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Challenges in dealing with water pollution issues in the West Java island

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Abstract
Water is the most basic need for all living things on Earth. The abundance of water on Earth makes humans indifferent to the efficient use of water, including human activities, which are said to cause increasing pollutant loads in surface waters. The western part of Java, consisting of DKI Jakarta, West Java and Banten, has the highest population pressure in all parts of Indonesia. This has led to a decrease in the environment's carrying capacity, especially in the region's water resources. Agricultural and industrial activities and household activities cause decreasing water availability in quantity and reducing water quality. This has become a trigger for water scarcity both in quantity and quality. Based on the data, the western part of Java Island has rivers with critical status. In this study, researchers will analyze water availability, water pollution problems, and challenges in overcoming water pollution, especially in the western part of Java Island. This study used a qualitative method by conducting a literature review. In overcoming water pollution, serious efforts need to be made, including increasing community participation in the manufacture of household-scale WWTPs, limiting the use of pesticides in agricultural activities, and improving water quality by improving land cover in the upstream area and increasing water absorption in urban areas.
Keywords: carrying capacity and capacity; water pollution; water resistance; water resources

1. Introduction

Water is a basic need for all living things on Earth. According to Miller & Spoolman (2018), the natural capital on Earth consists of the geosphere, atmosphere, hydrosphere and biosphere. As one of the natural assets on Earth, water is the most essential thing for life. So that all living things on Earth will not survive without water, including humans. Miller and Spoolman (2018) say that humans use or utilize water inefficiently and pollute it, including many humans who do not value water. The abundance of water on Earth makes people indifferent to water scarcity and quality. For all living things, water quality affects life. Poor water quality in rivers and seas will affect their ecosystems' life. According to Miller & Spoolman (2018), in their book, clean water is a global health problem; WHO estimates that on average more than 4,100 people die from waterborne infectious diseases because they do not have access to clean water.

According to research by Tundisi et al. (2015), four interrelated issues dominate water security: water availability, human vulnerability to hazards and disasters, human needs, and sustainability. Humans use water for various activities, such as drinking water and life support activities. In life support activities, water is used for power generation, recreation, and daily activities such as washing, bathing, etc. The increase in population that occurs will affect the increase in demand for water resources. According to Tundisi et al. (2015), when the need for water increases, contamination or contamination of water will also increase, which is very worrying.

According to the hydrological concept, the water cycle will never stop; the water cycle involves various components of the Earth's climate system, from the atmosphere to the Earth and back again to the Earth through the processes of condensation, precipitation, evaporation and transpiration (Ministry of Environment and Forestry, 2019). Ecosystems significantly affect the water cycle that occurs on Earth. Humans must be wise in managing land and nature to maintain the need for water as a continuous renewable resource. However, the opposite happened. Human activities in managing ecosystems and natural capital affect water availability, land degradation, water pollution, flooding, drought and high salinity. In research in South Asia, recycling the resulting wastewater can provide benefits, including reducing pollution entering water bodies and reducing the utilization of fresh water (Sathre et al., 2022). However, in the long term, recycling wastewater cannot be a solution to increasing water resistance.

According to law number 32 of 2019, environmental carrying capacity is the ability of the environment to support human life, other living things and the balance between the two. Meanwhile, environmental capacity is the ability of the environment to absorb energy and other components that enter and put into it. Water resources are one of the natural assets as part of the environment's carrying capacity; water is a support and an essential part of human life and other creatures. Likewise, with water capacity, existing water resources have a limited capacity. Entering energy or other components into water is one of the problems in water availability. This is known as water pollution. The government has a role in maintaining the stability of the availability of water resources, both for human daily needs, to support production processes, and to support water for agriculture and plantations. In research in Central Asia, the carrying capacity of water resources contributes across sectors and significantly contributes to developing sustainable agriculture and increasing food security. The research noted several things to deal with the issue of water carrying capacity in the future, including the need to evaluate improvements in agricultural infrastructure such as irrigation for water, evaluation of the global food trading system, focus on climate change issues within the framework of analyzing the carrying capacity of groundwater that has an impact on sustainable agricultural systems and food security (Zhao et al., 2022)

According to the Regulation of the Minister of the Environment Number 17 of 2009 concerning guidelines for determining the carrying capacity of the environment in regional spatial planning, the determination of the carrying capacity of the environment is carried out by knowing the capacity of the natural environment and resources to support human activities or residents who use space for survival. The regulation also states that the capacity of natural resources depends on the capability, availability and demand for land and water. The increase in population significantly affects the need for land and water. In research in Egypt, water availability is a challenge that needs to be faced and becomes an important issue. The study notes that climate change has a vital role in giving an additional burden to the issue of water availability, in addition to an increase in population which causes the level of competition for water needs to increase (Abd Ellah, 2020). In the concept of environmental carrying capacity, water carrying capacity is seen based on water availability and demand. Water availability is affected by the runoff coefficient for each type of land use and the area of each type. In contrast, water demand is influenced by the population, and the need for water per person is based on consumption patterns.

According to BPS data (2022), Indonesia's population in 2020 was 269,603,400 people, with the highest population in the western part of Java, namely DKI Jakarta, West Java and Banten. The highest population of Indonesia's population is in the western part of the island of Java, which consists of the province of West Java with a total of 49,565,200 people, DKI Jakarta with a total of 10,576,400 people and 12,895,300 people (BPS, 2022). Based on these data, around 27.09 per cent of Indonesia's population is in the western part of Java. Based on data from the Ministry of Environment and Forestry (2019), the status of the national water carrying capacity and capacity on the island of Java has exceeded due to the minimal difference between water availability and water utilization. This was dominated by household activities, as much as 10.77 per cent, and agricultural-based

economic activities, as much as 89.23 per cent. However, from the availability of water, a total of 118,901,282,137 m3/year is estimated to be able to support the population on the island of Java with a population of 151,650,200 people in 2020 without any consideration of development and changes to land on the island of Java.

In the long term, for the island of Java, especially the western part of Java, which has the highest population, issues related to water carrying capacity and capacity are serious. As in DKI Jakarta, the area with the highest density in Indonesia, there is a serious problem related to water availability. According to data from the Ministry of Environment and Forestry (2019), the total availability of water, which is 393,454,165.38 m3/year, is far below the amount used, which is 958,939,316.61 m3/year. In addition to problems related to water availability, the western part of Java Island is also experiencing severe problems in cases of water pollution. Various strategies can be implemented to solve the problem of water availability and environmental pollution. In one of the studies in Indonesia, developing the concept of water and soil conservation is one of the efforts to overcome the problem of water availability. The research noted that support for sustainability in the management of ecological landscapes in Indonesia is one of the opportunities for addressing the problem of long-term water availability. Indonesia has great potential, especially regarding the availability of ecological landscapes that can be managed optimally to promote water and soil conservation. In this study, it was noted that water and soil conservation can increase native plant adaptation to local rainfall and soil conditions, and can increase infiltration, improve soil hydrological characteristics, and can also reduce temperature, increase humidity, and reduce intensity levels (Dharmawan et al., 2023)

According to PP No. 20 of 1990, water pollution is the process by which living things, substances, energy, and other components enter the water through human activities so that the water quality drops to a certain level which causes the water to no longer function according to its designation. Apart from household activities, industrial activities also cause water pollution. According to BPS data (2020), from 2017 to 2019, the number of large and medium processing industries on the island of Java dominated, namely around 80.47 per cent. In 2019, large and medium processing industries were on the island of Java. Water pollution is caused by human activities that do not pay much attention to environmental aspects or have a perspective that only focuses on human activities without paying attention to the environment, known as anthropocentrism. The western part of Java Island is also an industrial centre which contributes to the pollution of watersheds. In addition to household and industrial activities, both small-scale industry and large industry, the western part of Java, especially the West Java province, is the third largest agricultural area in Indonesia after the provinces of East Java and Central Java, with an area of 1,604,109.31 ha (BPS, 2021). However, suppose the agricultural area of Banten province is combined with an area of agricultural land of 318,248.46 ha (BPS, 2021). In that case, it becomes the area with the most significant agricultural land area in Indonesia.

In research on one of the rivers in Garut, West Java, it was noted that the pollution level in the Cibatarua River water was in the polluted category. The study results noted that the contents of BOD, COD, oil, PH, fat, and dissolved oxygen exceeded the threshold set by regulations (Munfarida et al., 2020). The research recommends several things to improve river water quality, including wastewater management, reducing the release of pollutants into rivers, and applying biotechnology with simple and environmentally friendly technologies such as phytotechnology (Munfarida et al., 2020). Other studies in the lower reaches of the Cimanuk River are also categorized as lightly to heavily polluted; this indicates that there is uncontrolled waste disposal from the activities of the batik industry, cracker industry, domestic waste, and other activities along the downstream of the Cimanuk river (Sulthonuddin et al., 2019). The recommendation emphasized by the researchers is that there needs to be more stringent enforcement of environmental laws by regional governments in dealing with cases of environmental pollution.

The increasing population, high industrial processing activities, and agricultural activities that use excessive pesticides drive water pollution. This is one of the problems that need to be resolved in maintaining the resilience of the availability of clean water for

human life and living things in the region. Based on data from the western part of Java Island, current conditions are areas that have exceeded the carrying capacity and water holding capacity nationally. If added to the water pollution problem, it will become a severe problem for now and in the long term. For this reason, a solution is needed to overcome the problem of water pollution, especially in the western part of Java, namely DKI Jakarta, West Java and Banten Provinces. The purpose of this research is to analyze the factors that cause water pollution and solutions to deal with water pollution in the long term to reduce the vulnerability of water resources. This study used a qualitative method by conducting a literature review. This research is expected to be a recommendation for local governments in managing water in the long term.

2. Methods

In this study, the approach used was a qualitative approach by conducting a literature review. The researcher also conducted a literature review of related studies to strengthen concepts related to water availability, water pollution issues, and challenges in dealing with water pollution problems in the western part of Java, namely the provinces of DKI Jakarta, West Java and Banten. This study aims to analyze the challenges of water pollution issues and strategies for solving water pollution problems.

3. Results and Discussion

In the discussion section, the author will describe the western part of Java, which consists of the provinces of DKI Jakarta, West Java and Banten, such as geographical location and administrative area, population demographics, carrying capacity and capacity of water, water pollution problems, and solutions for dealing with problems water pollution.

3.1. General Description of the Western Part of Java Island

Java Island is the island with the largest population in Indonesia. This includes the western part of Java, consisting of DKI Jakarta, West Java and Banten provinces. Nationally, the western part of Java Island is the region with the largest population in Indonesia, and one of its provinces is the region with the highest population density in Indonesia. DKI Jakarta, West Java and Banten are the three provinces on the island of Java. The area of each province, namely DKI Jakarta, is 664.01 km2, West Java is 35,377.76 km2, and Banten is 9,662.92 km2, as seen in Table 1 below.

Table 1. Provincial capitals and area

Name of Provinced	Capital City Area	Area (km^2)
DKI Jakarta	Jakarta	664,01
Jawa Barat	Bandung	35.377,76
Banten	Serang	9.662,92

Source: BPS Data (2022) Researcher Processed (2022)

Then, each region has a village or kelurahan which is by the sea, and villages or kelurahan which are not by the sea. Detailed data can be seen in table 2 below.

Tabel 1. Number of Villages by the Sea and Not by the Sea

Name of Provinced	Seaside Village/Kelurahan	Non-Seaside Villages/Kelurahan
DKI Jakarta	17	250
Jawa Barat	221	5.736
Banten	146	1.406

Source: BPS Data (2022) Researcher Processed (2022)

The three provinces have different topographical levels: valleys, slopes or peaks, and plains. Based on BPS data, West Java province has the most significant number of villages with the highest peak topography, namely 2424 villages, with the most significant

number of villages in the Garut district. Then, West Java province also has the most significant number of villages with flat topography, namely 3,492 villages or sub-districts. Then, with the type of valley topography, there are 41 villages or sub-districts, most of which are in the Bogor district. Topographic level data for each province can be seen in Table 3 below.

Table 3. Number of villages based on the topographical level in West Java

Kabupaten/ Kota	Desa/Kelurahan Lembah	Desa/Kelurahan Lereng/Puncak	Desa/Kelurahan Dataran
Bogor	5	215	215
Sukabumi	–	–	386
Cianjur	–	166	194
Bandung	4	176	100
Garut	2	316	124
Tasikmalaya	1	261	89
Ciamis	–	194	71
Kuningan	4	170	202
Cirebon	5	75	344
Majalengka	3	151	189
Sumedang	2	235	40
Indramayu	3	3	311
Subang	2	89	162
Purwakarta	1	108	83
Karawang	2	23	284
Bekasi	–	–	187
Bandung Barat	1	94	70
Pangandaran	1	64	28
Kota Bogor	3	43	22
Kota Sukabumi	1	4	28
Kota Bandung	–	25	126
Kota Cirebon	–	–	22
Kota Bekasi	1	–	55
Kota Depok	–	–	63
Kota Cimahi	–	1	14
Kota Tasikmalaya	–	11	58
Kota Banjar	–	–	25
Jawa Barat	41	2 424	3 492

Source: BPS Data (2022) Researcher Processed (2022)

In the DKI Jakarta province, almost all of its territory is in the lowland topography, comprising 267 villages or sub-districts. In detail can be seen in Table 4 below.

Table 4. Number of Villages by Topographical Level in DKI Jakarta

Kabupaten/ Kota	Desa/Kelurahan Lembah	Desa/Kelurahan Lereng/Puncak	Desa/Kelurahan Dataran
Kepulauan Seribu	–	–	6
Kota Jakarta Selatan	–	–	65
Kota Jakarta Timur	–	–	65
Kota Jakarta Pusat	–	–	44
Kota Jakarta Barat	–	–	56
Kota Jakarta Utara	–	–	31
DKI Jakarta	–	–	267

Source: BPS Data (2022) Researcher Processed (2022)

Then, the Banten province has as varied topographical levels as the West Java region, namely with the number of villages or sub-districts in the form of plains totalling 1026 villages or sub-districts, 514 villages or sub-districts in the form of slopes or peaks, and 12 villages or sub-districts in the form of valleys—details for each district or city as shown in Table 5 below.

Table 5. Number of villages based on the topographical level in Banten

Kabupaten/ Kota	Desa/Kelurahan Lembah	Desa/Kelurahan Lereng/Puncak	Desa/Kelurahan Dataran
Pandeglang	–	208	131
Lebak	4	186	155
Tangerang	–	–	274
Serang	8	88	230
Kota Tangerang	–	–	104
Kota Cilegon	–	22	21
Kota Serang	–	10	57
Kota Tangerang Selatan	–	–	54
Banten	12	514	1 026

Source: BPS Data (2022) Researcher Processed (2022)

The areas of DKI Jakarta, West Java and Banten have the largest population in Indonesia. The highest percentage of the population is in the province of West Java, with a population percentage of 17.89 per cent. Then, it is the area that has the highest population density in Indonesia, namely the DKI Jakarta area, with a population density of 15,978 people per square km. In detail, the population, population growth rate, population percentage, density level, and sex ratio can be seen in Table 6 below.

Table 6. Population, Population Growth Rate, Population Percentage Distribution, Population Density, and Population Gender Ratio by Province, 2021

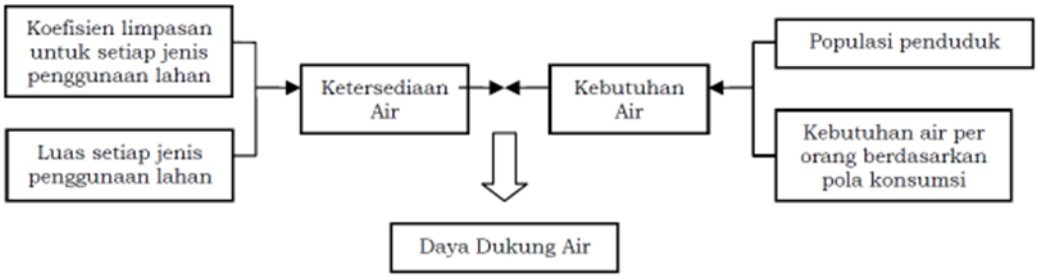
Provinsi	Jumlah Penduduk (Ribu)	Laju Pertumbuhan Penduduk per Tahun	Persentase Penduduk	Kepadatan Penduduk per km persegi (km2)	Rasio Jenis Kelamin Penduduk
DKI Jakarta	10 609,7	0,60	3,89	15 978	101,7
Jawa Barat	48 782,4	1,41	17,89	1 379	103,1
Banten	12 061,5	1,76	4,42	1 248	103,9
Indonesia	272 682,5	1,22	100,00	142	102,3

Source: BPS Data (2022) Researcher Processed (2022)

3.2. Carrying Capacity and Accommodation Capacity of the Western Part of Java Island

According to law number 32 of 2019, environmental carrying capacity is the ability of the environment to support human life, other living things and the balance between the two. Meanwhile, environmental capacity is the ability of the environment to absorb energy and other components that enter and put into it. According to the Regulation of the Minister of the Environment Number 17 of 2009 concerning guidelines for determining the carrying capacity of the environment in regional spatial planning, the determination of the carrying capacity of the environment is carried out by knowing the capacity of the natural environment and resources to support human activities or residents who use space for survival. The regulation also states that the capacity of natural resources depends on the capability, availability and demand for land and water.

In Figure 1, it is explained related to the concept of water-carrying capacity. The diagram explains the relationship between water availability and water demand. Water availability is influenced by two things: the runoff coefficient for each type of land use and the area of each type of land use. Meanwhile, the variable water demand is influenced by population, and water demand per person is based on consumption patterns. Water is one of the natural capital produced by ecosystems that humans and other living things can utilize for the continuation of life.



Gambar 1. Diagram Penentuan Daya Dukung Air
Figure 1. Diagram For Determining The Carrying Capacity Of Water
Source: Regulation of the Minister of Environment Number 17 of 2009

Conceptually, carrying capacity and carrying capacity, ecosystems consisting of biotic and abiotic components have interrelationships and dependencies with water as one of the ecosystem components. Water availability is strongly influenced by whether or not an ecosystem is good. Conceptually, the amount of available water will remain the same as the flow or cycle of water. However, the availability of water that humans can utilize is a problem. Land cover, natural vegetation types and landscapes will significantly influence water cycles and regulations. If the land cover on the upstream and riverbanks is good, then water availability in the river basin will also be good. Land cover and vegetation function as an absorbent and are then stored in groundwater. However, the opposite applies; if the land cover and vegetation are damaged, a flood disaster happens.

In the western part of the island of West Java, there are severe problems with water resources' carrying capacity and capacity. This region is an area with the highest population in Indonesia, which significantly affects the availability of water. Conceptually, the carrying capacity of water, the higher the population, the greater the human need for water. Water availability is minimal and influenced by land cover in each watershed or water catchment area. In addition, industrial and agricultural activities in this region are also the highest in Indonesia.

Based on the data, the western part of Java Island is the centre of the national capital, namely DKI Jakarta. Apart from the national capital, in this region, there are 13 other cities such as the cities of Bandung, Bogor, Bekasi, Sukabumi, Cirebon, Depok, Cimahi, Tasikmalaya and Banjar in West Java Province, and the cities of Tangerang, Cilegon, Serang City and Tangerang City South which is in the Province of Banten. Urban areas are the epicentre of problems related to vulnerability to water. The city is the centre of population activity, not only for residents who live in the area but also for immigrants. So that urban areas are synonymous with areas with high levels of density and with environmental problems such as high pollution, including water pollution.

In the West Java region, the city of Cimahi is the city with the highest population density with a density of 15,798.14 people per km2, followed by the city of Bandung with a density of 14,970.50 people per km2, and the city of Bekasi with a density of 14,886.45 people per km2. In detail, the area, population and density in the city of West Java can be seen in Table 7 below.

Table 7. Area, Total Population and Density Level of Regencies and Cities in West Java

Kabupaten/Kota		Luas (Km^2)	Jumlah Penduduk (2020)	Tingkat Kepadatan Penduduk (Jiwa/km2)
Kabupaten				
1.	Bogor	2.711	6.088.233	2246,07
2.	Sukabumi	4.146	2.470.219	595,85
3.	Cianjur	3.840	2.264.328	589,64
4.	Bandung	1.768	3.831.505	2167,19
5.	Garut	3.074	2.636.637	857,70
6.	Tasikmalaya	2.551	1.755.710	688,19
7.	Ciamis	1.415	1.201.685	849,42
8.	Kuningan	1.111	1.087.105	978,88
9.	Cirebon	985	2.209.633	2244,38
10.	Majalengka	1.204	1.210.709	1005,37
11.	Sumedang	1.518	1.154.428	760,33
12.	Indramayu	2.040	1.737.624	851,73
13.	Subang	1.894	1.612.576	851,44
14.	Purwakarta	826	971.889	1176,99
15.	Karawang	1.652	2.370.488	1434,75
16.	Bekasi	1.225	3.899.017	3183,18
17.	Bandung Barat	1.306	1.714.982	1313,39
18.	Pangandaran	1.010	401.493	397,52
Kota				
1.	Bogor	119	1.126.927	9509,93
2.	Sukabumi	48	330.691	6853,70
3.	Bandung	168	2.510.103	14970,50
4.	Cirebon	37	322.322	8627,46
5.	Bekasi	207	3.075.690	14886,45
6.	Depok	200	2.484.186	12402,95
7.	Cimahi	39	620.393	15798,14
8.	Tasikmalaya	172	663.986	3869,16
9.	Banjar	113	183.299	1615,11
Jawa Barat		35.378	49.935.858	1411,50

Source: Regency and City Area According to BPS (2016)

The West Java region has 10 major river areas, namely the Ciliwung, Cisadea, Cibareno, Citarum, Cimanuk, Cisanggarung, Citanduy, Ciwulan, and Cilaki Rivers. Based on BPS data (2018), the Ciliwung river has the most surface water availability with a total of 26,804.19 million m3 per year, followed by the Citarum river with a total water availability of 25,575.23 million m3 per year. In detail can be seen in table 8 below.

Table 8. Availability of Surface Water by River Basin in West Java

No.	River Area	Total Water Availability	Unit
1	CILIWUNG	9990,35	JUTA M^3/TAHUN
2	CILIWUNG	9011,32	JUTA M^3/TAHUN
3	CILIWUNG	7802,52	JUTA M^3/TAHUN
4	CISADEA - CIBARENO	7586,62	JUTA M^3/TAHUN
5	CISADEA - CIBARENO	5789,65	JUTA M^3/TAHUN
6	CISADEA - CIBARENO	5618,55	JUTA M^3/TAHUN
7	CITARUM	10724,8	JUTA M^3/TAHUN
8	CITARUM	7606,45	JUTA M^3/TAHUN
9	CITARUM	7243,98	JUTA M^3/TAHUN
10	CIMANUK - CISANGGARUNG	7111,68	JUTA M^3/TAHUN
11	CIMANUK - CISANGGARUNG	5854,2	JUTA M^3/TAHUN
12	CIMANUK - CISANGGARUNG	5851,24	JUTA M^3/TAHUN
13	CITANDUY	3079,13	JUTA M^3/TAHUN
14	CITANDUY	2613,87	JUTA M^3/TAHUN

15	CITANDUY	2482,36	JUTA M³/TAHUN
16	CIWULAN - CILAKI	5280,45	JUTA M³/TAHUN
17	CIWULAN - CILAKI	6220,33	JUTA M³/TAHUN
18	CIWULAN - CILAKI	5014,76	JUTA M³/TAHUN

Source: BPS data (2022) processed by the author (2022)

In Banten Province, there are 4 city areas and 4 regency areas. Banten Province has a population density of around 1231.98 people per km2. However, the cities of Tangerang and South Tangerang, which are buffer zones for DKI Jakarta Province, have a very high population density, namely for the city of Tangerang, 12,313.95 people per km2 and 9,201.37 people per km2. In detail, the area, population and population density in the province of Banten can be seen in table 9 below.

Table 9. Data on Area, Total Population and Population Density Level

Kabupaten/Kota	Luas Wilayah (Km^2)	Jumlah Penduduk	Tingkat Kepadatan Penduduk (Jiwa per Km^2)
Kab Pandeglang	2.747	1.272.687	463,32
Kab Lebak	3.427	1.386.793	404,72
Kab Tangerang	1.012	3.245.619	3207,58
Kab Serang	1.734	1.622.630	935,62
Kota Tangerang	154	1.895.486	12313,95
Kota Cilegon	176	434.896	2478,04
Kota Serang	267	692.101	2594,96
Kota Tangerang Selatan	147	1.354.350	9201,37
Provinsi Banten	9.663	11.904.562	1231,98

Source: BPS (2021) Researcher Processed (2022)

In the province of Banten, there are three river areas namely the Ciliman – Cibungur River, the Sidanau – Ciujung – Cidurian, and Ciliwung – Cisadane Rivers. Based on this, most of the river areas in Banten province have critical status with absolute scarcity availability class.

Table 10. Water Availability Data for Banten Province

No.	**Wilayah Sungai**	**Jumlah Ketersediaan Air**	**Satuan**
1	Ciliman - Cibungur	2183,03	JUTA M³/TAHUN
2	Cidanau - Ciujung - Cidurian	857,9	JUTA M³/TAHUN
3	Cidanau - Ciujung - Cidurian	747,43	JUTA M³/TAHUN
4	Cidanau - Ciujung - Cidurian	796,13	JUTA M³/TAHUN
5	Cidanau - Ciujung - Cidurian	2217,43	JUTA M³/TAHUN
6	Ciliwung – Cisadane	166,63	JUTA M³/TAHUN
7	Ciliwung – Cisadane	187,43	JUTA M³/TAHUN

Source: Water Resources Information System (2022)

Based on the data in Table 10, water carrying capacity and capacity in the western part of Java island, which consists of the provinces of DKI Jakarta, West Java and Banten, are experiencing problems in water availability and needs problems. This area has the highest population in Indonesia, with the highest population density in Indonesia, the highest number of urban areas, the area with the most significant agricultural land in Indonesia and one of the largest industrial centres in Indonesia. If left unchecked, water resources related

to availability and demand, in the long run, will experience a high level of vulnerability in terms of availability.

The problem of the availability of water resources in the western part of Java needs serious attention. Especially from the regional government, in order to focus on solving water availability, one of which is by improving natural ecosystems by planting trees in the upstream areas of rivers and riverbanks. In addition, it is also necessary to expand the water catchment area, especially in urban areas. Thus, the flood disaster caused by insufficient water absorption in rivers and other land areas did not occur. In addition, there is also a need for innovation, one of which is a rainwater harvesting system.

Rainwater harvesting collects stores, and reuses rainwater (Sari & Suhendri, 2018). According to Murdiana et al. (2019), rainwater harvesting has been adopted in urban areas when the raw water supply is insufficient for the community. In his research, drinking water companies such as PDAM in the North Jakarta area carry out the rain harvesting system. Rainwater harvesting systems are an alternative to the availability of clean water. When the soil cannot absorb the water cycle due to reduced land cover, this rainwater harvesting solution is the best solution, especially in urban areas with very few water catchment areas. In general, rain harvesting can be divided into two parts: collecting rainwater on the roof of the building (roof catchment) and collecting water from the ground catchment (Murdiana et al., 2019). This needs to be done by drinking water companies and the industry as an alternative in water utilization amidst the vulnerability to water availability.

In another study, it was conveyed that rainwater harvesting systems have been used by developed countries such as Singapore, which has limited land and has high water needs, as well as in Japan using it for the needs of flushing oil, fire fighting, and water supply in emergencies (Sari & Suhendri, 2018). Urban areas in the western part of Java Island, especially cities such as DKI Jakarta, Cimahi City, Bekasi City, Depok City, and Tangerang City, which on average, have the highest density level in the region. In addition, the area is also an area that has a large number of tall buildings. The potential for harvesting rainwater in the area of a high-rise building can meet the water needs of the building. Apart from that, through the encouragement of the government, the rainwater harvesting system can also become a program that is prioritized, especially in slum areas, in the slum area improvement program so that the problem of water availability in critical status can be resolved.

3.3. Water Pollution Problems

Water pollution, according to Government Regulation No. 20 of 1990 concerning water pollution control, is defined as the entry or inclusion of living things, substances, energy, and or other components into the water by human activities so that the water quality drops to a certain level which causes the water to no more extended function, according to its purpose. In developing countries, meeting the clean water needs is a big problem. It is included in Indonesia, especially West Java, DKI Jakarta, and Banten, one of the sources of clean water are rivers which have an essential role in drinking water and irrigation (Suriadikusumah et al., 2021). This is due to groundwater sources in the region experiencing degradation.

The high industrial activity in West Java, DKI Jakarta and Banten is a problem for the availability of clean water, especially river water. Industrial activity causes an increase in pollutants in river water. Apart from industry, people's daily activities are also a significant problem. This is because existing regulations have not touched human activities, and the potential for pollution by these activities tends to be high and uncontrolled. According to research on the Cipeusing River in West Java, industrial, household and agricultural activities have caused an increase in the entry of heavy metals, pesticides, nitrogen and household waste into the river, and the Cipeusing River makes a significant contribution to pollution in the Citarum River (Suriadikusumah et al., 2021). In this study, there are several parameters used as indicators of water pollution in the Cipeusing River, namely Total

Suspended Solid (TSS), Total Dissolved Solid (TDS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), nitrite content, and microbiology, such as E. Coli bacteria.

Based on BPS data (2022), in the DKI Jakarta area, there has been a decrease in the number of sub-districts that have the status of areas experiencing water pollution, namely from 2018 with 126 sub-districts, to 78 sub-districts in 2021. This is a good development considering that DKI Jakarta province has the highest population density in Indonesia. Not only the DKI Jakarta area, the provinces of West Java and Banten have also experienced a decline in the status of polluted villages. This is in line with the status of villages throughout Indonesia which has decreased significantly from 2018 to 2021.

Table 11. Data on the Number of Villages by Type of Environmental Pollution

Provinsi	Banyaknya Desa/Kelurahan Menurut Jenis Pencemaran Lingkungan Hidup (Desa)											
	Pencemaran Air			Pencemaran Tanah			Pencemaran Udara			Tidak Ada Pencemaran		
	2014	2018	2021	2014	2018	2021	2014	2018	2021	2014	2018	2021
DKI JAKARTA	54	126	78	2	10	10	17	42	42	200	138	173
JAWA BARAT	1131	1890	1217	118	144	129	833	869	556	4327	3723	4497
BANTEN	251	513	257	43	51	40	239	326	197	1141	888	1201
INDONESIA	8786	16847	10683	1301	2200	1499	11998	8882	5644	63841	61891	69966

Source: BPS data processed by the author (2022)

In addition to environmental pollution data, according to BPS data (2022) the percentage of households that have access to proper sanitation services has also increased for the DKI Jakarta, West Java and Banten areas from 2019 to 2021.

Table 12. Proportion of Households Having Access to Adequate Sanitation Services (percent)

Provinsi	Proporsi Rumah Tangga Yang Memiliki Akses Terhadap Layanan Sanitasi Layak (persen)		
	2019	2020	2021
DKI JAKARTA	92,89	93,04	95,17
JAWA BARAT	69,64	71,4	71,66
BANTEN	81,01	82	82,89
INDONESIA	77,39	79,53	80,29

Source: BPS data processed by the author (2022)

However, according to the strategic environmental study (KLHS) for the Jabodetabekpunjur area (Jakarta, Bogor, Depok, Tangerang, Bekasi, Puncak and Cianjur) there are around 158,417.89 Ha of the area experiencing water pollution. Based on these data, the area experiencing the highest water pollution is in the Bekasi Regency area, which is 25,835.38 ha, the highest in the North Cikarang sub-district. Then, the area of Bogor Regency with a total area of 25,835.38 Ha is polluted.

Zona	Luas (ha)		
	Tercemar	Tidak Tercemar	No Data
B1	73,166.02	197,905.64	
B2	23,689.59	82,932.79	
B3	8,609.97	69,622.56	
B4	17,000.64	67,506.27	
B5	16,395.94	89,930.81	
B6	3,717.67	2,454.19	
B7	1,349.51	1,547.39	
B8			734.04
L1	6,750.50	5,557.77	
L2	2.41	185.17	
L3	7,735.64	32,774.86	
L5		203.12	
Total	**158,417.89**	**550,620.57**	**734.04**

Kabupaten/Kota	Luas (ha)	
	Tercemar	Tidak Tercemar
B1	**73,166.02**	**197,905.64**
BEKASI	25,835.38	46,199.08
BOGOR	18,021.42	45,742.76
CIANJUR	72.57	604.61
DEPOK	3,397.30	9,823.71
JAKARTA BARAT	4,093.59	8,420.30
JAKARTA PUSAT	109.34	4,680.43
JAKARTA SELATAN	397.48	12,161.49
JAKARTA TIMUR	3,398.55	13,026.94
JAKARTA UTARA	7,139.26	5,817.98
KARAWANG		0.03
LEBAK		0.33
SERANG	0.15	
TANGERANG	9,733.00	37,599.48
TANGERANG SELATAN	967.99	13,828.51

Kecamatan	Luas (ha)	
	Tercemar	Tidak Tercemar
B1	**73,166.02**	**197,905.64**
BEKASI	**25,835.38**	**46,199.08**
CIKARANG UTARA	3,262.48	736.14
TARUMAJAYA	1,923.84	
BABELAN	1,907.27	1,155.08
SETU	1,895.88	2,932.03
CIKARANG TIMUR	1,488.46	1,633.02

Figure 2. Area of Water Pollution in each Zone in the Jabodetabekpunjur spatial pattern
Source: Jabodetabekpunjur Strategic Environmental Study (2019)

In several studies, the water pollution index is one of the measurement tools used to measure water quality. The water pollution index is an approach that minimizes the volume of data for most of the data and simplifies the water quality status (Effendi, 2016). The measuring parameters used in the water pollution index are physical, chemical and microbiological factors. In addition, another measuring tool used is the pollution index used to measure water quality, with an index size between 0.0 - 1.0 with good water quality criteria, between 1.0 - 5.0 with moderate pollution criteria, between 5 .0 – 10 with polluted criteria, and above 10 with highly polluted criteria (Effendi et al., 2015). With these measurements, the Ciambulawung River, which is a stream originating from the Mount Halimun Salak National Park in Banten province, has a pollutant index between 0.56 - 0.78, meaning that based on the pollution index, the water quality in the river is in good condition (Effendi et al., 2015). This study stated that human activities and micro-hydro in the area did not affect the quality of river water (Effendi et al., 2015).

In another study, in the waters of the Jatigede Reservoir, West Java province, using the same pollution index measurement tool, the results were between 1.75-3.01, meaning that the quality of the water sources in the Jatigede Reservoir is moderately polluted (Sami et al., 2021). Human activities in the Jatigede Reservoir that affect the high pollution index are fish cage cultivation, which causes a high BOD value in Jatigede Reservoir waters. In Jakarta, research was conducted on the Grogol River, with measurements using the pollution index; the results obtained were pollution index values of 2.369 – 5.890, with the criteria for the pollution index being towards polluted conditions. The research was taken based on rainy and dry seasons samples (S. Amira et al., 2018). In the Grogol River, human activities make the most significant contribution to pollution in river water; namely, the parameters that exceed the threshold value are BOD, COD, Phosphate, and detergents.

In addition to using the Pollution Index, another measuring tool for measuring water quality is using the Water Quality Index (WQI), namely with criteria 0-25 terrible criteria, 26-50 flawed criteria, 51-70 medium or moderate criteria, 71-90 good criteria, and above 91 with Perfect criteria (Putri & Wardhani, 2021). In this study, the research sample was to measure groundwater quality with a sample point of 30 groundwater sample points in the city of Cimahi, West Java, with an average result of groundwater quality with medium or medium criteria. Three locations had poor water quality, namely Cibeurem, Karang Mekar, and Baros (Putri & Wardhani, 2021). To carry out measurements using the WQI method, there are five physical parameters: TDS, turbidity, colour, odour, and temperature. Eleven chemical parameters are used: pH, iron, fluoride, hardness, manganese, nitrate, nitrite, sulfate, zinc, detergent, and astringent. Organic matter, and one microbiological parameter, namely total E.Coli bacteria (Putri & Wardhani, 2021).

With the measuring method using WQI, in the research on water quality in Lake Rawa Besar, Depok, West Java, using 30 sample points. In this study, the results were that the middle part of the lake was relatively clean, and then it got dirtier towards the edge of the lake (Lukiyansah et al., 2020). This research wants to see the link between land use and water quality and the existence of potential polluted sources resulting in high BOD and turbidity values caused by domestic waste (Lukiyansah et al., 2020). Land use around the Rawa Besar Depok Lake affects the water quality in the lake. According to Lukiyansah et al. (2020), there are several places of daily activity, such as poultry cages, fish cages, metal workshops, sawmills, tofu factories, garbage disposal sites, and food stalls which have the potential to become a source of contamination, for Big Swamp Lake.

Based on research data in West Java, DKI Jakarta and Banten, most areas have experienced water pollution. Both water pollution in river water, as well as groundwater pollution. The analysis in this study used a pollutant index and water quality index measuring instrument. This is due to high human activities such as industry, agriculture and daily human activities. In addition, land use also affects the quality of water, in particular groundwater and surface water such as lakes and rivers. However, according to statistical data from BPS (2022), the area has experienced a decrease in the number of villages experiencing water pollution from 2018 to 2021. Improvements in environmental sanitation in the household sphere drive this.

3.4. Causes of Water Pollution

Based on Unicef data (2022), almost 70 per cent of the 20,000 household drinking water sources tested in Indonesia were contaminated with faecal waste and contributed to the spread of diarrheal diseases. A study said that 7 out of 10 households in Indonesia consume drinking water contaminated with E. Coli bacteria (Ministry of Health, 2021). Based on these data, household activities are the most significant cause of water pollution in Indonesia. For densely populated areas, especially the DKI Jakarta Province, most households have used clean water producers' services. Based on BPS data (2021), in 2018, the number of customers for the Drinking Water Company (PAM) was 884,935 customers, then it became 885,353 customers in 2019, and in 2020 it rose again to 896,782 customers.

Water pollution occurs due to the entry of living things, foreign objects, or other components into clean water sources. In general, the areas of DKI Jakarta, West Java and Banten experienced degradation related to water quality, especially in urban areas. Based on BPS (2020), in the DKI area with five rivers taken as water quality samples, the rivers in the DKI Jakarta area experience mild to severe pollution. From the five rivers of Ciliwung, West Tarum, Situ Ragunan, Kalibata Lembang, and Sunter Pengumben, results were obtained based on 4 sample points that the Ciliwung river experienced light to heavy water pollution. Then, in 4 rivers in the province of West Java, which consists of the Ciliwung, Cisadane, Citarum, and Citanduy rivers, it was found that all these river locations experienced light to heavy pollution. Finally, in the province of Banten, with two rivers used as monitoring point samples, namely the Cidurian and Cisadane rivers, the results showed that the two rivers experienced mild to severe pollution.

According to the water pollution index and water quality indicators, several indicators indicate water quality, namely physical, chemical and microbiological factors. The WQI is detailed into five physical parameters: TDS, turbidity, colour, odour, and temperature. There are eleven chemical parameters, namely pH, iron, fluoride, hardness, manganese, nitrate, nitrite, sulfate, zinc, detergent, and organic matter, and one microbiological parameter, namely total E.Coli bacteria (Putri & Wardhani, 2021). Based on these indicators, several causes reduce water quality or the occurrence of water pollution. Among them are household and industrial activities as the leading cause of water pollution. Dominant household activities are due to unwise human behaviour, namely disposing of domestic liquid waste without management, the high use of detergents in washing activities, waste that is not managed correctly, and residual water from human waste such as faeces and water produced from activities in the bathroom. Meanwhile, another cause is the high industrial activity caused by the inability of a company to manage wastewater, especially for industries using hazardous chemicals in their production activities.

In a study conducted in Pontianak, physical indicators of water pollution can be seen from the level of water clarity or turbidity, colour and total dissolved solids (TDS) and chemically, including pH, iron, fluoride, hardness, nitrate, nitrite, and detergent (Naomi et al., 2019). Meanwhile, in research conducted on the Grogol River in Jakarta, the physical indicators used were temperature, conductivity, and TDS, and the chemical indicators used were pH, Dissolved Oxygen (DO), oil and grease concentrations, phosphate, detergent, NO3, BOD, and COD (S. Amira et al., 2018).

In the research conducted on the Grogol River, the temperature parameter did not have a significant effect. The results of this study were that the water temperature was in the range of 28OC – 30OC, and this temperature range did not affect water quality. Then, the DO results in the Grogol River were in the range of 2.2 mg/litre – 4.9 mg/litre during the rainy season and 2.23 mg/litre – 3.35 mg/litre during the dry season (S. Amira et al. ., 2018). Based on these results, there were several sample points with DO values below the standard, namely concentration levels below 3 mg/litre. The low concentration of DO values is due to the high amount of organic matter that enters the river water. According to S. Amira et al. (2018), The decrease in DO in the Grogol River is dominated by the entry of pollutants from organic waste from the activities of residents around the river and the use of detergents produced by the laundry business. In addition, home industry activities such as

the laundry business can also increase the phosphate content in water bodies. In addition, other organic wastes result from food scraps in household waste.

In a study conducted by Siti Amira et al. (2021) on the Krukut River, an increase in population also affected an increase in BOD values and a decrease in DO values. This is due to the behaviour of residents who still need to pay attention to sanitation, resulting in bad habits such as disposing of domestic waste without adequately managing the household environment. Based on this research, the behaviour of residents who do not care about environmental sanitation affects the water quality in the Krukut River. In addition, other activities, namely home industries such as workshops, affect the increase in the parameters of oil and grease in water bodies. This was proven by taking samples from the Grogol River, which showed that the oil and fat content was in the range of 0.24 mg/litre – 0.78 mg/litre during the rainy season and 0.13 mg/litre – 0.9 mg/litre (S. Amira et al., 2018). According to the study, the high oil and fat content will affect the river ecosystem, especially aquatic plants. The layer of oil and fat blocks the entry of sunlight into the water, disrupting the photosynthesis process in river water biota (S. Amira et al., 2018).

In another study in West Java, to be precise in the Saguling Reservoir, the parameters of water pollution studied were the ingress of heavy metals and sediment into water bodies. The research was conducted by taking samples from seven rivers, namely the Citarum, Cihaur, Cijere, Cimerang, Cipatik, Cijambu, and Ciminyak rivers. This study found that river sediments contained heavy metals that exceeded the standard, and the Citarum River was the most significant contributor to the pollutant load on the Saguling Reservoir. Heavy metals such as Cd, Cr, Cu, Pb, Hg, and others are a significant concern because they cause chronic poisoning in aquatic animals (Wardhani et al., 2021). Heavy metals are high due to industries in Bandung which still use coal as energy.

Apart from heavy metals, other studies in the Saguling Reservoir produced sediments with high concentrations of organochlorines. This is caused by the use of pesticides in agricultural activities around the Citarum River basin and the entry of pollutants into other tributaries (Oginawati et al., 2022). The research was conducted at 12 locations, with 9 sample points inside the Saguling Reservoir and 3 sample points outside the Saguling Reservoir. The research was carried out by taking water samples, sequestration and fish. Extraction, purification, evaporation and gas chromatography methods were used to measure the organochlorine residue in the study. The results showed the presence of several types of organochlorine compounds, namely lindane, aldrin, dieldrin, heptachlor, dichlorodiphenyltrichloroethane (DDT), and endosulfan.

The samples taken from water, sedimentation, and fish show that sedimentation has a higher organic chlorine concentration than samples from water and fish. Based on the research of Oginawati et al. (2022), water pollution is dominated by an increase in population, then supported by human behaviour that pays little attention to environmental sanitation. Other causes include home industries such as laundries, workshops, restaurants and home industries that pay little attention to wastewater management. In West Java, especially the Saguling Reservoir, high sediment and heavy metal content are the main parameters of water pollution. This is due to industrial activities around the Bandung area, which still use coal as energy in industrial processing. In addition, agricultural activities that use pesticides around the Citarum River basin and its tributaries also cause water contamination in the Saguling Reservoir.

3.5. Challenges in Overcoming Water Pollution

The increase in population is something that cannot be avoided. Including the areas of DKI Jakarta, West Java and Banten, which are the largest populations on the island of Java, including in Indonesia. The problem of water pollution is a significant problem, especially in urban areas. The causes of water pollution come from household waste, small industries to large industries, and agricultural activities that use excessive pesticides. This is a challenge that must be faced at this time, the availability of clean water is maintained, and future generations can still enjoy clean water, especially in urban areas.

Many efforts have been made to overcome the problem of water pollution. In the research conducted at the Krukut River, the study used a dynamic model approach using BOD and DO parameters. The research concluded that pollution control involving community participation in sanitation improves water quality (Siti Amira et al., 2021). Poor sanitation significantly impacts water quality, surface water, such as rivers and lakes, and groundwater quality. In addition, managing domestic wastewater for households, small industries, and large-scale industries also influences water quality standards by looking at physical parameters such as turbidity level, colour, temperature and chemical parameters such as BOD, COD, DO, and other chemical parameters. The impact of water pollution, apart from impacting human health, also has an impact on ecosystems, especially water ecosystems such as rivers, lakes or reservoir ecosystems. One successful solution is to involve the community in improving water quality by implementing sanitation and drainage for domestic wastewater treatment in households and industries.

According to S. Amira et al. (2018), in their research using a simulation model, it was found that interventions to increase community participation through the construction of a communal wastewater treatment plant (IPAL) can improve the water quality of the Grogol River. The existence of the WWTP can increase DO and reduce BOD levels in the water, affecting the life of river water ecosystems. In addition, using oil traps in small and large-scale industries can reduce the levels of oil and grease in water. This affects the quality of ecosystems, such as aquatic biota, due to increased sunlight entering the water. Sunlight that penetrates the water can increase the photosynthetic process of the aquatic biota in it, thereby having a positive effect on the ecosystem in it.

Another challenge is the significant industry that still uses coal as energy and agricultural activities that still use pesticides. For industries that still use energy from coal, one solution is to use more environmentally friendly energy, such as burning biomass or using other energy that is more environmentally friendly. In addition, implementing a wastewater treatment plant is a matter of obligation. So that the output of wastewater does not exceed the required threshold. Meanwhile, for agricultural activities, of course, innovation is related to the use of pest control that is more environmentally friendly, such as developing organic pest control and developing natural enemies of the pests that are generated. This is challenging; further research is needed to examine the effectiveness of these two things.

In addition to improving human behaviour, another thing that needs to be done is to improve land cover along river banks. Especially for the upstream area of the river, pollutants such as minerals that enter the water can be absorbed by the plants on the river border. For urban areas, increased water catchment development is an alternative to improve groundwater quality.

4. Conclusions

Water is the most basic and essential need for life, including human needs. The increase in population has led to an increase in the human need for water. Water is an unlimited natural capital, but ecosystem conditions affect the carrying capacity of water in quantity and quality and provide benefits for human life. Java Island has the highest population density compared to other islands, and the western part of Java Island, which consists of DKI Jakarta, West Java and Banten, dominates. The western part of Java Island has the highest population, population density, the largest and most significant number of industries, and the region with the highest agricultural land in Indonesia.

Based on existing data, surface water availability based on river area data in West Java and Banten Provinces, this western part of Java Island has a critically critical status and has a level of water availability with an absolute scarcity status. This is caused by the availability of less water compared to the needs and levels of utilization. In addition, another problem that causes water availability not to be appropriately utilized is the problem of environmental pollution. Water pollution is a severe problem, especially in urban areas where river and groundwater sources have experienced severe degradation. Many things cause water pollution, including poor sanitation, daily activities such as washing clothes and

washing kitchen utensils, unmanaged domestic waste, faeces, and industrial activities, both small and large scale industries, as well as agricultural activities. They are still using pesticides.

To overcome water pollution, serious efforts must be taken from all stakeholders, both the government and the private sector, including the community. Efforts that can be made include increasing community participation in manufacturing household-scale WWTPs and strict supervision for the industry in managing the wastewater produced. Then, it is also necessary to limit and reduce the use of pesticides in agricultural areas, especially in the upstream areas of DKI Jakarta, West Java and Banten. In addition, the rainwater harvesting system is also a solution to accommodate the availability of clean water, especially in urban areas. Lastly, to improve water quality, what needs to be done is to improve land cover in the upper reaches of rivers and to increase water absorption in urban areas. This study is limited to discussing water problems based on existing data and analysis of previous studies. So it is necessary for further research to deepen the water pollution problem in the western part of Java island to identify and analyze the problem in depth.

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We encourage all authors of articles published in this journal to share their research data. This section provides details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. A statement is still required when no new data are created or unavailable due to privacy or ethical restrictions.

Conflicts of Interest

The authors declare no conflict of interest.

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