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Preserving the Lake Toba ecosystem: Strategic planning to mitigate red devil fish invasion

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Preserving the Lake Toba ecosystem: Strategic planning to mitigate red devil fish invasion

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Abstract. Lake Toba is known as a tourism destination and also has aquaculture that is utilized for freshwater fish. However, several types of endemic fish and consumable fish cultivated in Lake Toba are facing the threat of extinction, and their populations are decreasing due to the presence of Red Devil Fish. The research aims to explain how the local government's strategic planning efforts mitigate the invasion of Red Devil Fish and preserve the ecosystem in Lake Toba. This research uses qualitative research with descriptive methods. This research prioritizes secondary data collection that can support research. Data analysis techniques include data reduction, data display, and conclusion. The results showed that the Indonesian government must overcome the problem of red devil fish invasion into the Indonesian aquatic ecosystem. The presence of Red Devil fish in Lake Toba has reduced the number and diversity of fish, including the extinction of several native fish species. The impact of this invasion damages the ecosystem and causes economic losses such as control costs and decreased fish production for public consumption. The local government's strategic planning in protecting the Lake Toba ecosystem from Red Devil fish invasion is carried out by controlling spatial planning, conducting talks, and collaborating with various related parties. The North Sumatra Provincial Marine and Fisheries Service and the Fish Family Association have implemented strategies to minimize Lake Toba's Red Devil fish population. Increasing community involvement in managing the Lake Toba ecosystem and reducing the Red Devil fish population is crucial.

1. Introduction

Lake Toba is a large lake in North Sumatra, Indonesia, famous for its natural beauty and cultural values. The lake is believed to have been formed by a large volcanic eruption around 75,000 years ago, which created a caldera. For the surrounding community, Lake Toba has a significant impact on the surrounding community in social and economic terms [1]. Tourism development and economic growth associated with Lake Toba have changed professions, traditional ceremonies, income, business opportunities, and employment opportunities for local communities [2].

In addition to tourism development, local communities get economic benefits through freshwater fish farming in Lake Toba. Lake Toba has a rich ecosystem that is eventually filled with water and habitat for various types of fish. In the field of fisheries, Lake Toba is utilized for both capture and cultivation fisheries. Fishery ponds developed are Bilih fish (*Mystacoleucus Pangenesis*), and aquaculture activities in floating net cages for red tilapia, black tilapia (*Oreochromis Niloticus*), and carp (*Cyprinus Carpio*) have been developed since 1988 [3].

However, some endemic fish species, such as *Neolissochilus thienemanni* and *Poropuntius tawarensis* in Lake Toba, face extinction threats, and their populations are dwindling due to red devil

fish farms [4]. It was introduced to Lake Toba through the ornamental fish trade and possibly through the release of fish from ornamental fish ponds around it. Red devil fish that prey on fish commonly caught by fishermen cause a decrease in catches and fishermen's income [5]. Red devil fish have high reproductive abilities and can reproduce quickly. This makes the spread of red devil fish challenging to control and increasingly threatens the Lake Toba ecosystem [5]. In dealing with the problem of red devil fish, the local government, which has authority over the local community, needs to take steps to control the population of this fish, protect endemic fish, and maintain the balance of the Lake Toba ecosystem.

Due to its invasion and potential harm to the native environment in the waters of Lake Toba, the red devil fish needs to be studied. The dependence of the surrounding community as fishermen on fish in Lake Toba is one of the main factors in preserving the ecosystem from the invasion of Red Devil Fish [1]. Therefore, ecosystem conservation in Lake Toba needs to involve local communities and governments through strategic planning, especially by the local government, to support ecosystem conservation efforts on Lake Toba. This research seeks to find out how the provincial government's strategic planning efforts mitigate the invasion of Red Devil Fish and preserve the ecosystem on Lake Toba.

2. Method

This research uses qualitative research with descriptive methods [6]. The focus of this research is to analyze the local government's strategic planning to mitigate the invasion of Red Devil Fish and preserve the ecosystem in Lake Toba by looking at the policy of the Regulation of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia Number 19/Permen-Kp/2020 concerning Prohibition of the Entry, Cultivation, Distribution, and Expenditure of Fish Species that are Harmful and Harmful into and from the State Fisheries Management Area of the Republic of Indonesia Against Red Devil Fish Cultivation in Lake Toba. This research prioritizes secondary data collection through journals, books, documents, online media, and other materials that can support research. Data analysis techniques include reduction, display, and conclusion [7].

3. Result and discussion

3.1. Red devil fish invasion in indonesia's aquatic ecosystems

One type of fish considered dangerous in the Regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 19/Permen-Kp/2020 is the red devil fish (*Amphilophus citrinellus*). Red devil fish originates from Central and South America, specifically in Nicaragua, Costa Rica, Honduras, and Mexico. The natural habitat of Red Devil fish is in freshwater waters such as lakes, rivers, and reservoirs. Red Devil fish are also found in several waters in Indonesia, such as in the Darma Reservoir in Kuningan Regency, West Java, and Bali [8]. Red devil fish have diverse food habits, but their leading food is plankton from the Chlorophycea class [9].

The invasion of Red Devil fish into several freshwater ecosystems in Indonesia attacks fish species diversity and the ecosystem. Red Devil fish is an invasive species that can cause a decrease in the variety of native fish species and result in economic losses due to controlling the spread of invasive species and reducing the production of economically valuable fish Fields [4]. The impact of invasive species on ecosystems concerns sustainable resource management, including fisheries areas [3]. The abundance of invasive fish species in freshwater aquaculture and natural aquatic systems causes extensive damage to nets and fishing gear and minimizes fishermen's income [10]. Managing with an ecosystem-based approach is necessary to ensure the sustainability of freshwater ecosystems in Indonesia. This approach considers resource use and management's social and economic aspects [11].

This study was made by considering several previous studies on the impact of harmful fish farming on native fish populations. Previous studies have shown the risk of alien fish in Cirata Reservoir, West Java, that introducing unknown fish into waters is allowed after a risk assessment by conducting risk management based on specific interests [12]. Invasion of alien fish can only occur with an extensive examination of its impact [13]. The effect of invasive red devil fish on fish diversity in inland public

waters in Indonesia affects the community's economic needs. It requires the role of related sectors through research and development on dealing with impacts, prevention of trade traffic and route entrants, and so on [3].

The Government of the Republic of Indonesia then issued Law of the Republic of Indonesia No. 32 of 2014 concerning Maritime Affairs. Referring to this regulation, the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia issued Regulation of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia Number 19/Permen-Kp/2020 concerning the Prohibition of the Entry, Cultivation, Distribution, and Expulsion of Fish Species that are Harmful and Harmful into and from the State Fisheries Management Area of the Republic of Indonesia. The regulation explains that red devil fish is dangerous and prohibited from being cultivated and bred. Therefore, efforts to conserve native ecosystems require cooperation between agencies. Cooperation between the government, research institutions, and local communities to implement effective control strategies. This involves coordination in monitoring, research, and implementation of control policies [14].

The Indonesian government needs to pay attention to the problem of foreign fish invasion, one of which is red devil fish, to the aquatic ecosystem in Indonesia. The attack of Red Devil fish on Indonesia's marine ecosystems has potential long-term consequences. The ecosystem's natural balance causes a decrease in native biodiversity, and Red Devil fish can disrupt the food web in Indonesia's aquatic ecosystems [14]. In addition, red devil fish can impact water quality by altering nutrient cycling and sedimentation patterns, changing the physical structure of habitats and habitat degradation, and reducing fisheries yields, causing economic losses to fishermen [7].

3.2. The threat of red devil fish to the ecosystem in Lake Toba
Red devil fish, or *Amphilophus labiatus*, is an exotic species introduced into several freshwater ecosystems. They are believed to be among the most critical threats to native fish in freshwater waters and their impact on native fish fauna [15]. Lake Toba is another freshwater ecosystem in Indonesia, home to several fish species, including those commonly consumed by locals [16]. Red devil fish can invade new habitats due to their physical characteristics. Its ability to colonize new habitats with a size of 15 inches in the ecosystem and its high reproductive rate and aggressive prey behaviour make it a dominant predator in its habitat [15].

Red Devil fish has also expanded into Lake Toba. Introducing this species caused uncontrolled growth that became a pest and harmed the surrounding community. The presence of Red Devil fish in Lake Toba has caused a decline in the number and type of fish, including the loss of several native fish. The impacts of this invasion include ecosystem changes, decreased biodiversity, and economic losses such as the cost of controlling alien fish species and decreased financial fish production [3]. These invasive species have caused ecosystem changes, reduced biodiversity, and economic losses to communities around Lake Toba.

Therefore, efforts are needed to reduce the population of Red Devil fish in Lake Toba. Efforts made also need to pay attention to the original ecosystem so that it is maintained. According to Rachmad, these efforts can be [14]:

a. Selective removal of individuals: Selective capture and removal of individual Red Devil fish to reduce the population. This can be done by using appropriate capture methods and considering the protection of native fish species.

b. Reproduction control: Controlling the reproduction of Red Devil fish by reducing their opportunity to breed. One way this can be done is by separating female and male fish to prevent spawning.

c. Public education and awareness: Increase public awareness about the negative impact of Red Devil fish on the Lake Toba ecosystem. Conduct education and socialization campaigns for the community about maintaining biodiversity and avoiding the spread of invasive species.

d. Development of economic alternatives: Encourage the Development of economic alternatives for local communities currently dependent on Red Devil fishing. By providing sustainable livelihood alternatives, pressure on the Red Devil fish population is hoped to be reduced.

In reducing the Red Devil fish population in Lake Toba, it is necessary to pay attention to protecting native fish species and maintaining ecosystem balance. Control efforts must be carried out sustainably and involve various related parties. In addition, further research must be done to evaluate effective control strategies without damaging the ecosystem.

3.3. Local government strategic planning in protecting the lake toba ecosystem against red devil fish
Red Devil fish threaten local species in Lake Toba due to their aggressive behaviour and tendency to prey on other fish. This condition can cause damage to the local ecosystem and threaten the survival of different species in the lake. The Regional Governments with authority and power in the Lake Toba area are the North Sumatra Provincial Government and the Toba Samosir Regency Government. Therefore, the local government's strategic planning in protecting the Lake Toba ecosystem against Red Devil fish takes various steps and efforts.

First, the local government can conduct discussions and collaborations with various related parties to control the use of space around Lake Toba. This aims to protect the environment and tourism in the area [17]. Second, the North Sumatra Provincial Maritime and Fisheries Service once held a Red Devil fishing competition in the waters of Lake Toba. This competition can be an effort to reduce the population of Red Devil fish in the lake [18]. Third, the Fish Family Association (PIKI) has initiated a way to reduce the population of Red Devil fish in Lake Toba. This effort aims to ensure that the presence of consumer fish such as tilapia, mujahir, catfish, and carp can return to normal in the waters of Lake Toba [19].

Local government strategic planning must involve various related parties [20], such as marine and fisheries agencies, research institutions, and local communities. With cooperation and coordinated efforts, it is expected to maintain the Lake Toba ecosystem and reduce the impact of the presence of Red Devil fish. Therefore, it is essential to strengthen community participation in supporting the Lake Toba ecosystem and controlling the Red Devil fish population. Local communities around Lake Toba have exerted efforts by catching ferocious fish to maintain the balance of the ecosystem. Communities can improve their understanding of the Red Devil fish and its impact on the Lake Toba ecosystem. With a better experience, the community can be more aware of the importance of maintaining the ecosystem and controlling the Red Devil fish population.

The Marine and Fisheries Service of North Sumatra Province once held a Red Devil fish catching competition in the waters of Lake Toba. The public can participate in this competition to reduce the population of Red Devil fish in the lake. The Fish Family Association has initiated a way to reduce the population of Red Devil fish in Lake Toba. The community can support this effort so that the presence of consumable fish such as tilapia, Mujahir, catfish, and carp can return to normal in the waters of Lake Toba. With the community's active role, a balance can be created in the Lake Toba ecosystem and control the Red Devil fish population. Therefore, there needs to be a collaboration between the local government, marine and fisheries agencies, research institutions, and the local community in maintaining the Lake Toba ecosystem. Previous research explains that partnership can help better risk management [21]. Collaboration can lead to more effective public policies that address societal challenges [22].

4. Conclusion
Red devil fish is an invasive species that can reduce the diversity of native fish species and result in economic losses due to controlling the spread of invasive species and reducing the production of economically valuable fish. The Indonesian government must address the problem of foreign fish invasion into Indonesian aquatic ecosystems, one of which is red devil fish. The presence of Red Devil fish in Lake Toba has reduced the number and diversity of fish, including the extinction of several native fish species. This invasion damages the ecology, reduces biodiversity, and incurs economic losses, such as the cost of regulating invasive fish species and decreased fish production for consumption by the people of Lake Toba. In addition, by reducing the population of Red Devil fish in Lake Toba, it is imperative to preserve native fish species and maintain the balance of the ecosystem.

The North Sumatra Provincial Government and the Toba Samosir Regency Government are Local Governments with authority and power in the Lake Toba area. Therefore, the local government's strategic planning in protecting the Lake Toba ecosystem from Red Devil fish attacks must be carried out in various ways and efforts. The local government can conduct talks and collaborate with multiple related parties to control space around Lake Toba. The North Sumatra Provincial Marine and Fisheries Service and the Fish Family Association (PIKI) have begun developing a strategy to minimize Lake Toba's Red Devil fish population. In addition, it is crucial to increase community involvement in managing the Lake Toba ecosystem and reducing the Red Devil fish population. Communities can learn more about the Red Devil fish and its impact on the Lake Toba environment.

5. References

[1]   Sihombing D I 2022 *SEPREN J. Math. Educ. Appl.* **4**
[2]   Junaedi I W R, Waruwu D, Sumartana I M, Hidajat B, Irawan I, Nguyen P and Ngin C 2023 *Int. Bus. Account. Res. J.* **7** 253
[3]   Kartamihardja E S, Fahmi Z and Umar C 2015 *J. Kebijak. Perikan. Indones.* **7** 1
[4]   Umar C, Kartamihardja E S and Aisyah A 2015 *J. Kebijak. Perikan. Indones.* **7** 55
[5]   CNN Indonesia 2022 *Ikan Perusak Ekosistem Danau Toba Tertangkap Kamera Kunyah Bangkai* (cnnindonesia.com)
[6]   Moleong L J 2017 *Metodologi Penelitian Kualitatif* (Bandung: Remaja Rosdakarya)
[7]   Miles M B, Huberman A M and Saldana J 2014 *Qualitative Data Analysis: A Methods Sourcebook* (London: Sage)
[8]   Juliawan I W, Arthana I W and Wulandari Suryaningtyas E 2020 *Bumi Lestari* **20** 40
[9]   Isroliyah A, Solichin A and Rudiyanti S 2021 *Jurnal Pasir Laut* **5** 96
[10]   Seshagiri B, Swain S K, Pillai B R, Satyavati C, Sravanti Y, Rangacharyulu P, Rathod R and Ratnaprakash V 2021 *Int. J. Fish. Aquat. Stud.* **9** 375
[11]   Tahir A 2018 *Pros. Simp. Nas. Kelaut. Dan Perikan.* **5**
[12]   Sentosa A A, Yuliana E and Astuti L P 2022 *BAWAL Widya Ris. Perikan. Tangkap* **14** 105
[13]   Wargasasmita S 2005 *J. Iktiologi Indones.* **5** 5
[14]   Rachmad B, Sihombing E and Sabariyah N 2019 *J. Kelaut. dan Perikan. Terap.* **2** 73
[15]   Ohee H L, Sujarta P, Surbakti S B and Barclay H 2018 *Biodiversitas J. Biol. Divers.* **19** 209
[16]   Jalova Jr M C, Lomantong A D, Calibo L G and Camarin M M 2021 *Isr. J. Aquac. IJA.* **73**
[17]   Info Sumut 2022 *Gubernur Diskusi Soal Pengendalian Pemanfaatan Ruang di Danau Toba* (Infosumut.id)
[18]   Hakim L 2022 *Lomba Tangkap Ikan Red Devil di Perairan Danau Toba Kab. Toba* (Dkp.sumutprov.go.id)
[19]   Piki-Sumut 2022 *PIKI Inisiasi Cara Kurangi Ikan Red Devil Di Danau Toba, Ini Solusinya* (Pikisumut.id)
[20]   Ridho H, Thamrin M H, Nasution F A and Indainanto Y I 2023 *Int. J. Sustain. Dev. Plan.* **18** 275
[21]   Bendz A and Boholm Å 2018 *Journal of Risk Research* **22** 674
[22]   Schneider B R 2013 *Journal IDB Working Paper No. IDB-WP-418*