

## ANALYSIS OF PRODUCTIVITY PER UNIT OF VOLUME IN TILAPIA (*Oreochromis niloticus*) FARMING USING BIOFLOK TECHNOLOGY IN GARUT REGENCY

Analisis Produktivitas Per Satuan Volume Usaha Pembesaran Ikan Nila (*Oreochromis niloticus*) Berbasis Teknologi Bioflok di Kabupaten Garut

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### ABSTRACT

Bioflok technology is an intensive aquaculture innovation that can improve space utilization efficiency through water management, stocking density, and the use of microorganisms in the rearing medium. This study aims to analyze productivity per unit volume in tilapia (*Oreochromis niloticus*) grow-out operations using bioflok technology in Garut Regency. This study was conducted in four sub-districts: Pangatikan, Sukawening, Wanaraja, and Kersamanah. The method used was a survey employing a quantitative descriptive approach. Data were collected through interviews, observations, and documentation from 37 respondents representing a total of 81 bioflok pond units. Productivity per unit volume was calculated based on the ratio of total tilapia production to pond volume a single cultivation cycle. The results indicated that there were differences were influenced by variations in pond size, production volume, stocking density, seed quality, feed management, and water quality management. The highest productivity was found in Pangatikan Subdistrict at 21.7 kg/m<sup>3</sup>/cycle, while other subdistricts showed varying productivity values according to their respective technical aquaculture conditions. The findings of this study indicate that tilapia farming using bioflok technology in Garut Regency has good productivity potential because it can yield high production in limited pond volumes, however it still requires optimal technical management.

**Keywords:** Bioflok, Garut Regency, Pool Volume, Productivity, Tilapia.

### ABSTRAK

Teknologi bioflok merupakan salah satu inovasi budidaya intensif yang dapat meningkatkan efisiensi pemanfaatan ruang melalui pengelolaan air, kepadatan tebar, serta pemanfaatan mikroorganisme dalam media pemeliharaan. Penelitian ini bertujuan untuk menganalisis produktivitas per satuan volume pada usaha pembesaran ikan nila (*Oreochromis niloticus*) berbasis teknologi bioflok di Kabupaten Garut. Penelitian ini dilaksanakan di empat kecamatan, yaitu Pangatikan, Sukawening, Wanaraja, dan Kersamanah. Metode yang

digunakan adalah survei dengan pendekatan deskriptif kuantitatif. Data diperoleh melalui wawancara, observasi, dan dokumentasi terhadap 37 responden dengan total 81 unit kolam bioflok. Produktivitas per satuan volume dihitung berdasarkan perbandingan antara total produksi ikan nila dengan volume kolam dalam satu siklus pemeliharaan. Hasil penelitian menunjukkan bahwa terdapat perbedaan produktivitas per satuan volume antar lokasi penelitian. Perbedaan tersebut dipengaruhi oleh variasi ukuran kolam, jumlah produksi, padat tebar, kualitas benih, manajemen pakan, serta pengelolaan kualitas air. Produktivitas tertinggi terdapat di Kecamatan Pangatikan sebesar 21,7 kg/m<sup>3</sup>/siklus, sedangkan kecamatan lainnya menunjukkan nilai produktivitas yang bervariasi sesuai dengan kondisi teknis budidaya masing-masing. Kesimpulan dari penelitian ini menunjukkan bahwa usaha pembesaran ikan nila berbasis teknologi bioflok di Kabupaten Garut memiliki potensi produktivitas yang baik karena mampu menghasilkan produksi tinggi pada volume kolam yang terbatas, namun tetap memerlukan pengelolaan teknis yang optimal.

**Kata Kunci:** Bioflok, Ikan Nila, Kabupaten Garut, Produktivitas, Volume Kolam.

## INTRODUCTION

As an archipelagic nation, Indonesia possesses vast marine and fisheries resource potential, with a marine area of 5.8 million km<sup>2</sup> (Anugrah & Alfarizi, 2021). This potential needs to be optimally managed, particularly as capture fisheries production is projected to decline by 16.41% in the first quarter of 2025 compared to the same period in 2025. This situation demonstrates the strategic role of aquaculture as an alternative to increasing fish production for consumption and reducing pressure on fish stocks in the waters. As demand for fish increases in both domestic and global markets, aquaculture development needs to be directed toward commodities with high economic value and high consumption levels, one of which is tilapia (*Oreochromis niloticus*), which is widely consumed by the public and plays a crucial role in the aquaculture sector (Phillips *et al.*, 2016).

As a widely cultivated fish commodity for consumption, increased tilapia production requires support from a cultivation system that optimizes land use and production inputs. Efforts to increase aquaculture productivity can be achieved through extensification and intensification approaches. Extensification is carried out by expanding the business area, while intensification emphasizes optimal land utilization through the more efficient use of production inputs such as capital, labor, and technology (Hidayati *et al.*, 2018; Marinus *et al.*, 2023). The use of appropriate production factors is crucial because inefficient management can lead to wasted costs, reduced income, and result in suboptimal production (FAO, 2016; Wungkana *et al.*, 2022). One intensive technology that can be applied in tilapia cultivation is biofloc technology, a cultivation system that utilizes a collection of microorganisms such as bacteria, fungi, protozoa, algae, and other organisms that form flocs (Yusup *et al.*, 2025). Biofloc technology has advantages because it can be applied in limited land, saves water and feed use, is environmentally friendly, and has the potential to increase feed efficiency by utilizing flocs as a natural food source (Sudaryati *et al.*, 2017; Yadav *et al.*, 2025). Therefore, biofloc technology is a suitable alternative to support the development of tilapia cultivation in Garut Regency.

The application of biofloc technology to tilapia cultivation is supported by the characteristics of tilapia, which have high commercial prospects, economic value, and are a key freshwater fishery commodity in high demand (Saleh *et al.*, 2019). Tilapia has been designated as one of Indonesia's leading fishery export commodities, with national production reaching 1.35 million tons in 2023 (BPS, 2023). In addition to its high economic value, tilapia can optimally utilize feed to support growth and survival (Setiyowati *et al.*, 2017). Its

adaptability to less-than-ideal environmental conditions and ease of cultivation make tilapia a suitable commodity for development using biofloc technology (Sibagariang *et al.*, 2020).

Tilapia development based on biofloc technology has the potential to be implemented in Garut Regency due to its substantial aquaculture resources. According to data from the Garut Regency Fisheries and Livestock Service in 2023, the potential area for fisheries reached 158,544,300 m<sup>2</sup>, or approximately 5.71% of the total area of Garut Regency. In the same year, Garut Regency's aquaculture production was recorded at 65,279 tons with a productivity of 0.41 kg/m<sup>2</sup>/year, contributing approximately 0.44% to the national aquaculture production of 14,823,768 tons (BPS, 2023; Garut Fisheries and Livestock Service, 2023). These data indicate that Garut Regency has potential for aquaculture development, but productivity still needs to be increased through more efficient business management, one of which is through cultivation intensification with the application of biofloc technology.

Although biofloc technology offers numerous advantages in increasing land, water, and feed efficiency, its application still faces several technical challenges that can impact aquaculture productivity. According to Yusup *et al.* (2025), suboptimal biofloc application procedures, incorrect feed selection, and poor water quality management can lead to lower productivity. Furthermore, overfeeding can lead to the accumulation of organic matter from undegraded feed residues, increasing ammonia levels, degrading water quality, and causing fish stress and loss of appetite (Sukoco *et al.*, 2016). These problems also have the potential to occur in tilapia farming using biofloc technology in Garut Regency, which began developing in 2024 in the districts of Pangatikan, Sukawening, Kersamanah, and Wanaraja. These four districts have differences in the number of farmers, pond sizes, stocking densities, water quality, feed management, seed quality, and cultivation experience, which are assumed to cause productivity variations between farmers and between regions. The relatively recent development of biofloc technology in Garut Regency has limited studies on productivity levels and the factors influencing them. Therefore, this study is crucial to analyze the productivity of tilapia fish farming using biofloc technology in Garut Regency as a basis for evaluating land use efficiency, production, and the sustainability of the farming business.

## RESEARCH METHODS

This research was conducted in Garut Regency, which includes Pangatikan District, Sukawening District, Wanaraja District, and Kersamanah District in March-April 2026. The location selection was carried out in areas that have implemented biofloc technology in tilapia fish farming activities. The research method used was a survey with a quantitative descriptive approach. Respondents were determined using a census method or saturated sampling, namely all active biofloc tilapia fish farmers in the research location, with a total of 81 respondents and a total of 81 pond units. The tools used included questionnaires, stationery, mobile phones, and laptops. The data used were primary and secondary data, primary data was obtained through interviews, observation, and documentation, while secondary data was obtained from the Central Statistics Agency (BPS), the Ministry of Maritime Affairs and Fisheries (KKP), the Garut Regency Fisheries and Animal Husbandry Office, and regulations related to fisheries. The data collected included respondent identity, number of ponds, shape and size of ponds, pond volume, number of seeds, production amount, stocking density, maintenance period, feed, and water quality. Data analysis was conducted quantitatively and descriptively by calculating productivity per unit volume using the formula: total tilapia production divided by pond volume. Productivity was expressed in kg/m<sup>3</sup>/cycle. The results were then presented in tabular form and analyzed to compare productivity between sub-districts and between farmer groups.

## RESULT

### Characteristics of Biofloc Cultivation Units

The characteristics of the biofloc cultivation units at the research sites are presented in Table 1. This table lists the number of farmer groups, the number of ponds, and the range of pond volumes in each sub-district as basic information for calculating productivity per unit volume.

Table 1. Characteristics of Biofloc Cultivation Units

No	Subdistrict	Number of Pokdakan	Number of Pools (units)	Pool Volume (m <sup>3</sup> )
1.	Pangatikan	4	33	3,5-45
2.	Sukawening	8	24	3,5-43,9
3.	Kersamanah	3	17	3,5-36
4.	Wanaraja	1	7	7,8

Primary Data Analysis, 2026

### Productivity Level

The productivity levels per Pokdakan are presented in Table 2. This table contains data on pond volume, total production, and productivity per unit volume expressed in (kg/m<sup>3</sup>/cycle) for each Pokdakan based on the last harvest cycle.

Table 2. Productivity Levels per Pokdakan

No	Subdistrict	Number of Pokdakan	Volum (m <sup>3</sup> )	Production (kg)	Productivity (kg/m <sup>3</sup> /cycle)		
1.	Pangatikan	Ni'san Farm	185,7	4.116,8	21,7		
		RCS Farm	69,9	1.290	18,4		
		Berkah Bersama	13,8	220,2	15,9		
		Bumdes Mitra	13,8	220,8	16		
		Sejahtera					
2.	Sukawening	Ato Lauk Bioflok	87,4	1.817	21,2		
		Nurul Hikmah	27,6	620,75	22,5		
		Barokah Mekar Mandiri 1	23,3	516,25	22,1		
		Barokah Mekar Mandiri 2	13,8	261,25	20		
		Barokah Mekar Mandiri 3	27,6	582	21		
		Barokah Mekar Mandiri 4	43,9	660	15		
		Egar Tunggal	27,6	582	21		
		3.	Kersamanah	KWT Bionic	72	1.636,3	22,7
				Mina Cioray	27,6	545,3	19,7
Sukamerang Jaya	24,2			482	19,9		
4.	Wanaraja	Arinfish	54,4	1.111,25	20,43		

Primary Data Analysis, 2026

Comparison of productivity per unit volume between sub-districts is presented in Figure 1. This bar graph is used to illustrate the differences in average productivity values in Pangatikan, Sukawening, Kersamanah, and Wanaraja sub-districts.

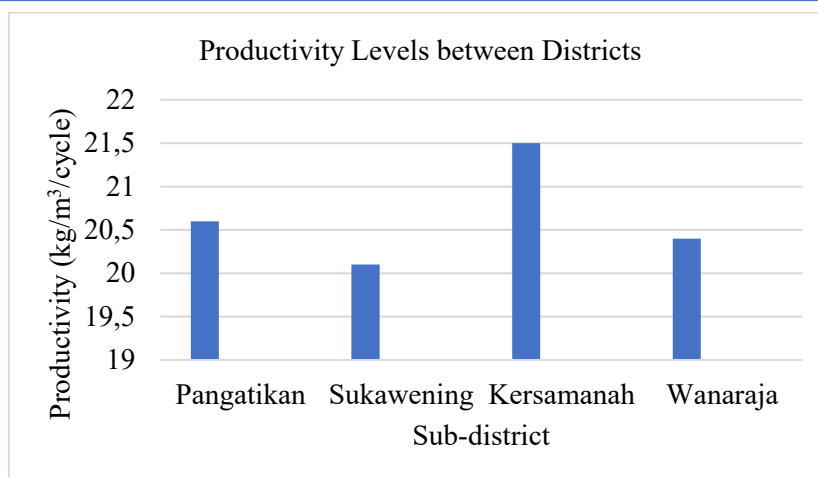


Figure 1. Productivity per Unit Volume between Districts in Garut Regency

### Factors Affecting Productivity

The results of the multiple linear regression analysis on productivity per unit volume are presented in Table 3. This table contains the coefficient values, standard errors, T-values, p-values, and VIFs for the variables seed quality, water quality, stocking density, feed efficiency, and length of experience.

Table 3. Results of Multiple Linear Regression Analysis on Productivity per Unit Volume

Term	Coef	SE Coef	T-Value	P-value	VIF
Constant	2,009	0,128	15,65	0,000	
X <sub>1</sub> Seed Quality	0,00885	0,00157	5,63	0,000	1,07
X <sub>2</sub> Water Quality	-0,01641	0,00402	-4,08	0,000	1,12
X <sub>3</sub> Stocking Density	0,011431	0,000419	27,30	0,000	1,43
X <sub>4</sub> Feed Efficiency	0,0035	0,0889	0,04	0,968	1,31
X <sub>5</sub> Length of Experience	0,00168	0,00116	1,45	0,151	1,03

Primary Data Analysis, 2026

## DISCUSSION

### Variation of Characteristics of Biofloc Cultivation Units

The characteristics of biofloc cultivation units in Table 1 show that tilapia rearing efforts using biofloc technology in Garut Regency are carried out by 16 farmer groups with a total of 81 ponds spread across the Pangatikan, Sukawening, Kersamanah, and Wanaraja Districts. Differences in the number of groups, the number of ponds, and pond volumes indicate that the application of biofloc technology at the research sites is carried out at various business scales. Pangatikan District has the largest number of ponds, namely 33 units with varying pond volumes ranging from 3.5 m<sup>3</sup>, 7.8 m<sup>3</sup>, 12.8 m<sup>3</sup>, and 45 m<sup>3</sup>, while Wanaraja District has the smallest number of ponds, namely 7 units with a uniform pond volume of 7.8 m<sup>3</sup>. Variation in pond volume is an important component because it is directly related to maintenance capacity, the number of seeds stocked, feed requirements, aeration requirements, and the resulting production potential. The majority of farmers at the research sites use ponds with a diameter of 3 or 7.8 m<sup>3</sup>, this is in line with the research of Saridu et al. (2023) that the use of a 3-diameter pond with a stocking density of 100 fish/m<sup>3</sup>, because it is considered a practical, economical, and suitable size for the application of group-scale biofloc. Thus, the characteristics of the cultivation units in this study indicate that biofloc technology can be applied to various pond

sizes, but the success of productivity still depends on the ability of the farmer in managing cultivation activities.

### **Comparison of Productivity Between Pokdakan and Sub-districts**

The productivity levels per fish farming group (Pokdakan) in Table 2 show variations in productivity across farmer groups. These differences indicate that productivity per unit volume is not only determined by pond size but also by the cultivation management practices within each Pokdakan. In Pangatikan District, the highest productivity was found in the Ni'san Farm Pokdakan at 21.7 kg/m<sup>3</sup>/cycle, while the lowest productivity was found in the Berkah Bersama Pokdakan at 15.9 kg/m<sup>3</sup>/cycle. These differences can be attributed to differences in business scale, production yield, seed quality, fish survival rate, and the farmers' technical experience in managing biofloc. In Sukawening District, the highest productivity was found in the Nurul Hikmah Pokdakan at 22.5 kg/m<sup>3</sup>/cycle, while the lowest value was found in the Barokah Mekar Mandiri 4 Pokdakan at 15 kg/m<sup>3</sup>/cycle. This indicates that a larger number of Pokdakan does not necessarily result in higher productivity if technical management across Pokdakan is not yet uniform. In Kersamanah District, the highest productivity was found in the KWT Bionic Fish Farming Group (Pokdakan KWT Bionic) at 22.7 kg/m<sup>3</sup>/cycle, while the lowest productivity was found in the Mina Cioray Fish Farming Group (Pokdakan Mina Cioray), which produced 19.7 kg/m<sup>3</sup>/cycle. In Wanaraja District, specifically the Arinfish Fish Farming Group (Pokdakan Arinfish), productivity was 20.43 kg/m<sup>3</sup>/cycle. These values indicate that the use of uniformly sized ponds can help farmers manage seed quantities, feed, and water quality more effectively. Therefore, the variation in productivity between fish farming groups in this study indicates that biofloc technology has the potential to increase production per unit volume, but its success is greatly influenced by the quality of technical management within each farmer group.

Figure 1 shows that productivity per unit volume between sub-districts ranges from 20.1 to 21.5 kg/m<sup>3</sup>/cycle. The highest productivity was found in Kersamanah District at 21.5 kg/m<sup>3</sup>/cycle, followed by Pangatikan District at 20.6 kg/m<sup>3</sup>/cycle, Wanaraja District at 20.4 kg/m<sup>3</sup>/cycle, and Sukawening District at 20.1 kg/m<sup>3</sup>/cycle. Differences in productivity values between districts were relatively small, but still indicated variations in yield due to differences in the number of ponds, pond size, production yield, seed quality, water quality, stocking density, feed efficiency, and husbandry management. The high productivity in Kersamanah District indicates that the pond volume used can produce high production if supported by good aquaculture management. Conversely, the lowest productivity in Sukawening District indicates that a large number of Pokdakan (Fishpond Farming Groups) and varying pond sizes do not necessarily result in the highest average productivity.

When compared to the earthen pond system, the research results of Pepayocha *et al.* (2022) showed that the productivity of tilapia harvested in earthen ponds was 19.52 kg/m<sup>2</sup>. This value is lower than the highest productivity in this study. This difference in productivity values indicates that biofloc technology has advantages in utilizing limited water volume and land due to the support of aeration management, stocking density, water quality, and the use of floc as supplementary feed.

Other research on saline tilapia cultivation using substrates also showed lower biomass values, ranging from 0.47 to 1.73 kg/m<sup>2</sup> (Campu *et al.*, 2020). Several conventional tilapia cultivation systems, such as extensive, semi-intensive, and intensive systems, have productivity values ranging from 0.03 to 15 kg/m<sup>2</sup>. This value is still lower than the highest productivity per unit volume in this study. This indicates that biofloc technology has the potential to be a more productive intensive cultivation system than conventional cultivation systems, especially if water quality, feed, stocking density, and aeration are optimally managed.

### **The Influence of Production Factors on Productivity**

The results of the multiple linear regression analysis in Table 3 show that seed quality, water quality, and stocking density significantly influence productivity per unit volume, while feed efficiency and length of cultivation experience do not. The seed quality variable has a positive coefficient of 0.0085 with a p-value of 0.000, indicating that improving seed quality tends to increase productivity per unit volume. This finding aligns with (Wijaya et al. 2025) who stated that healthy, active seeds from superior broodstock tend to have better growth and survival. These results also support the research of Ruhaimah et al. (2025) which showed that seed quality significantly influences the productivity of aquaculture businesses. In biofloc technology, seed quality is a crucial factor because fish are reared at high stocking densities, making unhealthy seeds more susceptible to stress and death.

The water quality variable has a negative coefficient of -0.01641 with a p-value of 0.000. Statistically, these results indicate that water quality significantly influences productivity per unit volume, but the direction of the effect is negative. The negative coefficient trend may occur because the relationship between water quality and productivity in the field is complex and influenced by other factors, such as differences in pond conditions, fish density, organic matter load, aeration requirements, and floc formation dynamics. Therefore, these results cannot be interpreted as implying that better water quality decreases productivity, but rather indicate that variations in water quality under the research conditions are related to pond technical conditions and maintenance management. Theoretically, water quality remains a crucial factor because it can affect fish metabolism, appetite, growth, feed conversion, and survival. This aligns with Widodo et al. (2023) who stated that water quality in the culture medium is a limiting factor for fish growth.

The stocking density variable has a positive coefficient of 0.011431 with a p-value of 0.000, indicating that stocking density significantly influences productivity per unit volume. These results indicate that increasing stocking density within the limits of the biofloc system's capabilities can increase fish production per unit pond volume. This finding aligns with the characteristics of biofloc technology, which allows fish to be reared at higher densities than conventional systems due to the support of aeration and the activity of microorganisms in processing nitrogenous waste. These results align with those of Rahmawati et al. (2026), who stated that stocking density significantly impacts tilapia cultivation productivity. However, increasing stocking density must be controlled, as excessively high stocking density without adequate aeration, feed, and water quality can reduce growth performance and increase the risk of stress in fish.

The feed efficiency variable had a p-value of 0.968, indicating no significant effect on productivity per unit volume. This is likely due to the relatively uniform Feed Conversion Ratio (FCR) values at the research sites, averaging 1.2, which is still better than the study by Budiayati et al. (2023), which found an FCR of 1.26-1.38 in tilapia cultivation. These results also align with those of Rahmawati et al. (2026), who stated that feed dosage had no significant effect on the dependent variable. Although not statistically significant, feed remains an important factor because it is directly related to fish growth, production costs, and water quality. The variable of length of experience also had no significant effect on productivity per unit volume, with a p-value of 0.151. These results align with those of Ruhaimah et al. (2025), who found that length of experience had no significant effect on productivity. This may be because most farmers at the research site were relatively new to biofloc technology, so differences in experience were not significant in explaining productivity variations. Based on the regression results, the main factors determining productivity per unit volume were seed quality, water quality, and stocking density.

## CONCLUSION

Based on the results of the analysis of productivity per unit volume of tilapia (*Oreochromis niloticus*) rearing business using biofloc technology in Pangatikan, Sukawening, Kersamanah, and Wanaraja Districts, Garut Regency, the level of productivity per unit volume shows different results in each region. The highest productivity value is in Kersamanah District at 21.5 kg/m<sup>3</sup>/cycle, followed by Pangatikan District at 20.6 kg/m<sup>3</sup>/cycle, Wanaraja District at 20.4 kg/m<sup>3</sup>/cycle, and Sukawening District at 20.1 kg/m<sup>3</sup>/cycle. These results indicate that Kersamanah District has the highest production capacity for the volume of ponds used. Production factors consisting of seed quality, water quality, stocking density together have a significant effect, while feed efficiency and length of experience together do not have a significant effect on productivity per unit volume. Seed quality and stocking density have a positive effect, while water quality shows a negative effect in the regression model. These results indicate that the productivity of tilapia fish farming efforts using biofloc technology at the research location is more influenced by the main technical aspects, especially seed quality, water quality control, and stocking density settings.

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