Fisheries development model to increase fish consumption in Tabanan, Bali

Budi Wardono¹, Risna Yusuf¹, Fauzan Ahmad², Estu Sri Luhur¹ and Freshty Yulia Arthatiani¹

¹Research Center for Marine and Fisheries Socio-Economics, Ministry of Marine Affairs and Fisheries, Jl. Pasir Putih 1, Ancol Timur Jakarta, Indonesia
²Senior modeler, system dynamics bandung bootcamp

E-mail: budi_ward@yahoo.com

Abstract Fish consumption level in Tabanan is lower than in other cities in Bali Province, because local habits, fish supply dependency from other regions, and the absence of fishing ports in that area. The research aims to increase fish consumption in Tabanan. The research was conducted in Tabanan Regency in May-June 2019. The data used are primary (fish farmers, fishermen, fish traders, and fish processing plants) and secondary data (fisheries statistics and statistics of Indonesia). Dynamic system approach was implemented, and several subsystems are considered: fish hatchery, fish farms, fishing, fish processing, and distribution between regions. The simulation is carried out with three scenarios: optimistic, pessimistic, and moderate/combined scenario. The results show that had no policy is implemented, the growth of fish consumption in Tabanan would always relatively be lower than provincial and national level. Increasing fish production by 4% annually from fishing and fish farming as optimistic scenario would enhance fish consumption in 2030 to 26.7 kgs/capita (group A/household) and 36.55 kgs/capita/year (if group A, B and C are included/household and non-household). The moderate scenario shows an improved performance than baseline and pessimistic scenarios.

1. Introduction

Food security is a strategic issue that concerns every country in the world. Food security is defined as a condition of fulfilling food for the state to individuals, which is reflected in the availability of sufficient food, both in quantity and quality, safe, diverse, nutritious, equitable and affordable and does not conflict with the religion, belief, and culture of the community live healthy, active, and productive in a sustainable manner. Based on this concept, the food security system in Indonesia comprehensively includes three sub-systems, namely: (i) food availability in sufficient quantities and types for the entire population, (ii) smooth and even distribution of food, and (iii) food consumption. Each individual who meets the adequacy of balanced nutrition [1]. Also state that food security at the regional level is determined by aspects of food availability, affordability, and utilization. According to Wiranthi et al. in 2014, policies that aim to improve education, access to credit, and intensive family planning have a major role in increasing household food security [2].

The aspect of food availability has been fulfilled, however, Indonesia is still faced with challenges in the use of food and nutrition. This condition indicates that people's consumption is not yet balanced, where carbohydrate intake is more dominant than protein. This condition creates nutritional problems in the community. Animal protein comes from livestock products (ruminant meat, poultry, eggs and milk) and fishery products (fish). The consumption of these animal groups increases every year [3].
Based on data from Food Security Agency in 2017, the proportion of food consumption from fishery products is greater than livestock products in 2013-2017 [4]. In 2017, the share of fish consumption was 53% of total animal food consumption, while the remainder (47%) came from livestock products. However, the growth in fish consumption tends to be lower (4.8% per year) than the growth in consumption of poultry meat which grows at 12.9% per year [5]. Meanwhile, according to Khomsan in 2010, people consider fish not yet occupying a strategic social position, which is used as an indicator of improving welfare [6].

Lack of public understanding of nutrition and the benefits of fish protein for health and intelligence is one of the factors driving the low fish consumption rate in Indonesia. This condition causes the behaviour in selecting fish as a source of protein in household consumption is still low. Indonesia's fish consumption rate reached 46.49 kg / capita / year in 2017 [7]. Indonesia's fish consumption is still lower than Japan which reaches more than 100 kg / capita / year, Singapore at 80 kg / capita / year, and Malaysia which reaches 70 kg/capita/year [8]. Apart from the problem of the low number of fish consumption, there are disparities in the level of fish consumption between regions. The lowest fish consumption rate in Java is 26.66 kg / cap compared to Maluku with the highest fish consumption rate of 51.87 kg / cap [9,10].

The low number of fish consumption is due to the low supply of fish, especially to inland areas, the technology for processing or preserving fish is not yet developed and distribution is still limited in terms of both quality and quantity [11]. To answer these challenges, industry can be a solution in increasing food security [12]. Fish is the main source of animal protein as indicated by contributing up to 40 percent of all animal protein consumed by the Indonesian population during 2005-2010 [13]. According to Arthatiani et al. in 2018, it shows that the participation rate of national household fish consumption reaches 87.92%, meaning that out of 100 Indonesians who consume fish, 88 people [10].

In the context of food security, fish is a strategic product, first because fish has advantages over other sources of animal protein; Second, the potential for fish production is very large; Third, the diversity of fish species is very high. Fourth, it saves energy as well as a source of energy. Fifth, the price is partly cheaper [14]. The low consumption of fish is caused by constraints in the aspects of food availability, affordability, and utilization. The industrial system from upstream to downstream can distribute fishery products to the community, so that fish consumption can increase.

Tabanan Regency has a low level of fish consumption when compared to other regencies / cities in Bali Province. Some of the contributing factors are the cultural habits of local people who prefer sources of animal protein from pork, and fish is not a staple menu. Fish availability is a problem because some of the fish demand comes from outside the region (especially catfish and fish as raw material for pindang). The unavailability of fishing ports causes fishermen to land fish at several landing points owned by fishermen. The problem of using water for fish farming is because water is prioritized for rice farming. Besides having limitations, Tabanan district has the potential to develop aquaculture. Tabanan Regency is the main producer of tilapia seeds, but only about 20% of the total 10 million seeds per year are grow out culture in Tabanan Regency. Most of the seeds are grow out farming for floating net cages in Lake Batur. The pindang fish industry is a source of processed fish in Tabanan Regency. The total production of pindang fish is 3 tons / day. Almost 100% of the raw materials for pindang fish come from outside the region. The pindang fish industry obtains raw materials from cold storage, the fish originating from outside the region. The potential for fisheries development is a challenge for the Fisheries Office to increase fishery production so that the fish needs of the people of Tabanan Regency are fulfilled.

Tabanan Regency has a food insecurity level of 5%, a fish consumption level of 11.51 kg / cap / year and a fish consumption participation rate of 80% [15]. Efforts to encourage increased fish consumption in Tabanan Regency, it is necessary to make a modelling analysis with a dynamic systems approach. Modelling by considering the existing fisheries sub-system in Tabanan Regency to increase fish consumption. Based on this background, the purpose of this study is to create a dynamic system modelling to increase fish consumption in Tabanan Regency.
2. Research Method

2.1. Research location and time
This research was conducted in Tabanan Regency, from May to June 2019. Primary and secondary data were used. Primary data were obtained from respondents of fish farming business actors, fishermen, product processors and traders. Sources of secondary data used are BPS Tabanan Regency, Department of Maritime Affairs and Fisheries Tabanan Regency. Focused discussions (FGDs) were conducted to obtain various information and alternatives for problem solving. Dynamic model analysis approach is used to solve the problem of this research.

2.2. Conceptions and Model Analysis
Dynamic systems modelling is useful for understanding a complex system over a period. Complexity can be caused by the many elements that make up a system (detail complexity), or because of the many linkages between the elements that make up the system (dynamic complexity). In a general social phenomenon that occurs is dynamic complexity caused by at least one of 3 problems: 1) policy resistance, policies implemented do not have the effect expected or even exacerbate the situation [16]; 2) there are trade-offs in time, where a policy only has a positive effect in the short term, but in fact has a negative effect on the long term, or vice versa; 3) sectoral trade-offs occur, in which policies towards improving the performance of a particular sector actually worsen the performance of other sectors.

The fishing industry is a system that has a high level of complexity. There are many linkages between the elements involved in the development of the fisheries industry, both in backward looking (such as the provision of industrial raw materials (capture fisheries and aquaculture) and forward looking (such as trading and marketing systems, as well as consumer preferences for processed fishery products). With the high complexity of the fishing industry, the systems approach is one method that can be used to solve complex, dynamic, and uncertain problems. According to Tasrif (2010) [17] and Sitompul (2009) [18], problems that can be accurately model using dynamic systems are problems. that: a). Has a dynamic nature (changes with time) and; b) The phenomenon structure contains at least one feedback structure.

In order to obtain a comprehensive model of the fisheries industry, a dynamic system methodology can be used based on the consideration of its ability to present the linkages between the elements (variables) studied and simulate the behaviour of the system if an intervention is made to the system. The assessment using the systems approach method includes the following stages: 1) system analysis; 2) system modelling; 3) system implementation; and 4) operating systems [19,20]. The research is based on two main things: 1) the status of the level of fish consumption per capita at the time of the study, the level of participation in fish consumption; and 2) contribution rate of fishery production (differentiated into capture fisheries and aquaculture fisheries). The dynamic model described is a fisheries model in Tabanan district with the following criteria: fish production sources from aquaculture and capture fisheries, food insecure status and a relatively low per capita fish consumption level.

The initial stage in developing the model is to formulate a conceptual model to be built. The components of the conception of the model include: goals, objectives, focus and direction of model development. The concept of the fishery industry model that is built includes the following components: a). Parameters of the system objectives to be achieved, namely the criteria that represent the expected system performance, namely the increase in fish availability and per capita fish consumption; b). The structure of the fisheries industry system consists of components which include: fish hatchery capacity, capture fisheries production, aquaculture production, pindang industry capacity, distribution system and per capita fish consumption; c). The policy scenario is an alternative policy which is expected to direct system performance based on the model structure towards achieving goals.

The initial assumptions in fisheries development modelling to increase fish consumption in Tabanan Regency, Bali Province are as follows:
a. The current Causal Loop Diagram, the main sub model is divided into (1) Capture and Aquaculture Production, (2) Cold Storage and the pindang industry, (3) Demand for both RT and Non-RT, and (4) Distribution mechanism, fish originating from outside regions, and Approaches to Consumption Figures per capita (including both non-households and households only).

b. The mechanism for bringing in fish from outside the region is determined based on meeting the needs of the RT first, then if there is any remaining domestic supply it will be compared with the need for the non-RT sector. If the supply is lower than the demand, it is possible that efforts will occur to bring in fish from outside the region.

c. Requests are divided into two, namely RT and non-RT requests. For household demand, the elasticity approach of GDP growth per capita to fish consumption demand is used with the initial figure used in 2014. Meanwhile, non-household demand is approached by the growth rate of the hotel sector and food and drink provision (percent per year) and the initial figure for 2014, a proxy for historical data.

d. Per capita consumption figures (including non-household) are used figures from Susenas-BPS processed by DITJEN PDS KKP, 2015-2017, while the per capita household consumption figures are used processed by Susenas 2017-BPS Processed by BBRSEKP (2019), where data is 2014, 2015, and 2018 is proxied from the existing trend assumptions (2016-2017).

e. The model has been validated for 6 main parameters, namely per capita Fish Availability (per capita consumption figure (including non-household), household per capita fish consumption (household per capita consumption rate), GRDP, Population, Pindang Fish Production, Capture Fisheries Production, and Aquaculture Production.

f. Policy aspects: fish hatchery, increased aquaculture and capture fisheries production, policies to bring in fish from outside the region and various other policies.

3. Results and Discussion

3.1. Identification Basic Model

The dynamic modelling process begins by identifying the existing conditions from the parameters in the model. Each sub model is built and developed based on the initial information available at this time (existing conditions). The modelling steps using a dynamic system, namely: Identify problems in the fishing industry current conditions. Identify the behaviour of the problem and map the problem based on data in the field. This variable is tested whether there is a significant relationship between one variable and another. In this step, a mental model is also created in the form of a Causal Loop Diagram (CLD) in Figure 1.
There are 4 main sub-models that are interrelated with each other in the Model, namely:

1. Production Sub model: The production sub-model is sourced from capture fisheries, aquaculture, and raw materials for industrial fishery production (represented by fish ponds) in Tabanan Regency. The production sub-model is simplified through a capture and aquaculture structure where production is determined by the average production and the trend of growth in capture and aquaculture production which is sourced from historical data.

2. Fishery Industry Sub model: The fishing industry sub-model is based on the phenomenon of cold storage (2 units with a capacity of 80 tons each) in Tabanan Regency and the pindang industry which gets raw materials from both cold storages. The pindang industry is the most dominant fishing industry in Tabanan Regency. The dynamics of the pindang industry are determined from the supply of raw materials from the production sub model and the input of raw materials sourced from outside Tabanan Regency, the production capacity of the scaling industry and the output / industrial output that enters the market.

3. Demand Sub model: The fish consumption demand sub-model is divided into two general groups, (1) household consumption and (2) non-household consumption (which is assumed to be for tourist consumption, as well as non-residents in general at the study location) which is generally influenced by two main drivers, namely the population (affects household consumption) and the economy /GDBR per capita (affects the consumption of residents and non-residents).

4. Distribution Sub model: In general, the distribution sub-model is a comparison between the supply demand for fish production and the fishery industry in Tabanan Regency, the supply in the production and fishery industry sub model is then compared with the demand sourced from the demand sub model. Lack of local supply ability to meet demand will be compensated by the amount of fish input that enters to meet fish demand.

**Figure 1. Causal Loop Diagram (CLD) Model.**
Based on this framework, the model was developed to answer the indicators of per capita fish availability \((A + B + C)\) and per capita fish consumption of the household (only \(A\)) through the flow of production, demand and distribution of fishery activity products and the processing industry. Some of the primary/secondary data used for the simulation came from several related agencies/stakeholders in Bali Province and Tabanan Regency.

3.2. General Characteristics of Fisheries in Tabanan Regency

The fishery industry in Tabanan Regency is aquaculture (enlargement and hatchery business), capture fisheries, and the pindang industry.

The fisheries potential of Tabanan Regency are as follows:
- Hatchery (UPR and BBI) = 117 units
- Pond aquaculture (tilapia, carp, catfish) = 2006 ha
- Mina Pady = 12,157 Ha
- Irrigation canals: 114.39 km
- Floating net = 50 units
- Capture Fisheries = 3,520 tonnes
- Processing RTP = 589 rtp

Fishery production in Tabanan Regency is dominated by aquaculture. Aquaculture production comes from ponds, rice mina and hatcheries. Tabanan Regency is the main producer of tilapia seeds, with a total production of 10,000,000 seeds per year. Most of the tilapia seeds for rearing are in Lake Batur, and only 10-20% are used by local farmers. Capture fisheries production is relatively small because there is no fishing port in Tabanan Regency. Fishermen in Tabanan are on a small scale with a fleet of vessels less than 5 GT. Efforts to increase capture fisheries production require government support to provide a Fish Landing Port (TPI), so that larger fishing boats can land fish at TPI.

Fish production and distribution systems affect the level of fish consumption in Tabanan Regency. The level of fish consumption in Tabanan Regency is still low compared to the level of Bali Province and the national level. The total fish distribution in Tabanan Regency based on field searches is 3,720 tonnes. This production is partly fish production in Tabanan and most of the fish originating from outside the region. Distribution of fish outside the usual area using refrigerated containers/cars. Fish consumption is influenced by population growth and GRDP growth in Tabanan Regency. Population growth and value of GRDP in Tabanan Regency as shown in Table 1.

| Year | Total Population | Increase population | Population growth (%) | GRDP per capita (IR/cap/year) |
|------|-----------------|---------------------|-----------------------|-------------------------------|
| 2011 | 682,670         |                     |                       | 9,739,094.40                  |
| 2012 | 688,135         | 5,465               | 0.80                  | 10,545,354.54                 |
| 2013 | 693,524         | 5,389               | 0.78                  | 11,530,340.81                 |
| 2014 | 698,825         | 5,301               | 0.76                  | 12,557,371.25                 |
| 2015 | 704,025         | 5,200               | 0.74                  | 13,798,656.90                 |
| 2016 | 722,479         | 18,454              | 2.62                  | 14,982,055.09                 |
| 2017 | 729,364         | 6,885               | 0.95                  | 16,207,041.79                 |

Source: [21]

The dynamic model framework was developed to answer indicators of per capita fish availability \((A + B + C)\) and per capita household fish consumption (only \(A\)) through the flow of production, demand and distribution of fishery activity products and processing industries. The secondary primary data used for the simulation came from several related agencies/stakeholders in Bali Province and Tabanan Regency.
3.3. Model Development

Based on CLD Based on these basic data, the model is developed based on four main sub-models. The dynamic model structure is shown in Figure 2.

![Model Diagram](image)

**Figure 2.** Basic model of fishery industry for increasing fish consumption in Tabanan regency

3.4. Components and Model Variables

Making a computer model of the fishing industry system (commonly called Stock Flow Diagram / SFD) is carried out based on a mental model that has been made based on existing theories and the results of discussions with stakeholders. In compiling a dynamic model based on information obtained in the field based on secondary data, the results of interviews with stakeholders and FGDs. Secondary
data used are capture fisheries production and aquaculture production and their potential (land area, source of irrigation, aquaculture business, hatchery business, fishing business, etc.).

Primary data related to business activities is obtained through interviews with business actors (aquaculture, capture fisheries, and processing industries). Information on the distribution of the number of traded fish was obtained based on observations and interviews with actors and the market (there is no secondary data available related to fish distribution data (in and out) from Tabanan Regency. Data entry into the model using Vensim software. Then the model is simulated with output in the form of graphs and tables that show the value of each of these variables after being simulated.

3.5. Fish Hatchery Sub Model
Fish hatchery sub model has a strategic position in the model. This sub-model is an input from the aquaculture sub-model which will then become a supplier of raw materials for the pindang industry. Currently, fish seed production is mostly used as a source of seed outside the region. Fish hatchery production is to meet the needs of domestic fish seeds and to meet markets outside the region. The quantity of seeds that are marketed outside the region. The ratio of fish hatcheries used in Tabanan Regency and those marketed outside the region is 1: 9. Meanwhile, fish hatchery production is very much determined by its survival rate and capacity. In this sub-model, fish hatchery survival rate is a constant whose magnitude is determined based on findings in the field. Meanwhile, the capacity is determined by the initial capacity which is determined at 10 million. Depreciation of fish hatcheries depends on the age of the business capital, which is 30 years. The expansion of fish hatchery capacity must be greater than the variables that have been formulated.

3.6. Fish Hatchery Sub Model
Fish hatchery sub model has a strategic position in the model. This sub-model is an input from the aquaculture sub-model which will then become a supplier of raw materials for the pindang industry. Currently, fish seed production is mostly used as a source of seed outside the region. Fish hatchery production is to meet the needs of domestic fish seeds and to meet markets outside the region. The quantity of seeds that are marketed outside the region. The ratio of fish hatcheries used in Tabanan Regency and those marketed outside the region is 1: 9. Meanwhile, fish hatchery production is very much determined by its survival rate and capacity. In this sub-model, fish hatchery survival rate is a constant whose magnitude is determined based on findings in the field. Meanwhile, the capacity is determined by the initial capacity which is determined at 10 million. Depreciation of fish hatcheries depends on the age of the business capital, which is 30 years. The expansion of fish hatchery capacity must be greater than the variables that have been formulated.

3.7. Aquaculture Sub Model
The aquaculture sub-model is in line with the capture fisheries sub-model, that the total aquaculture production is intended to be sold to the domestic market, used as raw material for the fish processing industry, and partly marketed outside of Tabanan. The total aquaculture production comes from aquaculture production in Tabanan Regency. Meanwhile, the supply of raw materials for aquaculture, apart from being determined by the quantity of aquaculture production, is also determined by the need for industrial raw materials and fraction of raw materials from capture fisheries.

3.8. Capture Fisheries Sub Model
Capture fisheries sub model has a significant role in analysing the quantity of fish entering the domestic market. The amount of capture fisheries production in the domestic market is the amount of capture fisheries production reduced by those marketed outside the region and its use as raw material for the capture fisheries industry. Capture fisheries production is very much determined by the magnitude of the trend of changes in capture fisheries production, while those marketed outside the region are determined by the fraction of capture fisheries which is a constant in the determined model of 0 Dmnl. Meanwhile, the use of capture fisheries products as industrial raw materials is determined
by the need for raw materials for the pindang industry and the fraction of raw materials for capture fisheries.

3.9. **Pindang Industry Sub Model**

Pindang Industry Sub model, pindang fish production is the multiplication of the pindang industrial capacity and the pindang CUF. The capacity of the pindang industry is determined by the amount of the initial pindang industry capacity plus its investment minus depreciation. Meanwhile, the CUF is a lookup function of the adequacy of raw materials. The initial pindang industry capacity is calculated by multiplying the pindang industry capacity per day with the operating time and the converter from month to year. The three variables that make up the pindang industrial capacity building are constants where the respective magnitudes are the pindang capacity of 10 tons per day, the operational time of the shading 25 days per month, and 12 months per year.

The adequacy of raw materials is determined by the number of cold storage stocks and the expected number of cold storage. The quantity of cold storage stock is the sum of the capacity with the cold storage input minus the sales. Meanwhile, the expected number of cold storage is determined by the multiplication of the pindang industrial raw material requirement with the sufficient time of pindang stock.

3.10. **Fish Adequacy Sub Model (Fish Distribution Sub Model)**

The fish adequacy sub-model is the ratio between the variable fish and fishery industrial products available to the variable demand for fish and fishery industrial products. Variables of fish and available fishery industrial products are influenced by fish stocks and fishery industrial products as well as the time of adequacy of stocks. Meanwhile, the variable demand for fish and fishery industrial products is calculated using the formula for relative GDP per capita ranked by the elasticity of GDP per capita multiplied by the initial per capita fish consumption and population. Some important constants in this sub-model are stock adequacy time of 1/12 year, GDP per capita elasticity of 0.75 Dmnl, initial per capita fish consumption of 9 kg / cap / year, and policy of additional raw materials of 0 Dmnl.

3.11. **Fish Consumption per Capita Sub Model**

The per capita fish consumption sub model is the ultimate sub model in the fishing industry model for increasing fish consumption. This per capita consumption variable will later become a reference for successful modelling and simulation. Fish consumption per capita is divided into household (A) and non-household (B + C) per capita fish consumption. The per capita household fish consumption variable is determined by the ratio between the difference between the supply of fish and fishery products and the consumption of fish for non-households compared to the population of the Tabanan population. Meanwhile, non-household fish consumption is determined by the multiplication of the percentage of non-household fish consumption and the supply of fish and fishery products. The supply of fish and fishery products is determined by the annual production of fish and fish imported from outside the region. Annual fish production is the sum of the production of the three fisheries sub-sectors that enter the market, namely aquaculture production, capture fisheries, and the pindang industry.

3.12. **Verification, Validation and Simulation**

Hartrisari in 2007 has done model testing with validation on models developed using system dynamics [20]. The model has been validated for 6 main parameters, namely Per capita Fish Availability (per capita consumption rate (including non-household), household per capita fish consumption (household per capita consumption rate), GRDP, Population, Pindang Fish Production, Capture Fisheries Production, and Aquaculture Production. The validation results are as in Table 2.
3.13. Fishery Industry Policy Scenario Simulation to Support Increased Fish Consumption

Policy aspects, namely: fish hatcheries, increased production, fish distribution policies from outside the region, and various other policies at this stage have been described and simulated / activated.

BASE scenario; is a scenario based on historical trends which is assumed to continue until the end of the simulation year in the model. In general, the assumptions in the Baseline conditions follow the previous, namely:

- Population growth rate of approximately 0.063% per year
- Economic growth rate averaging 5.87% per year
- The growth rate of the Food and Beverage Sector is an average of 7.5% per year
- Capture fisheries production rate is approximately 2.2% per year
- Aquaculture production rate is approximately 2% per year
- All of the pindang industry's raw material fractions come from outside the region (100%)
- The hatchery capacity of 10 million fish per year
- Fish fraction originating from outside the area for lack of fish demand is assumed to be 100%
- It is assumed that 46% of the total supply is allocated for non-household demand

The Baseline simulation produces the following behaviours:

Base simulation results are as shown in Figure 3. the following. Initial data from aquaculture production aspects show fluctuations in production until 2015, but in subsequent years it has increased. Policy simulations that can encourage higher fisheries production include utilization of fish

### Table 2. Validation of Key Indicators in the Model.

| Description                          | Time (Year) | 2014  | 2015  | 2016  | 2017  | 2018  |
|--------------------------------------|-------------|-------|-------|-------|-------|-------|
| The capacity of the pindang fish industry | model       | 3,000 | 3,000 | 3,000 | 3,000 | 3,000 |
|                                       | histories   | 3,000 | 3,000 | 3,000 | 3,000 | 3,000 |
| Fish availability per capita (ton/day) | model       | 2.2   | 19.04 | 18.2  | 15.3  | 15.23 |
|                                       | histories   | 20.2  | 19.15 | 17.46 | 15.25 | 15    |
| Fish consumption per capita (kg/cap/year) | model       | 12.7  | 19.04 | 18.2  | 15.3  | 15.23 |
|                                       | histories   | 12.7  | 12.1  | 11.51 | 10.98 | 10.5  |
| GRDP (IDR)                           | model       | 11,178,200 | 11,853,367 | 12,569,313 | 13,328,498 | 14,133,539 |
|                                       | histories   | 11,908,000 | 12,644,521 | 13,420,550 | 14,113,209 | -     |
| Population                           | model       | 432,886 | 435,622 | 438,347 | 441,144 | 443,932 |
|                                       | histories   | 432,886 | 435,574 | 438,279 | 441,000 | 443,500 |
| Pindang fish production (Ton)        | model       | 3,000  | 3,000  | 3,000  | 3,000  | 3,000  |
|                                       | histories   | 3,000  | 3,000  | 3,000  | 3,000  | 3,000  |
| Aquaculture production (Ton)         | model       | 4,022  | 3,005  | 3,394  | 3,358  | 3,356  |
|                                       | histories   | 4,022  | 3,057  | 3,394  | 3,314  |         |
| Capture fisheries production (ton)   | model       | 795    | 581    | 542    | 564    | 586    |
|                                       | histories   | 795    | 598    | 546    | 563    | 581    |
hatchery products, which were initially mostly sold to Lake Batur, then some of it must be grow out farming for aquaculture in Tabanan Regency.

Capture fisheries production, historical data, shows that production is still smaller than its sustainable potential. The simulation results show that until 2030 capture fisheries production shows a relatively small growth trend. This is due to the fact that in Tabanan Regency the available fleet is only outboard motorboats with a size of less than 10 GT. There is no fishing port (TPI) that can be used for landing fish using larger fishing boats. The availability of fish from aquaculture, capture fisheries and the total fish used as shown in Figure 3 shows how much the value of each of these variables is after the simulation.

The modelling system is built on sub-systems, there are strong interrelationships and interdependencies [22], Including the production facility subsystem, fishery business subsystem, fishery product processing subsystem, marketing subsystem, supporting facilities subsystem, income subsystem (fishing community and government), fisheries policy subsystem and policy subsystem.

Based on current conditions, if no policy is implemented, the estimated growth rate of household fish consumption in Tabanan Regency will be relatively low and will be increasingly left behind at both the provincial and national levels. The most dominant factor influencing consumers to consume fish is age [23]. The product development strategy that is carried out is to bring quality fresh fish closer, product development and various/types of processed with the right media, and closer to fish products at affordable prices.

Based on the results of existing data simulations, a policy scenario simulation is then carried out which may be implemented / operationalized in Tabanan Regency. The policy scenario carried out is the policy scenario which is still the domain of the duties and functions of the Ministry of Marine Affairs and Fisheries or the Office of Marine Affairs and Fisheries in Provinces and Districts.

The impact of the policy scenario affects the amount of fish consumption per capita in Tabanan Regency (Figure 4). Additional fish availability from increased local production (aquaculture and
capture fisheries) has an impact on the amount of fish consumption per capita. The biggest policy impact is in a scenario where the growth rate of capture fisheries and aquaculture production is 4% per year. If this policy is implemented, fish consumption in 2030 will increase to 26.7 Kg/capita (especially for households /A), and fish consumption will reach 36.5 Kg /capita /year when including non-household consumption (B + C).

Figure 4. Policies Scenario Impact on the Number of Fish Consumption Per Capita/year.

Efforts to increase the availability of fish in Tabanan Regency are still facing several problems, including facilities (fishing boats and fishing ports), human resources, water supply is prioritized for food crops rather than for aquaculture. This has resulted in a high dependence on fish supplies from outside the region. Efforts to increase fishery production (aquaculture and capture) must be a priority of the Tabanan Regency Marine and Fisheries Service program, so that the availability of fish for community consumption is fulfilled. The three aspects of efforts to increase fish consumption, namely availability, affordability and utilization, constitute an integrated effort to increase fish consumption in Tabanan Regency.

Industrialization activities face at least 4 (four) main problems [24], namely: a) raw materials: continuity of availability and quality of raw materials; b) quality assurance: for raw materials, products, quality certification and traceability; c) customer service: conformity of products to customer demand, availability of product supply to consumers, delivery of products in the right quantity and time; d) technological capabilities.

In line with efforts to increase fish supply, several studies in Indonesia have been carried out. Access, terrain conditions, and quality that are not guaranteed because they still use conventional transportation modes are logistical problems that cause the distribution system to be inefficient [25]. The development of the fishery industry in Konawe Selatan Regency is influenced by factors of technology, human resources, and local government regulations [26]. It is recommended to district governments to stimulate technological and regulatory factors that are proven to be able to increase capture fisheries production by increasing the number of catches. The addition of skilled labour is able to increase the GRDP of South Konawe Regency. Indonesia only ranks 6th out of 8 countries in Southeast Asia based on the level of fish consumption per capita [8]. The inequality of fish consumption in Java and outside Java is very high. According to Virgantari in 2012, the highest consumption of fresh fish is in Sulawesi and Maluku, the lowest is in Java [9]. In 2012-2018, the figure for fish consumption in Java Island was much lower than in other islands [7,10]. There are two strategies for developing a fisheries business system [27], namely, to provide fisheries farming system, starting from seed production to nursery and grow-out culture activities, as well as to develop provider of business inputs; and to improve existing fisheries farming system in the areas nearby to supply the needs of fish consumption in food shortage locations.
4. Conclusion
Efforts to increase fish consumption in Tabanan Regency have been carried out in various ways. Increasing production is one of the efforts made to increase the availability of fish in Tabanan Regency. In addition to increasing fish availability, efforts to increase fish production in Tabanan Regency also aim to reduce dependence on fish supplies from outside the region. The policy scenario carried out is the scenario of efforts to increase fish production (aquaculture and capture fisheries) by 4% per year starting in 2020. These efforts can increase fish availability while encouraging an increase in fish consumption to 26.7 kg/cap/year (specifically for consumption household (A)) and becomes 36.55 kg/cap/year when calculating consumption non the household (A + B + C). If these efforts are not carried out, the level of fish consumption in Tabanan Regency will always be left behind with other regions.

References
[1] Suharyanto H 2011 Food security [in Bahasa Indonesia] J. Sos. Hum. 4 186–94
[2] Wiranthi P E, Suwarsinah H K and Adhi A K 2014 Determinants of household food security: a comparative analysis of Eastern and Western Indonesia Indones. J. Agric. Sci. 15
[3] Muzayyanah M A U, Nurtini S, Widiati R, Syahlani S P and Kusumastuti T A 2017 Household decision analysis on animal protein food consumption: Evidence from DI Yogyakarta Province Bul. Peternak. 41 203–11
[4] Food Security Agency 2017 Food Security Statistics 2017 (Jakarta: Ministry of Agriculture Republic Indonesia)
[5] Food Security Agency 2018 Food Security and Vulnerability Atlas (Jakarta: Ministry of Agriculture Republic Indonesia)
[6] Khomsan A 2010 Food and Nutrition for Health [in Bahasa Indonesia] (Jakarta: PT Rajagrafindo Persada)
[7] Ministry of Maritime Affairs and Fisheries Republic of Indonesia 2018 Fish Consumption Per Capita [in Bahasa Indonesia] (Jakarta: Ministry of Maritime Affairs and Fisheries Republic of Indonesia)
[8] Yee C, Tran N, Dao C D, Sulser T B, Phillips M J, Batka M, Wiebe K and Preston N 2017 Fish to 2050 in the ASEAN region (Washington, D.C)
[9] Virgantari F 2012 Scenario of Projected Fish Consumption per capita in Indonesia [in Bahasa Indonesia] Prosiding Seminar Nasional Riset dan Kebijakan Sosial Ekonomi Kelautan dan Perikanan Tahun 2012 : Peran Hasil Penelitian Sosial Ekonomi dalam Mendukung Pembangunan Kelautan dan Perikanan Untuk Merespon Tantangan Kontemporer (Jakarta: Marine and Fisheries Socio-Economic Research Center)
[10] Arthatiani F Y, Kusnadi N and Harianto H 2018 Analysis of consumption patterns and models of fish demand according to household characteristics in Indonesia [in Bahasa Indonesia] J. Sos. Ekon. Kelaut. dan Perikan. 13 73–86
[11] Ronny 2014 West Sumatra Provincial Government Encourages People to Increase Fish Consumption [in Bahasa Indonesia]
[12] Hariyadi P 2014 Food Industry: Responding to the Challenge of Independent and Sovereign Food Security [in Bahasa Indonesia] Foodreview Indones. 9 22–4
[13] Food Security Agency 2012 2011-2015 Food Diversification Roadmap [in Bahasa Indonesia] (Jakarta: Ministry of Agriculture Republic Indonesia)
[14] Hutagalung S 2012 Food security and increased fish consumption [in Bahasa Indonesia] War. Pasar Ikan Maret 2012
[15] Statistics Indonesia 2016 National Socio-Economic Survey Central Bureau of Statistics [in Bahasa Indonesia] (Jakarta: Statistics Indonesia)
[16] Sterman J D 2000 Business Dynamics : System’s Thinking and Modelling for Complex World (London: Irwin/Mc Graw-Hill)
[17] Tasrif M 2010 Policy Analysis Using the System Dynamics Model [in Bahasa Indonesia]
(Institut Teknologi Bandung)

[18] Sitompul R F 2009 *Designing a Rural Community Development Model With a System Dynamics Approach [in Bahasa Indonesia]* (Jakarta: Lembaga Ilmu Pengetahuan Indonesia)

[19] Eriyatno 2003 *Systems Science, Improving Quality, and Management Effectiveness [in Bahasa Indonesia]* (Bogor: Institut Pertanian Bogor)

[20] Hartrisari 2007 *System dynamics: systems concepts and modeling for industry and the environment [in Bahasa Indonesia]* (Bogor: SEAMEO BIOTROP)

[21] Central Bureau of Statistics of Tabanan Regency 2019 *Tabanan Regency in 2018 figures [in Bahasa Indonesia]* (Jakarta: BPS - Statistics Indonesia)

[22] Mudiastuti R D, Nur T and Sudirman S 2014 Politan marine industry policy strategy to support the mamminasata concept: a conceptual model with a dynamic systems approach [in Bahasa Indonesia] *J. Eng. Manag. Ind. Syst.* 2

[23] Sokib N, Palupi N S and Suharjo B 2012 Strategi Peningkatan Konsumsi Ikan di Kota Depok, Jawa Barat *Manaj. IKM J. Manaj. Pengemb. Ind. Kecil Menengah* 7 166–71

[24] National Development Planning Agency (BAPPENAS) Indonesia 2016 *Strategic Study of Fishery Industrialization to Support Regional Economic Development* (Jakarta: Deputy for Maritime Affairs and Natural Resources)

[25] Insani A G R 2020 *Desain Model Kajian Strategi Industri Perikanan Untuk Mendukung Peningkatan Pembangunan Ekonomi Wilayah Selatan Jawa Timur Dengan Pendekatan Soft System Methodology (SSM)* (Institut Teknologi Sepuluh Nopember)

[26] Kholil M and Dwiharyadi D 2007 Model Simulasi Pengembangan Industri Perikanan di Konawe Selatan Dengan Pendekatan Sistem Dinamik *Bulletin* 13 27–43

[27] Hikmayani Y, Hafsiaridewi R and Purnomo A H 2017 Identifikasi Strategi Intervensi Sistem Usaha Perikanan Untuk Meningkatkan Pasokan Ikan di Lokasi Rawan Pangan *J. Sos. Ekon. Kelaut. dan Perikan.* 5 47–63