Cultivation of seaweed *Eucheuma cottonii* on longline with Floating Inverted Mosquito Net Model

[1]Ine Fausayana, [2]Muhidin, [1]Dasmin Sidu, [1]Putu Arimbawa

[1] Department of Agribusiness, Faculty of Agriculture, Halu Oleo University, Kendari, Southeast Sulawesi, Indonesia; [2] Department of Agrotechnology, Faculty of Agriculture, Halu Oleo University, Kendari, Southeast Sulawesi, Indonesia. Corresponding author: inefausayana@ymail.com

Abstract. Seaweed is one of the leading commodities of marine and fisheries sector which has high selling value. But the potential is not reflected in the income level and welfare of the farmers. Seaweed cultivation has a very high risk of crop failure due to several issues, among others, at first, seaweed farmers are still not able to fully utilize the technology, so at the time of planting farmers lose much seaweed both because of pests and plant diseases and because of the waves, secondly there are only four to five growing seasons of the year. The longline cultivation method of floating inverted mosquito net (FIMN) model serves to capture the seaweed that may fall or loose from the rope, from the time of planting to harvest. The purpose of this research is to know the difference of income and compare income before and after introduction of technology by using partial budget analysis. The study was conducted during one seaweed season (May - July 2016) on longline construction as much as 16 ropes. Each rope has a size of 50 meters (a rope is used to bind the seeds). The construction of technology was performed in March – April 2016. The results showed that during the process, from planting to harvest, seaweed that can be netted on the net overturned as much as 20 percent of the initial seedlings. On the debit side, income reducing is 218 USD. On the credit side, added income is 245USD, so the additional benefit is 28 USD.

Key Words: longline, floating net, inverted mosquito net, harvest increase, additional profit.

Introduction. Seaweed is one of the leading commodities of marine and fisheries sector which has high selling value. But the potential is not reflected in the income level and welfare of the farmers. "This untapped resource requires exploration as it can be a sustainable income generation activity along with the regular income activities to raise the socio-economic status of the community" (Islam & Haroon 2016).

There are some fundamental and very important hurdles that must be overcome to gain potential contributions through a biorefinery approach (Buschmann et al 2017). Titlyanov & Titlyanova (2010) present an overview of the state of global seaweed cultivation and discuss the various problems that arise during the application of the method. One of the main problems is the negative effect of large-scale monoculture of seaweed on natural benthic biocenoses. In Indonesia, research on seaweed cultivation technology to increase production has been done; among others is vertical line method or better known as "verticulture" which is expected to be one of the alternative developments with utilization of water column developed by Pong-Masak & Sarira (2015) and Nursidi et al (2017). Verticulture method is a method of cultivation by using a rope to bind the seeds of seaweed in a vertical position (perpendicular) by utilizing the water column up to the water's brightness limit. The study conducted by Failu et al (2016) analyzed the quality of *Kappaphycus alvarezii* seaweed carrageenan which was cultivated using the net basket method in Baruta waters, Sangia sub district, Wambulu, Buton regency of Southeast Sulawesi. A study was conducted by Muslimin & Sari (2017) on the response to the growth of seaweed *Sargassum* sp. which was cultivated by bag method at some depth level for optimization of seaweed production.

To increase production in addition to technical factors, the risk of seaweed cultivation is also affected by the behavior and socio-economic conditions of farmers, with the habitus that has been embedded and has become a skill (Fausayana 2014, 2017; Fausayana et al 2017). Standard methods of cultivating *Eucheuma cottonii*, utilizing the bottom method and the floating long line method was described by Zamroni & Yamao (2011), Valderrama et al (2015), Hendri et al (2018). Kasim et al (2017) conducted a research about a new method of seaweed cultivation, namely the floating cage cultivation. Cultivation of *Eucheuma denticulatum* and *K. alvarezii* using floating cages resulted in higher growth rates compared to cultivation on longline. The difference in results comes from reduced herbivore attack when the plants are in the protective cages.

The longline cultivation method of floating inverted mosquito net (FIMN) model is designed to minimize the risk of losing seaweed from planting to harvest. The inverted mosquito net can be made of nylon ropes or from fishing line. The benefits of fishing line are that is easier to clean than nylon ropes and photosynthesis.

Material and Method

Location and timing of study. This research was conducted in Bungin Permai Village, Tinanggea District, South Konawe Regency, Indonesia. This village is known as the floating net village. This location can be reached by using a motor boat with a distance of about 2 km from the mainland or 20 minutes distance from the coastal District Tinanggea. This village is all above the sea so it is known as floating net village.

Research stages starting from the construction, seaweed planting (*E. cottonii*), maintenance, harvesting until post-harvest handling. The study was conducted during one seaweed season (May - July 2016). While the implementation of the technology was done in March – April 2016.

Procedure of seaweed cultivation longline using FIMN model

1. The construction of longline cultivation media
   - Preparation of rope 50 m long
   - Installing the anchor rope as many as 8 pieces, equipped with a float ball 4 pieces
   - Application of a ring on the rope with a distance of 20 cm and tie a small float.
2. Preparation of inverted mosquito net (Figure 1).
3. Installation of an inverted mosquito net (Figure 2).
4. Procurement and handling of *E. cottonii* seeds. Procurement of seeds was done by choosing healthy seeds of 3 weeks old (21 days).
5. Installation of seaweed seedlings (Figure 3). Installation of seedlings was done immediately after the seed was taken with weight of 14 kg per rope.
6. Maintenance and control of plant pests and diseases. Maintenance and control of plant pests and diseases was performed daily.
7. Reinstallation of seaweed that falls in the cage. If there was seaweed that fallen in the cage they were reinstalled on the rope, except seagrass that aged over 35 day which was immediately harvested.
8. Harvesting and drying (harvesting was performed after 45 days culture; seaweed drying was usually done for by exposing to the sun 3 days, or until the water content reached maximum 30-34%.

Figure 1. The process of floating inverted mosquito net (FIMN) preparation.

Figure 2. The installation process of floating inverted mosquito net (FIMN).

Figure 3. The process of seaweed seed cultivation.

Economic analysis. Economic analysis consisted of the differences between using floating net of inverted mosquito net and without. Analysis of Partial Budget Analysis (Soeharto 1990) was applied. The analysis only looks at the changes or impacts caused by the introductory technology used in the model.

Results and Discussion. Seaweed cultivation has a very high risk of crop failure due to several problems, among others: 1) seaweed farmers are still not able to fully utilize the technology, so at the time of planting farmers lose much seaweed both because of pests and plant diseases and because of the waves; 2) there are only four to five growing seasons of the year. Seaweed cultivation cannot be performed during rough weather (Alin et al 2015).

In the process of seaweed cultivation starting from planting, through maintenance an until harvest is a very big chance of losing seaweed. In the process of planting seeds of seaweed that is when the rope will be installed then some of the seeds are detached from the bond. In the process of maintenance, loss of seaweed can occur due to violent waves or ice-ice disease and when the farmer checks the stretch of seaweed. While the loss at harvest occurs when the farmer pulls the rope onto the boat. Floating inverted mosquito net is applied in order to minimize the loss of seaweed (Figure 4).

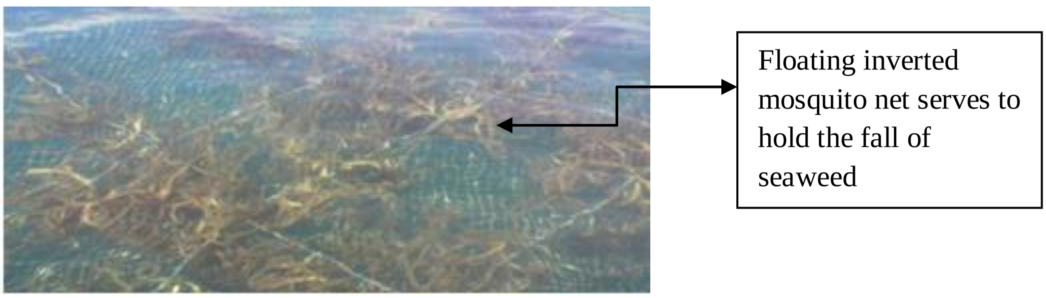

Figure 4. Construction of the FIMN model.

Economic analysis. Table 1 presents the comparison of results between longline cultivation, where the seaweed does not fall on the rope until harvest time (as a control), the harvest without using and using FIMN model. In this study there are three conditions, namely: (1) if the seaweed is planted intact in the rope to the harvest (with or without FIMN model) although this is difficult to occur, (2) without using floating net FIMN model (3) with using floating net FIMN model.

The weight of planting seedlings is 14 kg per rope, after 45 days then the weight of wet harvest increases 10 times, so that the wet harvest weight for 16 ropes of is 2,240 kg and yields dry weight of harvest is 320 kg. This is if the seeds of seaweed are planted all intact in the rope up to harvest. The second condition is the loss of seaweed from the rope as much as 20 percent of the weight of wet harvest.

Table 1

Comparison of wet harvest and dried harvest weight in three conditions

Conditions of seaweed on rope	*Seed weight (Kg)*	*Wet harvest weight (Kg)*	*Dried harvest weight (Kg)*
1. Seaweed intact until the harvest	14	2,240	320
2. Without using floating inverted mosquito net	14	1,792	256
3. Using floating inverted mosquito net	14	2,106	301

Without using FIMN model, the farmers will lose as much as 448 kg of wet seaweed or 64 kg of dried seaweed. The seaweed that falls into the FIMN can actually grow in the net nets until harvest, but the growth is not as optimal as the seaweed growth on the rope. Seaweed that falls into a 448 kg up turned FIMN model can grow with an average growth of 70%, so that seaweed that can be saved is 314 kg (the loss is just 134 kg), so it can produce 2,106 kg wet weight harvest or 301 kg dried harvest. The difference of the dried weight of seaweed between the FIMN model usage and without is 45 kg.

The FIMN placement, besides aiming to prevent the fall and lost of seaweed, also can be used to collect fish seed which can be taken by farmers to fill the fish cages.

Income analysis. The measure of the farmer's success is the production. This farming production is the result of cooperation of some factors as: cultivation land of seaweed, labor and capital. But to obtain higher production farmers need to improve the way of farming in accordance with the development of the science and technology. The production level generated on a 24 x 50 m cultivation plot or for 16 ropes (length of rope per 50 meter rope by distance per 1/2 m) in this study was 301 kg of dried harvest for construction using FIMN model and 256 kg of dry harvest for construction which did not used FIMN model.

Revenue is the quantity of dried seaweed harvest multiplied by the price of 0.94 USD per kg. Income for construction of the FIMN model is 230 USD, while the costs without FIMN is 203 USD (Table 2). Enterprises of seaweed *E. cottonii* are a business that is able to increase the farmer's income (Irmayani et al 2015). With their incomes earned from the sale of seaweeds, many farmers have experienced substantial improvements in their standards of living, seaweed farming has had a remarkably positive effect on the socioeconomic status (Valderrama 2012).

Table 2

The comparison of income in the three conditions

Conditions of seaweed on rope	*Revenue*	*Cost*	*Income*
1. Seaweed intact until the harvest	301	38	263
2. Without using Floating Inverted Mosquito Net	241	38	203
3. Using Floating Inverted Mosquito Net	283	53	230

Partial budget analysis. Added costs are money guarantees issued by farmers to implement their farming activities. Costs incurred which was not directly related to the manufacture of floating net bed nets were not analyzed. In the supplementary cost post, almost all fixed costs was not taken into account because they are not analyzed in partial budgets such as depreciation costs for long line construction except for the net shrinkage cost (made from ties). In addition, not all variable costs are included in the partial budget except the labor costs that make the net netting upside down so that the costs incurred are: increasing costs of 15 USD and no savings (Table 3).

Table 3

Partial budget of FIMN model

Specification	*USD*
Debit, income reducing	
Added costs	15
Reduced income due to the used technology	203
Total Losses	218
Credit, income reducing	
• Added income	24
• Reduced costs due to the used technology	24
Additional benefits for 16 ropes:	28

Decreased income due to net cost of 203 USD resulted in a loss on the debit side; therefore income reducing was 218 USD. On the credit side, income reducing was 245 USD, so the additional benefit was 28 USD.

Conclusions. The 16 ropes that were used as demonstration plots, it was concluded that without using FIMN model the farmers will lose as much as 20% of wet seaweed from the total seedlings planted. The weight difference of dry seaweed harvest between using and not using FIMN is 45 kg. The additional revenue from the use of FMNI technology is 245 USD. The additional profit is 28 USD.

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Authors:
Ine Fausayana, Halu Oleo University, Faculty of Agriculture, Department of Agribusiness, Indonesia, Kendari, 93232, Southeast Sulawesi, e-mail: inefausayana@ymail.com
Muhidin, Halu Oleo University, Faculty of Agriculture, Department of Agrotechnology, Indonesia, Kendari, 93232, Southeast Sulawesi, e-mail: muhidinunhalu@gmail.com
Dasmin Sidu, Halu Oleo University, Faculty of Agriculture, Department of Agribusiness, Indonesia, Kendari, 93232, Southeast Sulawesi, e-mail: dasminsidu07@yahoo.co.id
Putu Arimbawa, Halu Oleo University, Faculty of Agriculture, Department of Agribusiness, Indonesia, Kendari, 93232, Southeast Sulawesi, e-mail: arimbawa_kdi@yahoo.com

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