E-ISSN : 2541-5794
P-ISSN : 2503-216X

Journal of Geoscience,
Engineering, Environment, and Technology
Vol 03 No 01 2018

The Phenomena of Flood Caused by the Seawater Tidal and its Solution for the Rapid-growth City: A case study in Dumai City, Riau Province, Indonesia

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Received: Jan 13, 2018. Accepted: Feb 23, 2018, Published: 1 March 2018
DOI: 10.24273/jgeet.2018.3.01.1221

Abstract

A strategic city located on the northern coast of Sumatera Island known as Dumai City. This city is a growth and industrial city that always increase everyday economically. This city faces the flood problem that not only from the excess water from the rain, but also from the phenomena of seawater tidal. The tidal should not reach the mainland for the ideal situation, but the urbanization and development problem made it happen. Field observation and satellite data analysis shows the problem that happened in this city, also find out the solution how to make the seawater tidal will not being the flood when it occurs. The flood caused by the inadequate drainage condition is exacerbated by the low awareness of people who still do not maintain cleanliness, a lot of garbage that accumulates in the drainage causing the process of water flow to be inhibited. Geologically, the base rock of Dumai City consists of sand and peat which logically is a good system to absorb water because sand and peat are materials that have high porosity. Topographically, the city of Dumai is at an average height of three meters above sea level, so in fact, this city could be spared from the flood caused by the tide when it occurs. The solutions that can be proposed for this city are making the rivers being clean with normalization, well-designed drainage, Watergate and making an artificial lake for sinking the tidal seawater.

Keywords: Dumai City, Flood, Tidal, Urbanization, Environment

1. Introduction

Dumai City (Figure 1) is a strategic city (Budidarsono et al., 2013) located on 101^0.23'.37"-101^0.8".13' East and 1^0.23'.23"- 1^0.24'.23" North on the northern coast of Sumatera Island, making it economically provide hope and opportunity (Habibah et al., 2013) for people to settle and move in the largest city in Indonesia based on their area. The city has an area of 2,039.35 km² and has 316,668 inhabitants in 2014.

The problem appears when urbanization activities increased in Dumai City, with high community activity and development, giving a tremendous impact on environmental issues (Alkhatib et al. 2007; Amin et al., 2009; Badrun, 2017), especially those related to tidal phenomena.

The tidal of sea water (Lubis et al.[a,b], 2017) that caused flooding (Harwitasari and Van Ast, 2011; He et al., 2007) in many parts of Dumai city. But now, the flood that only happened around the mouth of the river and around the shore at the past time, extends to most areas of the city.

This issue if left continuously will make Dumai City will one day drown when the tide of seawater occurs (Lubis et al., 2017). This time count depends on the growth rate of development and urbanization improvement in Dumai City, especially since Dumai has been declared as one of the National Strategic Industrial Cities, it is not impossible that the sinking of Dumai City will be faster.

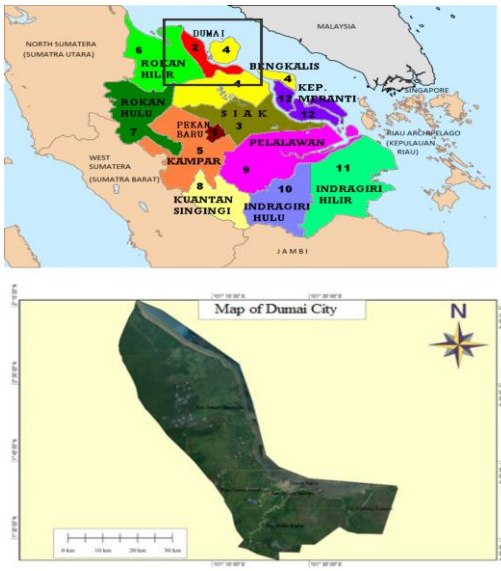


Fig. 1. Riau Province in Sumatra Island (above) and Dumai City as the research area and a part of Riau Province (below).

2. Problem Background

As a city on the coast, of course, Dumai City has a problem that can not be separated from the influence of the tide of sea water (Largier and Taljaard, 1991; Marfai et al., 2008). This problem is also faced by cities in other parts of the world, such as Chiba City in Japan, Amsterdam in the Netherlands, Goldcoast in Australia and many others. But cities in developed countries never experience flooding when tides occur (Marfai and King, 2008). It is also certainly influenced by good residential governance in this city.

The high number of development gives new problems to think about how to "run" the water from the flood. Currently, indeed The Local Government of Dumai City is actively making drainage, but this drainage is still not able to accommodate excess water discharge during the occurrence of pairs or rain.

The inadequate drainage condition is exacerbated by the low awareness of people (Figure 2) who still do not maintain cleanliness, a lot of garbage that accumulates in the drainage causing the process of water flow to be inhibited.

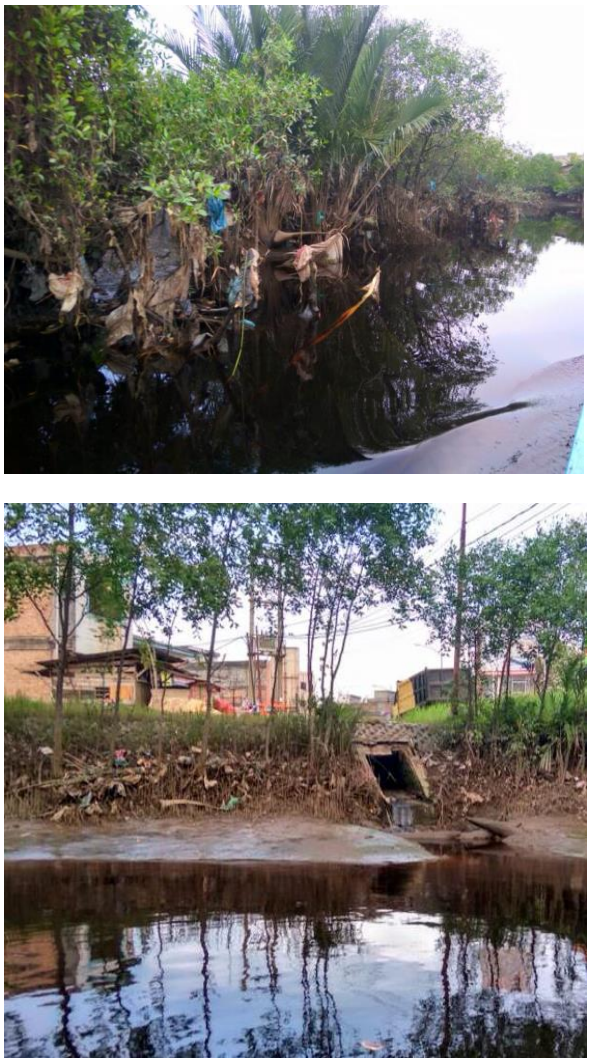


Fig. 2. Above and below: the low awareness of environment cleanness by the citizen.

3. Material and Method

For this research, we used some material and method to conduct and find the problem. One of them is field observation for the field measurement regarding the tidal flood. Results prove when the tide of seawater happened, the half-city area from the estuary to the central part of the city has been drowned (see Figure 2).

Compared to the past (within a matter of two decades), the Dumai City area experiencing flooding from tidal water has increased, meaning that the distribution of flood-affected areas now extends to the center of the city.

Geologically, the base rock of Dumai City consists of sand and peat which logically is a good system to absorb water because sand and peat are materials that have high porosity. Topographically, the city of Dumai is at an average height of three meters above sea level, so in fact, this city could be spared from the flood caused by the tide when it occurs.

The method was used in software (global mapper) is analyze contours using srtm map as a base map, the result of the analysis is a map of elevation or topographic the area. The Simulate Water Level Rise/ Flooding command allows the user to simulate the water coverage/ flooding if increase the water level by some depth over either a fixed single elevation (like 0 for sea level) or from a selected area feature, like a floodplain area. Other data used in addition to field observations are topographic data of SRTM (Sumatera srtm 57_12) and Landsat 7 (Kausarian et al., 2016; 2017; 2017). Topographic (Figure 3) and satellite data processing of Dumai city that has been used, then processed and simulated for the ideal condition of Dumai city into the potential water rise for this city.

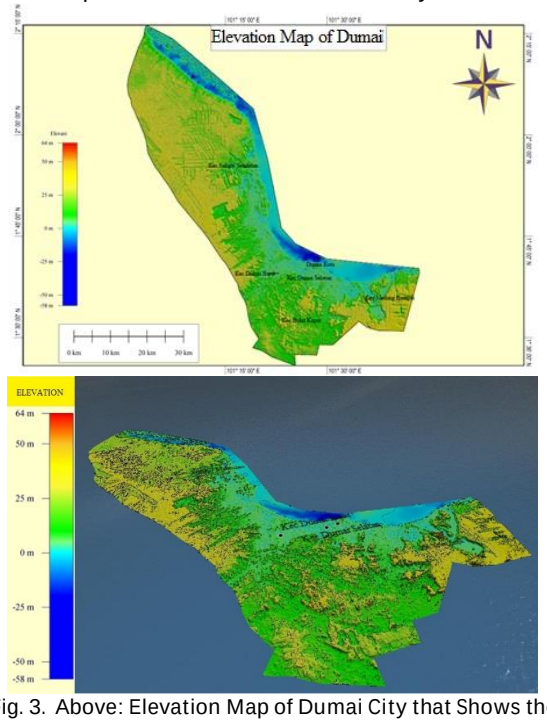


Fig. 3. Above: Elevation Map of Dumai City that Shows the Topographic Pattern, below: 3D morphological map of Dumai City

4. Result and Discussion

From the field observation and data analysis, the spatial arrangement based on the geology setting, geography, and topography of the area that influenced by the tide is different. For the Dumai city, actually greatly benefited by geography, because in front of this city there is an island named Rupat (Butar Butar and Fidiatur, 2016; Kausarian et al., 2017) which naturally becomes a protective shield from the swift currents coming from the Straits of Melaka.

Geologically, the base rock of Dumai City consists of sand and peat which logically is a good system to absorb water because sand and peat are materials that have high porosity. Topographically, the city of Dumai is at an average height of three meters above sea level (Figure 4), so in fact, this city could be spared from the flood caused by the tide when it occurs. And when the sinking simulation has been made, the city will be drowned when the water comes in 5-50 meters high (Figure 5). The simulation of the total area that will be drowned by the tide phenomena can be seen in table 1.

Satellite data shows the river flow in Dumai City consists of meanders, this is advantageous can accommodate the amount of water debit in high volume, so if the rivers used properly, for example by doing addition depth and normalization, this could serve as a catchment area of excess water caused by tidal phenomena in Dumai.

Moreover, Dumai City is supported by 15 rivers, so that when the tide occurs, this problem can be solved well, because the research data shows the maximum tide that occurs only as high as three meters. Another thing that can be taken into consideration is to make a water gate that must be higher than when the maximum tide.

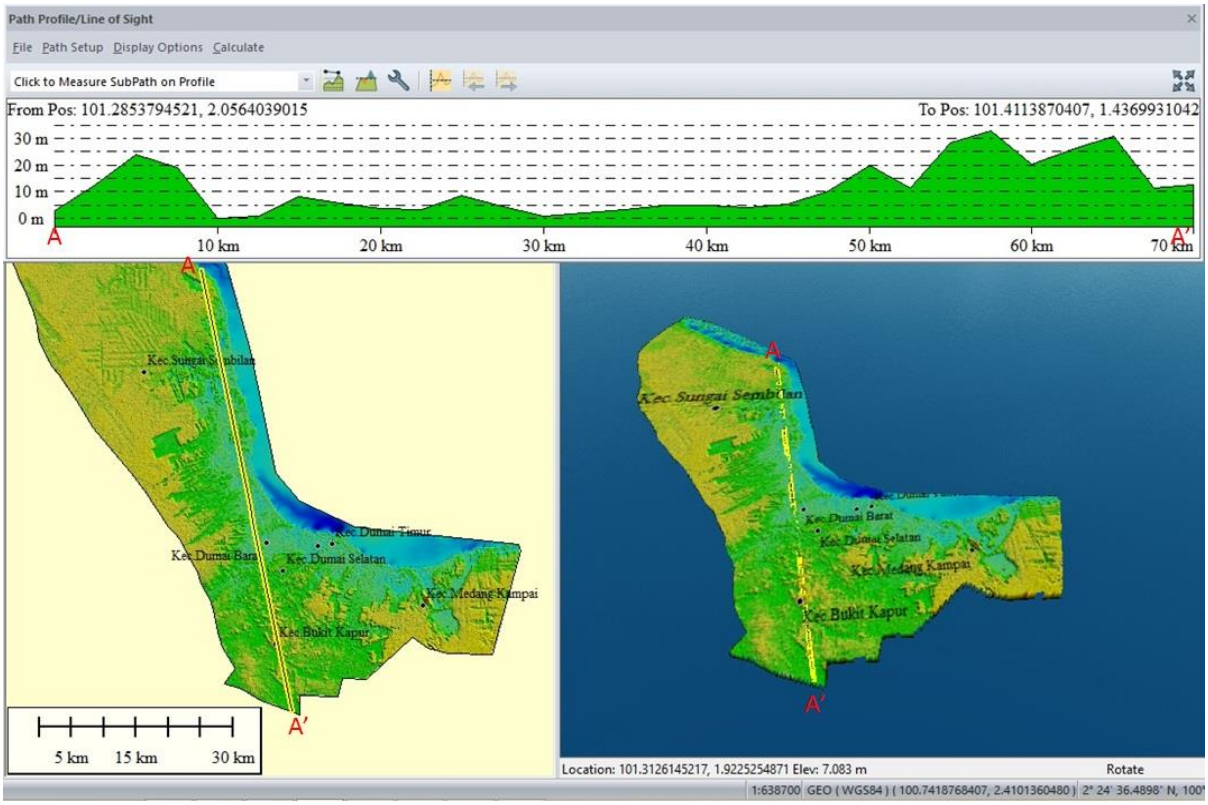
When the tide occurs, the water gates lead to the sea can be closed, so that at high tide, the water is not too much into the mainland.

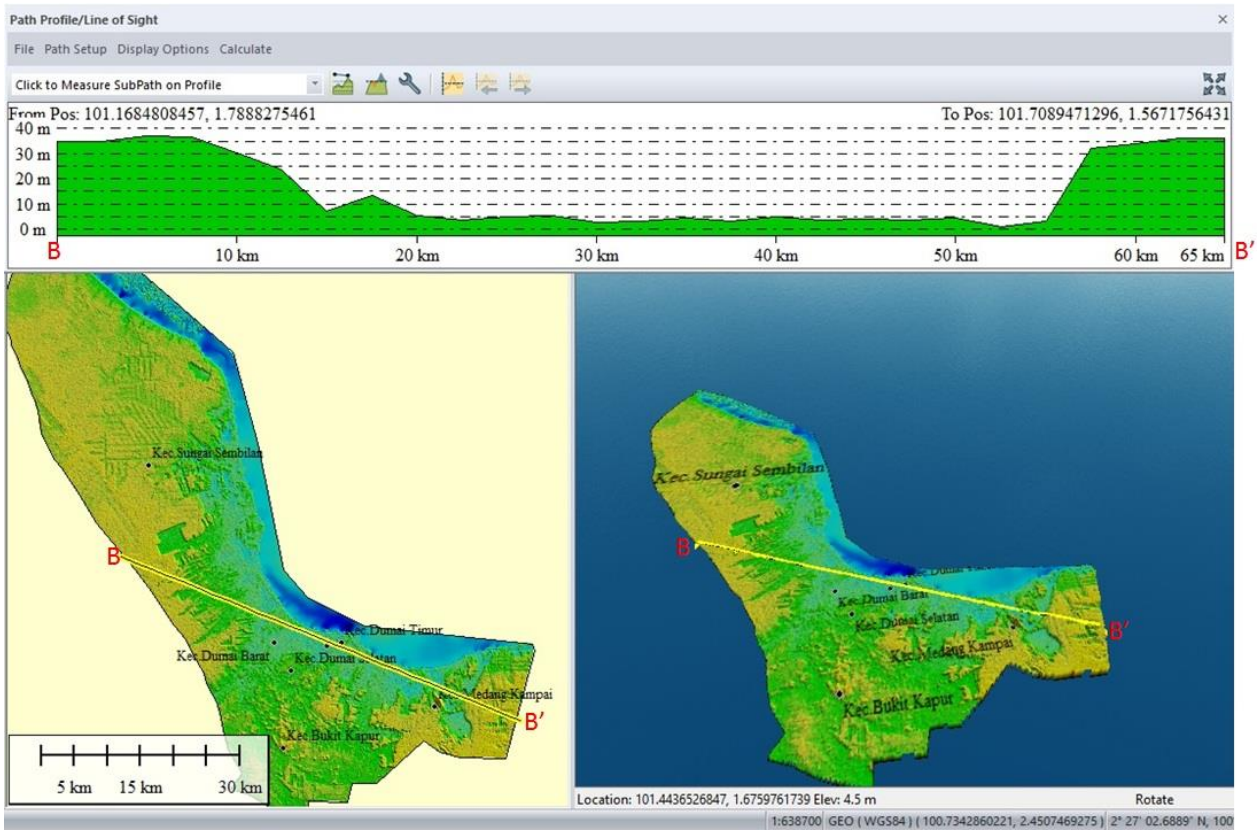
Another proposal is to do water bank trapping pattern, this concept is made by engineered the flow of water by making canals at some point and collected in one catchment area.This can be developed in another direction, such as making artificial lake as one of the alternative tourist entertainment for residents in Dumai.

Finally, of course, by taking advantage of the participation of companies engaged in activities at the sea edge of Dumai City. The Local Government entitled to ask them to participate to actively fix the beach, for example by raising the area of the beach, making water gates flow of the estuary.

Table 1. The prediction of the affected area caused by tide flood by the simulation of the water high.

No.	Water level (in meter)	Flood area (m^2)
1.	0	0
2.	3	1,117.4
3.	5	4,696.3
4.	10	9,565.5
5.	15	16,613
6.	25	19,367
7.	35	20,268
8.	50	21,744

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To Pos: 101.7089471296, 1.5671756431
40 m
30 m
20 m
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0 m
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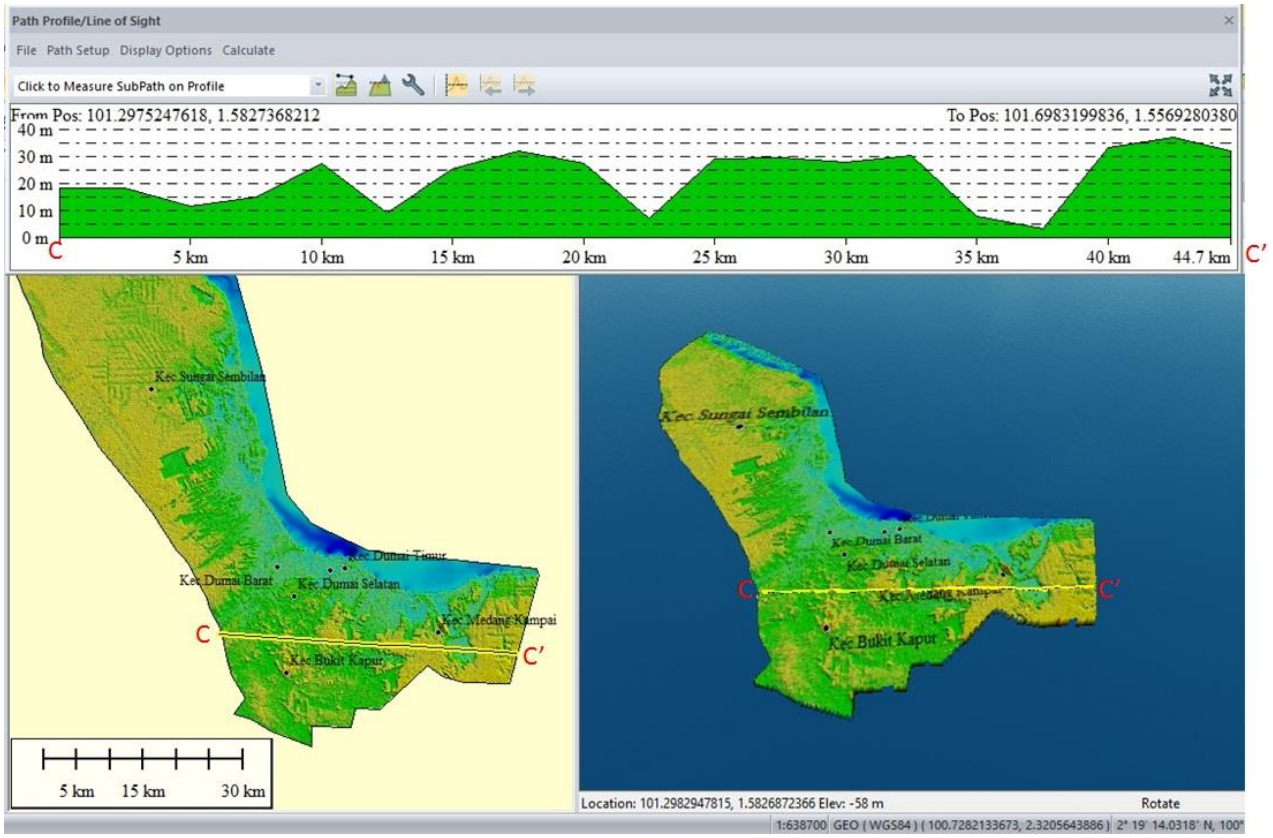
10 km
20 km
30 km
40 km
50 km
60 km
65 km
B'
Kec Sungai Sembilan
Kec Dumai Timur
Kec Dumai Barat
Kec Dumai Selatan
Kec Medang Kampai
Kec Bukit Kapur
5 km
15 km
30 km
Location: 101.4436526847, 1.6759761739 Elev: 4.5 m
Rotate
1:638700 GEO (WGS84) (100.7342860221, 2.4507469275) 2° 27' 02.6889" N, 100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35 km
40 km
44.7 km
C'
Kec Sungai Sembilan
Kec Dumai Timur
Kec Dumai Barat
Kec Dumai Selatan
Kec Medang Kampai
Kec Bukit Kapur
5 km
15 km
30 km
Location: 101.2982947815, 1.5826872366 Elev: -58 m
Rotate
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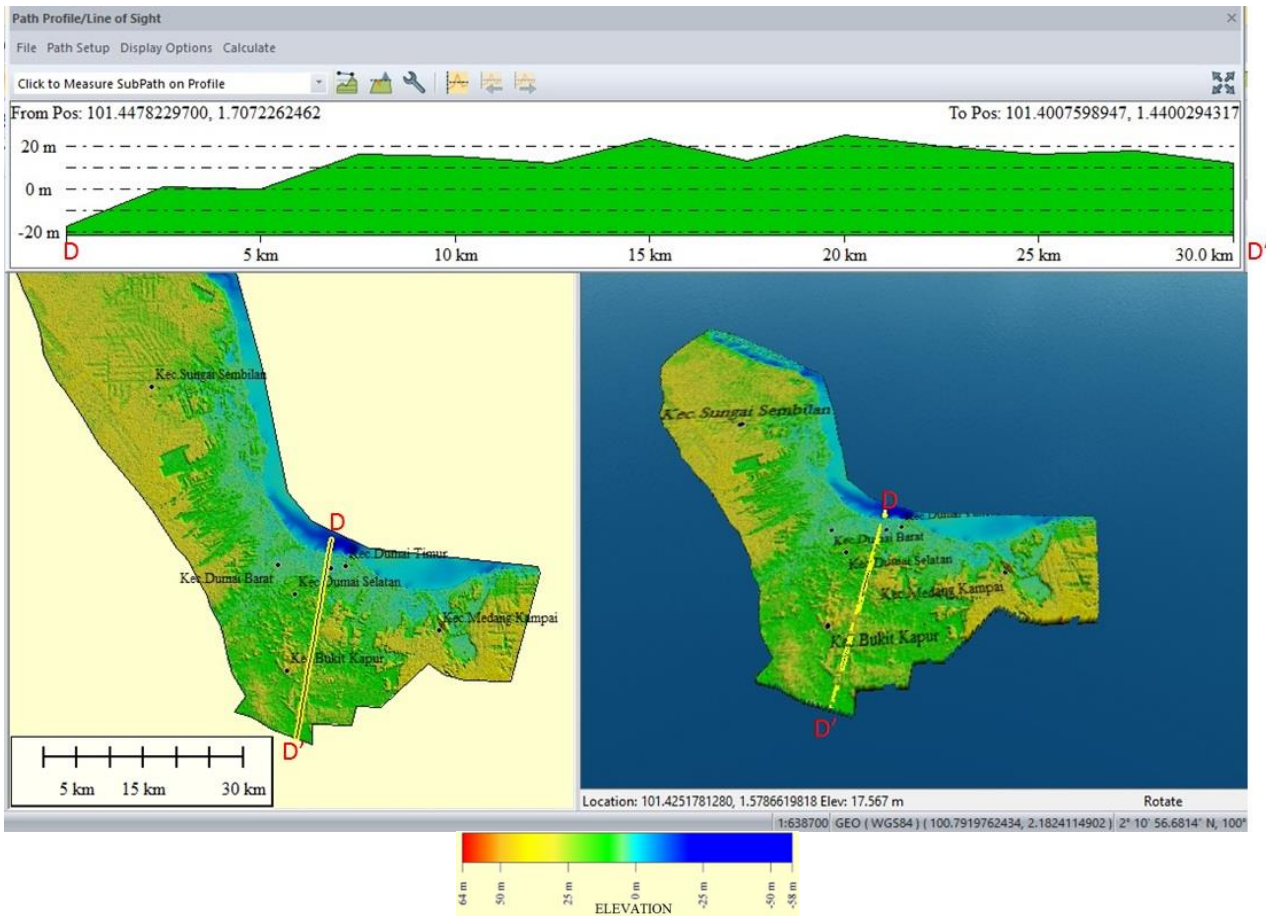
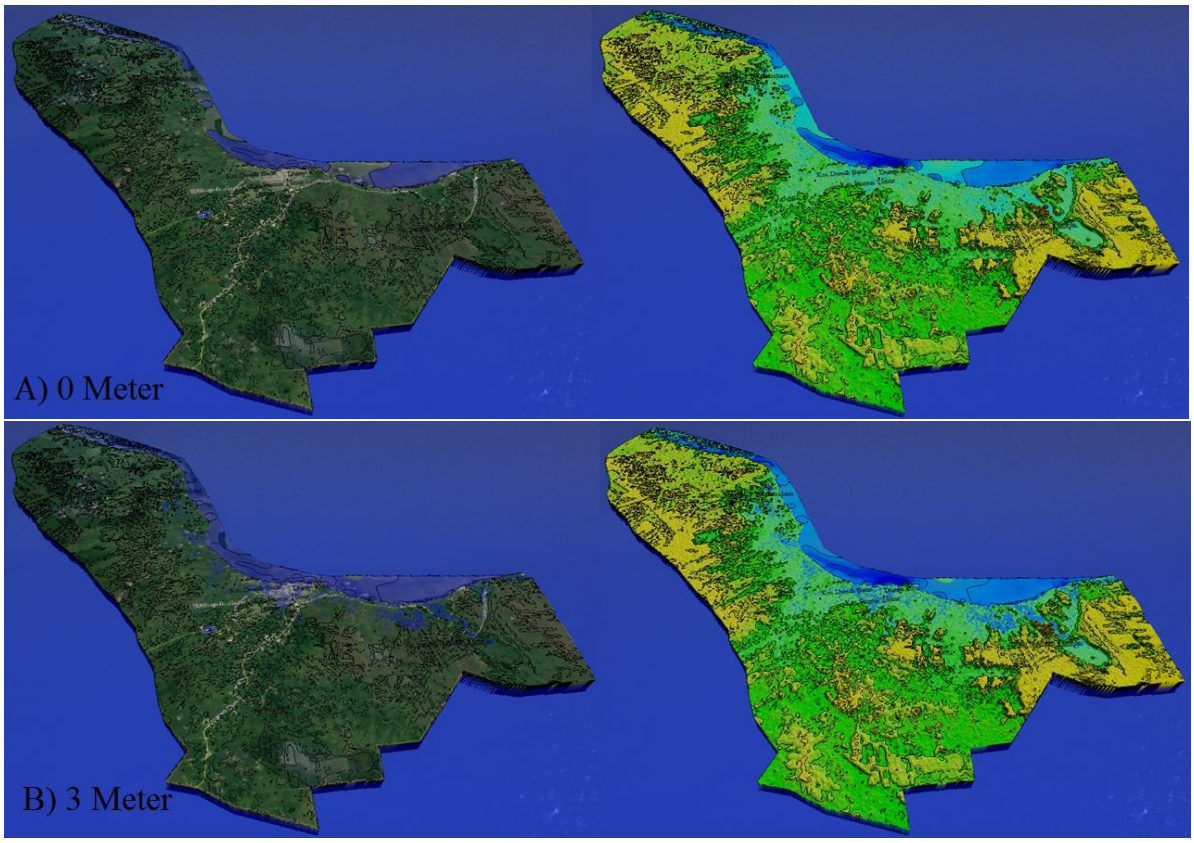
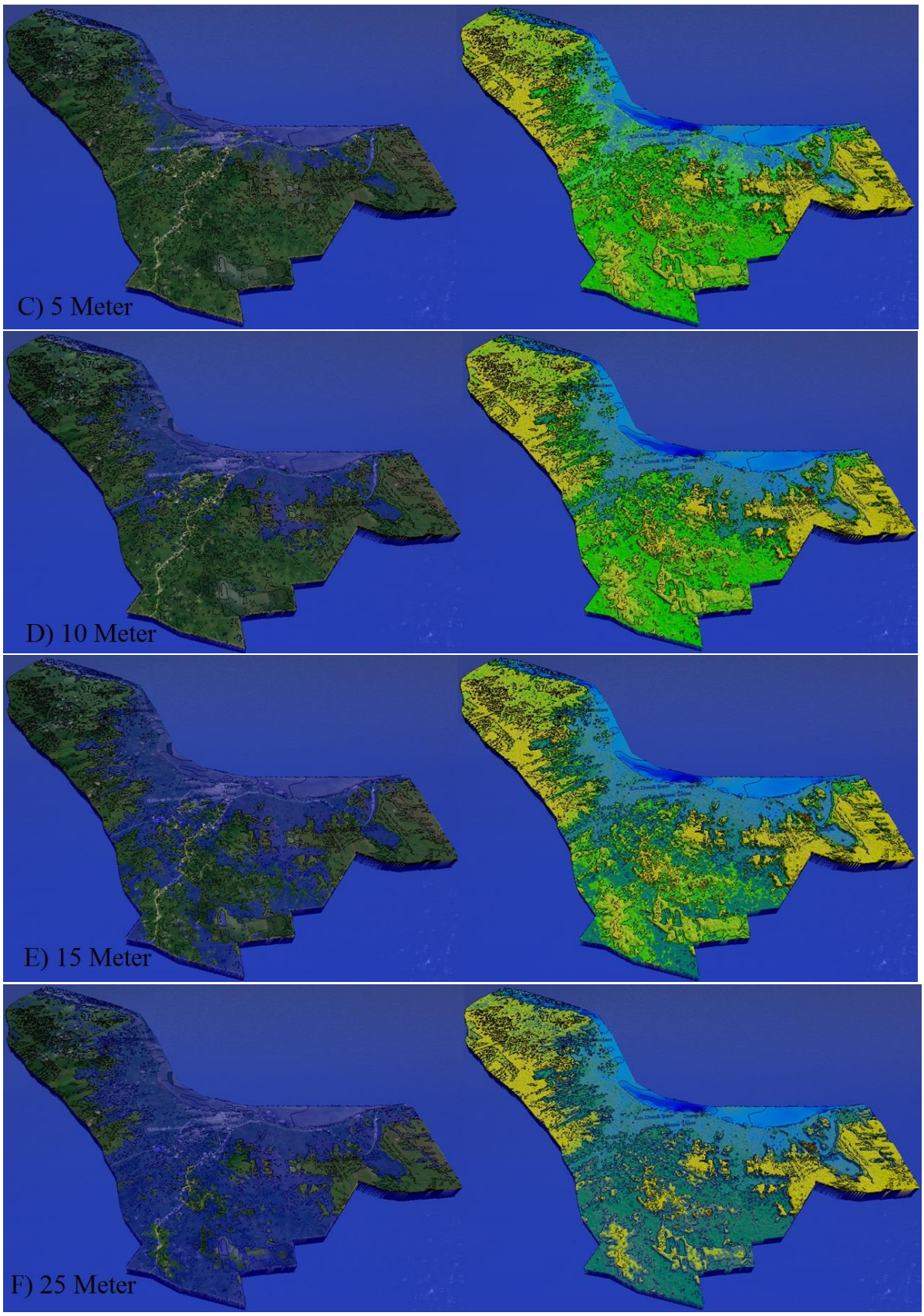


Fig. 4. The Cross Section for the Potetial Area of Dumai City as the Representative of Flood Possible Based on the Topography Profile. (Clockwise: A-A': From North to South, B-B': From Northwest-Southeast, C-C': From West-East, D-D': From Northeast-Southwest).




C) 5 Meter
D) 10 Meter
E) 15 Meter
F) 25 Meter

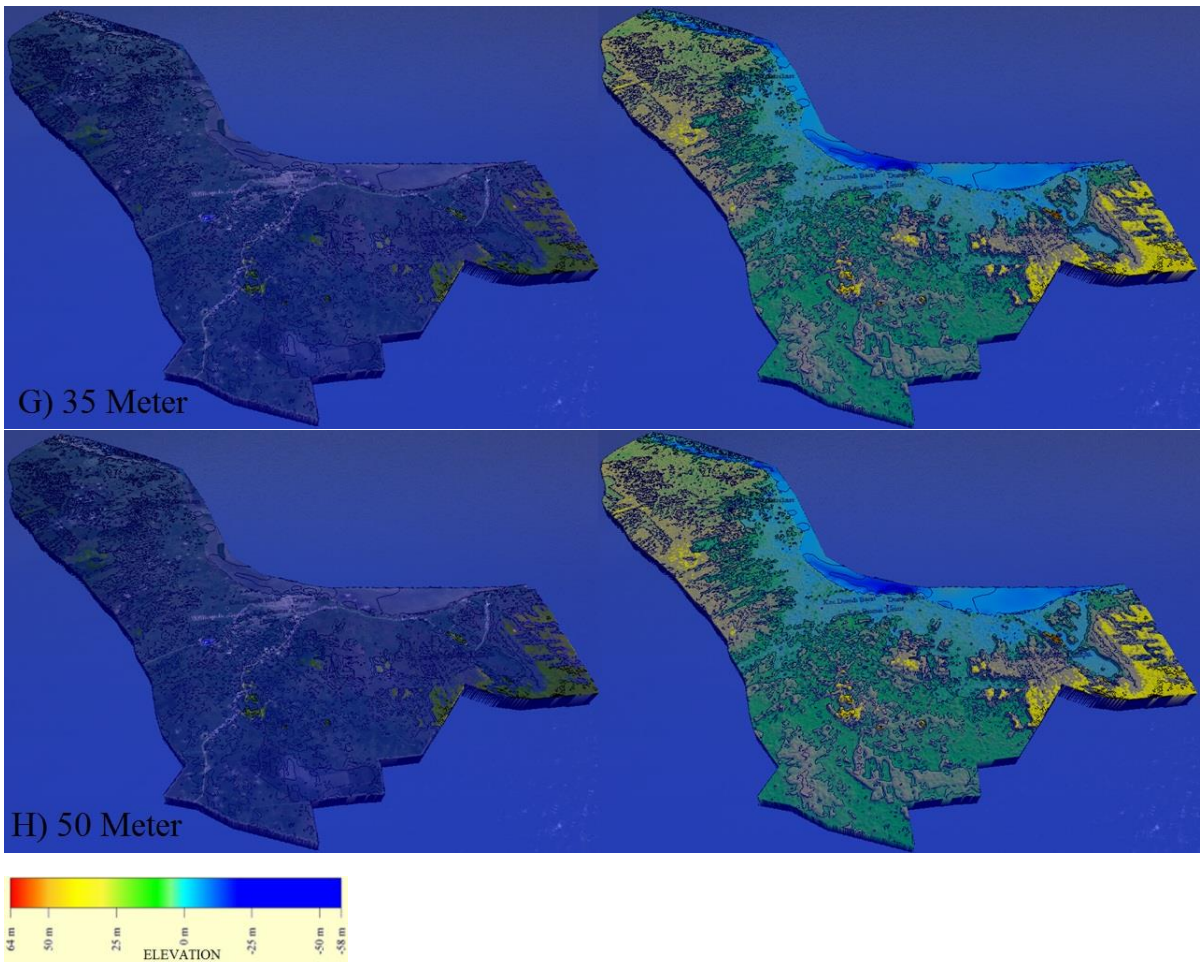


Fig. 5. The Simulation of flooding in Dumai City for the Ideal Condition, from the Simulation, the water height that can caused the flood is above 3 meters.

5. Conclusion

To overcome the flooding problems caused by the tidal seawater in the Dumai City, a thorough review needs to do that involves all aspects. Dumai City which continues to grow as an industrial city, need special treatment and attention in the future development. Especially for issues related to urbanization and the environment. The solution for the flooding phenomenon caused by the tidal water in this city should be increased as early as possible in order to avoid complex problems that will arise later.

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