

# The diversity of fish species and the disturbances in the Cikawung river, Cianjur, West Java, Indonesia

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**Abstract.** Partasasmita R, Nuari T, Erawan TS, Iskandar J. 2015. The diversity of fish species and the disturbances in the Cikawung river, Cianjur, West Java, Indonesia. *Nusantara Bioscience* 7: 171-176. The diversity of fish species in the Cikawung river, the south coast of West Java, Indonesia plays a very important role for the villagers around the river. This river is an important source of animal protein for villagers of Karangwangi, Cidaun, Cianjur, West Java, Indonesia. The river flow is partially included in the Bojonglarang Jayanti Natural Reserve area. Based on the information given by the local residents, the Cikawung river used to have many species of fish 15 years ago, but now the population find it very difficult to get the fish in the river. People suspect that it is related to the frequency of fishing in various ways such as nets, fishing rods and even toxic chemicals. The object of this study is to determine the diversity of fish species in the Cikawung river and its disturbances as well as preservation and traditional conservation efforts by local residents. The study was conducted at inside and outside the natural reserve. The method used is a combination of quantitative and qualitative methods. The quantitative data gathering was performed by using structured interviews with 86 respondents that were chosen randomly among residents in the vicinity of the Cikawung river, using questionnaires. The results show that there are 32 species of fish, consisting of 22 species in the natural reserve, and 20 species outside the conservation areas. There are only 10 species of fish that found inside the natural reserve, while there are only 9 species of fish species found outside. It is found that there is 76% of the species of fish that is extremely rare, while the fish that are commonly found is *Aplocheilichthys panchax* and *Puntius binotatus*. The existence of fish tends to be very rare due to the fishing activities that continue to occur and the intensive use of pesticides. The decline in species diversity and abundance of fish species in the Cikawung river initiate local government and community leaders to make the arrangement of the use of Cikawung river as traditional conservation areas with the issuance Karangwangi Village Regulation (Perdes).

**Keywords:** Cikawung river, Karangwangi, river fish, traditional conservation, West Java

## INTRODUCTION

Based on the history of ecology, diversity of fish species on the island of Java, though less than the diversity of fish species in Sumatra and Kalimantan, but in the past it is recorded that in Java there are a lot of fish diversity, including river fish. However, now the diversity and abundance of fish species in Java tends to fall compared to the previous conditions like in the river Gajahwong, Yogyakarta (Zaenudin 2013). It is caused by various factors, such as much forest loss, water pollution, disturbance arising from the construction of dams, and over-exploitation (Whitten et al. 1999; LIPI 2014). Forest damage caused disruption of river fish as seen in many small rivers in rural areas that run dry during the dry season due to damage to forest hydrology. Indeed, the government has done actions in setting the adequacy of forest area in each watershed, as stated in Article 18 of Indonesian Act No. 41 of 1999, that each watershed must be able to defend the forest area and the forest must cover 30% of the total watershed area. However, this requirement, in Java and other islands in Indonesia, is not met (FWI 2011). Pollution of rivers also becomes a disturbance to the diversity of fish, as can be seen in the case of the Citarum river. In the past the Citarum river had a special kind of local river fish, so

that villagers along the river could catch various species of fish with traditional equipment, such as nets (kecrik), angoh, fishing rod (useup) and traps (badodon). However, now the diversity of the species of fish in the Citarum has considerably decreased mainly due to river pollution from hundreds of factories were built in Citarum upstream (Iskandar 2014). In the Citarum river and Saguling dam it is recorded that there are as many as 23 species of fish, but the number is thought too far below the diversity of fish species in the past. In the period of 1989-1999, a total of five species of fish have become extinct from this river, namely kancra/soro (*Tor soro*), genggheh (*Mystacoleucus marginatus*, Valenciennes, 1842), kebogerang (*Mystus* sp.), tagih (*Hemibagrus nemurus*, Valenciennes, 1840) and lelawak (*Puntius buffoonery*, Bleeker, 1855) (Dhahiyat et al. 2001). Other factors such as the increasing population and economic development of the market (market economy) cause pressure on the fish resources anyway (cf. Iskandar 2012). People are looking for the fastest and most effective way to get as much fish as possible, even in ways that damage the environment, such as using pesticides or appliance electric shock. Such activities damage the biological resources of fish and the environment, as well as detrimental to the community for the long term. The community is the most disadvantaged party as a result of

loss or reduction in the species of fish.

Cikawung river (7,763 m) is a small river on the south coast of West Java, but it is very important for the life of the villagers in the vicinity as a protein source. The administration of Cikawung river is located in the area of Karangwangi village, Cidaun sub-District, District of Cianjur, West Java, Indonesia. Only a small part of this river is located upstream in the Cimaragang village, Cidaun, Cianjur. More than half the length of the river upstream is located in rural areas, while the rest are located in the downstream direction within the Natural Reserve of Bojonglarang Jayanti (Figure 1). Now, the diversity of fish species in the river is impaired by factors of environmental change and human behavior. In the past, the species and abundance of fish in the Cikawung river quite a lot, but nowadays tends to decrease. Certain species of fish is getting hard to find and fish catches from year to year continues to decline. This is partly because the volume of the Cikawung river getting smaller, particularly in the dry season due to environmental degradation in the watershed streams. Therefore, people in Karangwangi want a traditional way to restore fish populations. Conservation of

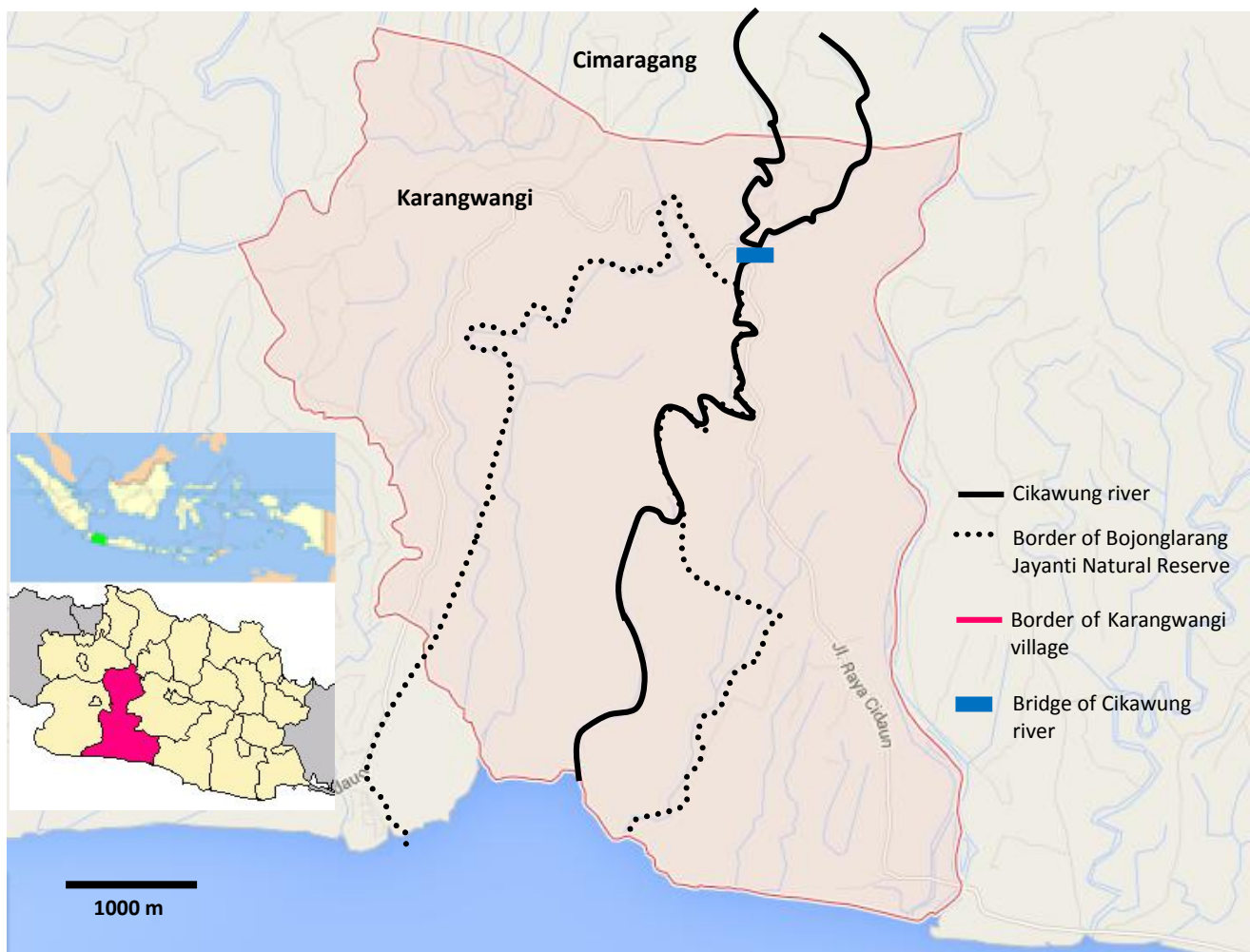
fish species in Cikawung river is expected to be useful for the utilization of fish resources that is optimum and sustainable.

The purposes of this study are (i) to make a list of the species of fish in the Cikawung river; (ii) to explore the various factors that have become a nuisance to many species of fish in the Cikawung river; and (iii) to assess the efforts of the villagers Karangwangi in protecting and conserving fish species of the Cikawung river.

## MATERIALS AND METHODS

### Area of study

This study was conducted in the village of Karangwangi, Cidaun, District of Cianjur, West Java, Indonesia. Cikawung river has a total length of 7,763 m, divided into two parts, namely the downstream located within the Natural Reserve of Bojonglarang Jayanti (2,857 m) and the middle and upper located in rural areas (4,906 m), in the village of Karangwangi and a small portion in the village of Cimaragang. Given the condition of the



**Figure 1.** Location of the study on the Cikawung river, Karangwangi village, Cidaun, District of Cianjur, West Java, Indonesia (Google Earth 2015)

Cikawung river upstream is located in forest areas, across the rural areas and Natural Reserve of Bojonglarang Jayanti, flows into the sea, then the diversity of fish species include freshwater fish and fish that migrates from the sea to freshwater. The community of Karangwangi generally only uses the Cikawung river from the bridge to the estuary of Cikawung (Figure 1).

### Procedure

The method that is used is a combination of quantitative and qualitative methods to study ethnobiological approach (cf. Martin 1995; Newing et al. 2011; Iskandar 2012). Quantitative methods that are used are in the form of a structured interview to the people that usually use Cikawung river by using questionnaires to 86 respondents who meet the qualifications of formula Lynch et al. (1974). The selection of respondents uses simple random sampling technique. Qualitative methods use observation and interviews. Observation was conducted to determine the diversity of river fish and the behavior of the population in fishing. Meanwhile, the interviews with informants that are purposively selected who are considered competent, with the selection of snowball sampling, with attention to diversity. The informants are the fisherman in the river, informal leaders, and village chief and several of his staff.

### Data analysis

The qualitative data were analyzed by means of cross-checking, summarizing, synthesizing, and narrated by descriptive analysis. Meanwhile, quantitative data from interviews with respondents were statistically analyzed, as calculated percentages of respondents and narrated by descriptive analysis (Newing et al. 2011).

## RESULTS AND DISCUSSION

### Diversity of fish species

The species of fish found in the Cikawung river and based on information from local residents are as many as 32 species. However, among some fish species cannot be identified because the sample was not obtained when sampling the fish in the river (Table 1). This suggests that these fish tend to be rarer than other species. Some respondents indicate that the very few species of fish that are caught are *Eleotris* sp. (1.16%), *Ophiocephalus pleurophthamus* (3.49%), and *Rasbora lateristriata* (2.33%), while the other fish that are often caught is *Puntius binotatus* (41.85%), *Sicyopterus cyanocephalus* (36.05%), *Anguilla marmorata* (26.74%), and *Aplocheilichthys panchax* (25.58%).

The number of fish in the Cikawung river when compared to the number of fish species in other river in West Java, such as Citarum river and Saguling dam (23 species) (Dhahiyat et al. 2001), Citarum upstream (20 species) (Kartamihardja 2008); Cisokan river (15 species) (Sutrisno et al. 2012) and the Cimanuk upstream (14 species) (Yuanda 2012) is relatively high. It is quite interesting, although smaller and relatively short,

Cikawung river compared to the Citarum river and Cimanuk river, but it has a fairly high diversity of fish species. This shows that the diversity of fish in the Cikawung river still higher than other rivers in West Java because the Cikawung river (57.47%) is located in conservation area, so that people afraid to catch fish on a natural reserve area. Diversity of fish species in the Cikawung river which is at the Natural Reserve of Bojonglarang Jayanti as many as 22 species (68.75%). The diversity of fish in the Citarum and Cimanuk rivers have diminished as a result of pollution and household waste plant at high river (Dhahiyat et al. 2001).

Based on the results of an inventory of the species of fish in the Cikawung river, it is known that the species of fish have biological properties or specific autoecology which may be important in relation to logging or farming in the region. This is because the demersal species eat benthic organisms. This species can be affected by siltation caused by river erosion (due to logging, land clearing near the river, etc.). The demersal fish are the giant mottled eel (*Anguilla marmorata*) and catfish (*Clarias* spp.). Among the demersal species, some have special means that allows it to attach themselves to the substrate such as rocks, boulders, fallen timber, etc., in fast-flowing water, for example, menga fish or cleft-lipped goby (*Sicyopterus cyanocephalus*). Usually the species belonging to the group called "cascade fish" or "belly sucking fish" was grouped into three parts, namely: Balitoridae, Cyprinidae, and Sisoridae (Meijaard 2006).

Based on these studies, it is known that some fishes of Cikawung river are potentially threatened. For example, fish that are benthic-pelagic (fish that likes to swim/move) that eat algae micro, diatoms (among others, as *Lobocheilos bo*, some *Osteochilus* spp., *Tor* spp.) and that eat fruits and forest plants (i.e. *Leptobarbus melanotaenia*, *Tor* spp.). These fishes are in potential danger, since it can be influenced by a decrease in the availability of food that occurs after the cultivation of forests in the 2000s that led to a lot of soil and silt into the water bodies and carried out to sea. In fact, the integration between the river and forest areas contributes greatly to the food source and shelter for fish. This is proved by the Cidaun fishermen around the natural reserve who complain that fish and shrimp catches reduced if the river water is polluted, especially polluted by toxic pesticides. Shrimp that are usually found a lot near the estuary will hide if the river water flowing into the sea contains toxins. Additionally, *Pangasius* spp. is also in potential danger the Cikawung river. The reason is that *Pangasius* spp. which normally migrate, much sought after because it has a high market value. Unfortunately, the behavior of seedling makes this species easily caught by nets (Meijaard 2006). Some fish in Cikawung river include in amphidromous categories, namely fish that is born in freshwater/estuarine, and then washed into the sea as larvae before migrating back to fresh water to grow into adults and lay eggs (Walter 2012); and several other species are catadromous that fish born in salted water, then migrate to freshwater as a teenager where they grow into adults before migrating back to the sea to spawn, such as giant mottled eel (*Anguilla marmorata*).

**Table 1.** Species diversity, distribution, and abundance of fish in the knowledge-based society Cikawung Karangwangi, West Java, Indonesia

Local name	Scientific Name	Spread		Abundance		
		A	B	a	b	c
Boboso	<i>Eleotris melanosoma</i> (Bleeker, 1852)	V	V		V	V
Benteur	<i>Puntius binotatus</i> (Valenciennes, 1842)	V	V	V		
Menga	<i>Sicyopterus cyanocephalus</i> (Valenciennes, 1837)	V	V	V		
Lubangsidad	<i>Anguilla marmorata</i> (Quoy & Gaimard, 1824)	V	V		V	
Lelehitam	<i>Clarias meladerma</i> (Bleeker, 1846)	V	V			V
Leledumbo	<i>Clarias gariepinus</i> (Burchell, 1822)	V	V			V
Kanayapan*	<i>Macrornathus maculatus</i> (G. Cuvier, 1832)	V				V
Soro	<i>Tor soro</i> (Valenciennes, 1842)	V				V
Corencang*	<i>Puntius</i> sp.	V				V
Uncun*	<i>Eleotri</i> ssp.	V				V
Buhung*	<i>Ophiocephalus pleurophthamus</i> (Bloch, 1793)	V				V
Salusur	<i>Schismatogobius bruynisi</i> (de Beaufort, 1912)	V				V
Bawal	<i>Colossoma macropomum</i> (G. Cuvier, 1818)		V			V
Mujaer	<i>Oreochromis mossambicus</i> (W. Peters, 1852)		V			V
Tawes	<i>Barbonymus gonionotus</i> (Bleeker, 1850)		V			V
Mangse (Belanak)	<i>Valamugil seheli</i> (Forsskål, 1775)	V				V
Tampele	<i>Betta</i> sp.	V	V			V
Paray	<i>Rasbora lateristriata</i> (Bleeker, 1854)		V			V
Cecere*	<i>Aplocheilus panchax</i> (F. Hamilton, 1822)	V	V		V	
Sidatkuning	<i>Anguilla bicolor</i> (McClelland, 1844)	V	V		V	
Soroklotok*	<i>Tor</i> sp.		V			V
Mas	<i>Cyprinus carpio</i> (Linnaeus, 1758)		V			V
Sepat	<i>Trichogaster trichopterus</i> (Pallas, 1770)		V			V
Kehkel	<i>Acrochordonichthys ischnosoma</i> (Bleeker, 1854)	V				V
Ceuray*	<i>Gambusia</i> sp.		V			V
Bogo	<i>Channa striata</i> (Bloch, 1793)		V			V
Patin	<i>Pangasius macronema</i> (Bleeker, 1863)	V				V
Blengit*	<i>Mystus nigriceps</i> (Valenciennes, 1840)		V			V
Nila	<i>Oreochromis niloticus</i> (Linnaeus, 1758)	V	V			V
Keting*	<i>Drepane</i> sp.	V				V
Lepokuning	<i>Tetraroge barbata</i> (Cuvier, 1829)	V				V
Lepohitam	<i>Neovespicula depressifrons</i> (J. Richardson, 1848)	V				V

Note: Data were obtained through interviews and field observations. Mark \* = Data only obtained through interviews. A: river in the territory of the Natural Reserve of Bojonglarang Jayanti; B: river outside Natural Reserve of Bojonglarang Jayanti; a: often encountered; b: rare; c: very rare

Based on interviews and field observations there are 12 species out of 36 species that have not been identified (Table 1). Among the 36 species, there are 9 species of fish that can be found both in natural reserve and outside the natural reserve, such as Broadhead sleeper (*Eleotris melanosoma*), Spotted barb (*Puntius binotatus*), menga (*Sicyopterus cyanocephalus*), Giant mottled eel (*Anguilla marmorata*), black catfish (*Clarias meladerma*), African catfish (*Clarias gariepinus*), Siamese fighting fish (*Betta* sp.), Blue panchax (*Aplocheilus panchax*), and Short fin eel (*Anguilla bicolor*). Some of this fish has potential as an ornamental fish such as Broadhead sleeper and Siamese fighting fish, while the other fish as a food fish. While Bearded Rogue fish (*Tetraroge barbata*) and Leaf goblin fish (*Neovespicula depressifrons*) are of unknown utility.

#### Disturbance factor

Results in Table 1 indicate that the Cikawung river can be categorized as one of the rivers that have the potential abundant diversity of fish in West Java or Indonesia in general, although the length of the flow is only 7,763 m.

However, there are now many disorders in the river that leads to endangerment to the existence of Cikawung river fish. In the past, people caught fish just for their daily food and there were certain times in which people used to catch fish in the Cikawung river. The community in Karangwangi, a few decades ago, caught fish using traditional methods, for example using a fishing rod (jeujeur, useup), net stocking (kecrik), lift nets (sirib), and fish filter (sair). In addition to the use of those tools, people have known natural toxins derived from plants. These poisons are the bark of the White siris tree (*Albizia procera* (Roxb.) Bent.), tua areuy seeds (vines, *Derris elliptica* Benth.), leaf of picung tree (*Pangium edule* Reinw. Ex Blume), gebang fruit (*Corypha utan* Lamk.), and iwung awi gereng shoots (*Bambusa bambos* (L.) Voss). Typically these toxins pounded then stocked up on the surface of a river or estuary. Chemical constituents in plants can result in fainting fish, then the fish would rise to the surface of the water. People also mixed such toxins with chili skin or chili powder (*Capsicum annum* L.). However, the use of various types of toxins was seldom. People prefer to use

tools such as the fishing rod to catch fish because it is more environmentally friendly and safe for health. Therefore, in the past the fish in the river was pretty much because the water quality was still quite good, and fishing by the inhabitants do not damage the sustainability of fish life.

Today people change the way to catch fish. Fishing at the present time is a job. People catch fish more intensively, thus reducing drastically the population of river fish. People of Karangwangi mostly still use fishing rod (40.07%). How to catch fish is not just using traditional fishing gear such as nets and poisons from the diversity of plant toxins (13.95%), but also using poison made of chemical synthesis, such as a mixture of 'petrol' and 'of soap'. Actually the use of poison was first introduced by settlers from Borneo. Not only that, people also use poison made of chemicals manufacturer, such as 'akodan' and 'adipo' which is actually a pesticides to kill pests (2.33%), and also electricity shock (3.49%) (Table 2).

From the history of ecology, the huge use of pesticide to kill fish in the river started in 1969, in accordance with the Green Revolution programmed in rice field cultivation to achieve the food self-sufficiency in Indonesia. Basically, the diversity of pesticides such as 'portas', 'tiodan', 'akodan', and 'adipo' are very effective to eradicate plant pests, such as locusts and worms in the area of agro-ecosystems belonging to the community. Then, they use pesticides to catch fish. According to the informants, 'adipo' is the only low levels of toxins that can kill white blood animals such as shrimp and crab, while 'akodan' has a high toxicity, which can kill red blood animals (all freshwater fish) and white blood. The use of such poisons is very easy, just pouring poison into the body of the river, usually from above (upstream) of the river, and then stirring the toxin along the water in the river. Rapid reaction to water animals, so in a short time the diversity of aquatic animals die immediately and float to the surface of the water. There's even a habit of catching fish in the river by using electric shocks. The use of the electric as fishing equipment by the inhabitants is commonly used surreptitiously. Ways to catch fish with electricity should not be done because it can kill target fish, fish eggs, and other organisms which are actually the food source for the fish itself. Such activities also violate Indonesian Act No. 5 of 1990 on Conservation of Natural Resources and Ecosystems. The shortage of public knowledge about the seasonal aspect of the fish, the economic factor that clashed with conservation, the lack of effective government bureaucracy in dealing with the population of endangered local river fish are the factors causing disturbances to the species of fish in the Cikawung river.

**Table 2.** Types of materials and equipments to catch fish in the Cikawung river by the community of Karangwangi, West Java

Tools name	Percentage (%)
Fishing rod	40,07
Fish nets and the like	59,84
Plant toxin	13,95
Pesticide and other synthetic chemicals	2,33
Electric	3,49

The use of Cikawung river by the public is open access and a common property that is risky to tragedy of the common (cf. Hardin 1968; Berkes and Farvar 1989; Iskandar 2001), given the fact that anyone may use this river which is a shared resource to meet anyone's daily needs. But, since this river geographically goes through the Bojonglarang Jayanti Natural Reserve, it can give positive effects to the fish to preserve and survive the fisherman *overfishing*. Overfishing is the application of an excessive effort to catch fish hugely (Widodo and Suardi 2008). Referring to Widodo and Suadi (2008), generally Cikawung river likely to have experienced overfishing in the form growth overfishing, recruitment overfishing, economic over fishing, and even Malthusian overfishing because there are too many high value fish such as Giant mottled eel (*Anguilla marmorata*) has been exploited excessively and the population is now scarce.

### Conservation and future efforts

From the foregoing description, it can be seen that in the past people had the rules they obey. In the past, leaders of indigenous villages, the influential public figures, can supervise fishing by people. In addition, the growing myths in the community about the fish have peculiarities. For example, they have the confidence not to eat river fish that weighed more than 5 kilograms because they believe it is a sacred fish. The tradition could indirectly help the conservation of river fish traditionally. Society used to recognize borders that they should not trespass, except for specific purposes such as pilgrimage or musty trail, given the natural reserves in forest areas where there are historical relics such as the soles of the feet of King Siliwangi. Some local residents consider the forest as a place that is forbidden to explore. In addition, people have myths that they should not bring home fish like carp, because it can cause death to person who eats it. There are also some small fishes that people believe should ignore when fishing. These small certain fishes are believed to have power to interest people to go after them while finally this person drown in the river to death.

In the past, even if people caught fish using poison, but the poison used is the poison of the plants are relatively harmless, for example *Albizia procera* and *Bambusa bambos*, which made the fish just unconscious and can be taken home by fisherman. The plants are also located on the Cikawung river bank, so it is not difficult to find. Natural toxins can be neutralized by natural cycles quickly so it is not dangerous in the long term. By looking at the first real cases of people that caught fish we can conclude that they did it with the local wisdom and local knowledge (corpus), trust (myth), and local institutions, as well as the role of traditional leaders (cf. Tolodo 2000; Iskandar 2012). Therefore, in the future, the efforts of Cikawung fishing must be sustainable by regarding the conservation efforts. People must be aware that the utilization of fish is not only for short-term interests, but also for the long-term interests. Various efforts to conserve the fish species in the Cikawung river has been tried, in order to get a sustainable fish utilization, despite a clash with the economic situation they face. For example, by giving the introduction of fish

into the river again. It is done by entering a new fish species that previously did not exist and restocking which means inserting a species of fish that was already there in this river (Syafei 2005). The example of fish stocking efforts in the Cikawung river done is putting Catfish (*Clarias* spp.) into this river, by the village government in 2012. However, those efforts failed because the stocked fish was killed by using toxic and electric by residents.

The village chief of Karangwangi said that the conservation of fish here is active community-based initiatives. They will imitate traditional conservation system of *lubuk larangan* in Sumatra and *sasi* in Eastern Indonesia. *Lubuk larangan* system is a form of water conservation established by agreement with the community, to conserve and utilize the fishery resources of the river. The system was then passed down through the generations by communities around the river to meet their needs (Triyanto and Lukman 2011; Iskandar 2012). Community-based conservation management is basically a part of a community-based resource management or Community-Based Management (CBM) (Carter 1996). There has been actually an initiative effort by the public in Karangwangi. For example, the village Chief together with the community has built a community surveillance system in the village by creating a village regulation in utilizing Cikawung river as a source of water for daily life and preserve the fish, lead to issuance of Karangwangi Village Regulation (Perdes). Hopefully that the whole village can monitor the resource utilization wisely, by not using materials and tools that are destructive, so the diversity of the population of fish in the river can be restored like conditions in the past. Therefore, the conservation of fish species which are the active participation of villagers needs support from various parties, so that these activities can be sustainable.

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#### REFERENCES

- Berkes F, Farvar MT. 1989. Introduction and Overview. In Berkes F (ed.) Common Property Resources: Ecology and Community-based Sustainable Development. Belhaven Press, London.
- Carter JA. 1996. Introductory Course on Integrated Coastal Zone Management (Training Manual). Pusat Penelitian Sumberdaya Alam dan Lingkungan, Universitas Sumatera Utara, Medan & Pusat Penelitian Sumberdaya Manusia dan Lingkungan, Universitas Indonesia, Jakarta & Environmental Studies Centres Development in Indonesia Project, Dalhousie University.
- Dhahiyat Y, Iskandar J, Salim H. 2001. Citarum upstream fisheries and aquaculture development in Saguling, Cirata and Jatiluhur dams. *Jurnal Ekologi dan Pembangunan* 5: 50-64. [Indonesian]
- FWI. 2011. The state portrait of Indonesian Forest Year Period 2000-2009. Forest Watch Indonesia, Bogor, Indonesia. [Indonesian]
- Google Earth. 2015. Google Earth Pro. Google Inc. California.
- Hardin G. 1968. The Tragedy of the Commons. *Science* 162: 1243-1248.
- Indonesian Act No. 41 of 1999 on Forestry
- Indonesian Act No. 5 of 1990 on Conservation of Natural Resources and Ecosystems
- Iskandar J. 2001. Human Culture and Environment: Study of Human Ecology. Humaniora Utama Press, Bandung. [Indonesian]
- Iskandar J. 2012. Ethnobiological and Sustainable Development. Pusat Penelitian Kebijakan Publik dan Kewilayahan, Unpad, Bandung. [Indonesian]
- Iskandar J. 2014. Pollution of Citarum. *Koran Pikiran Rakyat*, 3/3/2014. [Indonesian]
- Kartamihardja ES. 2008. Changes in the composition of fish communities and important factors affecting over forty years of age Ir. H. Juanda dam. *Jurnal Iktiologi Indonesia* 8: 67-78. [Indonesian]
- LIPI. 2014. Contemporary of Indonesian Biodiversity. LIPI Press, Jakarta. [Indonesian]
- Lynch SJF, Hoeltnsteiner RM, Cover CL. 1974. Data Gathering by Social Survey. Philippine Social Science Council, Quezon City.
- Martin GJ. 1995. Ethnobotany: A Methods Manual. Chapman & Hall, London.
- Meijaard E, Sheil D, Nasi R, Stanley SA. 2006. Wildlife conservation in Bornean timber concessions. *Ecol Soc* 11: 47. <http://www.ecologyandsociety.org/vol11/iss1/art47/> [October 4, 2015]
- Newing H, Eagle CM, Puri RK, et al. 2011. Conducting Research in Conservation: Social Science Methods and Practice. Routledge, London.
- Sutrisno H, Partomihardjo P, Triono T et al. 2012. A thematic study of flora and fauna in the area of hydropower project "Upper Cisokan PUMPED Storage". PLN-LIPI, Jakarta. [Indonesian]
- Syafei LS. 2005. Fish restocking for sustaining fisheries resources. *Jurnal Iktiologi Indonesia* 5: 69-75.
- Triyanto, Lukman. 2011. Building of a conservation system of fish habitat in the Citarum river through the adoption Lubuk Larangan system. Prosiding Forum Nasional Pemacuan Sumber Daya Ikan III. Pusat Penelitian Limnologi-LIPI. Indonesia. [Indonesian]
- Walter RP, Hogan JD, Blum MJ et al. 2012. Climate change and conservation of endemic amphidromous fishes in Hawaiian streams. *Endang Species Res* 16: 261-272.
- Whitten T, Soeriaatmadja RE, Afiff SA. 1999. Ecology of Java and Bali. Periplus, Singapore. [Indonesian]
- Widodo J, Suadi. 2008. Sea Fisheries Resource Management. Gajah Mada University Press. Yogyakarta. [Indonesian]
- Yuanda, Meydia A, Dhahiyat Y et al. 2012. The structure of fish communities in Upper Cimanuk river, Garut District. *Jurnal Perikanan dan Kelautan* 3: 229-236. [Indonesian]
- Zaenudin A. 2013. Species diversity and abundance of fish in the Upper and Central Regions of the Gajahwong river Yogyakarta. [Hon. Thesis] Universitas Islam Negeri Sunan Kalijaga Yogyakarta [Indonesia]