

# Cilegon's water crisis towards meeting sustainable development target

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**Abstract.** This paper discusses efforts in building the sustainability of coastal cities against the water crisis, with the study area in Cilegon, Banten Province. The study results in several studies that estimate that Cilegon will experience a water crisis in 2025. This is a challenge, especially in the effort to fulfill the sixth global target of Sustainable Development Goals, namely to fulfilling 100% clean water needs by 2030. To answer the research question, this study uses a system dynamic method by observing the simulations of relations between variables to be able to balance the gap between clean water needs and the availability of clean water in Cilegon. This study found that to balance this gap, Cilegon had to make technical engineering efforts to increase water availability and make a social engineering effort by reducing their needs for water. So the balance between the need and the availability of water will be achieved in 2030 in accordance with the SDGs target. This study recommends that in order to achieve the sustainability of a coastal city with clean water, a systematic effort is needed by managing the balance between the needs and availability of water in the coastal city.

## 1 Introduction

Sustainable Development Goals (SDGs) is a global action plan agreed by world leaders, including Indonesia, to end poverty, reduce inequality, and protect the environment<sup>[1]</sup>. The SDGs consist of 17 Goals and 169 Targets that are expected to be achieved by 2030. One of the SDG goals, namely Goal Number 6, is to ensure the availability and management of sustainable clean water and sanitation for all<sup>[2]</sup>.

Based on the 2018 National Socio-Economic Survey, the condition of fulfilling access to drinking water in Indonesia is currently only around 61.29%<sup>[3]</sup>. This figure is certainly still far from the target of achieving 100% access to safe drinking water nationally in 2030, as a commitment to realize the principle of No One Left Behind<sup>[4]</sup>.

Water itself is a limited natural resource<sup>[5]</sup>, and although Indonesia is a tropical climate country with fairly high average rainfall (more than 2,000 mm per year)<sup>[6]</sup>, in fact, Indonesia is actually expected to be experiencing a clean water crisis in 2025<sup>[7-8]</sup>. Instead of meeting

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the target of 100% of Indonesian people will have access to clean water if Indonesia is not careful; instead, it is trapped in a clean water crisis.

Cilegon City is a large city in Banten Province. Cilegon City is also a Coastal City because it is dealing directly with the Sunda Strait, which divides Sumatra Island and Java Island. The Sunda Strait is also a crossing point of the Indonesian Archipelago Sea Channel 1, so that the City of Cilegon grows and develops as one of the centers of industrial activity in Indonesia. The geostrategic advantage of the City of Cilegon as a coastal city encourages the development of the five functions of its coastal cities, namely settlements, urban areas, industry, tourism, and conservation<sup>[9]</sup>. The industrial function in the coastal city system is the function with the greatest growth rate, reaching up to 14% annually. This high industrial growth rate then triggered the high rate and amount of water demand in the city of Cilegon, while the community in most districts in the city of Cilegon have complained about the symptoms of the water crisis<sup>[10]</sup>, and the current water crisis is increasingly widespread<sup>[11]</sup>.

Cilegon City is currently only dependent on the Cidanau watershed, which is the main water source for the Krenceng Reservoir to meet all water needs in Cilegon City<sup>[12]</sup>, but PDAM Cilegon Mandiri as the provider of water needs for the City of Cilegon, said that as a result efforts to expand the activities of a number of industries, the availability of water at this time is insufficient to serve the additional needs of the community let alone increase industrial capacity<sup>[13]</sup>. This situation is a serious problem because 54.62% of the Gross Regional Domestic Revenue (GRDP) of Banten Province is contributed from the heavy industry and trade activities of the City of Cilegon<sup>[14]</sup>. So that the decline in the industrial growth rate of the City of Cilegon will not only affect the City of Cilegon but also for the Province of Banten to the National.

This situation is basically a classic problem where the City Government of Cilegon must take consideration in prioritizing the availability of water to maintain the Cilegon City Industrial Growth Rate or prioritizing the fulfillment of water for its communities. Basically, industrial activities are correlated with economic growth, community welfare, and poverty alleviation, which is the SDG's first goal. Whereas the fulfillment of access to water is the sixth objective of the SDG. So that opposing the two is not a discussion that must be raised, but how efforts to meet access to clean water to the people of the City of Cilegon while still maintaining the fulfillment of water needs for the industry is the question that will be answered in this study.

## 2 Method

This research is basically an effort to meet a coastal city's water needs in Indonesia to be sustainable. In an effort to achieve this goal, researchers conduct research with a quantitative approach because this research will be based on field studies, secondary data analyzes, in-depth interviews with stakeholders, and analysis of measurable variables; so that researchers are not biased in the implementation of theoretical testing of the situation on the ground, as well as to develop models and develop strategies needed.

In this study, the method used is the system dynamics analysis method to produce output in the form of a simulation of water resource balance in the City of Cilegon. The built water balance sheet system will be based on a discount ratio or the next to one, with the need for water as an asset and water availability as a liability. The water demand sub-system will consist of five sub-system functions of coastal cities, namely settlements, urban areas, industry, tourism and conservation. While the water availability sub-system will consist of four water sources available in the city of Cilegon, namely Cidanau river water collected in the Krenceng Reservoir, surface ground water, and collected rainwater, and desalinated seawater.

Cilegon City was chosen as a research location because Cilegon City fulfilled the consideration of determining the study area requirements, namely: an independent city, a coastal city that has geostrategic advantages, and has all the functions of a coastal city (settlement, urban, industrial, tourism, and conservation).

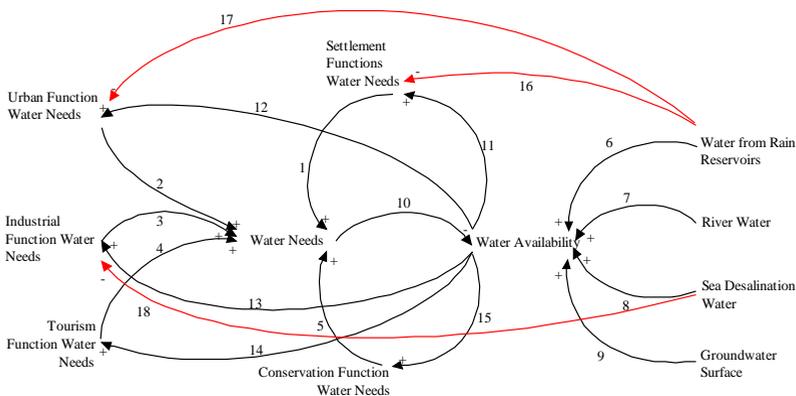
The data used from this study consists of primary data and secondary data. Primary data were obtained from sources, while secondary data were obtained from statistics released by the Central Statistics Agency of the City of Cilegon, previous studies, and other supporting documents.

### 3 Results and discussion

A causal loop diagram (CLD) is a structure of thinking to understand complex problems through simplification steps<sup>[15]</sup>. The Causal Loop Diagram Structure was created to help understand one variable's effect on another. Each variable was identified as a specific component or factor and interacting dynamically based on time and condition.

The model is an imitation of the actual condition<sup>[16]</sup>. The Cilegon City water resource balance model, which was built into the SFD, was also built by researchers because researchers have limited thinking capacity to solve very complex problems. So the model is used to help solve the problems encountered in this study.

One of the Goals in the SDG translated into SFD is Goal Number 6, which is to ensure the availability and management of sustainable clean water and sanitation for all. Objective Number 6 is also derived from 6 Targets, with 4 Targets that can be pursued to be achieved based on simulations from this study. Objective Number 6 and also the four Objectives are then translated into the Causal Loop Diagram as follows.



**Fig. 1.** SDG achievement causal loop diagram.

Causal Loop Diagrams (CLD) illustrate the concepts proposed by researchers in answering the challenges of achieving SDG Goal No. 6 by achieving 4 of the 6 Targets. The other 2 targets are targets related to Sanitation, so they are not included in the simulation. The efforts of researchers in achieving the 4 Goals are as follows:

- 1) By 2030, achieving universal and equitable access to safe and affordable drinking water for all.

This target will be translated into this study to provide access to 100% clean water to the people of the City of Cilegon. Researchers in the simulation will engineer the Water Needs Sub-System of the Settlement Function to meet the water needs of all the people of Cilegon City every day, which is as much as 150 Liters per Soul per Day.

- 2) By 2030, it has substantially increased the efficient use of water in all sectors and ensured a sustainable collection and supply of clean water to address water scarcity and substantially reduce the number of people experiencing water scarcity.  
This target will be translated into this study as an order to limit groundwater uptake (curve number 9) and increase the optimization of sustainable sources of clean water, namely water from the collection of rainwater (curve number 6) and water resulting from sea desalination (curve number 8).
- 3) In 2030, it is implementing integrated water source management at every level, including through appropriate inter-boundary cooperation.  
This goal will be translated into this study to manage the Cidanau watershed in an integrated manner through cooperation between boundaries. The management of the Cidanau watershed is expected to impact increasing the stock of Cidanau River Water (River Water Sub System).
- 4) In 2020, protect and improve water-related ecosystems, including mountains, forests, swamps, rivers, water catchments, and lakes.  
This goal will be translated into this study as an order to protect and improve water resources conservation areas. Through the Department of Environment and Forestry in 2017, the Government of Banten Province has strengthened the water ecosystem's role as a Conservation Area, one of which is to conserve water resources. This target is translated to at least maintain water needs for the function of conserving water resources (SDA Conservation Sub-System).

The functional interventions carried out are as follows:

- 1) Needs (Passiva):
  - a) Pressing the population growth rate, which currently reaches 2.42%, to 2% in accordance with the National average. This effort can be realized through the Family Planning Movement and the Limitation of Less Skilled Workers.
  - b) Pressing the rate of water use in the Settlement Function by 10%, from the previous 54,750 Liters / Life / Year, to 49,275 Liters / Life / Year. This effort can be realized through the Water Saving Movement at the Household level.
  - c) Reducing water use in the Urban Function by 10%, from previously 547,500 Liters / Facilities / Year, to 492,750 Liters / Facilities / Year. It can be realized through the policy of Water Saving in Office buildings, Trade, Health, and Education.
  - d) Press the water use in the Tourism Function by 10%, from the previous 54,750 Liters / Tourists / Year to 49,275 Liters / Tourists / Year. It can be realized through the Water Saving policy in Tourism Areas.
  - e) Utilization of Rainwater for Settlements by 5%. Every household can do this effort in using rain storage water to substitute non-consumption water needs, such as watering the yard, washing, bathing, and so on.
  - f) Urban Rainwater Utilization of 5%. This effort can be realized through the construction of Rainwater Reservation Installations to substitute non-consumption water needs in buildings owned by the City Government of Cilegon such as Government Buildings, Educational Facilities, Health Facilities, Trade Facilities, and Public Offices. The City Government of Cilegon can strengthen through a Regional Regulation that calls for this purpose.
  - g) Utilization of Sea Desalination Water for Industrial Needs. This effort was carried out to reduce the need for clean water from Krakatau Tirta Industri through substitution with Sea Desalination Water.
- 2) Availability (Asset):
  - a) Increase in efforts to collect rainwater by 10% from only 2%. This effort can be done by increasing the location of rainwater reservoirs which were previously only found in the Pulo Merak sub-district. The results of this water reservoir can be used to

increase the availability of clean water. The Regional Government of Cilegon City can issue Regional Regulations that encourage an increase in the number of rainwater collection facilities.

- b) Integrated management of the Cidanau watershed through cooperation between boundaries. This collaboration seeks to improve the Cidanau watershed starting from the upstream region, so that the flow of water that flows from the upstream area of the Cidanau River in Tangerang Regency can be maintained. So that the loss of water from the Cidanau River can be maintained. Banten Provincial Government together with the Central Government through the Cidanau River Basin Agency can issue Regional Regulations related to the prohibition of water use in the upstream area that does not have a permit, a ban on the conversion of land that is not in accordance with the purpose of conserving water resources, and an appeal for people who live along the watershed Cidanau to maintain the cleanliness of the Cidanau watershed.
- c) Increased utilization of water resulting from seawater desalination by 10% from previously only 2%. This water utilization is strived to reduce the need for clean water in the Industrial Function by substituting raw water with water resulting from sea desalination. The Regional Government of Cilegon City can issue a Regional Regulation that allows the private sector to carry out seawater desalination efforts to clean water for Industry. The Local Government of Cilegon City can also provide incentives to companies that have succeeded in reducing their raw water needs by substituting desalinated water.
- d) Reducing groundwater uptake, previously assumed that the community took 5 liters a day, then reduced it to only 4.5 liters per day.

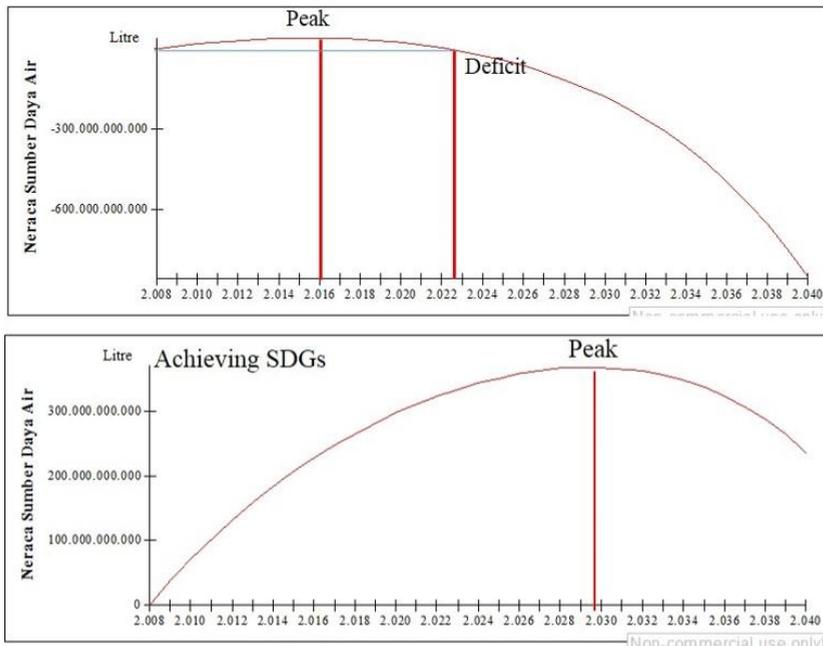
By providing the above treatments, changes in the condition of the Water Resources Balance are as follows.

**Table 1.** Comparison of Existing Water Resources Balance Sheet with Scenario of SDG 2030 Achievement

Year	Business as Usual Scenario	Achieving SDGs Scenario
2008	-	
2009	9.157.790.925	36.448.358.650
2010	17.158.588.393	70.260.728.443
2011	23.961.293.592	101.631.302.771
2012	29.520.382.324	130.733.175.825
2013	33.785.378.707	157.719.952.844
2014	36.700.262.178	182.727.166.825
2015	38.202.799.228	205.873.514.316
2016	38.223.790.159	227.261.920.964
2017	36.686.219.928	246.980.445.737
2018	33.504.300.714	265.103.030.943
2019	28.582.392.230	281.690.103.506
2020	21.813.784.011	296.789.031.262
2021	13.079.321.858	310.434.436.392
2022	2.245.858.299	322.648.366.409
2023	(10.835.495.660)	333.440.321.425

Year	Business as Usual Scenario	Achieving SDGs Scenario
2024	(26.331.343.199)	342.807.134.634
2025	(44.428.227.782)	350.732.701.118
2026	(65.335.145.459)	357.187.548.106
2027	(89.286.380.435)	362.128.237.766
2028	(116.544.705.729)	365.496.591.333
2029	(147.404.996.213)	367.218.720.984
2030	(182.198.307.431)	367.203.853.190
2031	(221.296.480.540)	365.342.924.365
2032	(265.117.341.554)	361.506.926.432
2033	(314.130.571.906)	355.544.976.336
2034	(368.864.337.352)	347.282.079.575
2035	(429.912.773.548)	336.516.553.398
2036	(497.944.439.376)	323.017.070.359
2037	(573.711.863.549)	306.519.277.361
2038	(658.062.326.292)	286.721.939.110
2039	(751.950.036.354)	263.282.547.886
2040	(856.449.884.376)	235.812.333.666

By looking at the comparison between the two tables above, it is known that the estimated water crisis based on existing conditions simulations should occur in 2022, by providing treatments based on the targets in SDG Goal No. 6, it is known that the water crisis in the Year 2022 can be avoided. Even the simulation results also show that until the year 2040 (10 years after SDG ended) the water crisis in the city of Cilegon is still inevitable. But if you observe the results depicted in the graph below then there are still conditions that need attention.



**Fig. 2.** Comparison of existing condition water charts with scenarios for achieving SDG objectives.

As seen in the two graphs in Figure 2, it is known that the top graph is a graph of existing conditions, with a water crisis that will occur in 2022. While the bottom graph is a scenario by implementing the achievement of SDG objectives. In the SDG chart, it is known that the peak of water availability will occur in 2026, and until 2040 there has not been a water crisis. But the direction of the graph remains down, which means that after 2040 the City of Cilegon will still experience a water crisis.

The water crisis after 2040 occurred for various reasons:

- 1) The absence of policy changes or the addition of new policies to adapt to the increasingly high levels of water demand that are difficult to meet,
- 2) Increasing industrial activity both in terms of number of companies and the capacity of water needed by industry, so that after the 2026 Simulation the availability of water in Cilegon City is less than its needs so that it starts to experience a deficit even though there are still water reserves at water sources such as the Krenceng Reservoir and Groundwater. But in the end, the balance sheet will experience negative or the City of Cilegon enters the water crisis condition.
- 3) The increasing population causes water demand for residential and urban functions to increase.

Thus based on the simulation results, the water resources management strategy to achieve SDGs in the city of Cilegon can be achieved in the sense that the availability of sustainable clean water for all can be met. But in the longer term, the governance strategy is not enough to guarantee that the fulfillment of water resources will continue to be sustainable.

## 4 Conclusions

Simulation results based on existing conditions have shown that as predicted by the Ministry of PUPR and also BAPPENAS that the City of Cilegon will experience a water crisis. The simulation results even estimate that the clean water crisis in the City of Cilegon occurred three years earlier than expected, namely in 2022. By intervening functionally, it can be concluded that the water crisis in 2027 did not happen, and achieving 100% access to clean water for the Cilegon City community can also be fulfilled while maintaining the Cilegon City Industrial Growth Rate. It is proven that the water crisis can be mitigated so that it does not occur until the end of the year 2027. However, by looking at the water balance curve of the City of Cilegon at the end of the year 2040, it can be seen that the curve graph tends to decrease, which means that one day the City of Cilegon will experience a Water Crisis, so that in fact an intervention with a pattern of achieving SDGs, is not enough intervention to achieve the sustainability of the City of Cilegon in meeting water needs for the community, industry, and all its activities.

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