Introducing the Urban Metabolism Approach for a Sustainable City: A Case of Jakarta, Indonesia

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Abstract

Research from Indonesia, especially on Jakarta as a metropolitan city is published only limitedly at an international level. This research that is a small pilot study on urban metabolism is one of few studies on the city. The purpose of study is to introduce urban metabolism, which can be used to analyse the city policies and initiatives from the perspective of urban sustainable development in the context of Jakarta city.

This study formulated the basic framework of urban sustainability of Jakarta based on a number of secondary data sources collected and utilized from the year of 2001, 2006 and 2011. Data was mainly from on-line public information and hardcopy data from the Central Statistic Body (BPS) and the Ministry of Environment (KLH) of the Republic of Indonesia.

This study generated an initial framework of urban sustainability that is expected to be applied further in future studies. It is found that the proposed framework that resulted from this study is able to show how sustainable Jakarta is; and how the city administrator has not been comprehensively highlighting sustainability issues through policies and initiatives.

Keywords

Sustainable City
Urban Metabolism
Urban Sustainable Development

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Introduction

As awareness and discussion on sustainable development and sustainable cities has increased, studies on urban metabolism have been becoming more significant. The concept of urban metabolism perceives a city as a living organism. It includes measuring and analysis of the technical and socioeconomic processes in a city, resulting in resource consumption, growth, production of energy, and elimination of waste (Kennedy et al, 2007). Since urban metabolism provides evidence on the overall significant resources inputs, outputs and storage, it is in line with the framework of sustainable development that emphasizes the needs to maintain regeneration and environment carrying capacity in terms of the use of material and energy and the disposal of waste and emission.

This is a small and basic study which is based on the concept of urban metabolism. This pilot research was organised by Trisakti University and Sandikta College of Administration Science supported by the University of Toronto. Research paper of Hoornweg, et. al. (2007) on urban metabolism in 7 world cities and the data collection format from University of Toronto become the main guidance to carry out the study.

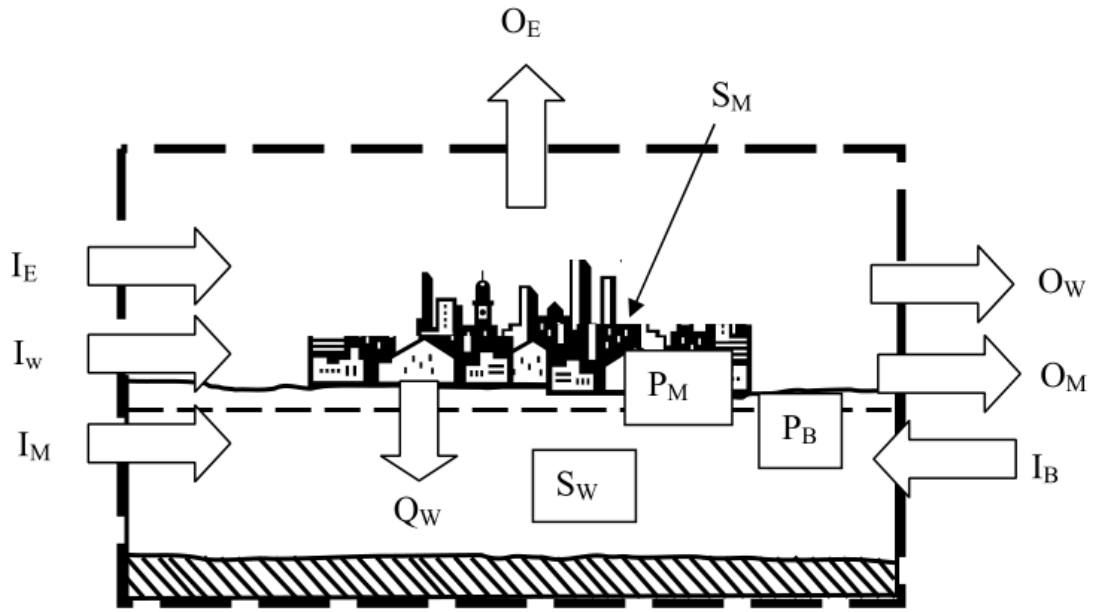
The purpose of study is to introduce urban metabolism as an approach for developing a sustainable city, by collecting urban metabolism data. Based on the available data, this study tried to construct and proposed a basic urban metabolism framework of Jakarta. The framework is expected to be sufficient for analysing the Jakarta initiatives on various sustainability issues including the climate change. Moreover, the study was initiated in order to show how urban metabolism can provide another perspective to help the city administrator to make public policies, create initiatives and motivate stakeholders toward a sustainable city.

Notwithstanding that a number of studies on urban metabolism have used different frameworks, this research used a standardize framework describing the urban metabolism developed by the World Bank. As presented by Hoornweg, et. al. (2007), the framework captures bio-physical stocks and flows within an urban metabolism; based on the Eurostat

Economy-wide Material Flow Analysis methodology. However, the framework application can be different and customized among urban metabolism studies due to many factors, e.g. characteristics of the city and availability of data.

The urban metabolism framework views an urban as an open metabolism to the environment. By using urban metabolism framework, sustainability of a city can be identified and measured in terms of its use of resources, internal dynamics and negative impact to the environment. Consequently, policies and initiatives on energy, material, water, biomass, waste and emission can be taken to make the city more sustainable. The urban metabolism framework is presented in Figure 1.

Figure 1: Urban Metabolism Framework



Source: Hoornwerg, et.al, 2012

In Figure 1, it is shown that the urban metabolism framework measures and analyses the inflows of energy (I_E), water (I_W), materials (I_M) and biomass (I_B) and the outflows of energy (O_E), water (O_W), and materials (O_M). Inside the urban area, the framework measures the internal flows of water (Q_W), storage of water (S_W) and materials (S_m), and also production of materials (P_M) and biomass (P_B).

The inflows and outflows of energy include electricity, fossil fuel, and cleaner and renewable energy that is imported, generated, consumed and exported by a city. The water inflow, outflow and internal process refer to clean water, waste water and recycled water. Material inflow stands for all imported significant material resources needed by a city while material production and material outflow indicates the solid waste and materials processed in a city or exported to other areas.

In the urban sustainability framework, biomass refers to biological material derived from living organisms, i.e. plants or livestock, which are imported, produced or consumed by the urban citizens.

Moreover, the application of design of urban metabolism framework is different among the cities. Some cities may have capabilities to produce biomass while others need to import it. Fossil fuels may be the dominant energy resources in some cities while the role of renewable energy in other cities is more significant.

This is because the design of urban metabolism framework is strongly connected with the sustainability aspects of a target city – including how the policies and initiatives of city administrator can address urban sustainable development.

Data Collection and Methodology

This study was initially designed as an internet-based small research project. Due to the lack of data available on the internet, this study finally obtained more hardcopy data from the Central Statistic Body (BPS) and the Ministry of Environment (KLH) of the Republic of Indonesia as the primary data sources. Data collected and utilized in this study was from the year of 2001, 2006 and 2011. Some other years' data was included in data collection to support the research analysis and computation of data estimation. However, only 2011 data was utilized to develop urban metabolism framework of Jakarta in order to support the analysis on the latest city planning, policies and initiatives on urban sustainable development.

In doing data collection, a data template developed by Christopher Kennedy (2013) from the University of Toronto, Canada, was used in this study. The city profile (i.e. population, GDP and municipality), biophysical characteristics (i.e. land area, cooling degree days, precipitation and solar radiation), and urban metabolism (i.e. inflow, outflows and internal process of energy, water, waste, emission, material and biomass) are the main data requirements.

Subsequent to data collection, data processing and computing were conducted to make the data presentable and fit into the urban metabolism framework. Qualitative analysis on the data and findings was made and then recommendations were generated based on the urban metabolism and sustainable development concept and principles. Scope of analysis included in this study were how the urban metabolism application could fit in the Jakarta setting, data collection and measurement issues and the open access of urban metabolism data for public, and also urban sustainable development policies and initiatives in Jakarta including the synergy between the city and central government to develop and implement policies and initiatives.

Data limitation has become the major issue of this urban metabolism study. First, data is not consistently available and the data formats may be different from year to year. As such, some variables could not be analysed and included in the framework of this study. The second issue was data validity. This study found that some data from different sources were in conflict. Thus, based the analysis and the professional judgment, some data which was considered doubtful was eliminated. From the academic perspective, questionable data may lead to unsure findings and it may consequently lessen the value of research – including its results, conclusions and recommendations. However, since this is a pilot study and the purpose of study is to introduce an urban metabolism framework, this study still can significantly contribute to the understanding of urban metabolism and sustainable cities, regardless the quality of the available data.

Jakarta: The Special District of National Capital City

Known as the Special District of National Capital City of Jakarta, or in Bahasa Indonesia "Daerah Khusus Ibukota Jakarta" (DKI Jakarta), this metropolitan district is located on the Java Island. It has five cities, which are Central, North, East, South and West Jakarta, and a municipality called the Thousand Island that is surrounded by sea. Jakarta is positioned near the equator and it has approximately 237.96 mm of precipitation (bappedajakarta.go.id) and 1,825 kWh/m^2 solar radiation per year (www.c40cities.org).

With a total land area of 662.33 km^2, Jakarta is a place for millions of people. Data from the Central Statistic Body shows that around 8.4 and 8.9 million people lived in Jakarta in 2001 and 2006 (Badan Pusat Statistik, 2001, 2007). The number grew and reached 9.8 million in 2011 (Badan Pusat Statistik, 2012b). The number does not count people living around the metropolitan area but commuting for work, business, study or other purposes in Jakarta.

Jakarta has at least 4 surrounding cities that contribute to the dynamic of metropolitan in terms of flows of people, goods and services. The cities are Bogor, Depok, Tangerang, and Bekasi. The surrounding cities and Jakarta together are called Jabodetabek and constitute as a bigger metropolitan area. The 2010 census indicates that more than 27 million people live in the all combined area.

In term of economy, Jakarta is one of the centres of the Indonesian financial system.

Significantly contributing to the national income, Jakarta's GDP has been consistently increasing for years. In 2001, the GDP was Rp. 411,691,000,000 (USD 41.2 million) and it reached Rp. 501,771,740,870 (USD 50.2 million) in 2006. Jakarta's GDP rose up to Rp. 982,540,043,960 (USD 98.2 million) in 2011, almost twice of the 2006's GDP. Regardless the increase of GDP, it is also estimated that around 3.5% of population still fall under the poverty line, which becomes an issue that the city government must address (Badan Pusat Statistik, 2001, 2007, 2012b).

Sustainability and Climate Change Mitigation and Adaptation

The increasing population and economy in Jakarta requires more resources and generates even more problems and challenges. Transportation, urban planning and settlement, public services, waste management, access to clean water, health, education and economy are some main issues that must be highlighted by the city administrator. In addition to that, Jakarta must deal with climate change issues, especially the increase of sea level and floods that cause damages and losses. It is in connection with the fact that 40-50% area of Jakarta lies below the sea level. In 2007, the big flood was estimated to cause USD 400 million losses (World Bank, 2011).

In order to address the climate change, the Jakarta administrator under the former governor, Fauzi Bowo, has planned and initiated mitigation and adaptation activities. Some of the mitigation activities are Green House Gas (GHG) emission baseline count, private vehicles emission counts, a regular car-free day on Sunday, kerosene to LPG conversion, blue bajaj program, and energy efficiency of government buildings in Jakarta. The adaptation programs mainly focus on anticipating the raise of sea level, tidal floods, canal and river flooding. The main programs are the sea wall construction, mangrove planting, urban settlement, waste management, and east and west flood canal construction. Some projects have been initiated and while large number of initiatives are still at the early stages. Overall, the results and outcomes are not measured and publicly available yet.

The following Table 1 and 2 describes the climate change mitigation and adaptation activities in Jakarta during the administration of the governor Fauzi Bowo.

Table 1: Climate Change Mitigation Activities in Jakarta

ACTION	SECTOR	DESCRIPTION
GHG Emission Baseline Count	Transportation/ Solid Waste	Collaboration between DKI government and local NGOs to measure and document a GHG emissions baseline starting in 2005
Transjakarta Busway	Transportation	Ongoing development of massive public transportation system of grade-level dedicated business
Private Vehicle Emissions Counts	Transportation	Required regulation and checking of emissions of private vehicles
Car free day	Transportation	Twice a month restriction of cars on major Jakarta thoroughfares to provide space for bicycling, walking and jogging
Kerosene to LPG Conversion	Energy/ Economy	Conversion of all kerosene gas canisters to liquefied petroleum gas
Blue Bajaj	Transportation/ Economy	Creation of blue bajaj which run on compressed natural gas rather than diesel
Energy Efficiency Building Retrofit	Energy/ Economy	Retrofits and upgrading for government buildings in Jakarta to increase energy efficiency, including low wattage bulbs and upgraded HVAC systems
Green Building Inventory	Construction	Sturdy about the feasibility of building methods and construction retrofits for private real estate and development in Jakarta
Carbon Finance Capacity Building	Energy/ Economic Development	Training and education within government for the development and management of carbon finance in Jakarta

Source: World Bank (2011). Jakarta Urban Challenges in a Changing Climate

Table 2: Climate Change Mitigation Activities in Jakarta

ACTION	SECTOR	CC AREA	DESCRIPTION
Sea Wall Construction	Infrastructure	Sea level rise, tidal floods	Construction of several sea walls in North Jakarta where the increase in volume and frequency of tidal flooding is increasing
Mangrove Planting	Environment/ Community/ Private	Sea level rise, tidal floods	DKI government and other local community groups planting mangrove trees in North Jakarta
Informal Settlements	Housing/ Land Use	Canal and river flooding/ tidal floods	Demolition of informal settlements along river banks whose presence is interfering with drainage. Also, these communities are extremely susceptible to floods
Waste Management	Solid Waste/ Sanitation	Canal and rivers flooding/ mitigation of GHG emission	Effort by the provincial government to develop waste management programs throughout the city
Online Warning System for Water Height at Bogor	Meteorological	Canal and river flooding	Website and measurement system for upstream water heights that drain drought Jakarta
East and West Flood Canal Construction	Infrastructure/ Water and Sanitation	Canal and river flooding	Construction of new major drainage canals for Jakarta
Green Space Protection and Development	Environment/ Land Use	Runoff absorption and carbon sinks	Protection and maintenance of existing green space, clearance of illegal settlements to return to green-space
Working Group on Adaptation and Mitigation at National Level	Advocacy, Education and Governance	Adoption/ poverty alleviation/ education/ mitigation	Working group, policy advocacy, education

Source: World Bank (2011). Jakarta Urban Challenges in a Changing Climate

Jakarta has also been committed to reduce emissions 30% by 2030 based on 2006 emission count. This is incorporated in the geospatial plan and development plan of Jakarta, which cover disaster risk reduction, greenhouse gas emission reduction, waste water management and treatment, public facilities and mass transportation improvement, and energy supply.

New City Administrator and Initiatives

In 2012, Fauzi Bowo was replaced by the new Governor Joko Widodo (popularly known as "Jokowi"). Jokowi has taken further actions to improve the city together with the Vice Governor, Basuki Tjahja Purnama or Ahok – both who are together well known as "Jokowi-Ahok".

In the transportation sector, the construction of Monorail and Mass Rapid Transportation system started in 2013. The projects are expected to be completed within 5 to 7 years and hopes to reduce the transportation problem in Jakarta. The city administrator also hopes to improve current transportation system by adding hundreds more busses, including the Trans Jakarta busses, in the near future. Trans Jakarta is a bus system using closed and dedicated lanes on the road. Since the system is only effective when people do not drive their private vehicles on the dedicated lanes, the city charges high fines to those who enter the Trans Jakarta lanes.

To address the threat of flood during the rainy season, city administrator hopes to improve surface water flow system by renovating certain areas of Ciliwung, Angke, Pesanggrahan and Sunter River, and maximizing the function of four dams, which are Ria Rio, Pluit, Tomang Barat and Pondok Labu Dam. It must be noted that Jakarta has 13

big rivers and 40 dams that are expected to keep away the city from the floods.

In 2013, Jokowi-Ahok relocated a number of low-income families living around Ria Rio and Pluit Dam to a new and better settlement (low-end apartments). In addition, the Jakarta government has also rearranged the wet market Tanah Abang and relocated street vendors and sidewalk sellers into the market building. That has created better transportation flow and significantly reduced the traffic jam in the area.

To support health and education of Jakarta citizens, the government has released the health and education support system called "Kartu Jakarta Sehat" (Jakarta Health Card) and "Kartu Jakarta Pintar" (Jakarta Smart Card). Both programs are dedicated for low income families to have access to public clinics, hospitals and basic education free of charge. In order to provide better air and views, public spaces, i.e. gardens, public parks and fountains have been renovated.

Furthermore, public service quality has also been improved by the Jakarta administrator. Unproductive officers are replaced and open selection mechanism for the position of Head District is applied. Incidental visit is carried out as part of monitoring and control on the city officers' performance.

In April 2013, after a long discussion with stakeholders and Lower House of Representative, the Jakarta administrator published a new geospatial plan (RTRW) and mid-term development plan (RPJMD) for 2013-2017. The documents are consisted of Jakarta's development plan that includes four major initiatives to address urban development issue:

1. Establishment of monorail transportation system.
2. Establishment of mass rapid transportation system.
3. Establishment of the giant sea wall in order to prevent tidal floods.
4. Establishment of deep tunnel that will be used as a transportation line in Jakarta as well as a system to capture the excess surface water during the flood. The tunnel itself will have three levels. Two are for transportation and one is for the water flow system.

Urban Metabolism Framework of Jakarta

This study collected a wide range of data on precipitation, solar radiation, greenhouse gas (GHG), solid waste, energy inputs for households, industry and transportation, biomass inputs, electricity consumption and losses, water production and consumption, liquid waste, and waste water.

Precipitation (237.96 mm per year) and solar radiation (1,825 kWh) indicated the city exposure to the rain and heat, and subsequently, the use of energy for cooling. In addition, one must also point out Jakarta's potentials and possibilities to utilize the solar energy and the rain and run-off water; as such these issues needed further study.

In term of energy inputs, Jakarta consumed electricity (35,061,376,775 kWh), natural gas 894,223,298 M^3), kerosene (121,832 kl), diesel fuel for industry (217,144 kl) and for transportation (1,242,186 kl), diesel oil (14,884 kl), and gasoline RON 92 (2,953,744 kl) (Pemerintah Propinsi DKI Jakarta, 2003, 2007) (Badan Pusat Statistik, 2012a). Jakarta also consumed clean water mainly the water provided by the public water companies (297,819,232 M^3) and also water from drilled well (6,4459,992 M^3) and well (1,404,795 M^3). Several major biomass inputs were rice (13,335 ton), spinach (3,649 ton), water spinach (11,250 ton) and sawi (5,493 ton) (Badan Pusat Statistik, 2002, 2011a, 2011b).

Furthermore, the domestic urban activities in Jakarta released waste water (500,056,001 Ml) and liquid waste (57,417 M^3), which refers to the septic tank waste treatment managed by the municipal. Throughout the year, the city also transported 87% of the city solid waste to the dumpsite in Bekasi area (1,820,003 ton). In term of emissions, Jakarta released greenhouse gases from the household (7,414,048 tCO^2), industry (18,791 tCO^2) and transportation sector (301tCO^2) (Badan Pusat Statistik 2002, 2011b).

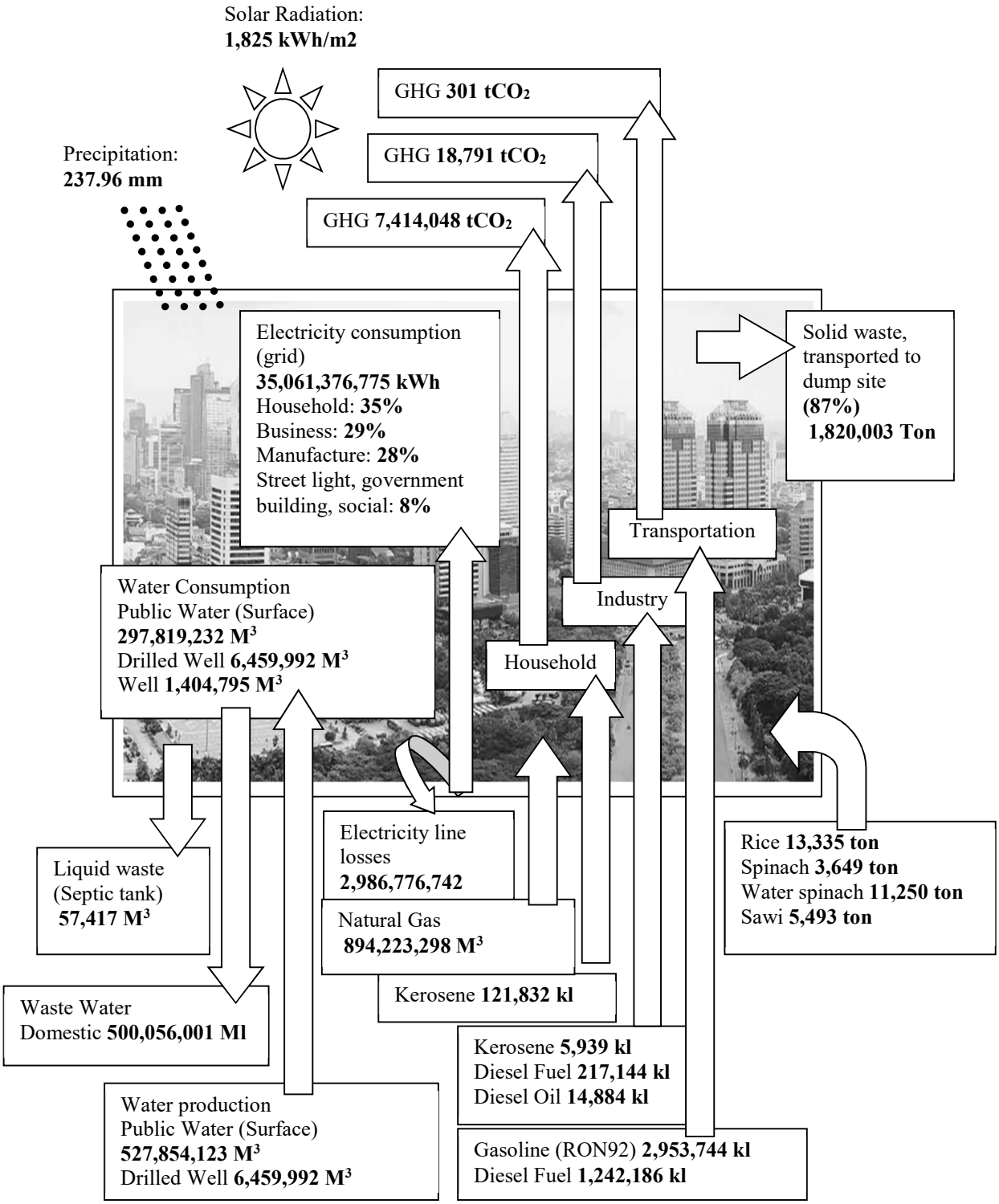
The analysis on the urban metabolism framework may lead to generate some further findings. From sustainability perspective, Jakarta is considerably less sustainable due to its dependency on fossil fuel. Moreover, Jakarta does not have yet a sufficient system to

manage its waste and emission outflows that bring negative impacts on the environment. This includes the absence of recycling facilities or environmental friendly treatment on solid waste, liquid waste and waste water.

In term of electricity consumption, household consumed 35% of total supply, followed by the business (29%) and industry (28%) (Badan Pusat Statistik, 2012a). In transportation sector, highest consumption was on gasoline. In contrast, transportation contributed less greenhouse gases among those of other sectors while the industry and household were ranked first and second highest.

The urban metabolism framework for Jakarta is presented in Figure 2

Figure 2: Urban Metabolism Framework for Jakarta



Further analysis on urban metabolism framework was conducted to identify the connectivity between the policies and initiatives of the city administrator with urban sustainable development issues in Jakarta. Establishment of monorail and mass rapid transportation is expected to solve transportation problems and encourage people to migrate from using private vehicles to public transportation. The establishment of deep tunnels will address both transportation and flood issues. All those initiatives will subsequently reduce energy consumption and greenhouse gasses. On the other hand, the giant sea wall is expected to prevent tidal flood in the future but its contribution to urban metabolism is very low.

Conclusions

Based on the previously explained analysis of study on Jakarta urban metabolism, this study may conclude that:

1. Urban metabolism is a suitable approach for the application of sustainable city principles because it provides information about sustainability aspects of a city based on the evidence of inputs, outputs and processes. To utilize the urban metabolism approach, the city administrator needs to define and establish a framework that specifically describes the sustainability context of the city.

2. Urban metabolism needs to be supported with clear identification of sustainability blueprint of a city. This includes its sustainability performance indicators, standards and minimum requirements. Therefore, its status and its gap towards sustainability can be analysed and further corrective actions can be taken.

3. Application of urban metabolism needs appropriate measurements and computations. It must be carried out consistently with appropriate units of measurement in order to generate data series for reviews on the trend of input, process and output.

4. In order to develop a sustainability blueprint properly, the urban policy makers and leaders must have adequate understanding on sustainable cities and how it can contribute to sustainable development. Otherwise, the effort to generate data and information of the urban metabolism framework will be unproductive.
5. From the perspective of sustainable city, urban sustainability framework of Jakarta shows that the city is less sustainable that the official view. The city development plan and initiatives do not appear to be sufficient enough to address the urban sustainable development issues, especially in the long run.

Recommendations

To address the above conclusions, this study proposes a number of recommendations:

1. To conduct further study that defines and establish more complex framework indicating the sustainability context of Jakarta. This can be initiated by universities or the city administrator. In order to maximize utilization of urban metabolism framework, the results shall be used as the guidance for the city in establishing a development plan, making policies and initiatives, and measuring performance.

2. To conduct further research to develop a sustainability blueprint of Jakarta based on the urban metabolism framework. This shall include sustainability performance indicators, standard and minimum requirements.

3. To establish an information system on the data collection, measurement and computation of the urban metabolism framework of Jakarta. This includes establishment of consistent and appropriate units of measurement, reviews on data series to identify trend of input, process and output, and how the information can be widely accessed by the public for academic or other purposes.

4. To empower policy makers and leaders in order to increase their understanding on sustainable cities, urban metabolism and sustainable development. This should include the key officers of Jakarta administrator and the related government institutions at national level.

5. To develop policies and initiatives in Jakarta towards a sustainable city, especially for the long run. This includes synergizing public policies and initiatives at national and provincial level on urban development issues. Some of which are the use of renewable energy to replace fossil fuel, establishment of waste and emission management system (i.e. recycling and reuse waste for other purposes), increase household participation on sustainable lifestyle, support industry initiatives on sustainability, and promotion of sustainable consumption of biomass, energy and water.

Limitations

The proposed framework of Jakarta's urban metabolism in this study may not be the ideal one because a number of significant data is still missing. For example, data on energy consumption does not include gasoline RON88 that is widely used and subsidized by the central government. The data of energy supply from private companies is also suspiciously not included in the statistic we were given. Moreover, material data on construction and biomass, i.e. poultry and farming data, is not complete.
Nevertheless, the framework presents another perspective on urban sustainable development and how it views government policies and initiatives in connection with a concept of sustainable city.

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Appendix One:

The Metabolism of Megacities Survey

PART 1: Definition of Megacity

Name of Megacity [1]:	
Population (year round residents) 2001 [2]	
Population (year round residents) 2006	
Population (year round residents) 2011	
GDP (2001)	
GDP (2006)	
GDP (2011)	
Is there a formal level of government for the metropolitan area?	Yes ○ No ○
Is there one or more coordinating bodies between constituent cities in the megacity? (If yes, give name)	Yes ○ No ○
Names of constituent cities (i.e. local municipalities)	

PART 2: Biophysical Characteristics

Land area (sq. kilometres)	
Urbanized area (sq. kilometres)	
Heating degree days (18°C base) [3]	
Cooling degree days (25°C base)	
Annual precipitation (mm)	
Annual solar radiation (kWh/m^2)	
Building gross floor areas (m^2) [4] Residential Commercial & Institutional Industrial	

[1] There is not a universally accepted approach for defining the boundaries of megacities. In practice, availability of data will dictate what area is used. Where there is choice, please try to use a region with a population of similar magnitude to that in Appendix One.

[2] Alternatively use years 2000, 2005 and 2010 throughout. (2001,2006 and 2011 are census years in many countries)

[3] HDD & CDD for 2011 can be determined at www.degreedays.net

[4] Gross floor area includes floor area on all storeys

PART 3: Urban Metabolism

	2001	2006	2011	Units	Source / Comments / Assumptions
ENERGY (STATIONARY)					
Electricity consumption (on-site renewable)				GWh	
Electricity consumption (grid)				GWh	
Electrical line losses (or non-revenue electricity)				GWh	
Natural gas (excluding power generation)				TJ	
Fuel oil (excluding power generation)				TJ	
Coal (excluding power generation)				TJ	
Biomass / biofuels (excluding power generation)				TJ	
<add fuels as appropriate>				TJ	
ENERGY (MOBILE)					
Gasoline				TJ	
Diesel				TJ	
Jet Fuel [5]				TJ	
Marine Fuel [6]				TJ	
<add fuels as appropriate>				TJ	
WATER					
Consumption				ML	
Line losses (or non-revenue water)				ML	
Production				ML	
Production (surface water)				ML	
Production (ground water)				ML	
WASTEWATER					
Wastewater volume				ML	
Wastewater loading				kt BOD	
WASTE					
Solid waste disposal on land				Kt	
Waste incineration				Kt	

[5] Based on fuel loaded onto planes at major airports either within or serving the megacity
[6] Based on fuel loaded onto ships at major marine ports the megacity, if applicable

Electricity Sources

		2001	2006	2011
Coal	%			
Oil	%			
Natural Gas	%			
Hydropower	%			
Nuclear	%			
Off-site Wind	%			
Off-site Solar	%			
<add sources as appropriate>	%			
GHG emissions factor [7]	t CO_2 e / GWh			

Electricity Consumption (2011)

Residential	%	
Commercial / Institutional	%	
Industrial	%	
Transportation	%	

Stationary Energy Consumption (2011; excluding Electricity)

Residential	%	
Commercial / Institutional	%	
Industrial	%	

Materials (YEAR 2011, or indicate if other:)

	Net Import	Production	Consumption (or Δ Stock)	Units	Sources / Comments
BUILDING MATERIALS					
Cement				Kt	
Steel				Kt	
<add building materials as available>					
FOOD [8]				Kt	
OTHER MATERIALS					
<add materials as available >				Kt	

PART 4: Role of utilities (regulation; potential to provide new energy-related services)

Electricity			
Number of local distributors	1-2 ○	3-5 ○	>5 ○
Ownership:	All Public ○	All Private ○	Mix ○
Is there a dominant distributor (i.e., serving >80% of market)?	Yes ○	No ○	

[7] Emissions factor at source of production, rather than per unit of consumption (i.e., excluding line losses)

[8] Exclude packaging (if possible)

Number of power suppliers (generators)	1-2 ○	3-5 ○	>5 ○
Ownership	All Public ○	All Private ○	Mix ○
Is there a dominant supplier (i.e., serving >80% of market)?	Yes ○	No ○	
Is there an independent regulator? [9]	Yes ○	No ○	
Feed in tariffs	Yes ○	No ○	
Other incentives for renewables (e.g., tax breaks, cash subsidies, green certificates)	Yes ○	No ○	Type:
Number of electric vehicles	:	unknown ○	
Number of electric vehicle charging points	:	unknown ○	
Number of buildings with PV	:	unknown ○	
% of consumption from independent generators	:	unknown ○	
Natural Gas			
Number of local distributors	1-2 ○	3-5 ○	>5 ○
Ownership	All Public ○	All Private ○	Mix ○
Is there an independent regulator?	Yes ○	No ○	
Number of natural gas vehicles	:	unknown ○	
District heating or cooling			
Number of district heating or cooling distributors	1-2 ○	3-5 ○	>5 ○
Ownership	All Public ○	All Private ○	Mix ○
% of city heating/cooling consumption from district schemes.	:	unknown ○	
Water			
Number of local distributors	1-2 ○	3-5 ○	>5 ○
Ownership	All Public ○	All Private ○	Mix ○
Is there an independent regulator?	Yes ○	No ○	
Wastewater (if different from water)			
Number of local collectors	1-2 ○	3-5 ○	>5 ○
Ownership	All Public ○	All Private ○	Mix ○

ICT
% of population with access to internet:
% of population using mobile phones:

Quality of Service

% of households without direct access to water:
% of households without direct access to drinkable water:
% of households without sewage:
% of waste water subject to treatment:

[9] Independent from local, state and national government

% of households living in areas without public waste collection:
% of households without grid electricity connection:
Average number of hours per year without electricity supply, planned or unplanned:

Open Format Question

Please identify any significant changes in the regulation, functioning or structure of utilities in the megacity (in the past few years) that supports sustainable urban development?

Preliminary Assessment of Urban Metabolism and GHG studies of Megacities

Megacity		**Population. (2010)**	**Notes**
Tokyo	Japan	34,000,000	GHG studies conducted annually
Guangzhou	China	24,200,000	Megacity does not correspond with provincial boundary. One published GHG study
Seoul	South Korea	24,200,000	Partial GHG study in early 2000s (likely updated)
Mexico City	Mexico	23,400,000	GHG study for central city (8.7million) from 2000. UM study in progress.
Delhi	India	23,200,000	Extended GHG study (incl. water & materials) to be published soon
Mumbai	India	22,800,000	
New York City	USA	22,200,000	GHG studies of central city (8.2 million) conducted annually
São Paulo	Brazil	20,900,000	GHG study from 2000. UM study for municipality (11.3 million)
Manila	Philippines	19,600,000	UM study for metro region (11.6 million)
Shanghai	China	18,400,000	Corresponds to provincial boundary; good data; several GHG studies published
Los Angeles	USA	17,900,000	Large UM study of LA county (9.5 million) in progress
Osaka	Japan	16,800,000	GHG studies conducted annually
Kolkata	India	16,300,000	
Karachi	Pakistan	16,200,000	
Jakarta	Indonesia	15,400,000	GHG study published for central city
Cairo	Egypt	15,200,000	UM study in progress
Moscow	Russia	13,600,000	
Beijing	China	13,600,000	Corresponds to provincial boundary; good data; several GHG studies published. UM study completed.
Dhaka	Bangladesh	13,600,000	GHG study of central city
Buenos Aires	Argentina	13,300,000	UM study for municipality (2.9 million)
Istanbul	Turkey	12,800,000	
Tehran	Iran	12,800,000	
Rio de Janeiro	Brazil	12,600,000	GHG study from 2005 (being updated) UM study for municipality (6.3 million)
London	United Kingdom	12,400,000	GHG studies conducted annually for GLA (7.4 million); UM study for GLA in early 2000s.
Lagos	Nigeria	11,800,000	
Paris	France	10,400,000	Published UM study