Increasing terminal capacity based on adaptive port planning case study at Cigading Port, Indonesia

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Abstract. The effective infrastructure in the archipelago country to distribute goods is through port loading and unloading activities. One of port that will be the object of this research is Cigading Port in the Banten Province. Main activities of this port are handling dry bulk and liquid bulk cargoes. This port will expand in line with port’s vision and mission to increase cargo handling. The expansion is carried out to achieve target of cargo handling to 26.81 million tons in 2025. This expansion is required big funding, proper planning and can be adjusted to the needs in the future. The purpose of this research is to gain conceptual design and development of various scenario that plausible in the future for Cigading Port. The research methodology will use framework of Adaptive Port Planning (APP) using scenario method. This framework gives advantages compared to conventional planning because of APP can identify, have flexibility in design, and can be adapted from the uncertainty factors in the future. By using this framework, port planner will have several scenarios based on the uncertainty factors that have been identified so he/she can determine the best decision to develop Cigading Port. As results, thirteen uncertainty factors are identified and also four plausible scenarios are developed and based on expert opinion one scenario is chosen that may be developed for conceptual design of the expansion Cigading Port.

1. Introduction
Indonesia is one of the archipelago countries where sea transportation can help distributing goods and economic growth which is important in the country’s development. The infrastructure that is being developed by the government is the seaport. In general, port infrastructure development is a construction that requires a very large investment, can not be returned, high risk and has a long economic return period.

One of the ports that going to expand, and the object of this research is Cigading Port. This port is located at Banten Province and was built in 1996. Most of the terminal activity on this port are specialized in dry bulk cargo handling especially on iron ore using ship unloader. At the moment, Cigading port has two terminals which are called Terminal 1 and Terminal 2. Loading/unloading cargo on Terminal 1 has reached 9.99 million tons in 2017 while Terminal 2 already reached 17.66 million tons.

According to internal report Cigading port on Terminal 1 and Terminal 2, in 2016 occupancy rate of equipment already 98% and berth occupancy ratio is 60.4%. This rate indicates that all terminal has reached optimum condition. While port activity always increases to double on the past decade from 7.7
millions to 17.7 million tons in 2017 and planning to increase iron ore production capacity, the port operator projecting cargo handling will rise to 26 million tons in 2025. Looking at these indicators and cargo forecast, Cigading port will have potential problems in the next few years if there are no additional facilities or expansion. The problems will increase dwell vessel time, the availability of storage yard & equipment, the possibility of bigger vessel berth and other uncertainty factors that may be happened in the future.

There are two main objectives on this research which are implementation of adaptive port planning (APP) by determining uncertainty factors that will be faced in Cigading port (RQ1) and the development of scenarios that plausible for Cigading port in the future (RQ2).

2. Literature review and method

2.1. Literature review

On the concept of infrastructure planning, there are uncertainty factors that require attention. These factors can be caused by changing on global trends, new regulatory polies and technology. Mostly planner doesn't consider the uncertainty into the project planning, which may cause potential problems because it's not in line with the expectation.

According to Blanchard & Fabrycky, uncertainty is defined as unknown information that related to specific causes and effects and originate from the exogenous or endogenous sectors of the system itself [1]. The port environment itself can be categorized as an engineering system. This system is defined as a man-made system to meet specific objectives and functional needs.

There is also research about adaptive port planning by Prakoso defining nine principles of uncertainty that affect world class ports as follows [2]: Multi-national company joint ventures; International standards and organization; Port related technology development; Consolidation of shipping lines; Distinctive local regulation; Challenging land acquisition; Dynamics of relevant government support; Relationship with neighbouring ports; Special economic zones.

With the uncertainties that affect port development, there should be a planning that can be adjusted to the needed conditions and can be flexible. Flexibility concept has three main layers in its application which are physical, operations/ procedures and services. Flexibility has four options to apply to the uncertainty factors. These options are no flexibility, just-in-time flexibility just-in-case flexibility and just for now flexibility [3].

APP framework is a combination between two basic methods that already developed which are infrastructure planning under uncertainty and adaptive policy. APP framework aims to achieve flexibility by bridging the gap between conventional method port planning and flexibility considerations. To develop APP framework has some methods as follow [3]:

- Brainstorming session.
- Probabilistic approach.
- Exploratory modelling and analysis (EMA).
- Scenario approach.

In this research scenario approach is chosen to implement the APP for the development of Cigading port. Some advantages of APP framework are generating alternative in a planning, identification of critical uncertainty and combining flexibility. Port planner can take decision on the planning stage and some actions are already prepared if the uncertainty occurs. During the implementation phase, the actions taken will always be monitored by the monitoring system. This system can read the external environment for new developments and planner is notified to modify the needs or review project plans [4]. There are six steps to adapt APP framework with the following steps:

- Define problem and strategy (1).
- Identification basic assumptions (2).
- Devise actions to increase robustness of basic alternatives (3).
- Incorporate flexibility in each basic alternative (4).
• Set up monitoring system (5)
• Prepare trigger / responses / contingency planning (6).

On this research, the implementation of APP framework will only focus until step 4. Step no (5) and (6) will be not included in this research.

2.2. Research methodology
To achieve goals of this research, there are two phases of analysis data that will be done. Phase 1 data analysis is identified uncertainty factors and obtained the dominant factors. The uncertainty factors are based on literature study and case study from the published journal and internal data from company. The identification of uncertainty factors is the most important step. These factors need to be determined by considering global trends, vision and mission of Cigading port, market research, environmental awareness and other things that may affected the port planning and need to be validated with port expert.

After identification is finished, the next step is expert validation phase 1 by distributing questionnaires to the experts where the purpose of this validation is to get dominant uncertainty factors. Five highest ranks from scoring will be converted to statistical data that have equivalent data from the uncertainty factors.

Data analysis phase 2 is the development of scenarios and analysing forecast demand to obtain cargo throughput. Scenario development is describing the narrative that might occur at Cigading port based on the dominant uncertainty factors. This research develops four scenarios and each scenario will be validated by expert also. The validation aims to find out the opinion whether they agree with the characteristics and to choose which scenario that plausible in the future for Cigading port.

Flow chart of the research methodology can be seen on figure 1 below.

Figure 1. Research methodology.

3. Results and discussions
3.1. Result and discussions uncertainty factors RQ 1
In this research, the development of Cigading port will use APP developed by Taneja (2013) in his dissertation the flexible port [4]. The APP method is a combination of two basic methods that have been widely developed, which are infrastructure planning method under uncertainty and adaptive policy making that making future cannot be known. Taneja and Walker write in journal adaptive port planning using real options, the stages for applying the APP method are divided into 6 steps which explained in section 2.1 [5]. However, this research is limited only to identify flexible options and evaluate them. The design of monitoring system, the response system and preparation steps taken will not be discussed in this study.
The uncertainties are taken based on the journal dealing with uncertainty in the design of the port infrastructure system from Ligteringen and Schuylenburg, that must relate to 4 major contexts [6]. The first one is project context that the uncertainty element refer to costs, construction delays, estimated material quantities, workers and material issues. While the second context is related to corporations such as improving services and corporate strategy. The third context is related to the market due to port infrastructure is usually associated with the development of global trends in shipping market and structural changes in shipping services. The fourth context is related with politics such as the existence of new regulations, privatization and environmental issues that have an impact on the port industry.

The first part of the research analysis is to determine uncertainty factors that will be affected with Cigading port planning and cargo throughput. The uncertainty factors are based on reference journals, port operator vision & mission, global trends, and any other issues in the port environment. These factors will be validated by port planner expert. In this research, five experts from design consultants, port operator and port regulator have been interviewed and asked for opinion to validate these factors. Based on the validation, thirteen uncertainties are identified that may be affected cargo throughput in Cigading Port.

Table 1. Uncertainties factors for development Cigading Port.

| No | Uncertainty Description                                      | Very Important / Very Influential | Quite Important / Quite Influential | Important / Influential |
|----|-------------------------------------------------------------|---------------------------------|------------------------------------|------------------------|
| 1  | Changing on Market demand needs                            | √√√                             | √                                 | -                      |
| 2  | Development of global and regional economic that affect cargo growth | √√√√                            | √                                 | -                      |
| 3  | New Equipment technology in the port system                 | √                               | √√                                | -                      |
| 4  | Climate change in the port environment                      | -                               | √                                 | √√                    |
| 5  | Trade war between superpowers country in the mineral sector | √√√                             | √                                 | -                      |
| 6  | Changes in cargo ship size                                 | √                               | √√                                | -                      |
| 7  | Regulation on the sustainability port or the application of the green port concept | √                              | √                                 | √√                    |
| 8  | Alternative energy sources in the future                   | √                               | √√                                | -                      |
| 9  | Development of transportation technology                    | √                               | √√                                | -                      |
| 10 | Evolution of changes in port functions                     | -                               | √                                 | √√                    |
| 11 | Joint venture between national and international companies  | √√√√                            | √                                 | -                      |
| 12 | Land acquisition                                           | √                               | √√√                                | -                      |
| 13 | Relations between the surrounding ports                    | √                               | √                                 | √                      |

Based on table above, top five of uncertainty factors that may be affected to port planning are number (1), (2), (3), (5), and (11). To translate these factors into mathematical functions, a linear regression of statistical data from various professional institutions will be carried out. For example, development of economic that related with cargo will be taken from GDP global and changing of market demands will be taken from volume import cargo to Indonesia.

Table 2. Description of each factors.

| Initial | Uncertainty Description               | Type of Factors |
|---------|--------------------------------------|-----------------|
| A       | Total volume of cargo throughput     | Dependent       |
| B       | GDP Global                           | Independent     |
| C       | Volume of import to Indonesia        | Independent     |
| D       | Trade balance between China and USA  | Independent     |
There are also findings in the results of the expert validation phase 1, the uncertainty factors related to regulation and the role functions of port. According to the regulator, the regulations are made based on political policy and many government agencies are involved in port development. For example, in the sea territory there are two ministries from ministry of transportation and ministry of fisheries who have roles in managing sea water areas.

To find flexible option, some scenarios planning is needed. These scenarios must be able to develop and may change and adapt over time based on new knowledge and the changing circumstances [7]. Scenarios are not forecasting but they are the descriptions of future alternatives so there’s possibility where scenario planning cannot be proven when the project is constructed [8]. In this study, 4 scenarios are made based on the identified uncertainty factors. Within APP framework, each option shall be evaluated to determine which scenario is the most economically profitable. However, in this research the evaluation is only based on promising cargo projection and expert validation.

### 3.2. Result and discussions uncertainty factors RQ 2

Total cargo volume is a function of several uncertainties in the system. Uncertainty can be modelled as a trend from historical data but not for all factors due to long terms data can give different results in the present [9]. Based on the literature, historical data can be used as a model for scenario planning. Scenarios are descriptions that will be discussed in the future based on key parameters that improve the system and drivers of factors. Scenarios are developed based on uncertainty factors that will be translated into traffic analysis so that can have different throughput cargo. There are four scenarios that will be taken in the research (Optimistic expansion SC1, Business as usual SC2, Moderate expansion SC3, and Low expansion SC4). Each scenario has following characteristics.

| Description                                      | SC 1   | SC2   | SC3    | SC4   |
|--------------------------------------------------|--------|-------|--------|-------|
| Total volume of cargo throughput                 | High   | High  | Medium | Low   |
| GDP and volume import                            | High   | High  | Medium | Low   |
| Foreign and local investment                     | High   | Medium| Medium | Low   |
| Awareness of sustainability and green port       | High   | Medium| Low    | Low   |
| Trade wars impact (increasing cargo throughput)  | High   | Medium| Low    | Low   |

Ligtheringen mentioned that the assumption of scenario development planning could be wrong when the project is constructed, so a monitoring system is needed to find out new information and make the scenario more adaptive [9]. However, this research monitoring system was carried out and assumed that the four scenarios could occur in the future. These scenarios will be asked by experts on validation phase 2 to find out recommendation scenario that could occur in the future.

Based on the second validation with port expert, from four possible scenarios the recommendation scenario with the biggest chance is business as usual (SC2) due to economic growing and Cigading port can still take the opportunity from trade wars to increase the cargo. This scenario applies many conditions to what is predicted. One respondent also added that SC3 might occur if other uncertainties factors are identified and considered in the development of Cigading Port.

Cigading port cargos are dominated with coal, iron ore, steel products and grain. Volume of cargo projection is using statistical data from port operator internal report combined with the influenced of uncertainty factors to determine compound annual growth rate (CAGR) for each cargo. The CAGR rate
is also validated with port expert and port operator to get realistic cargo throughput. Total cargo throughput from the recommended scenario is summarized in table 4.

| Years | Total Volume Dry bulk (million tons) |
|-------|--------------------------------------|
| 2019  | 21.00                                |
| 2023  | 23.40                                |
| 2025  | 23.80                                |
| 2028  | 33.30                                |

4. Conclusion
The important analysis of implementing adaptive port planning is identified uncertainty factors. Based on interviews with port experts on validation phase 1, the top five that may be affected Cigading port are changing on market demand needs, development of global and regional economic that affect cargo growth, new equipment technology in the port system, trade war between superpowers country in the mineral sector and joint venture between national and international companies. These factors will be translated into functions to see the cargo throughput. However, one factor (new equipment technology) is quite difficult to measure into statistical data, we changed this factor to another factor which is alternative energy source that can be translated into function of consumption of renewable energy. This factor may also have impact with Cigading port.

This research also develops four plausible scenarios based on the uncertainty factor which are optimistic expansion, business as usual, moderate expansion and low expansion. Looking at the throughput for each scenario and validation phase 2 with experts, the higher possibility that may be happened in the future is business as usual scenario (SC2). This scenario characteristic is assumed to have high expectation on GDP and volume import but will have medium expectation on the investment, trade war impact and awareness of sustainability port.

However, the adaptive port planning framework is a continuity procedure, this research can continue for monitoring and mitigation planning so the port planning will be more adaptive based on the future needs.

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