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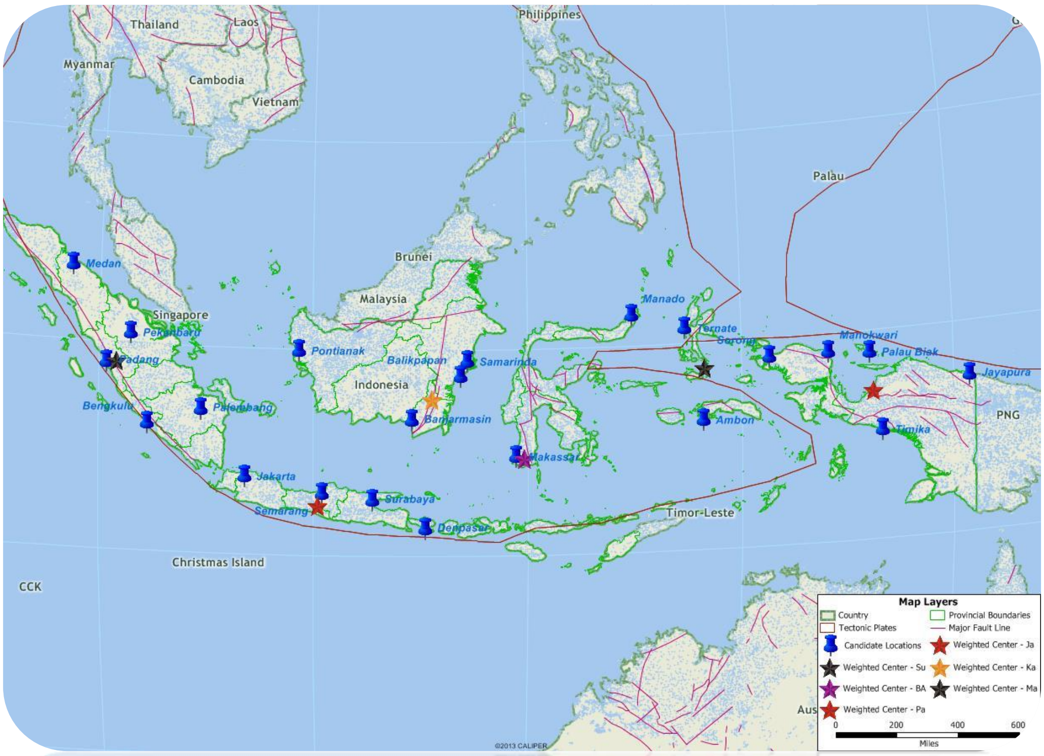
HOW TO IDENTIFY THE MOST APPROPRIATE LOCATIONS FOR ESTABLISHING AN EFFICIENT NETWORK OF EMERGENCY RESPONSE FACILITIES?

- A DISCUSSION PAPER

Volume 16-Mar-HL



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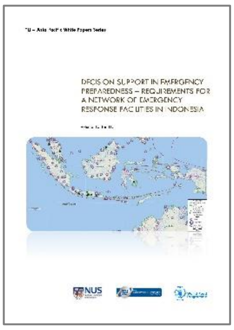

Decision Support in Emergency Preparedness Requirements for a Network of Emergency Response Facilities in Indonesia (Vol 16-Jan-HL)

Executive Summary

From the thoughts and methodology highlighted in in the whitepapers “Disaster Relief Supply Chains: Addressing Challenges in Robustness and Resilience to Enable Efficiency and Effectiveness in Humanitarian Response” (Volume 15 – Dec – HL), and “Decision Support in Emergency Preparedness – Requirements for a Network of Emergency Response Facilities in Indonesia” (Volume 16 – Jan – HL), this discussion paper presents the solution approach and preliminary findings equipped with sensitivity analysis of an exploratory study aimed at identifying the most appropriate locations for the nodes of a network of emergency response facilities in Indonesia.

Starting from a brief introduction on the problem description, the focus of discussion is then moved to the methodological approach used to address the challenge, model description, model assumptions, and preliminary findings of analysis.

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How to Identify the Most Appropriate Locations for Establishing an Efficient Network of Emergency Response Facilities?

Problem Description:

In the series of problems to consider in the decision making process concerning emergency logistics preparedness, the determination of the most appropriate locations for the Distribution Centers (DCs)[1] composing a network of emergency response facilities can be considered a key activity, given its significant impact on effectiveness and efficiency of disasters relief operations. Thus, it is critical for National Disaster Management Agencies and relief organizations *to optimally determine the locations for their emergency response facilities, as this has an integral relation with the security and protection of the society.*

Solution Approach:

To overcome the limitations of traditional approaches on tackling multi-criteria supply chain decision making, we developed a researched framework for addressing the location problem for a network of emergency response facilities. Geographic Information System (GIS) technology is used to integrate key information such as natural disaster hazard zones, population densities, strategic logistics infrastructure (e.g. ports, airport), and industrial cluster (refer to figure 1, 2, 3)

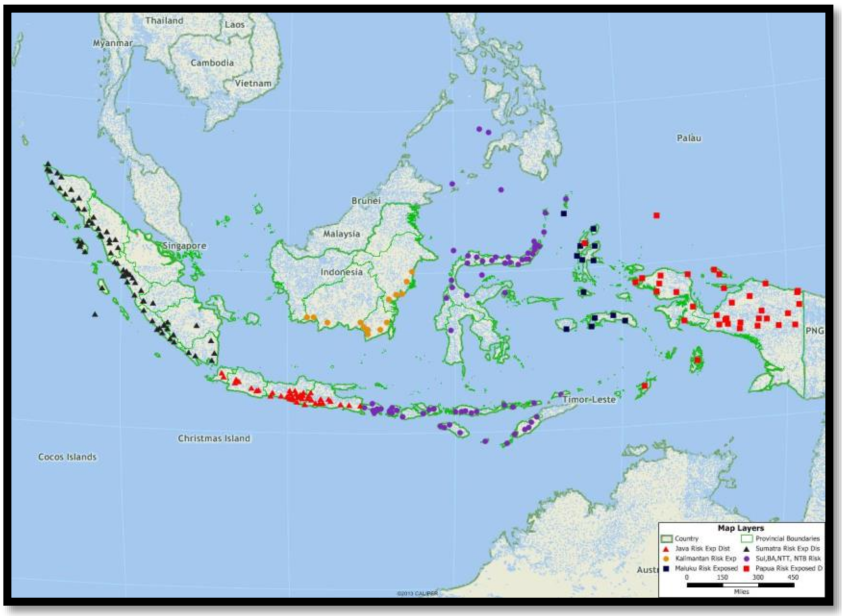

***Figure 1**. Regencies exposed to Major Natural Calamities (Earthquakes, tsunamis, volcanoes) grouped by geographic area*

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[1] In this context, Distribution Center will be used as synonym of Warehouse, as well as HRB (Humanitarian Relief Hub)

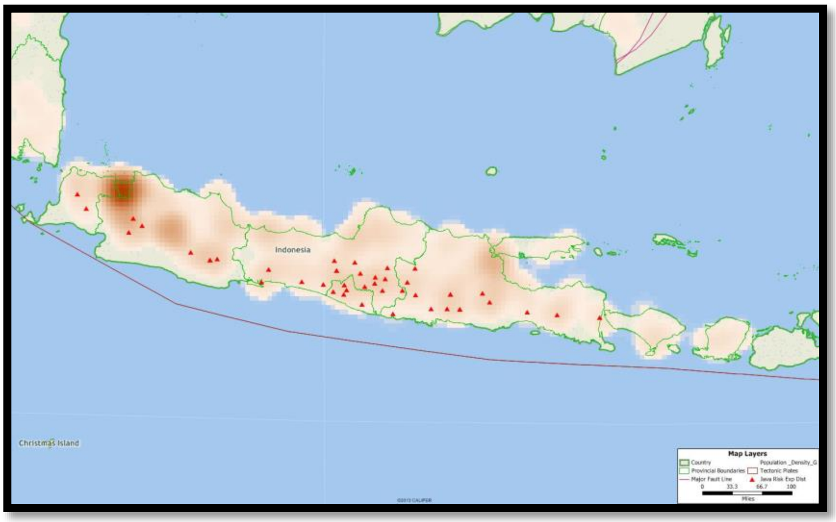

***Figure 2**. Example of overlay of Population Density, and regencies exposed to natural disasters (example of Java Island)*

***Figure 3.** Visualizing main logistics infrastructures - highways, major secondary roads, and airports grouped by size*

More specifically, GIS technology is supportive of advanced spatial analysis, and geographic patterns, and in this exercise, the technology has been widely used to quantitatively measure parameters such as population exposed to disasters, matrix of distances, geographical coverage for each hub based on travel time to reach disaster affected populations, lead time to reach pre-identified demand points, and Weighted Centre of Gravity[2] for each of the six geographic areas (refer to section "Model Assumptions" for more details).

[2] The Weighted Center of gravity (WCoG) identifies a central location that is closest to those risk exposed regencies with the highest weighted population (demand). In this context, the WCoG have been determined for each of the six geographic area, and they represent the points of aggregated demand for each area.

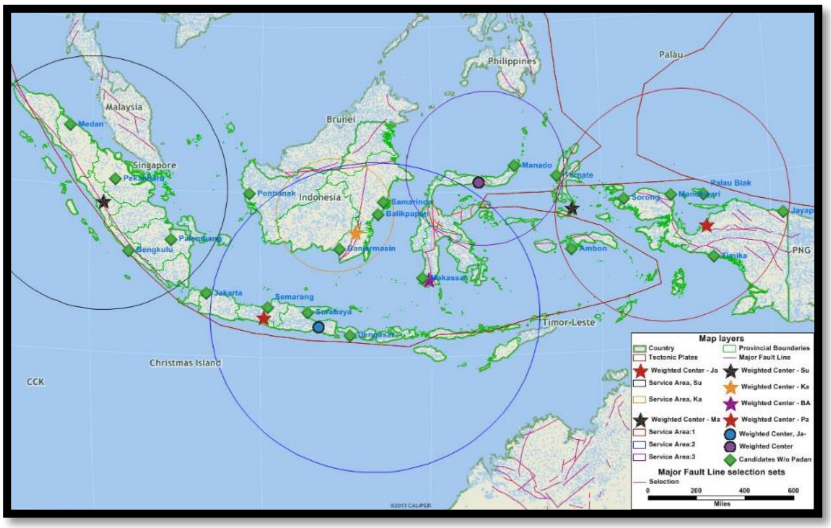

Figure 4. *Determination of WCoG for the identified geographic areas*

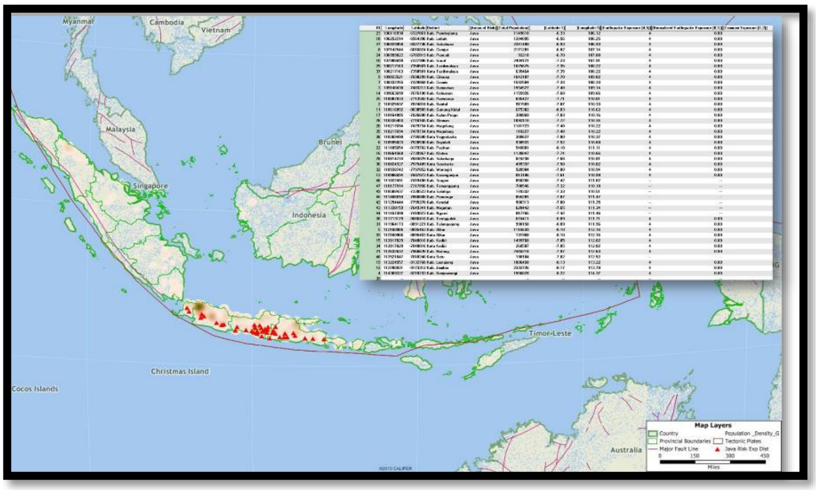

Figure 5*. Example of spatial analysis for determination of risk exposed population in Java Island*

The inputs of local supply chain experts, together with insights of GIS system analysis have enabled the identification of potential locations (nodes) for the network of Emergency response facilities throughout the country. In order to identify the optimal network configuration, the following steps have been undertaken:

a) **Definition of Location criteria for Site Selection** – A set of eight factors (DC location criteria) to compare the potential locations against have been defined (see Table 1);

b) **Ranking of Location criteria for Site Selection** – Location criteria for site selection are not equally important. Based on qualitative information gained from local supply chain experts, weights for the eight location criteria have been determined through the application of AHP methodology[3]. This analysis sets priorities in terms of key variables affecting the decision

[3] AHP is multi-criteria decision-making tool for supporting complex problems whose final decision is based on the evaluation of a number of alternatives in terms of a number of criteria

making process related with site selection for the nodes of the network of emergency response facilities (results in Table 1);

c) **Comparative analysis of network nodes** – The identified potential nodes for the network, have been grouped with respect of their geographic area, and then compared against the weighted DC location criteria (refer to Table 2 for results[4]).

Among the several multi-criteria decision-making methods available in literature, AHP has been chosen due to its capabilities to fully integrate quantitative and qualitative information.

Model Assumptions:

- In Model Configuration 1 (MC 1), in accordance with the concept that an emergency response facility should be located on "each [main] island", the country has been divided into six (6) main geographic/coverage areas: 1) Java-Bali-NTT-NTB, 2) Sumatra, 3) Kalimantan, 4) Sulawesi, 5)Maluku, and 6)Papua. In each of those areas there will be one node of the network of emergency response facilities[5];
- A WCoG for each of the geographic areas defined in MC 1 has been identified. These points are considered aggregated points of demands for relief items;

Results Up to Date:

Data collected through the workshop held in Jakarta (Indonesia) on January 27th, are acceptable as their Consistency ratio is equal to 0.0852 (acceptability limit 0.1), and the results of data analysis have been included into the following table 1 and 2;

SR NO	CRITERION	DESCRIPTION	WEIGHT	RANK
C1	Coverage	The geographical coverage for each hub based on travel time to reach disaster affected populations. This involves combining geographic population distribution with hazard zones.	**0.1813**	**3**
C2	Access to affected zones	Lead time to reach the affected populations.	**0.2155**	**1**
C3	Risk	HRFs should be outside of identified hazard zones (Exclusion criteria)	**0.2081**	**2**
C4	Access to infrastructure	Access to suitable infrastructure for transport (air, sea, land), with suitable operational capacities including storage, transportation assets, commercial service providers and mechanical handling equipment's.	**0.1666**	**4**
C5	Access to Corridor	The need for the HRF to be located within one of the major transportation corridors as pre-identified by the Indonesian Government	**0.0972**	**5**

[4] Results of Table 2 refer to Model Configuration 1, whose assumptions have been detailed in the section "Model Assumption"

[5] Being able to absorb a high level of flexibility in terms of Network Configuration, further Model Configurations have been considered and investigate (e.g. Model Configuration 2 considers the following 6 geographic areas: 1)Java, 2)Sumatra, 3)Kalimantan, 4)Sulawesi-Bali-NTT-NTB, 5)Maluku, and 6)Papua).

C6	Congestion	Heavily congested facilities (port, airports) and corresponding road access is a negative or exclusion criteria	**0.0476**	**6**
C7	Costs	Transportation costs for resupplying HRFs and running operations from the respective locations (includes sending goods from the hub to affected areas).	**0.0461**	**7**
C8	National development plan (NDP)	Proximity to Economic Centres identified in the National Master Plan for the Acceleration and Expansion of Indonesia -Economic Development 2011-2025, which includes expansion of logistics infrastructure to support the economic activities	**0.0376**	**8**

***Table 1**. DC location criteria for Site selection definition and AHP results*

Potential Locations (nodes)	Geographic Area	Location Criteria								Score
		Coverage Index	Access to Affected Zones Index	Risk Index	Infrastructure Index	Corridor Accessibility Index	Airport Congestion Index	Trasportation Cost Index	NDP Index - Relative	
Pekanbaru	Sumatra	1.000	1.000	1.000	0.707	1.000	0.252	0.717	1.000	0.919
Medan		0.769	0.294	0.899	1.000	1.000	0.095	0.996	1.000	0.756
Bengkulu		0.648	0.478	0.260	0.613	1.000	1.000	0.415	1.000	0.591
Palembang		0.216	0.319	1.000	0.427	1.000	0.244	0.360	0.719	0.550
Surabaya	Java, Bali, NTT, NTB	0.809	1.000	1.000	0.920	1.000	0.220	0.872	1.000	0.927
Semarang		1.000	0.321	0.925	0.760	1.000	1.000	0.896	1.000	0.809
Denpasar		0.313	0.545	0.285	1.000	1.000	0.204	0.591	1.000	0.586
Jakarta		0.302	0.148	0.618	1.000	1.000	0.125	1.000	1.000	0.583
Banjarmasin	Kalimantan	1.000	1.000	0.230	0.930	1.000	0.041	1.000	0.719	0.787
Balikpapan		0.715	0.938	0.155	1.000	1.000	0.020	0.298	0.579	0.677
Samarinda		0.712	0.635	0.165	0.448	1.000	1.000	0.246	0.719	0.570
Pontianak		0.017	0.226	1.000	0.793	1.000	0.075	0.092	1.000	0.546
Ambon	Maluku	0.495	0.833	1.000	1.001	1.000	0.504	1.000	1.000	0.868
Ternate		1.000	1.000	0.788	0.730	0.000	1.000	0.001	0.842	0.773
Timika	Papua	1.000	1.000	1.000	0.457	1.000	0.572	0.177	0.719	0.854
Jayapura		0.502	0.431	0.767	1.001	1.000	0.236	1.000	0.842	0.712
Sorong		0.738	0.381	0.673	0.892	1.000	0.566	0.408	1.000	0.698
Manokwari		0.612	0.688	0.664	0.566	1.000	0.629	0.636	0.719	0.689
Palau Biak		0.641	1.089	0.623	0.566	0.000	1.000	0.050	0.298	0.646
Manado	Sulawesi	1.000	1.000	0.639	0.680	1.000	1.000	0.530	1.000	0.866
Makassar		0.442	0.357	1.000	1.000	1.000	0.617	1.000	1.000	0.759
	Criteria Weightage	0.1813	0.2155	0.2081	0.1666	0.0972	0.0476	0.0461	0.0376	

***Table 2**. Preliminary results [“Model Configuration 1"]*

Sensitivity Analysis:

In order to incorporate considerations on operational emergency response capacity and structures into the model, a sensitivity analysis of results have been performed. In times of emergency in fact, entry points of relief items (seaports and airports) need to be equipped with (heavy) mechanical handling equipment (main deck/high loaders) so that vessels/aircrafts unloading operations are facilitated. In this configuration the model is tested under a scenario wherein the nodes require high infrastructural capacities (refer table 4 for results). The weightage of the remaining seven location criteria for site selection is decreased proportionally (refer Table 3).

SR NO	CRITERION	REFERENCE WEIGHT[6]	HIGH INFRASTRUCTURE CAPABILITIES
C1	Coverage	**0.1813**	**0.1241**
C2	Access to affected zones	**0.2155**	**0.1641**
C3	Risk	**0.2081**	**0.1541**
C4	Access to infrastructure	**0.1666**	**0.5610**
C5	Access to Corridor	**0.0972**	**0.0441**
C6	Congestion	**0.0476**	**0**
C7	Costs	**0.0461**	**0**
C8	National development plan (NDP)	**0.0376**	**0**

Table 3. *DC Location Criteria for Site Selection - Sensitivity Analysis - Weightage Comparison*

Potential Locations (nodes)	Geographic Area	Location Criteria								Score
		Coverage Index	Access to Affected Zones Index	Risk Index	Infrastructure Index	Corridor Accessibility Index	Airport Congestion Index	Trasportation Cost Index	NDP Index - Relative	
Medan	Sumatra	0.769	0.294	0.899	1.000	1.000	0.095	0.996	1.000	0.887
Pekanbaru		1.000	1.000	1.000	0.707	1.000	0.252	0.717	1.000	0.883
Palembang		0.216	0.319	1.000	0.427	1.000	0.244	0.360	0.719	0.517
Bengkulu		0.648	0.478	0.260	0.613	1.000	1.000	0.415	1.000	0.587
Surabaya	Java, Bali, NTT, NTB	0.809	1.000	1.000	0.920	1.000	0.220	0.872	1.000	0.979
Semarang		1.000	0.321	0.925	0.760	1.000	1.000	0.896	1.000	0.790
Denpasar		0.313	0.545	0.285	1.000	1.000	0.204	0.591	1.000	0.777
Jakarta		0.302	0.148	0.618	1.000	1.000	0.125	1.000	1.000	0.762
Banjarmasin	Kalimantan	1.000	1.000	0.230	0.930	1.000	0.041	1.000	0.719	0.890
Balikpapan		0.715	0.938	0.155	1.000	1.000	0.020	0.298	0.579	0.872
Pontianak		0.017	0.226	1.000	0.793	1.000	0.075	0.092	1.000	0.683
Samarinda		0.712	0.635	0.165	0.448	1.000	1.000	0.246	0.719	0.514
Ambon	Maluku	0.495	0.833	1.000	1.001	1.000	0.504	1.000	1.000	0.958
Ternate		1.000	1.000	0.788	0.730	0.000	1.000	0.001	0.842	0.819
Jayapura	Papua	0.502	0.431	0.767	1.001	1.000	0.236	1.000	0.842	0.857
Sorong		0.738	0.381	0.673	0.892	1.000	0.566	0.408	1.000	0.802
Timika		1.000	1.000	1.000	0.457	1.000	0.572	0.177	0.719	0.743
Palau Biak		0.641	1.089	0.623	0.566	0.000	1.000	0.050	0.298	0.672
Manokwari		0.612	0.688	0.664	0.566	1.000	0.629	0.636	0.719	0.653
Makassar	Sulawesi	0.442	0.357	1.000	1.000	1.000	0.617	1.000	1.000	0.873
Manado		1.000	1.000	0.639	0.680	1.000	1.000	0.530	1.000	0.812
	Criteria Weightage	0.12	0.16	0.15	0.56	0.04	0	0	0	

Table 4. *Preliminary results - Sensitivity Analysis*

The analyzed scenarios, MC1 and "High Infrastructure Capacities", highlight differences in terms of suitable location for the geographic areas of Sumatra, Papua, and Sulawesi, and an analysis of pros and cons of each alternative is presented in the following (refer to Table 5).

[6] Reference weightage refer to Location criteria for site selection weights calculated through the analysis of inputs from local SC experts

GEOGRAPHIC AREA	MC 1	SENSITIVITY	COMMENTS	Pros	Cons
SUMATRA	**Pekanbaru**	**Medan**	***Pekanbaru***	• *Proximity to disaster affected zones* • *Low exposure to disasters*	• *River port with limited capacity, and it does not accommodate heavier vessels* • *Airport lacks of mechanical handling equipment for wide-bodied aircrafts*
			Medan	• *Airport with mechanical handling equipment for wide-bodied aircrafts* • *Port with enough capacity to accommodate also heavier vessels*	• *Relatively far from disaster affected zones*
PAPUA	**Timika**	**Jayapura**	***Timika***	• *Low Exposure to disasters*	• *Limited infrastructures capacities*
			Jayapura	• *Best commercial hub for Papua* • *Good infrastructure capacities in place*	• *High Exposure to earthquake*
SULAWESI	**Manado**	**Makassar**	***Manado***	• *Proximity to disaster affected zones (assuming coverage of Sulawesi only)*	• *Exposure to natural disasters* • *Limited infrastructures capacities*
			Makassar	• *Good infrastructure capacities in place* • *Low Exposure to disasters*	• *Relatively far from disaster affected zones (assuming coverage of Sulawesi only)*

***Table 5**. Comparisons of Solutions*

Conclusions:

In this discussion paper we have presented the solution approach and preliminary findings of an exploratory study aimed at identifying the most appropriate locations for the nodes of a network of emergency response facilities in Indonesia. To incorporate considerations on operational emergency response capacity and structures into the model, a sensitivity analysis based on greater importance of infrastructure capacities has been performed. However, considering the preliminary stage of solution identification, we especially invite decision-makers from the National Disasters Management Office (BNPB) and leading institutions of the humanitarian community to provide us their inputs to enhance the model, and where required to further refine the requirements for the network of emergency response DCs. This would elevate the strategic impact of this study, which ultimately aims to reinforce the architecture of the humanitarian response through a well-coordinated framework within which all humanitarian stakeholders can significantly contribute, as well as adapt the model from its practical implication perspective, so that it can fit better the Indonesian case.

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