PORT PLANNING UNDER DEEP UNCERTAINTY

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ABSTRACT

This study is about the port planning under deep uncertainty using the framework of Scenario Based-Adaptive Port Planning (SB-APP). The framework gives sequential workflow on designing the future masterplan of the port. The alternative layouts and adaptive actions are some important outcomes of the framework. The port has to realize that uncertainties persevere and are very likely to influence the decision making for future planning. Instead of ignoring uncertainties, the port needs to make contingency planning to deal with them. This study has benefits to make a robust terminal masterplan of the port.

Keywords: Deep Uncertainty; Port Engineering; Port Management; Port Planning

1. INTRODUCTION

Ports confront many uncertainties in their futures, especially if we consider planning development. They are facing new demands in terms of functions and scales, new external constraints, and changed expectations, and yet must ensure functionality, capacity, and service quality during their design lifetime (Taneja, 2013). The inability to adapt may cause costly investment for a port or loss of cargo and a competitive position in the future. Thus, planning ideally needs to anticipate unexpected future developments and to ascertain that the infrastructure, once built, continues to function well (Taneja et al., 2012).

Traditional policy analysis compares static equilibria and assumes well-characterized systems capable of manipulation from outside. However, for most real-world policy problems, disequilibrium dynamics are crucial, uncertainties about the future are real and fundamental. Policy-makers have only limited sovereignty, and the best language to capture our understanding of the process may not be the best language to debate judgments about outcomes (Walker et al., 2001). Uncertainties persevere in the real field, and a planner needs to realize that in the planning process. The current planning practice might not quite robust enough to handle the uncertainties of the future in planning the project.

2. LITERATURE STUDY

Depending on the time horizon of the project, the type of planning can be distinguished as long-term (more than 20 years), medium-term (5-15 years), and short-term (1-5 years) (Ligteringen & Velsink, 2012; Soloducho-Pelc, 2015).

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For a long-term project, usually called a masterplan, deep uncertainty is involved in which multiple possibilities of future conditions prevail (Maier et al., 2016).

In that case, the use of scenarios is recommended, even though it is hard to attach its probabilities. Scenario planning simplifies the avalanche of data into a limited number of possible states. Each scenario tells a story of how various elements might interact under certain conditions (Taneja, 2013). A detailed narrative could direct some important aspects related to the defined scenarios. Defining vulnerabilities and opportunities need to be performed and prepare action plans to adapt the planning.

The Scenario-Based (SB) approach is one of the tools/techniques of Adaptive Port Planning (APP). Besides the brainstorm session, which is also used in this study as an initial action in the study, APP also delivers probabilistic approaches and Explanatory Modeling and Analysis (EMA) (Taneja, 2013). The scenario approach is about creating stories about a plausible future and preparing for the uncertainties of the future. Scenarios are a set of reasonably plausible but structurally different futures (Heijden, 2005). Scenarios help us to open up the future as a space of possibilities and give the port authority and the port planners a wide view of the range and impact of uncertainties.

The idea behind the Scenario Based-Adaptive Port Planning (SB-APP) framework is the adaptation required at any moment as an answer to a challenge. It is a continuous procedure that aims to increase the lifespan of waterborne transport infrastructure by increasing flexibility in the planning, contracting, and design phases (Arreco, 2015). This framework combines two existing methods in the planning of infrastructure under uncertainty, namely Assumption-Based Planning and Adaptive Policy Making. The SB-APP frameworks fundamentally have some steps of approaching the planning and produces an adaptive masterplan by assuming that the future is unknown.

The SB-APP aims to achieve flexibility by bridging the divergence between the traditional approach of port planning by integrating uncertainty and adaptive plans. It provides a framework for the planner to generate plausible alternatives in the context of the planning objectives; identify critical uncertainties (vulnerabilities and opportunities); and then, to explore, value, and incorporate flexibilities for handling these uncertainties (Taneja, 2013). Subsequently, we can prepare actions in the planning stage, or actions can be prepared in advance and taken as events occur.

3. METHODS

Brainstorming is a simplified approach for encouraging practical innovations in an organization (Paulus et al., 2018). The participants are theorists, practitioners, and (if possible) management members. We generate the ideas, subsequently graded by the participants, and only a few survive. Most of the surviving ideas make incremental contributions to the field, and on a rare occasion, there is a breakthrough contribution. An essential step within SB-APP is to identify the (relevant) developments that could plausibly happen within the time horizon. Most often, this step is done for the first step in the framework, defining the mutual objective of the project/organization, the definition of success, and strategy.

A site visit is also highly recommended in order to get comprehensive knowledge of the relevant project (Lawrenz et al., 2003). Sometimes the written report is not able to describe every single detail in the real field; observing the site gives us more feeling. We can conduct this activity in a series with a brainstorming session.

Such a dataset needed in the study consists of company annual report, government report/statistics on demography, economy, and energy, and third party/non-governmental organization report on

port and economy outlook. Also, we need the cargo trend/record for traffic projection. Those data are necessary, especially for the second step in the framework.

4. RESULTS AND DISCUSSION

4.1. Framework

An appropriate and suitable framework for the case study (deep uncertainty) in this research is Scenario Based-Adaptive Port Planning (SB-APP). This framework will be applied step by step regarding the context of the case study (see Figure 1). The framework also shows the workflow of the analysis in this study as a whole. There are four necessary steps in this framework:

1. Step I: Define the project. This step will explore more detail about the aims of the project and how we can approach it. We could compose a desk study, brainstorming, and a site visit to achieve this step.
2. Step II: Scenario Planning. In this step, we will develop scenarios of a future condition. The scenarios will be the basis of accomplishing a projection for the most promising cargos in the port.
3. Step III: Monitoring System and Contingency Planning. We realize that the developed scenarios have a limitation on describing all uncertainties. Therefore, this step is aimed at monitoring the signposts and prepare for contingency planning, either by executing a DEfensive action (DE), CoRrective action (CR), CaPitalizing action (CP), or REassessment (RE).
4. Step IV: Preliminary terminal layout. Alternative layouts could have been detailed for each cargo in this step. The quay length and storage areas are among the elements that we have to determine in the layout design.

Figure 1 Framework of SB-APP

4.2. Scenario Planning

The future scenarios are developed based on relevant uncertainties that might be faced by the port. Such uncertainty analysis will tell us critical uncertainties in which summing up almost all dimensions of uncertainties dataset. In a 2x2 scenario matrix, those critical uncertainties can be paired as horizontal and vertical axes to see the possible picture of the future. Some possible matrices of the future of the port are listed followed:

1. In order to see the approach type (either control or going with the market demand) of the government (in this case: the Port Authority) to the port and the favourability of economic growth, see the matrix in Figure 2.

		<u>Port Authority approach to port development</u>	
		<i>Control</i>	<i>Market demand</i>
<u>Economic Growth</u>	<i>Favourable</i>	Scenario 2	Scenario 1
	<i>Unfavourable</i>	Scenario 4	Scenario 3

Figure 2 Scenario of Port Authority approach to port development

2. In order to see the type of trend of energy terminal development (either intervened by the government will or going with the market trend) and the sustainability of the future, see the matrix in Figure 3.

		<u>Energy terminal trend</u>	
		<i>Government intervention</i>	<i>Market trend</i>
<u>Sustainability</u>	<i>Green</i>	Scenario 2	Scenario 1
	<i>Grey</i>	Scenario 4	Scenario 3

Figure 3 Scenario of the government approach to energy terminal development

We carry out scenario analysis for New Priok Port Development in Jakarta, especially for Phase II where intends to be developed after the year of 2035. Planning this specific project is surely bringing Port Planner to the deep uncertainty situation where different plausible conditions could happen in the future. Based on the analysis, we propose cargo growth and environmental issues

as critical uncertainties; and this leads us to 4 different scenarios, which are green growth, Business as Usual (BaU), moderate expansion, and no expansion (see Figure 4).

Figure 4 Scenario development of Phase II of the New Priok Project

We elaborate on the promising cargos in each scenario through scorecard analysis based on some related reports and expert discussion. Traffic analysis can then be defined to see future throughput for a particular port’s project with the basis of the current cargo trend. This projection will be one of the fundamental components of terminal layout development in the last step of the framework.

As for New Priok Development, some promising commodities are containers, liquid bulk, and renewable energy (see columns 1 and 2 of Table 1). General cargo and solar energy industries complete the list as the future potential of cargos in New Priok. We have assessed the robustness of the industry using an index with scale 1-10 (the higher the number, the most promising that particular industry in each scenario). In order to compare the industries within the scenario, we have evaluated its performance using index --, -, +, and ++ (indicating lower to higher performance).

Table 1 Comparison of industrial alternatives in four scenarios

Cargo sectors		Scen. 1 <i>Green Growth</i>		Scen. 2 <i>Business As Usual</i>		Scen. 3 <i>Moderate Expansion</i>		Scen. 4 <i>No Expansion</i>		Total
Containers		++	10	++	10	+	6	--	2	28
Liquid bulk	Oil	+	6	+	6	-	3	--	2	17
	Gas	+	6	+	6	-	3	--	2	17
Renewable energy	Bioenergy	+	6	--	2	-	4	--	2	14
	Windmill	+	6	--	2	-	4	--	2	14
Others	General Cargo	--	2	--	2	--	2	--	2	8
	Solar	--	2	--	2	--	2	--	2	8

Scen. = scenario

Currently, traffic in Port of Tanjung Priok consists of many kinds of freight transport for transported goods such as general cargo, bag cargo, liquid bulk, dry bulk, container, and others. Some types of vessels are also transported via Tanjung Priok to meet Indonesia's demand. All in all, the existing cargo (mostly container) shows the increasing trend as the improvement of Indonesia's economy, especially for regional Jakarta and West Java Province.

The forecasting of future cargo includes much work, and it is impossible to produce the exact numbers as in reality. In this study, those projections are defined based on scenarios that contain economic relations (see Figure 5). As can be seen, scenarios 1 and 2 are among the most attractive to the container's projection, which describes the high economic growth condition.

Figure 5 Containers throughput projection based on scenarios of Tanjung Priok

4.3. Monitoring System & Contingency Planning

The relevant future uncertainties are analyzed into contingency plans and make the scenarios more robust. The idea behind this step is controlling the possible uncertainties that have not been covered by the scenarios. This step is involving contingency planning for each signpost. There are some contingency plans (adaptive plans) in this step that we have to define to conduct robust planning, which are DEfensive Action (DE), CoRrective action (CR), CaPitalizing action (CP), and REassessment (RE).

Trigger response to critical values of the signpost variables that lead to the implementation of defensive or corrective actions or a policy reassessment. There four types of contingency actions, which are:

1. DEfensive actions (DE) are actions taken after the fact to clarify the plan, persevere its benefits, or meet external challenges in response to specific triggers that leave the basic plan unchanged,
2. CoRrective actions (CR) are adjustments to the basic plan in response to specific triggers,
3. CaPitalizing actions (CP) are actions taken after the fact to take advantage of opportunities that further improve the performance of the plan, and

4. REassessment (RE) is a process of initiating or restarting when the analysis and assumptions critical to the plan's success have lost validity.

We implement the monitoring system and contingency planning to prepare the port facing uncertainties in the future holistically. By doing so, we can see how the design alternatives deal with uncertainties and how adaptive planning complies with the project. The chart shown in Figure 6 visualizes the interaction of uncertainty, signposts, and adaptive plans needed in the project.

The port competitors, future renewable energy sources, and port policy related to shipping law in 2008 are some relevant uncertainties for New Priok that we have not treated them in specific. We have to evaluate those uncertainties in such a way that we can prepare defensive actions or even gain somethings (capitalizing). In this study, we give an example of adaptive plans for the case of the development of Port of Cilamaya as a port competitor for Phase II of New Priok Development.

Figure 6 Monitoring system and contingency plans

The planning of development of Port of Cilamaya/Patimban, around 100 km to the east of Tanjung Priok (See Figure 7), as a share of container handling in New Priok Port is coming up from Port Authority (PA). The PA plans to build this port up to 2030, with the optimum of its capacity is assumed to be taking around 30% of the total container throughput in Tanjung Priok.

Firstly, if the Port of Cilamaya is finalized as planned, based on throughput projection, Phase II of New Priok Development is not needed. The new port can handle the throughput share, and New Priok construction remains enough until Phase I. Secondly, Patimban development could reduce the market share of New Priok due to the same serviced hinterlands. Therefore, maintaining and strengthening the business relationship with the existing business clients of Tanjung Priok would be required as a defensive action (DE), especially for terminals in Phase I of New Priok. Thirdly, since Port of Cilamaya is a greenfield development, this is also an opportunity for Port of Tanjung Priok, through a subsidiary company like PT Pengembang Pelabuhan Indonesia (PPI) as the port developer, to assess the development of this port. Tanjung Priok could involve in the study process of development of the new port; this is capitalizing action (CP).

Figure 7 Cilamaya Port (Ministry of the Transportation Republic of Indonesia, 2017)

Figure 8 Monitoring system and contingency plans for New Priok Development

If the development of Port of Cilamaya is not favored, then New Priok could concentrate on its throughput projection. New Priok Development Phase II can still be continuing. The other issue will be hinterland congestion as a consequence of the adding up of massive throughput from New Priok. For that reason, we highly recommend Tanjung Priok finding solutions to this traffic issue, whether implementing a multi-stack road system or canalization in Cikarang and Bekasi (CBL Canal) as corrective actions (CR). Figure 8 shows the complete diagram of a monitoring system for the case of the port competitor in New Priok Development.

4.4. Preliminary Terminal Layout

In the last step of the framework, we can design a quay length and dedicated area needed in the terminal. Those items are fundamental components in the terminal layout. Since each scenario will tell different terminal requirements, then each scenario has its layout design.

The ship design length determines the quay length of terminals; it relates to the design cargo coming to the port. For single berth, it depends on the largest vessel length. For multiple berths, the quay length is calculated based on the average vessel length.

$$L_q = L_{s,max} + 2 \cdot 15 \quad \text{for } n = 1 \quad \text{..... eq.1 (Ligteringen \& Velsink, 2012)}$$

$$L_q = 1.1 \cdot n \cdot (L_s + 15) + 15 \quad \text{for } n > 1 \quad \text{..... eq.2 (Ligteringen \& Velsink, 2012)}$$

Where:

L_q = quay length (m)

$L_{s,max}$ = length of the highest ship (m)

L_s = length of a ship (m)

n = number of ships

The storage yard consists of several stacks areas, such as for export, import, reefers, hazardous cargo, and empties. The basic formula to calculate those areas as follows; we can see the throughput projection from the second step of the framework (in the form of N_c) rules the equation.

$$A = \frac{N_c t_d A_{TEU}}{r_{st} 365 m_c} \quad \text{..... eq. 3 (Ligteringen \& Velsink, 2012)}$$

Where:

A = required area (m²)

N_c = number of containers per year in TEU's

t_d = average dwell time (days)

A_{TEU} = required area per TEU inclusive of equipment traveling lanes

r_{st} = ratio average stacking height over nominal stacking height

m_c = acceptable occupancy rate

The trucks that deliver containers will enter the terminal through the gate. The three functions of the gate in handling cargo are:

1. for administrative formalities related to the cargo, including customs inspection and clearance,
2. for inspection of the boxes themselves (for possible damage), and
3. the instruction of the drivers to the location in the container transfer area.

The terminal also needs space for the office building and the workshop for repair and maintenance of the equipment. The requirement areas are flexible and vary per terminal.

5. CONCLUSION

The long-term port project contains deep uncertainty with multiple possible future conditions, and we treat it through the developed framework, called Scenario Based-Adaptive Port Planning (SB-APP). We have tackled some uncertainties by scenario planning that produces narratives of the future port's condition. We have controlled other uncertainties (the scenario planning cannot cover that) and prepared adaptive plans for them. The port has to realize that uncertainties persevere and are very likely to influence the decision making for future planning.

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