Conservation Management Model of Subayang River in the Kampar Regency, Province of Riau based on Local Wisdom using Belida Fish (*Chitala* sp.) as Bioindicator

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Abstract. This research was conducted on Subayang River, located in Kampar Regency, Riau Province, Indonesia, from January to December 2019. This research aims to determine the physical and chemical water characteristics of the Subayang River and the trend of the Belida fish (*Chitalla* sp.) population for constructing a river conservation management model based on local wisdom. A water sample was acquired from the Subayang river on three stations (upstream, middle stream, and downstream) to investigate the water's physical characteristics. The water sample was collected on each station iteratively at three different points at the river stream's left, middle, and right sides. The trend of Belida fish population data was gathered from interviews with the fishermen. Moreover, interviews with the traditional figure of the society around the Subayang river were also conducted. Then, the conservation model of the Subayang river was constructed by analyzing the interview and the population of Belida fish results using a system dynamic model. The investigation of the water physical and chemical shows that the Subayang river has a suitable environment for the growth of Belida fish. However, the Belida fish population trend in the last four years tends to decrease. The existence of "*lubuk larangan*" and "*pantang larang adat*", local wisdoms that give a positive affection towards the Belida fish population. Those traditional rules can restrict citizens from doing illegal fishing activities that hardly affect the Belida fish population.

Keywords: *Chitala* sp., conservation, population, Subayang river, local wisdom.

1. Introduction

Belida fish (*Chitala* sp.) was categorized as a nearly extinct species according to IUCN Red List. Since 1980, the Indonesian authority has labeled Belida fish as a protected wild animal. The protection of Belida fish in Indonesia was then strengthened by some government regulations issued in 1999 and 2018. Nevertheless, several studies reported that Belida fish's existence tends to decrease and threaten its population (Kottelat et al., 1993; Setiawan et al., 2016). The main factors of the Belida fish population shrinkage are the massive fishing and the river's water quality, which worsens year by year (Wibowo, 2011).

Figure 1. Belida fish (*Chitala* sp.) was found in Subayang river.

Belida fish was commonly found on the rivers in Asia and Africa (Hubert et al., 2015; Setiawan et al., 2016; Kottelat & Widjanarti, 2005). In Indonesia, Belida fish can be found on the big rivers and their tributaries on Sumatera, Java, and Kalimantan (Sunarno et al., 2007). Belida fish was commonly used as the core ingredient on various dishes since it has tasty meat. In addition, it also furtherly processed to made some traditional cuisines like cracker and *pempek*, which made Belida fish have a high social and economic value (Santoso, 2009).

Subayang river is one of the rivers in Riau province where currently Belida fish population can be found. Subayang river is a tributary of Kampar Kiri river which empties on the Kampar river. The upstream part of the Kampar river is located on Bukit Barisan's hills and has a clear water stream that flows up to the Kampar Kiri river. Along the Sebayang river, there are 16 villages with their villagers that interact with the river. The villagers have commonly used the Subayang river as a transportation route, economic activities, and household activities. Traditionally, each of the villages on the riverbanks of the Subayang river have marks written as "*lubuk larangan*" on certain parts of the rivers, showing a fishing restriction on specific periods. In the province of Riau, several region which have "*lubuk larangan*" are Kampar regency, Kuantan Singingi regency, and Rokan Hulu regency (Darmadi & Suwondo, 2016). Generally, *lubuk larangan* was applied once a year.

Along with the time, the socio-economical situation of the society on the riverbanks affects the ecological condition of the Subayang river, including the life of Belida fish. The trend of ecological change theoretically can be illustrated by a model. The modeling method is expected to give insight into the effect of the society's local wisdom on the riverbanks on the population of Belida fish. Hence, this research explained the physical and chemical factors of the waters on Subayang rivers to figure out the trend of the Belida fish population.

Eventually, a conservation management model of the Subayang river was developed based on local wisdom.

2. Study area

This research was conducted along the Subayang river, estimated to be around 80 km from January to December 2019. As shown in Figure 2, the Subayang river was emptied on the Kampar Kiri river as the tributary of the Kampar river. There are 16 villages along the riverbanks of the Subayang river, which administratively belong to Kampar Kiri and Kampar Kiri Hulu districts, Riau Province, Indonesia.

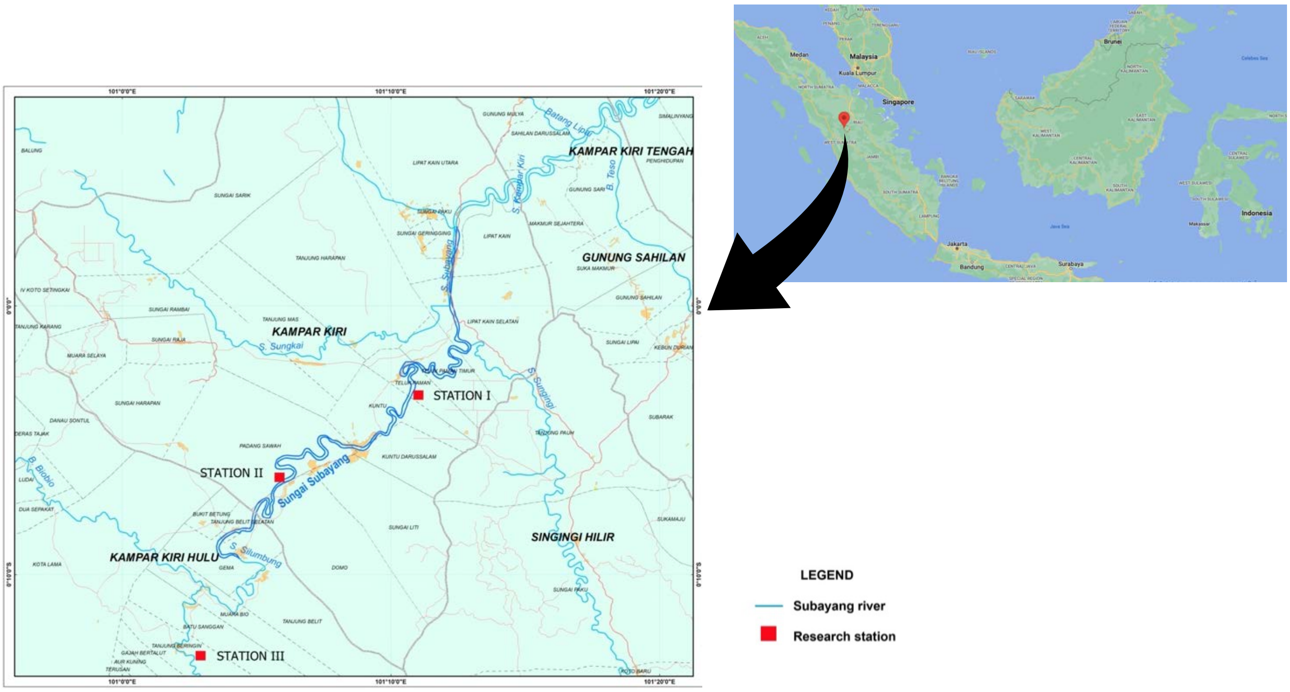

Figure 2. The map of the research location.

3. Materials and Methods

3.1. Measurement of Physical and Chemical Factor of the Rivers

A set of physical and chemical river water was iteratively acquired every month for one year on three stations representing the upstream, middle stream, and downstream of the Subayang river. The sample was taken from the left side, middle side, and right side of the rivers on each station. The observed physical and chemical factors consist of temperature, pH, *Dissolved Oxygen* (DO), turbidity, *Biological Oxygen Demand* (BOD), and *Chemical Oxygen Demand* (COD). The water temperature, pH, DO, and turbidity level was measured directly on the research site. Meanwhile, the BOD and COD measurement was performed in a laboratory managed by the Public Work Office of Riau Province. Table 1 outlined the parameters, equipment, and the waters physic-chemical analysis method used in this research.

Table 1. The parameters, equipment, and the waters physic-chemical analysis method.

Parameters	Measurement Unit	Equipment/ Analysis Method	Additional Information
Physical			
Temperature	^{0}C	Thermometer	*In Situ*
Turbidity	NTU	Turbidity Meter	*In Situ*
Chemical			
pH	-	Water Quality Meter	*In Situ*
BOD	mg/L	Titrimetric	Laboratory
COD	mg/L	Titrimetric	Laboratory

3.2. The Population Trend of Belida Fish

The data of the Belida fish population was obtained through interviews with the fishermen who performed direct observation when they performed a harvesting ceremony named "*panen lubuk*" on the last five years (from 2015 to 2019). The obtained data was then illustrated in graphical and tabular format for further analysis to gain an insight into the trends and inter-factors relations.

3.3. System Dynamic Modeling for Conservation Management

The system dynamic model was derived from the local wisdom of the villagers who live on the riverbanks of the Subayang river. That local wisdom was analyzed through observation and interviews. The results of the observation and interviews can reveal the local wisdom which has the most influence on the ecological condition of Belida fish and will be used as a modeling factor on the construction of system dynamic model.

3.4. The process of system dynamic modeling

The entire data obtained on this research was used as system components in the system dynamic model to illustrate each component's influence on the Belida fish population. The modeling activities were then performed by using Powersim Studio 10 software (Firmansyah, 2015). Figure 3 shows the procedure of system dynamic construction.

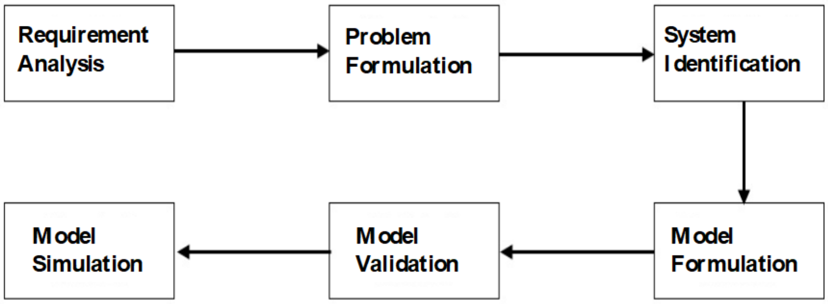

Figure 3. The procedure of system dynamic modeling, according to Firmansyah (2015).

Figure 4 below illustrates how each component is identified as part of the influence of each other directly or indirectly.

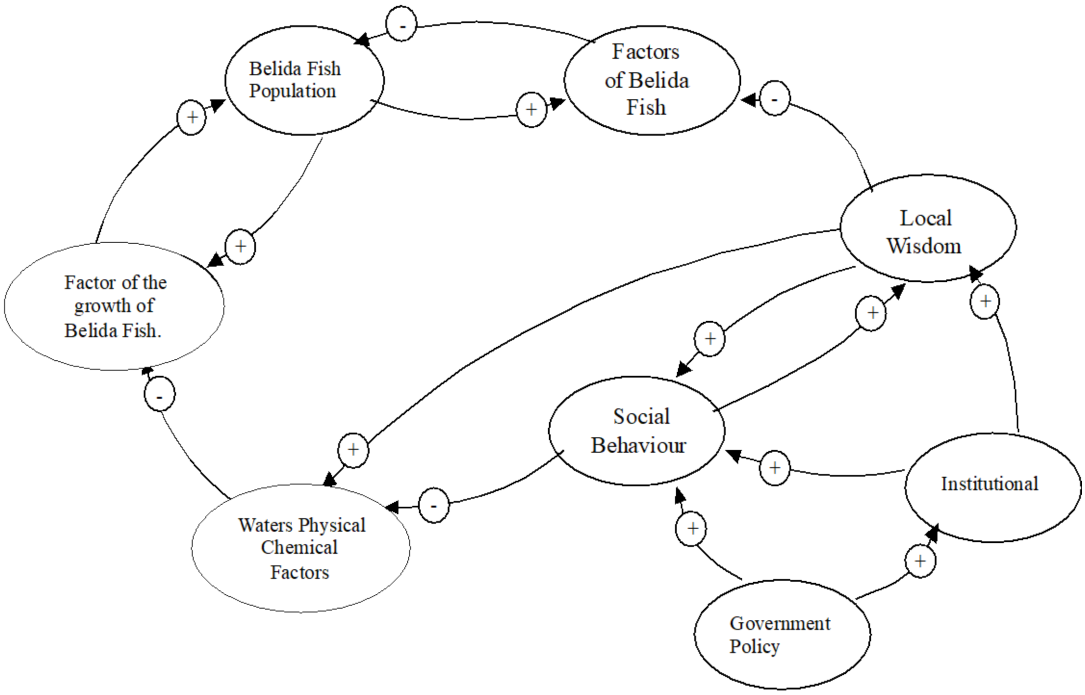

Figure 4. Causal loop diagram as the initial model of Belida fish population factors on Subayang River.

3.5. System Identification

In this phase, the causality relation was previously formulated using a causal loop diagram, was further transformed into a stock-flow diagram. The stock-flow diagram shows the function of each component within the system. Figure 5 shows a general model of stock flow.

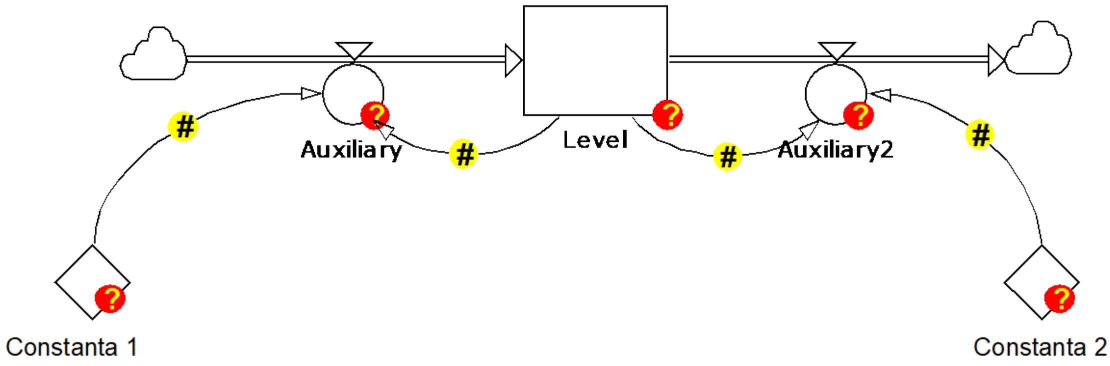

Figure 5. The general model of *stock flow diagram*.

3.6. Model Formulation

After the system model was constructed in the previous identification phase, the analytical result obtained with observation and interviews were assigned to the system model parameters. Even though this research was conducted in 2019, the data assigned to the level parameters were obtained in 2015. There are two underlying reasons. The first reason is the validation process (the phase after model formulation was performed by comparing the actual data available in the last five years with the projected data by system dynamic model. The second reason is related to the trend illustration. By overseeing the data from 2015, the simulation scenario after 2019 can give an insight into the trend of Belida fish population on every possible projection.

3.7. Model Validation

In this phase, the data assigned on model formulation was simulated for the five years (2015 – 2019). The changes of the data resulted from simulation then compared to the actual data on the same period. The comparison results are then used to justify the validity level of the constructed model. The formulation of model validation is outlined in Table 2. The model is valid if the value of both AME and AVE or at least one of them is less than 10%.

Table 2. The formulation of model validation.

Years	Real Data	System Dynamic Projection	Difference (%)	Percentage of Real Data	Percentage of System Dynamic Projection	(Percentage of Real Data)^2	(Percentage of System Dynamic Projection)^2
2015	X_1	Y_1	$(Y_1-X_1)/X_1$	X_1/X	Y_1/Y	$(X_1/X)^2$	$(Y_1/Y)^2$

2016	X_2	Y_2	$(Y_2-X_2)/X_2$	X_2/X	Y_2/Y	$(X_2/X)^2$	$(Y_2/Y)^2$
2017	X_3	Y_3	$(Y_3-X_3)/X_3$	X_3/X	Y_3/Y	$(X_3/X)^2$	$(Y_3/Y)^2$
2018	X_4	Y_4	$(Y_4-X_4)/X_4$	X_4/X	Y_4/Y	$(X_4/X)^2$	$(Y_4/Y)^2$
2019	X_5	Y_5	$(Y_5-X_5)/X_5$	X_5/X	Y_5/Y	$(X_5/X)^2$	$(Y_5/Y)^2$
Average	X	Y	AME			$(Xa/X)^2$	$(Y_a/Y)^2$
					AVE =	$((Y_a/Y)^2-(Xa/X)^2)/(Xa/X)^2$	

3.8. Model Simulation

The last phase of the methodological flow in this research is model simulation. In this phase, the trend of certain conditions overtime to the scenario was simulated. In this research, the experimental condition is the trend of the Belida fish population overtime based on the number of "*lubuk larangan*" scenario changes. The simulation result was then used to determine the recommended strategy as the conservation management model of Subayang river, which corresponds to local wisdom with Belida fish as Bioindicator.

4. Results and Discussion

4.1. Physical Factor of Subayang River

The measurement of physical and chemical was aimed to figure out the water quality of the Subayang river. There are six observed physical and chemical factors, namely water temperature, pH, *Dissolved Oxygen* (DO), turbidity, *Biological Oxygen Demand* (BOD), and *Chemical Oxygen Demand* (COD). Figures 6, 7, 8, and 9 and Table 3 show the measurement of the physical and chemical factors of the Subayang river.

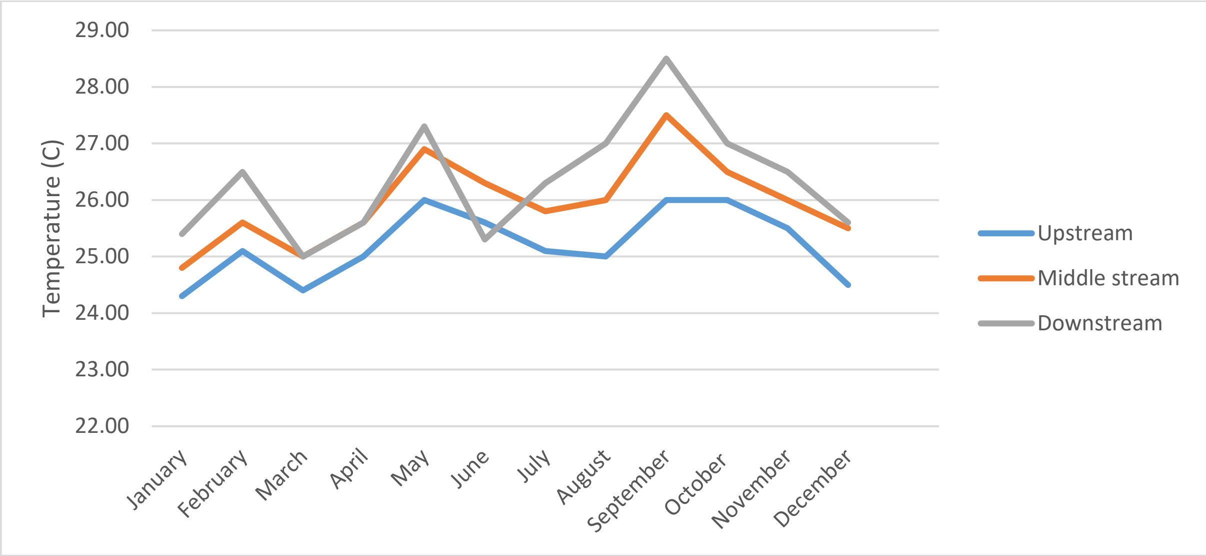

Figure 6. Water temperature of Subayang River during 2019.

As shown in Figure 6, the water temperature of the Subayang river is around 24.3 to 28.5°C. During 2019, the lowest and highest average water temperatures are 25.2°C and 26.3°C and belong to the upstream and downstream parts of the river consecutively. The lowest water temperature is 24.3°C and was recorded on the upstream in January. Meanwhile, the highest water temperature is 28.5°C and was recorded on the downstream in September. It showed that water temperature in Subayang river is suitable for aquatic biota life. Roberts (1992) stated that Belida fish will live well in the temperature range of 24 to 28°C.

Compared to other rivers in the province of Riau, the water temperature of the Subayang river is relatively low. For example, on the Siak river, according to Putri and Puryanti (2014), the water temperature is around 28.0 to 32.2°C. In addition to the Siak river, the waters on the reservoir of Hydolytic Power Plant, namely PLTA Kotopanjang, also have a higher water temperature than the Subayang river. The reservoir of PLTA Kotapanjang is located on the upstream Kampar river, and according to the report by Hasibuan et al. (2017) the water temperature on that reservoir is around 26.7°C to 33.3°C. Kampar River is the main river of the Subayang river. The lower temperature of the Subayang river compared to other rivers in Riau province is presumably due to its location. Subang river is located in the protected area of wildlife conservation Bukit Rimbang. Hence, the forest around the Subayang river is well maintained and has dense physiognomy with a wide canopy.

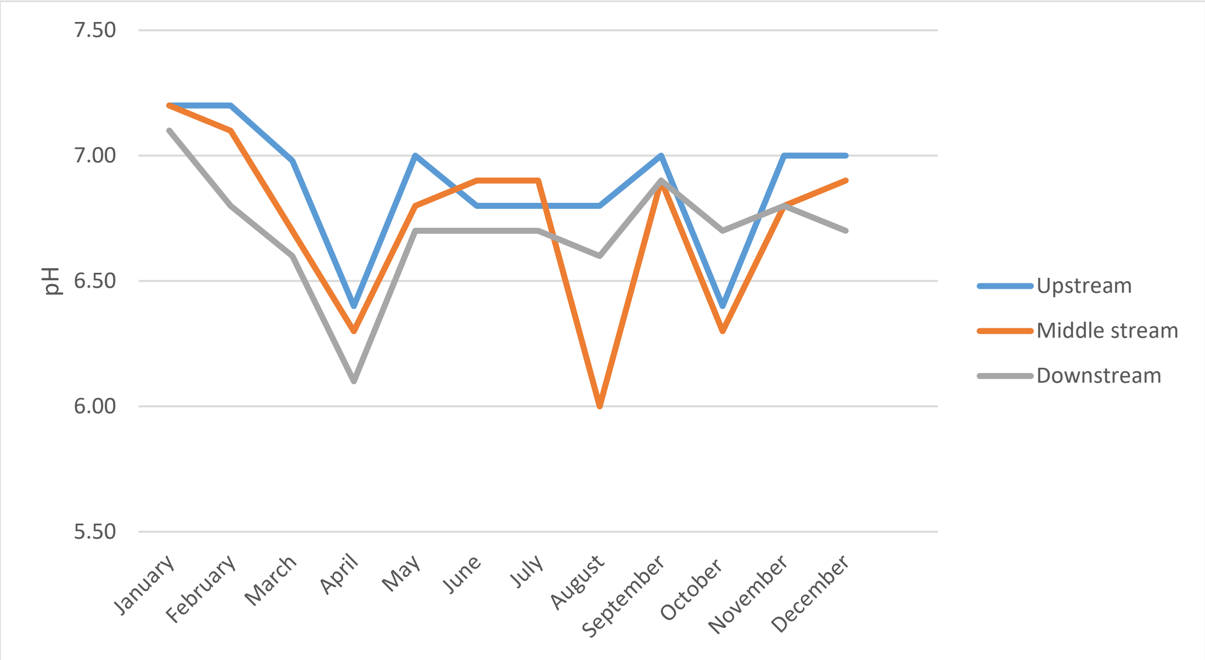

Figure 7. The pH of the water on Sungai Subayang during 2019.

Figure 7 shows the acidity level (pH) of waters on Subayang river, around 6.0 to 7.2. During 2019, the pH level of each upstream, middle stream, and downstream was relatively similar. The average value of pH level on upstream is 6.9. Meanwhile, the middle stream and downstream have the same value of pH average of 6.7. Adjie et al. (1999) and Wibowo and Sunarno (2006) reported that Belida fish could survive on waters with a minimum pH value of 4. A hypothesis proposed by Kristanto and Subagja (2008) presume that pH and water conductivity are related to the survival of the Belida fish egg.

The ideal pH level for most freshwater fish species is around 6.5 to 9.0 (Mitra et.al, 2018). The pH level beyond the ideal range will harm the freshwater fish's growth, survival, and reproduction ability and eventually lead to a high mortality rate (Kohinoor et.al, 2012). Various research reported that the water's pH level significantly influenced freshwater fish's growth and reproduction behavior (Gao et al., 2011; Sagar et al., 2012; Reynalte-Tataje et al., 2015). Physiologically, the pH change in the environment affected the fish in terms of its osmoregulation behavior (Bolner & Baldisserotto, 2007; Yanagitsuru et al., 2019). The abnormal pH fluctuation was also reported to negatively affect the growth and physiological condition of the fish (Zelennikov, 1997; Keinänen et al., 2003). The low pH level harmed the fish physiology and indirectly affected the survival of fish larvae (Keinänen et al., 2003).

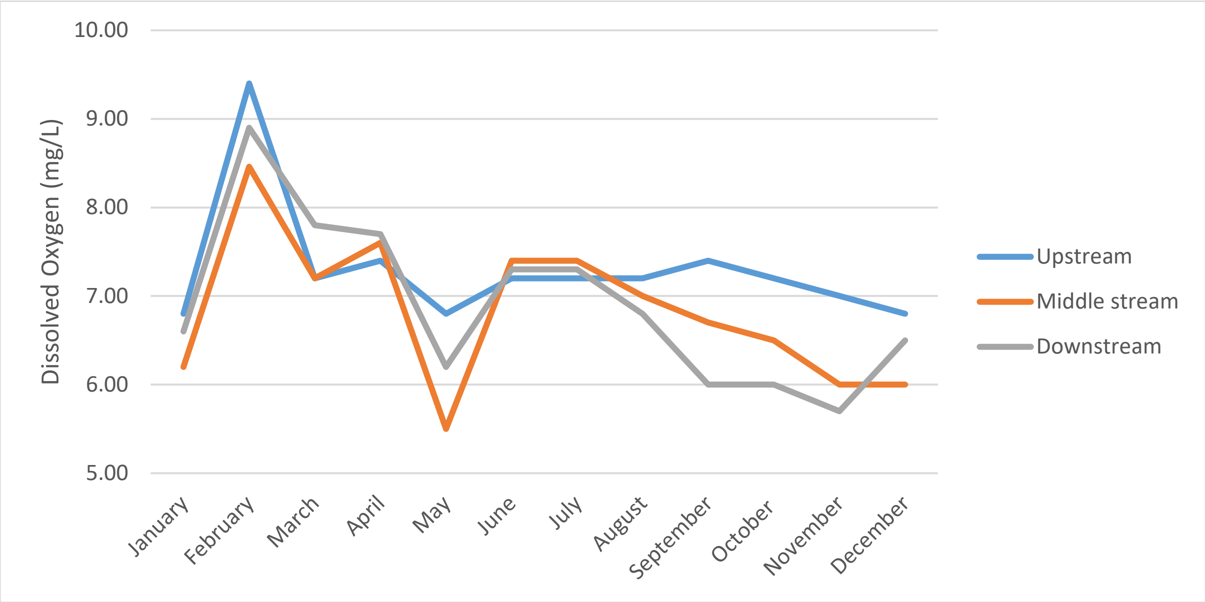

Figure 8. The dissolved oxygen on the waters of Subayang river during 2019

Figure 8 shows the level of DO on the Subayang river, which is around 5.5 to 9.4 mg/L. In 2019, even though the average value of DO on each part of the river was relatively similar, the DO level on the upstream was slightly higher than the middle stream and downstream of the Subayang river. The average DO level on each upstream, middle stream, and downstream is 7.3 mg/L, 7.1 and 7.2 mg/L, consecutively. The highest DO level on each upstream, middle stream, and downstream of Subayang river were recorded in February.

DO level is one of the critical factors of the environment, which significantly affects the fish life Mitra et al. (2014). Abdel-Tawwab et al. (2015) reported that the low level of DO on the water disrupted the growth, eating behavior, and innate immunity of the fish. Ecophysiologically, the low level of DO led to the behavioral change of the fish, including the change in activity, increasing operculum movement and surface breathing activity, and the niche habitat of the fish (Kramer, 1987). The lack of oxygen or hypoxia condition often led to the massive mortality of fish (Flint et al., 2015; Jeppesen et al., 2018). In addition, Wibowo & Sunarno (2006) reported that Belida fish could survive on waters with DO levels higher than 2 mg/L.

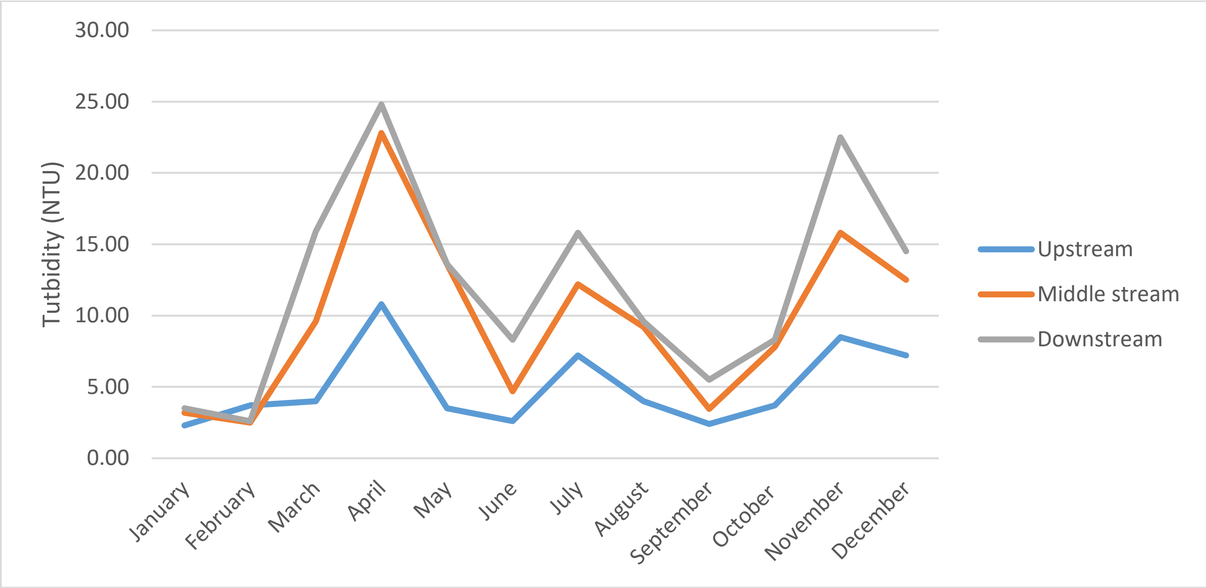

Figure 9. The turbidity level of the waters on Subayang river during 2019

Figure 9 shows the turbidity level on the Subayang river during 2019. The highest turbidity level of the waters on the Subayang river was recorded as 24.8 NTU in April downstream, and the lowest was recorded as 2.3 NTU in January on the upstream. During the observation period, the average turbidity level on the upstream was lower than the turbidity level on the downstream at the level of 12.1 and 5.0 NTU sequentially.

The high level of turbidity can harm the fish's gill structure and lead to the failure of the fish breathing system (Au et al., 2004). Furthermore, the high turbidity level also decreased the eating behavior and anti-predator ability and reproduction ability of the fish (Gray et al., 2012; Li et al., 2013; Kimbell & Morrell, 2015; and Nyanti et al., 2018). Ecologically, the high turbidity level is an obstacle to the sunlight penetration into the water, leading to the disruption of phytoplankton photosynthesis, which eventually decreases water fertility and productivity. The tolerable turbidity level of the waters for fish survival is around 25 NTU (Rowe et al., 2002).

The highest value of *Biochemical Oxygen Demand* (BOD) and *Chemical Oxygen Demand* (COD) is 3.72 and 10.39 recorded consecutively on the downstream and middle stream. The difference between COD and BOD values shows the high concentration of organic material in the water, which is biologically indecomposable. The higher the difference between COD and BOD value indicates that the water quality is getting lower. Ecologically, the high value of COD and BOD will decrease the DO level and disrupt the fish's growth in the waters (TVA, 2010; Chezhian et al., 2012; Mansour et al., 2017). Table 2 outlines the measurement result of BOD and COD on the Subayang river. Chezhian et al. (2012) and

Mansour et al. (2017) reported that the quality of the water is categorized as good if the value of BOD is less than 5 mg/L. Hence, the water quality of the Subayang river was still in good condition.

Table 3. BOD and COD value of the waters on Subayang river.

Physical-Chemical Factors	Upstream	Middlestream	Downstream	Average
BOD (mg/L)	1.61	2.62	3.72	2.65
COD (mg/L)	8.77	11.25	10.39	10.14

4.2. The Trend of Belida Fish Population

Figure 10 shows the trend of the Belida fish population on the Subayang river between 2015 and 2019. The population data of Belida fish were obtained from the fish collector collecting fish from the Fishermans around the Subayang river. Those collectors estimated the population trend of Belida fish based on the results of Belida fishing year after year.

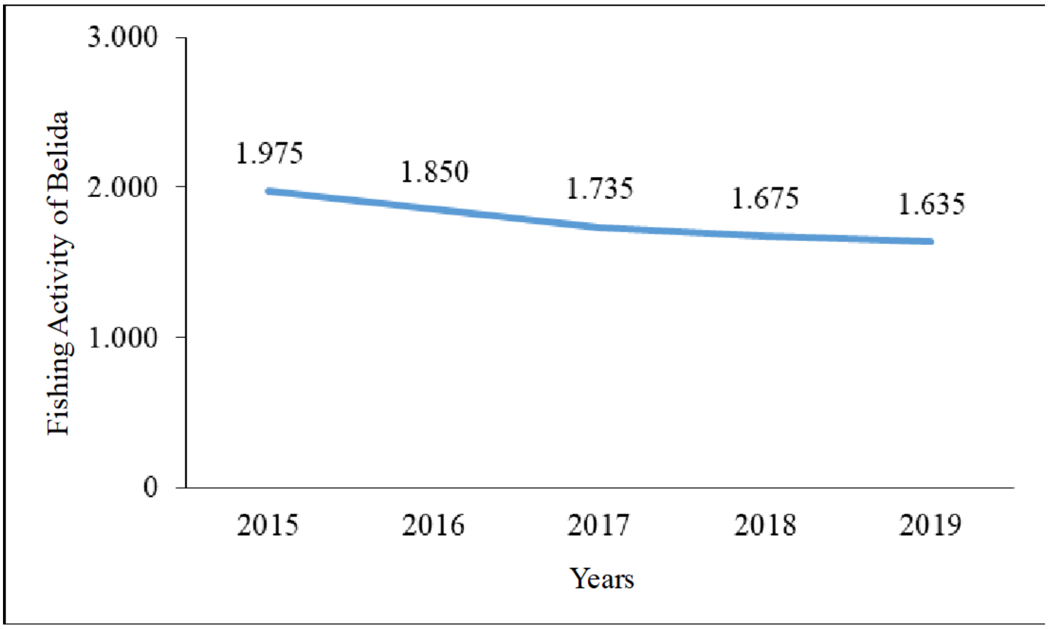

Figure 10. The trend of Belida fish population on Subayang river based on fishing activity results.

As shown in Figure 10, in the five years between 2015 and 2019, Belida fish fishing activity on the Subayang river tends to decrease. The range of decrement is between 2.4% to 6.3% or 4.6% each year by average. Nevertheless, the decrement percentage of the Belida fish population on the Subayang river is relatively lower than the decrement of the Belida fish population on the Kampar river and even at the national level. Ministry of Agriculture of the Republic of Indonesia (2000) reported that the annual production of Belida fish in Indonesia decreased from 8.000 tons at 1991 to 3.000 tons in 1998. Department of Fisheries and Marine Affairs (2008) also reported that Belida fish production in the Kampar river decreased from 50 tons in 2003 to 10 tons in 2007. Therefore, compared to the 4.6% per year at Subayang river, the decrease in Belida fish production at the National level (8.93% per year) and the Kampar river (20% per year) are higher.

4.3. System Dynamic Modeling for Conservation Management

4.3.1. *Lubuk Larangan*

Lubuk Larangan is a part of the river where fishing activity is prohibited during a specific period. Along the Subayang river, there are 16 locations of *Lubuk Larangan* in 2019. Table 4 outlines the locations of *Lubuk Larangan* on Subayang river. In addition to the 16 *Lubuk Larangan*, which is currently active, some Villages, namely Kuntu Darussalam and Desa Domo, also have *Lubuk Larangan* but are not actively operated.

Table 4. Locations of *Lubuk Larangan* on Subayang River.

No	Districts	Villages	Number of *Lubuk Larangan*
1	Kampar Kiri	Teluk Paman	0
2		Teluk Paman Timur	2
3		Kuntu Darussalam	0
4		Padang Sawah	1
5		Domo	0
6	Kampar Kiri Hulu	Tanjung Belit Selatan	0
7		Gema	0
8		Tanjung Belit	2
9		Muarabio	2
10		Batu Songgan	2
11		Tanjung Beringin	2
12		Gajah Bertalut	2
13		Aur Kuning	3
14		Terusan	0
15		Subayang Jaya	0
16		Pangkalan Serai	0
Total			16

Source: Respondents (2019).

4.3.2. System Dynamic Model of Belida Fish Population Change

The change of the Belida fish population on the Subayang river was influenced by various physical and chemical and social factors that played an integral part in river ecology. Figure 11 shows the causal loop diagram (CLD), which illustrates those factors to the Belida fish population. The constructed CLD for the Belida fish population on the Subayang river showed the affecting factors of the Belida fish population and their relationship with other factors. Those factors that influence each other will be analyzed and a base for constructing a stock-flow diagram (SFD). SFD construction aimed to predict the trend of population change based on physical and chemical factors and social factors presumed to influence the Belida fish population.

Figure 11, the CLD diagram shows the ecological factors, consisting of the Belida fish population and the water quality. Afterward, the social factors include villagers, local wisdom, *Lubuk Larangan*, waste production, traditional institutions, and government policy. Connecting lines illustrated the interactions between those ecological and social factors. From the CLD shown in Figure 11, it is clear that the ecological and social components influenced each other to determine the trend of the Belida fish population.

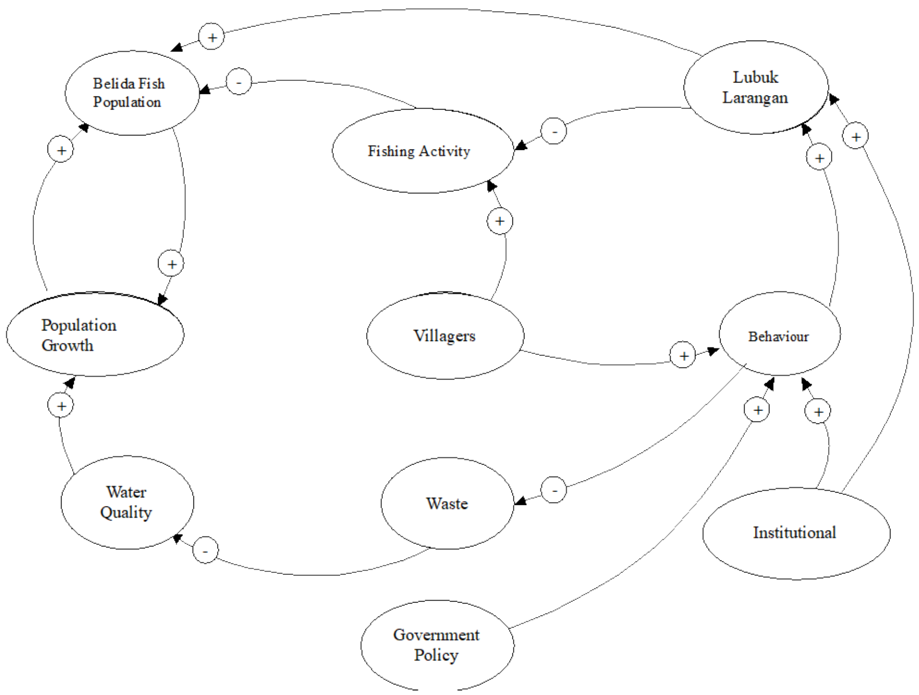

Figure 11. *Causal loop diagram* of influential factors to the Belida fish population on Subayang river .

After the construction of CLD, the next step was constructing the SFD. The SFD construction is based on analyzing factors that influence each other to the Belida fish population change shown in the CLD diagram. The SFD was used to predict the trend of change in the Belida fish population. Figure 12 illustrates the structure of SFD to predict the change in the Belida fish population and its influencing factors. The SFD diagram can be inferred from the influence of constant change on the level and other observed factors. The change applied to the constant was considered a possible scenario that can be implemented to a specific condition. That scenario aims to figure out the future trend which possibly occurred over the various factors.

From the SFD depicted in Figure 12, the future trend of the Belida fish population was mainly influenced by the villagers' population's growth, which subsequently influences the waste disposal behavior, waste production, water quality, and the growth of Belida fish. In addition, the existence of *Lubuk Larangan* also influenced the growth of Belida fish. Afterward, the influence factor of the Belida fish population-level decrement was the fishing activity, whether regular fishing or harvesting event on *Lubuk Larangan*.

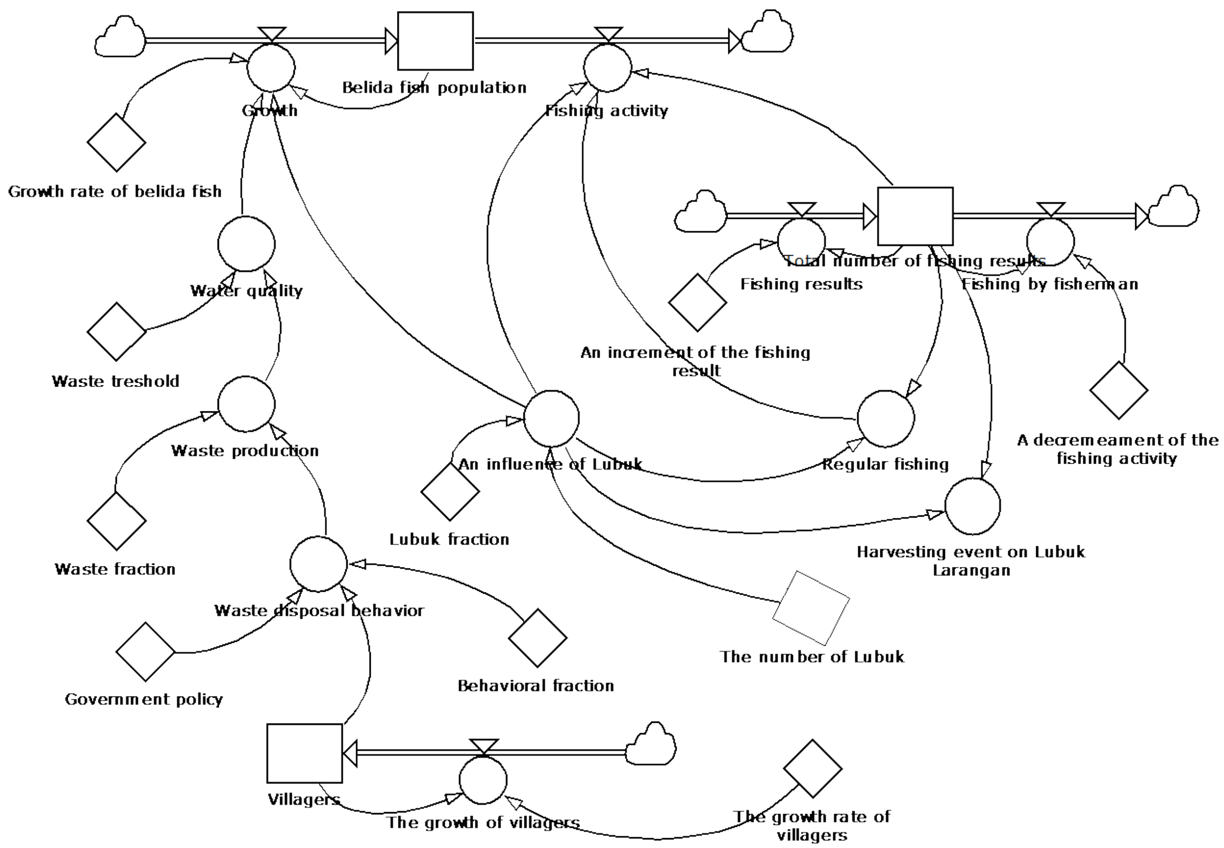

Figure 12. *Stock Flow Diagram* of the influential factor of the change of Belida fish population on Subayang river.

The constants employed in this research are the number of *lubuk*, a fraction of *lubuk*, a fraction of behavior, government policy, a fraction of waste, the boundary of waste and the growth rate of Belida fish (affecting Belida fish population), the growth of villagers (affecting villagers), and the decrement and increment of fishing activity (affecting total fishing results). The constant value assigned to the model can be found in appendix 1a. The validation of SFD results was then performed by comparing the SFD calculation with the total number of villagers obtained from Indonesia Central Bureau of Statistic (BPS) from 2015-2019 (https://www.bps.go.id) and the total fishing results of Belida fish between 2015 to 2019. From the validation process, the SFD constructed in this experiment has a validity level of AME and AVE of less than 10% (Appendix 1b).

After the SFD model was validated and verified, the next step was simulating the trend of the Belida fish population (ecological factor) corresponding to the change in the number of *Lubuk Larangan* (social factor). Figure 13 shows the trend of the Belida fish population in 20 years (2015-2035) using a fixed number of *Lubuk Larangan* (16 *lubuk*) scenarios. As shown in figure 13b, the continuous fishing activity of Belida fish, whether its regular fishing or harvesting event on *Lubuk Larangan* lead to the decrement of Belida fish population with equation $y = 10344x^{-0,096}$ with the time relation affect the change of population by 96.44%. The downtrend of the Belida fish population will continuously occur if no exact policies are formulated for the number of *Lubuk Larangan*, tradition, and waste disposal behavior over the river. The population of Belida fish will drop even further along with the growth of villagers. The growth of villagers' population will increase the disposal of domestic waste into the Subayang river, which lowers the water quality and harms the population growth of Belida fish.

A previous study showed that the local wisdom that directly positively impacts the Belida fish population was the existence of *Lubuk Larangan*. Ecologically, *Lubuk Larangan* provides a protected place and a safe period for the reproduction process of Belida fish. In addition, from a social perspective, *Lubuk Larangan* restricts the fishing area of Belida fish. Hence, the harvesting time on Belida fish on *Lubuk Larangan* was more effective than regular fishing activity. Therefore, the number of *Lubuk Larangan* was considered the defined scenario of local wisdom, potentially raising the Belida fish population. The quantity change scenario of Lubuk Larangan was performed by increasing or decreasing the number of *Lubuk Larangan*, which was simulated during a specific period. That defined scenario aims to infer the distinction of Belida fish population trend comparing to the fixed number of *Lubuk Larangan* scenarios with 16 *lubuk* in 2019.

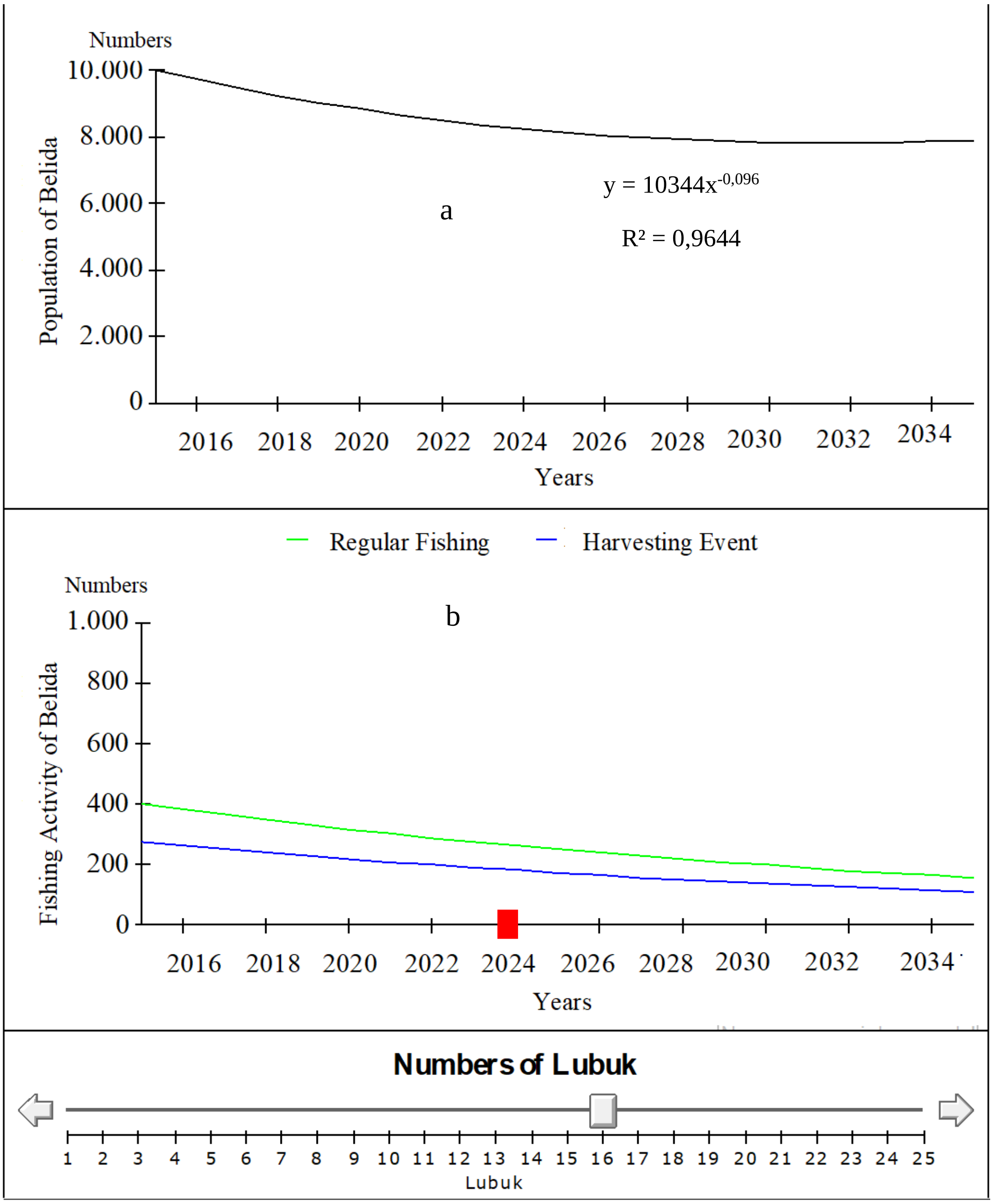

Figure 13. The trend of Belida fish population change with 16 *Lubuk Larangan*.

Figure 13 shows the trend of the Belida fish population with 16 *Lubuk Larangan* up to 2035. When the simulation was executed up to 2035 with an increasing number of *Lubuk Larangan* to 21 from 2021, the Belida fish population trend can be seen in Figure 14a. Meanwhile, Figure 14b illustrates the Belida fish population trend if the number of *Lubuk Larangan* was reduced to 10 lubuk in 2021.

Figure 14 shows that the increment and decrement of *Lubuk Larangan* affected the trend of Belida fish population on Subayang river compared to the fixed number of *lubuk* in 2019 (16 *lubuk*). Based on the simulation model, as shown in Figure 14a, if the number of

Lubuk Larangan was raised to 21 *lubuk* from 2021, the Belida fish population on the Subayang river tend to increase from 2021 to 2035.

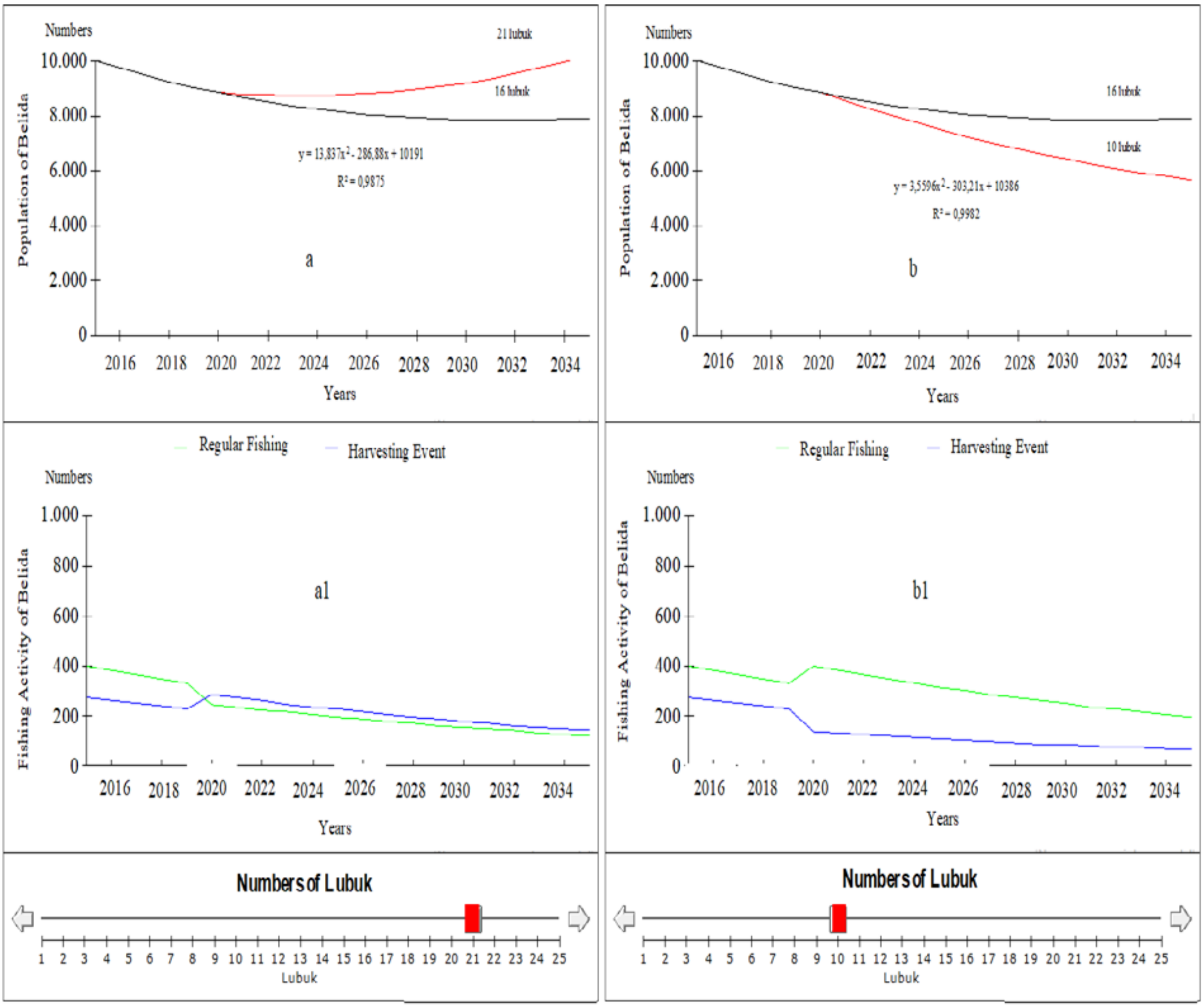

Figure 14. The trend of Belida fish population change with increment and decrement of *Lubuk Laranngan*.

5. Conclusions

The following conclusions were inferred based on the conducted observation and experiment.The physical and chemical factors of the Subayang river were in good condition for Belida fish's growth.The population of Belida fish on the Subayang river tended to decrease in the last 5 years.The local wisdom of Lubuk Larangan and Traditional Pantang Larang impacts the various positive aspects that influence the Belida fish population, such as reducing the illegal fishing activity of Belida fish by the villagers.

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Appendix

Appendix 1a. Constant value assigned to the system dynamic SFD using Powersim.

Number	Constant	Value	Notes
1	Waste threshold (mg/L)	5	Obeying the maximum threshold of BOD according to literature
2	Waste fraction (mg/L/person/year)	0.00072051	Calculated form standard of waste production of each person on each year than converted to occurred BOD if the wastes are disposed to the river.
3	Fraction of *lubuk* (%/*lubuk*)	2.550796553	Calculated based on the coefficient of the harvest results on *Lubuk Larangan* on each year compared to the total number of fishing activities than divided by the number of villagers
4	Behavioral fraction (%)	30	The number of villagers who dispose their waste to the river compared to the total number of villagers.
5	Operated policy (%)	0	This fraction was presumed with an analogy. Based on the obtained data, the villagers whom their village located around highway lead to the removal of waste disposal habit. Therefore, if there is highway construction, the fraction of waste disposal to the river is reduced.
6	The growth rate of Belida fish (%/year)	10	This assumption was obtained from the initial system dynamic simulation. Along with the annual downtrend of fishing results from 2015 to 2019, a 10% value was used. If the growth is getting higher, then the population tended to increase
7	The growth rate of villagers (%/year)	0.364721485	Calculated based on the annual data by BPS between 2015 - 2019
8	The increment of fishing results (%/year)	0	Can be assigned with the simulation if the number of fishing results is increased. However, from the observation in this research, there is no enhancement on each year.
9	The decrement of fishing results (%/year)	4.597900775	Calculated based on the results of Belida fish fishing activity on the last 5 years (2015-2019)

Appendix 1b. The validity test of system dynamic simulation using Powersim.

Villagers							
Years	**Data from BPS**	**SD**	**Validation**	**SD**		**Data^2**	**SD^2**
2015	12631	12631	0	115.2		12012.16	13271.04
2016	12665	12668	0.023687	78.2		5715.36	6115.24
2017	12777	12783	0.046959	36.8		1324.96	1354.24
2018	12812	12821	0.070247	74.8		5097.96	5595.04
2019	12818	12828	0.078015	81.8		5990.76	6691.24
Average	12740.6	12746.2				6028.24	6605.36
		AME<10 %	0.043782		AVE<10 %	9.57360689	

Total Results of Fishing Activity of Belida fish							
Years	**Real Data**	**SD**	**Validation**	**Data**	**SD**		**Data^2**
2015	679	679	0	69.2	59.4		4788.64
2016	636	648	1.886792	26.2	28.4		686.44
2017	596	618	3.691275	13.8	1.6		190.44
2018	576	590	2.430556	33.8	29.6		1142.44
2019	562	563	0.177936	47.8	56.6		2284.84
Average	609.8	619.6					1818.56
		AME<10 %	1.637312			AVE<10%	7.430054549