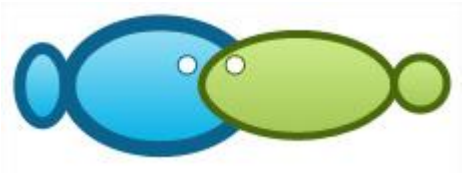

Policy scenario on Indonesian marine capture fisheries 2045

[1]Rony Megawanto, [2]Akhmad Fauzi, [3]Luky Adrianto, [2]Aceng Hidayat

[1] Natural Resources and Environmental Management Science, IPB University, Bogor, Indonesia; [2] Faculty of Economics and Management, IPB University, Bogor, Indonesia; [3] Faculty of Fisheries and Marine Science, IPB University, Bogor, Indonesia.
Corresponding author: R. Megawanto, romeo90245@yahoo.com

Abstract. This article develops a capture fisheries scenario of Indonesia 2045 by using the SMIC PROB-EXPERT method and software. Six scenarios are developed, which are Outward-Looking Scenario (government policy focus on fishing in the Exclusive Economic Zone and high seas), Expansive Scenario (government policy focus on increasing capture fisheries production and export from territorial waters), Smart-Fishing Scenario (government policy focus on application of technology 4.0 in managing fisheries), Conservative Scenario (government policy focus on fish stock improvement and marine ecosystem health), Processing Scenario (government policy focus on fish processing), and Subsidy Scenario (government policy focus on subsidies for small scale fishers). Net simple probabilities show that the highest probabilities is Outward-Looking scenario (68%) while combination of 2^n (2^6 = 64) scenario demonstrates that the highest probability is scenario combination of S20-101100 (20.8%) which is a combination among Outward-Looking, Smart-Fishing, and Conservative Scenarios. Meaning that scenario of Indonesian capture fisheries policy on 2045 should focus on increasing fisheries productions from Exclusive Economic Zone (EEZ) and high seas while in the coastal area, government will pay attention on improvement of fish stock and ecosystem health, include improving management effectiveness of Marine Protected Areas (MPAs). Regulator and fisheries community will implement smart-fishing concept by applying technology 4.0 in fishing, processing, and fisheries management. Meanwhile, sensitivity analysis shows that the prime mover is Conservative Scenario with elasticity coefficient 1.78, followed by the Outward-Looking Scenario with a coefficient of 1.366.

Key Words: probability, SMIC PROB-EXPERT, outward-looking, smart-fishing, conservative.

Introduction. Fisheries is an essential resource for protein needs, livelihood, income, and fisheries industries for millions of human beings in the world, including in Indonesia. Fisheries resources also have important cultural and ecological values for people's life. Fisheries are expected to give a significant contribution to the future related to food security and adequate nutrition for the global population (FAO 2016). UN (2013) estimates that the world population in 2045 will to reach 9.5 billion people, of which 318 million would be Indonesians. However, global fisheries show that biological sustainable level of fish stock experienced a decreasing level from 90% in 1974 to 68.6% in 2014. On the other hand, a biologically unsustainable level of fish stock increased from 10% in 1974 to 26% in 1989 and kept increasing reaching 31.4% in 2013 (FAO 2016).

Indonesian fisheries condition is also in overfished level as happening in the global fisheries status. The main threat that caused this condition is a common opinion that fisheries resources are a common-property where no one has the right to claim ownership of the fisheries resources in the sea except after catching it. Consequently, people will try to catch fish as much and as fast as they can before others. This will result in an increasing number of boats in the sea, catching fish that keeps decreasing. Overexploited fisheries resources causing fish catch to decrease and affect fisher's income that eventually resulted in fisher's poverty level. This statement has been confirmed by research in Cirebon Regency, Indonesia, where fishers that are in the poor category catches fish inside overexploited fisheries zone (Anas 2011). In national level, welfare analysis of fisher's household shows that the percentage of the poor household

working in marine captures fisheries reached 23.79%, while the percentage of Indonesia poor people in the same year was 11.25% (Sutomo & Marhaeni 2015).

The consequence of this poverty is that fishers use short pathways in catching fish through destructive fishing practices, such as the use of bombs and cyanide that destroys corals structures and kills juvenile fishes. Indonesia's coral reefs status currently is 6.39% very good, 23.40% good, 35.06% moderate, and 35.15% are in a bad condition (Suharsono 2017). Seagrass in healthy condition are only 5%, less healthy 80%, and in the poor condition are 15% (Hernawan et al 2017). In addition, mangrove forest deforestation rate reaches 52,000 ha per year (Murdiyarso et al 2015). Degradation of these coastal ecosystems lowers the fisheries resources abilities to reproduces and worsened overexploitation.

Malthusian overfishing theory shows a connection between poverty, overfishing, and destructive fishing practices. According to this theory, small scale fisheries in tropical developing countries are usually in a poor state and lack of alternative livelihood, hence, they find it difficult to stop fishing even though the fish resources rapidly decreasing over time. The number of fishers is also growing caused by either additional family member that became a fisher or new fisher from other sectors. These conditions result in destructive fishing practices as a way to survive (Pauly 1994). To summarize it all, there is a vicious circle between overfishing, poverty, and destructive coastal ecosystems. Therefore, this study aims to develop a capture fisheries scenario of Indonesia 2045 in order to improve fishers' welfare as well as ensuring sustainable fisheries resources.

Scenario planning is an approach in decision making process for a complex and changeable systems that provides menu of possible futures based on analysis and creative thinking. This promising approach has been used widely in various fields, including business and politics (Heijden 1996). Currently, scenario planning is also used in the environmental sciences to upgrade decision making process in complex ecosystems in order to prepare for modification of ecosystem services and to seek sustainable development strategies (Wollenberg et al 2000; Rotmans et al 2000; Peterson et al 2003; Bohensky et al 2006). In addition, the Millennium Ecosystem Assessment, used scenario planning in searching the ways in which policy decisions may encourage future ecosystem transformation, how ecosystem shift may constrain decision making in the future, and ways in which ecological reaction may lead to surprise (MEA 2005). In fisheries science, there have been no scenario planning exercises published in the fisheries science literature, nor in the context of resource user behavior (Davies et al 2015).

Based on above description, this study aims to develop a capture fisheries scenario of Indonesia 2045 in order to improve fishers' welfare as well as ensuring sustainable fisheries resources.

Material and Method. The synthesis of national capture fisheries scenario 2045 was analyzed using SMIC PROB-EXPERT (Cross-Impact Matrices and Systems) method and software that was established by Godet (1976, 2006) and Dupperin & Godet (1975) which is part of French School (Fauzi 2019). SMIC-Prob is developed based on probability theory, especially subjective probability, to assess possibility an event occurring or not in which generating tool in acquisitioning experts' knowledge through filling questioner. Stages of SMIC-Prob method are described in the Figure 1 (Fauzi 2019):

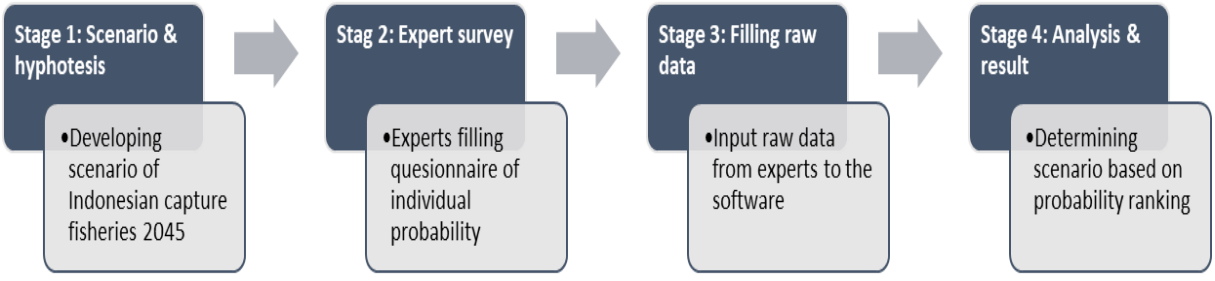

Figure 1. Stages of scenario analysis using SMIC-Prob.

Stage 1: Scenario and hypothesis. Formulation of hypotheses based on the analysis of capture fisheries management regimes, structural analysis, and stakeholder analysis. Based on these analyses, six hypotheses of Indonesian capture fisheries policy scenario in 2045 were developed as follows:

- Hypothesis 1 (Outward-Looking Scenario):

Most of fishing vessels in Indonesia (96% in 2015) was small boats (≤10 GT) that could only operating in the coastal areas. Meanwhile, medium (10-100 GT) and large scale (≥100 GT) of fishing vessels in Indonesia was only 4% in 2015. It means that only small number of Indonesia's fishing vessels catch fish in the Exclusive Economic Zone (EEZ) and high seas. Outward-Looking Scenario imagines that most of Indonesia's fishing fleets in 2045 will catch fish in the EEZ and high seas.

- Hypothesis 2 (Expansive Scenario):

Capture fisheries production in 2018 reached 6.72 million tons which is less than Total Allowable Catch (TAC) of 10 million tons per year. With gap between TAC and actual production of 3.28 million tons per year, an additional action is needed to increase capture fisheries production that also will increase fisheries export. Expansive Scenario imagines that Indonesia's capture fisheries production in 2045 to reach TAC and increases fisheries export mainly from territorial waters.

- Hypothesis 3 (Smart-Fishing Scenario):

Fisheries management in Indonesia still using manual and traditional technologies, including for fishing activity, post-harvest process, and fisheries management in general. Smart-Fishing is a new approach of fisheries management in the industry era 4.0, including E-log book, Vessel Monitoring System (VMS), smart and selective fishing gear, e-traceability, smart system for safety at sea, smart handing and processing, smart cold storage, smart fish school identification and classification, digital fish stock assessment, digital fish data collection and monitoring, and smart fisheries estate (Satria 2018). Smart-Fishing Scenario imagines that in the year 2045, fisheries business users and regulators apply technology 4.0 in fishing activity, fish processing, and fisheries management in Indonesia.

- Hypothesis 4 (Conservative Scenario):

Conservative Scenario is the opposite of Expansive Scenario that slowing capture fisheries production due to the overfishing condition in all Fisheries Management Area (FMAs) in certain group of fish. Although there are 20.19 million hectares of Marine Protected Areas (MPAs) in Indonesia currently, most of them are still paper parks where the management effectiveness is minimum. Additionally, protected fishes are still captured, marine pollution increases day by day, and marine ecosystem health are not in a good condition. Conservative Scenario imagines that in 2045, Indonesia improves fish stock condition where there is no overfished and marine ecosystem health are recovered.

- Hypothesis 5 (Processing Scenario):

Fish Processing Unit (FPU) utility in 2018 was around 36.1% (718 units) for medium-large scale and 62% (65,766 units) for small scale (MMAF 2019). FPU utility is not optimum due to the limited supply of fish raw material and lack of fish processing infrastructures. Processing Scenario imagines that in 2045, Indonesia has processing industries that produces high quality of processed fish product and dominate market of processed fish product for both global and domestic market.

- Hypothesis 6 (Subsidy Scenario):

Most of fisheries programs in Indonesia are possibly categorized as fisheries subsidy, such as fuel support, giving fishing boats and fishing gears to fishers, capital assistance, and others. Fisheries subsidy will be continued since most of fishers in Indonesia are

poor. Subsidy Scenario imagines that in the year 2045, Indonesia increases fisheries subsidy to small scale fishers in order to improve their prosperity.

Stage 2: Expert survey. Experts involved in filling the questionnaire are representatives from the Coordinating Ministry of Maritime Affairs, the Ministry of Marine Affairs and Fisheries, FAO-Indonesia Fisheries Program, UNDP-Indonesia Fisheries Program, Centre for Coastal and Marine Resources Studies (PKSPL)-IPB University, Satya Negara Indonesia University (USNI), and Environment Defend Fund (EDF) Indonesia. The expert survey was conducted through a questionnaire that contained six hypotheses above and divided into three categories as follow:

- Simple Probability P(i).
  Question to the expert: How is the probability of these six capture fisheries scenarios implemented until 2045?
- Conditional probability if realization P(i/j).
  Question to the expert: How is the probability of scenario i to happen if scenario j is realized?
- Conditional probability if non-realization $P(i/j^n)$.
  Question to the expert: How is the probability of scenario i to happen if scenario j is not realized?

Score probabilities of each questionnaire consist of five levels, which are:

i. Very improbable/not very probable event
ii. Improbable/slightly probable event
iii. Moderately/fairly probable event
iv. Probable event
v. Very probable event

Stage 3: Filling raw data. Score probabilities from experts were analyzed using standardized formula (Medina el al 2015) as follow:

$$P(i) = \frac{(\text{value-min})}{(\text{max-min})}$$

Raw data of probabilities from experts are adjusted to meet the following conditions:

- $0 \leq P(\ ) \leq 1$
- $P(i.j) = P(i/j).(P(j) = P(j/i).P(i)$
- $P(i) = P(i/j).P(j) + P(i/j^n).P(1 - P(j)$

Stage 4: Analysis and results. SMIC-Prob uses quadratic programming method to determine combination score of probability through the following objective function:

$$\min \sum_{ij}^{n} [P(i/j)P(i) - \sum_{k=1}^{r} t(ijk)\pi_k]^2 + \sum_{ij}^{n} [P(i/j^n)P(j^n) - \sum_{k=1}^{r} s(ijk)\pi_k]^2$$

with constraint:

$$\sum_{k=1}^{r} \pi_k = 1, \text{ and } \pi_k \geq 0 \text{ for all } k$$

The symbol of π_k illustrates the probability of scenario k that is sought from the minimization solution above. The value of t(ijk) will be equal to 1 when events i and j occur in scenario k, and zero when events i and j do not occur in scenario k. The value of s(ijk) will be equal to 1 when the value of event i occurs in scenario k but event j does not occur. Conversely, the value of s(ijk) will be zero if event i does not occur, but event j occurs in scenario k.

The solution of the quadratic programming above will produce the highest and lowest probability scores presented in tabular form, as well as the elasticity of the probability for each event in the form of:

$$e_{ik} = P(i)\Delta P(j)/P(i)\Delta P(i)$$

SMIC-Prob also calculates a score of scenario combination that are possible to implement or not to implement. This combination is based on the number of scenarios or events observed with a combination of:

$$r = 2^n$$

where n is the number of scenarios observed.

Results. A summary of the six scenarios described above is presented in Table 1.

Table 1

List of national capture fisheries scenarios 2045

No	*Long label*	*Short label*	*Description*
1	Outward-looking scenario	Outward	Government policy focus on capture fisheries in Exclusive Economic Zone and high seas
2	Expansive scenario	Expansive	Government policy focus on increasing capture fisheries production and export from territorial waters
3	Smart-fishing scenario	Smart-F	Government policy focus on application of technology 4.0 in fisheries management
4	Conservative scenario	Conserve	Government policy focus on fish stock improvement and marine ecosystem health
5	Processing scenario	Processing	Government policy focus on fish processing
6	Subsidy scenario	Subsidy	Government policy focus on fishery subsidy to small scale fishers

Probability score was given to the six scenarios by experts for simple probability ranging from 1 to 5 where 1 is not very probable (impossible to happen) and 5 is very probable (very possible to happen). Raw data of experts' opinion for simple probabilities calculated using SMIC-Prob software are shown in Figure 2.

Description of simple probability raw data in Figure 2 is as follow:

- Outward-Looking Scenario has a probability of 42% fairly probable and very probable, and 14% probable.
- Expansive Scenario has a probability of 42% not very probable and fairly probable, and 14% slightly probable.
- Smart-Fishing Scenario has a probability of 42% very probable, 28% fairly probable, and 14% probable and slightly probable.
- Conservative Scenario has a probability of 42% slightly probable, 28% fairly probable, and 14% probable and very probable.
- Processing Scenario has a probability of 42% fairly probable, 28% very probable, and 14% not very probable and slightly probable
- Subsidy Scenario has a probability of 28% not very probable, slightly probable, and fairly probable, and 14% for probable.

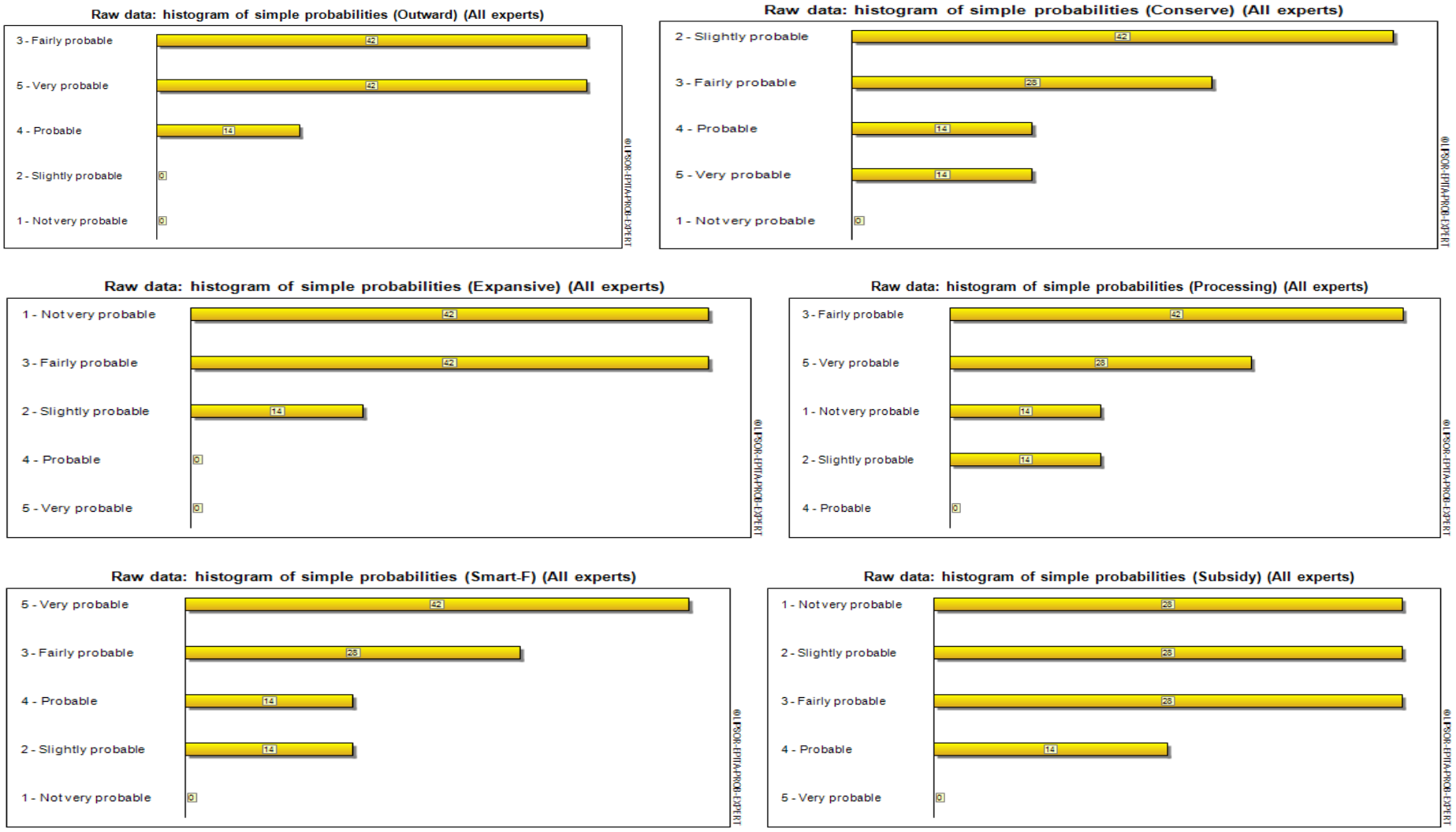

Figure 2. Histogram of simple probabilities (all experts) raw data.

Aggregate data of net data calculation on simple probabilities raw data are provided in Table 2.

Table 2

Net simple probabilities P(i)

	Probabilities
1: Outward	0.68
2: Expansive	0.28
3: Smart-F	0.65
4: Conserve	0.55
5: Processing	0.48
6: Subsidy	0.31

Table 2 shows that experts agreed that the highest probability from the six capture fisheries scenario in Indonesia 2045 is Outward-Looking Scenario (68%), followed by Smart-Fishing Scenario (65.2%), Conservative Scenario (54.7%), Processing Scenario (48.4%), Subsidy Scenario (31%), and Expansive Scenario (27.6%) as the lowest. It means that government policy in 2045 should focus on capture fisheries from exclusive economic zone and high seas, not from territorial waters that are already crowded by small scale fisheries.

Aggregate calculations toward raw conditional probabilities if realization that estimate the probability of one scenario to happen when another one certain scenario is realized is as presented in Table 3.

Table 3

Raw conditional probabilities in case of P(i/j) realization

	Outward	*Expansive*	*Smart-F*	*Conserve*	*Processing*	*Subsidy*
1: Outward	0.68	0.52	0.82	0.82	0.76	0.52
2: Expansive	0.21	0.28	0.25	0.07	0.45	0.37
3: Smart-F	0.78	0.59	0.65	0.78	0.64	0.53
4: Conserve	0.66	0.15	0.66	0.55	0.35	0.33
5: Processing	0.54	0.78	0.47	0.31	0.48	0.71
6: Subsidy	0.24	0.42	0.25	0.19	0.46	0.31

Table 3 shows that the highest conditional probabilities if realization is the Conservative Scenario if the Outward-Looking Scenario realized with the probability of 82%. Other high probabilities are the Smart-Fishing scenario if the Outward-Looking Scenario realized by 81.7%, the Outward-Looking Scenario if the Smart-Fishing scenario realized by 78.3%, and the Expansive Scenario if Processing Scenario realized by 78.3%. Meanwhile, the lowest probability is the Conservative Scenario if the Expansive Scenario realized by 7.4%.

Aggregate calculation on raw conditional probabilities if non-realization that estimate the probability of one scenario to happen when another one certain scenario is not realized is presented in Table 4.

Table 4

Net conditional probabilities in case of $P(i/j^n)$ non-realization

	Outward	*Expansive*	*Smart-F*	*Conserve*	*Processing*	*Subsidy*
1: Outward	0	0.74	0.43	0.51	0.61	0.75
2: Expansive	0.41	0	0.32	0.52	0.12	0.23
3: Smart-F	0.37	0.68	0	0.50	0.67	0.71
4: Conserve	0.31	0.70	0.35	0	0.74	0.65
5: Processing	0.37	0.37	0.51	0.70	0	0.38
6: Subsidy	0.47	0.27	0.42	0.46	0.17	0

Table 4 shows the highest conditional probabilities in the case of non-realization is the Subsidy Scenario if the Outward-Looking Scenario not realized by 75.3%. In other words, if the Outward-Looking Scenario is not realized, the probability of the Subsidy Scenario will be high, reaching 75.3%. Another high probability also experienced by the Expansive Scenario if the Outward-Looking Scenario is not realized by 74.1%. The lowest conditional probability is the Processing Scenario if the Expansive Scenario not realized by 11.6%.

The prospect of capture fisheries scenario 2045. The information above is still incoherent and needs to be corrected by probabilities calculation from the six scenarios to indicate the most probable scenario. The Table 5 shows the corrections for conditional probabilities in the case of realization of Table 3 from the calculation of P(i/j) - P(i).

Table 5

Conditional probabilities in case of P(i/j) - P(i) realization

	Outward	*Expansive*	*Smart-F*	*Conserve*	*Processing*	*Subsidy*
1: Outward	0	-0.16	0.14	0.14	0.08	-0.16
2: Expansive	-0.06	0	-0.03	-0.20	0.17	0.09
3: Smart-F	0.13	-0.06	0	0.13	-0.02	-0.12
4: Conserve	0.11	-0.40	0.11	0	-0.20	-0.22
5: Processing	0.06	0.30	-0.01	-0.18	0	0.23
6: Subsidy	-0.07	0.11	-0.06	-0.13	0.15	0

Table 5 shows the highest probability (82% in Table 3) for Conservative Scenario if the Outward-Looking Scenario realization increase by 13.9%. The lowest probability (7.4% in Table 3) for the Conservative Scenario if Expansive Scenario realization drops by 20.2%. The scenario that has the biggest increase is the Expansive Scenario if the Processing Scenario realized by 29.9%, while the scenario that has the biggest decrease is the Expansive Scenario if the Conservative Scenario realized by 40%.

Correction of conditional probabilities in the case of non-realization using $P(i/j^n)$ - P(i) formula are shown in the Table 6.

Table 6

Conditional probabilities in case of $P(i/j^n)$ - P(i) non-realization

	Outward	*Expansive*	*Smart-F*	*Conserve*	*Processing*	*Subsidy*
1: Outward	-0.68	0.06	-0.26	-0.17	-0.07	0.07
2: Expansive	0.14	-0.28	0.05	0.24	-0.16	-0.04
3: Smart-F	-0.28	0.02	-0.65	-0.16	0.02	0.05
4: Conserve	-0.24	0.15	-0.20	-0.55	0.19	0.10
5: Processing	-0.12	-0.11	0.02	0.22	-0.48	-0.10
6: Subsidy	0.16	-0.04	0.11	0.15	-0.14	-0.31

Table 6 shows the highest probability (75.3% in Table 4) for the Subsidy Scenario if the Outward-Looking Scenario non-realization increases by 7.2%. The lowest probability (11.6% in Table 4) for the Processing Scenario if the Expansive Scenario non-realization decreases by 16%. The scenario that has the biggest increase after correction is the Conservative Scenario if the Expansive Scenario it is not realized by 24.4%. Scenario that has the biggest decrease is the Outward-Looking Scenario if the Smart-Fishing Scenario it is not realized by 27.8%.

The most important in scenario analysis is scenario hierarchy and probability of the scenario realization that consist of 2^n combination of probabilities scenario. With six scenarios, there are 2^6 or 64 combinations of probability scenarios as shown in the Figure 3.

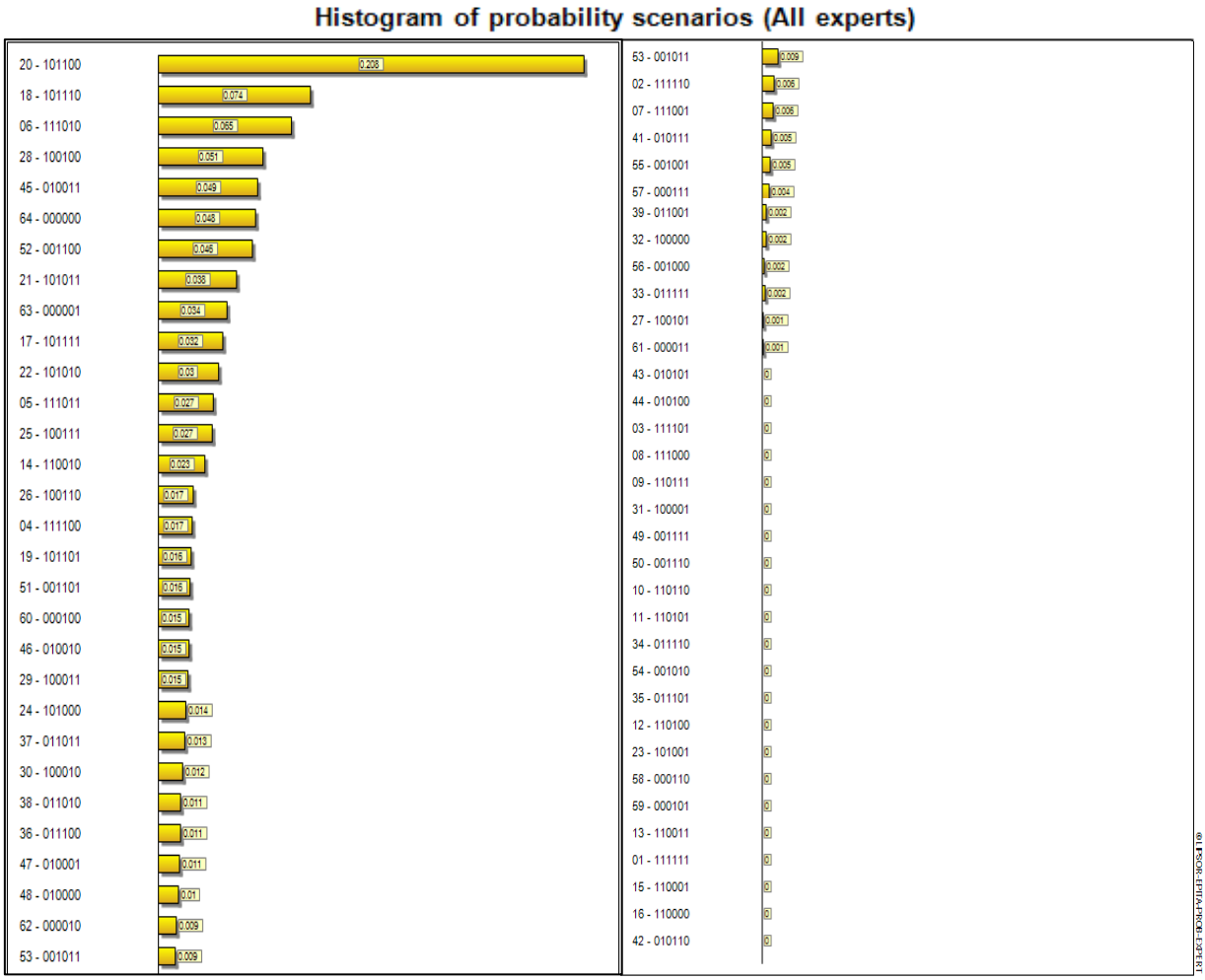

Figure 3. Histogram of probability scenario.

Figure 3 shows combinations of 64 probability scenarios in which five combinations of them have the highest probability scores. Description of each scenarios combination is presented in Table 7.

Table 7

The highest probability of the scenario combination

No	*Description scenario combination*	*Probability score*
1	S20-101100 (Outward-Looking, Smart-Fishing, and Conservative Scenario): Scenario S20 is a combination of the Outward-Looking, Smart-Fishing, and Conservative Scenarios. Under this scenario combination, capture fisheries policy focus on increasing fisheries productions and export from Exclusive Economic Zone (EEZ) and high seas while in the coastal area focusing on improvement of fish stock and ecosystem health, include improving management effectiveness of Marine Protected Areas (MPAs). Government and fisheries business users also implement smart-fishing concept by applying technology 4.0 in fishing, processing, and fisheries management.	20.8%

No	*Description scenario combination*	*Probability score*
2	S18-101110 (Outward-Looking, Smart-Fishing, Conservative, and Processing Scenario): Scenario S18 is a combination of Outward-Looking, Smart-Fishing, Conservative, and Processing Scenarios. This combination is similar to scenario S20 with the addition of the Processing Scenario. Increasing production of capture fisheries from EEZ and high seas is supported by the development of the Fish Processing Unit (FPU) for processing the fish catch. Catch processing by FPU also implement technology 4.0 to ensure that consumers could trace back where the fish they consumed came from: fishing ground location, fish processing location, exporter, and fish outlet.	7.4%
3	S06-111010 (Outward-Looking, Expansive, Smart-Fishing, and Processing Scenario): Scenario S06 is a combination of Outward-Looking, Expansive, Smart-Fishing, and Processing Scenarios. This combination is a production acceleration by optimizing all fishing ground, include territorial waters, EEZ, and high seas. Fish production supported by developing Fish Processing Unit (FPU) utilities that provide value added of capture fisheries in Indonesia. Furthermore, all fishing efforts and processing implement technology 4.0 to ensure traceability by the last consumers.	6.5%
4	S28-100100 (Combination of Outward-Looking and Conservative Scenario): Scenario S28 is a combination of Outward-Looking and Conservative Scenarios where the government focuses on increasing fisheries production in EEZ and high seas as well as improvement of fish stock and ecosystem health in the coastal area, include improving management effectiveness of MPAs that covered more than 20 million hectares. With this scenario, the government will effectively use its diplomacy to improve catch quota in RFMOs and encourage fishing fleets to catch fish in EEZ and high seas.	5.1%
5	S45-010011 (Combination of Expansive, Processing, and Subsidy Scenario): Scenario S45 is a combination of Expansive, Processing, and Subsidy Scenarios where the government will increase fish production to reach Total Allowable Catch (TAC) from fish stock estimation in the territorial waters. This fish catch increase supported by strengthening the Fish Processing Unit (FPU) to reach optimum utility. On the other hand, the government will also increase fisheries subsidies to small scale fishers.	4.9%

Sensitivity analysis. Sensitivity analysis provides information of which scenario needs to be improved and which scenario must be prevented to achieve expected condition. This analysis also calculates the impact of the actions/changes of a scenario upon other scenarios (Godet 1994). The Table 8 presents the elasticity matrix:

Table 8

The elasticity matrix

	Outward	*Expansive*	*Smart-F*	*Conserve*	*Processing*	*Subsidy*	*Absolute value*
1: Outward	1	-0.54	-0.07	-0.03	-0.17	-0.56	1.37
2: Expansive	-0.14	1	-0.13	-0.20	-0.05	-0.08	0.59
3: Smart-F	-0.08	-0.35	1	-0.07	-0.29	-0.41	1.20
4: Conserve	-0.13	-0.64	-0.14	1	-0.43	-0.44	1.78
5: Processing	-0.13	0.07	-0.18	-0.31	1	0.00	0.69
6: Subsidy	-0.17	-0.08	-0.16	-0.19	-0.07	1	0.65
7: Absolute value	0.64	1.68	0.68	0.80	1.00	1.49	-

Table 8 presents the elasticity coefficient where horizontal raw indicates the influence level of a scenario to other scenarios while the vertical column indicates the level of dependency of a scenario relative to other scenarios. Table 8 describes that prime mover or the most decisive scenario with the highest elasticity coefficient value (1.78) is the Conservative Scenario, followed by the Outward-Looking Scenario with a coefficient value of 1.366. Meaning that change in the Conservative and Outward-Looking Scenarios will give a great impact on other scenarios. Meanwhile, the scenario that has the highest dependency is the Expansive Scenario with elasticity coefficient values of 1.68, followed by the Subsidy Scenario with a value of 1.486. It means that the Expansive and Subsidy Scenarios are the most sensitive scenarios if there are changes in other scenarios. For example, if the probability of the Conservative scenario increases 100%, the probability of the Expansive Scenario will decrease by 64.2%. On the contrary, if the probability of the Expansive Scenario increases by 100%, the probability of the Conservative Scenario will only decrease by 19.6%.

Discussion. Scenario S20-101100 (a combination of the Outward-Looking, Smart-Fishing, and Conservative Scenarios) is a new paradigm of how Indonesia manages their marine fish resources in the future that is totally different from the way of Indonesian fisheries are managed for years. Since a few years ago until present, most of fishing fleets in Indonesian waters were subsistent and small scale fisheries (≤10GT) that reached 96% in 2015 while the proportion of medium scale (10-100 GT) and industrial scale (≥100 GT) were only 3.6% and 0.1% in 2015 accordingly. As the fishing vessels of the subsistent and small scale fisheries can only operate in a close distance, the coastal areas in Indonesia are crowded by these fishing vessels. On the other hand, Exclusive Economic Zone (EEZ) and high seas are relatively spacious from Indonesia's fishing vessels. Therefore the long-term policy, under Outward-Looking Scenario, is to promote Indonesia's fishing fleets towards EEZ and high seas. In other words, source of Indonesia fish production year 2045 will be mainly from EEZ and high seas.

In the coastal areas, Indonesia is well-known as a mega-biodiversity country with three main coastal ecosystems (coral reefs, mangrove, and sea grass) as habitat of many important fisheries. The crowded fishing boat in coastal areas worsens the health of these ecosystems and their fish stock. Government policy in the long-run will focus on improvement of coastal ecosystem health and fish stock, include through increasing management effectiveness of Marine protected Area (MPAs) currently reach 20.19 million hectares (MMAF 2019).

Indonesia already has management tool to measure management effectiveness of MPA that consists of 5 levels: red (the lowest), yellow, green, blue, and gold (the highest). However, most of the MPAs nowadays are still in the red and yellow level because lack of political will and minimum budget. In the future, under Conservative Scenario, government will pay more attention to improve management effectiveness of MPAs to the blue and gold level.

In the meantime, application of smart-fishing in the future is a must to ensure effectiveness and efficiency of fishery management in all level, from upstream to downstream. Under Smart-Fishing scenario, regulators and fisheries stakeholders will use state of the art technology to trace supply chain of the fish, number of fishing vessel operate in all Indonesian marine areas, location of fishing ground, exploitation level for each Fisheries Management Area (FMA), and other things related to fisheries management. This is again different from current situation where regulator and fisheries community still use traditional technology in managing fisheries resources.

Conclusions. The highest probability scenario based on net data calculation is Outward-Looking Scenario (68%) and the highest probability of combination scenario is the combination S20-101100 (20.8%) which is a combination of the Outward-Looking, Smart-Fishing, and Conservative Scenarios. Sensitivity analysis shows that the prime mover is Conservative Scenario with elasticity coefficient 1.78, followed by the Outward-Looking Scenario with a coefficient of 1.366. Meanwhile, the scenario that has the highest

dependency is the Expansive Scenario with elasticity coefficient values of 1.68, followed by the Subsidy Scenario with a value of 1.486.

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Authors:
Rony Megawanto, IPB University, Graduate School, Natural Resources and Environmental Management Science, Indonesia, 16144 Bogor, Baranangsiang Campus, e-mail: romeo90245@yahoo.com
Akhmad Fauzi, IPB University, Faculty of Economics and Management, Indonesia, 16680 Bogor, Dramaga Campus, e-mail: akhmadfauzi214@gmail.com
Luky Adrianto, IPB University, Faculty of Fisheries and Marine Science, Indonesia, 16128 Bogor, Dramaga Campus, e-mail: lukyadrianto@gmail.com
Aceng Hidayat, IPB University, Faculty of Economics and Management, Indonesia, 16680 Bogor, Dramaga Campus, e-mail: a.hidayat.esl@gmail.com

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