Key elements in the implementation of escape gaps recommendations for the protection of juvenile vulnerable squaretail coralgroupers (*Plectropomus areolatus*) in Karimunjawa Island

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Abstract. IUCN classified squaretail coralgroupers into vulnerable status. If this is ignored, there may be a risk of threatening its sustainability and changing its status to endangered. This condition needs proper regulation concerning juvenile protection. Escape gap recommendations are considered to be the proper solution for this particular issue because juveniles were able to release without reducing fishermen's revenues. When implementing an escape gap, various elements support failure and success. Therefore, it is necessary to know what elements will have an effect so that the program could implement successfully. This study aims to identify key elements in escape gap implementation. The key elements are identified through Interpretive Structural Modelling. This method is carried out systematically by ranking several elements that influence the implementation. The result showed that the implementation of the escape gap required prioritizing key elements. These keys are releasing juvenile grouper with high survivability (objectives), trial use of the escape gap on the trap (activities), worries of income reduction (obstacles), Marine and Fisheries Departments of Central Java (institutions involved), and fishermen (affected communities). These key sub-elements will drive other sub-elements to implement the escape gap in trap fisheries successfully.

1 Introduction

Karimunjawa has the potential of coral fisheries that have the opportunity to be utilized through fishing activities. One fishing gear used to catch demersal fish, including reef fish, is a trap, namely "bubu". Bubu is the dominant fishing gear in reef fishing activities in Karimunjawa. The trap operation was carried out by trapping squaretail coralgrouper (*Plectropomus areolatus*) as the main catch target.

Groupers play an important role in ecological functions [1]. As a top-level predatory fish [2], grouper can be used as a coral ecology indicator organism [3] through food chain network analysis. Should there be a decline in the population of top-level predators, there will be an abundance of trophic levels below it in the long term. This phenomenon threatens the trophic

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ecological balance [4] so that the ecological balance is disturbed. Efforts to restore balance are pretty difficult considering the slow growth coefficient (0.21/year), and the age reaches 30 years [5].

Squaretail coralgroupers are fish that have the risk of threatening their sustainability due to fishing pressure. IUCN (International Union for Conservation of Nature and Natural Resources) categorizes resources into nine statuses, namely not evaluated (NE), data deficient (DD), least concern (LC), near threatened (NT), vulnerable (VU), endangered (EN), critically endangered (CR), heredity in the wild (EW) and heredity (EX). Several types of groupers in Karimunjawa, such as longfin grouper and specklefin grouper are included in the least concern category [6, 7]. The squaretail coralgrouper has entered the vulnerable status [8].

Several non-governmental organizations already engaged in conservation, such as the Wildlife Conservation Society (WCS) and the Fisheries Resource Center of Indonesia (FRCI), also monitor fishing activities in Karimunjawa. WCS reported that the exploitation rate of squaretail coralgrouper had exceeded the optimum exploitation rate [9]. The status of grouper utilization in Karimunjawa is quite high, as can be seen from the F/M value of 1.03 [5]. On the other hand, the demand for grouper reaches 3000 kg per year [10] with a price range of IDR 250,000 to IDR 270,000/kg. This condition encourages fishers to tend to catch all sizes, including juveniles that have never spawned. If this is allowed, fishing activities may have the opportunity to threaten the sustainability status of grouper fish resources. This condition needs appropriate management efforts by not neglecting the protection of juvenile groupers.

Various regulations and management have been formulated, and some of them have been implemented, such as restrictions on fishing gear types and fishing zoning. The Karimunjawa National Park Office (BTNKJ) formulated the weight regulation through a joint agreement on marine and fishery resources management in Karimunjawa District, Jepara Regency in Chapter III (Special Rules and Agreements). The agreement's content is to recommend not to catch all species of grouper with a size of fewer than 300 grams. The regulation does not work well, as seen from the fishing communities that still catch fish below the recommended weight.

Escape gaps as a mechanical selectivity recommendation, considered as an appropriate and easy management method [11, 12] because juvenile fish were able to escape, so it could make fisheries more sustainable [13] without reducing fishermens' revenues [14]. Actually, without an escape gap, fishers can also release juvenile squaretail back into their habitat, but the catch and release process onboard has a risk of reducing survival rate [15].

Implementing the escape gap will undoubtedly face various elements that support failure so the fishers still catch grouper under recommended size. In order to avoid failure, it is necessary to know what elements will have an effect. Therefore, this study aims to examine how the right strategy in implementing the program can be carried out according to the objectives. The implementation strategy is formulated through Interpretive Structural Modeling (ISM). Based on the result obtained from ISM, essential elements that need to be resolved immediately are identified. When these key elements have been resolved, other elements can be immediately resolved so that the implementation of mechanical selectivity through escape gaps can be carried out as intended.

2 Methods

2.1 Research location

The research was conducted in Karimunjawa Island, Jepara Regency, Central Java Province (Figure 1). This location was chosen because of the potential for grouper fish resources, but there is no fishing technology that protects juvenile fish that are not suitable for catching. The interview activities were carried out in September - October 2020.

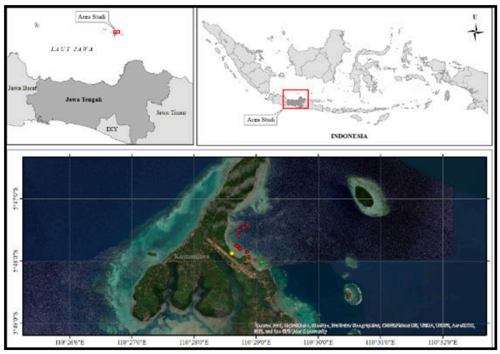

Fig. 1. Research location in Karimunjawa Island.

2.2 Interpretive Structural Modelling (ISM)

The key element in formulating the strategy for implementing mechanical selectivity recommendations through the escape gap in this study was formulated using the Interpretive Structural Modeling (ISM) method. ISM input comes from respondents (the experts) to explain the contextual relationship between sub-elements (expert survey). The purpose of the ISM analysis is to find the critical elements in formulating the right strategy for introducing recommendations for mechanical selectivity of trap that can release groupers that are not yet fit to be caught. Key elements are identified through the problem assessment process by making it a structured model [16, 17]. The ISM procedure is carried out systematically by ranking several elements that have the most influence on implementing the escape gap in trap fishing gear in Karimunjawa Island.

2.2.1 Data collection method

The data collection procedure was carried out through interviews with the experts. The considerations used in selecting experts as respondents are: 1) willingness to be interviewed, and 2) having position, experience, and credibility as an expert in fisheries resource utilization. The respondents were eight people, representatives of non-governmental organizations Wildlife Conservation Society (WCS), grouper exporters, Coastal Fishing Port (PPP) Karimunjawa, Karimunjawa National Park Office (BTNKJ), Marine and Fisheries Service of Central Java Province, Jepara Regency Marine and Fisheries Service, Field of Applied Testing of Fish Resources Utilization Techniques at the Indonesian Fishing Center (BBPI) and academic representatives. Element identification refers to research [18], in which the selection was based on a study of the literature and discussions with several experts. Each element is then broken down into sub-elements to identify contextual relationships.

2.2.2 Data analysis

The results of the interviews were analyzed using the ISM method by ISM Professional Software. The analysis was carried out in stages where the initial step of the analysis was to compose a Structural Self Interaction (SSIM) matrix using symbols V, A, X, and O as described below [19-21].
V : there is a relationship between Ei and Ej, not vice versa
A : there is a relationship between Ej and Ei, not vice versa
X : there is a relationship between Ei and Ej, and vice versa
O: there is no relationship between the two
The next step is compiling the Reachability (RM) matrix by changing the symbols V, A, X, and O with 1 or 0.
V : $e_{ij} = 1$ and $e_{ji} = 0$
A : $e_{ij} = 0$ and $e_{ji} = 1$
X : $e_{ij} = 1$ and eji = 1
O : $e_{ij} = 0$ and $e_{ji} = 0$

The RM matrix is then corrected according to the transitivity rules so that the final RM is obtained. The rule used is that if variable 1 affects variable 2, and variable 2 affects variable 3, then variable one must affect variable 3. After being corrected, then an assessment of agreement between respondents is carried out employing a consistency test [22] through the following formula:

$$C= \frac{(n \times n) - Y}{(n \times n)} \times 100\% \quad (1)$$

C is the consistency index, n is some sub-elements, and Y is the number of corrected modifications according to the transitivity rule. The final result of the ISM analysis is a diagram of the structure of the key elements, their relationship to the sub-elements based on the program used. The key sub-element structure and the Driver Power-Dependence plot consist of four autonomous, dependent, linkage, and independent [18, 23, 24] arranged in a matrix. Matrix interpretation refers to [23] as follows:

Sector I (*Autonomous*)	:	*Weak driver-weak dependent variables.* The sub-elements have weak driving force and linkages
Sector II (*Dependent*)	:	*Weak driver-strongly dependent variables.* The sub-elements have a weak driving force, but the linkage is quite strong with other sub-elements
Sector III (*Linkage*)	:	*Strong driver-strongly dependent variables*. Sub-elements have a solid driving force and linkage
Sector IV (*Independent*)	:	*Strong drive weak dependent variables*. The sub-elements have a strong driving force, but the linkage is quite weak with other sub-elements

3 Result analysis

Trap or basket trap is the traditional fishing gear made from sharpened bamboo stakes and dominantly used in reef fishing activities in Karimunjawa National Park. Generally, fishers put the trap between the corals and soak for two days by trapping squaretail coralgrouper (*Plectropomus areolatus*) as the main catch target. The mesh size of the trap is 3.5 cm. Traps used by Karimunjawa fishers have a funnel entrance, so the grouper that entered are trapped in the trap and will be difficult to escape (non-returned device), including juvenile grouper.

The use of escape gap recommendation refers to the previous studies [25] that use escape gap 7.5 cm could release 33.4% of juvenile grouper from the traps.

Based on a discussion with some experts, the key elements in implementing escape gaps recommendations for protecting juvenile vulnerable squaretail coralgroupers (Plectropomus areolatus) in Karimunjawa Island. Each element that has been identified are objective, required activity, obstacle, involved institutions, and affected community's element. Each element is then broken down into sub-elements to identify contextual relationships. The implementation of the escape gap in trap fisheries required prioritizing the key sub-element of each element. These key elements will drive other sub-elements to support implementing the escape gap in Karimunjawa trap fisheries.

3.1 Objective elements

The objective element is broken down into five sub-elements. Assessment of opinions among respondents through the consistency test obtained with 92% consistency (Table 1). It means that the opinions expressed are pretty consistent.

Table 1. Final reachability matrix of the objective element.

Final Reachability Matrix	Releasing juvenile grouper with high survivability	Preserving squaretail coral grouper resource recruit rate	Developing the sustainable trap fisheries	Reducing the amount of by-catch from trap fishing	Trap fishers understanding and applying escape gap to releasing juvenile grouper	**TOTAL DP (Y)**	**RANKING DP**
	(1)	(2)	(3)	(4)	(5)		
(1)	1	1	1	1	**1***	**5**	1
(2)	0	1	1	1	**1***	**4**	2
(3)	1	1	1	0	1	**4**	2
(4)	0	0	1	1	0	**2**	3
(5)	1	1	1	1	1	**5**	1
TOTAL D (X)	**3**	**4**	**5**	**4**	**4**		
RANKING D	3	2	1	2	2		

The results of the sub-element plot in the driver-power dependence matrix of the objective elements are presented in Figure 2. The objective elements are distributed in 3 sectors, namely sector II, and sector III.

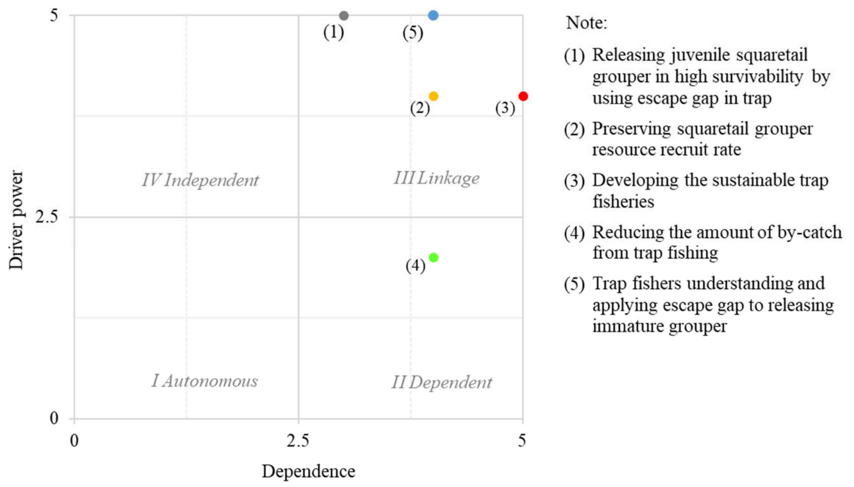

Fig. 2. Driver power-dependence matrix of the expected objectives element.

The sub-element of the structured goal element in 3 levels is presented in Figure 3. The sub-element of escaping grouper not yet worthy of catching high survival occupies the 3rd level position. These sub-elements are, at the same time, a key element in the program's main objectives.

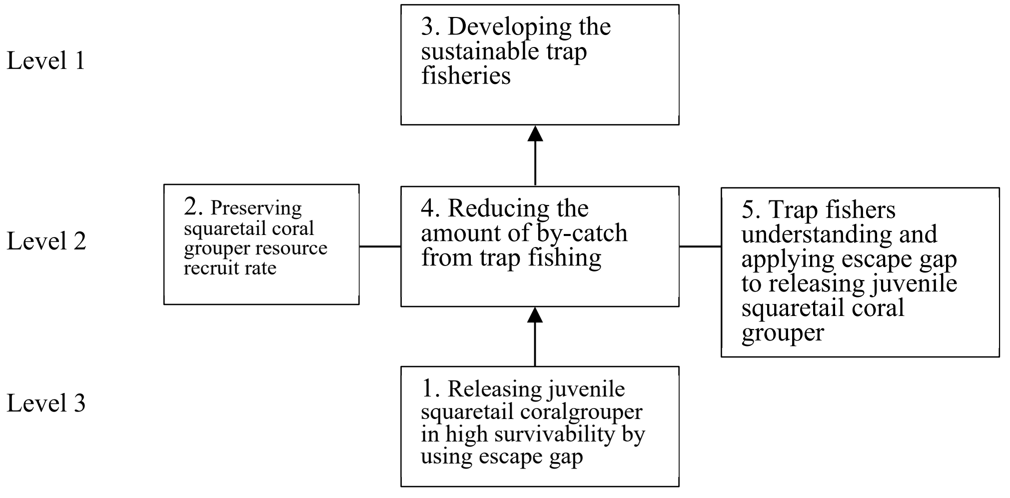

Fig. 3. Structural model diagram of the expected objectives element.

3.2 Required activity elements

The activity element is broken down into eight sub-elements. Assessment of opinions among respondents through the consistency test obtained with the value of 100% consistency (Table 2). It means that the opinions expressed are very consistent.

Table 2. Final reachability matrix of required activity element.

Final Reachability Matrix	Trial use of the escape gap on the trap	Limiting grow-out cage system	Improving the coordination between the related institutions and stakeholder	Improving supervision and enforcement of sanction for violations of the minimum catch size of squaretail coral grouper	Providing assistance to the fishermen	Improving the fishermen's awareness related sustainable trap fisheries	Enacting fishing gear regulation with escape gap for releasing juvenile squaretail coral grouper	Facilitate the funding for trap fishers to modificate the trap equiped escape gap	**TOTAL DP (Y)**	**RANKING DP**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		
(1)	1	1	1	1	1	1	1	1	**8**	1
(2)	0	1	1	1	1	1	1	1	**7**	2
(3)	0	0	1	0	1	1	1	1	**5**	3
(4)	1	1	1	1	1	1	1	1	**8**	1
(5)	1	1	0	1	1	1	1	1	**7**	2
(6)	1	1	1	1	1	1	1	1	**8**	1
(7)	1	1	1	1	1	1	1	1	**8**	1
(8)	1	1	0	0	1	0	0	1	**4**	4
TOTAL D (X)	**6**	**7**	**6**	**6**	**8**	**7**	**7**	**8**		
RANKING D	3	2	3	3	1	2	2	1		

The relationship between the sub-elements can be seen through the power-dependence driver matrix (Figure 4). All sub-elements in the required activity elements are distributed in sector III.

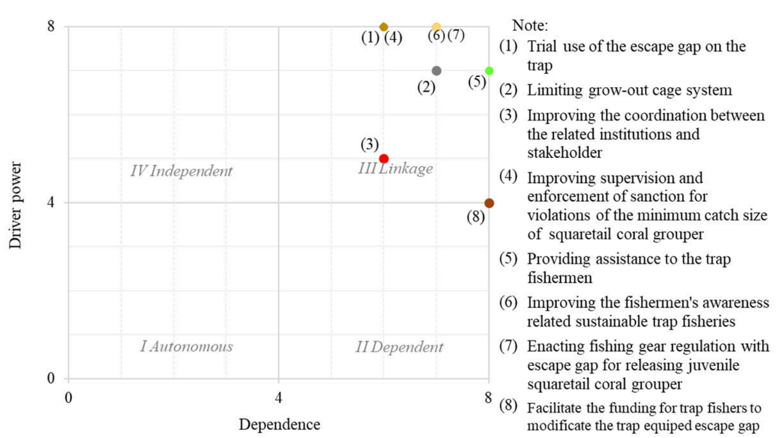

Fig. 4. Driver power-dependence matrix of the required activity element.

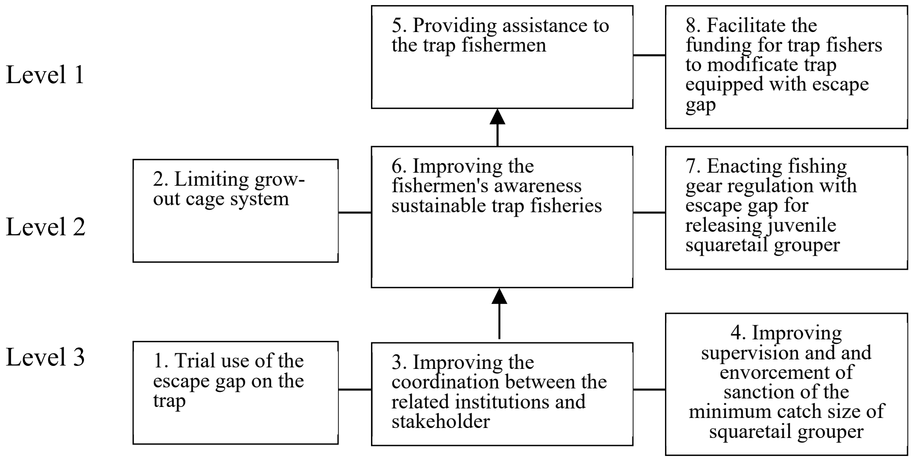

Fig. 5. Structural model diagram of the required activity element.

3.3 Obstacle elements

The obstacle element is broken down into eight sub-elements. The assessment of opinions among respondents through the consistency test was obtained with the value of 90.62% consistency (Table 3). This value means that the opinions expressed are quite consistent.

Table 3. Final reachability matrix of obstacle element.

Final Reachability Matrix	Worries of income reduction	Presence of grow-out cage system	Poor coordination between the related institutions or stakeholder	Poor supervision and minimum enforcement of sanctions for violations of the minimum catch size of squaretail coral grouper	The lack of assistance for the trap fishermen	Weak the fishermen's awareness related sustainable trap fisheries	The lack of information about escape gap utilization for basket trap	The lack of information about post-capture squaretail coral grouper survivability	**TOTAL DP (Y)**	**RANKING DP**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		
(1)	1	1	1	1	1	**1***	1	1	8	1
(2)	0	1	1	**1***	1	**1***	1	1	7	2
(3)	0	0	1	1	**1***	1	**1***	1	6	3
(4)	1	1	1	1	1	1	**1***	1	8	1
(5)	1	1	1	0	1	1	1	1	7	2
(6)	1	1	1	0	1	1	1	1	7	2
(7)	0	0	1	1	1	0	1	1	5	4
(8)	0	1	1	1	1	1	1	1	7	2
TOTAL D (X)	4	6	8	6	8	7	8	8		
RANKING D	4	3	1	3	1	2	1	1		

The sub-elements of the obstacle are distributed in quadrant IV (Figure 6). The sub-element with low dependence but a strong driving force is the concern of lowering income.

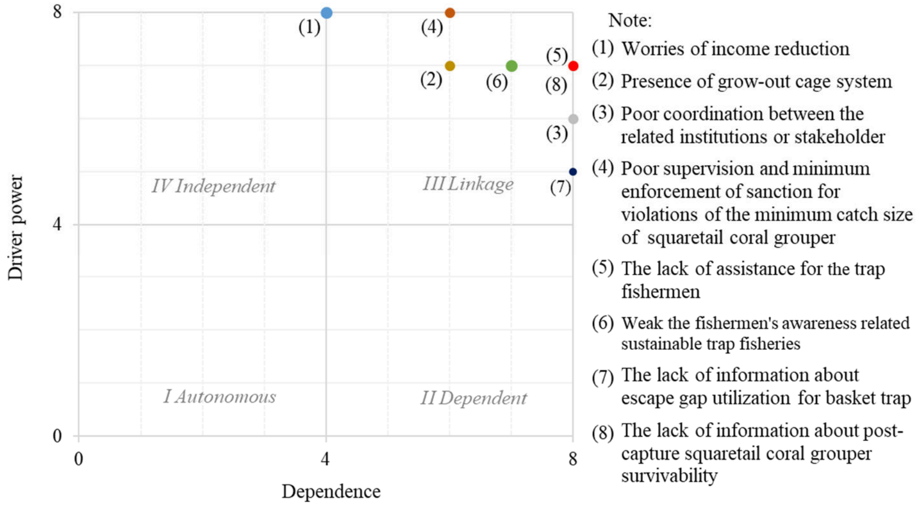

Fig. 6. Driver power-dependence matrix of the obstacle elements.

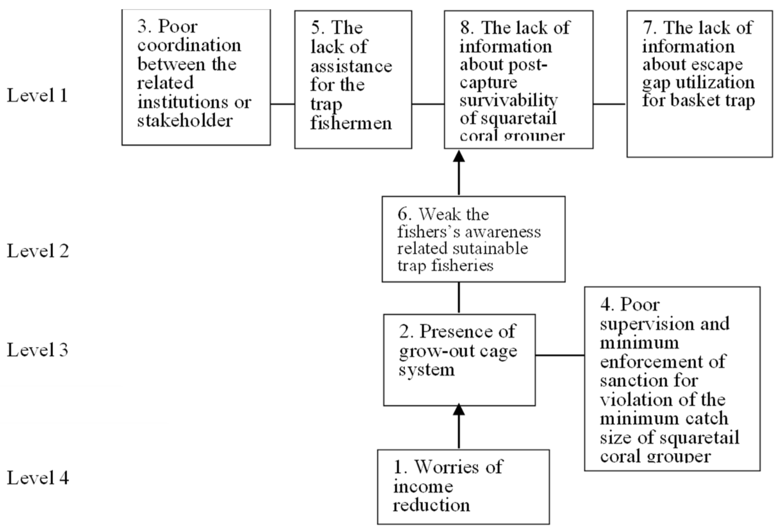

Fig. 7. Structural model diagram of the obstacle elements.

3.4 Involved institutions elements

The successful implementation of a program cannot be separated from the role of some related institutions and stakeholders. Through interviews and discussions with some experts, it is known that there are several institutions involved, namely the DKP at the provincial and district levels, PPP, Karimunjawa National Park Agency (BTNKJ), trap fishers' groups, NGOs, and exporters.

Table 4. Final reachability matrix of involved institutions elements.

Final Reachability Matrix	Marine and Fisheries Departments of Central Java Province	Marine and Fisheries Departments of Jepara Regency	Karimunjawa Coastal Fishing Port	Karimunjawa National Park	Fisher groups	Non-governmental organizations	Exporter	**TOTAL DP (Y)**	**RANKING DP**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
(1)	1	1	1	1	1	1	1	**7**	1
(2)	1	1	1	1	1	1	1	**7**	1
(3)	1	1	1	1	1	1	1	**7**	1
(4)	0	0	0	1	1	1	1	**4**	3
(5)	1	1	1	1	1	1	1	**7**	1
(6)	0	0	1	1	0	1	1	**4**	3
(7)	1	1	1	1	0	1	1	**6**	2
TOTAL D (X)	**5**	**5**	**6**	**7**	**5**	**7**	**7**		

All involved institutions' sub-elements are in the 3rd sector. The results of the power-dependence driver matrix are presented in Figure 8. Assessment of opinions between respondents through consistency testing was obtained with the value of 100% consistency. This means that respondents express their opinions with very high consistency.

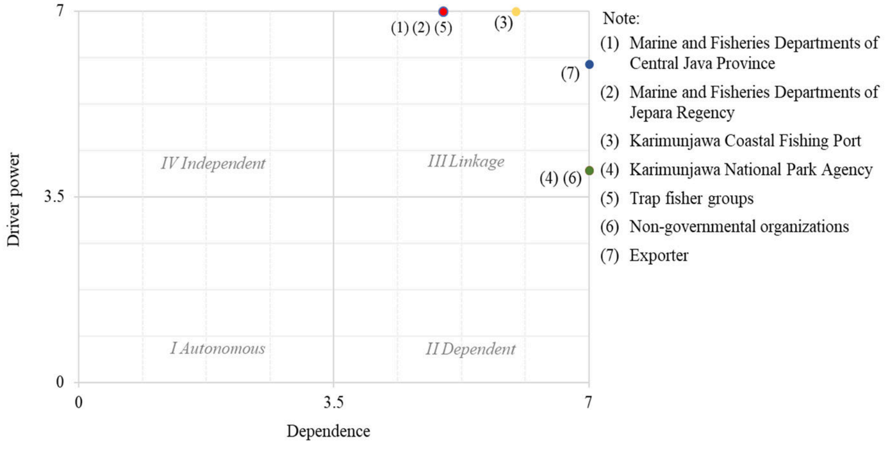

Fig. 8. The matrix of the power-dependence driver elements of the involved institution's elements.

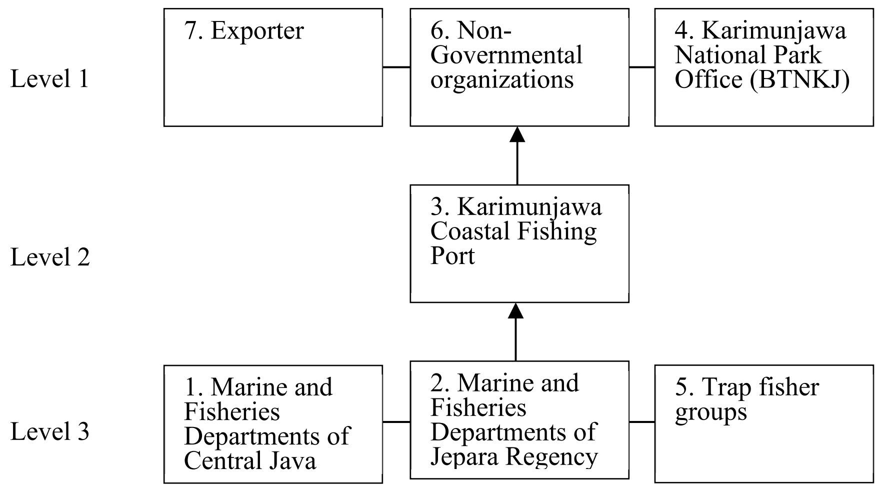

Fig. 9. Structural model diagram of the involved institution's elements.

3.5 Affected communities elements

Sub elements of the communities sector affected by escape gap implementation consist of 5 sub-elements: basket trap fishermen, grow out cage system owner, collector, exporter, and fisheries instructor. The result of SSIM analysis into the final reachability matrix is presented in table 5.

Table 5. Final reachability matrix of affected communities elements.

Final Reachability Matrix	Basket trap fishermen	Grow-out cage system owner	Collector	Exporter	Fisheries instructor	**TOTAL DP (Y)**	**RANKING DP**
	(1)	(2)	(3)	(4)	(5)		
(1)	1	1	1	1	1	**5**	1
(2)	0	1	1	1	1	**4**	2
(3)	0	0	1	1	1	**3**	3
(4)	0	0	0	**1**	1	**2**	4
(5)	0	0	0	0	**1**	**1**	5
TOTAL D (X)	**1**	**2**	**3**	**4**	**5**		
RANKING D	5	4	3	2	1		

The ISM output produced a driving force dependency matrix as shown in Figure 10 and a structural model presented in Figure 11. The basket trap fishermen are the key elements, meaning that fishers act as parties that drive and influence other sub-elements for the program's success. The fisherman sub-element in sector IV has low dependence but has a strong enough driving force. Assessment of opinions among respondents through the consistency test obtained a value of 100%. This value means that respondents express opinions with high consistency.

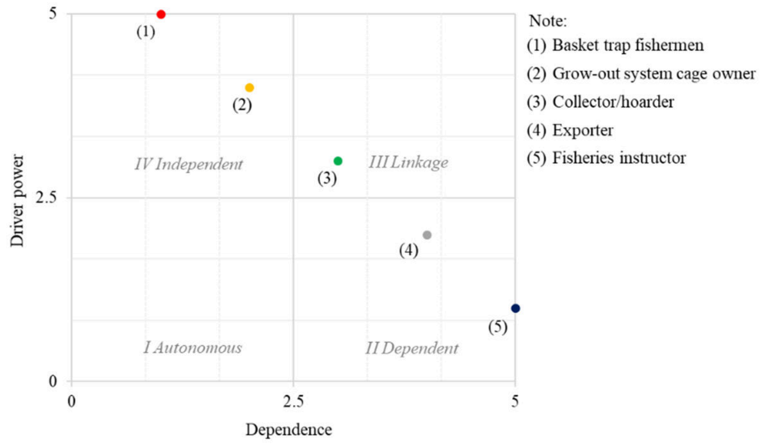

Fig. 10. Driver power-dependence matrix of the affected communities elements.

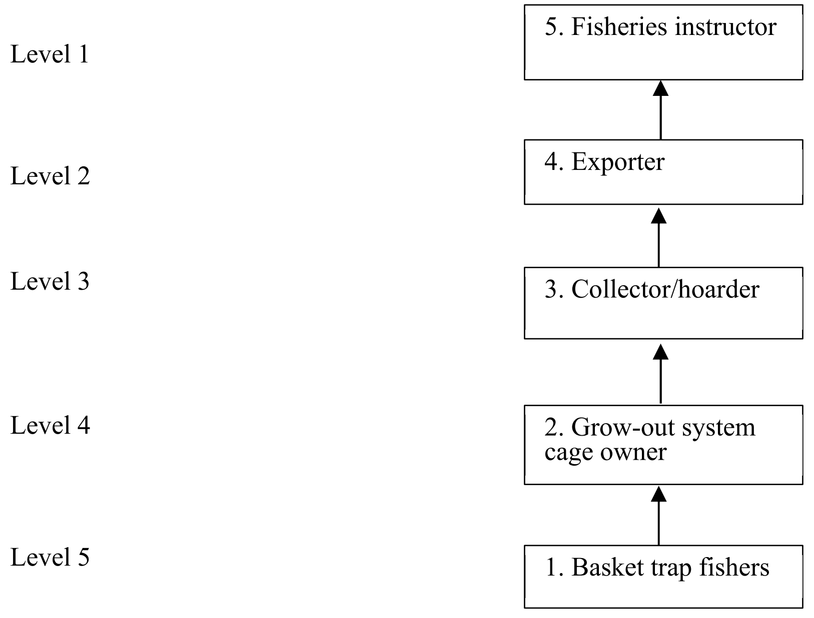

Fig. 11. Structural model diagram of the affected communities' elements.

4 Discussion

The output of ISM is obtained as a critical element as a critical factor that influences the success of implementation [26, 27]. There are five elements identified, namely the elements of objectives, required activities, obstacles, institutions involved, and affected communities. Each element is further elaborated into several sub-elements based on field conditions, discussions, interviews, and literature review.

The power-dependence driver matrix of the objective element (Figure 2) shows that the objective element in sub-element (5) releases juvenile squaretail coralgrouper in high survivability by using the escape gap in sector IV. It means that these sub-elements have low dependence, but the system's driving force is strong enough. Structurally, these sub-elements occupy level 4 as well as become critical elements. Sub-element (5) needs to be realized as a critical element before carrying out the other objectives. If trap fishers are already released juvenile squaretail coralgrouper by using an escape gap in a trap, fishing activities can protect the rate of resource recruitment. In the long term, trap fishing activities equipped with an escape gap can be a step towards sustainability.

There are some activities needed to fulfill the program's objectives. The activities with a high dependence are found in mentoring activities for fishers and facilitating access to capital to modify trap fishing gear. The activities that have a strong enough impetus for the realization of the program are the supervision improvement and sanctions for violations, testing environmentally-friendly traps, and technical regulations for fishing gear. Structurally, increased supervision and coordination between stakeholders is a key sub-element in the required activities. So far, there have been regulations regarding the minimum weight of grouper that can be captured. Regulations were formulated by the Karimunjawa National Park Office (BTNKJ) through a joint agreement on the management of marine and fishery resources in Karimunjawa District, Jepara Regency, in Chapter III (Special Rules and Agreements). However, supervision is limited to grouper distribution exits to prominent collectors in Karimunjawa Village, while fishing activities are spread to other villages such as Kemujan Village. Based on expert considerations, monitoring and coordination activities between stakeholders need to be carried out first. After the coordination is well established, the tasks and functions between institutions and stakeholders are cleared.

Thus the activity of technical regulations creation for fishing gear that can release captured juvenile squaretail coralgrouper fish can be carried out. As has been done in West Nusa Tenggara, as stated in the Action Plan for Sustainable Grouper and Snapper Fisheries Management, section 7 sub-section (3) states that the technical rules for fishing gear used to catch grouper and snapper. Such as basic gill nets that must use a mesh size of at least 4 (four) inches; when using a fishing line, the smallest size is number 4 (four). In addition, it is also necessary to limit cultivation activities with a grow-out system. If grow-out is limited, juvenile squaretail coralgrouper has no selling value, fishers who catch small sizes have difficulty accessing cultivator markets. The hope is that fishers will consider not catching fish that have no value. The realization of a comprehensive program can be supported by providing assistance to trap fishers and providing access to funding facilities for trap fishers to modify trap fishing gear equipped escape gap. Activities in the context of resource protection are also carried out in several countries. Papua New Guinea already enforces a closure of the area and a ban on commercial fishing activities from October 1 to November 30 with the enforcement of the law regarding minimum catch of squaretail coralgrouper grouper (36 cm). Australia has imposed a minimum catch size of 38 cm for grouper. Not much different from Phonpei, which prohibits the sale of grouper on March 1 – April 30 every year, this rule has been in effect since 1985.

Implementation of escape gap in trap fishing activity cannot be separated from the obstacles. The low level of awareness of the fishing community towards protecting the recruitment rate of squaretail coralgrouper resources is a key sub-element in the constraint element. It means that these obstacles must receive more attention to be addressed immediately. The program's implementation cannot be carried out if it only relies on several parties, including parties, to carry out supervision. The next obstacle is reducing income when using an escape gap that can catch juvenile-sized fish. Some fishermen are aware that catching fish below a recommended size will have a destructive impact in the future. However, this awareness is inferior to economic needs. The solution that can be offered is the use of bait to attract the attention of fish to enter and be trapped in the trap. Small trapped fish can release through the escape gap, while fish of suitable size are trapped in the trap. So that it can reduce the concerns of fishers because juvenile fish were able to release, so it could make fisheries more sustainable without reducing fishermens' revenues.

The success of the implementation cannot be separated from the role of some parties involved. In implementing this program, The Marine and Fisheries Department of Central Java Province, The Marine and Fisheries Department of Jepara Regency, and fishermen groups are the keys. These three parties have a high dependence and drive for the success of the program. The Marine and Fisheries Department of Central Java Province plays a role in the formulation of regulations based on the Marine and Fisheries Department of Jepara Regency proposal. Meanwhile, the fishermen's groups act as group reinforcement. Most fishermen who are members of a group will hold regular meetings. The meeting discussed various things ranging from assistance, seasons, yields to effective fishing locations. The following institution is PPP Karimunjawa which plays a role in monitoring through recording catches. The results of the structural matrix show that the involvement of institutions at the government level plays a vital role in the success of the program. The results are in line with the strategy formulated before [26], which shows the importance of the role of institutions at the government level in implementing the capture fisheries management model in the Karimunjawa National Park.

The results based on the ISM outputs also produce information on affected communities. Structurally, fishers are vital elements that can drive sub-elements and other elements in the program's success. The fishermen have low dependency but high driver-power for the success of the program. If the fishermen equipped the trap with an escape gap, it would reduce the juvenile-sized catch, which is usually sold to grow-out cage owners. The decrease in purchases of juveniles by grow-out owners also reduces purchases by local baskets/collectors, which in turn affects exporters in meeting the demand for grouper. In order to maintain the stability of meeting the demand for grouper and reduce fishing pressure, recommend compensating with cultivation activities.

5 Conclusions

Implementing the escape gap in trap fisheries to release juvenile squaretail coralgrouper required prioritizing the key sub-element of each element. These key are releasing juvenile grouper with high survivability (objectives), trial use of the escape gap on the trap also improving supervision and enforcement of sanction for violations of the minimum catch size of squaretail coral grouper (activities), worries of income reduction (obstacles), Marine and Fisheries Departments of Central Java Province (institutions involved), and fishermen (affected communities). These key sub-elements will drive other sub-elements to support successful implementation of escape gap in trap fisheries to release juvenile squaretail coralgrouper in Karimunjawa Island.

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