Reliability analysis of the Kolong Kebintik as water resources for special economic zone in Tanjung Gunung, Pangkalan Baru District, Central Bangka Regency

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Abstract. Tanjung Gunung, Pangkalan Baru District, Central Bangka Regency is an area that is included in the Special Economic Zone. The development of this area will have an impact on the increasing demand for water that must be provided by the management. The water resources will be supplied from Kolong Kebintik. Other than supply to the Special Economic Zone, it is also planned to supply water in Pangkalan Baru District. The water demand for Special Economic Zone is 43 l/s and water demand for the Pangkalan Baru District is 48.11 l/s. So the total domestic demand is 91.11 l/s. To guarantee water in Kolong Kebintik is still available to needs of the Special Economic Zone and Pangkalan Baru District, it is necessary to analyze the reliability using standard operating rule. If want to get 100% reliability of Kolong Kebintik, then use only 22.8 l/s of the total demand 43 l/s or only 53% of the needs of the Special Economic Zone.

1. Introduction

Tanjung Gunung, Pangkalan Baru District, Central Bangka Regency is an area that is included in the Special Economic Zone. The development of this area will have an impact on the increasing demand for water that must be provided by the management of the Special Economic Zone to support activities in the area. An alternative that can be used to supply water to Special Economic Zone is to use Kolong.

Kolong is basin on the ground surface formed from mining activities that are inundated by water [1],[2]. Kolong this case can also be called a reservoir. Utilization of kolong as a resource is an effective way of developing and managing an integrated water resources. Currently kolong has a big role to balance population growth and scarcity of water resources [3-5].

Pangkalan Baru District has 290 kolong. There are 3 of these kolong the priority areas and have the potential to becoming a water resources, namely Kolong Air PL, Kolong Krasak and Kolong Kebintik. When viewed from the volume of water resources availability, the largest average volume of the three
kolong is Kolong Kebintik. Therefore Kolong Kebintik is planned to be the water resources for the Special Economic Zone and Pangkalan Baru District. To guarantee the availability of water resources due to the release, a reliability analysis is needed. The method used to analyze the reliability of the kolong is the standard operating rule.

The standard operating rule is a simulation model to determine the reliability of the reservoir to release using a reservoir utilization approach. The standard operating rule is used as a guideline for the water release in the kolong by taking into account the inflow and level of water storage available [6][7][8]. Standard operating rule aim to release the amount of water equivalent to water demand and try to conserve water for future use [9][10]. This method will be used to analyze the reliability of the Kolong Kebintik for water demand in the next ten years (2019-2028). The amount of evaporation in the kolong is obtained from the multiplication of the inundation kolong area with the monthly average evaporation value as a result of the analysis using the energy balance method.

Based on the above problems, this study is focused on determining the reliability of the Kolong Kebintik to be sufficient the needs in Pangkalan Baru District and Special Economic Zone in Tanjung Gunung.

2. Material and Methods
2.1. Study Area
The location of this research is located in Kolong Kebintik, Tanjung Gunung, Pangkalan Baru District, Central Bangka Regency. Kolong Kebintik is located at coordinates 48 M 0631044, UTM 9761198 with surface area is 2.335 ha, catchment area is 294.723 ha and volume is 61,022.5 m³.

![Figure 1. Kolong Kebintik.](image1)

![Figure 2. Two-dimensional and three-dimensional of Kolong Kebintik.](image2)
2.2. Standard Operating Rule

Standard Operating Rule will be used to analyze the reliability of Kolong Kebintik. This method uses water availability and generate discharge data as input in the analysis. Analysis of water availability was analyzed using the NRECA method and generate discharge data was analyzed using the Markov Model.

3. Result and Discussion

The amount of water demand for the Special Economic Zone determined by the management is 43 l/s and the water demand for the Pangi Plain West District is calculated based on the projection of the population in 2028. Projections of population and water demand for Pangi Plain West District in 2028 are shown in table 1.

| Village          | Area (ha) | Population Projection | Total water demand (l/s) |
|------------------|-----------|-----------------------|-------------------------|
|                  |           | Year                  |                         |
|                  |           | 2019 | 2023 | 2028 | 2019 | 2023 | 2028 |
| Tanjung Gunung   | 1027.49   | 3632 | 3719 | 3832 | 3.46 | 3.54 | 3.65 |
| Benteng          | 373.41    | 2686 | 2952 | 3323 | 2.56 | 2.81 | 3.17 |
| Air Mesu Timur   | 3080.61   | 3373 | 3594 | 3890 | 3.21 | 3.42 | 3.70 |
| Dul              | 1463.16   | 6406 | 6953 | 7703 | 6.10 | 6.62 | 7.34 |
| Mangkol          | 459.87    | 4194 | 4552 | 5043 | 4.00 | 4.34 | 4.80 |
| Padang Baru      | 347.31    | 2688 | 3472 | 4780 | 2.56 | 3.31 | 4.55 |
| Jeruk            | 654.72    | 2449 | 2674 | 2985 | 2.33 | 2.55 | 2.84 |
| Beluluk          | 1050.64   | 4254 | 4617 | 5115 | 4.05 | 4.40 | 4.87 |
| Batu Belubang    | 597.87    | 3754 | 4219 | 4881 | 3.58 | 4.02 | 4.65 |
| Pedindang        | 754.37    | 2993 | 3475 | 4189 | 2.85 | 3.31 | 3.99 |
| Air Mesu Timur   | 795.37    | 2541 | 2593 | 2660 | 2.42 | 2.47 | 2.53 |
| Kebintik         | 222.45    | 1699 | 1873 | 2115 | 1.62 | 1.78 | 2.01 |
| TOTAL            | 10,827.27 | 40,669 | 44,693 | 50,516 | 38.74 | 42.57 | 48.11 |

So the total domestic water demand for the Special Economic Zone plus the water demand in Pangi Plain West District until 2028 is 91.11 l/s.

The NRECA model was used to analyze the availability of water in Kolong Kebintik for ten years (2009-2018). The result of the analysis are shown in table 2.

| Year | Jan | Feb | Mar | Apr | Mei | Jun | Jul | Agust | Sep | Okt | Nov | Des |
|------|-----|-----|-----|-----|-----|-----|-----|-------|-----|-----|-----|-----|
| 2009 | 152.35 | 52.61 | 344.75 | 2009 | 140.04 | 24.63 | 34.82 | 2.97 | 1.35 | 1.25 | 62.91 | 90.63 |
| 2010 | 152.45 | 38.12 | 338.55 | 218.30 | 50.44 | 95.10 | 56.94 | 320.46 | 109.11 | 188.62 | 286.97 | 279.78 |
| 2011 | 176.59 | 250.35 | 147.73 | 289.39 | 257.13 | 190.76 | 11.20 | 5.59 | 3.28 | 148.30 | 229.49 | 179.66 |
| 2012 | 82.88 | 391.01 | 168.37 | 11.51 | 33.22 | 46.63 | 79.58 | 3.37 | 1.82 | 1.15 | 72.07 | 75.30 |
| 2013 | 77.80 | 174.02 | 120.85 | 84.43 | 144.45 | 16.58 | 137.41 | 5.69 | 9.25 | 62.83 | 217.49 | 305.38 |
| 2014 | 141.49 | 10.45 | 5.08 | 187.02 | 48.16 | 4.79 | 8.65 | 2.01 | 0.60 | 0.55 | 12.33 | 116.41 |
| 2015 | 52.94 | 3.91 | 196.78 | 99.19 | 5.97 | 3.28 | 1.46 | 0.75 | 0.34 | 0.38 | 13.02 | 40.62 |
| 2016 | 76.43 | 290.97 | 273.02 | 185.68 | 162.87 | 123.81 | 7.78 | 81.47 | 4.20 | 187.26 | 73.65 | 60.42 |
| 2017 | 45.71 | 190.68 | 189.30 | 125.00 | 154.46 | 107.20 | 223.84 | 8.94 | 4.97 | 152.92 | 120.14 | 222.17 |
| 2018 | 111.98 | 8.32 | 226.69 | 171.51 | 160.48 | 69.59 | 5.57 | 2.98 | 34.66 | 206.39 | 249.63 | 65.97 |
| Total | 1,100.72 | 1,514.06 | 1,946.31 | 1,381.53 | 1,157.21 | 682.36 | 567.26 | 434.24 | 255.36 | 949.65 | 1,337.73 | 1,436.34 |
| Average | 110.07 | 151.41 | 194.63 | 138.15 | 115.72 | 68.24 | 56.73 | 43.42 | 23.56 | 94.96 | 133.77 | 143.63 |
| Max | 194.63 | March | 25.36 | September | 106.36 |
Using data in table 2, data forecasts are carried out to get the generate discharge for the next ten years (2019-2028) using the Markov Model. The simulation results are shown in table 3.

### Table 3. Simulation of the Generate Discharge Markov Model for 2019-2028.

| Year | Jan  | Feb  | Mar  | Apr  | Mei  | Jun  | Juli | Agu  | Sept | Okt  | Nov  | Des  |
|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 2019 | 93.50| 197.39| 219.38| 145.06| 137.49| 87.73| 77.91| 75.89| 53.61| 156.41| 203.97| 176.65|
| 2020 | 121.59| 202.67| 206.08| 186.55| 120.67| 71.52| 75.94| 42.45| 44.10| 153.38| 196.45| 226.29|
| 2021 | 112.32| 112.35| 208.06| 153.75| 118.63| 72.86| 71.52| 47.53| 36.63| 141.23| 206.04| 226.29|
| 2022 | 142.05| 198.85| 219.51| 161.36| 112.62| 72.86| 93.68| 88.77| 53.42| 127.72| 189.17| 201.62|
| 2023 | 140.30| 178.36| 196.60| 158.52| 109.23| 89.24| 73.47| 42.45| 44.10| 153.38| 196.45| 226.29|
| 2024 | 124.71| 220.80| 203.15| 180.08| 104.84| 89.66| 73.20| 67.45| 44.13| 130.98| 179.15| 199.55|
| 2025 | 135.24| 143.34| 271.20| 139.49| 106.60| 96.35| 58.23| 48.70| 134.00| 172.31| 220.30| 155.78|
| 2026 | 145.07| 163.21| 227.44| 154.64| 101.35| 58.23| 48.70| 134.00| 172.31| 220.30| 155.78| 199.55|
| 2027 | 112.32| 231.69| 174.97| 178.35| 99.48| 58.23| 48.70| 134.00| 172.31| 220.30| 155.78| 199.55|
| 2028 | 145.07| 163.21| 227.44| 154.64| 101.35| 58.23| 48.70| 134.00| 172.31| 220.30| 155.78| 199.55|
| Total | 1,252.98| 1,857.02| 2,135.59| 1,643.03| 1,295.75| 896.56| 731.95| 674.55| 441.33| 1,309.79| 1,791.45| 1,995.45|
| Average | 125.30| 185.70| 213.56| 164.30| 129.57| 89.66| 73.20| 67.45| 44.13| 130.98| 179.15| 199.55|
| Max  | 213.56| March | 213.56| 164.30| 129.57| 89.66| 73.20| 67.45| 44.13| 130.98| 179.15| 199.55|
| Min  | 44.13| September | 44.13| 58.23| 48.70| 134.00| 172.31| 220.30| 155.78| 199.55| 199.55| 199.55|

The comparison of the simulation results of the Markov Model (2019-2028) and the NRECA model (2009-2018) is shown in figure 3. The graph from the simulation results using the Markov model and the NRECA model shows the same pattern. From this graph, it can be concluded that the discharge from the simulation results of the Markov and NRECA models is compatible.

![Figure 3. Comparison of Simulation Results for Markov Model (2019-2028) and NRECA Model (2009-2018).](image-url)

Based on the analysis of water availability, it was found that the average maximum discharge occurred in March, namely 194.63 l/s. The average minimum discharge occurred in September, namely 25.56 l/s. The average discharge was 106.36 l/s. When compared between the water availability and water demand, the water availability exceeds water demand. However, it is necessary to simulate a standard operating rule to determine the reliability of the kolong.

Two scenario were carried out to get the best use of Kolong Kebintik as a water resources. 1st Scenario, Kolong Kebintik is used to supply water to the Special Economic Zone and Pangkalan Baru District with a release target of 91.11 l/s. The simulation results show that for the 100% fulfilment target, the reliability of Kolong Kebintik is 22% with 26 months of success, 94 months of failure. 2nd Scenario, Kolong Kebintik is only used to supply the needs of the Special Economic Zone with a release target of 43 l/s. The simulation results show that for the 100% fulfilment target, the reliability...
of Kolong Kebintik is 83% with 99 months of success, 21 months of failure. The simulation results of the two scenarios are shown in table 3 and table 4.

### Table 4. Simulation Results of the 1st Scenario.

| No | Release Target (%) | Reliability (%) | Demand Domestic (l/s) | Number of Successes (month) | Number of Failures (month) | Two Consecutive Failures |
|----|--------------------|-----------------|----------------------|-----------------------------|---------------------------|--------------------------|
| 1  | 100                | 22              | 91.11                | 26                          | 94                        | ✓                        |
| 2  | 80                 | 43              | 72.89                | 52                          | 68                        | ✓                        |
| 3  | 53                 | 78              | 48.11                | 94                          | 26                        | ✓                        |
| 4  | 47                 | 83              | 43                   | 99                          | 21                        | ✓                        |
| 5  | 38                 | 93              | 35                   | 112                         | 8                         | ✓                        |
| 6  | 36                 | 97              | 32.5                 | 116                         | 4                         | -                        |
| 7  | 26                 | 100             | 23.3                 | 120                         | 0                         | -                        |

### Table 5. Simulation Result of the 2nd Scenario.

| No | Release Target (%) | Reliability (%) | Demand Domestic (l/s) | Number of Successes (month) | Number of Failures (month) | Two Consecutive Failures |
|----|--------------------|-----------------|----------------------|-----------------------------|---------------------------|--------------------------|
| 1  | 100                | 83              | 43                   | 99                          | 21                        | ✓                        |
| 2  | 80                 | 93              | 34.4                 | 112                         | 8                         | ✓                        |
| 3  | 58                 | 98              | 25                   | 117                         | 3                         | -                        |
| 4  | 53                 | 100             | 22.8                 | 120                         | 0                         | -                        |

4. Conclusion

Based on the simulation results using the standard operating rule, the best choice in the utilization of the Kolong Kebintik is to focus on the Kolong Kebintik only for the water resources of Special Economic Zone. If want 100% reliability, then the use of water in Kolong Kebintik can only be used for 22.8 l/s of the total requirement of 43 l/s. This means that the water in Kolong Kebintik can only supply 53% of water demand in Special Economic Zone.

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