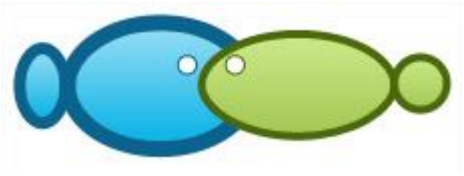

Minimizing the instability of seaweed cultivation productivity on rural coastal area: a case study from Indonesia

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Abstract. This research aims to identify, assess and select the key factor to improve and create the sustainability in productivity of seaweed cultivation by seaweed farmers in Southeast Maluku, Indonesia. This research is necessary to overcome the problems faced by the micro-scale enterprises on seaweed cultivation and by local government because of a significant declining in the number of productive micro enterprises on seaweed cultivation which have caused decrease on region total seaweed production since 2012. The results of this research showed the quality and quantity of seaweed as the most noted criteria by micro-scale enterprises seaweed cultivation. Results also demonstrated that openness and access to the technology were the key factors in resolving the problems and will improve the performance and sustainability of seaweed cultivation in Southeast Maluku, Indonesia.
Key Words: seaweed farmers, cultivation, Southeast Maluku, rural coastal area.

Introduction. Indonesia is the leading producer of carrageenan seaweeds started back in 2008 (Valderrama et al 2015). According to UN export statistics, Indonesia's output continues to increase at a faster rate than other countries (UN COMTRADE 2014), reaching around 230 thousand tons of dry seaweed by 2013. Maluku province has coastal line to support the seaweed cultivation and considering the great economic opportunity from seaweed, in 2014 Maluku Provincial Government has declared to make seaweed as the main export commodity of this region. Numerous countries have given their interest on seaweed from Maluku namely Denmark, Japan, China, Philippines, Korea, Taiwan, Australia and America (Directorate General of Agro Industry, Indonesian Ministry of Industry 2014). Southeast Maluku as part of Maluku province administration has first declared seaweed as their top commodities a year earlier in 2013.

Local government of Southeast Maluku considers seaweed as the top commodity, simply based on the evidence of previous years, starting with 2007 until 2012 seaweed was booming in Southeast Maluku. The selling price of seaweed at that time was around Rp.13.000 to Rp 15,000/Kg (equivalent $1 more/less) and that initiated massive occupation shifting in marine and fisheries sector in this region. During that period of time, many of fishermen from marine wild-fish catch, even public servant and army turned to be seaweed farmers; as the result total seaweed production since than has increased gradually and massively. However, as the regional development planning agency of Southeast Maluku and Teniwut & Kabalmay (2015) pointed out, since 2012 the number of active micros, individual and family based seaweed cultivation have decreased significantly which also lower seaweed production in Southeast Maluku.

Seaweed farms in this region are mostly run by family members or by village groups which consist of members from the same village, or by the combination of those two (Teniwut et al 2017). Based on the situation, the EU/Indian Ocean Commission (2012) referred as in the case of seaweed cultivation management village/family-based, the factors such as professionalism, knowledge and the degree on the use of science and technology related to cultivation activity are lower than in case of more educated people in other regions. In addition, the probability on the occurring of conflicts within the family

or between villagers is also higher in this region. However, the management of seaweed cultivation model village/family-based proven to give significant impact on socio-economy and lifestyle of coastal communities, in general because the earning from seaweed production by each micro scale enterprise can be directly felt by them and this suits the program of the central government of Indonesia who carries the concept of building from rural areas.

According to Hurtado (2013), the village-based family business has two main characteristics namely 1) the "nuclear family" ("mom and pop") model, where spouses share the farm work and income among themselves, their children, their parents and/or other first-degree blood relations; and (2) the "lead farmer" model, where one person or a small team of people own the enterprise, are actively involved in day-to-day operations, assume responsibility. Family members sometimes lack skills such as marketing, finance, or accounting, and the family must acquire such skills if the business is to survive (Dyer 1989). Village and family-based management also have the tendency on friction and conflict among its members, due to the absence of strict distribution on the division of tasks and responsibilities which will apparently couple with the lack professionalism, as pointed out by Graves & Thomas (2004). The challenges faced by micro and small enterprises are the lack of technology, quality of human resources, management capability, capital power and good organizations and institutions. Micro and small enterprises also have some identical characteristics which are limited ability on basic knowledge and skill in the use of latest and relevant technology (Lopez-Ortega et al 2016). These findings showed the complexity of the challenges faced by micro enterprises, making it requiring more and comprehensive attention, in particular for the coastal community who is living in rural coastal villages which usually located isolated from the urban area.

Seaweed farmers who mostly live in rural coastal area tend to have low intensity on the use of technology and lack of the basic knowledge about seaweed cultivation, limited on capital capabilities and spending power on production cost (Hurtado et al 2001; Krishnan & Kumar 2010; Hurtado et al 2014), the needs for the support from the both central and regional government, the importance of the quality of the coastal waters (Glenn et al 1999; Teniwut & Kabalmay 2015) and the needs of more competitive selling price of the product (Valderrama 2012). Those factors are some of the most crucial factors that must be addressed in order to increase the sustainability of productivity of marine and fisheries activities in rural areas, which is seaweed cultivation included on that matter.

Based on the background and empirical results that have been discussed above, the purposes of this research were to identify and analyze the relationship between the determining factors in seaweed cultivation in Southeast Maluku Regency; to analyze the effect of each determined factor on seaweed cultivation in Southeast Maluku Regency; to select priority factor to improve the performance and maintain the sustainability of seaweed cultivation productivity of micro enterprises in Southeast Maluku.

Material and Method. The variables used in this research were selected based on the empirical research conducted by Teniwut & Kabalmay (2015) where openness and access to technology, access and capital capabilities, the cost of production, the environment support, the government support, the fluctuation in the selling price of seaweed were variables that have been identified from micro enterprises on seaweed cultivation in Southeast Maluku, Indonesia. Constructs used in this research were developed from the previous research of Radulovich et al (2015), namely related techniques and technology in the seaweed cultivation, support of the environment and the surrounding area. In addition this study also used construct based on researches by Cabral et al (2016) on the financial cost of technology to determine location of seaweed cultivation and Valderrama et al (2015), on the expenses and capital from seaweed farmers on production.

Data collection. Data were collected in four months from February to August 2016 and in order to get more comprehensive result, the samples on this research were divided into three categories based on total production of seaweed. As it showed in Figure 1,

study locations on this research consist of six villages: first, villages with total number of the production of seaweed > 20 tons year^{-1} namely Letvuan and Ohoidertutu; second, villages with total production of seaweed ranging between 10 to 20 tons year^{-1} namely Namar and Ohoililir; and third, villages with the number of seaweed production < 10 tons year^{-1} namely Sathean and Debut. The total respondents of this research were 126.

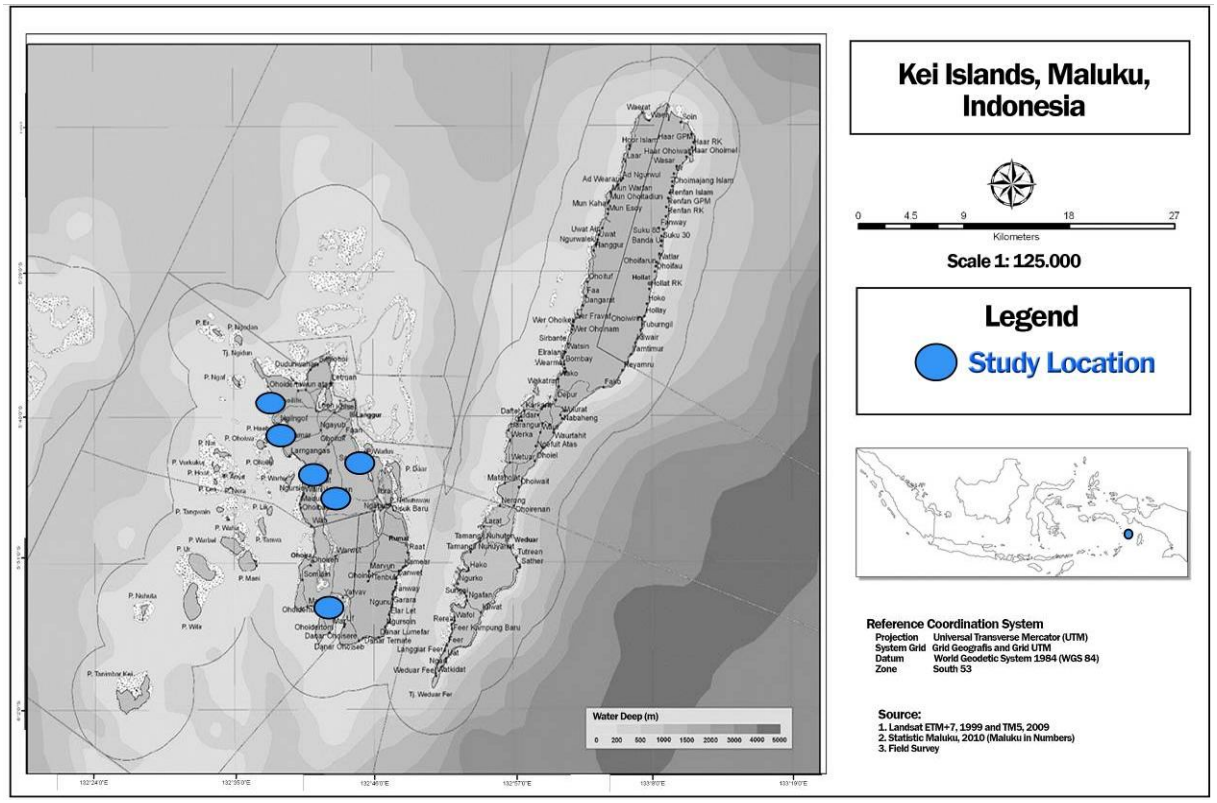

Figure 1. Study area in Kei Islands, Southeast Maluku Indonesia.

Data analysis and research stages. Analysis methods in this research consist in three types of data analysis as it is showed in Figure 2. The first method was the Pearson correlation to see the relationship between seaweed cultivation micro enterprises and their determined factors. The second method was hierarchical multiple regression analysis to select the factors that have the direct effect on seaweed cultivation micro enterprises, which those factors were divided into internal factors and external factors, which can be viewed separately but can be done simultaneously with hierarchical multiple regression analysis (Rutter & Gatsonis 2001). The third method was the analytical hierarchy process (AHP) to choose the best alternative to maintain and increase the sustainbility of seaweed cultivation in Southeast Maluku District.

Correlation. Correlation is a technique for investigating the relationship between two quantitative, continuous variables. We used Pearson product moment correlation coefficient to measure the relationship between independent variables and dependent variables. The equation can be seen as follows (Gujarati & Porter 2009):

$$r = \frac{n\sum XY - (\sum X)(\sum Y)}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2]}}$$

where r is Pearson product moment correlation coefficient, X is independent variables, Y is dependent variables, whereas n is number of pair scores.

Hierarchical regression analysis. Hierarchical linear modeling is a more complicated model from ordinary least squares (OLS) or linear regression analysis in general (Woltman et al 2012). An alternative strategy to the simultaneous model is one in which the independent variables are entered cumulatively according to logic of the research. Entering independent factor followed these steps, first the independet variables that considered as

internal factors included on the regression model, then followed with second step by entering independet variables that considered as external factors simultaneously. To choose which model to use, compare the R^2 of each step, and model with higher R^2 is the best model to use. Model equation can be seen as follows:

$$Y_i = \beta_0 + \sum[(\beta_1]X_1 + \beta_2 X_2) + (\beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6) + e_i$$

where Y is economy contribution of seaweed cultivation, X_1 is openess and willingnes to access technology, X_2 is acces to and capital capabilities of farmers, X_3 is cost production, X_4 is environment support, X_5 is government support and X_6 is perception in the selling price of seaweed, and *e* is the random sampling error term, β_n is coeficient of each indepent variable.

Analytical hierarchy process. The principle of hierarchic composition uses analytical hierarchy process (AHP) in order to measure composite priorities of every alternative with criteria from their priorities (Saaty 2003). The AHP is a powerful management science tool that has proven useful in structuring complex multiperson, multicriterion decisions in business and economics. We use Expert Choice to run AHP and number of criteria are based of performance criteria of seaweed cultivation collected by literature study and based on preliminary survey, namely consistency on harvest time; consistency on quantity and quality production; high quality of seeds; stability on financing and an effective and an efficient supply chain. The number of altenatives used on AHP depends on independent variables that significantly predict dependent variables from hierarchical regression result.

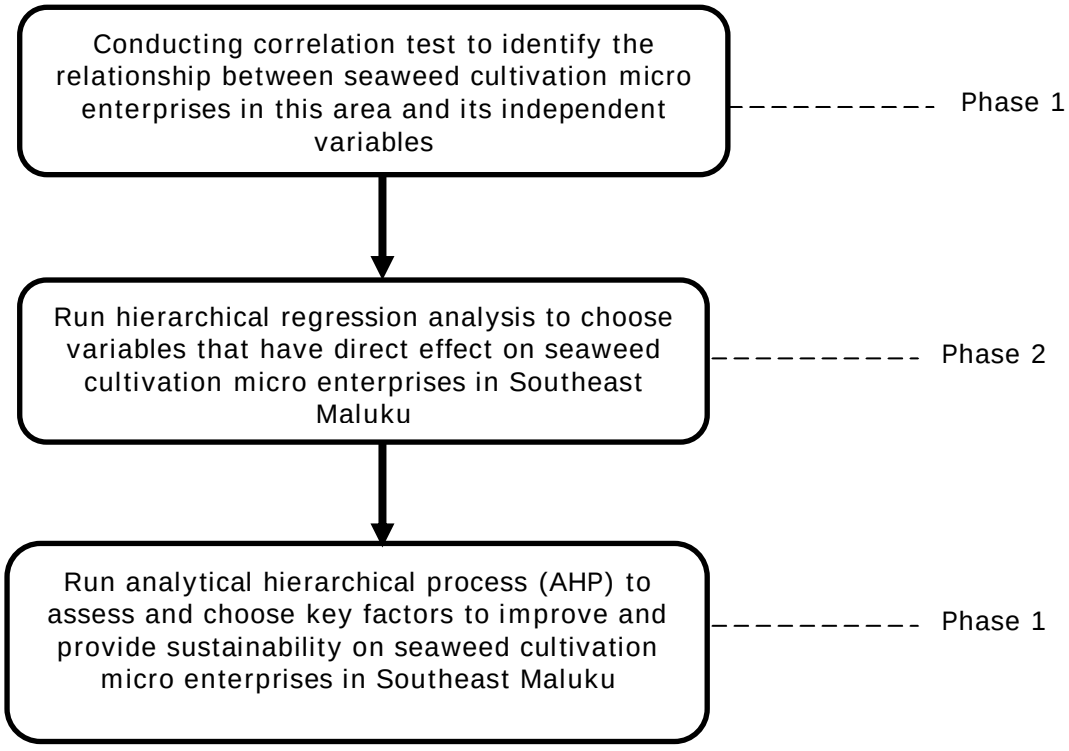

Figure 2. The stages of the research process.

Mechanism of this hierarchical multiple regression analysis was done by entering the group of factors that can be controlled by the seaweed farmers, which is internal factors namely openness and access to technology, access and capital capabilities, then followed by the factors that cannot be controlled by the farmers, which is the external factors namely the cost of production, the environment support, the government support, the fluctuation in the selling price of seaweed. The third method in this research was AHP, in order to assess and select the variable that is considered as the key factor that has the highest multiplier effect on improving and providing sustainability of seaweed

productivity in this area. Researchers such as Laininen & Hämäläinen (2013) and Chou et al (2013) showed that combination of quantitative analysis and AHP method was useful to get more comprehensive results and able to diminish weaknesses of each analysis method. The dependent variables in this research were the perception of micro enterprises on seaweed cultivation in Southeast Maluku, and independent variables were openness and access to technology, access, and capital capabilities, the cost of production, the environment support, the government support, the fluctuation in the selling price of seaweed.

Sampling frame. The profile of the respondents in this research can be seen in Table 1 below. The characteristic of seaweed farmers based on gender showed 81% of farmers were men. It has also been found that over 50% of seaweed farmers in this region were low educated. In addition over 50% of them are at age over 40 years whereas, over 50% have been doing seaweed cultivation activity for more than 6 years. Based on these results it showed that many of current seaweed farmers still do not have adequate formal education background, where it would be challenging for them to innovate and compete with seaweed farmers from other regions. Furthermore, result also showed that although there is a limited formal education, most seaweed farmers in the region were experienced enough, which is a huge advantage for their ability to make a continuous improvement based on their experience.

Table 1

Characteristics of the research respondents

The classification of respondents (N = 126)	*Description*	*The number of respondents*	*The percentage of respondents (%)*
Gender	Men	102	81.0
	Women	24	19.0
The level of education	Elementary	39	31.0
	Middle school	36	28.6
	High school	45	35.7
	Diploma	4	3.2
	Graduate	2	1.6
Age (years)	< 25	7	5.6
	25-30	19	15.1
	31-40	36	28.6
	41-50	34	27.0
	> 51	30	23.8
Duration of seaweed cultivation	< 3 years	22	17.5
	3-5 years	40	31.7
	6-8 years	38	30.2
	> 9 years	26	20.6

Results. Before continuing on data processing, we had to run a necessary test to check the validity and reliability of the instruments of this research. We used SPSS 23 and to test validity and reliability, we run Pearson correlation for phases one and two of this research, along with the hierarchical regression multiple analysis, and for the third phase we used expert choice to run the AHP.

Validity test. Validity determines whether the research truly measures what it was intended to measure by using the Pearson correlation product moment which was computed between the T-test and the each of the other tests, followed by the computation of partial correlations to obtain estimates of criterion validity (Pauole et al 2000). The results of the analysis can be seen in Table 2 and it showed all items of questions were statistically valid, meaning that all questions statistically represent variables used on this study.

Reliability test. Reliability tests are measured using Cronbach Alpha for internal consistency between the variables in the instrument. In Table 2 it can be seen that all Cronbach Alpha values were more than 0.6 and there are various opinions to the threshold value of Cronbach Alpha. According to Nunnally (1978), there should be a value of Cronbach Alpha of 0.7, however further research by Churchill & Peter (1984) proposed that measurement to pass the threshold of 0.6 can be accepted and this result was also supported by Loewenthal (2004) that Cronbach Alpha value of 0.6 can be accepted. So it can be concluded that all of the variables in this research are reliable.

Table 2

Validity and reliability test

Economic contribution on seaweed cultivation	*Cronbach's Alpha 0.628*
Seaweed cultivation is the main source of revenue for my family	0.756 (0.000**)
Seaweed cultivation is profitable	0.623 (0.000**)
Seaweed cultivation has great economic potential	0.702 (0.000**)
The revenue from seaweed cultivation meets the expectation	0.681 (0.000**)
Openness and access to technology	*Cronbach's Alpha 0.611*
Use of technology in seaweed cultivating activity	0.583 (0.000**)
Willing to pay more for technology to assist on seaweed cultivating	0.769 (0.000**)
Willing to attend training related to seaweed cultivating	0.662 (0.000**)
Able to access information related to knowledge and technology of seaweed cultivating	0.723 (0.000**)
The cost of production	*Cronbach's Alpha 0.689*
The high quality of seeds is at an affordable price	0.580 (0.000**)
Travel costs to buy seeds reachable	0.668 (0.000**)
The price of the equipment is fair	0.694 (0.000**)
The price of fuel is reasonable	0.695 (0.000**)
The cost to pay additional workers is reasonable	0.724 (0.000**)
Access and capital capabilities	*Cronbach's Alpha 0.632*
Have adequate capital	0.659 (0.000**)
Funding my own business	0.200 (0.025**)
Revenue and expenditure meet the expectation	0.679 (0.000**)
Have the ability on getting loan from commercial bank	0.714 (0.000**)
Current capital meets needs of seaweed cultivating	0.804 (0.000**)
The environment support	*Cronbach's Alpha 0.654*
The season in this region supports for seaweed cultivating	0.719 (0.000**)
The condition of the waters in this region supports the seaweed cultivating (wave, sea current and seabed)	0.727 (0.000**)
Degree of waste on the water in reasonable	0.641 (0.000**)
Location of seaweed cultivating is far from people daily activities	0.554 (0.000**)
Location of seaweed cultivating is far from the public activities such as sea transportation	0.650 (0.000**)
The government support	*Cronbach's Alpha 0.715*
The central government and/or local government give support to farmers' needs	0.828 (0.000**)
The central government and/or area provide sufficient facilities such as special market for sale and distribution of seaweed	0.789 (0.000**)
The central government and/or areas provide an assistance to access capital source from commercial bank to farmers	0.782 (0.000**)
The fluctuation in the selling price of seaweed	*Cronbach's Alpha 0.681*
The level of stability of seaweed selling price in the market (local and national)	0.662 (0.000**)
The selling price of seaweed results in accordance with the costs incurred during the process of seaweed cultivation	0.734 (0.000**)
There are more than 2 (two) buyers	0.563 (0.000**)
Easy to access the buyer	0.662 (0.000**)
To have the knowledge about the information buyers are located outside this region	0.695 (0.000**)

** significant on $\alpha = 0.01$; * significant on $\alpha = 0.05$; N = 126.

Hypothesis test. This research uses three phases to achieve the objectives, where the first is Pearson correlation test to examine the relationships between the independent variables and dependent variables. The second phase was hierarchical regression analysis in order to determine which independent variables have significant and direct effect on dependent variables. Then, in the third phase, we only used independent variables that significantly and positively affect the dependent variables to be run by AHP.

Pearson correlation test. The results of correlation between independent variables and dependent variables can be seen in Table 3.

Table 3

The results of the correlation between independent variables and the dependent variables

Independent variables	*Correlation coefficient*	*P value*	*The decision*
The cost of production	0.339	0.000**	Related
Access and capital capabilities	0.304	0.000**	Related
Openness and access to technology	0.322	0.000**	Related
The fluctuation in the selling price of seaweed	0.263	0.003**	Related
The environment support	0.270	0.000**	Related
The government support	0.114	0.202	Not Related

** significantly on α = 0.01; * significant on α = 0.05; N = 126.

The results of correlation test in Table 3 showed that five of the six independent variables had significant relationships with micro enterprises perception on seaweed cultivation in Southeast Maluku, marked by the p values (0.000-0.003) below alpha 0.05. The only independent variable that did not have the significant relationship with the dependent variable was the government support where its p value was over alpha (0.202 > 0.05). Therefore on the second phase of analysis data in this study only remaining five significant independent variables have been used in the next phase on hierarchical regression.

Hierarchical regression analysis. The results of the calculation of the hierarchical regression analysis are shown in Table 4.

Table 4

Hierarchical regression analysis

Internal factors	*Internal and external factors*	*Regression coefficient*	*P value*
Access and capital capabilities		0. 893	0.017**
Openness and access to technology		0. 232	0.007**
	Access and capital capabilities	0.092	0.838
	Openness and access to technology	0.153	0.073*
	The cost of production	0.591	0.160
	The fluctuation in the selling price of seaweed	0.233	0.539
	The environment support	1.314	0.002**
R^2 = 14.4%	R^2 = 23.7%		
F *value* = 10.377 (0.000)	F *value* = 7.434 (0.000)		
Durbin Watson = 2.043 (dL 1.6932 and dU 1.7252; 4-dL 2.3068 and 4-dL 2.2748)			
VIF < 2			
Npar Asymp.Sig = 0.200 > 0.05			

** significantly on α = 0.05 (95%); * significant on α = 0.1 (90%).

Hierarchical regression is a technique that can be used in regressing the outcome on the covariates and also as the indicator variable for treatment status and interactions between the treatment variables and each of the covariates to estimate treatment effects in data observed. Results in Table 4 showed two regression models and in order to choose the best one, see model with higher R^2 which was second model, so the second model was picked up. Despite the highest R^2 value accounts for only about 20 percent of the observed variations, due to large number of respondents (Crenshaw & Robison 2010) and type of the observant data (people) making R^2, is normal to have lower value in social studies than non-social studies (Cohen 1988; Reisinger 1997; Eitle et al 2002). This also means that it is possible to draw conclusions from this hierarchical regression result. In addition, Table 4 (and Appendix 1) also showed the classical assumption tests and result indicated regression result on this study did not have statistical biased problem.

Furthermore, results showed from two out of three internal factors namely access and capital capabilities, and the cost of production variables in total did not significantly predict the economic contribution on seaweed cultivation activity in this region, whereas openness and access to technology positively predict the economic contribution on seaweed cultivation activity in this region. In addition, result also indicated only one external factor that positively and significant predict the economic contribution on seaweed cultivation activity in this region namely the environment support, and fluctuation in the selling price of seaweed did not significantly predict the economic contribution on seaweed cultivation activity in this region.

According to the study structure, result of hierarchical regression would provide alternatives for policy maker in the region particularly to be focused on. By doing so, for entering phase three on this research only two independent variables were used on next phase. Therefore, in order to maintain the sustainability of seaweed cultivation in the region, this used AHP (Analytical Hierarchy Process) to choose the most significant factor to deal with by local and central government, between openness and access to technology, and the environment support.

Analytical hierarchy process (AHP). We conducted three FGD (Focus Group Discussion) with total 12 seaweed farmers to discuss two alternatives based on five criteria of seaweed productivity performance namely consistency on harvest time; consistency on quantity and quality production; high quality on seeds; stability on financing and effective and efficient supply chain. Illangasekare et al (2009) pointed out that minimum number of alternatives is two, thus AHP on this study was good to go. In Figure 3, result showed seaweed farmers in Southeast Maluku believe that consistency on quantity and quality production is the main factor that can hugely contribute on the sustainability of the seaweed cultivation in the region. Surprisingly, the financial factor which related to the cost production and the ability of farmers to support their business did not become one of the significant issues for seaweed farmers in the region. As for the most significant alternatives to be focused on by central and local government currently to maintain and increase the sustainability of seaweed cultivation in the region was openness and access to the technology at 0.564 compared with the environment support with 0.436.

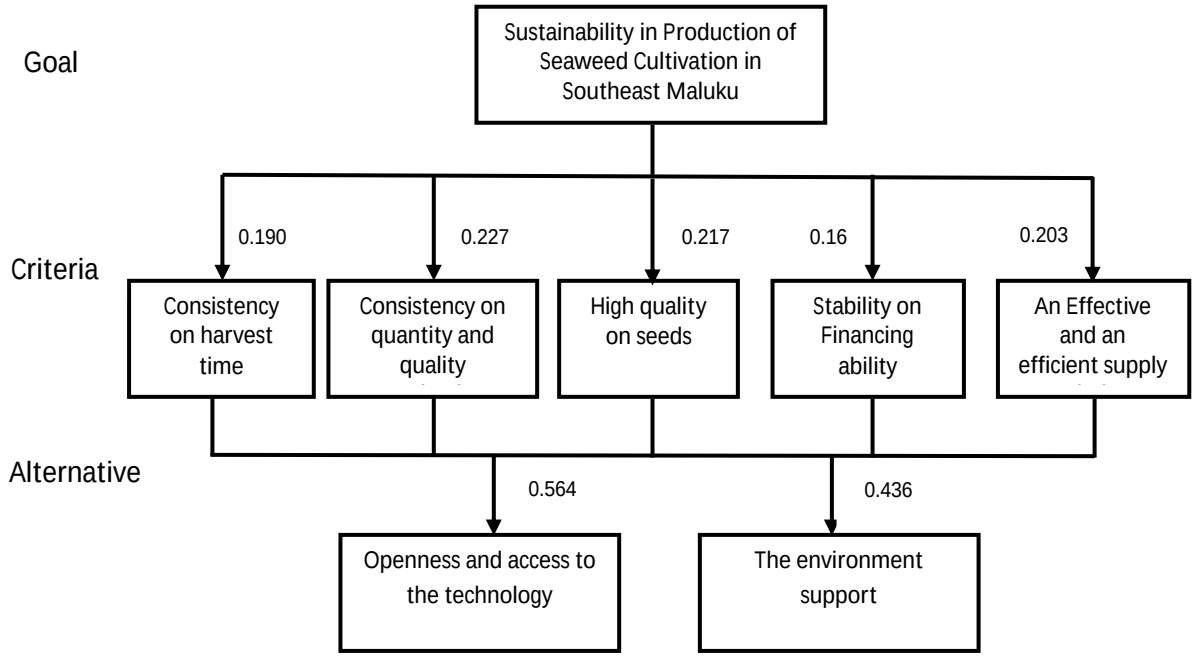

Figure 3. Result of analytical hierarchy process (AHP).

Discussion. Seaweed cultivation provides a greater multiplier effect on the improvement of socio-economy condition on coastal communities compare with other fisheries activity. In Southeast Maluku, seaweed cultivating is mostly conducted by family based micro enterprise which means higher revenue from seaweed production will increase the welfare of household members. The higher multiplier effect of seaweed cultivation makes it to be crucial to maintaining the sustainability of seaweed cultivation in the region.

The social profile of the seaweed farmer in the region affects their ability to compete with more educated and tech-savvy farmer from other region. Low educated factor also contributed to the decreasing on seaweed price and production in 2013, because most farmers tend to become impatience to harvest seaweed prior to seaweed maturity period which would decrease the quality of seaweed in the market, and this chain of occurrence also drove the selling price to record low. Aging factor of farmers also contributed to their ability to absorb latest technique and information regarding seaweed cultivation; with average over 40 years old and low education background makes the problem to become more complicated. Since the lack of education background and living in the coastal areas where access and the use of technology is limited also tend to become more resistant to new information (Oreg 2006).

The willingness to accept new technology and knowledge related to seaweed cultivation, also their ability to access to technology have an important role in improving the competitiveness of seaweed farmers in Southeast Maluku. In Indonesia, seaweed production also comes from Sulawesi and Bali, where farmers from these regions have the advantage of having an easier and faster access to the latest technology due to the geographical factor where it closer to the big cities in Indonesia. In order to compete with seaweed farmers from other regions, seaweed farmers in Southeast Maluku need to maintain consistency on the quantity and quality of seaweed production. Therefore, government and research institutions in the region have to put more emphasis on the consistency on the production by providing better access to sufficient technology, because the seaweed cultivation requires more knowledge compared with other fisheries sectors such as captured fisheries because there are more factors to pay attention to, namely hatchery, seed, to basic time and finance management (Teniwut 2016). The contribution of central and/or local government and research institution on the transfer of knowledge will overcome some real challenges that are faced by micro and small entrepreneurs (Ho et al 2016). As it showed in many developing countries, the role of

government was significant especially for micro enterprises development (Tambunan 2008).

The rapid development in technology provides more opportunity for increasing efficiency and effectiveness of seaweed cultivation activity. More empirical research to support the results of this study such as research conducted by Reddy et al (2007); Neori (2007); Ask & Azanza (2002), stated that the access and the use of knowledge and technology in aquaculture fisheries especially seaweed cultivation will increase farmer competitive advantage.

Conclusions and future research. This research gives significant contribution to resolve the problems faced by the seaweed farmer in this region. The result of this research showed that the openness and access to technology was the key factor to improve the sustainability on seaweed production where the consistency in the quality and quantity of production was the main factor to earn sustainability in seaweed cultivation. Although based on education background, most of the seaweed farmers in this region were low educated with average above 40 years old, which will hindered their ability in for innovation. The local government needs to provide training and intense mentoring on seaweed farmer in the region to increase their competitive advantage.

The future research is expected to focus on how to create an effective cluster based on the geographical area to provide better access for the local and central government to gather the information and assist seaweed farmer in every cluster. This is important because it will be more efficient on an effort to support developing of seaweed cultivation micro enterprises in this region. Further research should be performed on formulating a better training method that could match with the characteristic of coastal communities and the needs of seaweed farmer in this region, so the transfer of knowledge and technology can be more efficient and effective.

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