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Forecasting and Sustainability of Raw Water Supply for Indonesia's New Capital

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ABSTRACT

Environmental load issues in Jakarta, economic contribution to GDP, Java's dominance in land conversion, economic justice, and a water supply dilemma are all factors that contribute to Jakarta's excessive density. Therefore, the Indonesian government intends to relocate the Indonesia's capital to the Penajam Paser Utara district, in the East Kalimantan Province, in 2024. One of the challenges for the new capital, known as Indonesia's new capital (IKN), is securing a sustainable raw water supply for drinking. On the other hand, the potential of existing water resources is very limited in terms of resources and supporting infrastructure. This paper investigates the forecasting and sustainability of raw water supply for Indonesia's new capital. The hydrological feasibility method, which includes calculating the estimated supply and evaluating the sustainability of IKN raw water sources, was used in this study. The result showed the estimated raw water requirements for the IKN area during the period 2023-2073. The critical point of the resulting state is that the water resources of IKN by 2023 will be secure if the infrastructure plan is properly implemented. Meanwhile, IKN will be in deficit after 2045. Therefore, integrated water resource management is an important issue for the Indonesian government to minimize the limited raw water sources for IKN's sustainability.

1. INTRODUCTION

On Monday, August 26, 2019, the Indonesian government formally announced at a news conference held at the State Palace in Central Jakarta that the area would function as the country's new capital (IKN) [1]. The government decided to relocate the capital city from DKI Jakarta to parts of Penajam Paser Utara Regency and Kutai Kartanegara Regency by 2024 [2, 3]. According to data from the Central Bureau of Statistics for East Kalimantan Province for 2022, the population of Penajam Paser Utara Regency will reach 185,000 people in 2021 [4]. The Ministry of National Development Planning/National Development Planning Agency (PPN/ Bappenas) asserts that this plan will be implemented because it is included in the 2020-2024 national medium-term development plan and Indonesia Vision 2045 [5].

The government, through the Minister of PPN/Head of Bappenas, stated that relocating the capital city was necessary for several main reasons: Java's population was too dense, economic contribution to GDP, land conversion in Java dominated, economic equity, environmental burden problems in Jakarta, and a crisis of water availability.

There are various reasons why this move should be advantageous for Jakarta [6]: (1) it will alleviate intense road congestion; (2) it will slow down environmental degradation such as air and water pollution; (3) it will make Jakarta less vulnerable to natural disasters such as earthquakes, tsunamis, volcanoes, and floods; (4) it will reduce economic conditions and population concentration; and (5) it will mitigate land subsidence brought on by the pumping of groundwater [7].

Based on the document "Ideas of Planning and Design Criteria for the IKN" from the Ministry of Public Works and Public Housing (PUPR), the vision of the IKN of the Republic of Indonesia is to represent the excellent progress of the nation and serve as a catalyst for increasing Indonesian human civilisation. There are three key objectives: 1) reflecting the nation's identity; 2) ensuring environmental, social, and economic sustainability; 3) realising a city that is smart, modern, and of international standard [8, 9].

First, the IKN must be able to show the identity of the nation, which will be philosophically translated into Urban Design from the principles of the Indonesian state philosophy, namely Pancasila (Five Principles of the Indonesian state philosophy) [10], Bhinneka Tunggal Ika (unity in diversity) [11], NKRI (the archipelagic state of Republic Indonesia), and Gotong royong (working together). National identity is implemented in the form of morphology and city functions, spaces for community activities that encourage the principle of gotong royong (working together), and functions and containers that preserve the nation's history and culture (including Indonesia Sentris: cultural spaces, national galleries, museums, theatres, and art parks) [12].

Second, the IKN must realise social, economic, and environmental sustainability as an outcome of integrating social, economic, and environmental protection aspects [13].

Third, the IKN must also realise a smart, modern city with international standards. The IKN will become a compact city, relying on information and communication technology to achieve the goals of sustainable development (SDGs). The expectations set for the IKN will be achieved through regional development plans, economic growth, social progress, personnel, territory, environmental conservation and management, equipment, displaced, and security and defense.

Based on the safety strategy, there are at least three technical principles for the IKN that can be connected to security. These are: designing urban infrastructure with a rotating and flexible system; creating a city that is secure, convenient, and reasonably priced for all inhabitants, including children, women, elderly, and people with impairments; and developing a city that is efficient and productive using technology.

Even though the IKN doesn't have a comprehensive plan for security policy, all of these concepts can contribute to safety. The IKN Master Plan's approach to safety is more directly related to creating a prosperous city, ensuring accessibility to necessary facilities, and considering a comprehensive tenancy ratio when applying these three principles of direction [14].

In addition, the vision for the IKN is smart, green, beautiful, and sustainable, translated through the development of cities that are in harmony with nature through the concept of a forest city and a smart city [7]. One transformation from this concept is an emphasis on a 50% spatial pattern for green open space, which will also prioritise improving ecosystem quality, protection and conservation, especially in areas with high conservation value (HCV).

PPN/Bappenas, in the National Dialogue on the Transfer of the National Capital in Jakarta, explained that there would be four zones in the new capital city. The four zones are the central government core area (KIP), the State Capital area (K-IKN), the expansion area for the State Capital (KP-IKN$_1$), and the expansion area for the State Capital (KP-IKN$_2$). The central government core area is planned to cover an area of 5,600 hectares (ha). It will consist of the state palace, offices of state institutions, cultural gardens, and botanical gardens.

Then, the state capital area (K-IKN) will be built on 40,000 ha. This area will comprise housing for the State Civil Apparatus (ASN), education and health facilities, universities, science and techno-parks, hi-tech and clean industries, research and development centers, convention buildings, sports centers, and museums.

KP-IKN$_1$ will cover an area of about 200,000 ha, and will consist of a national park, orangutan conservation and zoo, non-ASN settlements, airports, and ports. Lastly, KP-IKN$_2$ will occupy more than 200,000 ha, containing a metropolitan area and developments with adjacent provinces. The government plans that the new government area will not be as expansive as a metro city [6].

The IKN will require approximately 256,000 ha of land, with a core city area of 56,180.87 ha and a government center of 5,600 ha [14]. The map of the location plan for the National Capital City and the zoning plan for the new capital city is shown in Figure 1.

One of the pressing issues faced by the new IKN is the problem of obtaining raw water for drinking purposes. Currently, only 28% of the people in the surrounding area have access to clean water [15, 16]. Moreover, the government aspires that the drinking water for the IKN should be of tap water quality [17]. However, the potential of existing water resources (SDA) is still limited, necessitating alternative sources of raw water to provide drinking water for the IKN.

The research question in this study is, "What are the alternative sources of water availability to ensure the sustainability of water resources in IKN?" This paper investigates the plan for raw water needs, alternative sources of raw water, analysis of the sustainability of raw water sources, and several alternatives to support the sustainability of raw water supply. The novelty of this study lies in presenting several alternatives to support the sustainability of the raw water supply for IKN's drinking water. Given its geographical proximity to the proposed new capital city, Penajam Paser Utara becomes a focal point for understanding how integrated water resources management principles can be applied within the IKN framework and when planning a new urban center. Hence, this study was conducted in Penajam Paser Utara in East Kalimantan Province, Indonesia, in 2022.

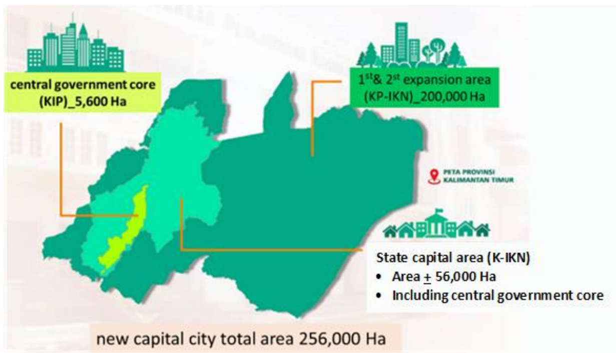

Figure 1. The IKN zoning plan

2. RESEARCH METHODS

The research approach of this study is descriptive. The research method predicts the population of IKN and adjacent areas based on 2019 data and population growth rates. The geometric method is utilized to estimate the population for the coming years. While this method is simple and accessible for short-to medium-term population predictions assuming stable growth patterns, it does not account for complex demographic dynamics and external factors [18]. The total population and the estimated water need of 150 l/person/day are then used to predict drinking water and raw water demands, projecting raw water demand for drinking water supply from 2023 to 2073 [19].

Integrated Water Resource Management is a comprehensive approach to managing water resources sustainably and coordinately. It recognizes the interconnectedness of various aspects of water management, including social, economic, environmental, and institutional factors. The sustainability of these sources is assessed through various criteria and indicators that ensure community well-being, such as assessing the availability of water for domestic use, and maintaining the long-term availability of water resources like surface water, groundwater, rainwater, wastewater reclamation/recycling, and saltwater [20]. This approach is used to evaluate the sustainability of the IKN.

In this method, the total potential of raw water resources is calculated by summing the current water resource potential and water resource development plans in IKN areas and adjacent regencies/cities. It then analyzes the total potential of water resources from existing infrastructure and infrastructure built with the predicted projected raw water demand for drinking water supply over the next 50 years. The result is scenarios for raw water supply that will be used to identify alternatives to fulfill the water supply. This water resource will be available if the anticipated infrastructure has been constructed. Finally, integrated water resource management is employed to address the issue [21, 22].

3. RESULTS AND DISCUSSION

3.1 Estimated raw water demand for drinking water supply system for IKN Area

The Minister of National Development Planning/Head stated that the IKN would have four zoning plans. The four zoning areas are the central government core area (KIPP), the State Capital area (K-IKN), the KP-IKN$_1$ expansion area, and the KP-IKN$_2$ expansion area. It is estimated that according to the plan, there will be around 1.5 million ASN who will stay at IKN. Assuming that one ASN family consists of 4 people, the Population in IKN will reach six million people or more. Thus, IKN will require the provision of drinking water in large quantities. The capacity of the drinking water delivery system in the supporting region adjacent IKN, which comprises Kutai Kartanegara Regency, Penajam Paser Utara Regency, Paser Regency, Balikpapan City, and Samarinda City, is given in Table 1 based on 2018 data. The total installed capacity of the Regional Drinking Water Company (PDAM) in the Regency/City in the Region is 5,946 $l.s^{-1}$ [23].

Estimates of the need for drinking water supply in the area are calculated based on the total population and the per capita drinking water needs in each area. The estimated population is calculated based on population data and population growth rate data in 2019. The estimated population in 2023 is calculated using the geometric method [24], written as follows:

$$P_n = P_0(1+r)^n \tag{1}$$

where, P_n: Amount in the projected year; P_0: Total initial Population; r: Average population growth rate per year; n: The period of the projected year.

Table 2 shows the estimated population in each Regency/City calculated using the above formula: Kutai Kartanegara Regency, Penajam Paser Utara Regency, Paser Regency, Balikpapan City, and Samarinda City. Population data and growth rates in each district/city are based on 2019 data [4]. The estimated population and drinking water demand per capita in each region, as well as the level of water loss in each PDAM, are used to calculate the estimated total SPAM demand of Kutai Kartanegara Regency, Penajam Paser Utara Regency, Paser Regency, Balikpapan City, and Samarinda City in 2023 [25].

Table 1. The capacity of PDAMs in regencies/cities in adjacent IKN

No.	ITEM	Unit	Capacity Installed (2019) Kutai Kartanegara Regency	Samarinda City	Penajam Paser Utara	Balikpapan City	Paser Regency
1	Installed capacity	$l.s^{-1}$	1,507	2,599	130	1,370	340
2	Real production volume	$l.s^{-1}$	1,168	2,502	80	1,227	301
3	Water loss rate	%	30.15	38.44	33.48	35.22	33.23
4	Total population in administrative area	person	674,759	953,059	170,475	649,806	274,206
5	Number of population served	person	308,320	671,995	31,224	310,048	88,740
6	Service coverage	%	46.37	70.51	39.07	47.71	65.34
7	Average rate	US$.	0.3	0.43	0.26	0.65	0.40

Table 2. Estimated population in regencies/cities in adjacent IKN areas in 2023

Regency/City	Population Year 2019 (Person)	Population Growth Rate (%)	Total Population Year 2023 (Person)
Kutai Kartanegara Regency	786,100	1.97	850.764
Penajam Paser Utara Regency	160,900	1.05	167,765
Paser Regency	231,700	1.89	249,719
Balikpapan City	560,800	1.41	593,104
Samarinda City	872,800	1.58	929,282

Calculating the total raw water in each PDAM has added a factor to the amount of water wasted during the processing. Estimates of the total drinking water supply (SPAM) and the total raw water demand in the area around IKN in 2023 can be seen in Table 3. The total drinking water supply demand in Kutai Kartanegara Regency, North Penajam Paser Regency, Paser Regency, Balikpapan City, and Samarinda City until 2023 is 9,757 $l.s^{-1}$. Water loss during water purification is estimated at 10% [26]. The total raw water needs for the regencies/cities around IKN are Kutai Kartanegara Regency, North Penajam Paser Regency, Paser Regency, Balikpapan City, and Samarinda City until the year 2023 is 10,732 $l.s^{-1}$. For the New Capital City, it is estimated that 1.5 million state civil apparatus (ASN) will be transferred. It is assumed that each ASN family consists of four people. Then the number of new IKN will reach around 6 million people, and it is planned to occur in 2023. The following assumptions are made: using 150 l/person/day of drinking water, the rate of water loss/leakage is 20%, and the peak discharge factor of 1.2. To calculate the need for drinking water supply, the results of the calculation of the estimated drinking water demands and raw water needs in 2023 are shown in Table 4.

Table 3. Estimated total drinking water supply and raw water demands in regency/city areas around IKN in 2023

Regencies/ Cities	Total Population Year 2023 (Person)	Drinking Water Needs Per Capita ($l.d^{-1}$)	Drinking-Water Needs Year 2023 ($l.s^{-1}$)	Water Loss/ Leakage Rate (%)	Total SPAM Needs Year 2023 ($l.s^{-1}$)	Amount of Wasted Water in WTP (%)	Total Raw Water Demand Year 2023 ($l.s^{-1}$)
Kutai Kartanegara Regency	850,764	220	2,166	30.15	2,819	10	3,101
North Penajam Paser Regency	167,765	190	369	33.48	493	10	542
Paser Regency	249,719	190	1,030	33.23	1,372	10	1,509
Balikpapan City	593,104	150	1,330	35.22	1,798	10	1,978
Samarinda City	929,282	220	2,366	38.44	3,275	10	3,602
Total raw water needs for regency/city areas around IKN							10,732

Table 4. Estimated drinking water and raw water demands for IKN (the basic year 2023)

Number of Population	The Planning Year (2023)	Number of Population	The Planning Year (2023)
Total population (people)	6,000,000	Total water demand ($m^3.d^{-1}$)	1,080,000
Resident service (%)	100	Total water demand ($l.s^{-1}$)	12,500
Drinking water consumption (l/person/day)	150	Peak factor	1.2
Water demand ($m^3.d^{-1}$)	900,000	Total drinking water needs at peak hour ($m^3.d^{-1}$)	1,296,000
Water demand ($l.s^{-1}$)	10,416.67	Total drinking water needs at peak hour ($l.s^{-1}$)	15,000
Water loss (%)	20	Amount of wasted water in IPAM (%)	10
Total water loss ($m^3.d^{-1}$)	180,000	Total raw water demand $m^3.d^{-1}$ ($m^3.d^{-1}$)	1,425,600
Total water loss ($l.s^{-1}$)	2,083	Total raw water demand ($l.s^{-1}$)	16,500

According to the calculations, IKN will need 15,000 $l.s^{-1}$ of drinking water during the planned year 2023, while 16,500 $l.s^{-1}$ would be needed for raw water. Thus, for the drinking water supply to IKN and its adjacent regencies/cities, namely Kutai Kartanegara Regency, Penajam Paser Utara Regency, Paser Regency, Balikpapan City, and Samarinda City, in the planning year 2023, a total raw water supply of 27,232 $l.s^{-1}$ is required. The geometric method calculates the projected raw water needs for drinking water supply in the IKN area and the adjacent regencies/cities. Assuming the population growth rate (in 2019) is for Kutai Kartanegara Regency at 1.97%, Penajam Paser Utara Regency at 1.05%, Paser Regency at 1.89%, Balikpapan City at 1.41%, Samarinda City at 1.58%, and IKN at 1.5% [4]. The results of the calculation of the natural water need for IKN and adjacent regencies/cities for the next 50 (fifty) years are shown in Figure 2. From the calculation results, it is seen that the estimated raw water needs for IKN and its adjacents in 2023, 2033, 2043, 2053, 2063, and the year 2073 are 27,232 $l.s^{-1}$, 31,828 $l.s^{-1}$, 37,211 $l.s^{-1}$, 43,522 $l.s^{-1}$, 50,918 $l.s^{-1}$, and 59,594 $l.s^{-1}$. The results of the calculation of the projected raw water need for IKN and adjacent regencies/cities for the next 50 (fifty) years are shown in Table 5 and Figure 2. From the calculation results, it is seen that the estimated raw water needs for IKN and its adjacent in 2023, 2033, 2043, 2053, 2063, and the year 2073 are 27,232 $l.s^{-1}$, 31,828 $l.s^{-1}$, 37,211 $l.s^{-1}$, 43,522 $l.s^{-1}$, 50,918 $l.s^{-1}$, and 59,594 $l.s^{-1}$.

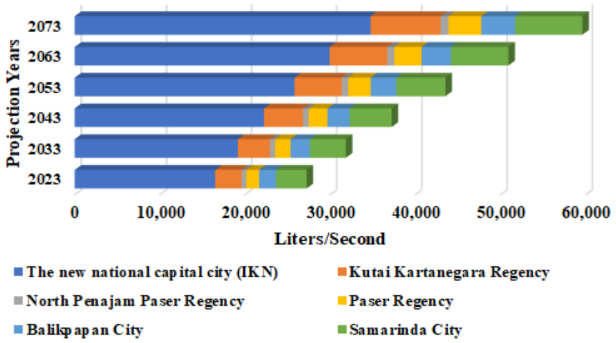

Figure 2. Projected raw water demands for drinking water supply in IKN areas and adjacent regencies/cities

Table 5. Projected raw water demands for IKN and adjacent regencies/cities for drinking water supply

No.	Regencies/Cities	Projection of Raw Water Demand ($l.s^{-1}$)					
		2023	2033	2043	2053	2063	2073
1	Kutai Kartanegara Regency	3,101	3,769	4,581	5,568	6,767	8,225
2	North Penajam Paser Regency	542	602	668	741	823	914
3	Paser Regency	1,509	1,820	2,194	2,646	3,191	3,848
4	Balikpapan City	1,978	2,275	2,617	3,011	3,463	3,984
5	Samarinda City	3,602	4,213	4,928	5,765	6,743	7,887
6	IKN	16,500	19,149	22,223	25,791	29,931	34,736
Total projection of raw water demand		29,255	33,861	39,254	45,575	52,981	61,667

3.2 The potential and planning for the development of natural resources in the IKN and adjacent area

According to the Kalimantan III River Basin Center (BWS), in East Kalimantan Province, six infrastructures have already been sources of raw water extraction. The six sources of raw water are the Manggar Dam in Balikpapan, with a capacity of 14.2 Mm^3; (million cubic meter) the Teritip Dam in Balikpapan, with a capacity of 2.43 Mm^3; the Aji Raden Embung in Balikpapan, with a capacity of 0.49 Mm^3, the Samboja Dam in Kabupaten Kutai Kartanegara with a capacity of 5.09 Mm^3, the Mahakam River Kalhol Intake with a capacity of 0.02 Mm^3, and the Lempake Dam in Samarinda with a capacity of 0.67 Mm^3 [27]. The five existing water resource infrastructures have a total raw water potential of 4,827 $l.d^{-1}$ [28, 29]. To support providing clean water for IKN, the government will build eight infrastructures for raw water sources included in the plan to support raw water in East Kalimantan. The eight infrastructures, namely the Sepaku-Semoi Dam, have a total raw water potential of 2,500 $l.d^{-1}$, for the supply of raw water for the City of Balikpapan (Sepaku) of 500 $l.d^{-1}$, and the raw water supply for IKN of 2,000 $l.d^{-1}$. The Batu Lepek Dam has a raw water potential of 14,500 $l.s^{-1}$, will be intended for raw water supply to IKN of 13,000 $l.s^{-1}$, and to meet the shortage of raw water supply in Kutai Kartanegara Regency of 1,500 $l.s^{-1}$. The Itchi Dam, with a raw water potential of 4,000 $l.s^{-1}$, is intended for IKN's raw water supply of 3,600 $l.s^{-1}$ and to meet the shortage of raw water supply for North Penajam Paser Regency of 400 $l.s^{-1}$. Lambakan Dam, with a raw water potential of 5,000 $l.s^{-1}$, is intended for IKN's raw water supply of 3,865 $l.s^{-1}$ and to meet the shortage of raw water supply in Paser Regency of 1,135 $l.s^{-1}$. The raw water intake from the Loa Kulu Intake of 2,000 $l.s^{-1}$ is used for the IKN raw water supply of 1,200 $l.s^{-1}$ and the Samarinda City raw water supply of 800 $l.s^{-1}$. Meanwhile, the Selamatyu Dam at 3,950 $l.s^{-1}$, the Safiak Dam at $l.s^{-1}$, and the Beruas Dam at 1,100 $l.s^{-1}$ are used for IKN raw water supply [28, 30]. From a number of these infrastructures, the government prioritizes the construction of the Batu Lepek dam in Kutai Kartanegara Regency, which is planned to be auctioned in 2020 as the main raw water supply for the location of the national capital city. The Batu Lepek dam's capacity will supply raw water needs in perspective IKN with a total of 14,300 $l.s^{-1}$. The potential of existing water resources and plans for developing natural resources in the IKN area and adjacent regencies/cities can be seen in Table 6. The Water Resources Infrastructure Plan in IKN can be seen in Figure 3. This table shows that the total raw water potential from the existing SDA infrastructure and the planned SDA infrastructure to be built is 38,777 $l.s^{-1}$. Based on the author's analysis, the scenario of raw water supply for IKN taken from the natural resource infrastructure to be built can be seen as shown in Figure 4. If the total potential of water resources from the existing infrastructure and the infrastructure to be built is plotted with the projected water demand for the IKN and the districts/cities around the IKN for the next 50 years, a graph will be obtained as shown in Figure 5.

Several limitations in estimating raw water needs, among others, barriers to the productivity of water treatment plants, the quantity of groundwater and surface water [31]. Likewise with uncertainties that can affect predictions of raw water demand such as global climate change, longevity of water supply infrastructure, land use and agricultural conditions, food markets, spatial developments, economic developments, future technologies, and societal values in the world [32].

3.3 Sustainability analysis of IKN for raw water sources

Suppose the total potential of water resources from existing infrastructure and infrastructure to be built is plotted with the projected water demand for IKN and regencies/cities around IKN for the next 50 years. A graph will be obtained, as shown in Figure 5. Suppose it is assumed that all-natural resource infrastructure plans have been built in Figure 5. in 2023. In that case, there is still a surplus of the raw water supply of 11,545 $l.s^{-1}$, and if there is no additional potential for raw water, after 2045, it is estimated that there will be a raw water supply deficit. If it is assumed that in 2023 only 80% of the total raw water potential can be utilized, in 2023, there will still be a raw water surplus of 3,790 $l.s^{-1}$. If there is no additional raw water potential, it is estimated that after 2031 there will be a raw water deficit. There will be a raw water deficit of 3,966 $l.s^{-1}$ in 2023 if only 60% of the total raw water potential development plan can be used. As a result, in the long term, it is necessary to find alternative potential raw water sources for IKN and the adjacent regencies/cities.

Table 6. Existing water resources potential and water resources development plans in IKN areas and adjacent regencies/cities [28, 29]

No.	Existing Water Resources Infrastructure	Potensi ($l.s^{-1}$)
1	Manggar Dam (Balikpapan City)	1,200
2	Teritip Dam (Balikpapan City)	260
3	Reservoir of Aji Raden (Balikpapan City)	150
4	Samboja Dam (Kutai Kartanegara Regency)	1,167
5	Kalhol intakes - Mahakam River, Samarinda City	1,000
6	Lempake Dam (Samarinda City)	1,050
	Water Resources Infrastructure Plan	
1	Sepaku Semoi Dam (North Penajam Paser Regency)	1,100
2	Selamayu Dam (Kutai Kartanegara Regency)	3,950
3	Loa Kulu Intake – Mahakam River (Kutai Kartanegara Regency	2,000
4	Lambakan Dam (Paser Regency)	5,000
5	Beruas Dam (Kutai Kartanegara Regency)	1,100
6	Safiak Dam (Kutai Kartanegara Regency)	2,500
7	Batu Lepek Dam (Kutai Kartanegara Regency)	14,300
8	ITCHI Dam (North Penajam Paser Regency)	4,000
	Total potential of raw water	33,950

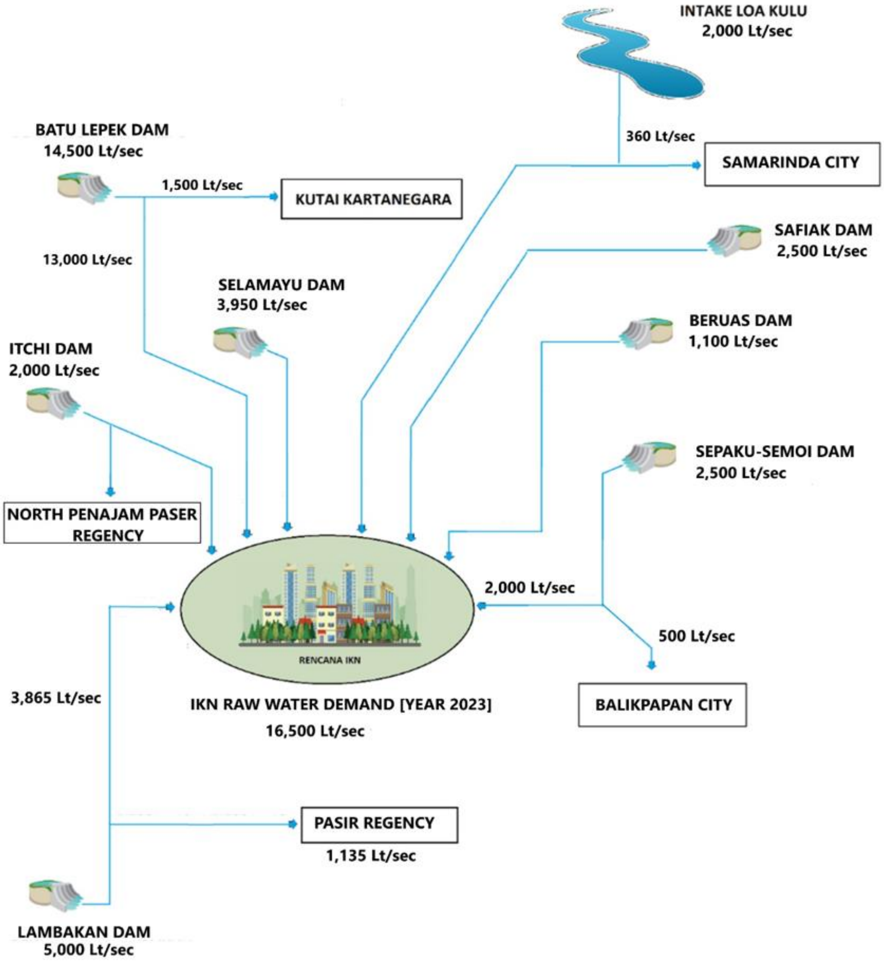

Figure 3. Water resources infrastructure plan at IKN

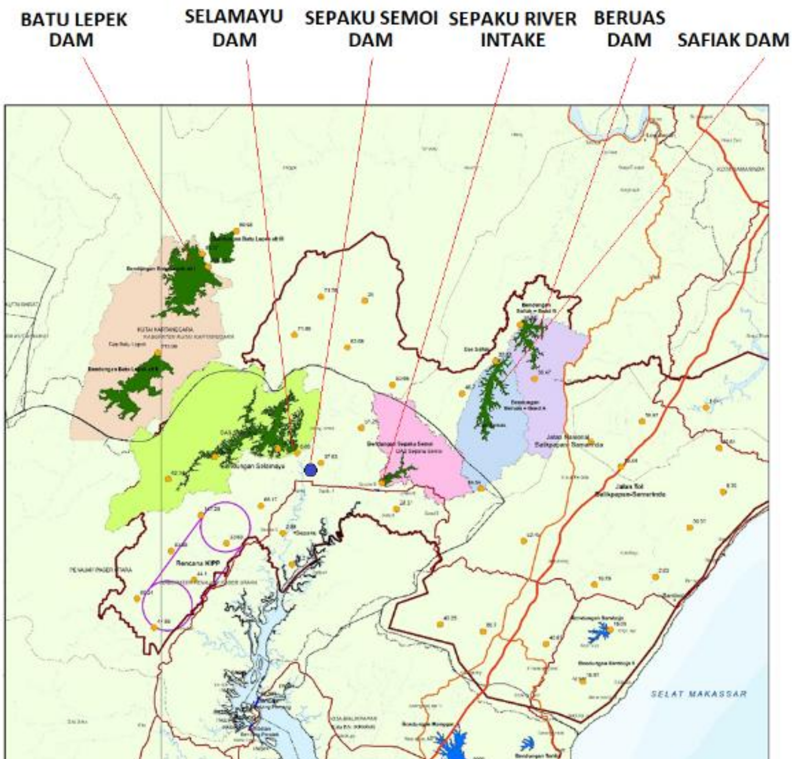

Figure 4. A scenario of raw water supply for IKN

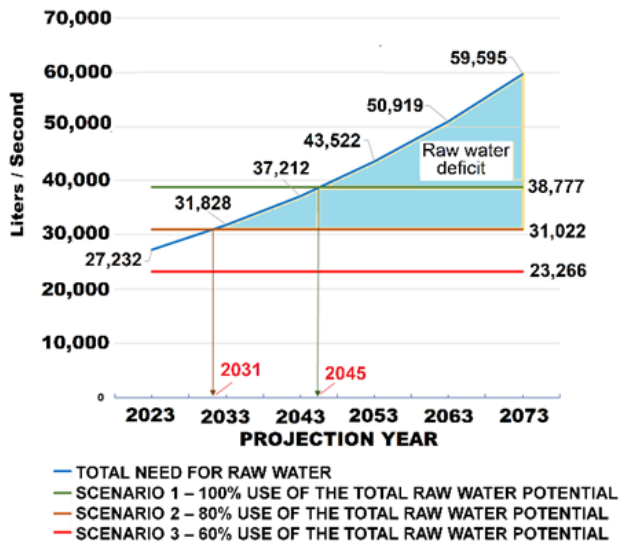

Figure 5. Graph of raw water demand projection for drinking water supply in IKN areas and surface potential of existing natural resources infrastructure and infrastructure plans to be built

3.4 Long-term alternatives to fulfill the raw water supply of IKN

One of the large raw water potentials that can still utilize is from the Mahakam River through the Loa Kulu intake, and it's just that the distance is relatively far, around 146 km [33]. Several other alternatives for supplying IKN raw water include the use of Rainwater for domestic purposes, the use of groundwater, the use of recycling wastewater into clean water, and the desalination of seawater into drinking water [34].

3.4.1 Raw water source from the Mahakam River

The Mahakam River is the name of the largest river in the province of East Kalimantan, which discharges into the Makassar Strait. This river, which has a length of 980 km and an estimated catchment area of greater than 77,800 km^2, is also one of the largest in Indonesia [35]. This river spans about 920 km and crosses the West Kutai Regency upstream to the Kutai Kartanegara Regency and Samarinda City downstream. The average flow rate is 2,500 l.s^{-1}. In contrast, the maximum flow rate is 3,250 l.s^{-1} [33]. Thus, this river can be used as an alternative source of raw water for IKN. One of the problems is that the distance between the intake location and the IKN location is quite far, which is about 146 km, and it will require a significant investment. In addition, the water quality of the Mahakam River begins to be polluted by both domestic and industrial wastewater [36].

3.4.2 Alternative utilization of groundwater for domestic purposes

Regarding topography, the IKN area is a folded hill composed of sandstone and clay, with coal inserted between the clay stones. The western part is a fold with a rock slope to the west, and the east side is a folded part with a rock slope to the east. The west-southeast anticline axis forms the lowlands for the IKN, which are often flooded parts. With such a position, groundwater aquifers tend to tilt outward from IKN candidates, and it is unlikely that groundwater will be found in the center of the IKN; groundwater will tend to be abundant on the west side of the IKN, which will come out as springs. Therefore, more tributaries will emerge from the west side. Shallow groundwater potential is still very possible in the middle of the IKN, but the potential is insignificant, only sufficient for household-scale needs. Still, it is rather tricky for large quantities or requires more in-depth information, especially for those that provide aquifer data in a relatively low position. Most of the area is in the district of Sepaku and District. Loakulu has a low groundwater-carrying capacity. In Sepaku District, the area with scarce groundwater carrying capacity is 55,310.22 ha (97.5%). At the same time, the area with moderate groundwater capacity is only 1,436.41 ha (2.5%). For Loa Kulu District, the area with low groundwater carrying capacity is 18,406.21 Ha, and this area with moderate groundwater carrying capacity is 1,155.41 ha (6.3%). All Core Areas and Core Locations of IKN have low groundwater carrying capacity. Sukaraja Village has an aquifer depth of 20-60 m with an average discharge potential of 0.7 l.s^{-1}, while at a depth of 0-20 m, groundwater quality has high levels of iron (Fe) with a potential discharge of 0.1 l.s^{-1}. Groundwater aquifers at a depth of 60 -100 meter have poor groundwater quality, as evidenced by several samples of deep bore wells with a depth of 100 meter; the groundwater quality is salty with > 10,000 s.cm^{-1} with a potential discharge of 0.7 l.s^{-1} [37].

3.4.3 Alternative utilization of wastewater reclamation

Urban wastewater is potential raw water that can be used to be reprocessed and utilised for various purposes because about 80-90% of the clean water used will become wastewater. Before being discharged into the environment, wastewater must be treated until it meets the applicable quality standards. It can be utilised or reused according to its designation if further processed. Several applications of wastewater recycling are used for various purposes, including agricultural or landscape irrigation, industrial use, groundwater recharge, and to supply clean water and general purposes, for example, flushing and fire fighting water and others [38]. The drought that dominated the millennium (2000–2009) heightened public interest in desalination and water recycling. Water reformation laws created standards for recycled water, including runoff and drinkable water rise. Brisbane has installed modernised reclaimed water treatment facilities for indirect potable reprocessing [39]. Several things need to be considered to examine several essential concepts and technologies for recycling wastewater. The first is the reliability of the treatment process (treatment process reliability), and the second is the quality of the treated water must comply with the quality standard for its purpose. One example of successful water reclamation and reuse is NEWater Factory in Singapore. Due to advancements in the membrane process, it is now technically and financially viable to enable the reclamation and reuse of water. Reclaimed water currently makes up 40% of Singapore's water supply, and the government anticipates it will eventually make up a more significant share [40]. Reclaimed water may be produced consistently and of high quality due to multi-barrier methods, including dual membrane filtering and UV disinfection, as well as a disciplined operational philosophy and extensive water quality management program [41].

3.4.4 Alternative utilization of rainwater for domestic purposes

One alternative to meet the needs of raw water in IKN so that there is no water deficit is using rainwater for domestic purposes by applying the Rain Harvesting (RWH) method. Rainwater Harvesting (RWH) has become increasingly utilised as a secondary water supply option for domestic and drinking needs due to the rising scarcity of groundwater and surface water due to human activity and climate change [42]. In rural parts of developing nations example, Vietnam, rainwater is frequently used as a natural, affordable water source because it is tastier than underground water. Increasing the utilisation of rainfall is a priority for the Vietnamese government, as evidenced by the Government Order No. 80/2014/CP on drainage and wastewater treatment, published in 2014 [43]. Two-thirds of Singapore's land area is used to collect water. Nonetheless, Singapore is striving to add 2,060.57 ha to the watershed area so that it covers 90% of its land, making it one of the few nations in the world to collect urban stormwater for drinkable use on such a big scale. The amount of rain that can be gathered and stored is constrained by the tropical nation's small size [44]. The use of rainwater is a significant potential alternative to meet the needs of raw water in the IKN because it is an area with a tropical climate located in the southeast of the Asian continent, which only has two seasons, namely the rainy season and the dry season. During the rainy season, we face abundant water, so the existing rivers cannot accommodate the amount of water, and floods occur. With high rainfall, various areas are often flooded because the capacity of rivers that divide the land has been reduced due to silting of rivers, accumulation of garbage at sluice gates, and illegal development on riverbanks [35]. Water conservation with the Roof Top RWH method has considerable potential to overcome the problem of raw water availability in IKN. Suppose the government provides a policy, so the community is willing to start water conservation efforts by harvesting rainwater in their homes and for industry, offices, hotels, shops, and others [45]. Although it has been known in Indonesia for a long time, this conservation technique has yet to be implemented thoughtfully. Many people have channeled rainwater from the roof of their houses with a paralon system; unfortunately, the water is directly discharged into the gutter. If rainwater from the roof is accommodated and collected for use, it will be able to reduce the water crisis.

3.4.5 Desalination of saltwater to freshwater

Another alternative to meet the needs of raw water in IKN is the application of desalination for saltwater to the freshwater method. In recent years, desalination technology and the prospect of desalination technology reduced water scarcity increasingly. Some countries have used desalination technology for commercial water supply, as shown in Table 7.

Table 7. Ranking of the top 10 countries using desalination technology [46]

No.	Country Total	Capacity ($Mm^3.d^{-1}$)	Market Share (%)
1	Saudi Arabia	9.9	16.5
2	USA	8.4	14.0
3	UAE	7.5	12.5
4	Spain	5.3	8.9
5	Kuwait	2.5	4.2
6	China	2.4	4.0
7	Japan	1.6	2.6
8	Qatar	1.4	2.4
9	Algeria	1.4	2.3
10	Australia	1.2	2.0

The cost of producing SWRO desalinated water with a capacity of fewer than 100 million liters per day (1,000 $m^3.l^{-1}$) is relatively high, but for a larger capacity of 100 million liters per day (Mld) the cost of water production is lower. The optimal size for SWRO desalination plants is 100-200 Mld. For the new Installation, SWRO has recorded total production in the range of US$ 0.5 – 0.8 per m^3. Newer SWRO installations generally produce water at a much lower production cost. The new SWRO installation has used energy recovery device technology (ERD) so that it can save more on energy costs [47].

4. CONCLUSIONS

The demand for raw water supply in regencies/cities around IKN, namely Regencies of Kutai Kartanegara, Penajam Paser Utara, Paser, Balikpapan City, and Samarinda City in 2023 is 10,732 $l.s^{-1}$. The raw water requirement for IKN in the planning year (2023) is 16,500 $l.s^{-1}$. Thus, for the supply of drinking water to IKN and its adjacent regencies/cities, namely Regencies of Kutai Kartanegara, Penajam Paser Utara, Paser, Balikpapan City, and Samarinda City, in the planning year (2023), a total raw water supply of 27,232 $l.s^{-1}$ is required. The potential for raw water from the existing and planned water resources infrastructure to be built is 38,777 $l.s^{-1}$. The calculation results show that the estimated raw water needs for IKN and its adjacentin 2023, 2033, 2043, 2053, 2063, and 2073 are 27,232 $l.s^{-1}$, 31,828 $l.s^{-1}$, 37,211 $l.s^{-1}$, 43,522 $l.s^{-1}$, 50,918 $l.s^{-1}$, and 59,594 $l.s^{-1}$. If it is assumed that all natural resources infrastructure plans have been developed by government, in 2023, there will still be a surplus of the raw water supply of 11,545 $l.s^{-1}$. If there is no additional raw water potential after 2045, it is estimated that there will be a raw water supply deficit. To overcome the problem of limited raw water sources for drinking water, IKN is implementing integrated water resource management. An alternative source of raw water is the Mahakam River. One issue is the Mahakam River 146-kilometer distance between the Loa Kulu intake and the IKN location, necessitating a significant investment. Furthermore, both domestic and industrial wastewater begins to pollute the Mahakam River's water quality. Other alternatives for IKN raw water supply include rainwater for domestic purposes, groundwater, recycling wastewater into clean water, and desalinating seawater into clean/drinking water. For the supply of drinking water in cities to remain sustainable, the concept of water resource management must be integrated. Desalination technology for urban drinking water supply systems is an advanced technology. The main problem at this time is the construction cost, and the cost of producing desalinated water is still relatively expensive compared to drinking water treatment technology using raw water. Desalination technology, therefore, represents the last alternative for providing drinking water for IKN in the lack of any other sources. However, the government can develop policies to overcome the water supply deficit by using rainwater in their homes and industries, utilizing wastewater reclamation/recycling, and desalinating of seawater for factories to meet their water demand. The results of this research will contribute knowledge on potential strategies to managing water resources in different regions of Indonesia, which will provide input for governmental initiatives and policies.

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NOMENCLATURE

c	water demand, $l.d^{-1}$
Q	discharge, $l.s^{-1}$
Q	discharge, $m^3.d^{-1}$
v	volume, $M.m^3$

ABBREVIATIONS

ASN	State civil apparatus
BWS	River basin centre
Bappenas	National development planning agency

BUMD	Regionally owned enterprises
BPPSPAM	Support Agency for Drinking Water Supply System
DHL	Conductivity
GDP	Gross domestic product
HCV	High conservation value
IKN	Indonesia's new capital
K-IKN	The IKN area
KIP	Central government core area
$KP\text{-}IKN_1$	The first expansion area for Indonesia's new capital
$KP\text{-}IKN_2$	The second expansion area for Indonesia's new capital
n	The period of the projected year
NKRI	The Archipelagic State of The Indonesian Republic
PDAM	Local Water Company
P_n	Amount in the projected year
P_0	Total initial population
PUPR	The ministry of public works and public housing
PPN	The ministry of national development planning
r	Average population growth rate per year, %
R&D	Research and development
RO	Reverse osmosis
RWH	Rainwater harvesting
Second/cm	Second/centimetre
SPAM	Drinking water supply system
SWRO	Sea water reverse osmosis
SDA	The potential of existing water resources
SDGs	Sustainable development goals
UV	Ultraviolet