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**SELF-SUFFICIENCY MODEL OF TILAPIA AQUACULTURE IN MINALIN,
PAMPANGA, PHILIPPINES**

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ABSTRACT

This study was conducted in order to create a self-sufficiency model of tilapia aquaculture in Minalin, Pampanga, Philippines. The specific objectives of this study include the following: (1) To dynamically visualize the effects of compounding factors on tilapia production and consumption in the municipality; (2) To forecast local tilapia sufficiency over a given period of time; and (3) To identify interventions that would improve tilapia self-sufficiency in the municipality.

The study used secondary data from published researches and from official websites of government offices in the Philippines. The researcher utilized STELLA Version 9.02 in order to dynamically visualize and communicate the self-sufficiency model of tilapia aquaculture in the municipality.

Available tilapia for local consumption was negatively affected by increasing population, change in capita consumption towards fish protein, reduction of available land for tilapia farming, poor water quality, diseases and extreme weather events. In order to lessen the compounding effects of these factors, interventions such as technology adoption, management of population growth and reduction of land conversion rate were deemed effective. The local tilapia sufficiency was prolonged from 16 years to 19 years because of these interventions. In addition, 50% reduction in land conversion rate could extend the local sufficiency of tilapia until the 26th year.

Keywords: Self-sufficiency model, tilapia, STELLA, aquaculture

INTRODUCTION

Aquaculture is now a growing business around the world contributing to a large percentage of the total world fish production. In 2011, its world production of 62.7 million tons has increased by 6.2% from 2010 [1]. In the Philippines, the province of Pampanga has become a major centre of production with its polyculture system, associating the shrimp with milkfish and sometimes tilapia and/or crabs [2]. Forty percent of tilapia production in Central Luzon has been supplied by Pampanga [3].

According to the World Health Organization (2003) [4], around 13-16% of total animal protein consumed by human is aquatic in origin. Tilapia in the Philippines is one of the main sources of protein for its continuously growing population because of its easy digestibility and high nutritional value [5].

Minalin is a fourth class highly urbanized municipality in the province of Pampanga and is located southwest of the capital city of San Fernando. It consists of 15 barangays with a total land area of 4,827 ha. Almost 57% of its land area is used for aquaculture activities. Minalin is known as producer of tilapia, milkfish, shrimp and crab [6]. As of 2014, Minalin has 1,755 pond units used for tilapia aquaculture [7].

Tilapia aquaculture in Minalin, Pampanga is likely to become even more important as populations continue to increase, as the quality of environment degrades, and the pressures on scarce land for agriculture continue to grow, pushing more people towards aquaculture as a ‘last-resort’ activity. In addition, tilapia production is affected by multitude of factors and their inherent interactions [7].

The “Self-sufficiency Model of Tilapia Aquaculture in Minalin, Pampanga, Philippines” has tried to answer these two central questions: (1) What are the compounding effects of increasing rate of land conversion and population growth, increasing preference for fish-protein source, poor water quality, adverse weather conditions, diseases, and adoption of new technologies and other interventions on local tilapia sufficiency?; and (2) Given the multitude of factors that affect tilapia production and consumption, does the municipality maintains its self-sufficiency over a period of time?

The general objective of this paper is to create a self-sufficiency model of tilapia aquaculture in Minalin, Pampanga, Philippines. Specific objectives include: (1) To dynamically visualize the effects of

compounding factors on tilapia production and consumption in the municipality; (2) To forecast local tilapia sufficiency over a given period of time; and (3) To identify interventions that would improve tilapia self-sufficiency in the municipality.

MATERIALS AND METHOD

The study used secondary data from the project “Development of Comprehensive Geo-referenced Database for Ecological Risk Analyses of Tilapia Pond Culture in Pampanga” of the Freshwater Aquaculture

Center in Central Luzon State University (FAC-CLSU). Other information needed in this study was searched in the official websites of government offices in the Philippines and from published researches. In order to dynamically visualize and communicate the “Self-sufficiency Model of Tilapia Aquaculture in Minalin, Pampanga, Philippines”, the researcher used STELLA Version 9.02. The DPSIR (Driver – Pressure – State – Impact – Response) framework is provided in Figure 1.

Figure 1: DPSIR framework for the sufficiency model of tilapia aquaculture in Minalin, Pampanga, Philippines

RESULTS AND DISCUSSION

Provided in Table 1 are the variables that were considered in the creation of

conceptual models. Majority of the variables used were based upon actual data generated

from government offices and research centers.

Shown in Figure 2 is the self-sufficiency model of tilapia aquaculture in Minalin, Pampanga, Philippines using STELLA Version 9.02. Variables affecting local tilapia production are land area allotted for production (1,293.08 ha), production rate (10,740 kg/ha/year) and extreme weather event (reduction by 3.26%). Meanwhile, tilapia consumption is affected by population (44,001), per capita consumption (31 kg/year) and change in per capita consumption (4%). In this model, interventions (Table 1) that could positively affect tilapia sufficiency in the locality were not included.

Reduction in land allotted for tilapia farming coupled with increasing population, disease outbreaks and extreme weather condition (typhoon) could lead to reduction of available tilapia for local consumption in the long run (Figure 2; Table 2). For the next 16 years, tilapia produced is always higher than tilapia consumed and this scenario would result to accumulation of surplus production (blue line in Figure 3; Table 2). If the author assume that tilapia is not a perishable good and surplus production is kept in the municipality, it appeared that local tilapia sufficiency is to be experienced

until the next 44 years (Figure 3; Table 2). In reality, tilapia is considered a perishable good and surplus production will be marketed outside the municipality. Using the latter scenario, starting at its 17th year, tilapia consumed is higher than tilapia produced. Hence, Minalin will import tilapia from the nearby municipalities of Pampanga starting at 239.70 tons (Figure 4; Table 2).

In Figure 5, interventions to improve production rate (e.g. technology adoption), to reduce land conversion rate (e.g. evaluation of Comprehensive Land Use Plan or CLUP, financial support from government) and to manage population growth rate (e.g. family planning, delimit migration in the municipality) were incorporated.

Based on studies conducted by FAC-CLSU, the use of sex-reversed tilapia and probiotics could increase the production by approximately 10%. Family planning program of the municipality for instance was effective in reducing population growth rate by 10%. Lastly, land conversion rate was reduced by 25% because of effort and assistance extended by the local and provincial government (Figure 6). Using the following assumptions, it turned out that local supply of tilapia for consumption was sufficient until the next 19 years. Minalin

will import tilapia starting at 75.84 tons (Figures 7 and 8; Table 3).

The author also tried to reduce the land conversion rate up to 50% and the other two interventions were remained constant

(Figure 8). Result showed that local tilapia sufficiency was prolonged to 26 years. For the next year, Minalin will import tilapia starting at 191.35 tons (Figures 9 and 10; Table 4).

Table 1: Variables used in the creation of self-sufficiency model of tilapia aquaculture in Minalin, Pampanga, Philippines

Variables	Value	Source
Average productive area for tilapia farming (2012-2014)	1,293.08 ha	FAC-CLSU
Average tilapia production (2012-2014)	10,740 kg/ha/year	FAC-CLSU
Reduction of production due to: Land conversion (2000-2014) Poor water quality Diseases	10-12% 12-15% 10%	Published report Published report World Organization for Animal Health Bureau of Agricultural Statistics (BAS)
Extreme weather events (Typhoon Yolanda on Central Luzon, 2013)	3.26%	
Increase of production due to: Technology adoption Reduction on land conversion rate	5-10% 25%, 50%	FAC-CLSU Assumption
Population (2010)	44,001 people	Philippine Statistics Authority (PSA)
Birth rate (2007-2010)	3.45%	PSA
Reduction of consumption due to: Reduction on population growth rate	10%	Assumption
Per capita consumption of tilapia in Pampanga (2012)	31 kg/yr	Assumption
Change in fish capita consumption (2003-2011)	4%	Bureau of Fisheries and Aquatic Resources (BFAR)

Figure 2: Local tilapia sufficiency model without interventions

Figure 3: Cumulative surplus production and insufficiency in available tilapia over time

Figure 4: The municipality will start to import tilapia on the 17th year

Table 2: Tabular result of the model without interventions

Year	Productive Area (ha)	Production (kg)	Consumption (kg)	Cumulative Surplus Production (kg)	Insufficiency (kg)
0	1,293.08	13,703,639.68	1,418,592.24	12,285,047.44	-12,285,047.44
1	1,163.77	12,333,275.71	1,467,533.67	24,570,094.87	-10,865,742.04
2	1,047.39	11,099,948.14	1,518,163.58	35,435,836.91	-9,581,784.55
3	942.66	9,989,953.32	1,570,540.23	45,017,621.46	-8,419,413.10
4	848.39	8,990,957.99	1,624,723.87	53,437,034.55	-7,366,234.13
5	763.55	8,091,862.19	1,680,776.84	60,803,268.68	-6,411,085.35
6	687.2	7,282,675.97	1,738,763.64	67,214,354.03	-5,543,912.33
7	618.48	6,554,408.38	1,798,750.99	72,758,266.37	-4,755,657.39
8	556.63	5,898,967.54	1,860,807.89	77,513,923.76	-4,038,159.64
9	500.97	5,309,070.78	1,925,005.77	81,552,083.40	-3,384,065.02
10	450.87	4,778,163.71	1,991,418.47	84,936,148.42	-2,786,745.24
11	405.78	4,300,347.34	2,060,122.40	87,722,893.66	-2,240,224.93
12	365.2	3,870,312.60	2,131,196.63	89,963,118.59	-1,739,115.98
13	328.68	3,483,281.34	2,204,722.91	91,702,234.57	-1,278,558.43
14	295.82	3,134,953.21	2,280,785.85	92,980,793.00	-854,167.36
15	266.23	2,821,457.89	2,359,472.96	93,834,960.36	-461,984.93
16	239.61	2,539,312.10	2,440,874.78	94,296,945.28	-98,437.32
17	215.65	2,285,380.89	2,525,084.96	94,395,382.60	239,704.07
18	194.08	2,056,842.80	2,612,200.39	94,155,678.53	555,357.59
19	174.68	1,851,158.52	2,702,321.30	93,600,320.94	851,162.78
20	157.21	1,666,042.67	2,795,551.39	92,749,158.16	1,129,508.72
21	141.49	1,499,438.40	2,891,997.91	91,619,649.44	1,392,559.51
22	127.34	1,349,494.56	2,991,771.84	90,227,089.93	1,642,277.28
23	114.6	1,214,545.10	3,094,987.97	88,584,812.65	1,880,442.86
24	103.14	1,093,090.59	3,201,765.05	86,704,369.78	2,108,674.46
25	92.83	983,781.53	3,312,225.95	84,595,695.33	2,328,444.41
26	83.55	885,403.38	3,426,497.74	82,267,250.92	2,541,094.36
27	75.19	796,863.04	3,544,711.91	79,726,156.56	2,747,848.87
28	67.67	717,176.74	3,667,004.47	76,978,307.68	2,949,827.74
29	60.91	645,459.06	3,793,516.13	74,028,479.95	3,148,057.06
30	54.82	580,913.16	3,924,392.44	70,880,422.89	3,343,479.28
31	49.33	522,821.84	4,059,783.97	67,536,943.61	3,536,962.13
32	44.4	470,539.66	4,199,846.52	63,999,981.48	3,729,306.86
33	39.96	423,485.69	4,344,741.23	60,270,674.61	3,921,255.53
34	35.96	381,137.12	4,494,634.80	56,349,419.08	4,113,497.68
35	32.37	343,023.41	4,649,699.70	52,235,921.40	4,306,676.29
36	29.13	308,721.07	4,810,114.34	47,929,245.12	4,501,393.27
37	26.22	277,848.96	4,976,063.28	43,427,851.85	4,698,214.32
38	23.6	250,064.07	5,147,737.47	38,729,637.53	4,897,673.40
39	21.24	225,057.66	5,325,334.41	33,831,964.13	5,100,276.75
40	19.11	202,551.89	5,509,058.45	28,731,687.38	5,306,506.55
41	17.2	182,296.70	5,699,120.96	23,425,180.82	5,516,824.26
42	15.48	164,067.03	5,895,740.64	17,908,356.57	5,731,673.60
43	13.93	147,660.33	6,099,143.69	12,176,682.96	5,951,483.36
44	12.54	132,894.30	6,309,564.15	6,225,199.61	6,176,669.85
45	11.29	119,604.87	6,529,168.99	0	6,407,639.24
46	10.16	107,644.38	6,757,813.37	0	6,644,789.65
47	9.14	96,879.94	6,994,693.31	0	6,888,513.06
48	8.23	87,191.95	7,240,605.26	0	7,139,197.11
49	7.4	78,472.75	7,495,078.01	0	7,397,226.73
Final	6.66			0	7,662,985.64

Figure 5: Local tilapia sufficiency model with intervention in productive area, production rate and population growth rate

Figure 6: Improvement of local tilapia sufficiency due to added interventions

Figure 7: The municipality will start to import tilapia on the 20th year

Table 3: Tabular result of the model with interventions (10% technology adoption, 10% reduction population growth rate and 25% reduction land conversion rate)

Year	Productive Area (ha)	Production (kg)	Consumption (kg)	Cumulative Surplus Production (kg)	Insufficiency (kg)
0	1,293.08	11,822,747.96	1,418,592.24	10,404,155.72	-10,404,155.72
1	1,196.10	10,936,041.86	1,461,150.01	20,808,311.43	-9,474,891.85
2	1,106.39	10,115,838.72	1,504,984.51	30,283,203.28	-8,610,854.21
3	1,023.41	9,357,150.82	1,550,134.04	38,894,057.49	-7,807,016.77
4	946.66	8,655,364.50	1,596,638.06	46,701,074.27	-7,058,726.44
5	875.66	8,006,212.17	1,644,537.21	53,759,800.71	-6,361,674.96
6	809.98	7,405,746.25	1,693,873.32	60,121,475.67	-5,711,872.93
7	749.23	6,850,315.28	1,744,689.52	65,833,348.60	-5,105,625.76
8	693.04	6,336,541.64	1,797,030.21	70,938,974.36	-4,539,511.43
9	641.06	5,861,301.02	1,850,941.11	75,478,485.79	-4,010,359.90
10	592.98	5,421,703.44	1,906,469.35	79,488,845.69	-3,515,234.09
11	548.51	5,015,075.68	1,963,663.43	83,004,079.79	-3,051,412.25
12	507.37	4,638,945.01	2,022,573.33	86,055,492.04	-2,616,371.68
13	469.32	4,291,024.13	2,083,250.53	88,671,863.72	-2,207,773.60
14	434.12	3,969,197.32	2,145,748.05	90,879,637.32	-1,823,449.27
15	401.56	3,671,507.52	2,210,120.49	92,703,086.59	-1,461,387.03
16	371.44	3,396,144.46	2,276,424.10	94,164,473.62	-1,119,720.36
17	343.59	3,141,433.62	2,344,716.83	95,284,193.98	-796,716.80
18	317.82	2,905,826.10	2,415,058.33	96,080,910.78	-490,767.77
19	293.98	2,687,889.14	2,487,510.08	96,571,678.55	-200,379.06
20	271.93	2,486,297.46	2,562,135.38	96,772,057.61	75,837.92
21	251.54	2,299,825.15	2,638,999.44	96,696,219.69	339,174.30
22	232.67	2,127,338.26	2,718,169.43	96,357,045.39	590,831.16
23	215.22	1,967,787.89	2,799,714.51	95,766,214.23	831,926.62
24	199.08	1,820,203.80	2,883,705.94	94,934,287.61	1,063,502.14
25	184.15	1,683,688.52	2,970,217.12	93,870,785.47	1,286,528.61
26	170.34	1,557,411.88	3,059,323.64	92,584,256.86	1,501,911.76
27	157.56	1,440,605.99	3,151,103.35	91,082,345.10	1,710,497.36
28	145.75	1,332,560.54	3,245,636.45	89,371,847.74	1,913,075.91
29	134.81	1,232,618.50	3,343,005.54	87,458,771.83	2,110,387.04
30	124.7	1,140,172.11	3,443,295.71	85,348,384.79	2,303,123.60
31	115.35	1,054,659.20	3,546,594.58	83,045,261.19	2,491,935.38
32	106.7	975,559.76	3,652,992.41	80,553,325.81	2,677,432.65
33	98.7	902,392.78	3,762,582.19	77,875,893.16	2,860,189.41
34	91.29	834,713.32	3,875,459.65	75,015,703.75	3,040,746.33
35	84.45	772,109.82	3,991,723.44	71,974,957.42	3,219,613.62

36	78.11	714,201.59	4,111,475.15	68,755,343.80	3,397,273.56
37	72.26	660,636.47	4,234,819.40	65,358,070.24	3,574,182.93
38	66.84	611,088.73	4,361,863.98	61,783,887.31	3,750,775.25
39	61.82	565,257.08	4,492,719.90	58,033,112.06	3,927,462.82
40	57.19	522,862.80	4,627,501.50	54,105,649.23	4,104,638.70
41	52.9	483,648.09	4,766,326.54	50,001,010.53	4,282,678.46
42	48.93	447,374.48	4,909,316.34	45,718,332.07	4,461,941.86
43	45.26	413,821.39	5,056,595.83	41,256,390.21	4,642,774.44
44	41.87	382,784.79	5,208,293.70	36,613,615.77	4,825,508.92
45	38.73	354,075.93	5,364,542.52	31,788,106.86	5,010,466.59
46	35.82	327,520.24	5,525,478.79	26,777,640.27	5,197,958.56
47	33.13	302,956.22	5,691,243.15	21,579,681.72	5,388,286.94
48	30.65	280,234.50	5,861,980.45	16,191,394.78	5,581,745.95
49	28.35	259,216.91	6,037,839.86	10,609,648.83	5,778,622.95
Final	26.22			4,831,025.88	5,979,199.41

Figure 8: Local tilapia sufficiency model with 50% reduction in land conversion rate while other interventions remained constant

Figure 9: Reduction of land conversion rate up to 50% has resulted to a more sufficient supply of tilapia in the locality

Figure 10: The municipality will start to import tilapia on the 27th year

Table 4: Tabular result of the model with interventions (10% technology adoption, 10% reduction population growth rate and 50% reduction land conversion rate)

Year	Productive Area (ha)	Production (kg)	Consumption (kg)	Cumulative Surplus Production (kg)	Insufficiency (kg)
0	1,293.08	11,822,747.96	1,418,592.24	10,404,155.72	-10,404,155.72
1	1,228.43	11,231,610.56	1,461,150.01	20,808,311.43	-9,770,460.55
2	1,167.00	10,670,030.03	1,504,984.51	30,578,771.98	-9,165,045.52
3	1,108.65	10,136,528.53	1,550,134.04	39,743,817.50	-8,586,394.49
4	1,053.22	9,629,702.10	1,596,638.06	48,330,211.99	-8,033,064.04
5	1,000.56	9,148,217.00	1,644,537.21	56,363,276.03	-7,503,679.79
6	950.53	8,690,806.15	1,693,873.32	63,866,955.82	-6,996,932.82
7	903.01	8,256,265.84	1,744,689.52	70,863,888.64	-6,511,576.32
8	857.86	7,843,452.55	1,797,030.21	77,375,464.96	-6,046,422.34
9	814.96	7,451,279.92	1,850,941.11	83,421,887.30	-5,600,338.81
10	774.21	7,078,715.92	1,906,469.35	89,022,226.11	-5,172,246.58
11	735.5	6,724,780.13	1,963,663.43	94,194,472.68	-4,761,116.70
12	698.73	6,388,541.12	2,022,573.33	98,955,589.38	-4,365,967.79
13	663.79	6,069,114.07	2,083,250.53	103,321,557.17	-3,985,863.54
14	630.6	5,765,658.36	2,145,748.05	107,307,420.71	-3,619,910.32
15	599.07	5,477,375.44	2,210,120.49	110,927,331.03	-3,267,254.96
16	569.12	5,203,506.67	2,276,424.10	114,194,585.98	-2,927,082.57
17	540.66	4,943,331.34	2,344,716.83	117,121,668.55	-2,598,614.51
18	513.63	4,696,164.77	2,415,058.33	119,720,283.06	-2,281,106.44
19	487.95	4,461,356.53	2,487,510.08	122,001,389.51	-1,973,846.45
20	463.55	4,238,288.71	2,562,135.38	123,975,235.96	-1,676,153.32
21	440.37	4,026,374.27	2,638,999.44	125,651,389.28	-1,387,374.83
22	418.35	3,825,055.56	2,718,169.43	127,038,764.11	-1,106,886.13
23	397.44	3,633,802.78	2,799,714.51	128,145,650.24	-834,088.27
24	377.57	3,452,112.64	2,883,705.94	128,979,738.51	-568,406.70
25	358.69	3,279,507.01	2,970,217.12	129,548,145.21	-309,289.89
26	340.75	3,115,531.66	3,059,323.64	129,857,435.09	-56,208.02
27	323.71	2,959,755.08	3,151,103.35	129,913,643.11	191,348.27
28	307.53	2,811,767.32	3,245,636.45	129,722,294.84	433,869.13
29	292.15	2,671,178.96	3,343,005.54	129,288,425.72	671,826.58
30	277.55	2,537,620.01	3,443,295.71	128,616,599.13	905,675.70
31	263.67	2,410,739.01	3,546,594.58	127,710,923.43	1,135,855.57
32	250.48	2,290,202.06	3,652,992.41	126,575,067.86	1,362,790.36
33	237.96	2,175,691.95	3,762,582.19	125,212,277.51	1,586,890.23
34	226.06	2,066,907.36	3,875,459.65	123,625,387.27	1,808,552.30
35	214.76	1,963,561.99	3,991,723.44	121,816,834.98	2,028,161.45
36	204.02	1,865,383.89	4,111,475.15	119,788,673.52	2,246,091.26
37	193.82	1,772,114.69	4,234,819.40	117,542,582.27	2,462,704.71
38	184.13	1,683,508.96	4,361,863.98	115,079,877.56	2,678,355.02
39	174.92	1,599,333.51	4,492,719.90	112,401,522.54	2,893,386.39
40	166.18	1,519,366.84	4,627,501.50	109,508,136.15	3,108,134.66
41	157.87	1,443,398.49	4,766,326.54	106,400,001.49	3,322,928.05
42	149.97	1,371,228.57	4,909,316.34	103,077,073.44	3,538,087.77
43	142.48	1,302,667.14	5,056,595.83	99,538,985.67	3,753,928.69
44	135.35	1,237,533.78	5,208,293.70	95,785,056.98	3,970,759.92
45	128.58	1,175,657.09	5,364,542.52	91,814,297.06	4,188,885.42
46	122.15	1,116,874.24	5,525,478.79	87,625,411.64	4,408,604.55
47	116.05	1,061,030.53	5,691,243.15	83,216,807.09	4,630,212.63
48	110.24	1,007,979.00	5,861,980.45	78,586,594.46	4,854,001.45
49	104.73	957,580.05	6,037,839.86	73,732,593.01	5,080,259.81
Final	99.5			68,652,333.20	5,309,274.01

The following are recommended for a long term tilapia sufficiency in Minalin, Pampanga: (1) As much as possible, land use conversion rate should be less than 5%.

Evaluation of the latest CLUP of the municipality will give them a general view of the problem. In Pampanga, tilapia farms are usually converted to rice farm because of

huge economic losses as caused by fish kill. The conversion could be indirectly lessened through providing technical and monetary assistance from the local and provincial government. These include provision of free fingerlings, holding of seminars to upgrade the skills and knowledge of the farmers, introduction of tested technologies in the farm level and many more; (2) The local and provincial government with the help of BFAR-Region III should tightly monitor the conditions of farm operation in order to maximize production. It is also helpful to establish a target yield per year to ensure tilapia sufficiency; (3) Strengthening the use of polyculture system should be an option. Tilapia could be communally reared with other protein-source commodities such as milkfish, shrimp or crab; (4) Establishment of post-harvest facilities is necessary for effective local utilization of the surplus produced tilapia; (5) It is essential that the municipal or provincial government has an environmental management plan that considers the disastrous effects of natural hazards and the potential aggravating effects of climate change. As much as possible, they should have a guideline on the construction of aquaculture facilities that could surmount flooding, typhoon and other hazards; and (6) Increasing awareness on family planning and

delimiting migration in the municipality are possible ways of managing population growth rate.

CONCLUSION

Using STELLA Version 9.02, the factors affecting the self-sufficiency of tilapia in Minalin, Pampanga, Philippines were dynamically visualized. Available tilapia for local consumption was negatively affected by increasing population, change in capita consumption towards fish protein, reduction of available land for tilapia farming, poor water quality, diseases and extreme weather events such as typhoon. In order to lessen the compounding effects of the above mentioned factors, interventions such as technology adoption, management of population growth and reduction of land conversion rate were deemed effective. The local tilapia sufficiency was prolonged from 16 years to 19 years because of these interventions. In addition, 50% reduction in land conversion rate could extend the local sufficiency of tilapia until the 26th year.

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