Sustainability index of the shrimp farming in Takalar Regency, Indonesia

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Abstract. This study aimed to determine the sustainability index in the development of shrimp culture in Takalar Regency, South Sulawesi, Indonesia. The indicators of the sustainability index were based on the ecological aspects (the suitability and environmental carrying capacity), economic aspects (levels of production and income), social aspects (labor absorption rate), as well as legal and institutional aspects. An analytical method was applied for measuring the sustainability Index of shrimp farming. The results showed that the sustainability index of each categories; the ecological aspects were in a fair sustainable category (69.26), with the traditional farming support as the contributing variable; the economic aspects were in a fair sustainable category (67.16) with a labor absorption rate in the traditional farming technology as the contributing variable; social and cultural aspects were in a fair sustainable category (65.10), with the number of households working in the cultivation using traditional technology as the contributing variable; as well as legal and institutional aspects were in a less sustainable category (42.75), with the availability of farm management rules as the contributing variable.
Key Words: environmental carrying capacity, region, technology, aspects, development.

Introduction. The potentials of aquaculture in the coastal areas have developed into bio-industrial food activities. It has been proven to be able to generate national income and also provide job opportunities. The large market of shrimp, stable selling prices, the technology application in every process of production, the availability of *aqua-input* commercially, the availability of potential lands, and the support of the government's policy lead to shrimp commodity to keep growing into a main fishery commodity and being a featured product to earn national income (Widigdo 2002; Kasnir et al 2014).

The technology of shrimp culture consists of intensive, semi-intensive, and traditional shrimp farming technologies. The division of its farming technology is based on several criteria, namely: food, water management, stocking density, the size of the ponds, and production. Intensive shrimp farming can generate high production, yet the operational length of the cultivation is short; otherwise, in traditional shrimp farming, the production is small but the operational length of the farming is long (Boers 2001).

Furthermore, it is said that the traditional shrimp farming is a shrimp farming whose making and operation do not use a modern equipment, commonly carried out by farmers who have low knowledge, are oriented towards sustainability, and depend the productivity on the nature, while intensive shrimp farming uses a modern technology by using food input to spur the growth of shrimp, and is usually less oriented to the preservation of nature.

The utilization of various farming technologies has impacts on the environmental damage which is the result of the organic waste generated primarily from leftover food, feces, and dissolved materials, discharged into coastal waters and significantly affecting the quality of the coastal environment (Johnsen et al 1993). The main components which are greatly considered in the sustainable development are economic and social and environmental components, each of which is related to each other in one system triggered by the strength and purpose (Munasinghe 2003). The economic sector is intended to see the development of human resources, in particular through the increase of the consumption of goods and services. The environmental sector is focused on the

protection of the integrity of ecological systems. The social sector is aimed at improving human relations, the realization of the aspirations of individuals and groups, and the strengthening of values and institutions. The development of the economic dimension is often evaluated through the meaning of benefit measured as the willingness to pay for goods and services consumed (Munasinghe 1992). Furthermore, it is said that the sustainable development should be based on four factors (Munasinghe 2004), namely: (1) the integration of the concept of environmental "equity" and economy in decision-making; (2) special consideration of economic aspects; (3) special consideration of environmental aspects; and (4) special consideration of socio-cultural aspects. Therefore, the present study is aimed at determining the sustainability indices in the development of shrimp farming in Takalar Regency, Indonesia. The indicators of sustainability indices are based on ecological, economic, social and cultural aspects as well as legal and institutional aspects.

Material and Method

Study site. This research was conducted in the coastal areas of Mangara Bombang District, Takalar Regency, Indonesia.

Samples and data sources. Data were obtained by observation and direct interview by using questionnaires which had been prepared at the research site. The respondents were selected using purposive sampling, categorized based on their roles as policy makers (Department of Maritime Affairs and Fisheries, Agency for Regional Development - BAPEDDA, Department of Environment, Department of Spatial Design, traders, businessmen and fish farmers) based on the groups of the technology level of farming, namely intensive shrimp farming with 126 individuals/m^2 and intensive shrimp farming with 50 individuals/m^2. The determination of the respondents by means of cluster was based on the group of farming technology with a simple random, with a precision of 10% (Djarwonto 2000) with the formulation:

$$n = N / Nd^2 + 1$$

Where: n = number of samples
N = total population
d^2 = precision specified

Data analysis. Analysis of sustainable development index of shrimp farming was performed using Rapfish Applications (Rapid Appraisal for Fisheries) according to Pitcher & Preikshot (2001).

a. Attribute compilation

The assessment of good and bad category of the development of farms was based on the results of the analysis of the ecological, technological, social, economic and institutional dimensions. The index value in each dimension reflected the category of the good and bad governance by using the reference of the bad to good in the interval of 0-100. The index interval was an interval of ≤24.9 in a *bad* status, interval from 25 to 49.9 in *less* status, interval from 50 to 74.9 in *sufficient* status, and the interval >75 in *good* status (Johnson & Wichern 1992). Attributes and scores were used to assess the good and bad governance of the farm area. Those attributes were obtained based on the results of analysis, field observations, literature study, and the previous research with the principles of management in a sustainable manner.

b. Attribute ratings

The category analysis of the good and bad development of the farms with the approach of Sustainability Index of Aquaculture Fishery Governance (SIAFIGO) was done with the application of *Rapfish*. There were several steps being taken in this approach, which is shown in Figure 1. Each attribute in each dimension was given a score reflecting the condition of accountability of the dimensions studied. The score range was determined based on criteria that could be found from the results of field observations

and analysis of the secondary data. The range of scores was from 0 to 3, depending on the circumstances of each attribute, defined as *bad* to *good.* The criteria for the making the scores for each attribute was based on four dimensions.

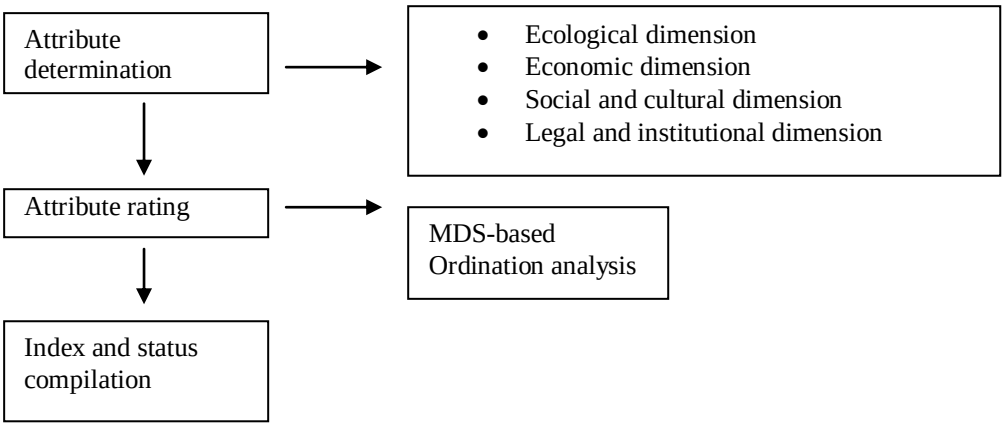

Figure 1. Stages of SIAFIGO analysis.

c. Multidimensional scaling analysis (MDS)

Multidimensional scaling (MDS) is a statistical analysis technique that does multidimensional transformation (Kavanagh & Pitcher 2004; Fauzi & Anna 2003; Budiharsono 2007). Through the method of the axis rotation, the position of these points can be projected on a horizontal line where the extreme point of "bad" was given a score of 0% and the extreme point of "good" was given a score of 100%.

Broadly speaking the procedures of SIAFIGO ordination are as follows:

1) The results of field data (primary and secondary) of all dimensions undergo scoring.

2) Determine the main reference of "good" and "bad" by attributing good and bad scores on all attributes.

3) Make two other main points, namely "midpoint", which is a bad point and a good point.

These two additional main points of reference become a reference of vertical direction ("up" and "down").

4) Make additional reference points referred to as "anchors", which can be used to help the results of ordination. These points act as a stabilizer which creates a kind of "envelope" so that the points of research location are not outside the envelope. These points are also useful in conducting a regression analysis to calculate the "stress" that is a part of the MDS.

5) Standardize the score for each attribute with the formula:

$$X_{ik}\ sd = \ldots \frac{x_{ik} - x_k}{s_k}$$

Description:

$X_{ik\ Sd}$ = the score value of the standard of *i* research site (including its reference points),

where *i*= 1, 2, ... n, of each *k* attribute, in which *k* = 1,2, ... p;

X_{ik} = the initial value score of *i* study sites (including reference point), in which *i* = 1,2, ... n of each *k* attribute,

in which *k* = 1, 2, ... p;

X_k = the mean scores of each *k* attribute, in which *k* = 1, 2, ... p;

S_k = the standard deviation of scores of each *k* attribute, in which *k* = 1, 2, ... p.

6) Calculate the distance between two dimensions with a method of *Euclidean distance* with an *n* dimesion which is written as follows.

$D^2\ (ij) = \Sigma\ (X_{ik} - X_{ik})^2$

7) Make ordination for all attributes for each dimension based on aspects.

8) An algorithm of multidimensional scaling analysis. In the analysis of MDS, the attribute dimensions, which are originally in a large number becomes only two dimensions will be the axes of X and - Y. The result of the ordination is the matrix V (n x 2) in which *n* is the number of the location studied.
9) The distance between objects is calculated using 2 dimensions = d_{ij}. This d_{ij} value is then regressed to the value of D_{ij}. The result of simple regression will yield an equation $d\hat{}_{ij} = A + Bd_{ij}$, in which $d\hat{}_{ij}$ is the expected value of D_{ij} on 2-dimensions, which is the Dij value on the regression line. Thus, the value of $d\hat{}_{ij}$ can be calculated from the value of d_{ij}. From these two values, stress values can be calculated.

The value of "stress (standardized residual sum of square)" is calculated through a simple regression analysis using the distance value at the time of two dimensions and four dimensions. MDS analysis stops if the value of "stress" has met the desired requirements, in this case <0:25 or if the "stress" does not go down again in alliteration.

Furthermore, the process of "rotation" and the "fliping" is done so that the position of the main reference point of "bad" and "good" are parallel to the x-axis, while the "top" is above the x-axis and "down" are under the x-axis. To guarantee the absence of errors in the position of a point that is opposite the mirror, and then the process of "flip" for specific points experiencing an error is conducted.

In this study, four categories of sustainability status based on a basic scale (0-100) were composed. The sensitivity analysis was performed to see which attributes were most sensitive in giving contributions to SIAFIGO in the study area. The influence of each attribute was seen through the changes of root mean square (RMS) ordination, particularly on the x-axis or sustainability scale. The greater the change in RMS due to the loss of a particular attribute, the greater its role in the formation of SIAFIGO values in sustainability scale, or the more sensitive this attribute in the governance of marine fishing tourism.

The evaluation of the influence of random error in the process of estimating the ordination value of the governance used Monte Carlo analysis (Johnson & Wichern 1992).

d. Sensitivity analysis

The sensitivity analysis was performed to see which attributes were most sensitive and very sensitive in contributing to the effectiveness index on marine fishing tourism governance in the area of research (Johnson & Wichern 1992). The role of each attribute to the index value of the effectiveness of the governance was analyzed by "attribute leveraging", so the change in ordination could be seen if a particular attribute was removed from the analysis.

e. Monte Carlo analysis

Monte Carlo analysis was performed in order to evaluate the effects of the error by estimating a certain statistical value (Johnson & Wichern 1992). An analysis with a Monte Carlo method is useful to study about:
1) The effects of errors in the scores of attributes that are caused by the understanding of the sustainability conditions of marine fishing tourism.
2) The effects of variations in scoring as a result of differences in opinion or judgment by different research.
3) The stability of a repeated MDS analysis process (iteration) and the quality of the stability of the points of method reference carried out.
4) Data entry errors or missing data.
5) The high value of stress of the results of analysis.

Results and Discussion. In Table 1 can be seen the obtained result of the present research result concerning the result assessment on each dimension and each attribute (variable).

Table 1

Assessment data on each dimension and each attribute (variable)

Dimensions and attributes (Variables)	*Score*	*Indicator assessment*		*Information*	*Recapitulation of respondents assessment (dominant value)*
		Good	*Bad*		
Ecological dimension					
Pond utilization compared to condition of conformity analysis outcome	0,1, 2,3	0	3	(0) Very suitable, >75%; (1) suitable 50> -75%, (2) Less suitable, 25- <50% (3) Not suitable <50%	00000000000000000111 11111111111111112222 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 233333333333333
Intensive cultivation support capacity	0,1,2	2	0	Referring to result of carrying capacity analysis, (0) utilization >100% of carrying capacity (cc); (1) utilization 51-100% of cc; (2) utilization <50% of cc	00000000001111111111 11111111111222222222 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222
The carrying capacity of traditional cultivation	0,1,2	2	0	Referring to result of carrying capacity analysis, (0) utilization >100% of carrying capacity (cc); (1) utilization 51-100% of cc; (2) utilization <50% of cc	00000000000000000000 01111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 111111112222222
Semi-intensive cultivation support	0,1,2	2	0	Referring to result of carrying capacity analysis, (0) >100% utilization of carrying capacity (cc); (1) utilization 51-100% of cc; (2) utilization <50% of cc	00000000000001111111 11111111111222222222 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222
Economic dimension					
The amount of business capital for intensive cultivation/ha	0,1,2	2	0	Referring to the result of business capital analysis (0) ≥75 million; (1) 25-75; million, (2) <25 million	00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000001111111 11111111111111111111 111111222222222
The amount of business capital for semi intensive cultivation/ha	0,1,2	2	0	Referring to the result of business capital analysis (0) ≥75 million; (1) 25-75; million, (2) <25 million	00000000000000000001 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 111122222222222

Dimensions and attributes (Variables)	*Score*	*Indicator assessment*		*Information*	*Recapitulation of respondents assessment (dominant value)*
		Good	*Bad*		
Economic dimension					
The amount of venture capital for traditional cultivation/ha	0,1,2	2	0	Referring to the result of business capital analysis (0) ≥75 million; (1) 25-75; million, (2) <25 million	00000000001111111111 11112222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222
Level of profit of intensive cultivation/ha (Rp/ha/cycle)	0,1, 2,3	3	0	Referring to Charles (2001); (0) loss, (1) return of capital, (2) marginal profit, (3) very profitable	00000001111111111111 12222222222222222222 33333333333333333333 33333333333333333333 33333333333333333333 33333333333333333333 333333333333333
The level of profit of semi intensive cultivation/ha (Rp/ha/cycle)	0,1, 2,3	3	0	Referring to Charles (2001); (0) loss, (1) return of capital, (2) marginal profit, (3) very profitable	00000000001111111111 11111111112222222222 22222222222222222333 33333333333333333333 33333333333333333333 33333333333333333333 333333333333333
Level of profit of traditional cultivation/ha (Rp/ha/cycle)	0,1, 2,3	3	0	Referring to Charles (2001); (0) loss, (1) return of capital, (2) marginal profit, (3) very profitable	00001111111111222222 22222222222222222233 33333333333333333333 33333333333333333333 33333333333333333333 33333333333333333333 333333333333333
Absorption of intensive cultivation labor	0,1,2	2	0	Refers to Rapfish: (0) low, 1 person/unit, (1) moderate, 2 persons/unit (2) high, ≥3 persons/unit	00000000011111111111 11112222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222
Absorption of semi intensive cultivation labor	0,1,2	2	0	Refers to Rapfish: (0) low, 1 person/unit, (1) moderate, 2 person/unit (2) high, ≥3 persons/unit	00000000000000111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 112222222222222
Absorption of traditional cultivation labor	0,1,2	2	0	Refers to Rapfish: (0) low, 1 person/unit, (1) moderate, 2 persons/unit (2) high, ≥3 persons/unit	00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000111 11111111111111111111 111111111122222

Dimensions and attributes (Variables)	*Score*	*Indicator assessment*		*Information*	*Recapitulation of respondents assessment (dominant value)*
		Good	*Bad*		
Economic dimension					
Allocation of working hours on intensive cultivation	0,1,2	2	0	Referring to fishery statistics (0) <25%, (1) 25-50%, (2) >50%	00000000011111111111 11111111222222222222 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222
Allocation of working hours on semi-intensive cultivation	0,1,2	2	0	Referring to fishery statistics (0) <25%, (1) 25-50%, (2) >50%	00000000000000001111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 111122222222222
Allocation of working hours on traditional cultivation	0,1,2	2	0	Referring to fishery statistics (0) <25%, (1) 25-50%, (2) >50%	00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 000000000001112
Intensive business capital	0,1,2	2	0	Loan (0) <25%, (1) 25-50%, (2) >50%	00000000000000111111 11111111111111111111 11112222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222
Semi-intensive business capital	0,1,2	2	0	Loan (0) <25%, (1) 25-50%, (2) >0%	00000000000000111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 111222222222222
Traditional business capital	0,1,2	2	0	Loan (0) <25%, (1) 25-50%, (2) >50%	00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 000000000001122
Social and cultural dimensions					
Level of education in intensive cultivation	0,1,2	2	0	(0) did not finished primary school, (1) graduated junior high school (2) did not graduated from University/Higher Education	00000000011111111111 11111111111111111222 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222

Dimensions and attributes (Variables)	*Score*	*Indicator assessment*		*Information*	*Recapitulation of respondents assessment (dominant value)*
		Good	*Bad*		
Social and cultural dimensions					
The level of education in semi-intensive cultivation	0,1,2	2	0	(0) did not finished primary school (1) graduated junior high school (2) did not graduated from University/Higher Education	00000000000000111111 11111111111111111111 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222
Level of education in traditional cultivation	0,1,2	2	0	(0) did not finished primary school (1) graduated junior high school (2) did not graduated from University/Higher Education	00000011111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 112222222222222
Number of households working in intensive cultivation	0,1,2	2	0	Referring to Charles (2001): (0) <1/3 (1) 1/3 - 2/3 (2) >2/3 of the total population in the community concerned	00000000000001111111 11111111111111111111 11111111122222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222
Number of households working in semi-intensive cultivation	0,1,2	2	0	Referring to Rapf: (0) <1/3 (1) 1/3 - 2/3 (2) >2/3 of the total number of communities	00000000000111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111112 222222222222222
Number of households working in traditional cultivation	0,1,2	2	0	Refers to Rapfish: (0) <1/3 (1) 1/3 - 2/3 (2)> 2/3 of the total number of communities	00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000111111111111 111111111111112
Knowledge of environmentally friendly intensive cultivation	0,1,2	2	0	(0) low, if answer is <25%, (1) enough, if answer is 25-50%, (2) high, if answer >50%	00000000000000111111 11111111111111122222 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222
Knowledge of semi-intensive cultivation that is environmentally friendly	0,1,2	2	0	(0) low, if answer is <25%, (1) enough, if answer is 25-50%, (2) high, if answer is >50%	00000000000111111111 11111111111111122222 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222

Dimensions and attributes (Variables)	*Score*	*Indicator assessment*		*Information*	*Recapitulation of respondents assessment (dominant value)*
		Good	*Bad*		
Social and cultural dimensions					
Knowledge of traditional cultivation that is environmentally friendly	0,1,2	2	0	(0) low, if answer is <25%, (1) enough, if answer is 25-50%, (2) high, if answer is >50%	00000011111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111122 222222222222222
Legal and institutional dimensions					
Availability of groups of intensive cultivators	0,1,2	2	0	(0) none (1) exists, 1-4 groups (2) exist, ≥5 groups	00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 000000000000000
Availability of semi-intensive cultivation group	0,1,2	2	0	(0) none (1) exists, 1-4 groups (2) exist, ≥5 groups	00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 000000000000000
Availability of traditional farmer groups	0,1,2	2	0	(0) none (1) exists, 1-4 groups (2) exist, ≥5 groups	00000111111111111111 11112222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 22222222222222222222 222222222222222
Group relationships with other groups	0,1,2	2	0	(0) does not exist (1) exists	00111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 111111111111111
Cultivation group's relationship with the government	0,1,2	2	0	(0) does not exist (1) exists	00000001111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 111111222222222
Cultivator group relationships with entrepreneurs	0,1,2	2	0	(0) does not exist (1) exists	00000000011111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 111111111111222

Dimensions and attributes (Variables)	*Score*	*Indicator assessment*		*Information*	*Recapitulation of respondents assessment (dominant value)*
		Good	*Bad*		
Legal and institutional dimensions					
Availability of formal cultivation management regulations	0,1	1	0	(0) does not exist (1) exists	00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 000000000000000
Availability of personnel of extension workers	0,1,2	2	0	(0) does not exist (1); rarely (1 time/month); (2) many or frequently located (>2 times/month)	00000000000011111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 111111111111222
Intensity that violates the law in relation to cultivation	0,1,2	2	0	(0) there are high (frequency >2 per year); (1) low (1/year); (2) does not exist	00000000000000000000 00000000000000000000 00000000000000000000 00000000000000000000 00001111111111111111 11111111111111111222 222222222222222
The level of social infrastructure (social facilities and public facilities)	0,1,2	2	0	Referring to Charles (2001); (0) does not exist, (1) limited, (2) high	00000000011111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 11111111111111111111 111111111111111

The analysis of the 39 attributes with dimensions (multi-dimension) in this study resulted in the index value or the location point of 49.43. This reflects the position of the sustainability of farms in Takalar Regency which was found to be less sustainable in which the position was above the line of two reference points or main reference, namely a good point and a bad point. The existence of a location point above the main reference line of a good and bad point which had a tendency to the main reference point of *up* point indicates a process of flip. *Up* point on the vertical coordinate *y* must be greater than the *down* point with a logical operation being used (Susilo 2003).

The results of SIAFIGO analysis in the ecological dimension consisted of the supporting attributes of current intensive, semi-intensive and traditional farming as well as ponds rather than the results of the analysis of the suitability conditions. The value of local position was at 69.26. This value indicates that the index of the sustainability of farms in the ecological dimension in the category of quite sustainable attributes of the ecological dimension had a contribution in determining the sustainability index, and the dominant attributes which became the contributing factor of sustainability index value of ecological dimension were the supporting attributes of the traditional farming, followed by intensive and semi intensive farming, as well as land suitability and level of utilization.

The emergence of main contributing attribute in the form of supporting power of traditional farming was predicted as a result of the low support to the aquaculture which has been caused by the use of illegal chemicals.

Another contributing factor was the supporting power of intensive aquaculture. This should be a concern so that the supporting power of intensive farming can be protected by the means of effective and efficient feeding so it does not have impacts on

the high level of waste produced, which eventually can reduce the natural power of environment to support the life of organisms.

The results of SIAFIGO analysis on the economic dimension consisted of the attribute of the amount of the business capital for farming activities for each intensive, semi-intensive and traditional farming. The profit levels of shrimp farming were gotten from each intensive, semi-intensive and traditional farming; work-force absorption from each intensive, semi-intensive and traditional farming; and the source of capital from each intensive, semi-intensive and traditional farming.

The value of local position 67.16. This value indicates that the sustainability index of the farm development in the economic dimension was in the sustainable category of fair (quite sustainable). To look at each attributes that affected the index value, this research used leverage analysis (Figure 1) of the 15 attributes analyzed, which then indicates that the attributes having high sensitivity or the attribute of the contributing factor of the index value of the economic dimension was work-force absorption in the traditional farming and the allocation of hours of work on traditional cultivation. The attributes of work-force absorption and the allocation of working hours in the traditional farming had a relatively high average compared to the other 13 attributes. The emergence of attributes or main lever factors in the traditional farming was caused by the low work-force absorption in traditional farming technology. To increase the rate of work-force absorption, efforts on counseling and the improvement of skills as well as mentoring are needed, so that the land which at first was cultivated using traditional technology can be enhanced by semi intensive technology or improved by poly-culture farming efforts to optimize land cultivation, so that the workforce can be increased.

The second factor or attribute was the allocation of working hours in the traditional farming, which was influenced by the allocation of working hours in the service of traditional aquaculture activities with a low total number of working hours per cycle since farmers sometimes did some work at a particular time only, especially during preparation and stocking, while the maintenance was done by the time of harvest. To improve the allocation of working hours on the traditional farming, efforts to increase the level of production through some improvements on the technology and poly-culture farming system are needed.

The results of SIAFIGO analysis in the social and cultural dimension consisted of knowledge of attributes on the environmentally friendly traditional farming, knowledge on the environmentally friendly semi-intensive farming, knowledge of the environmentally friendly intensive farming, the number of households working in the traditional farming, the number of households working in semi-intensive farming, the number of households working in intensive farming, the level of education in the traditional farming, and the level of education in the semi-intensive and intensive farming.

The value of local position 65.10. This value indicates that the index of farm sustainability in the social and cultural dimension was in the sustainable category of fair (quite sustainable). The attributes that were analyzed showed that the attributes having high sensitivity to the index value of the social and cultural dimensions which were attributes or contributing factor of index values of social and cultural aspects were the number of households working in the traditional farming. The number of households working in the traditional farming was the number of traditional farming households in the study site and of such percentage, around 90% was traditional farming households, while the rest was the number of households working in the semi-intensive and intensive farming. The number of households working in the traditional farming activities was relatively high because the traditional farming is a kind of a hereditary job and because the skills/knowledge and capital are limited.

The results of SIAFIGO analysis in the legal and institutional dimensions consisted of attributes in the level of social infrastructure, the intensity of breaking the law in relation to aquaculture, the availability of counseling personnel, the availability of farm management, the relationship between the groups of aquaculture with the entrepreneurs, the relationship between the groups with the government, the relationship between some

groups with other groups, the availability of traditional farmer groups, the availability of semi-intensive farming groups, and the availability of intensive farming groups.

The value of local position 42.75. This value indicates that the index of farm sustainability in the legal and institutional dimensions was in the sustainable category or fair (quite sustainable). Out of 10 attributes analyzed, the attribute having high sensitivity levels included as a contributing factor in the index value of the legal and institutional dimensions was the availability of formal regulations of aquaculture management and the availability of traditional farming groups. The emergence of an attribute which was a main contributing factor to the index value of the sustainability of the legal and institutional dimensions was caused by the lack of available policies related to the management of cultivation from zones and land suitability from various technologies to the technical regulations related the facilities of fish production. Due to the non-existence of these rules, the society (farmers) used the land without considering the suitability and carrying capacity. The uncontrolled facilities of fish production can damage the environment and other factors, which eventually cause conflicts and environmental damage as well as the inefficiency of the use of land.

The second contributing factor was the availability of traditional farmer groups. This factor emerged due to the unwillingness of the society (farmers) to make a group, the remote locations, and the lack of benefits of group work (except if the group work offers a new assistance). The low awareness of farmer groups needs to be a concern for the government and counselors so that the planned programs can be applied in groups.

SIAFIGO analysis in each dimension shows that among the dimensions analyzed, the ecological, economic, social and cultural, legal and institutional dimensions had the level of sustainability index values included in the category of insufficient (less sustainable) to fair (quite sustainable) in the development of sustainable shrimp culture in Takalar Regency. The value of sustainability index for each dimension can be seen in Table 2.

Table 2

The index value farms development sustainability in each dimension

Dimension	*Ecological*	*Economical*	*Social and cultural*	*Legal and institutional*
Value	69.26	67.16	65.10	42.75

From Table 2, it is clear that the sustainable index has a slightly higher value compared to the other dimensions recorded in the ecological, economic and socio-cultural dimensions. This gives an indication that the legal and institutional dimensions need more attention than the other dimensions, especially in the implications of the policy by taking into account the attributes with a lower average value compared to other attributes.

The sustainability index value for each dimension was different. In the concept of sustainable development, all index values of each dimension must have an equal value, yet in a various conditions of regions or in the same location, a priority of a particular attribute to be a contributing factor needs to be taken into consideration.

Some statistical parameters obtained from the SIAFIGO analysis using MDS method serve as standard to determine the feasibility of the results of studies conducted in the study area. Table 3 presents the stress values and R^2 (squared correlation) for each dimension and multi-dimensions. This value was used to determine whether or not additional attributes were needed to reflect the dimensions studied accurately (approaching actual conditions).

The results of analysis of each attribute in the ecological, economic, social, cultural, legal and institutional factors/dimensions (Table 3) showed that the value of the standardized residual sum of square (stress) was still below 25%. Thus, every dimension and multi-dimensions had a stress value which was smaller than the provision stating that the value of the stress on the analysis by the MDS method was sufficient if the obtained value was at 25%. The smaller the stress value obtained means the better

quality the results of analysis, meaning that the level of consistency of the answers of various respondents were relatively equal from each dimension/aspect and its attributes.

Table 3

Results of SIAFIGO analysis for some statistical parameters

Statistical parameter	*Ecological dimension*	*Economical dimension*	*Social and cultural dimension*	*Legal and institutional dimension*	*Multi-dimensions*
Stress	0.15	0.13	0.13	0.13	0.13
R^2	0.93	0.95	0.95	0.95	0.95

Thus, the understanding and knowledge of these aspects were relatively familiar and the selected respondents fulfilled the expectations, while the value of squared correlation (R^2) in each dimension, if is higher than 90%, indicates that the attributes offered by each dimension associated with the development of the farming had a close or strong relationship, between each dimension and its constituent attributes. Thus, the data obtained from the respondents and attributes of the questions from various dimensions related to the status of the sustainability indices have been considered valid, because the stress value and the value of R^2 have met the standard analysis. R^2 coefficient value of the results of analysis is better if the value of the coefficient is higher (close to 1). Therefore, both parameters (the value of stress and R^2) showed that all the attributes used in the analysis of the sustainability of the development of shrimp culture (farm) in Takalar Regency was relatively good in explaining the four dimensions of management which were analyzed.

To test the confidence level of the multidimensional index value of each dimension, Monte Carlo analysis was used. This analysis is a computer-based analysis that was developed in 1994 using the technique of random numbers based on the statistical theory to obtain the alleged opportunities for a solution of the equation or mathematical model. Mechanisms to obtain such solutions include repetitive calculations. Therefore, Monte Carlo analysis will be faster when using a computer. Monte Carlo name is taken from the name of the city of Monte Carlo for the analysis Monte Carlo, in principle, is similar to roulette game in Monte Carlo. This Roulette can be considered as a simple random number generator.

Monte Carlo analysis in the analysis of SIAFIGO was used to see the effect of errors in making scores on each attribute of each dimension caused by faulty procedures or misunderstanding of the attributes, variations in scoring because of differences in opinions or judgment by different researchers, stability process of MDS analysis, errors in data entry or missing data, and the value of stress which was too high. The results of SIAFIGO analysis in the form of a sustainable index of sustainability had a high level of confidence.

The results of Monte Carlo analysis performed with a few repetitions contained errors which did not change the value of the total index and each dimension significantly. At the 95% of confidence interval, the index development of farms in Takalar Regency using Monte Carlo analysis was at 47.52. The difference in value between the results of the analysis of MDS and Monte Carlo indicates that the status of index value of the sustainable farm development in the 95% of confidence interval obtained results that did not experience much difference between the results of the analysis of MDS and that of Monte Carlo analysis. The differences in the index values of accountability between the results of the analysis of MDS method and Monte Carlo indicate several points: 1) an error in the making of scores for each attribute which was relatively small, 2) variations in scoring as a result of different opinions were relatively small, and 3) the analysis process carried out repeatedly was stable, 4) data entry errors and missing data could be avoided. The difference in the results of the analysis which was relatively small, as presented in Table 4, shows that the analysis of SIAFIGO using MDS to determine the sustainability index of system studied had a high level of confidence, and at the same

time it can be concluded that the method of SIAFIGO analysis performed in this study can be used as one of the evaluation tools to assess rapidly (rapid appraisal) of the sustainability of the system of farm development.

Table 4

Results of MDS and Monte Carlo analysis to SIAFIGO value and each dimension at the 95% confidence interval

Index status	*Result*	
	MDS	*Monte Carlo*
Multi-dimensions	49.43	49.33
Ecological dimension	69.26	68.92
Economical dimension	67.16	66.71
Social and Cultural dimension	65.10	64.30
Legal and institutional dimension	42.75	42.79

Analyzing the sustainability of aquaculture in Takalar Regency from the ecological, economic, social, cultural, and legal and institutional dimensions, the categories which were quite sustainable were the ecological, economic and socio-cultural dimensions while the less sustainable ones were the legal and institutional dimensions, so these dimensions should be prioritized in the development of aquaculture (farms). SIAFIGO methods need to be developed primarily to determine the types of attributes that can be used as raw attributes, especially ecological dimension, by using the supporting attributes from the analysis results to assess the sustainability index of the development of aquaculture (farms) in Indonesia.

Conclusions. Analyzing the sustainability of aquaculture in Takalar Regency from the ecological, economic, social, cultural, and legal and institutional dimensions, the categories which were quite sustainable were the ecological, economic and socio-cultural dimensions while the less sustainable ones were the legal and institutional dimensions, so these dimensions should be prioritized in the development of aquaculture (farms).

Suggestions. The SIAFIGO methods need to be initially developed to determine the types of attributes that can be used as raw attributes, especially ecological dimension, by using the supporting attributes from the analysis results to assess the sustainability index of the development of aquaculture (farms) in Indonesia.

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