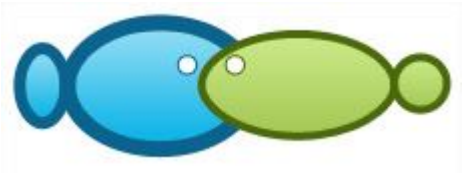

The strategy of capture fisheries development in Pamekasan Regency, Madura Island

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Abstract. An effective capture fisheries strategy in Pamekasan Regency needs to be implemented for job creation, food security, and economic growth. Pamekasan Regency is a coastal regency located on Madura Island, Indonesia. The purpose of this study was to develop a capture fisheries development strategy in Pamekasan Regency. We used several analytical methods, including maximum sustainable yield (MSY), SWOT analysis and TOWS matrix. This study used several data, including statistical data, observations and interviews. Interviews were conducted involving keypersons and 30 fishermen as respondents. The research revealed that the waters of Pamekasan Regency have experienced overfishing. We recommend some capture fisheries development strategies including: diversification of fishermen family businesses, optimization of fish auction place, regulation of fishing gear, development of the fish processing industry, climate change mitigation, fisheries resources research, extension and empowerment of coastal communities. The implementation of these strategies can be applied in future fisheries policy.
Key Words: fisheries strategy, MSY, SWOT analyis, TOWS matrix, Pamekasan Regency.

Introduction. The capture fisheries sector has a strategic role for Pamekasan Regency. Fishing became one of the main livelihoods of coastal communities in Pamekasan Regency. In 2018, there were 10,619 fishermen in Pamekasan Regency. This amount is greater than other types of coastal community professions, such as sea salt producers (1,461 person), fish processors (344 person), seaweed (*Eucheuma cottonii*) cultivators (101 person), shrimp farmers (23 person) and milkfish farmers (30 person) (Fisheries Department of Pamekasan Regency 2020). Small-scale fisheries are the main source of seafood production in the world. Small-scale fisheries in the world also have a vital role in job creation, livelihood sources, food security and poverty reduction especially in low-income countries (Yuerlita 2013; Murshed-e-Jahan et al 2014; Purcell et al 2014; Ishengoma 2016; Pathmanandakumar 2017). Therefore, capture fisheries business has a crucial role in the development of Pamekasan Regency, both related to employment, poverty reduction, food security, and economic growth.

Regional development requires the right strategy. Strategy is a way to achieve objectives, including short-term goals and long-term goals. Strategy is a way to create the future (Vasilevska & Vasić 2009). In the Medium-Term Development Plan of Pamekasan Regency (based on Regency Regulation No. 9 of 2019), a development vision has been set, namely "Pamekasan Regency is a developed, prosperous and highly competitive regency by relying on sustainable agriculture and fisheries according to the God's will". Therefore, the capture fisheries development strategy in Pamekasan Regency has an important role in realizing the development vision and mission of Pamekasan Regency.

The research purpose was to develop a capture fisheries development strategy integrated with purposive strategic value for Pamekasan Regency. The strategy needs to take into account the conditions of the external and internal environment including political, regulation, economic, social, technology, and natural resources. The characteristics of fish resources in the waters area of Pamekasan Regency and the socio-

economic characteristics of fishermen need to be a key study in the development of capture fisheries development strategies in Pamekasan Regency.

Material and Method

Research location. This study was conducted in Pamekasan Regency from May to June 2020 (Figure 1). Pamekasan Regency is located on Madura Island with coordinates at 113°19'-113°58' East Longitude and 6°51'-7°31' South Latitude (BPS-Statistics of Pamekasan Regency 2019a).

Figure 1. Pamekasan Regency map.

The type of data and data analysis. The research data were obtained from several government agency documentation, including Fisheries Department of Pamekasan Regency, BPS-Statistics of Pamekasan Regency and Development Planning Agency of Pamekasan Regency. The results of survey and discussions conducted with key persons (formal and informal figures) and interviews with 30 fishermen were also taken into the analysis due to the data collected in developing the strategic value.

Data analysis was performed through descriptive quantitative approach. Maximum sustainable yield (MSY) estimation used the Schaefer model. Strategy development used SWOT (strengths, weaknesses, opportunities, and threats) analysis and SWOT matrix. SWOT analysis is the analysis method most widely used by managers and policy makers in developing strategies. Some researchers in the previous studies have also used this method, including: Oreski (2012), Viegas et al (2014), Aspan et al (2015), Wijayanto (2016), Furqan et al (2017), and Wijayanto et al (2019).

Results and Discussion. Pamekasan Regency has a coast length of 34 km in the south and 18 km in the north (BPS-Statistics of Pamekasan Regency 2019a). In general, the southern regions of Madura Island (including Pamekasan Regency) are more densely populated than the northern regions, while the central regions tend to have the least population density. This condition had already occurred at the beginning of the 19th century (Kuntowiyono 2017). This is due to the interrelated social-economic relations between Madura Island and Java Island (it is located in the south area of Madura Island),

where Java is the economic center of Indonesia. Madura Island and Java Island have also been connected with the bridge of Suramadu (acronime for Surabaya and Madura) which was inaugurated first time for public on June 10, 2009. In 2018, the population of Pamekasan Regency was 871,497 people. The average population growth of Pamekasan Regency is around 1.08% per year (BPS-Statistics of Pamekasan Regency 2019a) and the average economic growth is 5.5%.

The progress of macro-economy. Economic growth needs to be pushed higher than population growth to increase gross domestic product (GDP) per capita as an indicator of community welfare (Table 1). In general, Pamekasan Regency's economic growth is higher than the national economic growth as it has an average of 5.1% per year. Whereas gross regional domestic product (GRDP) of Pamekasan Regency is still below the average of regencies and cities in East Java province. GRDP of Pamekasan Regency is even the smallest on Madura Island (BPS-Statistics of East Java Province 2019). According to the Brückner & Schwandt (2013) study, the population has a relationship with GDP per capita, more exactly the population growth has a negative correlation with GDP growth per capita.

Table 1

The progress of economic and population in Pamekasan Regency

Indicators	*2014*	*2015*	*2016*	*2017*	*2018*
Population (person)	836,224	845,314	854,194	862,914	871,497
Population growth (%)	1.07	1.09	1.05	1.03	1.04
GRDP base on current price (IDR trillion)	11.07	12.30	13.53	14.64	15.95
Economic growth (%)	5.62	5.32	5.35	5.04	5.46
The contribution of agriculture, forestry, and fisheries in the GRDP based on current prices (%)	35.96	35.84	35.11	33.77	32.71
GRDP growth of agriculture, forestry and fisheries (%)	4.45	3.79	3.26	0.43	1.60
Fisheries economic growth (%)	7.64	6.79	6.19	5.41	3.02

Source: BPS-Statistics of Pamekasan Regency (2019b), Regency Regulation No. 9 of 2019.

The combined contribution of the agriculture, forestry, and fisheries sectors to the GRDP of Pamekasan Regency is the largest (above 30%). This shows that the economic dependency of Pamekasan Regency is relatively high in the sector. However, the combined agriculture, forestry and fisheries experienced a slowdown in economic growth, while the fisheries sector have aggressive growth with an average growth of 6.6% per year. This shows that the fisheries sector is the prime mover of economic development in Pamekasan Regency. It is the occupation with the largest basis in Pamekasan Regency.

The progress of capture fisheries. Capture fisheries in Pamekasan Regency have a dominant role compared to aquaculture and fisheries processing. In addition to significant employment, capture fisheries also contribute significantly to production (Table 2).

Table 2

The progress of fisheries production of Pamekasan Regency

Indicators(tonnes)	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Marine capture fisheries	20,286	22,522	24,392	23,689	21,689	19,554
Brakish water culture production	535	572	564	628	705	232
Pond culture production	311	601	716	337	1002	451
Marine culture production	312	196	211	277	138	104
Sea salt production	82,500	89,282	123,534	3,208	54,831	128,247

Source: Regency Regulation No 9 of 2019.

Capture fisheries in Pamekasan Regency are dominated by small-scale fishing businesses that use outboard motorboats (Table 3). Other terms for small-scale fisheries include:

artisanal, local, coastal, traditional, small, subsistence, non-industrial and low tech fisheries (Pathmanandakumar 2017). Small-scale fishing business has characteristics including limited capital, fishing areas in coastal waters, one day fishing, and small fishing capacity. Some of the fishing gear used by fishermen with a small-scale business in Pamekasan Regency include gill net, trammel net, trap ('bubu'), fishing line, boat lift net and cast net. While the fishing gear that produces the largest production for Pamekasan Regency is purse seine (Figure 2). Purse seine, surface Danish seine, and bottom Danish seine in Pamekasan Regency are included in the medium-scale fishing business using vessels of 20 to 30 GT.

Table 3

Fishermen, boats, vessels and fishing gears

The type of data	*Number*
Fishermen (person)	10,619
Fishermen-owner (person)	2,632
Fishermen-crew (person)	7,987
Boat without motor (unit)	35
Outboard motor boats less than 5 GT in size (unit)	1,279
Outboard motor boats more than 5 GT in size (unit)	34
Vessel size less than 5 GT (unit)	301
Vessel size more than 5 GT (unit)	104
Purse seine (unit)	63
Surface Danish seine (unit)	729
Bottom Danish seine (unit)	141
Dredge gear without vessel (unit)	660
Boat lift net (unit)	53
Cast net (unit)	68
Gill net (unit)	521
Trammel net (unit)	68
Trap (‘bubu’) (unit)	140
Hand line (unit)	60
Troll line (unit)	126

Source: Fisheries Department of Pamekasan Regency (2020).

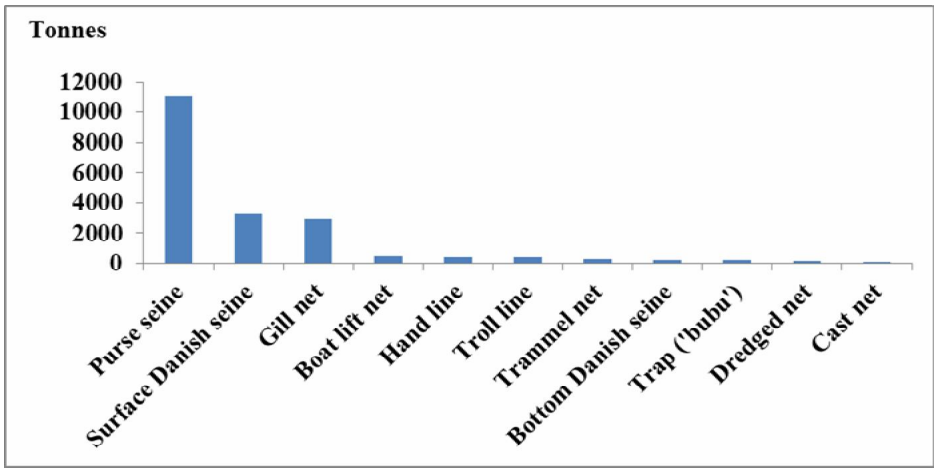

Figure 2. Main fishing gear production (Source: Fisheries Department of Pamekasan Regency (2020)).

The main fishing ground of Pamekasan Regency fishermen is the Madura Strait (for fishermen living on the south coast) and the Java Sea (for fishermen living on the north coast). The number of fishermen on the south coast is greater than on the north coast (Fisheries Department of Pamekasan Regency 2020). The main catches and the fishing gears used of Pamekasan Regency's capture fisheries can be seen in Table 4.

In general, capture fisheries in Indonesia, including in Pamekasan Regency, are multi-gears and multi-species fisheries. The more types of fishing gear and types of fish

resources taken during the fisheries lead to the complexity of the fisheries management. It is because there are interactions between types of fishing gear and between species. That makes negative externalities relation (Wijayanto et al 2020). In multi-species fisheries, fishing strategies change if fish targets are different. Fish targets are also influenced by stock per species (Sadiyah & Prisantoso 2011). Multi species fisheries are indeed a characteristic of tropical fisheries. Based on interviews with fishermen, the peak fishing season usually occurs from January to March. While April is the transition of the peak season to the moderate season. The moderate season occurs from May to July. While August is a transition between the moderate season to the famine season. The famine season occurs in September to November, and December is a transition between the famine season to the peak season. However, the weather is relatively difficult to predict and it affects the fishing season (Primyastanto 2018). Based on interviews, 63% of respondents stated that unpredictable weather is the main challenge in fishing busines.

Table 4

Main fish catches in 2019

The type of fish	*Number (tonnes)*	*Main fishing gears*
Big pelagic fish		
a. Skipjack tuna	1,251.90	Purse seine, troll line
b. Mackerel tuna	558.50	Gill net, surface Danish seine, hand line
c. Narrow-barred Spanish mackerel	498.20	Gill net, payang, hand line, troll line
d. Longtail tuna	41.80	Gill net, troll line
e. Frigate tuna	10.60	Gill net
Small pelagic fish		
a. Indian mackerel	3,966.40	Purse seine, gill net, bottom Danish seine
b. Shortfin scad	3,109.80	Purse seine, hand line, gill net
c. Indian anchovy	2,442.40	Boat lift net
d. Yellowstripe scad	1,250.30	Purse seine, boat lift net, surface Danish seine
e. Goldstripe sardinella	876.50	Purse seine, hand line
Demersal fish		
a. Giant trevally	913.80	Purse seine, surface Danish seine
b. Black pomfret	538.70	Gill net, surface Danish seine
c. Japanese threadfin bream	300.00	Gill net, surface Danish seine
d. Largehead hairtail	122.50	Gill net, trammel net
e. Goatfish	80.20	Gill net, trammel net
Non-fish		
a. Squid	721.00	Gill net, surface Danish seine, bottom Danish seine
b. Swimmer crab	224.30	Trap ('bubu'), gill net
c. 'Rebon' shrimp	158.00	Boat lift net
d. Bamboo shells ('lorjuk')	112.50	Dradge gear
e. White shrimp	85.80	Surface Danish seine, trammel net, gill net
f. Pink shrimp	81.80	Surface Danish seine, trammel net, gill net
g. Western shrimp	52.80	Surface Danish seine, trammel net, gill net
Marine fisheries production	19,554.10	

Source: Fisheries Department of Pamekasan Regency (2020).

MSY analysis. The availability of time-series fisheries data in Pamekasan Regency is relatively limited, including data on the number of trips per fishing gear. Therefore, we used the number of fishermen as a fishing effort in this study. The availability of time series data related to production and the number of fishermen in each sub-district was inadequate in this study, so that the aggregation was conducted (Table 5).

$$CPUE = 3.42 - 0.00013\ E \quad (1)$$

$$R^2 = 79.18\%$$

$$C = 3.42\ E - 0.00013\ E^2 \quad (2)$$

where: CPUE is catch per unit effort (tonnes per fisherman);
E is fishing effort (number of fishermen);
C is the catch of fish (tonnes per year).

Table 5

The progress of production, fishermen and catch per unit effort (CPUE)

Years	*Fishermen*	*Production (tonnes)*	*CPUE*
2009	14,476	19,330	1.335314
2010	14,608	19,594	1.341320
2011	14,608	20,435	1.398891
2012	14,608	20,603	1.410392
2013	14,608	21,563	1.476075
2014	14,608	22,522	1.541758
2015	15,008	23,190	1.545176
2016	11,462	23,689	2.066742
2017	11,462	21,689	1.892253
2018	10,619	19,554	1.841416

Source: Fisheries Department of Pamekasan Regency (2020).

MSY analysis shows that the waters of Pamekasan Regency have experienced overfishing. Over-fishing has occurred before 2016 when E > E_{MSY} (Table 6 and Figure 3). In this condition, restrictions on number of fishermen, fishing gear, and fleets are needed (Campbell et al 2018). However, these policies can cause conflict between the government and fishermen. This is because fishermen are accustomed to open access condition with loose regulations.

Table 6

MSY analysis

C_{MSY} and E_{MSY}	*Number*
C_{MSY} (tonnes per year)	21,682
E_{MSY} (fishermen)	12,677

Note: C_{MSY} is catch or production in the maximum sustainable yield level. E_{MSY} is fishing effort in the maximum sustainable yield level.

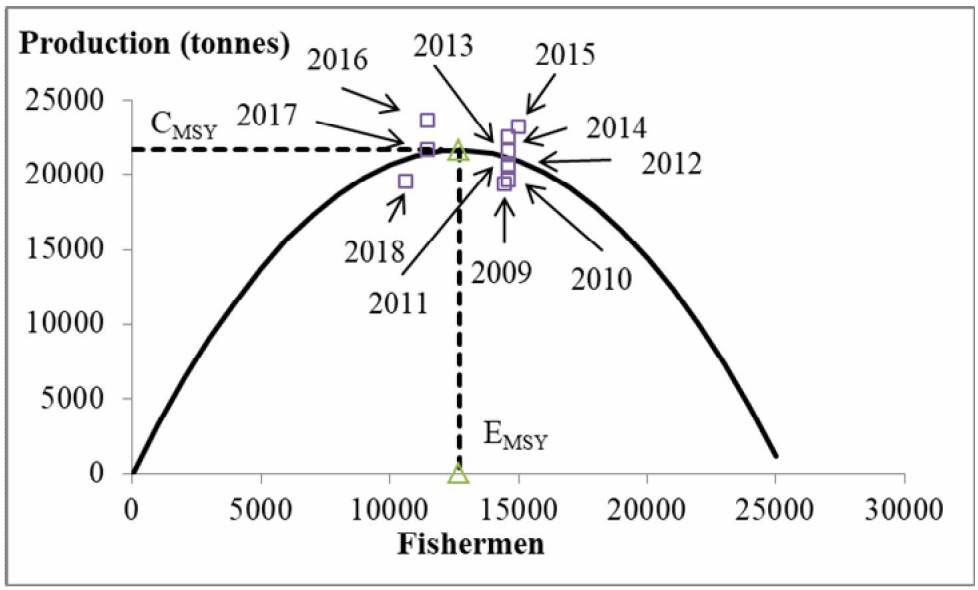

Figure 3. The relationship of marine fisheries production and number of fishermen.

Policy of fishermen number limiting is not a simple problem. Fishing is actually not the favorite occupation for Pamekasan Regency people. So the one who became a fisherman is partly because of compulsion of the situation. If there are other prospective alternative livelihoods, then the number of fishermen in Pamekasan Regency will tend to decrease.

Alternative strategies. There are several strengths, weaknesses, opportunities, and threats that need to be considered in developing a strategy using SWOT analysis and TOWS matrix. Following are the results of the SWOT analysis and TOWS matrix.

A. Strengths:
   1. Legal basis (code S1). The legal basis as the basis of fisheries development in Pamekasan Regency is available. Law 45 of 2009 has been established by the Indonesian government as a national regulation for fisheries activities which is complemented by regulations that are below a more technical level. This can be used as a legal basis in the development of capture fisheries in Pamekasan Regency.
   2. Medium-term regional development plan of Pamekasan Regency (code S2). Pamekasan Regency Government has a medium-term regional development strategic plan with 'minapolitan' as one of its pillars based on Regency Regulation No. 9 of 2019. 'Minapolitan' is a concept of sustainable development based on the fisheries.
   3. Availability of micro credit programs (code S3). The Indonesian government has a micro credit scheme that can be optimized to develop traditional fisheries with low interest rate. As an illustration, the interest rates for small-scale business loans for micro and small scale businesses are 6% per year, while the interest rates for corporate credit vary between commercial banks with a value above 9% per year.
   4. Availability of fishing port (code S4). The infrastructure of the fishing port in Branta Pesisir village is relatively adequate as a fishery center in Pamekasan Regency. The location of the Branta fishing port is adjacent to the Branta Sea Port. The management of Branta Sea Port provides opportunities for fishermen to use of the port facilities at the Branta Sea Port.
   5. Government institutions (code S5). The existence of the Fisheries Department as government agency for fisheries affair can be optimized to encourage the development of capture fisheries in Pamekasan Regency.

B. Weaknesses:
   1. Management of fish resources (code W1). Management of fish resources in Pamekasan Regency is still weak, and still tends to be open access and leads to common tragedy. This is proven by the fact that the waters of Pamekasan Regency have been overfishing. Data availability as a basis for managing fish resources is also still weak, including availability of production data, trips, coordinates of fishing ground and characteristics of fish resources per species. Though the data is very necessary in making policies and plans.
   2. Branta fish auction place is not actively conducting fish auction (code W2). Although it has a Branta fish auction place, but fish auctions are not conducted. Whereas fish auction is one of the ways to make fish prices reasonable and beneficial to both parties, both for fishermen and fish buyers.
   3. Human resources quality (code W3). In general, the mean years schooling of Pamekasan Regency residents is 6.25 years (BPS-Statistics of Pamekasan Regency 2019a). That means that the population of Pamekasan Regency is dominated by only completing basic education. Fishermen's formal education background is also still low. Insights and adaptability of fishermen to the latest technology is also still weak. The managerial and business skills of the fishermen also still need to be developed.
   4. Limited local government budget (code W4). Local government budget constraints cause infrastructure investment and fishermen empowerment programs to be limited. Original local government revenue of Pamekasan Regency in 2018 amounted to IDR 222 billion. As an illustration, the original government revenue of DKI Jakarta (state capital) was IDR 43.3 trillion in 2018, while Surabaya City (provincial capital) was IDR 3.7 trillion, and Sumenep Regency was IDR 180 billion. Original local government revenue can reflect the ability of the budget, where there are economic disparities between regions in Indonesia. Pamekasan Regency government expenditure budget in 2018 was IDR 1.7 trillion, and the largest proportion is for employee expenditure (salary and benefits in exchange for work load given), while for capital expenditure is only IDR 317 billion.

5. Supervision (code W5). Supervision activities require adequate personnel, equipment and budget. With limited resources available, the supervision of illegal, unreported and unregulated fishing is weak.

C. Opportunities:
1. Potential fish resources (code O1). Fish resources in the waters of Pamekasan Regency can be a basic capital for the development of capture fisheries.
2. Commodities of high sale value (code O2). Some of the fishery resources in the waters of Pamekasan Regency have a high selling price, including crab, shrimp, squid, skipjack, mackerel, and pomfret.
3. Market potential (code O3). The market potential is relatively high, both local, national and international markets. Increased per capita income and increased per capita fish consumption (both local and national) provide market opportunities for fish marketing from Pamekasan Regency fishermen.
4. Local wisdom (code O4). The Pamekasan Regency community is religious. Religious leaders are respected by the community in Pamekasan Regency. It can be a social capital for empowering fishermen in Pamekasan Regency.
5. Political support (code S5). The issue of coastal economic development is a popular issue that has become a key result area of politicians. This high political support can be optimized to push the development of capture fisheries in Pamekasan Regency.

D. Threats:
1. Non-environmentally friendly fishing gear (code T1). Some fishermen in Pamekasan Regency still use non-environmentally friendly fishing gear, including Danish Seine. Danish seine is not selective, including catching juveniles of various fish. This has the potential to cause depletion of fish resources (Wijayanto et al 2020).
2. Decline in fish resource stocks (code T2). Overfishing causes a decrease in fish resource stock. Decline in fish resource stocks affects the ability and reproductive capacity of fish resources (Pathmanandakumar 2017).
3. Fish processing industry is not developed yet (code T3). The fish processing industry in Pamekasan Regency is still small in number and is traditional (Primyastanto 2018). There are 136 traditional salted fish producers, 119 boiled fish producers, 7 smoked fish producers, 9 dried anchovies producers, 15 fish paste producers, 6 shrimp paste producers, 2 'lorjuk' (*Solen* spp.) processors and 6 crab meat pickers.
4. Unfair patron-client relationship (code T4). The patron-client relationship with the bargaining power of fish traders being stronger than traditional fishermen is still found in Pamekasan Regency. This phenomenon is also found in other areas of Indonesia (Adhuri et al 2016; Kasim et al 2019). The fish traders provide loans to fishermen who need financial credit (for productive or consumptive activities), and fishermen pay their debts with sale their fish catches of which prices are determined by fish traders. Client-patrons relationships are a consequence of the high-risk and high-uncertainty nature of fishing business activities. For clients, this relationship is considered to be social security. On the other hand, patrons need clients related to social, economic, and even political interests (Hefni 2009; Aida et al 2020).
5. Uncertain weather and climate change (code T5). Capture fisheries business has high uncertainty related to weather and catches. It was also complained by most respondents. With the phenomenon of climate change, it also becomes an additional challenge for fishermen (Helmi & Sasaoka 2018; Kinseng et al 2019).

The combination of external and internal environmental analysis is the basis for developing alternative strategies using the TOWS matrix (Table 7). There are 7 alternative strategies to implement in the development of capture fisheries in Pamekasan Regency.

Table 7

TOWS matrix

	S (1 to 5)	*W (1 to 5)*
O (1 to 5)	SO1. Diversification of fishermen family businesses (S1, S2, S3, S4, S5, O1, O2, O3).	WO1. Optimization of fish auction place function as a fish marketing center (W2, O2, O3, O4, O5).
T (1 to 5)	ST1. Management of environmentally friendly fishing gear (S1, S2, S3, S5, T1, T2); ST2. Fish processing industry development (S1, S2, S3, S4, S5, T3); ST3. Climate change mitigation (S1, T5).	WT1. R&D of fish resources (W1, W4, W5, T1, T2, T5); WT2. Extension and empowerment of fishermen and their families (W1, W3, T1, T2, T3, T4).

Diversification of fishermen family businesses (SO1 strategy) can be developed with either businesses related to capture fisheries or not. Wife of fishermen can be empowered for fish processing business or non-fisheries business. This will increase the economic resilience of fishermen households, including in fish famine season. Micro-credit for fishermen families is needed for productive and prospective businesses. The problem of asset assurance is one of critical problems in the administration of micro-credit. Business-management and socio-cultural assistance needs to be done so that micro-credit cannot become bad credit. According to Dey et al (2008), if there is a decline in fisheries production capacity, it is necessary to allocate fisheries to other business sectors (eg aquaculture, fish processing, tourism, etc.) and fishermen need to be facilitated with credit and training. However, turning fishermen into fish farmers is not easy because it changes work patterns drastically (Helmi & Sasaoka 2018; Kinseng et al 2019).

Fish auction place can be used as a fish marketing center (WO1 strategy) so that the price received by fishermen is a reasonable price. Fish auction place can also be a source of information and data collection on fishermen's catches needed in policy development. Fish auction place also needs to be regulated so that fish quality assurance can be maintained. Formal and informal (socio-cultural) approaches are needed to encourage fish auction place to run optimally. According to Solihin et al (2016), fishing ports (including fish auction place) are vital in fisheries development. This is related to fishing bases, marketing center and fish procesing industrial center for generating economy growth.

Fishing gear regulation (ST1 strategy) is important to make a win-win solution for fisheries businesses in the long run and it is proven to be important to do (Eliasen et al 2019; Veiga-Malta et al 2019; Zimmermann & Jørgensen 2017). Actually fishing gear regulation is not easy to implement when fishermen are accustomed to open access conditions and loose regulations. However, fishing gear regulation is very important to support the sustainability of the fishing industry. In the long term, it is necessary to apply total allowable catch (TAC) and fishing quotas per fisherman for avoiding the risk of overfishing. However, it takes time (cannot be applied in the short term) and a socio-cultural approach is needed. In addition, the development of environmentally friendly and pro-poor fishing technologies of small-scale gear size (eg gill net and hook-and-line) needs to be done in line with resource rehabilitation (Dey et al 2008).

The development of the fish processing industry (ST2 strategy) is important to increase the added value of fishery products. It can create jobs and become sources of economic growth. Leading commodities need to be determined based on criteria for total production and market potential. Capture fisheries and fish processing industries are mutually supportive. The integration of capture fisheries and the fish processing industry is one of the key success factors in the fishing industry development (Šilovs 2018).

Climate change mitigation (ST3 strategy) as a global issue also needs the attention of fisheries stakeholders in Pamekasan Regency. The coastal area in Pamekasan Regency is the most populous area that is vulnerable to sea level rising. The people of Pamekasan Regency need to contribute in practicing environmentally friendly lifestyles,

related to mangrove rehabilitation, consumption behavior, waste management, and energy use. All respondents acknowledged that waste management is a problem in coastal settlements. The government also needs to spearhead the use of environmentally friendly energy sources, including solar energy for household consumption. Solar energy also could replace part of fossil energy sources that be used on capture fisheries production. According to Dey et al (2016), fish supply from coastal fisheries can decrease due to climate change and damage to the coastal environment. According to FAO (2012), climate change can affect fisheries in 3 ways, namely (1) indirect wider socio-economic effects (eg freshwater use conflicts), (2) biological and ecological responses to physical changes (eg productivity and fish stock), (3) direct physical effects (for example sea level rise and flood).

The study of fish resources (WT1 strategy) needs to be done especially around Madura waters involving other regencies and cities, including Sampang, Bangkalan, Sumenep, Gresik, Surabaya, Sidoarjo, Probolinggo, and Situbondo. According to Vasilevska & Vasić (2009), regional strategy needs to be consistent and support one another with other regions. Data of fish resources is very important in the management of fish resources, related to migration patterns, fish stocks, biodiversity, size of first length maturity, spawning ground and nursery ground. Production data per type of fish will be better if available in details based on time, catch area, and type of fishing gear. Data of production and trips per fishing gears are also important, including recreational fishing activities. Fisheries management needs to balance between the needs of stakeholders regarding the utilization of fish resources. Fisheries management is very complex due to high uncertainty both related to the availability of fish resource stocks and socio-economic interests (Holland 2010; Murshed-e-Jahan et al 2014). According to Pathmanandakumar (2017), multi-species fisheries and small-scale fisheries in developing countries are very complex and fishermen are confused by the rules regarding the legal size of fish that can be caught.

Extension and empowerment of fishermen and their families (WT2 strategy) is very important to improve the quality of human resources and strengthen community institutions. According to Atukunda et al (2018), extension and empowerment are critical factors for making social change. Coastal community empowerment can be done by extension staff, academics, NGOs and community leaders. Synergy between stakeholders is needed. The life pattern of coastal communities needs to be improved. Coastal areas are very crowded and dirty. Rubbish is not handled properly and waterways are not smooth. Some coastal residents still wash, bath, and dispose the trash in rivers and the sea. That is not good for public health. Communication, discussion and community involvement in community empowerment are very important. According to Murshed-e-Jahan (2014), fisher to fisher communication is generally effective for discussing conflict resolution.

Regional development requires the right strategy to create the expected future. Strategies need to use a comprehensive approach, not partial. Some alternative strategies above can be synchronized. Each alternative strategy in public policy can be synergized, both SO, ST, WO and WT strategies (Wijayanto 2016).

Conclusions. Based on this study, it was proven that the waters of Pamekasan Regency had experienced overfishing. We recommend some capture fisheries development strategies in Pamekasan Regency including: diversification of fishermen family businesses, optimization of fish auction place, regulation of fishing gear, development of the fish processing industry, climate change mitigation, research of fish resources, extension and empowerment of coastal communities.

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