several tropical countries since it has shorter harvesting times and can be stored for longer periods by further processing. These maggots also supply the food to several endemic fish in Grogol River so the native ecosystems can be restored and able to cultivate fish as protein addition in the future. This maggot farm is best located in several RPTRA near the neighbourhood area.

Adding Carbon dioxide harvesting is needed to help filter the air in South Tanjung Duren since this sub-district has been affected by polluting industries found in greater Jakarta. Carbon dioxide processing will potentially supply several chemicals needed by various industries such as polymers, carbon fibres, and synthetic fuels and even more, it can feed up algae as alternative sources of fibre food. However, these processing plants have different criteria to put down. Calculating the wind flows to make sure that these processing plants can absorb

optimum CO2 is needed in the early stage. Since it produces a lot of noise, these harvesting plants should be put a bit further from the residential zones but near the closest source of CO2 such as a highway and beside a river to cultivate algae.

Besides solar panels as energy generators in dry seasons, this district will be equipped with dry-steam power plants that use heat produced by plastic and other waste coming from other sources. The heat produced by those plants is transferred using a copper line protected by heat insulators from several zones and compiled to generate enough heat to heat the water and produce steam. The electricity would then be stored in several batteries that could be used in social housing that needs support.

The most important things in this metabolism system are catalyzing facilities because they can affect the economic aspects of South Tanjung Duren communities. They should involve the communities at their heart to increase their sense of belonging. Therefore, the catalyzing programs not only sell the products that South Tanjung Duren produces such as food court and fertilizer supplies, but also laboratories and food security centers. This food security centre was designed to fulfil the entire year for half a million population in South Tanjung Duren with a five-year renewal cycle. It means, that if there are scarcity of several raw materials supplied by another region of Indonesia, South Tanjung Duren inhabitants should not be worried about the volatility price that might happen.

Fig. 17: Urban Metabolism Framework in South Tanjung Duren

The best place to put this food security centre is near the Kopro traditional market since these facilities need a huge number of freezers and chillers to contain foods and should be connected directly to three power plants to ensure 24/7 electricity.

The laboratories themselves take roles in enhancing multivitamins and minerals in plantations and fish. Their main task is enhancing the fertilizer qualities and creating optimum nourishment for fish farming. Since the raw materials to create fertilizer and pellets are quite excessive, these products can also become commodities to trade to other districts. Therefore, these facilities should be put in several places that have good accessibility such as Jl. South Tanjung Duren as main road.

6.0 CONCLUSION

From the simulation done in the South Tanjung Duren area, it is found that an established neighbourhood such as this sub-district can contain the potential resources that can be developed to create a self-sustaining area. The exploration of urban fabrics in the research objects within the perspective of urban metabolism may open up the possibilities for the implementation of this framework innovatively, especially using the strategy of urban infill. The involvement of all communities in the neighbourhood is essential since this approach to the neighbourhood scale is dependent on it when every part of the community is in an interdependent position. This simulation also found out that the involvement of local government in conditioning the city regulation is needed to promote the urban infill strategy to accommodate the facilities required.

Seeing that, there is no doubt that there is very potential to have an innovative approach using an urban infill strategy to shape an urban metabolism framework on a neighbourhood scale through four strategies, such as Collecting Resources, Creating Biotopes, Channelling Energy and Catalysing as proposed by Tillie et al. (2014). This research could inspire other regions too by extracting contextual resources in each region which eventually could help the city to be resilient and self-sustaining.

Accuracy in data collection has been a major challenge in this research since it is needed to implement and inject a massive new facility in an existing neighbourhood. An experimental strategy such as adaptive reuse needs flexibility for it to be implementable and it could be quite challenging to implement in another region with a lack of government facilities or in a region with hyper densities. This flexibility may require the local government policy to be more adaptive with the long-term self-sufficient objectives so the neighbourhood may be more ready to face challenges such as isolation from the pandemic.

This flexibility, however, would be important to pursue an effective and successful circular economy, which plays an important role in circular urban metabolism. Circular urban metabolism creates a framework for redesigning urban spaces, rethinking urban activities, as well as social infrastructures, including reducing, reusing and recovery of the available resources, which is something important that could be discussed in the future studies aiming for global sustainability through proper urban planning.

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