Developing port-city conceptual design to improve regional industry competitiveness

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Abstract. As an archipelago country, Indonesia continues to face significant problems with port infrastructures and coastal area including financial shortage, complex bureaucracy not to mention development priority. Port-city is one of a city concept aims to facilitate the regional development by taking port as the hub for economic activities and mobility. This research use Dumai port in Riau Province, the Republic of Indonesia as the case study to evaluate the potential implementation of the port-city concept. Two methods are being used to evaluate the project feasibility namely life-cycle cost approach and public-private partnership scheme. It will regulate the division of responsibility between identified parties. The result shows three components to develop the concept including the port, industrial area and supporting infrastructure. This concept may generate 10.37% of the internal rate of return. This research also suggest public-private partnership scheme to generate optimum division of responsibility between each parties in the project.

1. Introduction
As an archipelago country, Indonesia has a high dependency on the marine transportation. In 2009, Indonesia's ports handled an estimate of 968 million tons of cargo [1]. The contribution of domestic and international cargo in Indonesia almost similar, with a ratio of 44% to 56% respectively. With the increasing population and economic growth, this figure will continue to increase soon.

The government attempt to respond to this need by issue the regulations of the Republic of Indonesia Number 16, 2017 about Marine policy in Indonesia. In this regulation, the government aims to improve the welfare of coastal communities and islands by developing the port and its surrounding area. One of the targeted locations in this policy is the city of Dumai, located in the Sumatera Island, and Riau Province of Indonesia. The location can be seen in Figure 1. Despite its potential to the economic growth and city expansion, the Dumai Port has no plan for expansion or terminal extended shortly.

Port cities can be effective when three factors are involved, namely a competitive port, economic growth of a city generated from port activities, and by negative impacts due to the presence of the seaport is mitigated [2, 3]. To achieve the aforementioned factors, it is essential for the city to plan
comprehensively the surrounding regions based on three essential pillars such as maritime cluster, industrial area, and urban waterfront [4, 5, 6].

![Figure 1. The City Area of Dumai in Riau Province](image)

Port-cities concept is vital to support government vision as the maritime powerhouse [7, 8]. Dumai port is one area that potentially improves the economic competitiveness and generates revenue for local government. This research aims to develop Dumai port and its surroundings by taking into account coastal city development and cost-sharing through a public-private partnership.

2. Literature Study
The most accepted development model of how the port developed into a port city was the Anyport model by Bird, which explained the expansion of the port. This model shows that port development arises due to changing maritime technology. The Anyport model will show a change from spatial relations between ports and cities. As time goes by, the port will be built away from the business center of the city. In this model, three stages occur in the development of the port and the surrounding area; setting, expansion, and specialization. (Bird, 1980). These three stages can be explained as follows:

- **Setting** is the first stage of the construction of the port. In general, the first consideration of port construction is due to geographical factors. Port usually appears as a result of marine activities, such as fisheries, and shipbuilding. Before the industrial revolution, the port had existed and developed, but it was still pure, without significant changes in the shape and function of the port and the surrounding area. Most of the port activities are related to warehousing and wholesale trade located in the surrounding area.

- **Expansion** is the stage that occurs due to the industrial revolution. The industrial revolution made industry and transportation significantly increase. The area around the port was developed to accommodate the increasing number of passenger and freight boats. Increasing the size and number of ships encourages the construction of new terminals. Also, the integration of rail lines with ports has made access to hinterland easier. Activities related to ports are now developing to cover industrial activities.

- **Specialization** is the port development stage to achieve special functions to handle goods ships such as containers, agricultural products, oil, and coal. This phase causes warehousing needs to increase dramatically. Larger capacity vessels also require the construction of deep sea ports which often lead to the construction of new ports and facilities.
Although the Anyport model explains, in general, the development of the port and the development model that can be carried out, there are still some weaknesses in Bird's view. According to (Notteboom & Rodrigue, 2005), this model does not explain the increasing port that acts as a transhipment hub in the maritime network. With the emergence of a very long shipping lane, a port with very remote land access arises because of its function as a transit point.

Also, the Bird model does not take into account the land area as a driver in the dynamics of development. Regionalization means that development is more integrated by the context of the existing land. Regionalization means that development is more integrated by the context of the existing land. This concept can be illustrated as follows:

![Figure 2. Illustration of port evolution in the concept of regionalization](image)

3. Methodology
The research follows four stages to reach the targeted result. Firstly, the study determines the components required for Dumai port development. This stage starts by identifying the needs of the port infrastructure through desk study and secondary data from similar port cities across the globe. Secondly, research methodology is determined by considering case study and conceptual design of port-city from benchmarking process. Thirdly, a life-cycle cost analysis is used to evaluate the concept design by involving initial cost, operation & maintenance, and revenue [9, 10]. The result will then processed using a public-private partnership to generate division of responsibility between both parties. Last, an in-depth interview with three Indonesian infrastructure experts will be performed to confirm the result of the life cycle cost [11].
4. Result and Discussion

4.1. Design and Development
The concept design of Dumai port-city follows the coastal development standards and related regulations. The concept design represents by zoning design on Dumai port map. Designing this zoning attempt to minimize adverse impacts such as pollution, noise, and others as well as to increase land use compatibility.

Figure 4. The concept of Dumai’s Port City in Riau Province

The zoning considers the negative impact of port and industrial area to other types of buildings and surroundings. The industrial area needs a specific space as an overall buffer as about 150 meters and 100 meters for primary buffer area. It is defined as a neutral area in between different type of buildings to minimize disturbance from one area and vice versa. In this research, 200 meters was implemented for buffer zone area and will be used for logistics area and retail. The zoning area can be seen as figure 4.

The zoning regulates the area into several districts. Port and industrial area located in the coastal area represented by white color in the above figure. The port consists of three types of the terminal; liquid bulk terminal, dry bulk terminal, and container terminal. On the other hand, the industrial area comprises of marmalade jam processing, pineapple processing, modified cassava flour (MoCaF), and crude palm oil (CPO). Detail of the other nine districts can be seen in Table 1.
Tab 1. The design concept in the area of Dumai Port-City

| Zone                          | Color | Area (Ha) | Information                                                                 |
|-------------------------------|-------|-----------|-----------------------------------------------------------------------------|
| Port & Industrial Area        |       | 390       | Supported by water treatment plant, wastewater treatment plant and renewable power plant |
| District 1                    |       | 29        | Commercials consist of retail and warehouse                                 |
| District 2                    |       | 35        | Warehouse area                                                               |
| District 3                    |       | 46        | Retail, park, business, modern market and resort                             |
| District 4                    |       | 43        | Residential (low rise building and landed house)                             |
| District 5                    |       | 22        | School, hospital, and commercials                                           |
| District 6                    |       | 82        | Residential (villa and landed house)                                        |
| District 8                    |       | 40        | Landed house and allocated for high-income                                  |
| District 9                    |       | 47        | Landed house and allocated for middle to low income                         |

4.2. Initial Cost
The initial cost of the port consists of a liquid bulk terminal, dry bulk terminal, and container terminal. Liquid bulk terminal divided by dock, mooring, and storage. The dry bulk terminal has larger components than the liquid terminal by adding types of equipment, warehouse and stacking field. The industrial area that consists of several industries has its particular components and related types of equipment. Initial cost also considers land acquisition and reclamation as well as required utilities such as power plant, water treatment plant and wastewater treatment plant. The assumptions in determining the cost of components are based on various standards such as ARCADIS and standard from Ministry of Public Works. The summary of the initial cost of the project can be seen in the following table.

Table 2 (a). Breakdown Cost of Port-City Concept in Dumai

| No | Component                        | Cost of Investment (US$) |
|----|----------------------------------|--------------------------|
| 1  | Port Terminal                    |                          |
| a  | Liquid terminal                  | 18,356,421.48            |
| b  | Dry bulk terminal                | 32,950,330.21            |
| c  | Container terminal               | 211,305,552.92           |
| 2  | Industrial area                  |                          |
| a  | Marmalade jam                    | 1,286,267.33             |
| b  | Pineapple processing             | 4,097,759.94             |
| c  | MoCaF                            | 61,666.67                |
| d  | CPO                              | 43,457,283.41            |
| 3  | Land                             |                          |
|    | Land acquisition                 | 1,609,057,514.40         |
|    | Reclamation                      | 26,337,067.67            |
4.3. Operation and Maintenance
Operation and maintenance (OM) cost in the study considered the functions that consist of the port, industrial development and supporting infrastructure. The OM cost considered the operational stages of each function and divided into three; 2023, 2025 and 2027. The assumption to generate the OM baseline cost derived from various reports and standards such as the Ministry of Public Works, local government standard and literature study. These costs are increasing by follows inflation of about 5.12%. The OM cost of each function is summarized in the following table.

Table 3. Operation and Maintenance Cost of Dumai’s Port City

| No | Component               | 2023       | 2025       | 2027       |
|----|-------------------------|------------|------------|------------|
| 1  | Port                    | 3,458,344.12| 3,845,575.78| 4,276,165.86|
| 2  | Industrial development  | 9,898,459.11| 19,261,886.09| 30,598,063.27|
| 3  | Supporting Infrastructure| 5,531,978.39| 10,764,941.94| 17,100,421.69|
|    | TOTAL                   | 18,888,781.62| 33,872,403.81| 51,974,650.82|

4.4. Revenue
Revenue is generated from particular functions in the conceptual design of Dumai Port City. It consists of fourteen sources of income such as retail, warehouse, resort, business area, modern market, low-income apartment, landed house, schools (elementary, junior high, senior high), hospital, hotel, villa, and malls. The size of each source will be divided which one being sold, rent, charged retribution or other means of income collection.
Table 4. Source of Income for Project Revenue

| Sources of Income   | Category            | Charge       | Unit   |
|---------------------|---------------------|--------------|--------|
| Retail              | Sell                | 109,375.00   | Per unit |
|                     | Rent                | 7,291.67     | Per m²  |
|                     | Retribution         | 3.33         |         |
| Warehousing         | Sell                | 68,333.62    | Per unit |
|                     | Rent                | 6,212.15     | Per unit |
| Resort              | Rent                | 885.42       | Per unit |
| Business Area       | Sell                | 445,601.85   | Per unit |
|                     | Rent                | 40,509.26    | Per unit |
| Modern Market       | Rent                | 340.28       | Per unit |
|                     | Sell                | 10,264.40    | Per unit |
| Low-income apartment| Rent                | 598.76       | Per unit |
|                     | Retribution         | 3.33         | Per m²  |
| Landed House        | Sell                | 128,685.90   | Per unit |
|                     | Rent                | 4,289.53     | Per unit |
|                     | Retribution         | 3.33         | Per m²  |
| Elementary School   | Building maintenance| 191.67       | Per student |
|                     | Tuition             | 327.75       | Per student |
| Junior High School  | Building maintenance| 263.54       | Per student |
|                     | Tuition             | 396.75       | Per student |
| Senior High School  | Building maintenance| 263.54       | Per student |
|                     | Tuition             | 396.75       | Per student |
| Hospital            | Rent                | 8,450.87     | Per patient |
| Hotel               | Rent                | 18,325.00    | Per room |
|                     | Sell                | 58,603.74    | Per unit |
| Villa               | Rent                | 2,930.19     |         |
|                     | Retribution         | 5.83         | Per m²  |
| Mall                | Rent                | 1,763.24     | Per room |

Those sources of income that is sold to the users such as retail, warehouse, business area, low-income apartment, landed house and villa estimated to complete in five years after the construction stage. On the other hand, hospital revenue is based on 60% of patient occupancy rate. Further, income from schools is from building maintenance and tuition fees.

From the initial cost, operation and maintenance cost and revenue from each function in the project, the result shows an internal rate of return for about 10.37%. An industrial area, mainly palm oil processing, contributes a more considerable revenue, thus affect positively to the overall revenue of the project. However, this rate of return is slightly below the expected weighted average cost of capital (WACC) from construction company/investors perspective as about 11%. Thus, a public-private partnership scheme will be used to analyze further the project to reach an expected rate of return.

4.5. Financial Analysis

In conducting the financial analysis, the research has to reach a specific value of WACC by the companies. It is a capital calculation from the corporation by taking into account the equity, debt and debt ratio from the internal company [12]. The value varied among others, for instance, the industrial sector has 10.51% of WACC. While the chemical sector shows 11.51%, real estate around 11.10% and health sector about 10.31%. Chemical sector is the highest WACC related to the project; therefore this value is set for the baseline for financial analysis. The value must be surpassed in order the project declared feasible in term of technical and financial consideration.

The research analyzes 42 scenarios to generate an optimum result of sharing between the public and private investors. The division of responsibility between two parties conducted in four models; initial
cost, operation, and maintenance cost, initial cost and operation, and maintenance cost as well as initial cost, operation and maintenance cost. In initial cost, three scenarios were delivered, a 60% government sharing with 40% private, equal distribution and 40% government and 60% private. Moreover, the result shows that 40% of share from the government reach a rate of return of about 15.88%. It is a typical scheme that has been applied in many other nations through build-operate-transfer, where the government support the infrastructure and private gain the revenue and maintain the infrastructure. Surely the public may access the infrastructure, but sunk cost from government relatively large and sometimes may affect the state budget.

The second model is the sharing conducted in operation and maintenance. The scheme generates three scenarios with a similar division of responsibility from initial cost. Limited implementation found using this type of model around the world, and the result shows insignificant IRR. Scenario 4 as the government contributes about 60% of operation and maintenance cost produce 12.02% of IRR. While the lowest, produce 11.49% of IRR.

The third model is sharing concept in initial cost and operation and maintenance cost. Nine scenarios were evaluated, and the lowest IRR about 17.49% and the highest is 25.93%. This scheme offers a higher rate of return for the private investors due to government involvement in the initial stage and operation and maintenance stage. In contrary, the government has to bear a higher cost to accommodate not only initial cost but also operation and maintenance cost.

The fourth model proposes a cost-sharing in every project life cycle including the revenue. A 27 scenario was elaborated by this research, and the result shows a range of rate of return started by 14.04% to 20.88%. The maximum IRR is used as the baseline for further evaluation where the private contributed 40% in initial cost and operation and maintenance cost and gained 80% of the profit from the project.

The evaluation was conducted by dividing each function in the project to either belong to private or public responsibility. For instance, private will contribute for industrial construction (70% of palm oil, marmalade industry, MoCF processing industry and pineapple processing industry), 40% of reclamation and mixed-use area (road, greenery, mosque, retail, ware house, business area, resort, landed house, schools, hotel, villa, and mall). The government contributes in industrial construction (30% of palm oil), 60% of reclamation, land acquisition, utilities (power plant, WTP, and WWTP), port (dry bulk terminal, liquid terminal, and container terminal) and mixed-use area (modern market, low-income apartment, and hospital). The detail of the division of responsibility between private investors and government summarized in figure 5.

Figure 5. Division of Responsibility between the Government and Private Investors

Based on the above division of responsibility, the final scene is produced. The government should support the initial cost about 59.38% and invest in operation and maintenance around 31.74% but obtained revenue of 33.96%. This scheme generates optimum IRR about 15.41%. It is argued that the
value is adequate to attract private investors to the project and the support from the government gained maximum benefits for the people.

5. Conclusion
The port-city concept aims to support government vision as a global player in maritime transportation. Its existence also attempts to improve regional competitiveness by creating new economic activities and increase the connectivity and mobility of people and goods. This research use a case study of Dumai Port in Riau Province, Republic of Indonesia. The result shows that the port city may consist of port, industrial area, and supporting infrastructure. Port divided into the liquid terminal, dry bulk terminal, and container terminal. The industrial area comprises of marmalade jam processing, pineapple processing, modified cassava flour and palm oil. The last type of industry is the highest contributor among others in term of revenue. Last, utilities consist of a renewable power plant, water treatment, and wastewater treatment plant.

The life cycle cost analysis illustrated the concept of the port city in this research generates 10.37% of the internal rate of return. An evaluation through sharing concept in every construction project stages proposes a significant increase of IRR to 15.41%. The scenario suggests the private contributes 40.62% of the cost in the initial stage and 68.87% of the cost in the operation and maintenance stage. From that share, they will receive 66.04% of the total project revenue.

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References
[1] Nathan Associates 2011 Technical Inputs for NPMP Revision Final Report. Jakarta: Australia-Indonesia Partnership Indonesia Infrastructure Initiative
[2] Merk O 2014 The effectiveness of port-city governance. Alix, Y. Delsalle & B. Comtois, C.(eds) Port-City governance. Editions EMS 233 245
[3] Berawi M A, Miraj P, Gunawan, and Islamiah E R 2018 IOP Conf Ser Earth Environ Sci 1977 040001
[4] Hesse M and Rodrigue J P 2006 Growth and Change 37 499
[5] Jung B M 2011 AJSL 27 1
[6] Hall P and Clark A 2004 Transforming urban waterfronts: fixity and flow 17
[7] Gipouloux F 2011 The Asian Mediterranean: port cities and trading networks in China, Japan and South Asia (Edward Elgar Publishing)
[8] Hoyle B S 1989 Geoforum 20 429
[9] Berawi M A, Ibrahim B E, and Miraj P 2019 JDBE 19 40
[10] Rahman H Z et al 2018 IJTech 3 549
[11] Berawi M A, Susantono B, Miraj P, and Nurmadinah F 2018 Aviation 22 115
[12] Fernandez P 2010 Business Valuation Review 29 4