Floating net cage aquaculture production in Indonesia

by Junaidi Junaidi

Submission date: 21-Jan-2022 06:17AM (UTC+0700)
Submission ID: 1745058450
File name: Floating_net_cage_aquaculture_production_in_Indonesia.pdf (376.66K)
Word count: 5821
Character count: 30824

Floating net cage aquaculture production in Indonesia: Assessment of opportunities and challenges on Lake Maninjau

Junaidi[1], Hafrijal Syandri[2], Azrita[3], Abdullah Munzir[1]

[1] Department of Fisheries Resources Utilization, Faculty of Fisheries and Marine Sciences, Universitas Bung Hatta Padang, West Sumatera, 25133
[2]Department of Aquaculture, Faculty of Fisheries and Marine Science, Bung Hatta University, Padang, Indonesia
[3]Department of Biology Education, Faculty of Education, Bung Hatta University, Padang, Indonesia.

*Corresponding Author: Junaidi (junaidi@bunghatta. ac. id), Tel +62751-7051678.

Abstract: Aquaculture activities of floating cages in Lake Maninjau have recorded significant growth, even as the largest contributor to the total annual production of aquaculture in West Sumatra Province. Our study aimed to assess the output of floating net cages in Lake Maninjau, Indonesia. We analyze the characteristics of fish farming, fish fry, feed supply, production, challenges, and opportunities to increase aquaculture production in the future. We used purposive sampling in this study—the interview method used a questionnaire form to obtain information from 80 fish-cultivating households in lake Maninjau. Data analysis used descriptive statistical methods. The results showed that in 2018, the number of floating net cages was 17,596 nets. The majority (n = 33, 41.25%) of fish farmers have floating net cages ranging from 20 to 40 nets per household, and (n= 54, 67.5%) are used for tilapia cultivation. We recorded (n = 62, 77.5%) fingerlings sources from private hatcheries. Six companies supply commercial feed pellets for 2,000 tons per month for aquaculture activities. Japfa Comfeed Indonesia Ltd provides 35% of the feed. The fish species cultivated were Nile tilapia, common carp, Giant gourami, Clarias, and pangasius catfish with gross yields (kg/m^3/cycle) were 12, 11.5, 10.4, 7.88, and 8.89, respectively. Fish farmers face the most challenging conditions: poor water quality, mass mortality of tilapia, high fish feed prices and low fish selling prices, and non-cash payments. We recommend ensuring the development of floating net cages in Lake Maninjau for a better future to use the concept of "sustainability." Therefore, it is necessary to operate as many as 6,000 nets under the carrying capacity of cultivation based on the Regional Regulation of Agam Regency Number 5 of 2014 concerning Maninjau Lake Management which is placed proportionally in eight villages. Giant gourami is prioritized for cultivation because it is resistant to poor water quality and high market prices.

Keyword: Aquaculture, lake fisheries, cage, ecosystems health, challenges

1. Introduction

Aquaculture activities have been responsible for the supply of fish for human consumption; because of this reason, aquaculture continues to grow faster compared to other major food production sectors [1]. Indonesia is a rich country with natural water resources that can be utilized for aquaculture development in the future [2]; [3]; [4]. In 2016, aquaculture Indonesia occupied 1,201,275 ha of land, consist of 250,640 ha (20.86%) inland, 674,135 ha (56.12%) was coastal, and 276,500 ha (23.02%) was marine [5]. Based on the data above, the aquaculture sector plays an important role in Indonesia economically [4]; [6]; [7]. Lately, the freshwater aquaculture commodities developed in Indonesia were Clarias catfish, Pangasius catfish, common carp, and Nile tilapia [8]. These species have contributed as much as 14.0%, 11.0%, 13.4%, and 22.7% to Indonesian aquaculture production, respectively [2], which derive from the ponds, floating net cages, and paddy-fish integrating farming [5].

Aquaculture activities are floating net cages in Lake Maninjau date back to 1992 when Yulinus Farm Limited successfully harvested fish from floating net cages constructed in their farm. At that time, the fish species was culturing were common carp (*Cyprinus carpio*). Still, Nile tilapia was more dominating farmed in the last ten years, and other species, like Giant gourami, Clarias pangasius [9]; [10]. In 2015, in Lake Maninjau, floating net cages were recorded as many as 16,608 nets compared to only 16 nets recorded in 1992 [11]. However, the number of floating net cages and other supporting industries is increasing in Lake Maninjau. Therefore, there is required for a strategy to guide its investment based on the "sustainability" concept, i.e., the practice of cultivating floating net cages to grow sustainably. At the same time, its negative environmental impact must reduce significantly [12]; [13].

On the other hand, we have not recorded information on the characteristics of floating net cages and socio-demographic indicators and the number of floating net cages in each village in Lake Maninjau. Including the fish cultivated, seed sources, and activities related to commercial feed provision and feed supply companies. Therefore, this study evaluates farms' characteristics and socio-demographic indicators, the number of cages in each village, species of fish cultivated, feed supply companies, and harvested production. Apart from these data, we will also analyze the opportunities and aquaculture challenges of floating net cages in Lake Maninjau. This data is fundamental to consider fish farming activities with floating net cages in the future based on the "sustainability" concept.

2. Methods

2.1 *Study area*

This study was conducted in Lake Maninjau, Tanjung Raya Sub-district, Agam District, West Sumatera Province, Indonesia. This lake was categorized as Tecto-volcanic with longitude at E: 0012'26.63"- S: 0025'02.80" and E: 100007'43.74"- E: 100016'22.48", and the altitude of 461.50 m above sea level. About 150 km Southwest of Padang City. The biophysical characteristics of Lake Maninjau are presented in Table 1. Tanjung Raya sub-district has a 35,309 population [14]; the community's main activities in Lake Maninjau were floating net cage fish farming and Tilapia hatcheries activities on the lake border.

Table 1. Biophysical characteristics of Lake Maninjau

Biophysical characteristics	units	value
Surface area	km^2	99.7
Length of coastline	km	52.7
Maximum length	km	16.46
Maximum width	km	7.5
Maximum depth	m	168
Average depth	m	118
Relative depth, Zr	%	1.51
Volume of water	km^3	10.4
Water retention time	year	25
Catchment area	km^2	132.6

Data sources: [15]

2.2 *Study design*

In this study, we used the purposive sampling method. The interview method was conducted by questionnaire form to obtain information regarding 80 fish farmers' households characteristics (10 households each village) from 850 fish farmers households in eight villages, Tanjung Raya sub-district [16]. The eight vilages, namely Koto Malintang, Tanjungsani, Sungai Batang, Maninjau, Bayur, Dou Koto, Koto Kaciek, and Anam Koto. We conducted this survey in the Tanjung Raya District of Danau Maninjau in March-July 2018. Primary data collection included the total of floating cages in each village, fish farming operators of floating net cages, fish feed supply, fish seed availability, and harvested production. Then, we also analyzed the challenges faced by the fish farmer in floating net cages. On the other hand, we obtained additional relevant information about the fish farming activities in floating net cages from the manager of the feed selling companies and field observation.

Before we collected primary data, a questionnaire was designed, and a pre-test was run with several floating net cage farmers in each village. The changes of questionnaires form are made according to the data requirement. The final questionnaires were improved, rearranged, and modified based on the response from the pre-tested questionnaires. In addition to primary data, we also collected secondary data such as a dataset of the number of floating net cages for 2001 to 2018 was collected from the Department of Fisheries Agam District, West Sumatera Province. Mapping involved geo-referencing the number of floating net cages in each village based on GPS location established for floating net cages presence in the Lake Maninjau using Arc GIS 10.0.

2.3 *Data analysis*

The data collected were organized into charts, tables, and graphs in Microsoft Excel to conclude the response; all answers were coded and transferred to the Statistical Package for Social Scientists (SPSS) version 17.0.

3. Results and Discussion

3.1. Farms' characteristics and socio-demographic indicators

Fish farmers' households in Lake Maninjau have practiced the production methods and the single floating net cage system for economic reasons. The type of unit production consists of the iron frame coated with anti-rust material (iron paint), supporting the four floating net cages a 75 m^3 (size 5 x 5 x 3 m) constructed using a 10 mm mesh size. The units were in combination with other facilities (i.e., float, feeding station, and cage pathway). The float used were plastic drums with double ring type, 58 cm of body diameter, 93 cm of total height, 8.6 kg of product weight, and 200 L volume of full. In contrast, in Lake Victoria, Kenya, fish farmers had a cage ranging from 8 to 125 m^3, and the size variations of the pens related to the difference in financial resources [17].

The number of floating net cages increased exponentially between 2001 and 2018 and has increased by 90.14% in the last five years (Figure 1) [14]. In this context, fish farmers' interest is growing for the floating net cage business. Table 2 shows the number of floating net cages in each village around Lake Maninjau. Tanjung Sani village had the highest number of floating net cages culture establishments (n = 4,364, 24.80%) from a total of 17,596 cages in Lake Maninjau. Koto Gadang village, and Duo Koto had the lowest floating net cages culture establishments (*n* = 660, 3,75%) and (*n* = 653, 3.71%), respectively. The difference in the number of floating net cages in each village is mainly due to the length of the lake's coastline owned by each village.

For example, we show floating net cages in Bayur Village (Figure 2). Most of the floating net cages (n =45, 56.26%) were located 300 m from the shore. This factor is mainly because most farmers prefer the zone due to its better water quality and protection from potentially damaging winds and currents. On the other hand, from the mapping results, there are also floating net cages placed around the weir zone of the hydroelectric power plant. Several areas (<100 m) of each village are "Rasau Rindu Wisata" zones which function as fish breeding zones, thereby affecting natural fish populations and are therefore protected from fishing.

This survey involved 80 fish farmers' households from a sample of 850 fish cultivating households. Overall, we recorded 2,274 floating net cages from 80 respondents. In term of fish farmers as job or profession, the respondent was classified as full time fish farmers (*n* =54, 67.5%), part-time fish farmers (*n* =10, 12.5%), fisherman and fish farmers (*n* =13, 16.25%) and others (*n* =3,3.75%). In this case, they referred to persons who owned cages but were neither full-time fish farmers nor part-time fish farmers of fisher (Fishers who regularly for fishing). They could have been village office clerks, teachers, shopkeepers, or civil servant pensions in this context. The average monthly income of the respondent's household is USD 172.41 per month, with the majority of respondents living in the Maninjau lake area (n = 75, 93.75%). This income is lower than the income of caged fish farmers in Lake Victoria, Kenya (USD 2,832 per month). At the same time, 82% of them live in rural areas of the Lake Victoria region [13].

Furthermore, the majority of floating net cages were individually owned (*n* = 60, 75%), feed traders owned (*n* = 15, 18.75%), and fish traders owned (*n* = 5, 6.25%) (Figure 3). At the same time, the number of floating net cages in each fish farmers' household ranges from 4 and 60 nets. The majority (*n* = 33, 41.25%) of the fish farmers' household had floating net cages ranging from 20 and 40 nets, 41 and 60 nets (*n* = 22, 27.08%), 8 and 20 nets (*n* = 18, 23.33%), and 4 and 8 nets (*n* = 7, 8.33% (Figure 4).

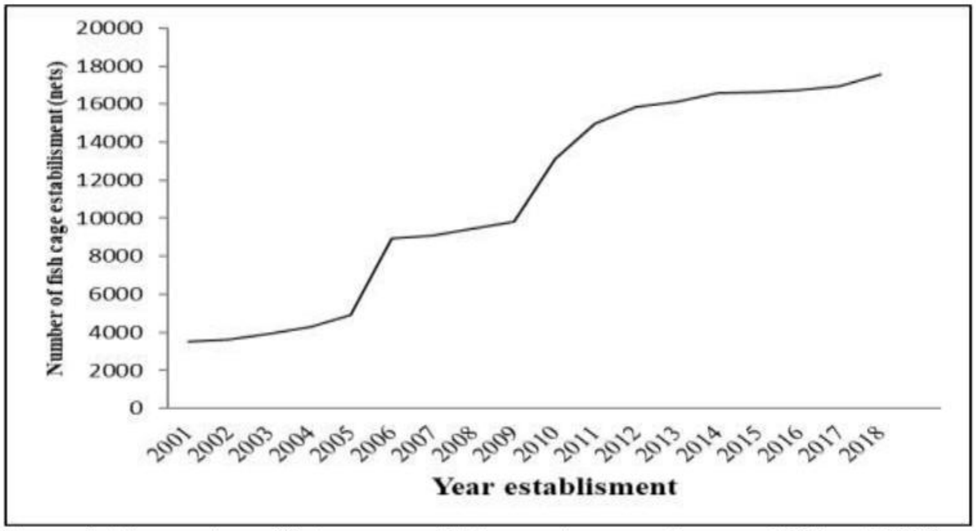

Figure. 1. The number of fish cage establishments between the years 2001 and 2018 in Lake Maninjau, Indonesia

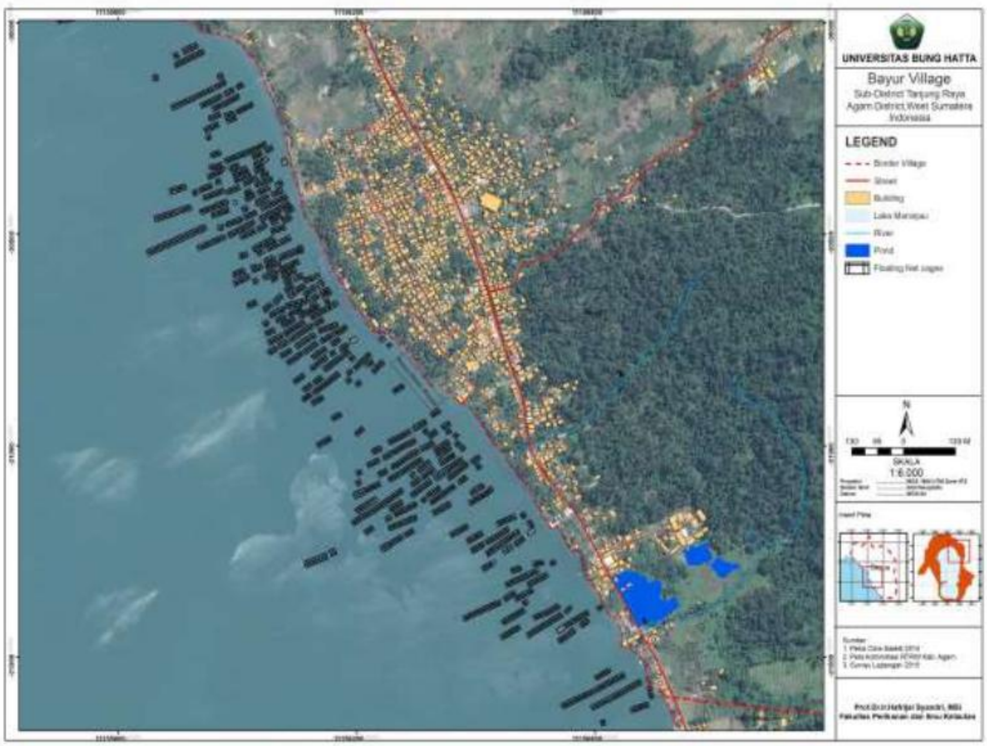

Figure 2. Mapped floating net cage culture locations in the Bayur Village Lake Maninjau, Indonesia

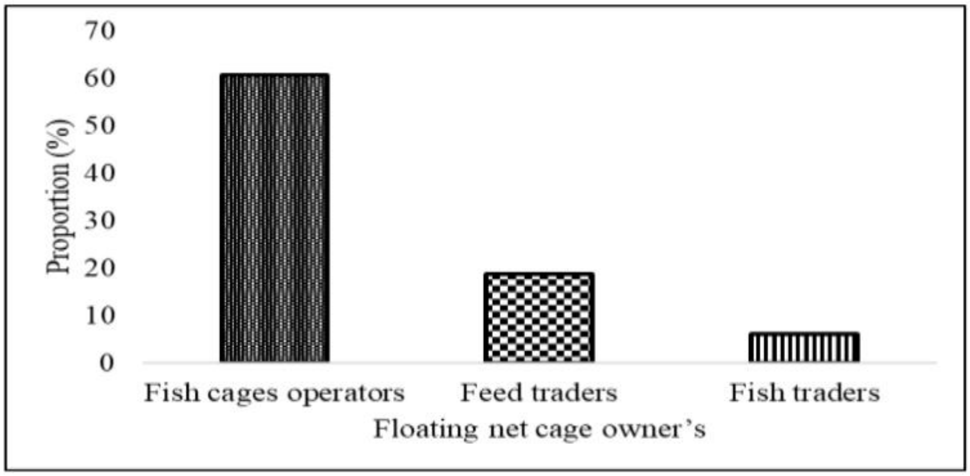

Figure 3. Owners of floating net cages in Lake Maninjau

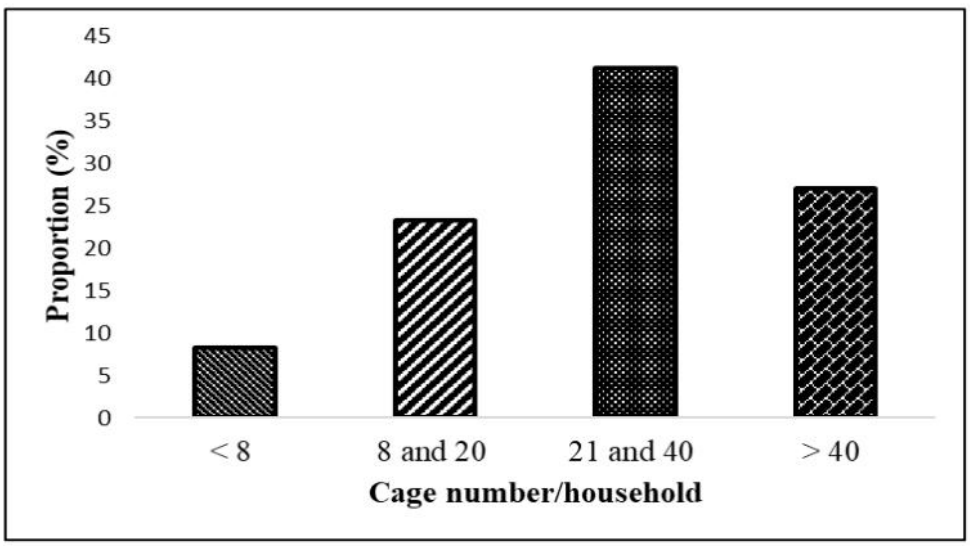

Figure 4. Ownership of floating cages per fish farmers household in Lake Maninjau

Table 2. Distribution of floating net cages in eight villages of Lake Maninjau, Indonesia

	Floating net cage location	Number of floating net cages	Proportion (%)
1	Maninjau	1,332	7.57
2	Bayua	3,354	19.06
3	Duo Koto	653	3.71
4	Koto Kocik	1,265	7.19
5	Koto Gadang VI Koto	660	3.75
6	Koto Malintang	3,459	19.66
7	Tanjung Sani	4,364	24.80
8	Sungai Batang	2,509	14.26
	Total	17,596	100

Data source**:** Based on the GIS mapping, 2018

3.2 Species culture and stocking densities

The fish species culture was Nile tilapia (*Oreochromis niloticus*), common carp (*Cyprinus carpio*), Clarias catfish (*Clarias sp*), Pangasius catfish (*Pangasius hypophthalmus*), and giant gourami (*Osphronemus goramy*). Other researchers also reported that Nile tilapia is the predominant species cultured in cages [13] [18]; [19]. In this study, the majority (67.5%) of the floating net cages have been used for cultured Nile tilapia, 18.75% for common carp, 5.00% for Clarias catfish, 3.75% for Pangasius catfish, and 5.0% for giant gourami (Figure 5). Catfish and pangasius are culturing because the production cycle is short. They can be fed feed dead tilapia, which comes from the floating net cages in this area and is resistant to poor water quality. At the same time, although the growth rate of giant gourami is slow, this species is resistant to poor water quality and has a high market price. The average stocking density of Nile tilapia fingerlings was 100 fish/m^3 (7,500 fish per nets), common carp and giant gourami was 66 fish/m^3 (5,000 fish per nets), Clarias catfish and Pangasius catfish were 133 fish/m^3 (10,000 fish per nets). In this study, the provision of tilapia fingerlings for cage culture was sourced from private fish hatcheries, individual hatcheries and caught from Lake Maninjau (Figure 6). While the fingerlings of common carp, Clarias catfish, and giant gourami from private companies in Luak District, Lima Puluh Kota Regency, West Sumatra Province, which is 75 km from Lake Maninjau. We collect catfish seeds from Kampar Regency, Riau Province, 120 km from Lake Maninjau.

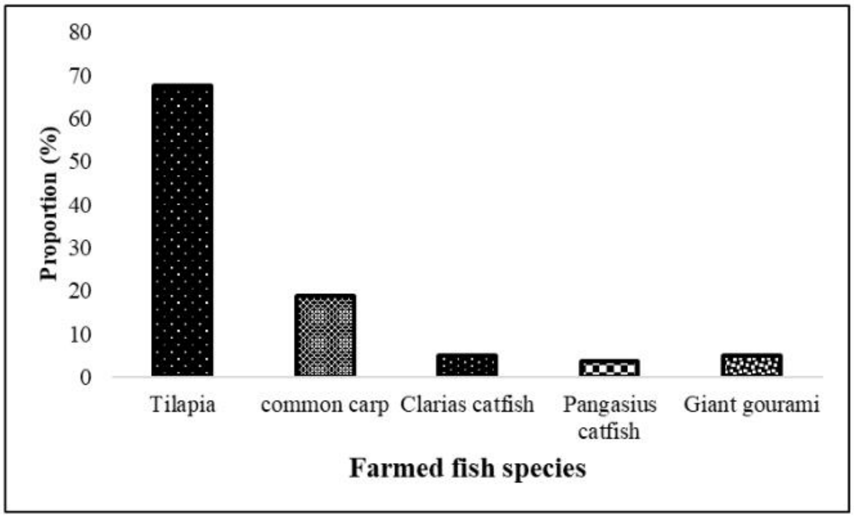

Figure 5. Number Fish farmers households in Lake Maninjau, Indonesia

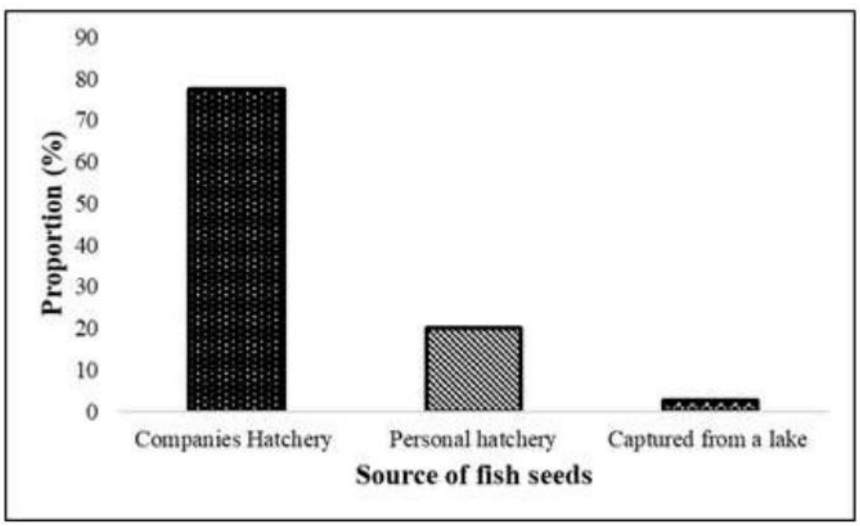

Figure 6. Sources of tilapia fingerlings for aquaculture activities

3.3 Fish feed

This study revealed that fish farmers in Lake Maninjau were carried out aquaculture activities for 60 to 180 days per production cycle to achieve market sizes. Most fish farmers fed the fish twice a day at 09:00 to 10:00 AM and 4:00 to 5:00 PM. Fish were hand-fed at a 3% body weight rate per day until study termination. According to Thongprajukaew et al. [20], tilapia cultivation operations fed twice a day (06.00 hours and 18.00 hours) are optimal in feed management. Conversely, feeding fish im-properly can be a problem for fish farmers in developing countries [21]. This study noted that feed used was floating and sinking commercial feed. On the other hand, cage fish culture in Lake Victoria uses feed types floating, sinking, slowly sinking, and not sure [13].

This study also noted that feed used to produce in floating net cages fish was supplied from a feed company in North Sumatra Province, Indonesia. Currently, the feed supply to Lake Maninjau, Tanjung Raya District, averages 2,000 tons per month. Commercial feed was supplied by seven companies, namely Japfa Comfeed Indonesia Ltd, Central Proteina Prima Ltd, Mabar Feed Indonesia Ltd. Meanwhile, Malindo Feedmill Ltd, Sinta Prima Feedmill Ltd, Universal Agri Bisnisindo Ltd, and Cargill Feed and Nutrition Ltd (Figure 7). Feed was transported by truck; the distance from the location of the animal feed company to Lake Maninjau is 650 km. The quality of feed by fish farmers is 60% of the best quality, 30% of good quality, while 10% of the grade is relatively poor. In Lake Kariba in Zambia, the feed supply by two companies ranges between 50 and 100 tonnes per day [19]. In contrast, Aura et al. [13] state that cage farmers obtained feeds from nine companies in Lake Victoria, Kenya.

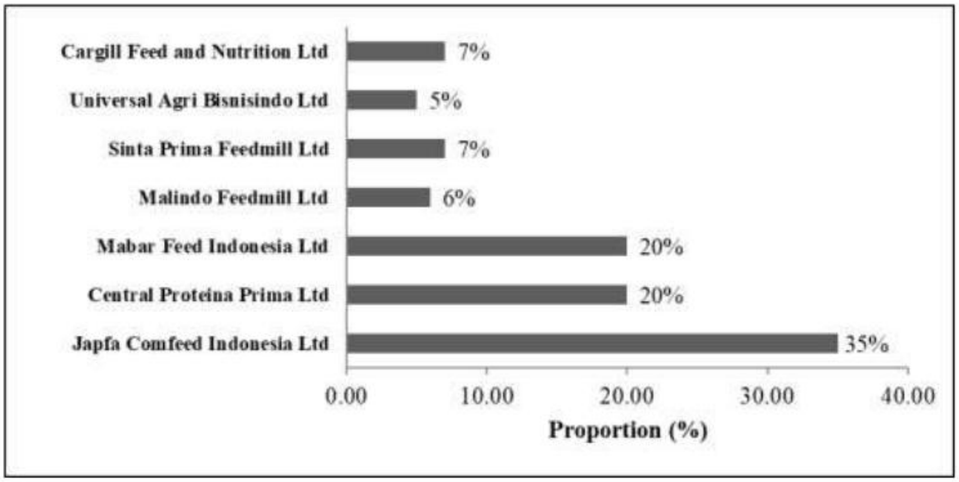

Figure 7. Fish feed supplied by each company to Lake Maninjau

3.4 Harvested fish

Based on the records of fish farmers, tilapia fish and gourami were given commercial feed every day at 09.00 and 10.00 and 16.00 and 18.00. The amount of feed given ranged between 3% and 5% of body mass. Meanwhile, Clarias and Pangasius catfish were not fed commercial feed but were given dead tilapia from the surrounding cage culture. The tilapia and common carp were reared in floating net cages for each production cycle average of 120 days, whereas giant gourami for 170 days. Conversely, Clarias catfish and pangasius were raised for 60 and 75 days. Harvested weight tilapia fish and Giant gourami average are 200 and 300 g/fish, and the gross yield of tilapia fish was 12 kg/m^3/cycle and giant gourami 10.4 kg/m^3/cycle. Feed conversion ratio (FCR) tilapia fish was 1.68, and giant gourami was 1.65, respectively. While harvested weight, Clarias catfish was 125 g/fish, and Pangasius catfish was 150 g/fish. The gross yield of Clarias catfish and pangasius ranged from 7.88 and 8.89 kg/m^3/cycle, respectively. We did not record the FCR for Clarias and pangasius catfish because these fish are not fed commercially by fish farmers.

3.5 Significant challenges in the aquaculture

First challenges

In this study, we found several challenges in the development of tilapia aquaculture in Lake Maninjau. Most fish farmers face the challenge of mass mortality of fry in the early period of their cultivation activities; due to poor water quality. In recent years, the water quality of Lake Maninjau has been heavily polluted, with a hypereutrophic status [22]. According to [23], cyanobacteria dominate eutrophic lakes, and Cyanobacteria produce Cyanotoxin [24]. [25] reported that fish mass mortality was associated with toxins from cyanobacteria. Meanwhile, the main challenge for tilapia cultivation worldwide is the disease from *Streptococcus agalactiae*, which causes huge losses for tilapia farmers [26]. In comparison, [28] stated that Tilapia Lake Virus (TiLV) was found together with well-known pathogenic bacteria such as Aeromonas spp, which negatively impacted the survival of Tilapia fish. Whether TiLV lives in Lake Maninjau and negatively affects the survival rate of tilapia was not examined in this study. However, the infection of TiLV can decrease tilapia production and can cause a serious socio-economic impact [28]; [29]; [30]; [31]; [32].

Second challenges

The price of commercial feed pellets (IDR 12,000/kg) is also the second challenge for tilapia aquaculture in Lake Maninjau; because the selling price of fish is not proportional to the cost of feed. Tilapia is a target species with local market prices (IDR 19,000/kg) and higher production levels (about 85% of total production). In addition, the price of common carp was IDR 22,000 /kg, giant gourami was IDR 40,000/kg, Clarias catfish was IDR 15,000/kg, and Pangasius catfish was IDR 14,000/kg. The feed cost contributes approximately 60% of the operating expenses in the aquaculture system in Lake Maninjau. Furthermore, most of them have experienced challenges in estimating the right amount of feed to fish, so the FCR values varied between 1.6 and 1.8. Similar to the finding of [33] and [20], who states that the feed was the most significant input of the operating costs in an intensive aquaculture system, so the optimum feeding without waste will determine the system's economic viability. Therefore, feeding fish according to their needs can improve productivity, helps to reduce feed loss, and maintain a suitable aquaculture environment [34]. At the same time, some critical challenges in fish farming activities are theft and predators such as birds and crocodiles [19]. However, this study found that the are theft and predator above did not become a challenge for fish farmers in Lake Maninjau. Due to the farmers running their fish farming activity around their residence.

Third challenges

Based on Agam Regency Government Regulation Number 5 of 2014 concerning Management of Maninjau Lake. The number of floating net cages allowed for cultivation activities based on the carrying capacity of cultivation is 6,000 nets. In this study, fish farmers have not implemented the above government regulations. Most aquaculture producers (58.34%) stated that the law prevented them from increasing their production and reducing their income. Meanwhile, few agricultural activities can be carried out on lakes due to the narrow, hilly, and rocky land areas [16]. However, David et al. [35] state that water bodies must be used rationally based on the ecological carrying capacity to sustain aquaculture production. For example, in Lake Victoria, Kariba, Malawi, and Taihu, fish farmers have been complied with the best regulations to promote sustainable aquaculture [36]; [37]; [38]. In addition, government regulations have been applied along the Norwegian coast to determine salmon cages' spatial distribution, such as the size and structure of cage ownership [39].

Furthermore, the continued water damage was the third challenge of the fish farmers to increase fish production. Other researchers found that the lake damage was caused by nitrogen and phosphorus components in the water bodies [35]; [40]. According to [41], the availability of nitrogen, phosphorous and total organic matter in the water bodies was significantly higher after fish mass mortalities and harmed the water quality of Lake Maninjau. Then, releasing nutrients from cage aquaculture activity on the aquatic environment affects water quality and conflicts with multiple users. But also exert a negative feedback effect in the cage operations themselves [35]; [40]; [42]; [43].

Table 3 shows that the poor water quality, fish mass mortality, and uncertainty of operational aquaculture law were the main factors challenges in fish aquaculture activities in Lake Maninjau. On the other hand, the biophysical variables such as disease, pollution, and lack of appropriate environment do not make it challenging for caged fish farmers in Lake Maninjau. In some countries, political, social factors and local community participation are dominant challenges for aquaculture development [3]; [44]; [45]; [46].

Table 3. Factors affecting prospect for expanded aquaculture production in Lake Maninjau

Constraints	Proportion (%)
Fish mass mortality	87.50
High cost of feeds	83.33
Low the fish sale price	72.61
Poor water quality	95.83
Government regulatory not supporting	41.66
Legal uncertainty/absence of aquaculture law	85.33
Payment for the sale of fish is not cash	70.66

Conclusions

The fish farming of floating net cages at Lake Maninjau has represented a significant proportion of aquaculture production for decades and is an economic investment in the region. However, floating net cage fish farming activities in Lake Maninjau have not yet adopted the "sustainability" concept; because they have not cultured fish based on the carrying capacity of cultivation. At the same time, its negative environmental impact, mainly water quality, is getting worse significantly. Most fish farmers produce tilapia, which cannot tolerate poor water quality resulting in mass deaths during the production cycle.

Based on GIS mapping, most of the cages (n = 45, 56.26%) were located at a distance of 300 m from the shoreline and a depth of less than 50 m. Some of this area (<100 m) is being designated as "Rasau Rindu Wisata," which serves as a fish breeding zone. In addition, all cage aquaculture operators for tilapia, common carp, and giant gourami use commercial feed. However, the resulting FCR ranged from 1.65 to 1.68, so the feed efficiency was very low, ranging between 59% and 60%. In contrast, the waste load released into lake water bodies ranges between 40% and 41%.On the other hand, challenges faced by fish farmers are heavily polluted water, mass mortality of tilapia, high feed costs, low selling prices of fish, and unpaid fish sales, including legal uncertainty/absence of floating cages aquaculture regulations environmental friendly.

Furthermore, considering the challenges above, we recommend that the cultured species resist poor water quality, like giant gourami. This species has a high market price and is a herbivorous fish that can eat various plants such as sente leaves (*Alocasia macrorrhiza*) and other young plants and can substitution partially commercial feeds. Furthermore, we also recommend that the government of Agam Regency make regulations regarding environmentally friendly floating net cage fish farming by allocating certain zones for tourism and not placing cages in the weir zone of Hydroelectric Power Plants. This policy allows optimal Lake Maninjau for various activities such as floating cage operations, tourism, water use for Hydroelectric Power Plants, and other sustainable aquaculture activities.

Declaration of Competing Interest

The authors have no conflict of interest.

Acknowledgments

The authors thank the Ministry of Finance, the Republic of Indonesia, for supporting this study through the competitive grants scheme Productive Innovative Research (Policy/Governance) 2019 with the contract number: PRJ-99/LPDP/2019. The appreciation goes to all of the students, fish farmers, and partners who helped the author during data collection in the field.

References

1. FAO. (2018) The state of world fisheries and aquaculture 2018: contributing to food security and nutrition for all, Rome.
2. Tran N, UP Rodriguez, CY Chan, et al. (2017) Indonesian aquaculture futures: An analysis of fish supply and demand in Indonesia to 2030 and role of aquaculture using the Asia Fish model. Mar. Policy, 79: 25-32. https://doi.org/10.1016/j.jclepro.2017.06.133
3. Senff P, S Partelow, L F Indriana, et al. (2018) Improving pond aquaculture production on Lombok, Indonesia. Aquaculture, 497: 64-73. https://doi.org/10.1016/j.aquaculture.2018.07.027
4. Pouil S, R Samsudin, J Slembrouck, et al. (2019) Nutrient budgets in a small-scale freshwater fish pond system in Indonesia. Aquaculture, 504: 267-274. https://doi.org/10.1016/j.aquaculture.2019.01.067
5. CDSI, Central Data Statistic Indonesia. (2016) Ministry of Marine and Fisheries Republic of Indonesia. CSI. *Center for data, statistics and information (CSI)*. Marine and Fisheries in Figures. Ministry of Marine and Fisheries Republic of Indonesia. 2018. https://kkp.go.id/wp-content/uploads/2018/01/KKP-Dirjen-PDSPKP-FMB-Kominfo-19-Januari-2018.pdf
6. Syandri H, Azrita, Junaidi, et al. (2015) Social Status of the fish-farmers of floating-net-cages in Lake Maninjau, Indonesia. J. Aquac. Res. Dev, 7:1. DOI: 10.4172/2155-9546.1000391
7. Rimmer MA, Sugama, K Rakhmawati, et al. (2013) A review and SWOT analysis of aquaculture development in Indonesia. Rev. Aquac. 5, 255–279.

https://eiado.aciar.gov.au/sites/default/files/RimmerEtAl%282013%29ReviewSWOTAquaculture DevelopmentIndo.pdf

8. Henriksson PJGN, Tran, CV Mohan, et al. (2017) Indonesian aquaculture futures evaluating environmental and socio-economic potentials and limitations. J. Clean. Prod, 162:1482-1490. https://doi.org/10.1016/j.jclepro.2017.06.133
9. Syandri H, Azrita, A Mardiah, et al. (2018) Nitrogen and phosphorus waste production from different fish species cultured at floating net cages in Lake Maninjau, Indonesia. Asian J. Sci. Res, 11 (2): 287-294. DOI: 10.3923/ajsr.2018.287.294
10. Syandri H, Azrita, Sumiarsih, E, et al. (2021) Nutrient loading and farm characteristics of giant gourami fish aquaculture systems in Lake Maninjau, Indonesia: Basic knowledge of production performance. F1000Research, 10:378. https://f1000research.com/articles/10-378/v2
11. Syandri H, Azrita and Niagara, et al. (2016) Trophic Status and load capacity of water pollution waste fish culture with floating net cages in Maninjau Lake, Indonesia. Eco. Env. & Cons. 22 (1): 469-476. http://www.envirobiotechjournals.com/article_abstract.php?aid=6717&iid=207&jid=3
12. Ahmed N, Thompson S. (2019) The blue dimensions of aquaculture: A global synthesis. Sci. Total Environ; 652: 851-861. doi:10.1016/j.scitotenv.2018.10.163
13. Aura CM, Musa S, Yongo E, et al. (2017) Integration of mapping and socio-economic status of cage culture: Toward balancing lake-use and culture fisheries in Lake Victoria Kenya. Aquac. Res; 49 (1): 532-545. https://doi.org/10.1111/are.13484
14. CSA, Central Statistics Agency. (2018) Agam District, West Sumatera Province, Indonesia. https://agamkab.bps.go.id/
15. Syandri H, Junaidi, Azrita, Yunus.T, 2014. State of aquatic resources Maninjau Lake West Sumatra Province, Indonesia. Journal of Ecology and Environmental Sciences, 1 (5): 109-114.
16. Central Bureau of Statistics (CBS) of Agam Regency. (2017). Agam Regency in Figures 2017.
17. Opiyo MA, Marijani, E Muendo, et al. (2018) A review of aquaculture production and health management practices of farmed fish in Kenya. Int. J. Vet. Sci. Med. 6, 141–148. https://doi.org/10.1016/j.ijvsm.2018.07.001
18. Mbowa S, Odokonyero, T Munyaho AT, et al. (2017) Harnessing floating cage technology to increase fish production in Uganda, Research Series No. 138.
19. Hasimuna OJ, S Maulu, C Monde, et al. (2019) Cage aquaculture production in Zambia: Assessment of opportunities and challenges on Lake Kariba, Siavonga district. Egypt. J. Aquat. Res, 45: 281-285. https://doi.org/10.1016/j.ejar.2019.06.007
20. Thongprajukaew K, S Kovitvadhi, U Kovitvadhi, et al. (2017) Effects of feeding frequency on growth performance and digestive enzyme activity of sex-reversed Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758). Agric. Nat. Resources, 51(4): 292-298. https://doi.org/10.1016/j.anres.2017.04.005

21. Prem R and VK Tewari (2020) Development of human-powered fish feeding machine for freshwater aquaculture farms of developing countries. Aquac Eng, 88:102028. https://doi.org/10.1016/j.aquaeng.2019.102028
22. Syandri H, Azrita, A Mardiah, et al. (2020) Water Quality Status and Pollution Waste Load from Floating Net Cages at Maninjau Lake, West Sumatera Indonesia. IOP Conf. Ser. Earth Environ. Sci., 430(1), 01203
23. Ji B, H Qin, S Guo, et al. (2018) Bacterial communities of four adjacent fresh lakes at different trophic status. Ecotoxicol. Environ. Saf, 157:388-394. https://doi.org/10.1016/j.ecoenv.2018.03.086
24. Burgos MJG, J L Romero, R P Pulido, et al. (2018) Analysis of potential risks from the bacterial communities associated with air-contact surfaces from tilapia (*Oreochromis niloticus*) fish farming. Environ. Res. 160: 385-390. https://doi.org/10.1016/j.envres.2017.10.021
25. Zhao, M S Xie, X Zhu, et al. (2006) Effect of dietary cyanobacteria on growth and accumulation of microcystins in Nile tilapia (*Oreochromis niloticus*). Aquaculture 261: 960 – 966. https://doi.org/10.1016/j.aquaculture.2006.08.019
26. de Oliveira TF, GA Queiroz, JP Teixeira, et al. (2018) Recurrent *Streptococcus agalactiae* infection in Nile tilapia (*Oreochromis niloticus*) treated with florfenicol. Aquaculture 493: 51-60. https://doi.org/10.1016/j.aquaculture.2018.04.037
27. Nicholson P, N Mon-on, P Jaemwimol, et al. (2019) Co-infection of tilapia lake virus and *Aeromonas hydrophila* synergistically increased mortality and worsened the disease severity in tilapia (*Oreochromis* spp.). Aquaculture 520: 734746. https://doi.org/10.1016/j.aquaculture.2019.734746
28. Hounmanou YMG, RH Mdegela, TV Dougnon, et al. (2018) Tilapia lake virus threatens tilapiines farming and food security: Socio-economic challenges and preventive measures in Sub- Saharan Africa. Aquaculture 493: 123-129. https://doi.org/10.1016/j.aquaculture.2018.05.001
29. Ferguson HW, R Kabuusu, S Beltran, et al. (2014) Syncytial hepatitis of farmed tilapia, *Oreochromis niloticus* (L.): a case report. J. Fish Dis. 37, 583–589. https://doi.org/10.1111/jfd.12142
30. Tsofack KJE, Zamostiano, R Watted, et al. (2017) Detection of Tilapia Lake Virus in Clinical Samples by Culturing and Nested Reverse Transcription-PCR. J. Clin. Microbiol. 55, 759–767. https://doi.org/10.1128/JCM.01808-16
31. Amal MNA, CB Koh, M Nurliyana, et al. (2018) A case of natural co-infection of Tilapia Lake Virus and *Aeromonas veronii* in a Malaysian red hybrid tilapia (*Oreochromis niloticus* × *O. mossambicus*) farm experiencing high mortality. Aquaculture, 485: 12-16. https://doi.org/10.1016/j.aquaculture.2017.11.019
32. Mugimba KK, Chengula, AA Wamala, et al. (2018) Detection of tilapia lake virus (TiLV) infection by PCR in farmed and wild Nile tilapia (*Oreochromis niloticus*) from Lake Victoria. J. Fish Dis.. https://doi.org/10.1111/jfd.12790

33. Ali H, MM Rahman, K Murshed-e-Jaha, et al. (2018) Production economics of striped catfish (*Pangasianodon hypophthalmus*, Sauvage, 1878) farming under polyculture system in Bangladesh. Aquaculture 491: 281-390. https://doi.org/10.1016/j.aquaculture.2017.12.004
34. Verdegem MCJ, Bosma RH (2009) Water withdrawal for brackish and inland aquaculture and options to produce more fish in ponds with present water use. Water Policy 11, 52–68 Supplement 1.
35. David GS, ED Carvalho, D Lemos, et al. (2015) Ecological carrying capacity for intensive Tilapia (*Oreochromis niloticus*) cage aquaculture in a large hydroelectrical reservoir in Southeastern Brazil. Aquac Eng, 66:30-40. https://doi.org/10.1016/j.aquaeng.2015.02.003
36. Musinguzi L J, Lugya, P Rwezawula, et al. (2019) The extent of cage aquaculture, adherence to best practices and reflections for sustainable aquaculture on African inland waters. J. Great Lakes Res. 45(6): 1340-1347. https://doi.org/10.1016/j.jglr.2019.09.011
37. Jamu D, M Banda, F Njaya, et al. (2011) Challenges to sustainable management of the lakes of Malawi. J. Great Lakes Res. 37: 3-14. https://doi.org/10.1016/j.jglr.2010.11.017
38. Jia P, W Zhang, Q Liu, et al. (2013) Lake fisheries in China: Challenges and opportunities. Fish. Res., 140: 66-72. https://doi.org/10.1016/j.fishres.2012.12.007
39. Asche F, KH Roll, R Tveteras, et al. (2009) Economic inefficiency and environmental impact: An application to aquaculture production. J Environ Econ Manage. 58:93-105. https://doi.org/10.1016/j.jeem.2008.10.003
40. Lindim C, A Becker, B Grüneberg, et al. (2015) Modelling the effects of nutrient loads reduction and testing the N and P control paradigm in a German shallow lake. Aquac Eng, 82:418-457. https://doi.org/10.1016/j.ecoleng.2015.05.009
41. Syandri H, Azrita, Junaidi, et al. (2017) Levels of available nitrogen-phosphorus before and after fish mass mortality in Maninjau Lake of Indonesia. J. Fish. Aquat. Sci., 12 (4): 191-196. DOI: 10.3923/jfas.2017.191.196
42. Du H, Z Chen, G Mao, et al. (2019) Evaluation of eutrophication in freshwater lakes: A new non-equilibrium statistical approach. Ecol. Indic., 102:686-692. https://doi.org/10.1016/j.ecolind.2019.03.032
43. Ni Z, X Wu, L Li, et al. (2017) Pollution control and in situ bioremediation for lake aquaculture using an ecological dam. J. Clean. Prod., 172: 2256-2265. https://doi.org/10.1016/j.jclepro.2017.11.185
44. Young N, C Brattland, Digiovanni, et al. (2019) Limitations to growth: Social-ecological challenges to aquaculture development in five wealthy nations. Mar. Policy, 104:216-224. https://doi.org/10.1016/j.marpol.2019.02.022
45. Holden JS, B Collicutt, G Covernton, et al. (2019) Synergies on the coast: Challenges facing shellfish aquaculture development on the central and north coast of British Columbia. Mar. Policy, 101:108-117. https://doi.org/10.1016/j.marpol.2019.01.001.
46. Weitzman J, (2019) Applying the ecosystem services concept to aquaculture: A review of approaches, definitions, and uses. Ecosyst. Serv., 35:194-206. https://doi.org/10.1016/j.ecoser.2018.12.009.

Floating net cage aquaculture production in Indonesia

ORIGINALITY REPORT

18%	14%	9%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	1073zb3xfs20yv98x228do7r-wpengine.netdna-ssl.com Internet Source	<1 %
2	Armand Faganel, Roberto Biloslavo, Aleksander Janeš. "chapter 11 Towards an Innovative Ecotourism Business Model Framework", IGI Global, 2020 Publication	<1 %
3	Bosma, R.H.. "Sustainable aquaculture in ponds: Principles, practices and limits", Livestock Science, 201107 Publication	<1 %
4	Submitted to University of South Florida Student Paper	<1 %
5	Vanessa Queirós, Ulisses Miranda Azeiteiro, Sara Cristina Antunes. "Feeding inhibition tests as a tool for seston quality evaluation in lentic ecosystems: salinization impact", Annales de Limnologie - International Journal of Limnology, 2019 Publication	<1 %

6	Submitted to Xiamen University Student Paper		<1%
7	www.colinmayfield.com Internet Source		<1%
8	Submitted to Abilene Christian University Student Paper		<1%
9	C Bouvet de Maisonneuve, S Eisele, F Forni, Hamdi, E Park, M Phua, R Putra. "Bathymetric survey of lakes Maninjau and Diatas (West Sumatra), and lake Kerinci (Jambi)", Journal of Physics: Conference Series, 2019 Publication		<1%
10	Submitted to Kisii University Student Paper		<1%
11	content.sciendo.com Internet Source		<1%
12	Submitted to University of Sheffield Student Paper		<1%
13	ecologicalprocesses.springeropen.com Internet Source		<1%
14	www4.fisheries.go.th Internet Source		<1%
15	AsianCarp.us Internet Source		<1%

16	Submitted to University of New South Wales Student Paper	<1 %
17	pureadmin.qub.ac.uk Internet Source	<1 %
18	othes.univie.ac.at Internet Source	<1 %
19	Arie Dwi Alristina, Dewinta Hayudanti, Rizky Dzariyani Laili, Rossa Kurnia Ethasari. "Soaking time of lime solutions (Citrus aurantifolias) against the metal content reduction of cadmium in green shellfish (Perna viridis)", International Journal of Public Health Science (IJPHS), 2021 Publication	<1 %
20	Christophe Jaeger, Marc Roucaute, Sarah Nahon. "Effects of a lagoon on performances of a freshwater fishpond in a multi-trophic aquaculture system", Aquatic Living Resources, 2021 Publication	<1 %
21	Faiz Ahmad Ansari, Abhishek Guldhe, Sanjay Kumar Gupta, Ismail Rawat, Faizal Bux. "Improving the feasibility of aquaculture feed by using microalgae", Environmental Science and Pollution Research, 2021 Publication	<1 %
	aslopubs.onlinelibrary.wiley.com	

22	Internet Source	<1 %
23	www.1noclegi.pl Internet Source	<1 %
24	Submitted to Zambia Centre for Accountancy Studies Student Paper	<1 %
25	explora.unex.es Internet Source	<1 %
26	Namatovu Safina, Atukunda Gertrude, Obeti Lawrance, Walozi Ronald et al. "Profitability and Viability Analysis of Aquaculture Production in Central Uganda: A Case of Urban and Peri-Urban Areas", Asian Journal of Agricultural Extension, Economics & Sociology, 2018 Publication	<1 %
27	Submitted to Universiti Sains Malaysia Student Paper	<1 %
28	journals.plos.org Internet Source	<1 %
29	umanitoba.ca Internet Source	<1 %
30	www.ijsrd.com Internet Source	<1 %

31	Iwan Chandra Binsar Hamonangan Simanjuntak, Fuad Muhammad. "Carrying Capacity of Kedungombo Reservoir for Net Cage Culture", E3S Web of Conferences, 2018 Publication	<1%
32	ier.uek.krakow.pl Internet Source	<1%
33	www.pnas.org Internet Source	<1%
34	www.revistacomunicar.com Internet Source	<1%
35	D A Taskov, T C Telfer, D A Bengtson, M A Rice, D C Little, F J Murray. "Managing aquaculture in multi-use freshwater bodies: the case of Jatiluhur reservoir", Environmental Research Letters, 2021 Publication	<1%
36	Submitted to Udayana University Student Paper	<1%
37	ph02.tci-thaijo.org Internet Source	<1%
38	mdpi-res.com Internet Source	<1%
39	www.researchpublish.com Internet Source	<1%

40	Hatim Albasri, Jesmond Sammut. "A comparative study of sustainability profiles between small-scale mariculture, capture fisheries and tourism communities within the Anambas Archipelago Small Island MPA, Indonesia", Aquaculture, 2022 Publication	<1 %
41	www.cambridge.org Internet Source	<1 %
42	Darmawan, Nurjali, T Nugroho. "Fishing industry comprehensive health standard on fish market: The case of Muara Angke", IOP Conference Series: Earth and Environmental Science, 2019 Publication	<1 %
43	Yuto Takeuchi, Yusaku Akashi, Yoshihiko Kiyasu, Norihiko Terada et al. "Clinical Evaluation of a Combo Rapid Antigen Test QuickNavi-Flu+COVID19 Ag for Simultaneous Detection of SARS-CoV-2 and Influenza Viruses", Cold Spring Harbor Laboratory, 2021 Publication	<1 %
44	openaccess.nhh.no Internet Source	<1 %
45	Maskun, Aminuddin Ilmar, Marthen Napang, Naswar, Achmad, Hasbi Assidiq. "Legal analysis of lobster export policies in	<1 %

Indonesia: The principle of sustainable development approach", IOP Conference Series: Earth and Environmental Science, 2020
Publication

46	docplayer.net Internet Source	<1 %
47	fpk.unair.ac.id Internet Source	<1 %
48	B Budijono, I Suharman, A Hendrizal. "Dynamics Water Quality in Koto Panjang Reservoir, Indonesia", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1 %
49	Submitted to Glasgow Caledonian University Student Paper	<1 %
50	Muhammad Arif Salsabil, Astri Rinanti, Melati Ferianita Fachrul. "Analysis of water quality in Maninjau Lake, West Sumatera, Indonesia using phytoplankton", MATEC Web of Conferences, 2018 Publication	<1 %
51	Surya Hardi, R Andira, I Nisja, B Octrialdi, M Pinem. "Economic Design of Substation Grounding Grid using ETAP Software: A Case Study of 2 x 500 MVA Galang Substation", Journal of Physics: Conference Series, 2021 Publication	<1 %

52	openpublichealthjournal.com Internet Source	<1 %
53	agris.fao.org Internet Source	<1 %
54	repositorio.espe.edu.ec Internet Source	<1 %
55	researchdata.edu.au Internet Source	<1 %
56	www.elsevier.es Internet Source	<1 %
57	akjournals.com Internet Source	<1 %
58	ambi-agua.net Internet Source	<1 %
59	dro.deakin.edu.au Internet Source	<1 %
60	ifst.pericles-prod.literatumonline.com Internet Source	<1 %
61	journals.ashs.org Internet Source	<1 %
62	journals.humankinetics.com Internet Source	<1 %
63	pbsociety.org.pl Internet Source	<1 %

64	repository.seafdec.org Internet Source	<1%
65	text-id.123dok.com Internet Source	<1%
66	umu.diva-portal.org Internet Source	<1%
67	www.cesam.ua.pt Internet Source	<1%
68	www.valleyinternational.net Internet Source	<1%
69	Merrifield, D.L.. "Assessment of Chlorogloeopsis as a novel microbial dietary supplement for red tilapia (Oreochromis niloticus)", Aquaculture, 201002 Publication	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		