Translating Policy Research into Practical Actions on Low Carbon Transport in Developing Cities
-Lessons from stakeholder engagement in Bandung & Semarang City, Indonesia -

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Abstract: Transformative actions on climate change and other sustainability issues at city level is important to achieve GHG emission reduction. To anchor transformative actions, a wider societal consensus building based on science policy process is key element. This paper explores process to prioritize policies and detail actions of selected policy on low carbon transport in Indonesian cities. We apply Analytic Hierarchy Process to facilitate decision-making process in Bandung city and Semarang City. The authors identified the important of tailoring AHP structure based on existing strategies. The framework could be applied for different goals set of problems to prioritize action on low carbon transport in Bandung and also detail action necessary to improve bus operation as one of selected action on the low carbon transport in Semarang city. The diversity of perspective, capacity dealing with climate issues, priority and forward looking allows stakeholders to have consensus for translation to concrete actions.

Keywords: Transformative actions, stakeholder engagement, Analytic Hierarchy Process, Low Carbon Transport, Bandung, Semarang

1. INTRODUCTION

In 2010, Indonesia's government pledged a nationally appropriate mitigation action (NAMAs) to the United Nations Framework Convention on Climate Change (UNFCCC) that aimed to reduce greenhouse gas (GHG) emissions by 26% relative to business-as-usual (BAU) emission projections by 2020. The baseline study shows the largest emitters was land use change and forestry sector which contribute about 67% of total GHG emissions in Indonesia. Meanwhile, the energy sector (fossil fuel consumption) contribute about 23 % of total GHG emissions in Indonesia (Bappenas, 2013). Looking at energy sector, transport sector contribute about 70% of total GHG emissions from energy sector, while industry contribute 23%; electricity about 3% and the remaining commercial and residential contribute

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at the same level around 1% (Secretary General of National Energy Council, 2016). In contrast with situation at country level, urban areas had different condition because the energy sector is major contributor. Within the energy sector in urban area, transportation sector is leading because major industries were usually relocated outside of city to sub-urban or even rural areas. An example of emission inventory which was done by environmental management agency of Bandung city shows energy sector contribute about 90% of total GHG emission in Bandung city (EMA, 2016). Further, urban transportation emits about 60.55% of total GHG emission of energy sector or equal to 54.5% of total GHG emissions from all sectors in the city (EMA, 2016). Similar situation also found in Semarang city. The CO_2 emission was estimated around 2,823 ktCO2e in 2015. The urban transport as the largest emitter contributes around 71.6% of total emission of Semarang city (IGES, 2017). In response to these situations, the Indonesia's government began to implement ten initiatives under the national action plan (RAN) or local action plan (RAD) to support environmentally sustainable transport. The national government has hence place a growing amount of emphasis on sustainable low carbon transport to achieve its climate goals. The national strategy focus on five major pillars: (a) Transportation and its interaction with land-use and spatial planning; (b) Improvement on urban mobility; (c) The reduction of urban traffic jam through transport demand management by "push and pull" strategy and implementation of smart transport or intelligent transport to improve traffic supply management; (d) The reduction of urban emission and air pollution and (e) improvement on traffic safety (Kementrian PPN/Bappenas, 2016). The next logical step in pursuing those goals and strategy has been task sub-national and municipal governments with their policies and climate mitigation action plans to reduce GHG emissions (Jaeger, 2015). There was variety on the translation from national to sub-national governments and also there is still the gap between policy research documents and practical actions at local level.

Cities have increasingly been identified as important places for sustainability transitions and system innovation on climate issues (L Fuenfschilling, et al., 2018; Frantzeskaki et al., 2017; Hodson et al., 2017; Loorbach and Shiroyama, 2016). Many researchers and practitioners have noticed that various measures and recommended programs in climate mitigation actions in urban areas has mutual and multi-dimensional effects on transport services, economic development such as city's productivity, poverty reductions, equity and another well-being aspects of the sustainable development goals (SDGs). However, each transport policies give different effects on the transport system itself, as well as on the social economy context and environment aspects (climate and air pollution). The Institute for Global Environmental Strategies developed an evidence-based approach on climate co-benefits that mitigate climate change while addressing other development priorities which consisted of five main steps: 1) developing an emissions inventory for air pollution and GHGs for the transport sector; 2) prioritising local policies and measures that could reduce air pollution and GHGs based on existing plans; 3) quantifying the impacts of priority policies and estimate reductions in air pollution and GHGs for selected policies; 4) building a consensus across relevant stakeholders on follow-up actions based on the quantitative analysis; and 5) translating policy recommendations into practical actions (IGES,2018).

The decisions to prioritize policies in the second step of five steps co-benefit approaches involve many intangibles that need to be traded off. The policies have to be measured by using several criteria which is an intrinsically complex multi-dimensional process (Berritella et al,, 2007). It could be solved by various decision support techniques such as cost-benefit analysis (Zhang et al, 2006), SWOT analysis; life-cycle analysis (Bristow & Nellthorp , 2000; Stavros et al., 2004) and Multi-Criteria analysis (Sayers et al., 2003; Tzeng et al., 2005). The Analytic Hierarchy Process (AHP) has become significant methodology due to its capability for facilitating multi-criteria decision-making (Ramanathan, 2001). The AHP is also one of the most commonly used methodologies to evaluate and quantify subjective judgement. The Analytic Hierarchy Process (AHP) is a method of measurement for formulating and analyzing decisions. Saaty (1980) provided a theoretical foundation for the AHP that is a decision support tool which can be used to solve complex decision problems taking into account tangible and intangible aspects. Therefore, it supports decision makers to make decisions involving their experience, knowledge and intuition. The AHP also capable to handle uncertainty due to different preference and judgement among policy makers. Although the AHP has been found to be one the best method for multi-criteria decision making process, its application in climate mitigation action on transport sector in developing cities is limited.

The transition towards a climate compatible urban development and efforts to curb urban GHG emissions are particularly challenging in developing cities given the need a wider societal consensus building among relevant stakeholders (Junghans, L., et al, 2018). Framing climate mitigation actions also involves two methodological challenges (a) the establishment of linkages between actions and outcomes (e.g. through a quantitative modeling approach) and (b) a way of objectively comparing the outcomes of different actions. At city level, local stakeholders often has limited capacities on technical capacity, knowledge and resources in order to implement all recommended policies and actions. The decisions are also made in a context of uncertainty and rapid change/development in countries and there is an involvement process of various actors at city level which have different focus and priority make it difficult for various actors to reach a consensus on what constitutes mitigation. Therefore, Prioritizing policies and action plans by considering multi stakeholder engagement and consensus building among key stakeholders on the multi criteria decision making process in key important element to achieve GHG emission reductions at the city level. This article explores the policy process for consensus building in two capital cities of West Java province (Bandung) and central java province (Semarang) Indonesia. These two cities was selected to represent example of dynamic and agglomeration of cities in Indonesia which already had local action plans. We apply simple AHP structure which consist of two levels in each cities. In Bandung, the AHP structure was developed based criteria for decision making and alternative policy options for prioritizing action plans based on the existing masterplan. In the second case, AHP structure was developed for specific and detail action to improve bus operation. The improvement of public bus system was selected as one of priority action on low carbon transport in Semarang city.

The remainder of the article is divided into four sections. The next section illustrates the literature on multi criteria decision making process in prioritizing public policies and its application in developing Asian Cities. A third section describes study location includes the actions plans for each city. A fourth section underlines results. A final section concludes with a discussion of future research areas.

2 LITERATURE REVIEW AND METHODOLOGY

2.1 Multi Criteria Decision Making Process with Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a method of measurement for formulating and analyzing decisions. The AHP is a theory of measurement through pairwise comparisons and relies on the judgement of experts to derive priority scale (Saaty, 2008). The AHP decompose decisional process in a hierarchy of criteria, sub-criteria, attributes and alternatives through a set of weights that reflect the relative importance of alternatives (Berritella, 2007). The application of AHP gives more balanced outcomes for various conflicting criteria compared to traditional economic evaluation method (M.Tabucanon and Lee, 1995). Therefore, AHP has been widely applied in transport studies. The AHP was applied to evaluate bridge improvement programs in United Stated (Saito, 1987); to select alternatives of public transport system (Tracz & Wawrzynkiewiez, 1993); to evaluate transit privatization project in Detroit metropolitan areas (Khasnabis & Chaudhury, 1994). The application of AHP also very useful for multifaceted planning process also of alternative for developing rail transit network in Istanbul (Yilmaz & Gercek, 2015).

The AHP decomposes the decision problem into elements, according to their common characteristics, and levels, which correspond to the common characteristic of elements. The topmost level is “focus” of the problem or ultimate goal; the intermediate levels correspond to criteria and sub-criteria, while the lowest level contains “decision alternatives”. If each element of each level depends on all elements of upper level, then the hierarchy is complete; otherwise, it is defined incomplete. The elements of each level are compared pairwise with respect to a specific element in the immediate upper level.

To make a decision in an organized way to generate priorities, we need to decompose decision into the following steps.

a. Define the problem and determine the kind of knowledge sought.
b. Structure of decision hierarchy from the top with goal of decision, then objectives from a broad perspective, through an intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of alternatives).
c. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare elements in the level immediately below with respect to it.
d. Use priorities obtained from comparisons to weight priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

Table 1 reports the pairwise comparison scale used in the AHP developed by Thomas Saaty (2008). It allows to convert the qualitative judgments into a numerical values, also with intangible attributes. For computing the priorities of the elements, a judgmental matrix is assumed as follows:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

where a_{ij} represents the pairwise comparison rating between the element i and element j of a level with respect to the upper level. The entries a_{ij} are governed by the following rules: $a_{ij} > 0$; $a_{ij} = 1/\ a_{ji}$; $a_{ii} = 1\ \forall i$. Following Saaty (1980, 1990), the priorities of the elements can be estimated by finding the principal eigenvector w of the matrix A, that is:

$$AW = \lambda_{\max} W \quad (2)$$

When the vector W is normalized, it becomes the vector of priorities of elements of one level with respect to the upper level. λmax is the largest eigenvalue of the matrix A. In cases where the pairwise comparison matrix satisfies transitivity for all pairwise comparisons it is said to be consistent and it verifies the following relation:

$$aij = a_{ik}a_{kj} \qquad \forall i,j,k \tag{3}$$

Table 1 The AHP Pairwise Comparison Scale

Numerical Values	Verbal Scale	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favor one element over another
5	Strong importance	Experience and judgement strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another, its dominance is demonstrated in practice
9	Extreme Importance	The evidence favoring one element over another is of the highest possible order of affirmation

Source: T.Saaty (2008). Notes: Intensities of 2,4,6,8 can be used to express intermediate values.

T. Saaty (1980) has shown that to maintain reasonable consistency when deriving priorities from paired comparisons, the number of factors being considered must be less or equal to nine. AHP allows inconsistency, but provides a measure of the inconsistency in each set of judgments. The consistency of the judgmental matrix can be determined by a measure called the consistency ratio (CR), defined as:

$$\mathrm{CR} = \frac{CI}{RI} \tag{5}$$

where CI is called the consistency index and RI is the Random Index. Furthermore, Saaty (1980, 1990) provided average consistencies (RI values) of randomly generated matrices (Table 2). CI for a matrix of order *n* is defined as:

$$\mathrm{CI} = \frac{\lambda max - n}{n-1} \tag{6}$$

In general, a consistency ratio of 0.1 or less is considered acceptable, this threshold is 0.08 for matrices of size four and 1.11 for matrices of size five.

Table 2 The Average Consistencies Of Random Matrices (RI Values)

Size	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

2.2 AHP Framework in Bandung and Semarang City

This study apply simple AHP structure which consist of two levels: criteria for decision making and alternative policy options for prioritizing local action plans in developing Asian Cities especially Indonesia.

2.2.1 Bandung city

In order to evaluate alternative transport policies, we developed AHP structure in two different levels; level 1 is criteria for decision making and second level represents alternatives of transportation policy (Figure 1). The criteria helps policy makers to make judgement or decisions on policy options/alternatives such as: influence on quantity (C1) and quality (C2) of urban transport service; affordability (C3) and implementable (C4) of policies and plan and environmentally sustainable (C5). In the second level, stakeholders were asked to prioritize actions among eleven alternative policies listed in the questionnaire which were selected based on the existing Transport Masterplan of Bandung city. Those eleven alternative policies represent Avoid-Shift-Improve (ASI) approach consists of these following actions: (1) School Zoning; (2) Pedestrian Facilities; (3) Work Scheduling; (4) BRT (Bus Rapid Transit) System; (5) Revitalization of Angkot; (6) Car Free Day in Certain Road; (7) School Buses; (8) Promoting LRT/MRT; (9) Eco Driving; (10) Inspection and Maintenance Program and (11) Automatic Traffic Control System (ATCS) (Figure 1). The alternative policies mentioned in figure 1 can be explained in detail in Table 3.

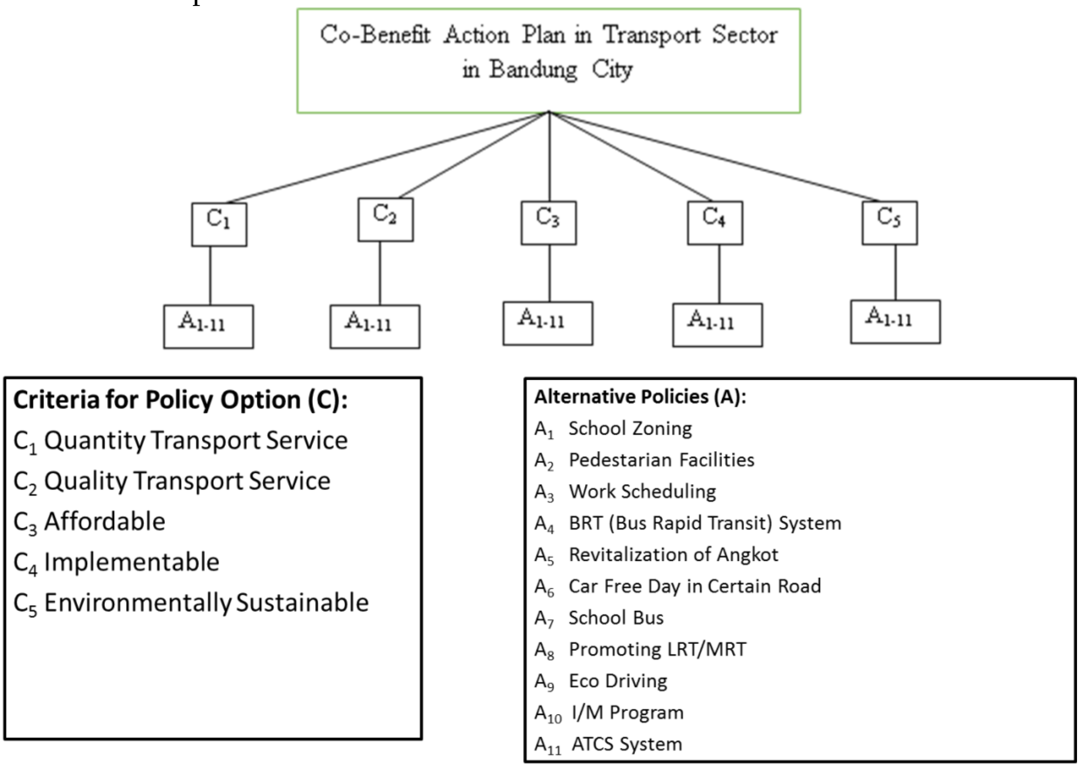


Figure 1 AHP framework for Bandung City

2.2.2 Semarang city

In Semarang, the AHP was specifically applied to different context. The local stakeholders would like to focus on specific options to improve the existing Quasi-BRT services as main public transport in Semarang city. In this context, the AHP structure of Semarang City is an extension of Bandung's structure on option 5 (A5) in figure 1. The local stakeholders identified the necessity to have more detailed options and alternative in order to improve the existing Quasi- BRT system especially on the ridership and level of services. Then, research team refined the structure and tailoring it to the local situation. The AHP structure also consists of two levels, first level describe important elements of BRT system which was developed based on BRT Scorecard (ITDP, 2014) such as: (a) Service Planning (C1); (b) Infrastructure at Station (C2); (c) Design of Station (C3); (d) Communication (Public Relation) (C4); and (e) Access to BRT route (C5). Second level explain about detail alternative actions for each elements which refer to the BRT score card (Figure 2 and Table 4).

The questionnaire survey was done for different experts among key stakeholders in both cities. The key stakeholders are government staffs; academia; private sectors and non-state actors/non-government organization to represent the citizen groups.

Table 3 Alternative Policies in Bandung city

No	Category	Alternative Polices	Description
A	Avoid	1. School Zoning	Registration school students based on their residence. Students will attend school at a location adjacent to the residence. This policy will reduce unnecessary trips. The students also be able to come to school by walking, bicycle and other non-motorized modes.
		2. Pedestrian Facilities	Dedicated space along the roads and it paved to provide and improve safety and comfortability for walking.
		3. Work Scheduling	Differentiate the work/school hours of employees. The government related offices start and stop their works earlier than private company. Similar policy was applied for school students.
B	Shift	4. Bus Rapid Transit (BRT) system	Bus Rapid Transit system which namely as Trans Metro Bandung (TMB). It adopted semi-BRT concept because of its mixed traffic system.
		5. Revitalization of Angkot	Revitalization of public transportation especially paratransit (minibus/Angkot). It attempts to manage paratransit system become a regular public transportation, such as: fix stopping place, fix schedule, employed driver and so on.
		6. Car Free Day	Car Free Day is an event to prohibit the usage of motorized modes in a certain road section at a certain period. This policy is more focus on campaign activity that aims to change people's behaviour to increase share of non-motorized transport means (bicycles and walking).
		7. School Bus	The city government provides public bus at several routes and fix schedule to serve pupil / student encourage the reduction of private vehicles usage.
		8. Promoting LRT/MRT	LRT (Light Rail Transit) system is rail based public transport which will be built in urban areas which its construction is lightweight and can run alongside other traffic. MRT (Mass Rapid Transit) is another rail based public transport system which have higher speed and capacity.
C	Improve	9. Eco Driving	Eco Driving is a new driving culture (smarter) that makes best use of advanced vehicle technologies for and more fuel-efficient driving.
		10. I/M Program	A regular programs to check and measure the exhaust emission level of vehicle to improve ambient air quality. By regular inspection, the owner can also do regular maintenance to improve the combustion system of vehicle engine.
		11. ATCS system	A traffic control system based on information

			technology in an area that aims to optimize network performance through the optimization and coordination of road traffic regulation at every intersection.

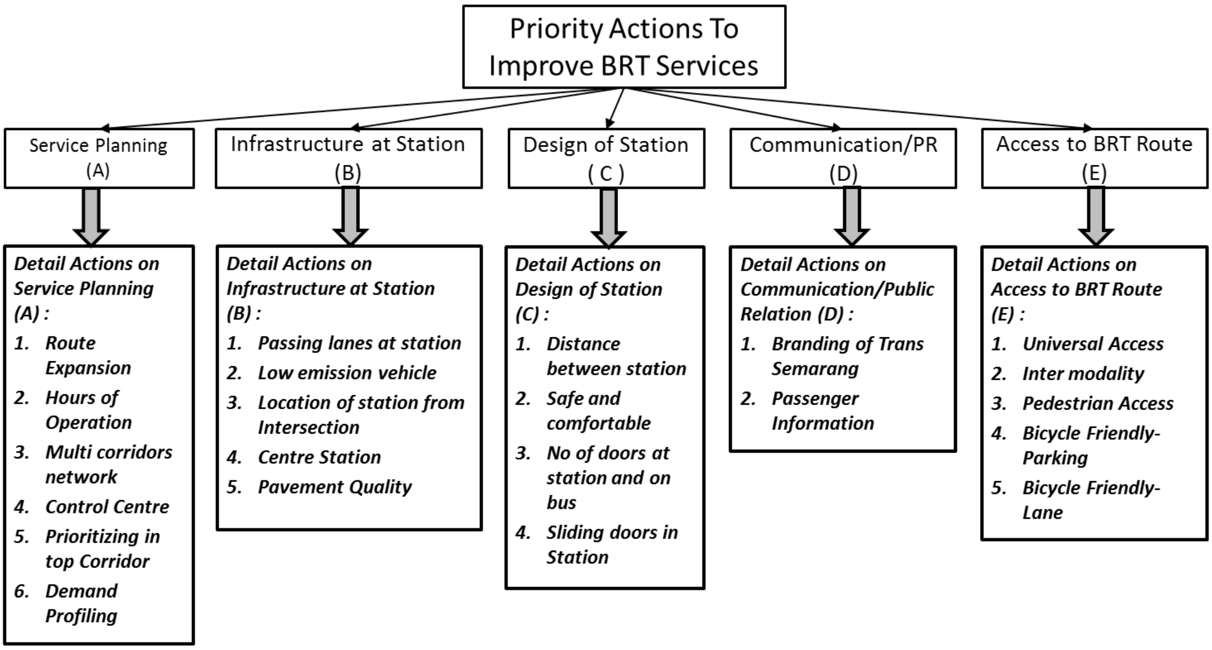


Figure 2 AHP structure for Semarang City

Table 4 Detail Actions to Improve Bus Service in Semarang city

No	Category	Alternative Polices	Description
A	Service Planning	1. Route expansion	Expansion of existing 4 corridors in 2015 to 6 corridors in 2016 and up to 12 corridors.
		2. Hours of operation	Improve the existing operation hour of Bus Rapid Transit system from 5 AM to 19 PM.
		3. Multi corridors network	Ideally, BRT should include multiple corridors that intersect and form a network, as this expands travel options for passengers and makes the system more viable as a whole.
		4. Control Centre	Control centers for BRT that monitors of all buses and should be integrated with automatic traffic control system in urban transport system.
		5. Prioritizing in top corridor	BRT corridor is located along one of the top BRT corridors in terms of bus ridership which will ensure that a significant proportion of passenger benefit from the improvement
		6. Demand Profiling	Build a dedicated BRT infrastructure in the highest-demand segments of a road ensures that the greatest number of

			passengers benefit from the improvements.
B	Infrastructure at Station	1. Passing lane at stations	Passing lanes at station stops that allow both express and local services which allow stations to accommodate a high volume of buses without getting congested with buses backed up waiting to enter.
		2. Low emission vehicles	Retrofit the existing bus with low emission buses such as Clean Diesel, CNG or EV Buses
		3. Location of station from intersection	Stations should be separated from intersections but it should be located closed to intersections to avoid delays.
		4. Centre Station	Centre stations which serving several directions of the BRT system makes transfers between several directions easier and more convenient.
		5. Pavement Quality	Good-quality pavement which ensures better services and operations for a longer period to minimize the needs for maintenance on the bus corridors.
C	Design of Station	1. Distance between station	The optimum distance between stations and consistent across different land-use type within the city which save the time for customers to walk to station and maintain bus speed (services).
		2. Safe and comfortable	Safe (crime aspects) and comfortable station environments.
		3. No of doors at station and on bus	To support the boarding and alighting activities at the bus stations.
		4. Sliding doors in Station	Sliding station doors for get on and get off of the passengers which improve quality of station environments, reduce risk of accidents, protect passengers from weather and prevent pedestrians from entering the station in unauthorized locations.
D	Communications / (Public Relations)	1. Branding of Trans Semarang	BRT brands and strong identity that appeals to its customers from stations to the buses
		2. Passenger Information	Information about when the “next bus” will arrive at stations and “next stop” on the buses
E	Access to BRT Routes	1. Universal Access	Accessible for all special-needs costumers.
		2. Inter modality	The BRT corridors should be integrated to other public transport system (physical integration and fare payment)
		3. Pedestrian Access	Pedestrian access to BRT system.
		4. Bicycle-Friendly Parking	Bicycle parking at station which allow customers to use bicycles as feeders to the BRT corridors.

		5. Bicycle-Friendly Lane	Bicycle-lane network integrated with BRT corridors which improve customer access, provide a full set of sustainable travel options and enhance road safety.

3. LOCATION OF STUDY

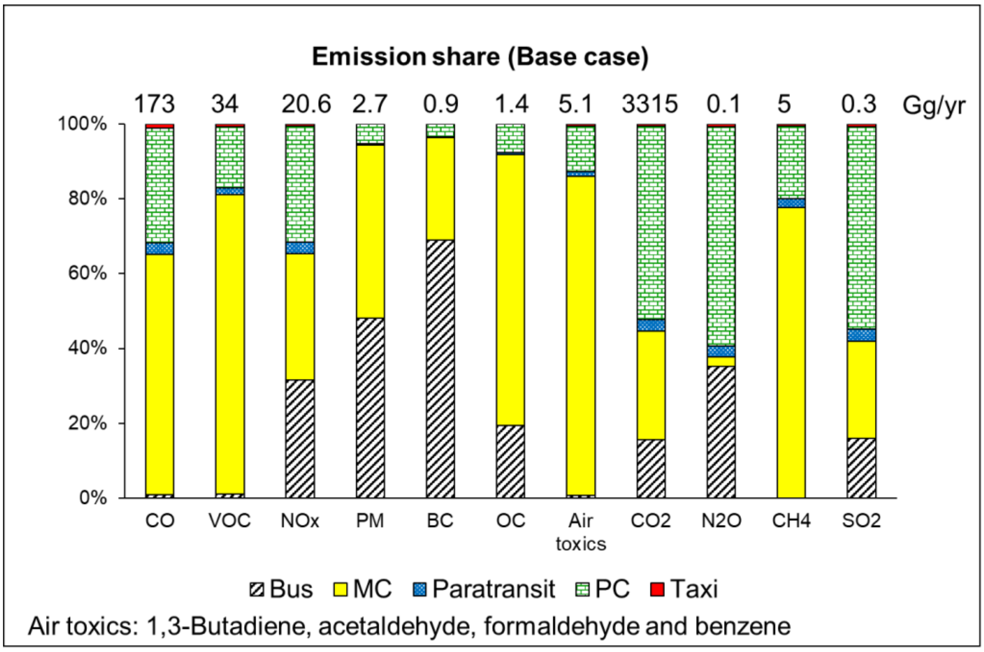
The data for this study was gathered from Bandung and Semarang, Indonesia. Bandung is the capital of West Java Province, located about 180 kilometers from Jakarta. Bandung's official population reached 2.3 million people in 2010 but more than 5 million people live on Bandung's urban fringe or surrounding cities. Bandung launched a masterplan for the transport sector with various policies and measures in 2013. Due in part to rapid urbanization and growing mobility demands, Bandung has been actively seeking alternative modes of transport to supplement its overstretched public transport system and reduce traffic.

Semarang is the capital city of Central Java Province and the fifth largest city in Indonesia located around 450 km in the eastern part from the capital city of Jakarta. It is located in between two main cities in Java Island, Jakarta and Surabaya city. Total population of city is 1,595,267 persons and 471,327 households (as of 2015) and total area of a little more than 370 square kilometres. The gross regional domestic product (GRDP) per capita at 6,461.5 USD (1USD=13,000 IDR) and the largest contributor to GRDP is secondary sector such as manufacturing food, beverage and tobacco, chemical and pharmaceuticals, and other industry such as textile and transport equipment (IGES,2017). The build-up of Semarang and surrounding areas has led to urban sprawl that placed strain on transport services and infrastructure. The city also face various physical challenges due to its coastal geography, such as tidal flooding, erosion, land subsidence and rising sea levels. These issues present serious challengers for Semarang, making it increasingly important to become more resilient. Then, Semarang became member of the Rockefeller 100 Resilient Cities (100 RC) program and developed a Resilience Strategy (2016) with components on mobility that aim to encourage residents to shift from private vehicles to public transport (BRT system).

3.1 GHG Emissions Challenges

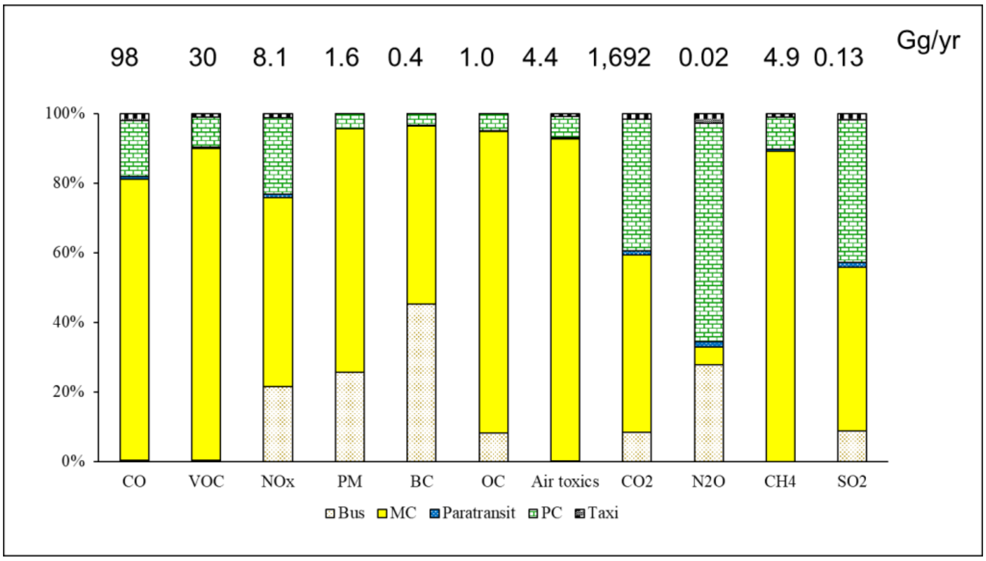
It is necessary to analyze the priority policies based on the existing documents (masterplan and city resilient strategy) and impacts on the GHG emissions reduction and air pollutants based on current emission level. The baseline helps to show various sources of pollutants and GHG emissions within the city. The International Vehicle Emissions (IVE) model was used to develop an emissions inventory for 15 pollutants from the road transport sector in both cities. The IVE model is an open source model developed by the International Sustainable Research Center (ISSRC) and the University of California at Riverside (UCR). The model is designed to analyze traffic fleet and emissions from over 700 technologies of various fuel types and air/fuel control combinations. The IVE model uses two main inputs, vehicle fleets and vehicle activity (i.e. driving behaviour), and accommodates site-specific emissions and adjustment based on the specific local context of both cities. Data was collected through a combination of primary data surveys in the two cities and surrounding cities; and secondary data was collected through publically available sources. Outputs from the model were diverse from tailpipe emissions produce during hot-stabilized engine operations (hot running emissions), excess tailpipe emissions associated with cold engine starting (start-up emissions), and volatile organic compounds (VOC) evaporative running losses.

Emissions for each of the 15 types of pollutants were then defined according to their sources: passenger vehicles (PC); motorcycles (MC); public buses; taxis and paratransit. Generally, private car gives largest contribution on CO_2 emissions, while motorcycle is largest emitter of CH_4. Looking at site specific context, private vehicles (car) is the largest GHG emitter, while buses is the largest emitter of particulate matter (PM) in Bandung city. The buses, private cars and motorcycles share equal contribution on the NOx emissions in Bandung (Figure 3). The other findings was observed in Semarang city. We found motorcycle is the largest emitter for climate and air pollution (CO_2, CH_4, PM and NOx) due to their population in the city (Figure 4). These findings support the evidence of local context depend upon traffic situation of each city which need to be addressed in selection of appropriate counter measures.



Source: (IGES, 2018)

Figure 3 Total emission, emission share by vehicle categories in Bandung, 2015



Source: (IGES, 2018). Note: Air toxics were the sum of 1,3-butadiene, acetaldehyde, formaldehyde, NH_3 and benzene emissions.

Figure 4 GHG Emission inventory for Semarang City (2016)

3.2 Questionnaire Survey for Analytic Hierarchy Process

Facing different challenges on developing sustainable transport for each city, team would like to support local authority to prioritize the local action plans. To examine the decision making process, we conducted a face to face interview to gather opinion of 11 alternative transportation policy among 40 people of local experts/various stakeholders in Bandung city. This approach was performed to make a judgment on the determination of alternative transport policy. The highest rank is an alternative policy which should be prioritized based on expert opinions. Otherwise, lower rankings means less priority of policy alternatives. Distribution of questionnaires in local government, represented by the agency related to the environment and transport who are part of policy makers. Respondents from academia refer to the lecturers and researchers who are knowledgable on transport, environment, and its related fields. In case of Semarang, instead of above mentioned group of respondents, we also distribute questionnaire to the respondents from academia refer to the lecturers and researchers who are knowledgable on transport, environment, and its related fields or have a direct experience with BRT Trans Semarang and public transport in general. They give viewpoints from more theoretical and ideal sides on public transportation issues in Semarang City. While the selection of NGO/community represent the view and expectation of citizens, the private sectors give their insights on the current and possible impacts of public transport in Semarang City to their activities as well as to the public. There are a total 44 respondents for expert/stakeholders survey:

- Academia from Diponegoro University (UNDIP), Catholic University (UNIKA) Soegijapranoto, State and University of Semarang (UNNES): 10
- Government staffs from Transportation Agency, Development Planning Agency, Landscaping Agency, Environmental Agency, and Public Work: 9
- NGO-Community (local and international): 10, and
- Private Sector from BRT operators, housing developers, transport service providers: 15.

4. EMPIRICAL CASE STUDY

To prioritize local policies and measures that could reduce air pollution and GHGs emission based on existing plans, a face to face interview with local stakeholders was conducted from October to December 2015 in Bandung city and one year later, from October to December 2016, in Semarang City.

4.1 Prioritizing Transport Action Plans in Bandung City

By applying the procedure previously outlined, the results indicate the highest importance of criteria “Environmentally Sustainable” (C5) about 28.87%. This result shows all stakeholders want an environmentally sustainable transport system applied in Bandung. The local stakeholders had future goal to preserve the environment deterioration caused by vehicle pollutions. The second and third factors quality of transport system (C2) and affordability of transport services (C3) about 21.78% and 20:17% respectively. The actions should be implementable is the next important aspect. While the quantity of transport service least considered in developing action plan. Looking at the eigenvector of the criteria comparison matrix, reported in table 5, whose components provide an estimate of the weights of the criteria. The principal eigenvalue of this matrix is λmax= 5.052, with a consistency ratio CR=0.01<0.1. Thus, the results are consistent.

To examine among 11 available policy alternatives, we found 3 top priority policies as follows: (1) eco driving (83.81%); (b) Pedestrian Facilities (79.88) and (c) Revitalization of minibus/ Angkot as shown in Figure 5. The city mayor has strong initiatives and program to improve pedestrian facilities in Bandung. The municipal government made serious efforts since 2013 and they gained appreciation from citizen. The pedestrian improvement program create safe walking environment as one of indicator of SDGs and also increase willingness longer per day in Bandung city (Nugroho, 2018).

Table 5 Matrix of Criteria Comparison in Bandung city

Criteria	C1	C2	C3	C4	C5	Weight vector	Percentage (%)
C1	1.000	0.377	0.395	0.432	0.457	0.0939	9.397
C2	2.653	1.000	0.964	1.117	0.753	0.2178	21.780
C3	2.532	1.037	1.000	0.883	0.620	0.2017	20.170
C4	2.315	0.895	1.132	1.000	0.562	0.1977	19.778
C5	2.188	1.328	1.614	1.781	1.000	0.2887	28.875

Source: Author calculation

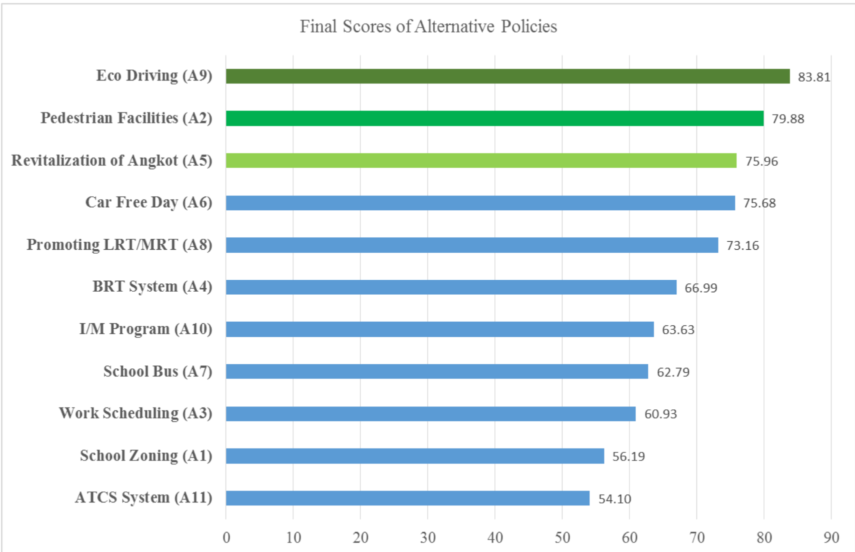


Figure 5 Final Score of Alternative Policies in Bandung

4.2 Prioritizing Transport Action Plans in Semarang City

We conducted interview survey to prioritize detail action plans to improve Quasi-BRT Trans Semarang. The first priority should be given to improve accessibility to BRT route (C5). The second priority was the improvement of BRT service planning (C1), then the provision of better information and communication platform about BRT services to public (C4) as the third priority. Development of sufficient infrastructure at BRT station (C2) and refinement of BRT station design (C3) are consecutively the last two priorities. As results from the eigenvector of the criteria comparison matrix reported in table 6 whose components provide an estimate of the weights of criteria, the principal eigenvalue of this matrix is λmax= 5.0232, with a consistency ratio CR=0.0058<0.1. Thus, the result for Semarang city also consistent.

Looking at the alternative actions, improvement of accessibility to BRT route was selected as the most important action among alternative actions. It is following the logical reason due to the fact that the existing coverage areas of quasi-BRT system still limited and focus on the main road and do not yet cover all areas within city boundary. Without intermodality, it is hard to solve the first and last mile of trips for transit users. Additional cost for feeder services is expensive and create another burdensome for public transit users. Figure 6 shows the priority of detailed actions derived from five proposed subjects. Finally, it break down to the lower options for action plan. Top three priorities should be given for these following actions: (a) to improve the inter modality; (b) universal access to all citizen and (c) pedestrian access to public transport system (figure 6).

Table 6 Matrix of Criteria Comparison in Semarang City

Criteria	C1	C2	C3	C4	C5	Weight vector	Percentage (%)
C1	1.000	0.827	0.594	0.717	0.458	0.192	19.23
C2	1.209	1.000	0.701	0.977	0.475	0.165	16.53
C3	1.684	1.427	1.000	0.508	0.265	0.123	12.26
C4	1.394	1.024	1.967	1.000	0.482	0.192	19.18
C5	2.182	2.105	3.775	2.077	1.000	0.328	32.80

Source: Author calculation

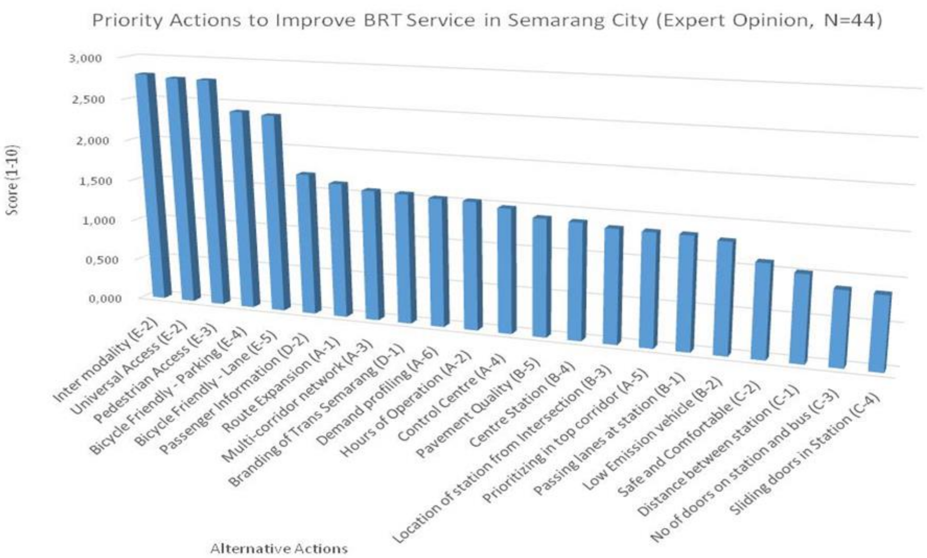


Figure 6 Priority Actions in Semarang City

4.3 Consensus Building for the Follow-up Actions and its Impacts

Drawing upon the initial results, the research team developed three scenarios that were broadly aligned with these priorities in each city. The quantitative analysis was made once again by using International Vehicle Emission model that was used in the inventory of GHG emissions and combine with several scenarios developed based on selected policies by local stakeholders. Following the analysis, second wave policy dialogues was convened to share the study results. The dialogue was conducted once again with multi stakeholders who were involved as respondents of questionnaire survey for the AHP to prioritize local policies and actions. The research team provide quantitative analysis to help stakeholders an overview of possible options for the follow-up actions which was discussed at policy dialogue. Having the evidence based on quantitative analysis led those involved in both city, Bandung and Semarang, to agree on the need to do follow-up actions considering the maximum impacts on co-benefit emission reduction to GHG emission and air pollution, affordability and its applicability.

The decisions coming out of this dialogue set the implementation of concrete plans based on the existing plan in each city. For example, in Bandung, local stakeholders agreed to implement the action plans that focus on behavioural of citizen: (a) eco-driving which will give maximum gain to reduce GHG emissions and air pollutions and (b) promote non-motorized transport. The capacity building and training on eco driving was done in the following year for the drivers of government vehicles, taxi companies and minibus/angkot driver as one of pilot project. The monitored data from the pilot initiative activities suggested an overall average of 7% improvement in fuel efficiency; 8% reduction of CO_2 emissions and 11% reduction of particulate matter (IGES, 2019). While the follow-up action on improvement of pedestrian facilities led the behavioural change of citizen to increase the willingness to walk further in a day (Nugroho, 2018). In case of Semarang city, the stakeholders translate policy recommendation into several activities such as: (a) Developing guidelines for reforming the city's BRT system which advocate a "place making" approach that would create quality of space for residents; (b) in addition to the infrastructure reforms recommended in the guidelines, stakeholders also sought change to the behaviour and attitudes focusing to particular group, young generation, of BRT user to encourage the high school students to keep use BRT rather than moving to motorcycles; (c) To reduce emission, local government conducted retrofit program to install hybrid diesel-compressed natural gas (CNG) engine on the existing buses. The pilot initiative on awareness raising campaign on behavioural change for school trip among junior high school students increase the intention to use and the ridership of quasi-BRT Trans Semarang (Nugroho, 2019). Introducing low-emission vehicles for bus fleets brought very small reduction of GHG emissions around 0.03% compare to the total emission at city level in 2015 which was written in introduction section of this article (Nugroho, 2019).

5. CONCLUSION AND WAY FORWARD

Framing climate mitigation actions involves two methodological challenges (a) the establishment of linkages between actions and outcomes (e.g. through a quantitative modeling approach) and (b) a way of objectively comparing the outcomes of different actions. The decisions to prioritizing policies in developing low carbon transport in the city level involve many intangibles that need to be traded off. The Analytic Hierarchy Process (AHP) has become significant methodology and widely apply due to its capability for facilitating multi-criteria decision-making and also one of the most commonly used methodologies to evaluate and quantify subjective judgement. This article discuss application of AHP in climate mitigation action on transport sector in Bandung and Semarang City.

We use similar structure and level of AHP, however it was tailored to the local context. In Bandung, it was developed based on policy options listed in the transport masterplan which is much broader. In the first level, it was constructed from five types of criteria for developing low carbon transport policies: quantity of transport service availability; quality of transport services, affordability to implement the policy by city stakeholders, the policy should be implementable and environmentally sustainable. While in Semarang, the AHP was applied to specific action necessary to improve the existing public transport system, quasi-BRT Trans Semarang. It looks an extension or the expansion of the AHP structure which was developed for Bandung. Then, in the first level of Semarang's AHP focus on service planning; infrastructure at BRT station; design of BRT station; communication/PR and improvement on access to BRT. The second level consists of more detail alternative policies in Bandung and detail action to improve quasi-BRT in Semarang city. In Bandung, we assess 11 alternative policies based on transport masterplan. While in Semarang, we analyze 22 detail alternative actions to improve BRT services. The application of Analytic hierarchy process (AHP) is suitable for both cases. The application of AHP helps local stakeholders in Bandung and Semarang to make judgement to prioritizing the alternative policies based on individual preferences. Quantitative analysis based on emission inventory and simulation scenario through quantitative model approach helps the local stakeholders to get overview of the impacts of selected policies and actions which then led the consensus building among policy makers went smoothly.

Transformative process from oriented research activities to practical actions and project development on low carbon transport in developing cities brought multiple benefits to the city. The initiatives by local government would have not been possible without cooperation with various local stakeholders. Involvement of stakeholders from the early stage of process would led the ownership and participation on translating policy-oriented research to practical actions. The local initiatives promise potential reduction of GHG emission and other air pollutant at city level. A general and city wide policies potentially gave higher impact as shown in Bandung. While the detail action and specific actions to improve bus system could deliver a modest reduction in Semarang city.

This study is not free of shortcomings. Experiments on cities and climate changes involve plurality of actors and opinion hinder the fulfilment of the goals. Multi stakeholder engagement and policy dialogues in itself are not enough to advance in urban transformative process. Stakeholders need to develop an understanding on climate change and sustainable development issues in order to fully engage in the process. Researchers and intermediate organization could support to improve the gap in the city level. Further research is needed to examine better approach on the co-design and collaborative process on the transformative actions at city level. The scalability and transferability to other sectors and other cities are the next priority issues for research.

6. ACKNOWLEDGMENT

This work is supported by the Institute for Global Environmental Strategies (IGES). The work in Bandung and Semarang city is a component of a series of Transport Related Co-Benefit Research in Indonesia with funding from the Ministry of Environment Japan's project "Measures to Address Air Pollution in China and other Asian Countries using a Co-Benefit Approach". The work in Semarang partially funded by Research Grant PNBP DIPA Universitas Diponegoro No:SP DIPA-042.01.2.400898/2016.

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