

Analysis of carrying capacity of ponds in Tayu District, Pati Regency, Central Java, for a saline tilapia (*Oreochromis niloticus*) strain, using the phosphorous budget model

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Abstract. Tilapia is the leading fish culture in Pati Regency. Tilapia cultivation area reaches 582 ha, with a productivity of 1-2 tons/ha/cycle. The Department of Maritime Affairs and Fisheries of Pati Regency targets the achievement of production in 2025 of ± 5 tons/ha/production cycle. This research was conducted to assess the carrying capacity of cultivated ponds so that the planned production target can be achieved, while still paying attention to environmental sustainability. Observations were made on 9 aquaculture ponds in 3 villages in Tayu District, Pati Regency. Observations were made for 1 production cycle, ranging from 90 to 110 days. The data collected included land area, production, phosphorus concentration in water, feed and sediment, amount of feed, and volume of water turnover. The results showed that of the 9 ponds observed, only 2 ponds matched the carrying capacity, while the rest had exceeded the carrying capacity. The achievement of the production target of 5 tons/ha/retention cycle is carried out by improving water quality management, so that salinity and dissolved oxygen meet the requirements for tilapia cultivation, by reducing the P load from aquaculture activities, and by improving feeding management, so that feed utilization is more efficient and increases the rate of production of tilapia flushing by increasing the volume of water change.

Key Words: environmental sustainability, feed, fish production, semi-intensive, traditional plus.

Introduction. Fish production needs to continue to increase, along with the increase in the population of Indonesia, as fish is the main source of protein for many people in Indonesia. Tilapia (*Oreochromis niloticus*) is a euryhaline fish (Ridha 2008) that can grow rapidly in a culture environment, easy to breed, easy to cultivate, and adaptive to changing environmental conditions (Prahasta & Masturi 2009; Melo et al 2013). Tilapia has a protein content of 13-36% (Murthy & Rajanna 2011; Kurniasih & Rosmawati 2013; Jim et al 2017). Due to this, tilapia is one of the leading aquaculture fish in Indonesia (KKP 2015), including in Pati Regency, Central Java Province (Nurchayati 2021).

The area of tilapia cultivation in Pati Regency reaches 582 ha (DKP Pati 2019), with an average production of 1–2 tons/maintenance cycle. The cultivation patterns applied in the area consist of a traditional plus pattern with a density of 20000–30000 fingerlings per ha, and a semi-intensive pattern with a density of 40000–50000 fingerlings per ha. Both patterns utilize water pumps to fill the ponds with water, with a water change volume of 2.4% per day in the traditional plus pattern and 24.4% in the semi-intensive pattern. Both patterns use commercial fish feed, with feed conversion values of 0.5-1 in the traditional plus pattern and 1-1.5 in the semi-intensive pattern. To increase the concentration of oxygen in the culture medium in a semi-intensive pattern, a waterwheel is usually used (Nurchayati 2021).

Pond productivity in traditional cultivation patterns ranges from 1000–2000 kg/Ha/cycle; and 3000–7000 kg/ha/cycle are obtained in the semi-intensive cultivation

patterns (Adiwijaya et al 2003; DKP Pati 2019). The low productivity of fish farming land is caused by the high mortality rate, both due to unfavorable environmental quality and disease attacks (Nurchayati 2021). However, DKP Pati Regency targets the average production achievement in 2025 of ± 5 tons/maintenance cycle (DKP Pati 2019). This study was conducted to examine the carrying capacity of fish ponds in Pati Regency so that the planned production targets can be achieved, while still paying attention to environmental sustainability including aquatic ecosystems (O'Doherty Jensen et al 2011).

Carrying capacity is defined as the ability of the land to sustainably support a certain amount of production (Beveridge 1996; Davies & McLeod 2003; UNEP 2011; Byron et al 2011). Analysis of land carrying capacity is very important in the development of aquaculture (Ross et al 2013). In aquaculture, in addition to the ability to support production (production carrying capacity), it is also known as physical, ecological, and social carrying capacity (Inglis et al 2000; McKindsey et al 2006). Physical carrying capacity is related to the suitability of the land to produce certain products. The carrying capacity of production is related to the optimal production that can be produced by the land. Ecological carrying capacity is related to the ability of the land to produce products sustainably. Social carrying capacity is related to the possible social impact of aquaculture activities.

Several methods can be used to analyze the carrying capacity of the environment for aquaculture activities (Beveridge 1996; Pulatsu 2003; Jiang & Gibbs 2005; McKindsey et al 2006; Byron et al 2011). The phosphorus budget model is one of the methods used to analyze the carrying capacity of a lake or pond for fish farming activities (Beveridge 1996; Pulatsu 2003; Mhlanga et al 2013). Phosphorus is an essential element needed by all fish, for bone growth and normal growth (Sakamoto & Yone 1980; Takeuchi & Nakazoe 1981). Phosphorus can be a limiting factor for lake productivity and can be used to determine aquatic biomass production (Dillon & Rigler 1974, 1975; Beveridge 1984; Boyd 1990).

Material and Method. The research material consisted of cultivated tilapia (*O. niloticus*), artificial feed used as well as culture media and fish pond sediment. Samples were collected from each rearing pond with a traditional plus (TP) pattern (4 units of ponds) and semi-intensive (SI, 5 units of ponds). The TP ponds studied were located in the villages of Sambiroto (3 units) and Tunggulsari (1 unit), Tayu Subdistrict, Pati Regency. The SI ponds studied are located in the villages of Jepat Lor (3 units) and Tunggulsari (2 units), Tayu Subdistrict, Pati Regency. The sampling locations are presented in Figure 1. The study was conducted from July to October 2020.

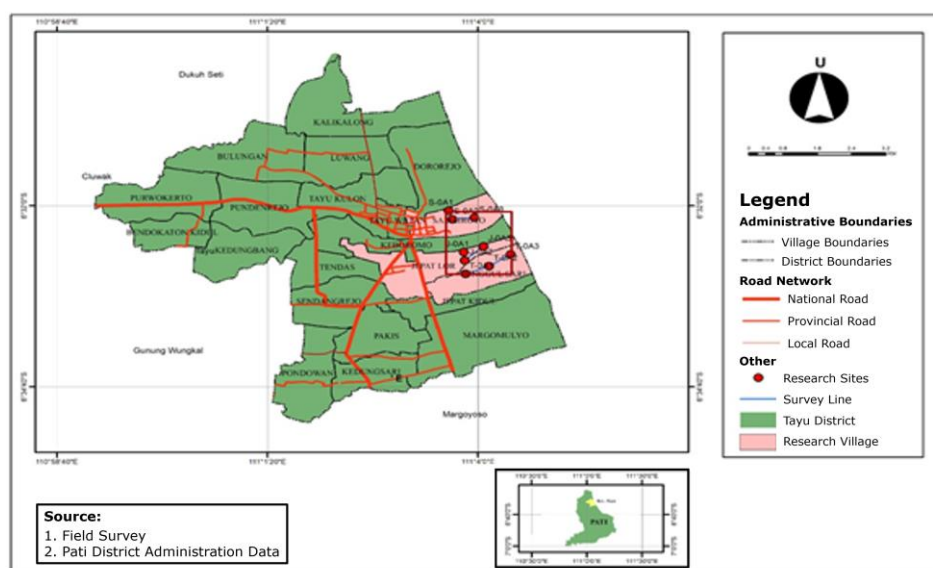


Figure 1. Research sampling locations.

The variables measured were the total phosphorus concentration in fish meat, feed and culture media water (in the form of phosphate), and fish pond bottom sediment. Analysis of the phosphorus concentration in the feed was carried out on all types of feed used: starter, grower, and finisher in each of the studied pond plots.

A sampling of fish meat for analysis of phosphorus concentrations in fish meat was carried out at the time the fish was harvested from each pond studied. In each pond, 3 fish samples were taken. A sampling of water for analysis of phosphorus concentration in water in the form of orthophosphate was carried out every week for 1 production cycle (90-110 days). Water samples were collected from each pond. Using a Kemmerer Water Sampler, 1 L was collected per sample. The samples were transferred to a PE cleaned sample container. The sample container was tightly sealed, stored in a cooling box, and transported to the laboratory, where it was kept in a cool place until the analyses.

Analysis of phosphorus concentration in fish feed and fish meat was carried out by wet digestion method (Zachariadis et al 1995) using sulfuric acid (H₂SO₄). 5 g of feed and fish meat samples were used. Sediment sampling for analysis of total phosphorus concentration was carried out once a week. Sediment samples collected from the bottom of tilapia ponds had 1 kg, and were collected using a sediment-corer. The samples were transferred into LDPE plastic bags and then stored in a cooling box. Once in the laboratory. Preliminary treatments of sediment samples refer to Nitric Acid-Hydrochloric Acid Digestion (APHA, AWWA and WPCF 1989). Analysis of phosphorus concentrations in feed, fish meat, water, and pond sediments was carried out by a Shimadzu-Atomic Absorption Spectrophotometer (AAS)-6200 (APHA 1998).

The phosphorus concentration measured in the research material was then used to assess the carrying capacity of the land using the Phosphorus Budget Model (Beveridge 1996; Pulatsu 2003; Mhlanga et al 2013), with the following stages:

1. Determining the total phosphorus concentration in a steady state based on measurements made during 1 cycle of cultivation activities.
2. The capacity of the pond for aquaculture is determined based on the difference between the productivity of the pond before and after being used for aquaculture.
3. Pond capacity is the difference between [P] before the pond is used and [P]_i after it is used for tilapia fish farming activities; the maximum concentration of P that can be accepted by the fish pond is [P]_f.

The phosphorus assimilation capacity of tilapia aquaculture pond water was determined with the following formula:

$$(P) = [P]_f - [P]_i$$

Because (P) is related to the total capacity of P waste from fish farming activities (L_b), with pond area (A) and flushing rate (ρ) and the ability of water bodies to accommodate waste, the following equations were used:

$$(P) = [L_b * (1 - R_b)] / (Z * \rho)$$

$$L_b = [\Delta(P) * Z * \rho] / (1 - R_b)$$

$$R_b = x + [(1 - x) R]$$

$$R = 1 / [(1 + 0.75\rho^{0.507})]$$

Where: R - phosphorus retention coefficient; Z - mean depth (m); ρ - flushing coefficient; R_b - a fraction of L_b dissolved into the sediment; x - net P-total deposition into the sediment.

The flushing coefficient is calculated according to the following equations:

$$Q = A * Z$$

$$V = (V_h - V_i) * t_r$$

Where: ρ - flushing coefficient; Q - volume of fish pond water (m^3); V - volume of wasted water during cultivation activities (m^3); V_h - volume of pool water before being discharged for water changes (m^3); V_i - volume of pool water after being discharged for water changes (m^3); t_r - fish rearing time in 1 cycle (days).

The carrying capacity (CC) of the pond for tilapia cultivation is calculated according to the equation:

$$CC = [(Lb * A)] / PhL$$

$$PhL = WT_{feed} * Ph_{feed}(\%) - [WT_{fish} * Ph_{fish}(\%)]$$

Where: A - fish pond surface area (m^2); PhL - phosphorus waste load from cultivation activities (kg); WT_{feed} - total weight of feed used in fish farming/maintenance cycle (kg); Ph_{feed} - phosphorus content in feed (%); WT_{fish} - total weight of fish produced in one rearing cycle (kg); Ph_{fish} - phosphorus content in fish meat (%).

Results and Discussion. The ponds studied were located in 3 villages (Sambiroto, Jepat Lor, and Tunggulsari) in Tayu District, Pati Regency, Central Java Province, distinguished by traditional plus and semi-intensive cultivation patterns. Table 1 presents data on land area, cultivation technology applied, stocking density, biomass weight at harvest, and feed utilization.

Table 1
Land area, cultivation technology applied, stocking density, biomass weight at harvest, and feed utilization at each sampling location

<i>Production Factors</i>	<i>S1-TP</i>	<i>S2-TP</i>	<i>S3-TP</i>	<i>J1-SI</i>	<i>J2-SI</i>	<i>J3-SI</i>	<i>T1-SI</i>	<i>T2-TP</i>	<i>T3-SI</i>
Land area (m^2)	10750	18500	10500	9750	10200	10100	10500	15000	10000
Number of stocking (ind)	30000	55000	30000	50000	55000	50000	55000	45000	50000
Stocking density (ind m^{-2})	2.79	2.97	2.86	5.13	5.39	4.95	5.24	3	5
Average initial weight (g)	1.45	1.5	1.49	1.57	1.53	1.51	1.55	1.48	1.49
Initial biomass weigh(kg)	43.5	82.5	44.7	78.5	84.15	75.5	85.25	66.6	75
Average final weight (g)	193	201	196	209	211	207	202	189	200
Final biomass weight (kg)	1390	4090	1646	5016	6383	5175	5666	2977	4800
Survival rate (%)	24.01	37	27.99	48	55	50	51	35	47.68
Fish rearing duration (days)	110	110	110	90	90	90	90	110	90
Feed weight (kg)	1335	2504	1465	6020	7000	6050	6900	1902	6300
FCR	0.96	0.90	0.89	1.20	1.10	1.17	1.22	0.64	1.31
Production per ha	1.293	2.211	1.568	5.145	6.258	5.124	5.396	1.985	4.8
Cultivation technology	Traditio nal Plus	Traditio nal Plus	Traditio nal Plus	Semi Intensi ve	Semi Intensi ve	Semi Intensi ve	Semi Intensi ve	Traditio nal Plus	Semi Intensi ve

Note: source: Nurchayati (2021); S1-TP: pond-1 sampling location in Sambiroto Village; S2-TP: pond-2 sampling location in Sambiroto Village; S3-TP: pond-3 sampling location in Sambiroto Village; J1-SI: pond-1 sampling location in Jepat Lor Village; J2-SI: pond-2 sampling location in Jepat Lor Village; J3-SI: pond-3 sampling location in Jepat Lor Village; T1-SI: pond-1 sampling location in Tunggulsari Village; T2-TP: pond-2 sampling location in Tunggulsari Village; T3-SI: pond-3 sampling location in Tunggulsari Village.

Both types of fish pond cultivated with traditional plus and semi-intensive patterns utilize commercial feed for fish. The amount of feed used in the studied traditional plus ponds ranged from 1335 to 2504 kg, while in the semi-intensive ponds it ranged from 6020 to 7000 kg. Production of traditional plus ponds studied ranged from 1293 to 2211

kg/ha/cycle and semi-intensive production ranged from 4800-6258 kg/ha/cycle. The survival rate of fish cultured with the traditional plus pattern ranges from 24.01-37%, while in the traditional plus cultivation pattern it ranges from 47.68-55%.

One of the variables measured to determine the carrying capacity of fish ponds for aquaculture is the concentration of phosphorus in fish feed and meat. The measurement results are presented in Table 2. The concentration of phosphorus in feed ranged from 1.0857 to 1.0873%, while in fish meat it ranged from 0.2320 to 0.23675%.

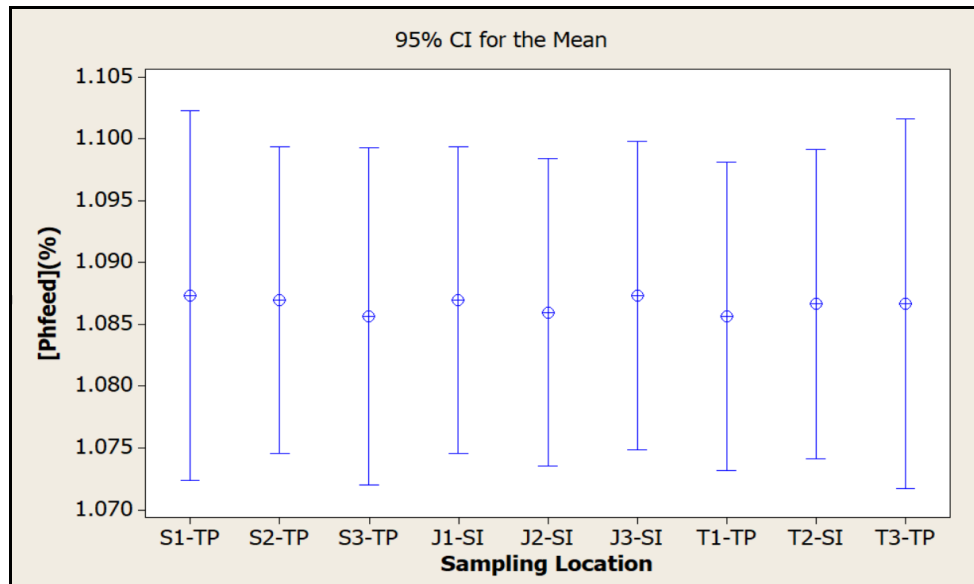


Figure 2. Phosphorus content (%) in fish feed (Ph_{feed}).

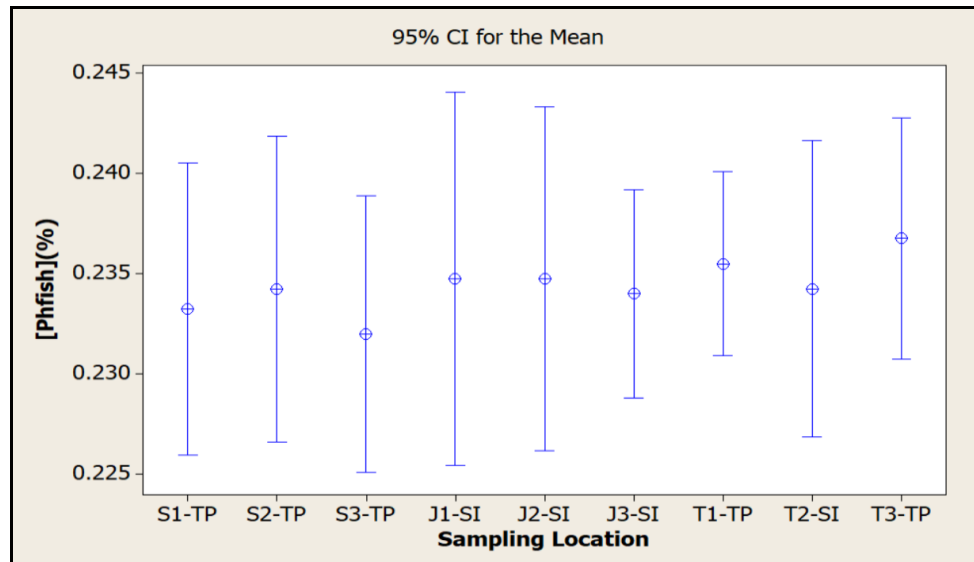


Figure 3. Phosphorus content (%) in tilapia (*Oreochromis niloticus*) meat (Ph_{fish}).

The results of the analysis of variance showed that the phosphorus content in the feed and fish meat was not significantly different ($p > 0.05$).

The remaining feed and excretion matter of tilapia is discharged into the environment, contributing to the phosphorous content. Phosphorus in water occurs in the form of phosphate. The results of the measurement of total phosphate in fish rearing media are presented in Table 2.

Table 2
Phosphate concentration (mg m^{-3}) in tilapia (*Oreochromis niloticus*) rearing media during the study

No	Sampling Location	Phosphate concentration (mg m^{-3})			
		Lowest	Highest	Average	Standard Deviation
1	S1-TP	0.16	0.49	0.37	0.09
2	S2-TP	0.10	0.38	0.225	0.09
3	S3-TP	0.15	0.45	0.35	0.08
4	J1-SI	0.05	0.78	0.58	0.19
5	J2-SI	0.05	0.63	0.40	0.15
6	J3-SI	0.06	0.62	0.43	0.15
7	T1-SI	0.15	0.66	0.46	0.15
8	T2-TP	0.21	0.48	0.325	0.09
9	T3-SI3	0.20	0.88	0.75	0.19

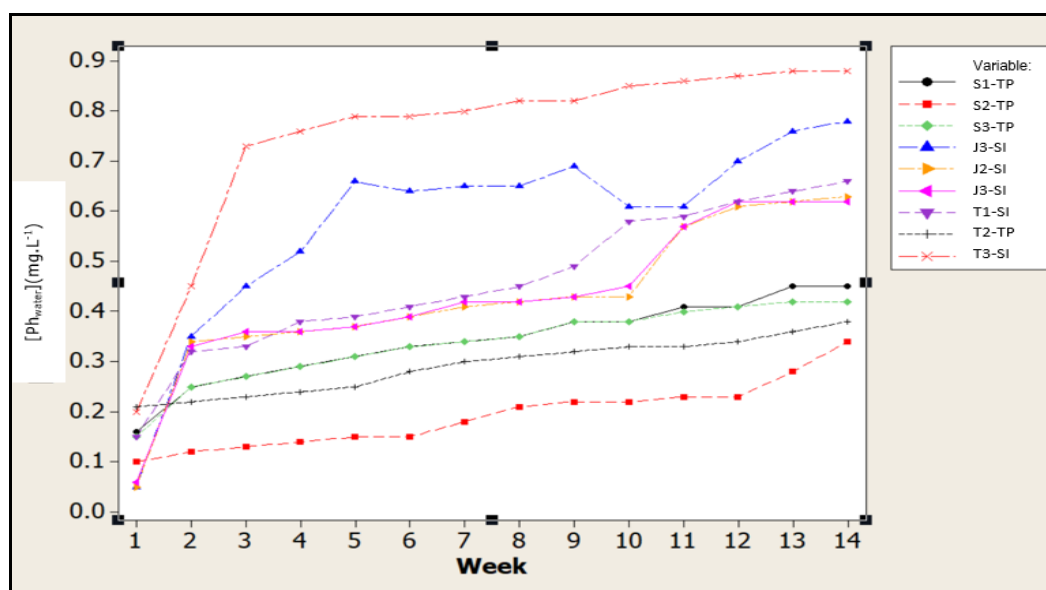


Figure 4. Fluctuations in phosphorus concentration in fish culture media ($\text{mg PO}_4 \text{m}^{-3}$) at various sampling locations during the 14 weeks of the study.

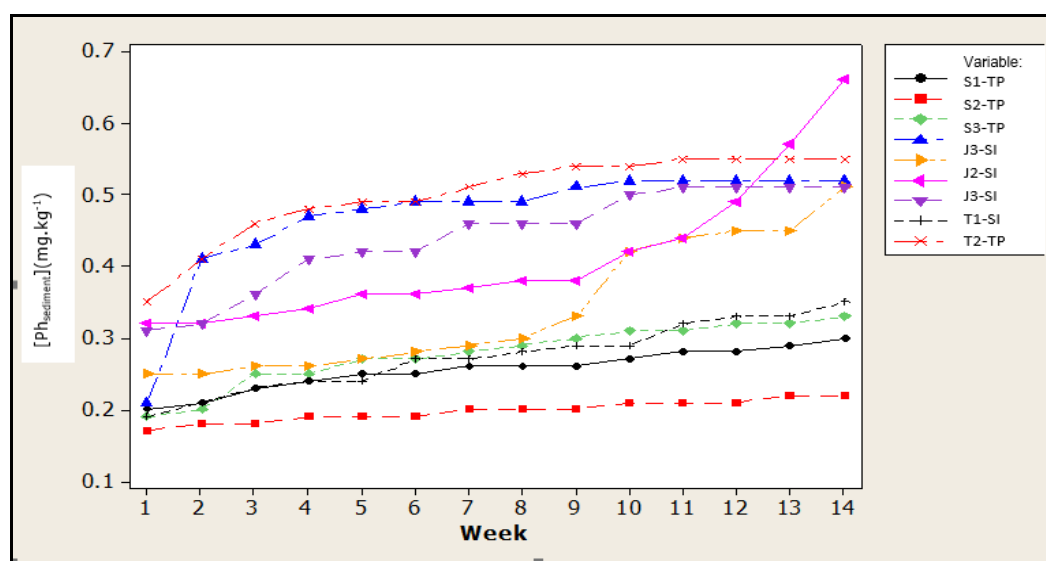


Figure 5. Fluctuations of phosphorus concentration in sediment ($\text{mg P total kg}^{-1}$) at various sampling locations during the 14 weeks of the study.

The production of phosphate waste produced by cultured fish is influenced by the amount of fish biomass kept and the amount of feed consumed by the fish. The results of the regression analysis showed that, overall, regardless of the applied cultivation pattern, the relationship equation of the concentration of phosphate in the water was $(Y\text{-mg/m}^3) = 0.435 - 0.000138 X_1 + 0.000130 X_2$ ($R^2=0.71$, $p<0.05$). In the traditional pattern, the regression equation was $Y = 0.690 + 0.00091 X_1 - 0.000335 X_2$ ($R^2=1$, $p<0.05$) and in the semi-intensive pattern the regression equation was: $y = 2E+07X_{14} - 4E+07X_{13} + 3E+07X_{12} - 1E+07X_1 + 2E+06$ ($R^2=1$). X_1 was the biomass weight of fish production/cycle (kg), and X_2 was the weight of biomass feed used/cycle (kg).

Based on the measured variables, an analysis of the carrying capacity of each fish studied pond was carried out, with the results presented in Table 3. The pond with the highest carrying capacity (11168.75 kg/ha/cycle) is pond two, located in Jati Lor village, which implements semi-intensive aquaculture (J2-SI). Meanwhile, the pond with the lowest carrying capacity (2872.87 kg/ha/cycle) is pond one, located in Sambiroto village, which applies the traditional plus cultivation pattern (S1-TP).

Table 3

Results of measurements/calculations of variables needed to determine the carrying capacity of fish ponds

Carrying capacity variables	Sampling Location								
	S1-TP	S2-TP	S3-TP	J1-SI	J2-SI	J3-SI	T1-TP	T2-SI	T3-TP
Production (kg)	1389.6	4090.4	1646.4	5016	6382.8	5175	5666.1	2976.8	4800
Feed (kg)	1335.3	2504	1465.6	6020	7000	6050	6900	1902.2	6300
Ph-Feed (%)	1.0873	1.087	1.0857	1.0870	1.086	1.0873	1.0857	1.0867	1.0867
Ph-Meat (%)	0.2332	0.2342	0.232	0.2347	0.2347	0.234	0.2355	0.2342	0.2367
	5	5	0.232	5	5	0.234	0.2355	5	5
PhL (kg/cycle)	11.277	17.636	12.091	53.662	61.036	53.674	61.567	13.697	57.096
	92	718	883	34	377	167	334	419	
Pi (mg/m ³)	0.37	0.225	0.35	0.58	0.4	0.43	0.46	0.325	0.75
Pf (mg/m ³)	60	60	60	60	60	60	60	60	60
D(P) (mg/m ³)	59.63	59.78	59.65	59.42	59.6	59.57	59.54	59.68	59.25
A (m ²)	10750	18500	10500	9750	10200	10100	10500	15000	10000
Z (m)	0.6	0.6	0.8	0.75	0.7	0.7	0.7	0.5	0.6
V (m ³)	6450	11100	8400	7312.5	7140	7070	7350	7500	6000
Vh (m ³)	6450	11100	8400	7312.5	7140	7070	7350	7500	6000
Vi (m ³)	6295.2	10833.6	8198.4	5,529	5,398	5,345	5556.6	7,320	4536
Tr (day)	110	110	110	90	90	90	90	110	90
Q (m ³)	17028	29304	22176	160593.48	156794.4	155257.2	161406	19800	131760
ρ (cycle ⁻¹)	2.64	2.64	2.64	22	21.96	21.96	21.96	2.64	21.96
$0.75\rho^{0.507}$	1.2269	1.2269	1.2269	3.5915	3.5914	3.5914	3.5914	1.2269	3.5914
	1	1	1	665	42	42	42	1	42
$R_b = x + ((1-x)R)$	0.5537	0.5207	0.5427	0.4603	0.4212	0.4837	0.3742	0.5482	0.3742
X	0.19	0.13	0.17	0.31	0.26	0.34	0.2	0.18	0.2
$R = 1/(1+0.75\rho^{0.507})$	0.4491	0.4491	0.4491	0.2178	0.2178	0.2178	0.2178	0.4491	0.2178
$L_b = D(P)*Z*p/1-R_b$	211.22	197.02	275.03	1807.2	1576.6	1768.1	1457.7	173.90	1244.8
	69	31	42	556	887	002	001	50	249
CC (kg) = $(L_b*A)/PhL$	2013.3	2066.6	2388.2	3283.6	2634.8	3327.0	2486.0	1904.4	2180.2
	9	7	6	328	59	78	34	3	31
CC/Ha	1872.9	1117.1	2274.5	3367.8	2583.1	3294.1	2367.6	1269.6	2180.2
	2	2	4	285	95	36	52	2	31

Note: Pi - concentration phosphorous in fishpond water before being; Pf - concentration phosphorous after it is used for tilapia fish farming activities; D(P) - the maximum concentration of P that can be accepted by the fish pond; Ph-Feed - phosphorus content in fish feed; Ph-Meat - phosphorus content in fish meat; WT_{feed} - total weight of feed used in fish farming/maintenance cycle; WT_{fish} - total weight of fish produced in one rearing cycle; PhL - phosphorus waste load from cultivation activities; L_b - the total capacity of P waste from fish farming activities; A - pond area; ρ - flushing rate; R - phosphorus retention coefficient; Z - mean depth; R_b - a fraction of phosphorus dissolved into the sediment; L_b - phosphorus waste load from cultivation activities; x - net P-total deposition into the sediment; Q - volume of fish pond water; V - volume of wasted water during cultivation activities; Vh - volume of pool water before being discharged for water changes; Vi - volume of pool water after being discharged for water changes; t_r - fish rearing time in 1 cycle; CC - carrying capacity.

The survival rate of fish cultured in fish ponds with the traditional plus pattern is lower (24.01-37%) compared to that of the semi-intensive culture pattern (47.68-55%). The high mortality rate is caused by 2 factors, namely high salinity at the start of maintenance and low dissolved oxygen. The salinity of the culture media reached 19.9 ppt at the beginning of maintenance. Good salinity at the beginning of tilapia rearing should not exceed 5 ppt (Bastian & Wahid 2008).

The concentration of dissolved oxygen in fish ponds with traditional plus technology ranges from 1.3 to 10 mg L⁻¹, while in ponds with semi-intensive technology it ranges from 2.98 to 9.94 mg L⁻¹. An oxygen concentration as low as 3 mg L⁻¹ interferes with fish growth (Sucipto & Prihantono 2007). Doudoroff & Shumway (1970) reported that freshwater fish can die within 2 days if the oxygen concentration is less than 3 mg L⁻¹. Indonesian National Standard (2009) requires that dissolved oxygen (DO) concentrations for tilapia cultivation must be ≥3 mg L⁻¹. An oxygen concentration of 2.3-3.0 mg L⁻¹ inhibits tilapia growth (Melard & Philippart 1981; Tran-Duy et al 2008).

Phosphorus is an essential nutrient needed by aquatic biota. Fish need phosphorus for bone formation and biomass growth, maintaining acid-base balance, and protein and fat metabolism (Sakamoto & Yone 1980; Takeuchi & Nakazoe 1981). The need for phosphorus in aquatic animals is 0.29-0.90% (Beveridge 1984). Tilapia needs phosphorus up to 0.65% (Watanabe et al 1980). Thus, the feed used with phosphorus levels of 1.30 and 2.52% meets the requirements of tilapia (Beveridge 1984).

After being metabolized in the fish body, phosphorus in the feed will be converted into meat, after the energy needs for respiration, adaptation to environmental conditions, and movement are met (Watanabe et al 1988; Tang et al 2012). The rest of phosphorus metabolism in the form of waste is excreted in the form of urine and feces. In water, phosphorus is available in the form of dissolved phosphate and particulate phosphate. Total phosphate measured in tilapia culture media ranged from 0.05 to 0.78 mg m⁻³. The water quality standard for total phosphate in aquaculture in Indonesia is 0.2 mg L⁻¹ (Ministry of Secretary of State of the Republic of Indonesia 2021). The optimal phosphate content for phytoplankton growth, which is another important factor for the growth of larvae and fry, ranges from 0.27 to 5.51 ppm (Widjaya et al 1994). Phosphorus levels in the waters ranged from 0.005 to 0.02 mg L⁻¹.

The concentration of phosphate in the water is not only affected by the density of fish but also by the amount of feed given as fish feed. In the traditional plus cultivation pattern, the concentration of phosphate in the water is related to the density of fish, reflected by the total biomass of fish production, and the amount of feed given. Not all of the feed given is eaten by fish, some being deposited on the sediment along with fish feces.

The low feed conversion value in the traditional plus pattern of tilapia cultivation occurs because the feed is mainly natural, while in the semi-intensive pattern the feed conversion is higher because the fish feed is almost completely commercial. Nonetheless, the range of feed FCR found in this study was still lower than the feed FCR in tilapia culture in general. Beveridge (1984) stated that the FCR of feed in intensive tilapia cultivation ranges from 2.0 to 2.5.

Phosphorus in water, especially in the form of particulates or dissolved phosphorus bound in particulates, will experience deposition and settle into the sediment. Total phosphorus in sediments measured during the study ranged from 0.17 mg kg⁻¹ (S2TP pond) to 0.66 mg kg⁻¹ (J3SI pond).

The model developed by Dillon & Rigler (1974, 1975) is a modification of the Vollenweider model (1975; 1976), which later became known as the phosphorus budget model, stating that the concentration of P in the water is related to the P load received by the pond/lake, the volume of the pond (surface area and depth of pond/lake), and flushing rate.

Based on the phosphorus budget model used in this study, the carrying capacity of the pond was presented in Table 3. The model calculation results show that there are only 2 ponds that produce fish biomass still meeting the carrying capacity, namely ponds 1 and 3 in Sambiroto village (S1-TP and S3-TP), while other pools have exceeded the carrying capacity. In ponds cultivated as they are today, to produce fish biomass that

exceeds the carrying capacity of the pond, it is necessary to improve production technology so that the sustainability of the pond ecosystem remains. Actions that can be taken are to reduce fish mortality to a minimum survival rate of 60-70% by improving water quality, so that salinity and dissolved oxygen meet the requirements for tilapia aquaculture, by reducing P load from aquaculture activities, by improving feeding management so that feed utilization is more efficient, and to increase the rate of rinsing by increasing the volume of water change from what is currently done.

Conclusions. The results of the analysis of the carrying capacity of fish ponds using the phosphorus budget model show that from the 9 ponds studied, only 2 ponds have a production still below the carrying capacity, namely ponds 1 and 3 in Sambiroto village (S1-TP and S3-TP). The other seven ponds for fish production had exceeded the carrying capacity. Increasing pond production can still be done, but for ponds whose production exceeds the carrying capacity, several actions must be taken to increase the carrying capacity, namely improving water quality management, reducing P load from aquaculture activities, improving feeding management, increasing the flushing rate, and increasing the volume of water change.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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