Fish community structure before reservoir inundation in Cipanas, West Java

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Abstract. The reservoir is an artificial lake created by blocking the flow of the river using transverse construction of the river or dam made of rock, soil or walls. The purpose of the research was to determine and map the structure of fish community before reservoir inundation in the Cipanas River. The study used survey methods with sampling data collection techniques. The research station was determined using a purposive sampling method. The study was conducted at three stations representing inundation plan areas (6° 41'51" S and 108° 01'32" E) and after inundation plans (6° 38'53" S - 108° 02'06" E and 6° 37'51" S - 108° 02'53" E) of Cipanas Reservoir. The parameters measured included relative abundance, diversity index (H'), dominance (C), uniformity (E), and water quality. Fifteen fish species of seven families were collected from Cipanas River. The diversity index was moderate which ranged of 1.20 ≤ H ≤ 2.08, the dominance index was low to moderate which ranged of 0.16 ≤ C ≤ 0.51, and the uniformity index was low to moderate which ranged of 0.27 ≤ E ≤ 0.47. The structure of the fish community at the station I was relatively unstable, while at stations II and III were classified as depressed. Water quality in the Cipanas River was in a good condition and support the life of fish based on the water quality standards class II and III according to the Government Regulation no. 82 of 2001.

Keywords: Diversity, Unstable, Fish Community Structure, Cipanas River, Distress.

1. Introduction
Cipanas River is one of the rivers in West Java tipped in the Tampomas Mountain Region, Buah Dua, Sumedang across the Majalengka and Indramayu which empties into the Java Sea. This river has a length of about 90 km with a watershed area of 416 km² (Central Water Resources Center 2017) [1]. The Cipanas watershed is topographically high, the river valley is deep enough with land use in the form of forests, gardens, rice fields, and settlements. The river water is used as a source of water irrigation, fisheries, and daily necessities for people who live around the river [2].

The Cipanas Dam was built on the Cipanas River since 2016 which is located on the border of Cibuluh village in Sumedang Regency and Cikawung village in Indramayu Regency. The dam formed a reservoir with an area of 1,378.16 ha which covered five Villages in three Districts, with the majority
of the land are 962.62 ha (69.84%) Perhutani land, followed by community-owned land 283.53 ha (20.57%) and state-owned land 132.01 ha (9.57%) [3].

The building of the Cipanas Reservoir has several benefits, including flood control by cutting flood discharges of 475 m³/sec, irrigating 10,500 ha of agricultural land with raw water supplies of 0.50 m³/sec, generating power plants with a capacity of 2.5 Mega Watts, and offering tourism object [4].

Dam construction has positive and negative impacts in various aspects, one of the negative impacts is in the field of fisheries. Dams could affect the behavior of the flow pattern by changing the flow pattern from lotic to lentic therefore affecting the ecosystem [5]. One example is the existence of small and large rocks along the river which act as a fortress in holding back the rate of river sedimentation that may be affected by habitat alteration [6].

Dams in Indonesia generally do not construct a fishway (fish ladder) so they can interrupt fish migration along the river, especially the potadromous which migrate from upstream to downstream in their lives. River fragmentation by the dam will affect the diversity of fish species so that it can change the structure of river fish communities in the upstream and downstream of the dam.

Later, the presence of the Cipanas Reservoir could be a threat to the diversity and sustainability of fish resources. Widyatni and Prihadi [7] stated that the existence of reservoirs has a negative impact on biodiversity because it causes the loss of local fish species, permanently changes hydrology and river ecosystems, decreases water quality, and hamper the flow of nutrients needed by the fish. Craig [8] mentioned that of the 66 cases of reservoirs in the world, 73% showed a negative impact on the fish species diversity, and only 27% gave a positive impact. Kartamiharjda [9] reported that within a period of 40 years (1968-2007) after The Djuanda Reservoir West Java had been flooded, there was a change in fish community and a decrease in the number of fish species from 31 species to 18 species.

According to information from fishermen around the Cipanas Dam construction site, there were a lot of deep rivers basins that were inhabited by native and introduced fishes, such as Barb, tinfoil barb, common barb, java barb, silver barb, uceng, jeler, keting, betok, paray biasa, paray jangkung, local catfish, baung, cork, nile tilapia, mujair, and lais. Lais (Ompok bimaculatus) is one of the native fishes of West Java that has potamodromous characteristic. According to IUCN Red List [10], the conservation status O. bimaculatus is NT (Near Threatened) so that its habitat should be maintained to reserve O. bimaculatus sustainability in the natural habitat.

Therefore, it is necessary to conduct a study on the structure of the fish community in the Cipanas Reservoir inundation plan which can be used as basic information on the fisheries resource management in the Cipanas River.

2. Materials and Methods
The study was conducted from June to September 2018 at three stations (figure 1). The station I was located in Karanglayung, Conggeang, Sumedang at coordinates 6°41’51” S and 108°01’32” E. The depth of the river was ranged from 1 to1.5 m with the bottom substrate consists of rock, gravel, and sand. The riverbank vegetation was dominated by Syzygium sp, Bambusa sp, and Gluta sp. The land surrounding the station I was covered by a production forest with teak stands and rain-fed rice fields. This station was a meeting place for five tributaries (Cigarugui, Cigarukgak, Ciporang, Citallo, and Ciuyah) that flow into the Cipanas River as the main river.

The station II was located on the border of Cibuluh Village and Cikawung Village at coordinates 6°38’53” S and 108°02’06” E. The depth of the river was ranged from 1.5 to 2.5 m with bottom substrate consists of gravel, rock, and sand mixed with mud. The riverbank vegetation was dominated by Bambusa sp. and Pilea sp. Plantations and agriculture owned by the surrounding community.. Station III was located in Cikamurang Village, Indramayu Regency at coordinates 6°37’51” S and 108°02’53” E. The depth of the river was ranged from 2 to 3 m with sand-based substrate mixed with mud. Riverbank vegetation was dominated by weeds such as Chymbophogon achiculatus and Gymnura crepedioides. The surrounding land were plantations and settlements.
Figure 1. Map of the Cipanas River research stations.

Water quality parameters measured in situ were temperature, dissolved oxygen, pH, and light penetration. Temperature and dissolved oxygen were measured using oxygen meter DO-5510, pH was measured using pH meter Hanna, and light penetration was measured using a Secchi disc. Other parameters such as total suspended solid (TSS), total dissolved solid (TDS), and chemical oxygen demand (COD) were analyzed in the laboratory of Water and Environmental Research and Development, Ministry of Public Works and Public Housing Bandung.

Fish samples were collected using a cast net with mesh sizes of 1.5 cm, 2 cm, and 3 cm. The fish samples were identified referring to the Kottelat et al [11] and in Research Center for Biology, Indonesia Institute of Sciences (LIPI).

2.1 Data analysis
Data were analyzed using quantitative descriptive analysis based on the abundance, diversity index, dominance, and uniformity.

(1) Relative abundance
According to Odum [12], the relative abundance of fish populations is calculated using the following formula:

$$KR = \frac{ni}{N} \times 100\% \quad \text{.................................................. (1)}$$

Explanation:

KR = Relative Abundance (%);

ni = The number of individuals of each species;

N = The number of individuals of all species.

(2) Diversity
The fish diversity index is calculated using the Shannon-Wiener diversity index [12] with the following formula:
\[ H' = -\sum_{i=1}^{n} P_i \ln P_i \] ................................. (2)

Explanation:
\( H' \) = Shannon-Wiener diversity index;
\( P_i \) = Proportion of the number of individuals of one particular species to the total number of individuals (ni/N);
\( i = 1,2,3,...,n. \)

Where:
\( H' \leq 1 \) = Low diversity;
\( 1 \leq H' \leq 3 \) = Medium diversity;
\( H' \geq 3 \) = High diversity.

(3) Dominance (C)
Dominance index (C) is used to find one group of individuals dominating against another group of individuals, which could be calculated using the Simpson formula (C), as follows:

\[ C = \sum_{i=1}^{n} P_i^2 \] ................................. (3)

Explanation:
\( C \) = Dominance index;
\( P_i \) = Proportion of individuals in fish species;
\( i = 1,2,3,...,n. \)

Where:
\( 0 < C \leq 0.5 \) = Low dominance;
\( 0.5 < C \leq 0.75 \) = Medium dominance;
\( 0.75 < C \leq 1.0 \) = High dominance.

(4) Uniformity of Fish
Fish uniformity is calculated using the Evenness Uniformity Index with the following calculation formula:

\[ e = \frac{H'}{\ln S} \] ................................. (4)

Explanation:
\( e \) = Evenness uniformity index;
\( H' \) = Diversity index;
\( S \) = Total number of species.

Where:
\( 0 < E \leq 0.4 \) = Low uniformity, depressed community;
\( 0.4 < E \leq 0.6 \) = Medium uniformity, unstable community;
\( 0.6 < E \leq 1.0 \) = High uniformity, stable community.

Map visualization analysis using the Arcmap GIS software was performed to map the fish community structure in order to facilitating the delivery of information to stakeholders.

3. Results and Discussion
3.1 Water quality
Water quality is one of the factors that affect the life of aquatic organisms. The water quality of the Cipanas River at each station during the study is shown in table 1.
Table 1. Water quality of Cipanas River.

| Parameter                          | Station | EIA[3] result of Cipanas Reservoir | Water Quality Standard Government Regulation number 82 of 2001[1] |
|------------------------------------|---------|------------------------------------|---------------------------------------------------------------|
|                                    | I       | II                                 | III                                                      |
| Temperature (°C)                   | 29      | 28.1                               | 28.5                                                      | 26 – 26.5 | Deviation 3 | Deviation 3 |
| Light Penetration (cm)             | 43      | 50                                 | 56                                                       | -         | -         | -           |
| Total Suspended Solid (mg L⁻¹)     | 168     | 109                                | 56                                                       | 52 – 400  | 50        | 400         |
| Total Dissolved Solid (mg L⁻¹)     | 411     | 405                                | 424                                                      | 235.5 – 508.75 | 1000   | 1000         |
| Current (ms⁻¹)                     | 0.7     | 0.3                                | 0.35                                                     | -         | -         | -           |
| Dissolved oxygen (O₂) (mg L⁻¹)     | 7.8     | 6.2                                | 6.6                                                      | -         | 4         | 3           |
| pH                                 | 7.7     | 7.6                                | 7.6                                                      | 8.21 – 8.47 | 6–9     | 6–9         |
| Chemical Oxygen Demand (mg L⁻¹)    | 22      | 13                                 | 14                                                      | 34.32 – 40.28 | 25     | 50           |

Note:  
Class II: infrastructure/facilities for water recreation, aquaculture, animal husbandry, and irrigation.  
Class III: Aquaculture, animal husbandry, and irrigation.  
EIA: Environmental Impact Assessment

Water temperature in the Cipanas ranged from 28.1°C to 29°C, while according to the Environmental Impact Assessment (EIA) of Cipanas Reservoir showed that water temperature ranged from 26°C to 26.5°C. Government Regulation No. 82 of 2001 [13] required water temperatures to have a deviation value of three. Kordi [14] stated that aquatic organisms could live well at temperatures of 23°C to 32°C. This showed that the Cipanas River is still good for the growth and development of fish. The difference in temperature values is influenced by various factors, such as weather conditions, air temperature, geographical height, and coverage by vegetation (monitoring result in the field).

Light penetration indicates the ability of light to penetrate the water layer to a certain depth that is closely related to photosynthetic activity by primary water producers, such as phytoplankton and plants as a food source for herbivorous fish. The light penetration observed at three stations ranged from 43 cm to 56 cm. Light penetration in the waters can be influenced by the turbidity values caused by TSS and TDS in the waters. The concentration of TSS and TDS were quite high with TSS values ranged from 56 mg L⁻¹ to 168 mg L⁻¹ and TDS ranged from 405 mg L⁻¹ to 424 mg L⁻¹. Although the TSS and TDS concentrations were quite high, they were still below the quality standard threshold for fisheries according to Government Regulation No. 82 of 2001.

The flow velocity of the Cipanas River varied from 0.3 ms⁻¹ to 0.7 ms⁻¹ and the highest was found at station I. Based on the field observation, the station I has higher river slope compared to other stations. This was in accordance with Yustina [15] which stated that river flow velocity could be influenced by differences in the river slope and the presence of plants along the river basin. Mason [16] divided the current classification into five categories: very fast (> 1 ms⁻¹), fast (0.5 to 1 ms⁻¹), moderate (0.25 to 0.5 ms⁻¹), slow (0.1 to 0.25 ms⁻¹), and very slow (<0.1 ms⁻¹). It can be concluded that the current at station I was classified as fast, while stations II and III were classified as medium.

Dissolved oxygen (DO) is the amount of dissolved oxygen in the waters expressed in mg L⁻¹ and is one of the key elements in the metabolic processes of aquatic organisms, especially the process of
respiration [13]. The dissolved oxygen content of the Cipanas River ranged from 6.2 mgL\(^{-1}\) to 7.8 mgL\(^{-1}\). The minimum dissolved oxygen content for fisheries is 4 mgL\(^{-1}\) according to Government Regulation No. 82 of 2001[5]. This shows that the dissolved oxygen content of the waters of the Cipanas River can support for fish life.

pH is one of the limiting factors for aquatic organisms. The pH value of Cipanas River ranged from 7.6 to 7.7. According to the EIA document, the pH value of the Cipanas Reservoir ranged from 8.21 to 8.4. Based on Government Regulation No. 82 of 2001[13], the pH range for the fisheries are from 6 to 9. This shows that the pH values of the Cipanas River still support the development of aquatic organisms. Barus [17] also stated that the ideal pH value for aquatic organisms ranged from 7 to 8.5.

COD describes the amount of oxygen needed to completely overhaul organic compounds in water, both those that could be degraded biologically or that were difficult to degrade to CO\(_2\) and H\(_2\)O[18] thus describing the content of organic matter in the waters as a source of nutrients for primary aquatic producers such as phytoplankton. The COD concentration of Cipanas River ranged from 13 mgL\(^{-1}\) to 22 mgL\(^{-1}\). According to the EIA Cipanas Reservoir document [3], the COD concentration ranged from 34.32 mgL\(^{-1}\) to 40.28 mgL\(^{-1}\). The COD concentration at the station I was the highest compared to other stations, this was presumably because the station I is a meeting place where five Cipanas rivers flow and has a fairly good riverbank vegetation cover as a source of nutrient input. According to Government Regulation No. 82 of 2001, the recommended maximum limit of COD concentration for fisheries is 50 mgL\(^{-1}\). The COD concentration along the sampling stations was in the ranges for sustaining the fisheries.

3.2 Catch composition and relative abundance

3.2.1 Catch composition

A total of 15 fish species belonging to seven families were collected from the sampling stations. The most dominant fish group was the Cyprinidae (seven species, 46.7% of the total species collected). The second largest group of fishes were the Cichlidae and Bagridae (two species, 13.3%), and the other families were Siluridae, Channidae, Anabantidae, and Nemachilidae (each with 1 species, 6.7%) (table 2). The dominance of Cyprinidae was presumably because the cyprinids have high fecundity and able to take advantage of natural food in the waters. This was in accordance with the statement of Djuhanda [19] and Yuanda [20] that the cyprinids inhabit most of the freshwaters because they were able to adapt in various river water conditions and able to take advantage of the natural conditions they occupied to breed.

The fish community in the Cipanas River had similarities with the fish community in the Serayu River, Central Java, which was also dominated by the Cyprinidae family. Haryono et al [21] stated that the waters in the Serayu River which have been fragmented by the Mrica Reservoir of the Great Panglima Dam General Soedirman, Banjarnegara District, had 22 fish species from 13 families identified with 8 species including Cyprinidae family.

| Familia      | Local Name | Common Name | Scientific Name       | Conservation Status(*) | Station/Fish |
|--------------|------------|-------------|-----------------------|-------------------------|--------------|
| Cyprinidae   | Lalawak    | Barb        | Barbonymus balleroides| √(NE)                   | 23 60 14     |
|              | Lalawak batu/Tengadak | Tinfoil Barb | Barbonymus schwangenfeldii | √(LC)                   | 2 - -        |
|              | Genggehek  | Common Barb | Mystacoleucus marginatus | √(LC)                   | 15 5 19      |
|              | Beureum panon | Java Barb   | Systomus orphoides    | √(NE)                   | 8 3 -        |

Table 2. The structure of fish community in the Cipanas River, West Java.
According to the IUCN Red List, the conservation status of the collected fish species was divided into 3 categories, including Near Threatened (NT), Least Concern (LC), and Data Deficient (DD). Management efforts are needed in the fish species which are in the NT and LC. *Ompok bimaculatus* [11] is in the Near Threatened category, while the others such as *Barbonymus schwanenfeldii* [22], *Barbonymus gonionotus* [23], *Mystus nemurus* [24], *Mystacoleucus marginatus* [25], *Channa striata* [26] and *Oreochromis niloticus* (Linnaeus, 1758) are assessed Least Concern.

3.2.2 Relative abundance

The highest relative abundance of fish in the Station I was barb (29%); the second was common barb (19%); the third was tinfoil barb silver rasbora and java rasbora (10%); followed by two spot butter catfish and barred loach (6%); and the lowest abundance of fish were tinfoil barb, two spot catfish, nile tilapia, and Mozambique tilapia (3%) (figure 2a).

The highest relative abundance of fish at the Station II was barb (71%); the second was genggehek and lais (6%); the third was java barb, two spot catfish, and nile tilapia (4%); and the lowest relative abundance was river catfish, barred loach, and Mozambique cichlid (2%) (figure 2b).

The most dominant fish species at the Station I and II was barb, this was presumably because there were still lots of vegetation on the riverbanks as a food source. According to Tjahjo and Purnamaningtyas [27], main food source of barb is macrophytes with complementary foods such as zooplankton, fish, and detritus. Lalawak is one of the Indonesian native fish species which is distributed in Kalimantan and Java [12]. The fish is potential as aquaculture commodity, but not much effort has been made for lalawak aquaculture development [28].

The highest relative abundance of fish at the station III was Java barb (30%); the second largest relative abundance were common barb and two spot catfish (25%); the third largest relative abundance was tinfoil barb (17%); the fourth largest relative abundance was stripped snakehead (4 %); and the
lowest relative abundance were nile tilapia, Mozambique cichlid, and climbing gourami (1%) (figure 2c).

Station III was dominated by silver barb (*Barbonymus gonionotus*) presumably because the slow current at station III is favored by silver barb and adequate food sources are provided. According to Reid [29] silver barb lives in the rivers with fairly slow current habitats and migrates to flooded swamp forest areas during periods of high water.

(a) Station I

(b) Station II
Figure 2. Relative abundance of fish in the Cipanas River, West Java (a) Station I; (b) Station II; and (c) Station III

3.3 Index of Diversity ($H'$), Index of Evenness (E), and Index of Dominance (D)
The fish diversity index at each station was different, which ranged from 1.20 to 2.08. This showed that fish diversity was classified as moderate (figure 3). Fish diversity at the station I was higher compared to other stations. Good vegetation cover at the riverbank and production forest coverage of the land could be the reason of higher fish diversity at station I compared to other stations. Moreover, the station I receives the waters from five tributaries, therefore, providing the food sources that could be utilized by the phytoplankton. Fish diversity is influenced by several factors, such as land use, riverbank vegetation, and physicochemical parameters of the water quality. High or low diversity index of a community's species is largely determined by the species richness and distribution of individuals within the species (E) [13].

Figure 3. Fish diversity in Cipanas River, West Java

The dominance index (C) at each station was different with values ranging from 0.16 to 0.51 (figure 4). The fish dominance index at the station II was higher compared to other stations. The Dominance at the station II was in the medium category, while the stations I and III were classified as
low. The dominant fish caught in station II was barb. The dominant group is one or types of groups that control a community population [24]. The Station II is a suitable habitat for barb spawning and laying fish egg indicated by the riverbank rocks and sandy gravel substrate. Barb is widely distributed, lives in a group, and can take advantages of the potential of existing food resources in the water so that it dominated in an area of water. This was in line with the statement of Gonawi [30] that the large number of individuals and groups would affect the high abundance because it could be found in a large numbers at each observation.

The fish evenness index (E) for each station was different with values ranging from 0.27 to 0.47 (figure 5). The fish dominance index at the station I was higher compared to other stations which in the medium category, while stations II and III were classified as low. The uniformity index at the station I was 0.47 (moderate) which showed an unstable fish community structure, while the stations II (0.27) and III (0.37) were low which showed the structure of the depressed fish community (figure 6). Krebs [31] stated that the smaller the evenness of a population, the distribution of individuals dominates.
The distribution of fish species in the Cipanas River was different at each station. A total of 15 fish species in the Cipanas River were recorded which consists of 13 native fish species (86.67%) and two introduced species (13.33%). According to information from several fishermen respondents, introduced fish were accidently released from the pool owned by residents and deliberately stocked in the Cipanas River. The Cipanas Dam construction is not equipped with a fishway which will give a negative impact on the structure of the fish communities in the station II and III, especially when flooding the dam water; and it is suspected that the *Ompok bimaculatus*, whose status is near threatened, is decreasing.

4. Conclusion
A total of 248 fish were collected from the Cipanas River, consisting of seven families and 15 species with unstable community structures at the station I and depressed at the station II and III. One of the native fish, two spot butter catfish (*Ompok bimaculatus*), is categorized as Near Threatened according to the IUCN Red List. Further study needs to be conducted when the Cipanas Dam is flooded to observe the impact of the dam on fish habitat, particularly *Ompok bimaculatus* habitat.

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