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An Application of Adaptive Network Urbanism

A Study Case from Border Area in Indonesia

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Abstract: Today's architect and urban designer neglected the networked world's vast flows developed by other innovators. An urban space may consist of several network system series. Urban network capacity to evolve within multiple choices concerning connections or adaptive shall be considered ultimately in the planning direction. As an adaptive principle, the network should be able to modify its own structure, and it should be adapted to various changes and changing needs and desire of its users. Adaptive network urbanism considers as a planning approach, which focuses on the dynamic system that can be evolving dynamically. The application of adaptive planning can be developed through anticipation and adaptation by preparing "plans" that may respond to the needs. This study applies the adaptive approach at the border area by proposing new networks on the existing infrastructure network to watch the "dynamical interplay" among areas, especially among Paloh district as a border area and Sambas district as the capital city. This study is specifically tried to identify the new links or expansion configuration by repeatedly proposing new links and re-calculations until it finds or gives alternatives for the best connection or "a prepared plan". There are five types of "adaptive" approaches to be considered in developing the strategic areas from the research findings. These approaches are (1) network transforms or new link, (2) network extension, (3) addition (new) node, (4) other supporting networks as a supplement network, and (5) inter-country connection to improve relationship and cooperation.

1. INTRODUCTION

Today's architect and urban designer argued by Drewe (2005) neglected the vast flows of the networked world and paradigmatic challenge of the network concept developed by other innovators concerning spatial planning. They still are influenced by zonal thinking and have not seen the infrastructure of cities within their domain. Associated with (urban) planning, adopting from Castell, Beauregard (2005) mentioned that a network consists of a set of components in the city (urban space), linked to each other to achieve one or more common purposes. An urban area may consist of several series of (network) system. Beauregard (2005) noted that the network disaggregates the city into a series of systems: e.g. waters supply, sewage disposal, housing, or transportation. Then, it is continued by the contemporary version of this "perspective" turned into networks; about the system of the city and linked externally to other city/system.

Network cities or urban network is defined as emerging, functional, connected sets of urban centres at the regional (Bertolini & Dijst, 2003). Urban network interlinks transport (linkages) and land use by creating a network of places, connected by corridors that allow for the movement of goods and people or activity centre (Western Australian Planning Commission, 2005). Road and water still constitute the main arteries for exchanging people, goods, energy, and information (van der Vleuten & Kaijser, 2005). In addition, the infrastructures or utilities will play a key role in promoting the increasingly polarised, fragmentary, and undemocratic cities, which are managed to serve the needs (Marvin & Graham, 1993). Beside physical environment, by the network, city to city can have a long-term partnership such as in the field of environment, education, socio-cultural, disaster management, economic, finance, and poverty (Tjandradewi & Marcotullio, 2009).

Drewe (2005) adopted Dupuy (2008) "levels of network" in terms of diagrammatic exposition of network-level within the city/urbanism. Dupuy distinguished three interacting levels of operators that (re) organise urban space. Level 1 involves the suppliers of technical networks: water, energy, transport, and telecommunication. Level 2 is known as the functional network of common interest users, such as production, distribution, consumption, and social contacts. Level 3 indicates that functional networks users make actual, selective use of technical networks and services for their particular purposes: households or company creates its own virtual city. While Heydebrand (1999) described there are three different types of network in getting more understanding about the network as metaphor, those are (1) technical network (telephone, internet), (2) transactional networks (transportation, trade), and (3) social and socio-technical networks. Cited from several Authors, Wandl et al. (2012) put forward that in its modern meaning, urban network or network urbanism is characterised by three principles criteria, such as:

1. Topological criterion: the geometrical or physical configuration of a network; the way in which nodes of a network are physically connected.
2. Kinetic criterion: referring to movement and communication between nodes, which translated in speed, the relationship between space and time
3. Adaptive criterion: is the capacity of a network to evolve over time and space. The network should be able to modify its own structure of nodes and links. It should be adapted to various change, such as its users' needs and desire (Petrou & Hadjisoterou, 2014; Wandl et al., 2012).

De Graaf (2012) carried out a definition of "adaptive". According to him, adaptive urban development is a design to anticipate and react to changes in the environment and society. Urban adaptation has to deal predominantly with adjusting physical structures and integration to adapt principles of "adaptation – assessment – planning – implementation – evaluation" (Birkmann et al. 2010). Followed by Berke et al. (2014), they said that "predict and plan" should be based on foresight, adaptation, and multiple possible scenarios in the futures. It can also be done by considering the notion of dynamical networks (Gross & Sayama, 2009), by watching the behaviour of single nodes and by examining the classes of nodes (Ito, J & Kaneko, 2009) in the focus of the "network analysis" procedures or application to identify or to describe the adaptive processes.

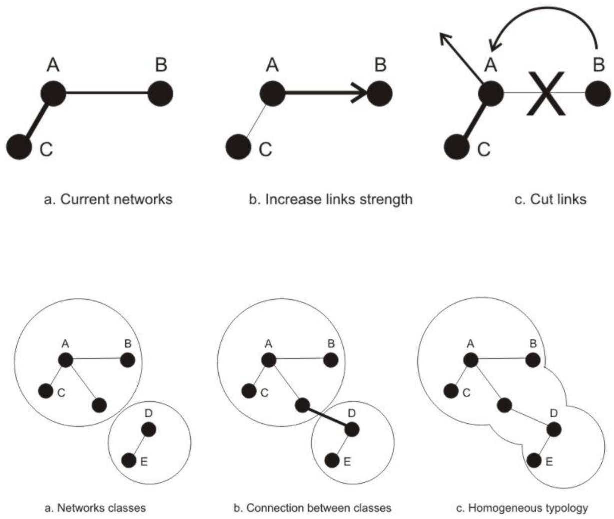


Figure 1. Dynamical Network: (Above) By Single Node, And (Below) By Group/Classes
Source: Interpreted from Ito, J & Kaneko (2009)

Gross and Sayama (2009) explained that a dynamical network is a concept in which the nodes can be an individual dynamical system where the pattern of links (network topology) can be evolving dynamically. In such situations, it results in a dynamical interplay between the state and the network's typology. In this case, we can estimate the connected/unconnected nodes and their influences by watching a single node's behaviour. Links between nodes can be connected (to spread/increase the influences) or to be cut. However, if we cut the links, a dynamical loop will be formed between topologies and networks' states, decreasing the influences (Figure 1). Besides watching the behaviour of single nodes, it is also possible to observe a network dynamic by examining the classes of nodes, such as increasing the link strength between nodes in similar states and effectively weakening the connection between nodes in different states. By these conditions, the rule leads to the evolution of two distinct classes of nodes: “Leaders” (strong influence) and “Followers” (little influence).

From some insight above, the network should modify its own structure of nodes, links and it should be adapted to various changes and changing needs and desire of its users, which is called the “adaptive” criterion. To examine it (adaptive), we can estimate the connected/unconnected nodes and their influences by watching the behaviour of “a single node” or “group”, either by increase/decrease or connect/disconnect the nodes. The general adaptive approach and the implementation can be performed through several ways such as repeat monitoring and evaluation, future prediction/forecast, new needs/ demands of its users, opportunities and new ideas, design and experiment (Ahern, Cilliers, & Niemelä, 2014; Hetz & Bruns, 2014; Kropp, Zolin, & Lindsay, 2015; Moore & Hockings, 2013; Petrou & Hadjisoterou, 2014).

From the Indonesian spatial plan perspective, the Government has endorsed the National Spatial Plan (in 2008). The strategy and policy within the national spatial plan are divided into two “forms” of plans: (1) spatial structure and (2) spatial pattern. Commonly, spatial structure (plan) describes accessibility to urban services as well as the quality and range of services and infrastructure. In contrast, spatial pattern describes the function of areas, such as protected areas, cultivated areas, and “strategic areas”.

As the recognition of the existences of “special areas”, Indonesia's national spatial plan has introduced “strategic areas”. These areas are assigned based on national importance and priorities (strategic) in national security, economic development, socio-cultural, high technology, and environment protection. Besides, the term strategic areas are also used in the urban hierarchy system. As for the urban hierarchy system, several areas are promoted to be “national strategic activity centre”, defined as urban area assigned to foster development in some national border areas.

Given its location and consideration in the past development that are more concerns in “security” matters, it leads to the untouched “welfare” development within the border areas. Today, most of Indonesia's borders areas remain lagging with the limited facilities and infrastructure compared with opposite countries. As a consequence, along with the national development mission statement to distribute the welfare, the Government changes the paradigm of development from “inward-looking” to “outward-looking” by utilising the border areas as a gate of economic and trade activities with other adjacent countries in coordination with the National Authority of Border Management established in 2010

Border areas are often isolated and have low accessibility, so the residents prefer to interact with their neighbouring country (Malaysia) rather than Indonesia’s nearby city. At present, with the spirit of reform and regional autonomy, the central Government, through state laws and regulations, has been paying special attention to the border areas through the establishment of the strategic areas, both in the urban system (in spatial structure) as well as the national strategic area (in the spatial pattern). All of the regulations provide guidance and direction to local governments to give special attention and encourage the accelerated development in the border areas.

One of Indonesia's regencies, which has a border area (as a strategic activity centre), is the Sambas regency. Sambas Regency is one of the regencies in West Kalimantan province, located in the northern part of West Kalimantan (Figure 2). This region has a total area of 6,395.70 sq. km, or about 4.36% of the total area of West Kalimantan (146,807 sq. km). As recorded in (Sambas Central Statistical Bureau, 2014), the Sambas regency is divided into 19 districts and 183 villages. From the regional economic perspective, the main economic activities in Sambas regency are still dominated by the agriculture sector, followed by trade-hotel-restaurant, processing industry, and services. In 2013, a population in Sambas regency was recorded as 515,571 with a population density of around 81 persons per sq. Km. As reported by West Kalimantan Province Border And Lagging Area Development Agency (2013), the common problems in border areas were in the range of low quality of human resources, unclear spatial planning, underdeveloped condition, geographic condition, and obscurity of authority-coordination, lack of infrastructure and services, and lacking law enforcement. The infrastructure here is one of the main problems in Sambas’s border areas, especially in access (in terms of transportation/road and telecommunication).

From the Sambas regency spatial plan and networking perspective, The Sambas district (regency’s capital city) is designated as a regional activity centre, which serves the provincial or regional scale activities. On the other hand, border areas in Paloh (Paloh district) and Aruk (Sajingan Besar district) are designated as national strategic activity centres, defined as an urban area that encourages the development in the border area. Based on the preliminary study of two strategic areas in Sambas regency (Sambas district and Paloh district), most of the movement and "flow" is oriented to the areas along the main corridor (Southern part). This corridor connects the main economic attractiveness (to province capital city; Pontianak city) with a shorter distance (Muazir & Hsieh, 2014, 2015, 2016). However, most of these connected areas are unable to push the border areas and surroundings (Northern part) to be more advanced. The gap is displayed in the "profile" of the regency (e.g. population density, facilities, infrastructure, business units, etc.) and the ease of connectivity and accessibility.

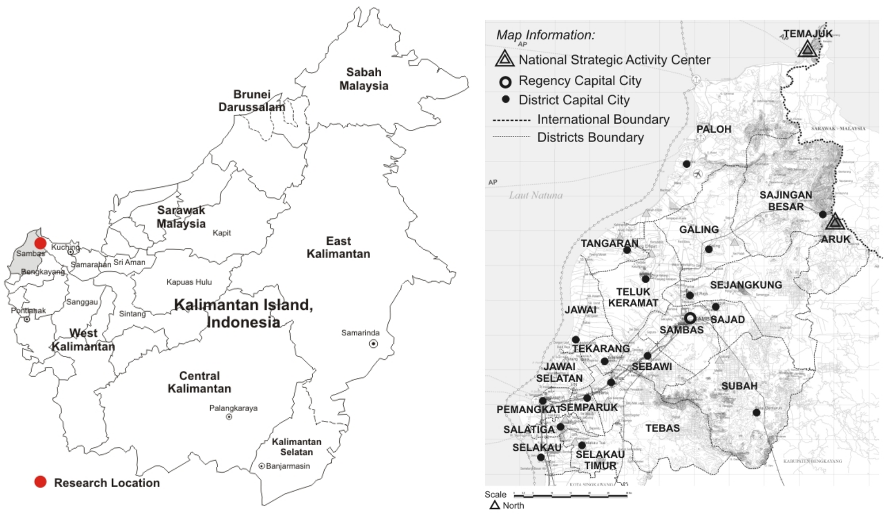


Figure 2. (Left) Sambas Regency Inside Kalimantan Island; (Right) Sambas Regency

Based on the above border areas issues, this study applies the adaptive approach at the border area by proposing new networks on the existing infrastructure network to watch the "dynamical interplay" among areas, especially among Paloh district as a border area and Sambas district as the capital city. These "strategic area" should be a "growth machine" for the surrounding to develop border area. Each area should interact with both, balanced, and has an equal distribution according to each area's specifications. Therefore, network analysis as a concept can be used to explore the interaction and adaptively. Furthermore, this study explores the existing urban network among areas in "strategic regency" in Indonesia (Sambas Regency, West Kalimantan Province). This study tries to simulate and "improve" the connection among related areas based on one of the urban network criterion approaches, adaptive, so each area has a better connection or alternatives as a preparation plan. Adaptive criteria were chosen in this study because we want to study the impact of various changes on modifying nodes and linking structures based on the existing network. Therefore, prediction and simulation performed by repeatedly proposing new links and re-calculations until it founded or giving alternatives for the best connection to have a better choice in interacting and connecting each other.

2. METHOD

For network measurement, at least three types of "basic" network analyses can be used in performed network measurement (Borgatti et al., 2013), which is (1) centrality, (2) subgraph, (3) and equivalence. Four basic centrality measures are (1) degree, (2) closeness, (3) betweenness, and (4) eigenvector (Table 1). The second approach is a subgroup, groups of actors who interact with each other to such extent that they could be considered separate entities or cohesive subgroups (Borgatti et al., 2013). According to (Wasserman & Faust, 1994), cohesive subgroups are subsets of actors among whom there are relatively strong, direct, intense, frequent, or positive ties and can be explored through "clique". The last approaches in network analysis are structural holes and structural equivalence (Table 1).

Table 1. Analysis Concept

No	Analysis Tool	Definition	Source
1	Degree (in/out)	Number of lines that are incident with it; number of ties of a given type that a node has	Borgatti, Everett, & Johnson, 2013; Scott, Baggio, & Cooper, 2008
2	Closeness	It reflects how close the actors are to reach others, which means that an actor is central if it quickly interacts with all others	Wasserman & Faust, 1994
3	Betweenness	The one between the others and the one in the middle becomes a "bridge" between others; the flow controller.	Borgatti, Everett, & Johnson 2013; Wasserman & Faust, 1994
4	Eigenvector	An effort to find the most central actors in terms of the overall network structure; A measure of "popularity" that a node is connected to nodes that are well connected themselves.	Borgatti, 1995; Borgatti, Everett, & Johnson, 2013; Hanneman & Riddle, 2005
5	Clique	Groups or actor who interact closely with each other formed a solid group, with a minimum of 3 as the number of the smallest group	Borgatti et al., 2013; Wasserman & Faust, 1994
6	Structural Holes	It is a relationship of non-redundancy between two contacts; Space between connected people, "buffer" between other members; As a result of the hole, the two connections provide network benefits.	Burt, 1992; Hanneman & Riddle, 2005
7	Structural Equivalence: Blockmodels	Partitioning the vertices of the graph into similarity classes (block)	Wasserman & Faust, 1994

The concept of structural holes leads naturally to the hypothesis that an actor, who has many structural holes (buffer or space; no tie between actors) in its own network, has an incentive to work as a broker in between, and except some profit from doing so (Hanneman & Riddle, 2005; Swedberg, 1994). Structural holes are the gaps between non-redundant contacts. The two connections provide network benefits with that area in some degree additive rather than overlapping (Burt, 1992). The calculation can be performed by calculating the number of alters that ego has, minus the average number of ties that alters has (effective/efficient size). According to Borgatti et al. (2013), structural equivalence directly connects an actor to other actors in the network. It is based upon identifying similar positions and seeks clusters of nodes that are connected to each other. They illustrate that two actors/nodes are structurally equivalent if they send ties to the same third parties and receive ties from the same third parties. Both actors do not need to have a direct tie. Concluded by Wasserman and Faust (1994), two actors are structurally equivalent if they have identical ties to and from all other actors in the network. Structural equivalence can calculate using blockmodels.

From the perspective of nodes and their adaptive configuration, the application to identify or describe the adaptive processes can be made by considering the notion of dynamical networks, which divide node behaviour into two, by single node (parts of the network) and by groups (the whole network). We can estimate the connected/unconnected nodes and their influences by watching the behaviour of nodes (single or group) from their connection to other nodes and their link strength.

This study was executed with several activities such as and supported with UCINET software (Borgatti et al., 2002), the activities included as (Figure 3):

1. Diagnose the existing urban networks centrality to check parts of the network (nodes). This activity is conducted by measuring the centrality indicators of the network, such as (1) outdegree, (2) indegree, (3) farness, (4) closeness, (5) betweenness, and (6) eigenvector (Table 2).
2. Diagnose the group/classes or "structural position" of the existing urban networks. This activity is conducted by measuring the (7) subgraph/clique, (8) effective, (9) efficient, and blockmodels (block) (Table 2).
3. Develop an "adaptive network urbanism" approach by preparing multiple choices concerning connections in response to various changes and changing users' needs and desires. This stage conducted by proposing new links based on the existing networks, the available nodes/ links among strategic areas, and regional issues or demand (regional policy) to improve the connectivity between strategic areas.
4. Network simulation and re-calculate (adaptive process) the centrality measures of each node and each block/class's structural position to compare. The comparison based on the existing and the changes (the total of reduction and increment) of each indicator (1-9), as well as their block interaction strength (groups/classes change). To do that, we compare several indicators and their impact on the areas of study. The measurement indicators consist of: (1) outdegree, (2) indegree, (3) farness, (4) closeness, (5) betweeness, (6) eigenvector, (7) clique, (8) effective, (9) efficient, and blockmodels.
5. Comparing the results of existing network conditions with proposed alternatives by seeing the increase or decrease score. Besides, the tendency of interactions within a "block" also observe. The comparison is conducted by listing and comparing all the scores obtained both on the existing network and the proposed networks. Afterwards, each increased (the most) or decreased (the least) score was counted and ranked.
6. Developing the "adaptive network urbanism" strategy that can be carried out in the development of areas/regions through the results of findings

Table 2. Existing Network/ Proposed Links/ Network Comparison Table

CODE	**AREA**	**Existing Network / Proposed Networks**									
		Measurement Indicators									
		1	2	3	4	5	6	7	8	9	**Block**
A	Selakau										
B	Selakau Timur										
Etc.	Etc.										

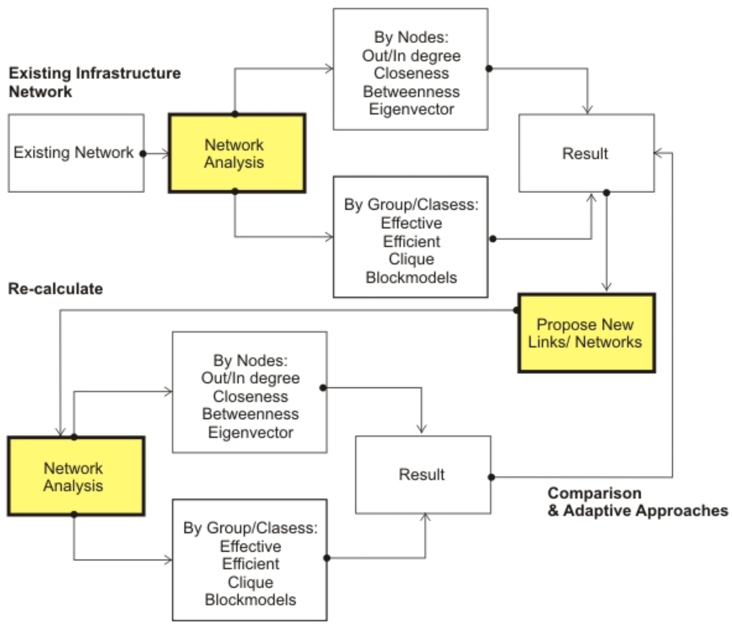


Figure 3. Research Flow

3. RESULT AND DISCUSSION

3.1 Adaptive Network Urbanism: Existing Network and the Modified/Multiple Choices

This part will focus on measuring network elements by nodes (in or out-degree, farness/closeness, betweenness, and eigenvector). It also constructs their structural position of groups/classes by performing subgraph/clique, effective/efficient and blockmodels that can provide information about the position and role of areas/locations inside the whole existing network. The types of infrastructure to be used are infrastructures that have a point-to-point connection of areas following Indonesian spatial plan, such as (1) roads, (2) ports, (3) airports, (4) railway, (5) water supply, (6) energy (electricity), (7) waste management, and (8) telecommunication. The proposed connection/ networks (pN) considered based on the available new links among strategic areas (Paloh = S, and Sambas = H), related government work-plans or policies, and the current or expansion plan such as water supply, waste management, and telecommunication. The emphasis of the "adaptive" in this study is trying to explore alternatives or possible network connections. The proposed network (pN) is a direct relationship between node-to-node relationship at the plan, which in reality, the physical condition may affect the direct connection.

3.2 Adaptive Network Urbanism: Changes and Comparison in Modified/Multiple Choices

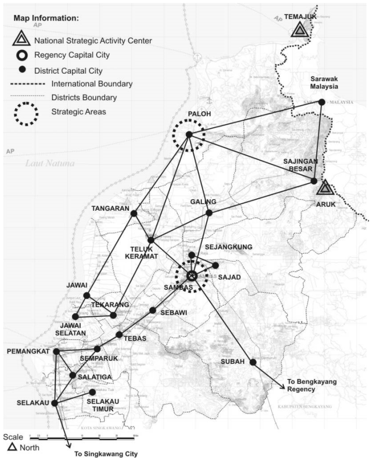
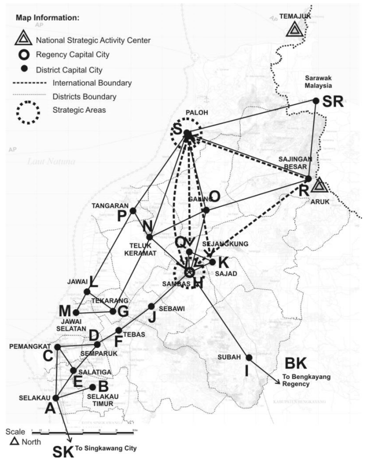
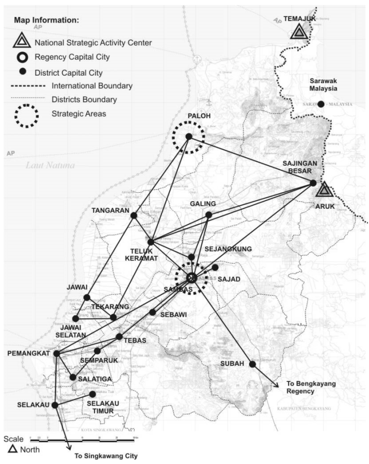
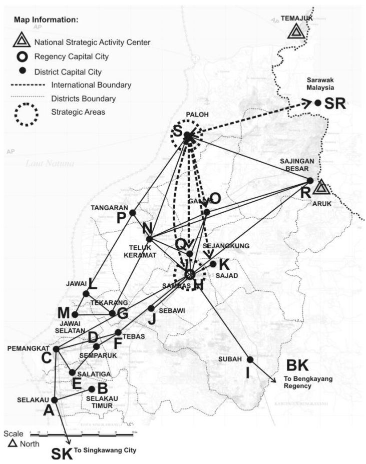
Adaptive network urbanism is considered a planning approach that focuses on the dynamic system that can evolve dynamically. The approach can be made by watching single nodes' behaviour and examining the classes of nodes in the form of a network. The application of adaptive planning can be developed through anticipation and adaptation by preparing "plans" that may respond to the needs and demands. In this part, we develop adaptive network urbanism by creating multiple networks and then seeing its score changes, indicating the importance of nodes/links for future plans. From the existing network and proposed network simulation (based on table 3), the score changes indicate in figure 4.

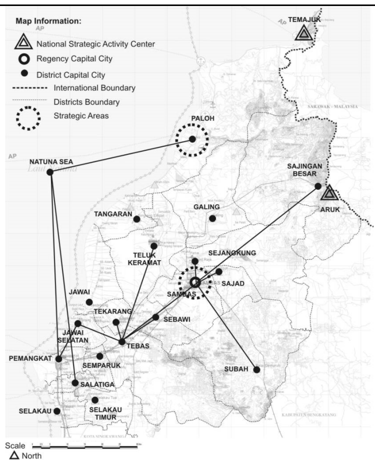
CODE	AREA	Existing Network									pN1 (S-H)									pN2 (S-Q-H)								
		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
A	Selakau	4	4	107	19.	18.	0	1	3.5	0.8	4	4	105	20	18.	0.	1	3.5	0.8	4	4	107	19.	18.	0.	1	3.5	0.8
B	Selakau Timur	1	1	127	16.	0	0.	0	1	1	1	1	125	16.	0	0.	0	1	1	1	1	127	16.	0	0.	0	1	1
C	Pemangkat	3	3	92	22.	12.	0.	2	1.6	0.5	3	3	90	23.	12.	0.	2	1.6	0.5	3	3	92	22.	12.	0.	2	1.6	0.5
D	Semparuk	3	3	79	26.	38.	1.	0.4	2.3	0.7	3	3	77	27.	38.	1.	0.7	2.3	0.7	3	3	79	26.	38.	1.	0.7	2.3	0.7
E	Salatiga	3	3	92	22.	12.	0.	2	1.6	0.5	3	3	90	23.	12.	0.	2	1.6	0.5	3	3	92	22.	12.	0.	2	1.6	0.5
F	Tebas	2	2	69	30.	42.	4.	0	2	1	2	2	67	31.	42.	4.	0	2	1	2	2	69	30.	42.	4.	0	2	1
G	Tekarang	3	3	77	27.	11.	26.	1	2.3	0.7	3	3	77	27.	10.	20.	1	2.3	0.7	3	3	77	27.	10.	22.	1	2.3	0.7
H	**Sambas**	**6**	**6**	**55**	**38.**	**68.**	**50.**	**1**	**5.3**	**0.8**	**7**	**7**	**53**	**39.**	**68.**	**62.**	**1**	**5.8**	**0.8**	**6**	**6**	**55**	**38.**	**63.**	**51.**	**1**	**5.3**	**0.8**
I	Subah	2	2	73	28.	9.	14.	0	2	1	2	2	71	29.	9.	16.	0	2	1	2	2	73	28.	9.	14.	0	2	1
J	Sebawi	2	2	61	34.	46.	14.	0	2	1	2	2	59	35.	46.	16.	0	2	1	2	2	61	34.	46.	14.	0	2	1
K	Sajad	2	2	74	28.	0	18.	1	1	0.5	2	2	72	29.	0	20.	1	1	0.5	2	2	72	29.	0	22.	1	1	0.5
L	Jawai	3	3	91	23.	1.	21.	1	2.3	0.7	3	3	91	23.	1.	15.	1	2.3	0.7	3	3	90	23.	1.	17.	1	2.3	0.7
M	Jawai Selatan	2	2	95	22.	0	12.	1	1	0.5	2	2	95	22.	0	8.	1	1	0.5	2	2	95	22.	0	10.	1	1	0.5
N	Teluk Keramat	5	5	61	34.	33.	63.	2	3.8	0.7	5	5	61	34.	23	58.	2	3.4	0.6	5	5	61	34.	30.	59.	2	2.5	0.7
O	Galing	4	4	64	32.	14.	57.	2	2.5	0.3	4	4	64	32.	3.	54.	1.7	2	0.5	4	4	64	33.	10	54.	2	2.5	0.6
P	Tangaran	3	3	75	28.	5.	39.	0.8	2.3	0.7	3	3	75	28	6.	34.	0.6	2.3	0.7	3	3	74	28.	6.	36.	0.2	2.3	0.7
Q	Sejangkung	2	2	74	28.	0	18.	1	1	0.5	2	2	72	29.	0	20.	1	1	0.5	3	3	67	31.	4.	35.	1	2.3	0.7
R	Sajingan Besar	3	3	79	26.	2.	39.	1	1.6	0.5	3	3	79	26.	0.	36.	1.3	1.6	0.5	3	3	78	26.	1.	37.	1.5	1.6	0.5
S	**Paloh**	**5**	**5**	**74**	**28.**	**8.**	**61.**	**2**	**3.4**	**0.6**	**6**	**6**	**61**	**34.**	**19.**	**66.**	**2**	**4**	**0.6**	**6**	**6**	**71**	**29.**	**12.**	**64.**	**2**	**4.6**	**0.7**
BK	Bengkayang	1	1	93	22.	0	3.	0	1	1	1	1	91	23.	0	3.	0	1	1	1	1	93	22.	0	3.	0	1	1
SK	Singkawang	1	1	127	16.	0	0.	0	1	1	1	1	125	16.	0	0.	0	1	1	1	1	127	16.	0	0.	0	1	1
SR	Sarawak	2	2	93	22.	0	27.	1	1	0.5	2	2	80	26.	0	25.	0.5	1	0.5	2	2	90	23.	0	26.	0.6	1	0.5

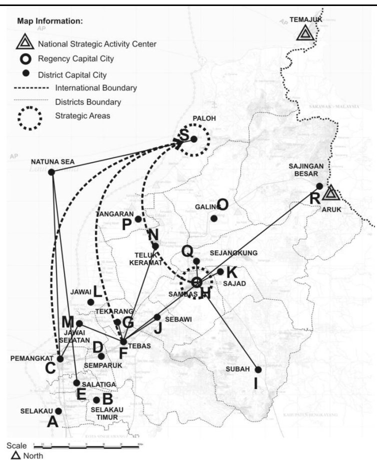
CODE	AREA	pN3 (S-K-H)									pN4 (R-H)								
		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
A	Selakau	4	4	107	19	18.	0.	1	3.5	0.8	4	4	105	20.	18.	0.	1	3.5	0.8
B	Selakau Timur	1	1	127	16.	0	0.	0	1	1	1	1	125	16.	0	0.	0	1	1
C	Pemangkat	3	3	92	22.	12.	0.	2	1.6	0.5	3	3	90	23.	12.	0.	2	1.6	0.5
D	Semparuk	3	3	79	26.	38.	1.	0.7	2.3	0.7	3	3	80	26.	38.	1.	0.7	2.3	0.7
E	Salatiga	3	3	95	22.	12.	0.	2	1.6	0.5	3	3	90	23.	12.	0.	2	1.6	0.5
F	Tebas	2	2	69	30.	42.	4.	0	2	1	2	2	67	31	42.	4.	0	2	1
G	Tekarang	3	3	77	27.	10.	22.	1	2.3	0.7	3	3	77	27.	11.	20.	1	2.3	0.7
H	**Sambas**	**6**	**6**	**55**	**38.**	**63.**	**51.**	**1**	**5.3**	**0.8**	**7**	**7**	**53**	**39.**	**69.**	**60.**	**2**	**6.1**	**0.8**
I	Subah	2	2	73	28.	9	14.	0	2	1	2	2	71	29.	9.	16.	0	2	1
J	Sebawi	2	2	61	34.	46.	14.	0	2	1	2	2	59	35.	46.	16.	0	2	1
K	Sajad	3	3	67	31.	4.	35.	1	2.3	0.7	2	2	72	29.	0	20.	1	1	0.5
L	Jawai	3	3	90	23.	1	17.	1	2.3	0.7	3	3	91	23.	1.	15.	1	2.3	0.7
M	Jawai Selatan	2	2	95	22.	0	10.	1	1	0.5	2	2	95	22.	0	9.	1	1	0.5
N	Teluk Keramat	5	5	61	34.	30.	59.	2	3.8	0.7	5	5	61	34.	30.	57.	2	3.8	07
O	Galing	4	4	64	32.	10.	54.	2	2.5	0.6	4	4	64	32.	2.	56.	2	2	0.5
P	Tangaran	3	3	74	28.	6.	36.	0.2	2.3	0.7	3	3	75	28	5.	32.	0.2	2.3	0.7
Q	Sejangkung	2	2	72	29.	0	22.	1	1	0.5	2	2	72	29	0	20.	1	1	0.5
R	Sajingan Besar	3	3	78	26.	1.	37.	1.5	1.6	0.5	4	4	66	31.	8.	50.	1.7	2.5	0.6
S	**Paloh**	**6**	**6**	**71**	**29.**	**12.**	**64.**	**2**	**4.6**	**0.7**	**5**	**5**	**74**	**28.**	**4.**	**56.**	**2**	**3.4**	**0.6**
BK	Bengkayang	1	1	93	22.	0	3.	0	1	1	1	1	91	23.	0	4.	0	1	1
SK	Singkawang	1	1	127	16.	0	0.	0	1	1	1	1	125	16.	0	0.	0	1	1
SR	Sarawak	2	2	90	23.	0	26.	0.6	1	0.5	2	2	80	26.	0	27.	0.6	1	0.5

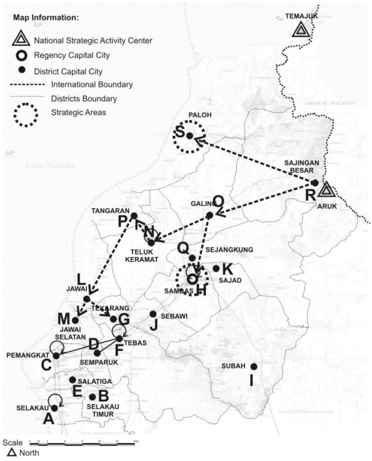
Figure 4. Network Comparison in Road Network

Table 3. Existing Network and Proposed Links/Network of Strategic Areas

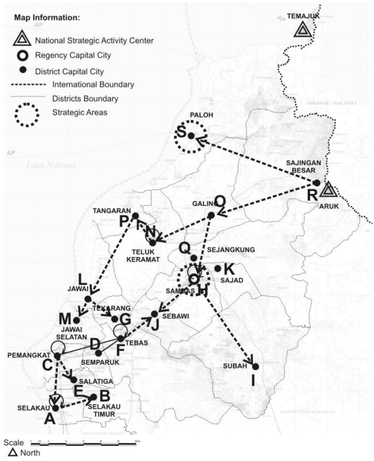
Existing Network	Proposed Network (pN) (Options)
 **Road Network**	 There are at least four alternative routes to make Paloh (S) and Sambas (H) closer from the existing network perspective. The alternative routes are (1) **S** directly to **H**, (2) **S-Q-H**, (3) **S-K-H**, and (4) **S-R-H** to "close" the structural holes between R and H.
 **Public Land Transportation Network**	 The alternative routes are (1) S directly to **H**, (2) **H-Q-S**, (3) **H-K-S**, (4) **H-O-S**, and (5) try to connect **S** to **SR** (neighbouring country).

<table>
<tr><th>Existing Network</th><th>Proposed Network (pN) (Options)</th></tr>
<tr><td>


Public Sea/River Network</td><td>


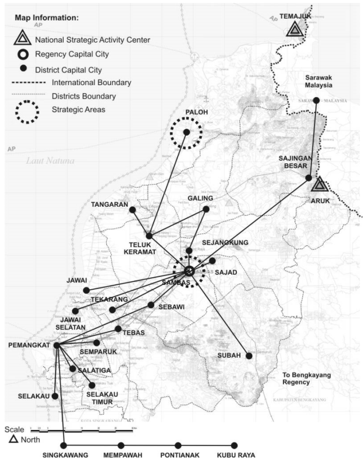
In the absence of river streams to S (border area), there is only one alternative to reach S, which goes along the seaside in Sambas or Natuna Sea through C or F ports that directly access the sea. However, even though the goal is to connect S with other “developed” areas in Sambas regency, a cruise through the sea is not recommended for small passenger boats.</td></tr>
<tr><td>


Water Supply Network

There are only six districts that have been served by the Regional Water Company (PDAM) in Sambas regency in the current conditions. The districts are H, F, D, C, A, and N. Each water source and pump generally only serves specific locations with limited area.</td><td>


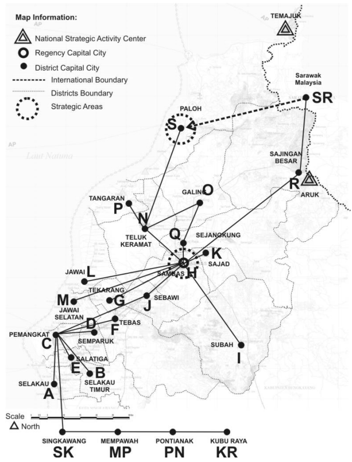
Seen from the supporting infrastructure (e.g. patterns of existing roads) and government development plan for water piping, the water piping development from R can be developed through S by following the road pattern that already exists to facilitate development maintenance.</td></tr>
</table>

<table>
<tr><th>Existing Network</th><th>Proposed Network (pN) (Options)</th></tr>
<tr><td>



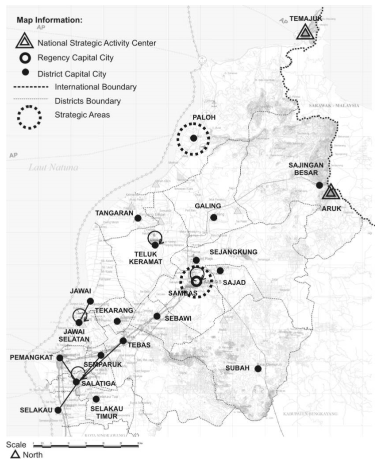
Electricity Grid Network

</td><td>



A similar strategy with area R can be used: by connecting/ buying electricity from Sarawak (SESCO) to S and integrating it into the electricity system.

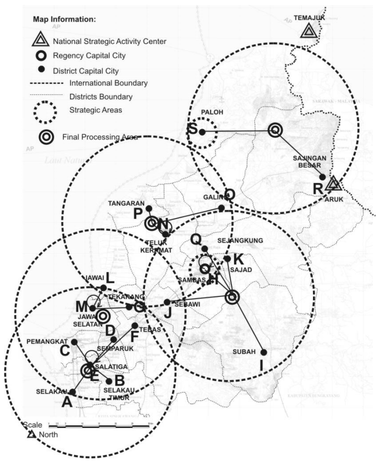
</td></tr>
<tr><td>



Waste Management Network

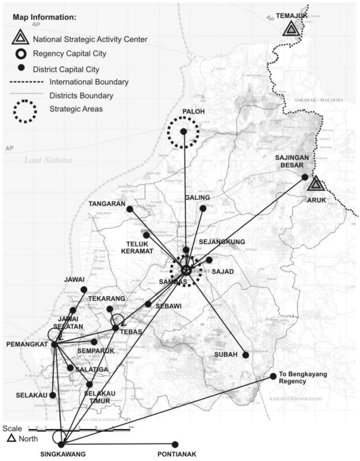
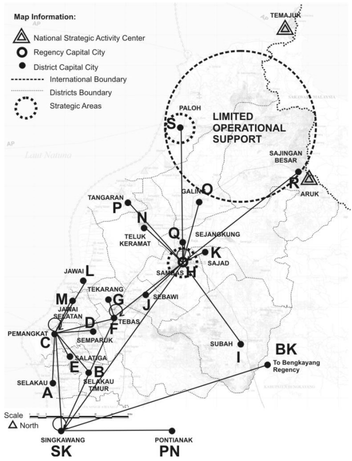
From the existing condition, waste management in Sambas utilises four final processing area spread across districts and only serve nine districts, such as H, F, D, C, E, A, N, L, and M.

</td><td>



To support the resident activity in border areas, it needs to provide the (waste) final processing area to serve both districts (S and R). This condition is because the existing services and the expansion cannot reach the border areas, measured by the distance and time.

</td></tr>
</table>

<table>
<tr><th>Existing Network</th><th>Proposed Network (pN) (Options)</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Telecommunication Network</td><td>The distribution of telecommunication towers has reached the border areas. The construction was based on the “social obligations” of the telecommunications company. However, even the towers have covered all districts, for border areas, some infrastructure needs to provide for towers operational, such as road and electricity, to fulfil the fuel supply.</td></tr>
</table>

Road Network

After each option/alternative was compared for the road network, option number 4 seems to have the optimum score among the others. However, the “benefits” mostly distributed not to S. Other than that, option number 1 with a direct connection between H and S became the “second” grade. In number 1, the adjustments score (benefit) also influences several areas in far-end areas and near border and number 2. Additionally, in number 1, H and S have a good interaction inside the same blocks; both are connected directly in one group/block amongst other groups within the overall network. Option number 1 means S and H has been in the same group/class and can interact closely. Overall, we can estimate the connected/unconnected nodes and the score changes to evaluate the existing network (Tabel 4).

Table 4. Score Rank for Road Network

Options/ Proposed Network (based on Table 3)	Adaptive Plans & Score Changes					
	Score Reduction (Indicators 1-9)		Score Increment (Indicators 1-9)		Areas Interaction (Blockmodels)	
	Amount	Rank	Amount	Rank	Linked	Rank
S-H	11	**3**	24	**2**	Strongly (0.291)	**1**
S-Q-H	9	**2**	13	**3**	Strongly (0.156)	**2**
S-K-H	9	**2**	11	**4**	Strongly (0.156)	**2**
R-H	7	**1**	28	**1**	Weakly (0.111)	**3**

Public Land Transportation

Judging from the overall comparison, similar to the road network, option number 1 that connects directly area H (Sambas) with S (Paloh) seems to have the optimum score among the others (Figure 5). In contrast, others have a diverse rank. For the record, in option number 1, the score increases primarily occur in H and S and some far-end areas. While in option number 3, H does not receive any benefits, but it distributes to other areas near the border, such as O and R (Table 5).

CODE	AREA	Existing									pN1 (H-S)									pN2 (H-Q-S)								
		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
A	Selakau	2	1	58	34.	19.	7.	0	3	1	2	1	57	35.	19.	6.	0	3	1	2	1	58	34.	19.	5.	0	3	1
B	Selakau Timur	0	1	77	25.	0	1.	0	1	1	0	1	76	26.	0	1.	0	1	1	0	1	77	25.	0	1.	0	1	1
C	Pemangkat	4	2	43	46.	38.	28.	2	3.8	0.7	4	2	42	47.	38.	25.	2	3.8	0.7	4	2	43	46.	38.	24.	2	3.8	0.7
D	Semparuk	3	1	60	33.	0.	14.	2	1.7	0.5	3	1	59	33.	0.	12.	2	1.7	0.5	3	1	60	33.	0.	12.	2	1.7	0.5
E	Salatiga	0	2	61	32.	0	9.	0.4	1	0.5	0	2	60	33.	0	8.	0.4	1	0.5	0	2	61	32.	0	8.	0.4	1	0.5
F	Tebas	0	3	47	42.	3.	25.	1.3	1.8	0.6	0	3	46	43.	3.	23.	1.3	1.8	0.6	0	3	47	42.	3.	22.	1.3	1.8	0.6
G	Tekarang	3	0	56	35.	12.	18.	1	2.3	0.7	3	0	56	35.	11.	16.	1	2.3	0.7	3	0	56	35.	12.	17.	1	2.3	0.7
H	**Sambas**	**9**	**0**	**35**	**57.**	**69.**	**68.**	**2**	**7.7**	**0.8**	**10**	**0**	**34**	**58.**	**70.**	**71.**	**3**	**8.4**	**0.8**	**9**	**0**	**35**	**57.**	**69.**	**65.**	**2**	**7.7**	**0.8**
I	Subah	1	1	52	38.	10	16.	0	2	1	1	1	51	39.	10.	15.	0	2	1	1	1	52	38.	10	14.	0	2	1
J	Sebawi	0	1	54	37.	0	15.	0	1	1	0	1	53	37.	0	15.	0	1	1	0	1	54	37.	0	14.	0	1	1
K	Sajad	0	1	54	37.	0	15.	0	1	1	0	1	53	37.	0	15.	0	1	1	0	1	54	37.	0	15.	0	1	1
L	Jawai	1	2	71	28.	1	11.	1	2.3	0.7	1	2	71	28.	1.	10.	1	2.3	0.7	1	2	71	28.	1.	10.	1	2.3	0.7
M	Jawai Selatan	0	2	73	27.	0	6.	1	1	0.5	0	2	73	27.	0	5.	1	1	0.5	0	2	73	27.	0	6.	1	1	0.5
N	Teluk Keramat	3	4	41	48.	36.	63.	2	5	0.7	3	4	41	48.	27.	61.	3	4.7	0.6	3	4	41	48.	34.	63.	3	4.7	0.6
O	Galing	2	2	46	43.	0.	50.	2	1.5	0.3	2	2	46	43.	0.	46.	2	1.5	0.3	2	2	46	43.	0.	49.	2	1.5	0.3
P	Tangaran	3	0	56	35.	5.	23.	0.4	2.3	0.7	3	0	56	35.	6.	24.	1	2.3	0.7	3	0	56	35.	5.	25.	0.5	2.3	0.7
Q	Sejangkung	0	3	47	42.	0	41.	0.6	1	0.3	0	3	47	42.	0	38.	0.1	1	0.3	1	3	46	43.	2.	47.	1.3	2	0.5
R	Sajingan Besar	0	4	46	43.	3.	48.	1.7	2	0.5	0	4	46	43.	0.	47.	1.4	1.5	0.3	0	4	46	43.	2.	47.	1	2	0.5
S	**Paloh**	**2**	**1**	**57**	**35.**	**0.**	**30.**	**2**	**1.6**	**0.5**	**2**	**2**	**45**	**44.**	**5.**	**43.**	**1**	**2**	**0.5**	**2**	**2**	**56**	**35.**	**1.**	**40.**	**3**	**2.5**	**0.6**
BK	Bengkayang	0	1	71	28.	0	3.	0	1	1	0	1	70	28.	0	3.	0	1	1	0	1	71	28.	0	3.	0	1	1
SK	Singkawang	0	1	77	25.	0	1.	0	1	1	0	1	76	26.	0	1.	0	1	1	0	1	77	25.	0	1.	0	1	1

CODE	AREA	pN3 (H-K-S)									pN4 (H-O-S)									pN5 (S-SR)								
		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
A	Selakau	2	1	58	34.	19.	6.	0	3	1	2	1	58	34.	19.	5.	0	3	1	2	1	63	33.	18.	7.	0	3	1
B	Selakau Timur	0	1	77	25.	0	1.	0	1	1	0	1	77	25.	0	1.	0	1	1	0	1	83	25.	0	1.	0	1	1
C	Pemangkat	4	2	43	46.	38.	27.	2	3.8	0.7	4	2	43	46.	38.	24.	2	3.8	0.7	4	2	47	44.	36.	27.	2	3.8	0.7
D	Semparuk	3	1	60	33.	0.	13.	2	1.7	0.5	3	1	60	33.	0.	11.	2	1.7	0.5	3	1	65	32.	0.	14.	2	1.7	0.5
E	Salatiga	0	2	61	32.	0	9.	0.4	1	0.5	0	2	61	32.	0	7.	0.4	1	0.5	0	2	66	31.	0	9.	0.4	1	0.5
F	Tebas	0	3	47	42.	3.	24.	1.3	1.8	0.6	0	3	47	42.	3.	21.	1.3	1.8	0.6	0	3	51	41.	3.	24.	1.3	1.8	0.6
G	Tekarang	3	0	56	35.	12.	17.	1	2.3	0.7	3	0	56	35.	12.	17.	1	2.3	0.7	3	0	59	35.	11.	18.	1	2.3	0.7
H	**Sambas**	**9**	**0**	**35**	**57.**	**66.**	**68.**	**2**	**7.7**	**0.8**	**9**	**0**	**35**	**57.**	**69.**	**64.**	**2**	**7.7**	**0.8**	**9**	**0**	**38**	**55.**	**68.**	**68.**	**2**	**7.7**	**0.8**
I	Subah	1	1	52	38.	10	16.	0	2	1	1	1	52	38.	10	14.	0	2	1	1	1	56	37.	9	16.	0	2	1
J	Sebawi	0	1	54	37.	0	15.	0	1	1	0	1	54	37.	0	13.	0	1	1	0	1	58	36.	0	15.	0	1	1
K	Sajad	1	1	50	40.	1.	23.	0	2	1	0	1	54	37.	0.	13.	0	1	1	0	1	58	36.	0	15.	0	1	1
L	Jawai	1	2	70	28.	1.	10.	1	2.3	0.7	1	2	71	28.	1.	10.	1	2.3	0.7	1	2	74	28.	1	11.	1	2.3	0.7
M	Jawai Selatan	0	2	73	27.	0	6.	1	1	0.5	0	2	73	27.	0	6.	1	1	0.5	0	2	77	27.	0	6.	1	1	0.5
N	Teluk Keramat	3	4	41	48.	33.	63.	2	5	0.7	3	4	41	48.	34.	63.	3	4.7	0.6	3	4	43	48.	37.	63.	2	5	0.7
O	Galing	2	2	46	43.	0.	49.	2	1.5	0.3	3	2	45	44.	2.	55.	3	2.2	0.4	2	2	49	42.	0.	50.	2	1.5	0.3
P	Tangaran	3	0	55	36.	5.	24.	1	2.3	0.7	3	0	56	35.	5.	25.	1	2.3	0.7	3	0	58	36.	5.	24.	1	2.3	0.7
Q	Sejangkung	0	3	47	42.	0	40.	0.1	1	0.3	0	3	47	42.	0	39.	0.1	1	0.3	0	3	50	42.	0	41.	0.1	1	0.3
R	Sajingan Besar	0	4	46	43.	2.	48.	1.3	2	0.5	0	4	46	43.	2.	48.	1.8	1.5	0.5	0	4	48	43.	6.	48.	1.3	2	0.5
S	**Paloh**	**2**	**2**	**55**	**36.**	**2.**	**35.**	**1**	**3**	**0.7**	**2**	**2**	**56**	**35.**	**0.**	**41.**	**1**	**2**	**0.5**	**3**	**1**	**58**	**36.**	**9.**	**32.**	**1**	**3**	**0.7**
BK	Bengkayang	0	1	71	28.	0	3.	0	1	1	0	1	71	28.	0	3.	0	1	1	0	1	76	27.	0	3.	0	1	1
SK	Singkawang	0	1	77	25.	0	1.	0	1	1	0	1	77	25.	0	1.	0	1	1	0	1	83	25.	0	1.	0	1	1
SR	Sarawak																			0	1	78	26.	0	7.	0	1	1

Figure 5. Network Comparison in Public Land Transportation Network

Table 5. Score Rank for Public Land Transportation Network

Options/ Proposed Network (based on Table 3)	Adaptive Plans & Score Changes					
	Score Reduction (Indicators 1-9)		Score Increment (Indicators 1-9)		Areas Interaction (Blockmodels)	
	Amount	Rank	Amount	Rank	Linked	Rank
H-S	16	**3**	23	**1**	Strongly (0.417)	**1**
H-Q-S	11	**2**	9	**3**	Strongly (0.150)	**2**
H-K-S	8	**1**	8	**4**	Strongly (0.150)	**2**
H-O-S	11	**2**	14	**2**	Strongly (0.150)	**2**
S-SR	24	**4**	7	**5**	Strongly (0.150)	**2**

Public Sea/River Network

From the data/findings, there are at least three major ports in Sambas, located in C, F, and H, which distribute passengers through the river to other areas in Sambas regency. In the absence of river streams to S (border area), there is only one alternative to reach S, which goes along the seaside in Sambas or Natuna Sea through C or F ports that directly access the sea. However, even though the goal is to connect S with other "developed" areas in Sambas regency, a cruise through the sea is not recommended for small passenger boats due to high waves that reach an average of 0.75 meters. Moreover, when the tide comes in certain months, the Natuna Sea has a wave height that reaches 2.5-5 meters. Regarding this situation, the passenger boat heading to S is not recommended to pass through the sea. Public transportation can be supported by land transportation

Water Supply Network

Judging from the overall comparison, option number 2 connects all areas inside the regency (based on government plan extension), seems to have the optimum score (Figure 6). However, both alternatives have been better than the current one, which only serves six districts locally. This condition is because they provide a new piping connection to the border area (S). As a note, option number 2 provide a link to all districts, while options number 1 only expand and improve the water piping only for nine districts, including H and S. Furthermore, for option number 2, both strategic areas are including at the same blocks. However, the density matrix score is 0 (Table 6).

CODE	AREA	Existing Network									pN1 (Government Plan)									pN2 (Government Plan Extension)								
		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
A	Selakau	0	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	96	18.	11.	18.	0	2	1
B	Selakau Timur																			0	1	113	15.	0	8.	0	1	1
C	Pemangkat	0	1	21	23.	0	70	0	1	1	0	1	133	9.	0	-0	0	1	1	2	2	81	22.	30.	35.	0	3	1
D	Semparuk	0	1	21	23.	0	70.	0	1	1	0	1	133	9.	0	-0	0	1	1	0	1	87	20.	0	20.	0	1	1
E	Salatiga																			0	1	98	18.	0	15.	0	1	1
F	Tebas	2	0	20	25.	10	100	0	2	1	2	0	132	9.	1.	-0	0	2	1	3	0	70	25.	45.	46.	0	3	1
G	Tekarang										0	1	80	15.	0	26.	0	1	1	0	1	112	16.	0	4.	0	1	1
H	**Sambas**	**0**	**0**	**-**	**-**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**77**	**15.**	**0**	**34.**	**0**	**1**	**1**	**4**	**1**	**58**	**31.**	**62.**	**70.**	**0**	**4**	**1**
I	Subah																			0	1	75	24.	0	30.	0	1	1
J	Sebawi																			0	2	63	28.	47.	51.	0	2	1
K	Sajad																			0	1	75	24.	0	30.	0	1	1
L	Jawai										2	1	73	16.	19.	54.	0	3	1	2	1	95	18.	21.	11.	0	3	1
M	Jawai Selatan										0	1	80	15.	0	26.	0	1	1	0	1	112	16.	0	4.	0	1	1
N	Teluk Keramat	0	0	-	-	0	0	0	0	0	1	1	69	17.	24.	62.	0	2	1	1	1	71	25.	36.	25.	0	2	1
O	Galing										2	1	70	17.	25.	69.	0	3	1	2	1	62	29.	56.	42.	0	3	1
P	Tangaran										1	1	70	17.	22.	57.	0	2	1	1	1	82	21.	29.	16.	0	2	1
Q	Sejangkung																		1	1	2	59	30.	52.	49.	0	2	1
R	Sajingan Besar										2	0	75	16.	10	44.	0	2	1	2	0	77	23.	11.	23.	0	2	1
S	**Paloh**										**0**	**1**	**82**	**14.**	**0**	**22.**	**0**	**1**	**1**	**0**	**1**	**94**	**19.**	**0**	**10.**	**0**	**1**	**1**

Figure 6. Network Comparison in Water Supply Network

Table 6. Score Rank for Water Supply Network

Options/ Proposed Network (based on Table 3)	Adaptive Plans & Score Changes					
	Score Reduction (Indicators 1-9)		Score Increment (Indicators 1-9)		Areas Interaction (Blockmodels)	
	Amount	Rank	Amount	Rank	Linked	Rank
Government Plan	7	2	29	2	Strongly (0.250)	1
Government Plan (Extension)	4	1	50	1	Weakly (0.000)	2

Electricity Grid Network

There is only one option in expanding the electricity network. It connecting/buying electricity from Sarawak (SESCO) to area S. Seen from the comparison result (Figure 7), there is a significant score increase in nearly all of the indicators in the "modified" network in S (border area and surrounding).

CODE	AREA	Existing Network									pN1 (New Connection)								
		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
A	Selakau	0	1	67	34.	0	17.	0	1	1	0	1	67	34.	0	17.	0	1	1
B	Selakau Timur	0	1	67	34.	0	17.	0	1	1	0	1	67	34.	0	17.	0	1	1
C	Pemangkat	7	1	45	51.	61	63.	1	7.7	0.9	7	1	45	51.	61.	62.	0	7.5	0.9
D	Semparuk	0	1	67	34.	0	17.	0	1	1	0	1	67	34.	0	17.	0	1	1
E	Salatiga	0	1	67	34.	0	17.	0	1	1	0	1	67	34.	0	17.	0	1	1
F	Tebas	0	1	67	34.	0	17.	0	1	1	0	1	67	34.	0	17.	0	1	1
G	Tekarang	0	1	64	35.	0	22.	0	1	1	0	1	64	35.	0	22.	0	1	1
H	**Sambas**	**9**	**1**	**42**	**54.**	**74.**	**83.**	**1**	**9.8**	**0.9**	**9**	**1**	**42**	**54.**	**72.**	**83.**	**1**	**9.8**	**0.9**
I	Subah	0	1	64	35.	0	22.	0	1	1	0	1	64	35.	0	22.	0	1	1
J	Sebawi	0	2	54	42.	0	40.	1	1	0.5	0	2	54	42.	0	39.	1	1	0.5
K	Sajad	0	1	64	35.	0	22.	0	1	1	0	1	64	35.	0	22.	0	1	1
L	Jawai	0	1	64	35.	0	22.	0	1	1	0	1	64	35.	0	22.	0	1	1
M	Jawai Selatan	0	1	64	35.	0	22.	0	1	1	0	1	64	35.	0	22.	0	1	1
N	Teluk Keramat	3	1	58	39.	20.	32.	0	4	1	3	1	57	40.	20.	33.	0	4	1
O	Galing	0	2	78	29.	0.	16.	0	2	1	0	2	77	29.	0.	16.	0	2	1
P	Tangaran	0	1	80	28.	0	8.	0	1	1	0	1	79	29.	0	9.	0	1	1
Q	Sejangkung	1	1	62	37.	3.	27.	0	2	1	1	1	62	37.	3.	27.	0	2	1
R	Sajingan Besar	0	2	62	37.	8.	24.	0	2	1	0	2	61	37.	7.	25.	0	2	1
S	**Paloh**	**0**	**1**	**80**	**28.**	**0**	**8.**	**0**	**1**	**1**	**0**	**2**	**76**	**30.**	**1.**	**11.**	**1**	**2**	**1**
KR	Kubu Raya	0	1	121	19.	0	0.	0	1	1	0	1	121	19.	0	0.	0	1	1
MP	Mempawah	1	1	79	29.	16.	5.	0	2	1	1	1	79	29.	16.	5.	0	2	1
PN	Pontianak	2	0	99	23.	8.	1	0	2	1	2	0	99	23.	8	1.	0	2	1
SK	Singkawang	1	1	61	37.	23.	18.	0	2	1	1	1	61	37.	23.	18.	0	2	1
SR	Sarawak	1	0	84	27.	0	6.	0	1	1	2	0	78	29.	0	10.	0	2	1

Figure 7. Network Comparison in Electricity Grid Network

For block interaction, S (Paloh) is located in block 2, and there is a score increase in the member's interaction, while the score of Sambas (H) in block 1 is the same as that of the existing one. There is one block interaction (send ties) between block 1 (H) and block 2 (S).

Waste Management Network

Similar to the water supply network, waste service in Sambas regency is still limited, and it only covered nine districts. For the comparison, it also seems rather difficult to compare the existing one with the planned one. It is based on the prescribed standards issued by the Ministry of Public Works for the planned one. It was based on the existing condition, and it only expands the covered service areas at the maximum range or distance. Judging from the overall comparison, option number 2 that adds a new (waste) final processing area for border areas, seems to be the first rank. Option number 2 is the latest development which considers the service area extends from the existing condition (Figure 8). By doing so, waste management problems (limitation) in the border areas and other districts kindly can be addressed.

CODE	AREA	Existing Network									pN1 (Extension Plan)									pN2 (Development Plan)								
		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
A	Selakau	1	0	43	18.	0	50	0	1	1	1	0	196	8.	0	44.	0	1	1	1	0	245	7.	0	44.	0	1	1
B	Selakau Timur										1	0	196	8.	0	44.	0	1	1	1	0	246	7.	0	44.	0	1	1
C	Pemangkat	1	0	43	18.	0	50.	0	1	1	1	0	196	8.	0	44.	0	1	1	1	0	256	7.	0	44.	0	1	1
D	Semparuk	1	0	43	18.	0	50	0	1	1	1	0	196	8.	0	44.	0	1	1	1	0	256	7.	0	44.	0	1	1
E	Salatiga	0	4	40	20.	21	100	0	4	1	0	5	192	8.	8.	100	0	5	1	0	5	252	7.	6.	100	0	5	1
F	Tebas	1	0	43	18.	0	50	0	1	1	1	0	196	8.	0	44.	0	1	1	1	0	256	7.	0	44.	0	1	1
G	Tekarang										1	0	241	6.	0	0	0	1	1	1	0	307	5.	0	0	0	1	1
H	**Sambas**	**0**	**0**	**-**	**-**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**208**	**7.**	**5**	**0**	**0**	**4**	**1**	**0**	**4**	**270**	**6.**	**3.**	**0**	**0**	**4**	**1**
I	Subah										1	0	211	7.	0	0	0	1	1	1	0	273	6.	0	0	0	1	1
J	Sebawi										1	0	211	7.	0	0	0	1	1	1	0	273	6.	0	0	0	1	1
K	Sajad										1	0	211	7.	0	0	0	1	1	1	0	273	6.	0	0	0	1	1
L	Jawai	1	0	64	12.	0	0	0	1	1	1	0	241	6.	0	0	0	1	1	1	0	273	6.	0	0	0	1	1
M	Jawai Selatan	0	1	64	12.	0	0	0	1	1	0	2	240	6.	0.	0	0	2	1	0	2	307	5.	0.	0	0	2	1
N	Teluk Keramat	0	0	-	-	0	0	0	0	0	0	2	240	6.	0.	0	0	2	1	0	2	306	5.	0.	0	0	2	1
O	Galing										1	0	241	6.	0	0	0	1	1	1	0	307	5.	0	0	0	1	1
P	Tangaran										1	0	241	6.	0	0	0	1	1	1	0	307	5.	0	0	0	1	1
Q	Sejangkung										1	0	211	7.	0	0	0	1	1	1	0	273	6.	0	0	0	1	1
R	Sajingan Besar																			0	1	324	5	0	0	0	1	1
S	**Paloh**																			**1**	**0**	**324**	**5.**	**0**	**0**	**0**	**1**	**1**

Figure 8. Network Comparison in Waste Management Network

Table 7. Score Rank for Waste Management Network

Options/ Proposed Network (based on Table 3)	Adaptive Plans & Score Changes					
	Score Reduction (Indicators 1-9)		Score Increment (Indicators 1-9)		Areas Interaction (Blockmodels)	
	Amount	Rank	Amount	Rank	Linked	Rank
Extension Plan	11	1	16	2	No Link	
Development Plan	11	1	21	1	No Link	

Telecommunication Network

Currently, there is a telecommunication tower in Temajuk village (area S), but the limitation of electricity obstructs the operational. Although it can use a diesel power plant, diesel transportation problems also make telecommunication tower operational be blocked. Therefore, supporting infrastructures such as better road condition and sufficient electricity should be provided. Viability for the resident to run their daily activities can be brought by providing good access, electricity, and telecommunication.

According to Glasson & Marshal (2007), regional growth can have several constraints, such as lack of infrastructure and innovation. In supporting regional development, areas should be connected and interacted with each other by sharing the flow of goods and services. By increasing connectivity in several determinants, it is possible to improve production, reduce time and cost, encourage trade, change the land function, increase employments and social contact, and ultimately stimulate regional economic growth. Moreover, according to Bhaduri (1992), areas with the highest degree of "direct" connections potentially become more accessible and develop into a higher city/area hierarchy.

One of the urban development concepts close to and can be evolved into an integrated urban network is polycentric development. Functional polycentric was introduced by Burger et al. (2014), stating that to develop a better urban network, it should be no orientation towards any particular centre; the centres are relatively equal in terms of the magnitude of their external linkages or their centrality. Theoretically, to develop an urban network with multicentre, regional cores should be reinforced by allowing a partial transfer competence to facilitate polycentricity (Deraeve, 2014). For the smaller cities, it needs to gradually improve access to services and agglomeration diseconomies in the large cities (Meijers et al., 2016)

Based on the result above, it is necessary to improve the potency of interaction among strategic areas by an adaptive approach, which provides multiple choices and prepares future scenarios by allowing partial transfer from/to other regions or improving connectivity. By re-directing the links or increasing the interaction, it is possible for "closeness" and re-configuration of the centrality among areas to interact and provide alternatives of activity centres equal in terms of their external magnitude linkages. As the summary, the connectivity improvement strategies to offer multiple choices of networks (adaptive) summarised as follows:

Table 8. Network Improvement on the Existing Network

No	Infrastructure Networks	Improvement Strategies
1	Road	• Create new links or transform the network based on the available nodes between strategic areas. • Direct link/orientation between strategic areas has a higher impact of benefit and successfully makes strategic areas into the same block (class).
2	Public (Land) Transportation	• Create new links or transform the network based on the available nodes between strategic areas. • Direct link/orientation between strategic areas has a higher impact of benefit and increases interaction density inside the same block (class).
3	Water Supply	• It has a limited-service of coverage • Based on the government/institution work-plan, the service coverage can be expanded • The extension plan (connecting all districts) has a higher impact of benefit and successfully makes strategic areas into the same block (class)
4	Electricity	• It has distributed (served) in all districts. However, some villages still have not powered by the electricity • Based on the existing network, it can be expanding by purchasing electricity from the neighbouring country to increase the electricity connectivity • By connecting the electricity to the neighbouring country, it will bring an advantage to border area (especially)
5	Waste Management	• It has a limited-service of coverage • Based on the regulation about waste final processing location, the service coverage can be expanded • The extension plan (which divided districts based on the location of final waste processing) and by adding a new node (final waste processing) between border areas has a higher impact of benefit
6	Telecommunication	• It has distributed (served) in all districts. However, some villages still have not served by the telecommunication signal because of the limited supporting infrastructures (network) such as electricity and access roads. • It needs to be supported by other infrastructure networks

4. CONCLUDING REMARKS

Based on the network conditions in Sambas regency (particularly among strategic areas; Sambas and Paloh), it appears that the interaction between strategic areas has not had any appropriate direction yet. Most of the infrastructure network in Sambas regency is centralised in Sambas district because of the consideration of Sambas district as the capital city and public service activity. Sambas and some networks, areas in the Southern part of Sambas also become the most centralised areas. In contrast, the border area is still considered a “rear part” of the country; the last part of the country to be developed.

To improve the interaction among the strategic areas for encouraging development in the border area and supporting the international gate, the concept of "direct" connectivity or “shortcut” with their impacts (in a single node or group) would be worth considering. The improvement of the connection in the existing infrastructure/facilities is deemed based on the adaptive criteria. This approach provides and prepares multiple network configurations choices and the predictions of the impacts based on the needs and limitations. The "predict and plan" for possible scenarios in the future can be achieved by doing this. In this study, the development outcomes derived from Sambas district as well as West Kalimantan Province are planned to reach the border areas (Paloh district) easily.

From the findings above, based on the current condition in the strategic areas with their limitation, there are five types of "adaptive" approaches that consider can be developing in strategic locations, there are:

1. Network transforms or a new link, such as in the road and public (land) transportation network,
2. Network extension, such as in the water supply and electricity network,
3. Additional (new) node, such as in the waste management network
4. Another supporting network as a supplement network, such as in the telecommunication network, and
5. Inter-country connection to improve relationship and cooperation, such as in the public (land) transportation and electricity grid.

A significant score transformation (change) which provide an optimum interaction, mainly occurs in the direct interaction between strategic areas (e.g. area H to area S). However, as one of the considerations, connecting to other regions between strategic areas can also provide and share benefits to certain zones.

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