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DETERMINING OF THE SUITABLE LOCATION FOR THE DEVELOPMENT OF COASTAL TRANSIT ORIENTED DEVELOPMENT

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Abstract: Basic needs of commuters from small islands, local society and tourists from several hotels have yet to be fully fulfilled within radius 500 meters from the four ports at Fort Rotterdam, Makassar. To fulfill them, they had to travel to the main shore of Makassar city using motorized vehicle which is redundant in distance, time and cost. This research is aimed at determining suitable location for the development of coastal Transit Oriented Development (TOD). Selected location could effectively prevent redundancy of distance, time and cost of the commuters, local society and tourists. Technique analysis applied Expert System, Fortran 90 application and Spatial Analysis test based on Geographic Information System. The result showed that location at Kayu Bangkoa neighborhood was selected as the potential location for coastal TOD development.

Keywords: Coastal TOD; expert system; GIS; Makassar; spatial analysis

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INTRODUCTION

This research is review and further research of previously published one in Surabaya in October 2016 baseon the suggestion from the audience and deeper study, using expecially spatial analysis technique and math formula Moran's I and Contiguity, to consider support of neighboring grid in order to determine potential location for more accurate coastal TOD (Arief, *et al*., 2017).

Commuter from small islands, local society and tourist who stayed at the hotel around Fort Rotterdam experienced redundancy of distance, time and cost in fulfilling their basic needs at the main shore of Makassar city (Maslow, 1943; Knowles, 1993; Knowles, 2012; Ngo, 2012). This happened due to the absence of some goods and services at the port area around Fort Rotterdam as transit location. (Knowles, 1993) and (Ngo, 2012).

In fulfilling their basic needs, they used motorized vehicle as those needs were located out of comfortable walking radius about 500 meters from transit location (Cervero & Guerra, 2013; Cervero, 2012). But, massive public transportation was not the transport used generally as it was not avaliable on time although it is pollutive and expensive, furthermore it tends to get traffic congestion and traffic accident (Galelo *et al*., 2014; Vale, 2015; Al-Mosaind, 1998; Lindsey & de Palma, 2015).

To prevent redundancy and traffic chaos of goods and people, all the needed goods and services are ideally available within transit location at Fort Rotterdam neighborhood (Ngo, 2012; Galelo *et al*., 2014). Those needs can be fulfilled if the development of intergrated coastal TOD with commuter's needs, the avaliability of basic needs service, pedestrian route and also comfortable transportation facilities are done (Cervero & Guerra, 2013; Galelo *et al*., 2014; Vale, 2015).

Coastal TOD development is carried out based on; TOD principles, needs of commuter, local society and tourist; public port characteristic and also supporting and retarding potency around Fort Rotterdam. One of the TOD principles is, transit location, residence, working place, shopping place have to be able to be accessed by walking comfortably, cycling or massive public transportation (Hiremath *et al*., 2013). Massive public transportation is needed to minimize the use of motorized vehicle, for instance, private car as it is not eco-friendly (Rahul & Verma, 2013).

TOD prevents urban sprawl, promotes higher diversity and land use, more massive public transportation use, high accessibility for pedestrian in the surroundings of transit location (Vale, 2015; Yan-yan *et al*., 2016; Papa & Bertolini, 2015). Urban sprawl should be prevented as much as it could in order to erase redundancy of land use encouraged by sporadic and spreaded infrastructure development (Young, *et al*., 2016).

If the diverse land use around transit location is integrated with pedestrian, bicycle rider and massive public transportation use, that is the key success of TOD development (Vale, 2015; Cervero & Kockelman, 1997; Chakrabarti, 2015). In order to make it interesting and healthy for pedestrian and bicycle rider, it needs to provide route for them which is safe, comfortable, easy to use, closer distance completed along with trees and parks Mateo & Babiano (2016), Litman (2014), Zakaria & Ujang (2015) and Davies & Weston (2015).

Coastal TOD development costs much, consequently, it needs integrated partnership and collaboration among few stakeholders; government, society, private and entrepreneur (Renne, 2008; Susanti, *et al*., 2016). Commuter uses motorized vehicle to reach traditional markets, shopping places, stores and working places since they are easier and more flexible Davies & Weston (2015) and Feudo (2014).

Main activity at the four ports within transit location is handling and loading passengers and basic needs of the commuter from and to small islands. Those needs cover, comestibles, building materials taken from shopping places, stores and traditional market (Maslow, 1943; Noltemeyer *et al*., 2012).

Another activity is doing exercise and culinary recreation leading to disturbed traffic smoothness and tidiness as many motorized vehicle are parked at the road shoulder and the road bed (Arnott & Inci, 2006; Davies & Weston, 2015; Green *et al*., 2016), Pedestrian thinks no guarantee about safety, comfortability, the fuel is redundant, noisy, creating much emission and hence the air get polluted and operational and maintenance cost turn to be higher as well (Hiremath *et al*., 2013).

To accommodate all the basic needs of commuter from small islands, local society and tourist, it is urgent to develop coastal TOD to make better quality of life (Susanti *et al*., 2016). The model of coastal TOD development is matched with the supporting and retarding potency in the surroundings environment within radius 500 meters from port as transit location in the vicinity of Fort Rotterdam.

The city of Makassar was founded by the Dutch colonial government on 1 April 1906 with its government center inner the Fort Rotterdam. Approximately 1 km to the north there is the port of Wilhelmina, which is currently called the international Port of Soekarno-Hatta. At the front, there is a boat pier for marine tourism and a small marina boat, and to the south there is Bangkoa port for commuters from small islands surrounding Makassar city, and Losari pier for marine tourism (Yudono *et al*., 2016; Yudono, 2013).

All the stakeholders should cooperate and collaborate integratedly in developing coastal TOD in order to be able all the public services to fulfill basic needs of commuter, tourist and local society efficiently

(Cervero & Kockelman, 1997; Renne, 2008; Vale, 2015; Wey, 2015).

The purpose of the research: (1) analyze supporting and retarding potency for spatial planning development within radius 500 meters to the four transit locations at Fort Rotterdam Makassar; (2) to select and determine one most suitable location to develop coastal TOD around Fort Rotterdam Makassar; and (3) establish determination model of coastal TOD location in the public port and tourism area in the vicinity of Fort Rotterdam Makassar.

DATA

The research of coastal TOD development took place at four transit locations around culture conservation of Fort Rotterdam Makassar. Those are POPSA port, Kayangan, Kayu Bangkoa port and Losari beach pavilion. POPSA and Kayangan port were used by commuter, tourist and local society as transit location to have culinary tourism, water tourism and water sport in the small islands, for instance; swimming, jet sky, diving and snorkeling. Those islands are Laelae, Samalona, Kodingareng, Barrang Lompo, Barrang Caddi, Lumu-lumu and Bone Tambung.

There are a culture conservation Fort Rotterdamn, hotel, store, office, traditional market, bank, workshop, health facility, education facility, halte and Somba Opu shopping place around those four transit locations. Kayu Bangkoa port is mostly utilized by commuter to transit and continue their trip to the main shore of Makassar city to fulfill their basic needs. Beside commuter from small islands, it is used by local society and tourist to go to small islands for various purposes ; having tourism activity, visiting their realtives, conducting research and working as civil servant. Around Kayu Bangkoa transit location, it has service facilities; stores, hotel, residence, health and education facility and also Somba Opu shopping place.

Besides, Losari beach pavilion is widely used by commuter coming from main shore of Makassar and tourist who stay at hotels in its surroundings to have culinary tourism and water sport around it. Parking area for private vehicle, worshipping facility, BRT halte, hospital, hotel, shopping place, bank, office, residence and another service facility are provided.

Water transportation facility to service commuter from and to small islands; Barrang Caddi, Barrang Lompo dan Kodingareng is motor boat with capacity 50-60 passangers. It serves passsangers from and to Speedboat Lae-lae, Samalona, Lumu-lumu dan Bone Tambu. Travel time from the nearest island to the port are various; Lae-lae 5-10 minutes, Lumu-lumu and Bone Tambu around 30 minutes and motor boat from to Barrang Lompo Island, Barrang Caddi and Kodingareng around 60 minutes.

The cost per passenger of water transportation such as speed boat is more expensive than using motor boat, taxi, pete-pete (public car) and BRT at the shore. Pedicab is cheaper than speed boat but remains more expensive than of other kinds of ship and transportation at the shore. That comparison can be seen at **Table 1**.

Widely used transportation within Makassar city are pedicab, *pete-pete* (public car), private vehicle and taxi. International tourists who stay at hotel around Fort Rotterdam go to the port by walking and sometimes by taxi. It is different with domestic tourists and society around Fort Rotterdamn who usually take motorized vehicle (car or motorcycle) although it is pollutive. Distance and position of small islands from the ports around Fort Rotterdam can be seen at following **Fig. 1**.

Travel distance of each commuter, tourist and local society is various enough. It depends on each destination. Shortest travel distance is about 1 mile by speedboat from Lae-lae Island to the port and the longest is from Barrang Lompo, it is about 13 mile. Commuter from Bone Tambu and Lumu-lumu islands went to the Makassar shore using motor boat and transit at public port, Paotere.

Coastal TOD development around Fort Rotterdam is based on all the supporting and retarding potency within radius 500 meters from port in accordance with the function of spatial use today. Commuter travels to their own destination related to their needs. Their destination mostly located out of radius 500 meters, thus encourage them to use motorized vehicle or non-massive public transportation.

Table 1. Cost comparison of passenger per type of transportation

Type of Transportation	Pedicab	BRT	Microlet	Taxi	Motor boat	Speed boat
Pedicab	=	>	>	>	>	<
BRT	<	=	<	<	<	<
Microlet	<	>	=	<	<	<
Taxi	<	>	>	=	>	<
Motor boat	<	>	>	<	=	<
Speed boat	>	>	>	>	>	=

= is tariff per passenger is same, < is tariff per passenger is cheaper, and > is tariff per passenger is more expensive.

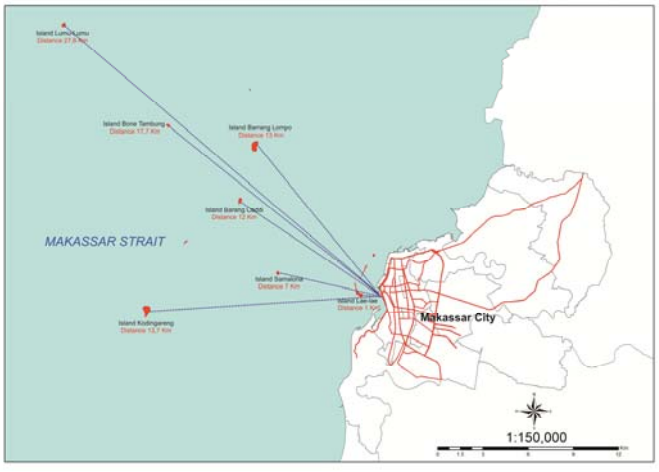

Fig. 1 Position of small islands toward transit location.

Table 2. Supporting and retarding potency

	Potency	Radius 500 meters from transit location (Ports)			
		POPSA	Kayangan	Bangkoa	Losari
A.	Supporting potency (Community Design + Architecture)				
1	Workshop	7	8	6	0
2	Café	1	2	1	1
3	Meeting Hall	4	4	0	1
4	Hotel/homestay	16	19	24	15
5	Provate office	13	15	16	16
6	Government office	30	30	29	3
7	Post office	1	1	0	0
8	Cooperation	2	2	0	0
9	Shop house	71	90	131	61
10	Residence	217	312	485	609
11	Restaurant	30	35	42	31
12	Worshipping facility	6	6	6	2
13	Sport facility	0	0	2	2
14	Educational facility	10	11	12	22
15	Transportation facility	15	15	16	4
16	Health facility	0	0	1	12
17	Gas station	0	0	0	2
18	Barber shop	1	1	0	0
19	Traditional market	3	4	4	0
20	Bank	6	7	8	1
21	Shopping place	0	0	1	1
22	Lybrary	0	0	0	1
23	Empty areas	271,924	308,005	316,785	270,512
24	The number of hotel room	824	861	860	1225
25	The number of stayed goest	700	732	731	1041
26	Retribution	0	expensive	cheap	0
27	BRT halte	1	1	1	1
28	Commuter number	58	526	386	0
B.	Retarding Potency (Community Design + Architecture)				
1	Police office	2	5	6	0
2	Culture conservation	16	16	16	0

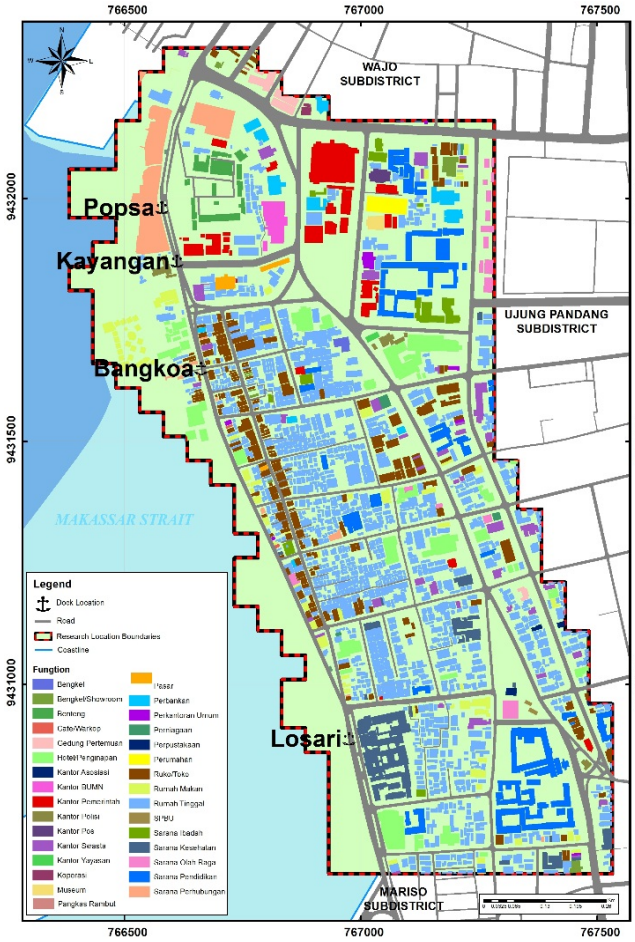

Fig. 2 Land Use of Kayu Bangkoa and surroundings
Source: Makassar Land Use, Survey, Processed 2016.

Coastal TOD development has yet to be developed efficiently against land use and residence. Residential is still built horizontally; complete shopping centers remain unavailable as well as office, educational, health building and another which are not vertically built and ecofriendly. Pedestrian route, park and trees are not enough. Therefore, it could not give a guarantee of comfortability and safety for pedestrian. Those four ports, each of them has supporting and retarding potency in the development of spatial design of coastal TOD. Those potencies can be seen at **Table.**

The location of coastal TOD development around the four transit locations can be seen at **Fig. 2** about existing land use around Fort Rotterdam. The lack of infrastructure and facility of public service and unavailable massive public transportation urgently needed by commuter indicate the importance to build and develop coastal TOD. Limited infrastructure troubles the commuter and local society in fulfilling their basic needs while unavabiality of massive public transportation forces them to use their private vehicle. Even though BRT is already available, it has yet to be connected with departure and arrival schedule of motor boat including public service locations, for instance, traditional market, shopping centers, office and residential.

To develop massive public transportation, it requires vesting incentive for its user and businessman in that field. Along with the incentive, disincentive is also should be given to those who use private vehicle for example expensive parking tariff. As a result, coastal TOD development is hoped to be able to integrate all the importance of stakeholders with all the services of commuter, local society and tourist needs for goods.

METHOD

To obtain data about spatial use, survey and observation were conducted within radius 500 meter from the port around Fort Rotterdam. The results were presented into grid 50 m × 50 m. Furthermore, it held direct interview with the commuters related to origin, destination, needs and their expectation. It applied expert system and spatial analysis based on GIS by using: Fortran 90 application, Microsoft Excel and ArcGIS. It is to determine suitable potential location for coastal TOD development as transit location at Fort Rotterdam neighborhood.

Expert system consists of 35 rules and 144 determining factors (CF) as shown at **Fig. 3** and **Table 3**. Expert system possess rule which both support and retard the location determination of coastal TOD development. The implementation of TOD development is also determined by political policy and government fund.

The area of water police office its land use, can not be changed into the area of coastal TOD development. Its development is determined by political policy of government and budget availability. The result of data processing through ArcGIS, ArcView Microsoft Excel, Fortran 90 application and Spatial showed selected grid or suitable location for TOD development.

Those selected locations were re-examined through spatial statistical analysis. It objects to find the weight of each grid or location based on their neighbor grid, (Triastuti Wuryandari, Abdul Hoyyi, & Dewi Setya Kusumawardani, 2014). Main grid correlation level with neighbor grid as stated in the **Eq. 1** in Moran's I (Briggs, 2007).

$$I = \frac{N\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{(\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij})\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad (1)$$

where I = Moran's Index, N = grid number, X = mean value of variable, X_i = variable amount at main grid, Xj = variable value at another grid, W_{ij} = *weight* index of grid i until j. Value of Moran's I is 0,384858 which means the value of main grid and its neighbor are both high and have spatial correlation as shown at **Fig. 4**.

Moran's I is divided into four quadrants: (1) Quadrant High-High (HH), when main grid and grid in its surrounding are both high; (2) Quadrant Low-Low (LL), when main grid and grid in its surrounding are both low; (3) Quadrant High-Low (HL if there is a difference in which main grid is high while its neighbor grid is low; and (4) Quadrant Low-High (LH) when the main grid is lower than its neighbor grid. If it is at quadrant HH or LL, it means it has positive spatial correlation but when it is at HL or LH, it has negative spatial correlation. Negative one is not potential to be developed as coastal TOD.

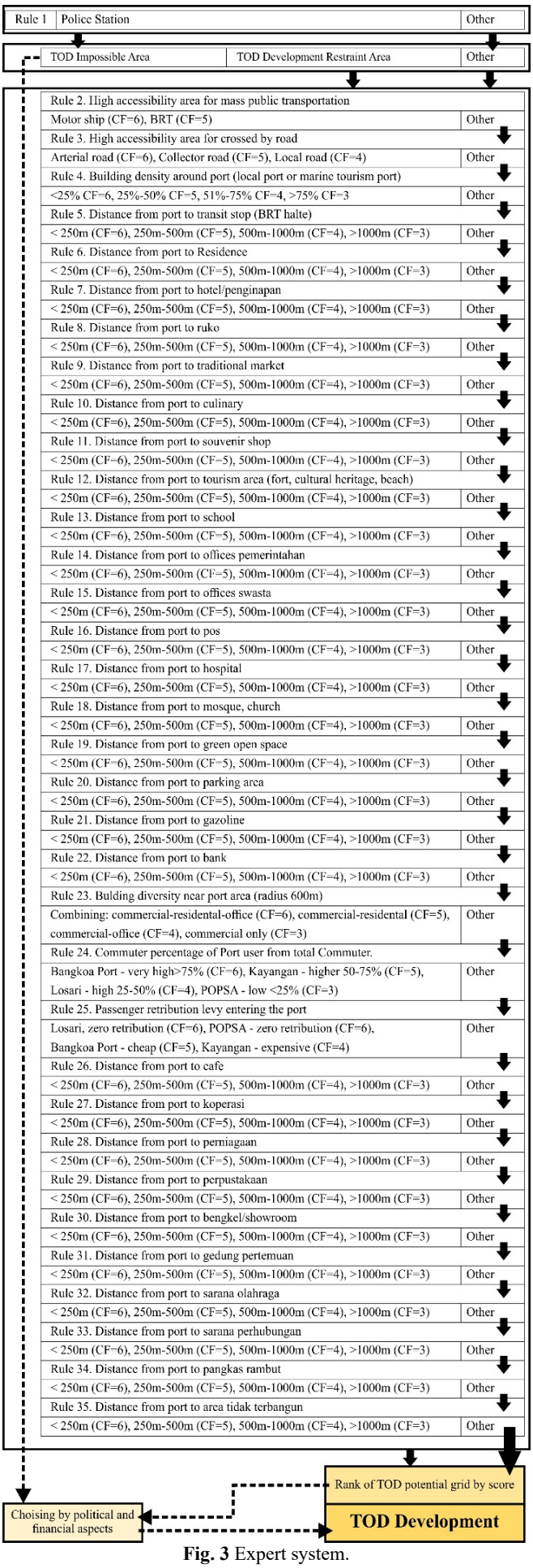

Fig. 3 Expert system.

Table 3. The set up the certainty factors (CF)

Factor	Category	CF	Code
Police station	Police station	**Y/N**	PS
High accessibility area for mass public transp.	Motor ship	6	MS
	BRT	5	BR
High accessibility area for crossed by road	Arterial road	6	AR
	Collector road	5	CR
	Local road	4	LR
Building density	<25% (very low)	6	BD
	25-50% (low)	5	
	51-75% (high)	4	
	>75% (very high)	3	
Distance to sarana perhubungan/transit stop (BRT halte) (TS), residence (RS), hotel (HT), shopping centre (SC)	< 250m (very near)	6	TS, RS, HT, SC
	250-500m (near)	5	
	500-1000m (far)	4	
	>1000 m (very far)	3	
Distance to shop house (ST), traditional market (TM), culinary area (CA), souvenir shop (SS), cagar budaya (TA)	< 250m (very near)	6	ST, TM, CA, SS, TA
	250-500m (near)	5	
	500-1000m (far)	4	
	>1000 m (very far)	3	
Distance to School (SH), kantor peme-rintahan (KP), kantor suasta (KS), Pos (KO), hospital (HO), mosque/church (MC)	< 250m (very near)	6	SH, KP, KS, KO, HO, MC
	250-500m (near)	5	
	500-1000m (far)	4	
	>1000 m (very far)	3	
Distance to green open space (OS), parking area (PA), gasoline (GZ), bank (BK),	< 250m (very near)	6	**OS**
	250-500m (near)	5	
	500-1000m (far)	4	
	>1000 m (very far)	3	
Building diversity near port area (radius 600 m). (DV).	Commercial, residential, office (more diverse)	6	DV
	Commercial, and residential (diverse)	5	
	Commercial, and office (less diverse)	4	
	Commercial only (not diverse)	3	
Commuter percentage of Port user from total Commuter.	Bangkoa > 75% (very high)	6	FR
	Kayangan 50-75% (higher)	5	
	Popsa 25-50% (high)	4	
	Losari < 25% (low)	3	
Distance to café (CE), koperasi (KE), business (PI), Library(PP), workshop, show room (BS),	< 250m (very near)	6	CE
	250-500m (near)	5	
	500-1000m (far)	4	
	>1000 m (very far)	3	
Distance to Meeting building (GP), sport facility (SO), transportation (SP), barber shop (PR), empty area (AT).	< 250m (very near)	6	GP
	250-500m (near)	5	
	500-1000m (far)	4	
	>1000 m (very far)	3	

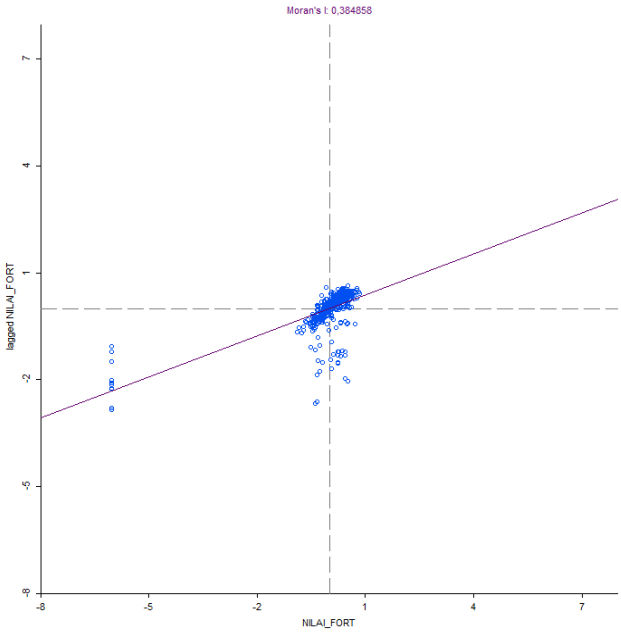

Fig. 4 Scatter plot Moran's I.

Table 4. Value and Rank of Coastal TOD Development Location

No. Grid	X axis	Y axis	Value	Ranking	Explanation
248	8	18	167	I	Around Kayu Bangkoa Port, clustered and supported by its neighborhood.
273	9	20	166		
260	8	19	166		
191	6	12	166	II	Around Kayu Bangkoa Port, clustered and less supported by its neighborhood.
192	6	14	165		
208	7	15	165		
26	10	4	166	III	Around Radio of Republic Indonesia (RRI), transit stop it is not coastal TOD, but supported by its neighborhood.
17	10	3	161		
27	11	4	160		

Accurate and really high Hot spot and grid beyond its neighbor grids and positive as well can be found by using Local Indicator, it is Local Indicators of Spatial Association (LISA) as shown at **Fig. 5**.

Significant selected grid can be found using this method completed by significance test for each grid. Spatial correlation can also be measured by Geary's C methhod (Contiguity) it has scale 0-2. If it is 0, it means positive, 1 means random, and 2 means negative or dispersed (Briggs, 2007).

$$C = \frac{[(N-1)[\sum_i \sum_j W_{ij}(X_i - X_j)^2]}{2(\sum_i \sum_j W_{ij}(X_i - \overline{X})^2} \quad (2)$$

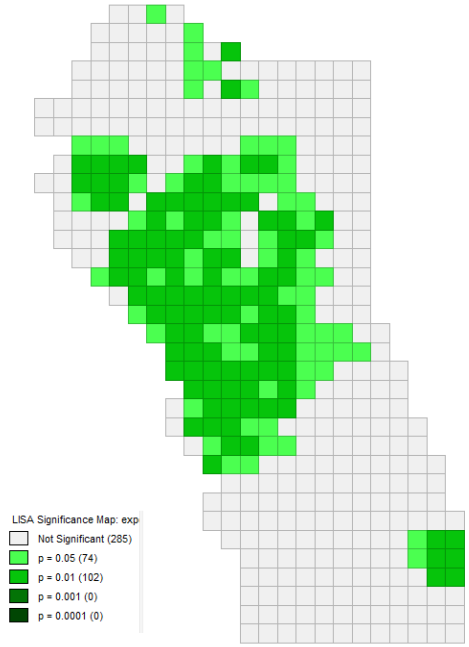

Fig. 5 LISA Significant Map

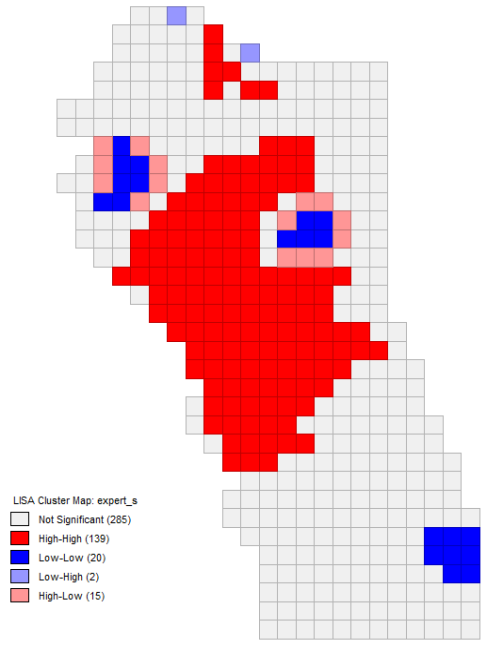

Fig. 6 LISA Cluster Map

where C = Contiguity value, N = grid value, X = *mean value of* variable, X_i = variable value at main grid, Xj=variable value at another grid, W_{ij} = grid weight index i until j.

RESULT AND DISCUSSIONS

Result

The four ports: POPSA, Kayangan, Kayu Bangkoa and Losari Beach pavilion. The highest grid was number 169, it equals to 168 but unfortunately, it was not supported by its neighborhood. High grid and also the one which are selected as first priority of coastal TOD development was grid 248 located around Kayu Bangkoa.

The second priority was number 191 and 192 but it did not receive strong support from its neighbor and so was with grid 26, hence, it is only as transit stop. Selected grids as priority location can be seen at **Table 4** in the following.

The value of each selected grid as I and II priority shown in Table 3 for coastal TOD development can be seen at the following Figure. Those locations were selected after the highest value determined from expert analysis and Fortran 90 program application and then furthermore analyzed by spatial technique analysis. It was found, the location around Kayu Bangkoa selected as I priority for development of coastal TOD. The II priority was around Kayu Bangkoa as well but it is closer to Losari beach pavilion.

Location around RRI and municipal office of Makassar could be developed as transit stop for massive public transportation connected with the location of coastal TOD development and another TOD at the shore within the route of massive public transportation corridor. This result is acquired from determination location through spatial analysis which can be seen at scutter plot Moran's I value at **Fig. 4**, LISA Significant map at **Fig. 5** and LISA Cluster Map at **Fig. 6**.

Discussions

The more complete Certainty Factor (CF) that corresponds with potency and principle of TOD is, the more accurate the selected location for coastal TOD development is going to be. Redundancy of distance, cost and time of commuter, local society and tourist will be eliminated if the transit location is set up as location for coastal TOD development.

CONCLUSIONS

The location selection for spatial planning development of coastal TOD is influenced by the number of rules and factors at expert system. Grid value or obtained location is then analyzed through spatial analysis to find more location that is suitable. It must be convinced that this selected location can prevent redundancy of energy, distance, cost and time of commuter, local society and tourist who stay at hotel to fulfill their basic needs since all of them are already available within walking radius 500 meters from transit location.

Safety and comfortability of bicycle riders and pedestrians is more convincing as optimization of coastal TOD principle manifestation, the service of goods and services including stores, working place, residence, fuel, gas and drinking water are provided every time within the location of coastal TOD development. Spatial analysis use, gives more suitable,

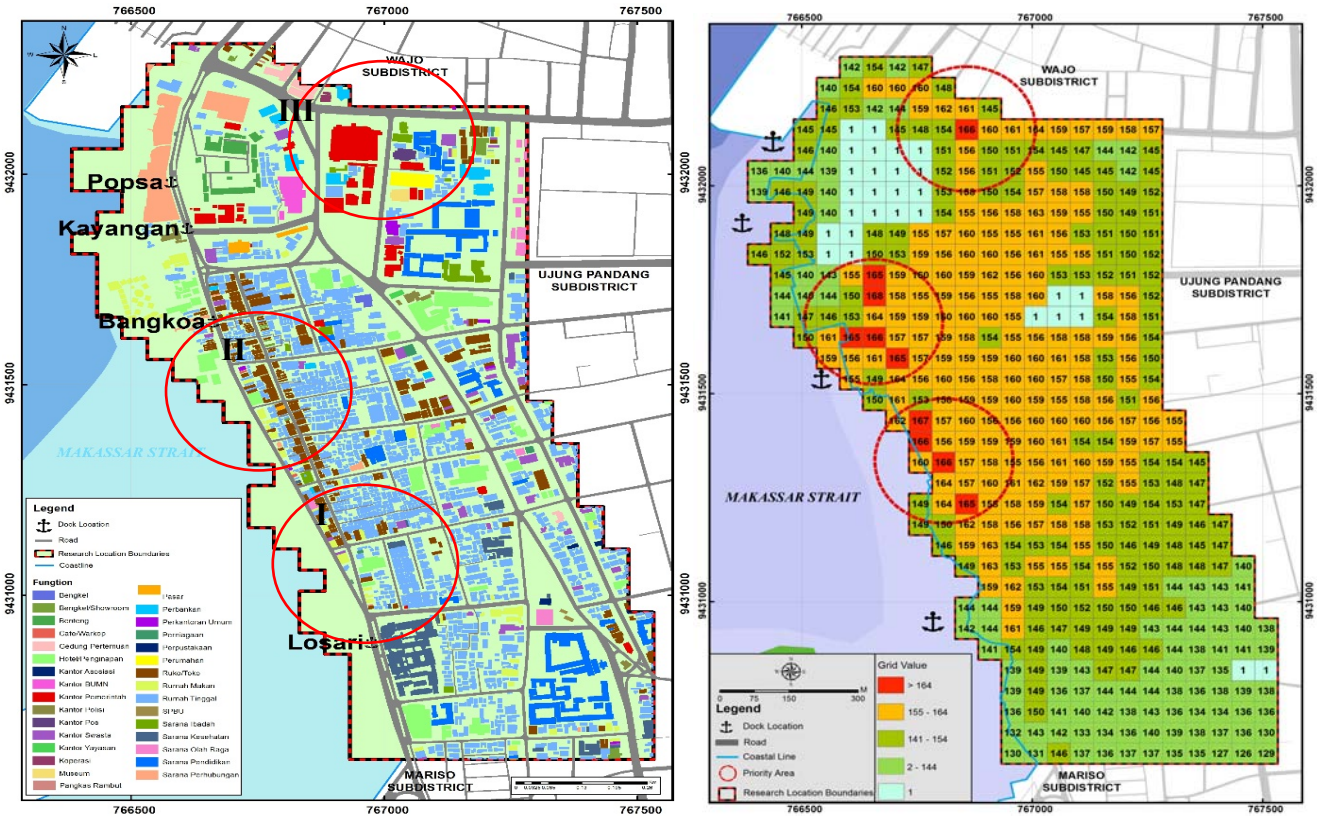

Fig. 7 The Most Suitable Location for Development of Coastal TOD

accurate and objective coastal TOD development in accordance with main grid potency and the support from its neighboring.

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