The development of Indonesian seaweed based on innovation cluster model

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Abstract. In 2018, Indonesian production of the seaweeds Eucheuma cottonii and Gracilaria sp. reached 11.08 million tons and 1.55 million tons, respectively. However, the economic value obtained is low, as 85% of the production is still exported as a raw material. The remainder is exported as semi-refined materials, i.e. ATC chips and semi refined carrageenan (SRC), with very little refined carrageenan. There are no companies processing seaweed into end products where seaweed is the main raw material, such as in the food industry, pharmaceuticals, cosmetics, etc. The supply chain from upstream (aquaculture) to intermediate (intermediate products) and downstream industries is not efficient in Indonesia, because almost all intermediate and downstream industries are concentrated in big cities like Jakarta and Surabaya while the bulk of the upstream industry is spread across large expanses of eastern Indonesia. As a result, the bargaining position for upstream products produced by farmers is weak. All of these problems are expected to be minimized by referring to a holistic work plan through Seaweed Innovation Clusters, enhancing communication and collaborative collaboration of Quadruple-Helix ABGC (Academic, Business, Government and Community) and other supporting elements as the main pillar of the innovation cluster. With this synergy, added value, and business continuity, the role of seaweed in raising regional competitiveness can be improved.

1. Introduction
Seaweed is an important commodity for the Indonesian economy. This is significant because seaweed commodities have high economic value, being one of the non-oil export commodities, are a source of income for most coastal communities and of employment in both the aquaculture and industrial sectors, and there is still much potential for the development of seaweed cultivation in Indonesia. Various processed products derived from seaweed also show that seaweed commodities can have high economic value if they can be processed fully domestically, so that more of the added value created
can be enjoyed by farmers and processing producers in Indonesia. However, the fact is that, even though Indonesia has become the world's number one exporter, especially for the seaweeds *Eucheuma cottonii* and *Gracilaria* sp., as Indonesia's seaweed exports are still dominated (over 80%) by dry raw materials, most of the added economic value is expected to occur abroad, enjoyed by the countries importing Indonesian seaweed raw materials. For example, the formulation industry that utilizes processed seaweed is estimated to produce 500 derivative products with high added value [1].

The development of seaweed in Indonesia was initiated in 1986 by various institutions, including both central and local governments, R&D institutions, universities, the private sector and the community. This development tended to be implemented partially and individually, with a lack of collaboration and synergy. As a result, the problems faced by farmers, the coastal communities and the industry are still the same now as in previous years, and relate to superior seed availability, cultivation and post-harvest technology, supply chains that are too long, fluctuating prices, downstream industries that have not yet been developed, need for heavy investment in the seaweed industry because most of the equipment and technology is still imported, and so forth.

Up to the present time, Indonesian seaweed production is still going up and down, while many farmers have suffered losses due to pests and seaweed diseases that have not yet been handled properly. The growth of the processing industry has lagged behind production, especially the downstream seaweed industry which basically does not exist yet; the industry that is growing in Indonesia seems likely to just process more *Eucheuma cottonii* into alkali treated cottonii (ATC) and semi-refined carrageenan (SRC) with minimal production of refined carrageenan (RC).

The Indonesian seaweed processing industry comprised 23 companies processing *Eucheuma cottonii* (ATC, SRC and RC) by 2017. The industry is spread across 17 districts/cities in 10 provinces, namely Bangka Belitung, Banten, West Java, Central Java, East Java, NTB, NTT, South Sulawesi, Gorontalo and North Maluku, with a total installed capacity of 25,992 tons and annual raw material requirements amounting to 102,835 tons. For the *Gracilaria* sp. (gelatine) seaweed industry, there was a total of 14 companies with industrial presence spread across 8 regencies/cities in 4 provinces, namely North Sumatra, Banten, West Java and East Java, with an installed capacity of 7,658 tons and annual raw material requirements of 66,911 tons [1].

In general, the development of Indonesian seaweed is still constrained by the lack of synergy, collaboration and coordination between the central and regional governments. Ministries, institutions, and local governments need to communicate in developing the upstream and downstream industries. Going forward, in the context of the industrialization program, development needs to be implemented in parallel between the upstream and downstream; this is to ensure that we do not lose the momentum by continuing to fill the production market, while we build a competitive downstream industry.

A new system is needed for the competitive developing of Indonesia's seaweed. And all of the challenges above are expected to be minimized by referring to a holistic work plan through the development of seaweed innovation clusters, by strengthening communication, synergy, collaboration and Quadruple-Helix ABGC cooperation (Academic, Business, Government and Community) as well as other supporting elements, that become the main foundation of the innovation cluster. With this synergy and collaboration, added value, business continuity and the role of seaweed in increasing regional competitiveness can be improved.

2. Innovation Clusters Model

The Innovation Cluster is a collection of stakeholders consisting of governments, academics, the business community, communities and other institutions that have similar characteristics, operate in the same sector and region, systemically and holistically designed to encourage intensive collaboration and interaction, sharing resources, knowledge exchange and contribute effectively in the process of technology transfer, technology diffusion, business networking, marketing and information dissemination [2].

The innovation cluster is a model to build and enhance the synergies, interactions, relationships, collaborations and collaboration of Quadruple-Helix ABGC (Academic, Business, Government and Community) and other supporting elements, to permanently and continuously solve problems together. ABGC components/elements as cluster members work together in groups formed according to the
needs to achieve common goals. Innovation cluster members work together to solve common problems and goals, and not individually solve separate parts of the problem. Thus, during the collaboration, cluster members work together to build common understanding and concepts to solve each part of the problem or tasks in the context of shared goals.

The innovation cluster is an evolution of the original concept of a business cluster, which is a group of companies that are geographically connected and related institutions in a particular field [3]. The difference is in terms of innovation which did not appear in the 1990 concept, although it was implied that companies and other entities in the ecosystem could work together to stimulate the development of new technologies and accelerate learning. Porter's emphasis is on the achievement of competitive advantage through easier access to experts, suppliers, customers, specialized information, and products and services so that the costs are lower and the products have higher quality. An example of the success of an innovation cluster that has a large impact on the regional economy as well as for the country is Silicon Valley.

The development of innovation clusters proves that each country or region has its own uniqueness with respect to the composition, concepts and framework of their innovation clusters. As an example, Silicon Valley in the US, where the most advanced innovation cluster has a strong social network, is associated with local financing sources, has an established relationship with universities, laboratories and federal companies. This leads to the capacity for convergence and the creation of innovative products and technology, starting with semiconductors to nanotechnology and ICT. The determining actors for the development of this innovation cluster were Stanford University, Hewlett-Packard, University of California-Berkeley, Xerox PARC, IBM San Jose, and University of California - San Francisco.

Examples of other innovation clusters that are considered successful include the Cambridge Science Park or the Cambridge cluster in England. In this innovation cluster, the University seeks to help innovation by solving problems faced by the British industry by developing the Cambridge Science Park which provides space for research and offices for British Startup Companies. This idea sparked the growth of the companies and attracted other stakeholders to join and create an innovation cluster.

Another example is the innovation clusters in India, where an innovation cluster is defined as the geographical grouping of institutions/companies that will catalyse and strengthen the culture of innovation throughout the ecosystem. The focus is on innovation in products, processes, services and delivery which will in turn enable growth and development. Partnership and collaboration are the goal of NINC to create a fast growing cluster in India.

A study of innovation clusters revealed that the greatest strength of innovation clusters is on partnership and collaboration, where all actors and stakeholders are connected in a symbiotic relationship, as in the examples in Cambridge, England, and India [4]. Based on these examples, it can be concluded that entrepreneurship, a growing market and a supply of skilled labour are the three main ingredients for the success recipe of the innovation cluster. Human connection/interaction with the technology community is a major factor in Silicon Valley, but cluster development is actually led by entrepreneurs [5].

Some factors that influence the development of innovation clusters are (1) the synergy of research institutions and universities; and (2) the support of public institutions [6]. Research shows that support from government and public institutions can in some cases have an impact, for example, the US Department of Defence investment in Silicon Valley helped the initial development of the incipient electronics industry. In other cases public institutions are more active in both promoting the growth of existing clusters through infrastructure development, university funding and provision of grants and loans; (3) Access to finance; (4) The existence of multinational companies; (5) Interpersonal networks; (6) Shared values and alignment of interests; (7) The mobility of people. Innovation requires a continuous movement of people who transfer their skills, experience, and knowledge. Schematically, the Innovation Cluster approach can be seen in Figure 1.
The essence of an innovation cluster is a system, unity or collaboration of various elements (actors, institutions, linkages, networks, interaction processes, and policies). The collaboration will affect the direction of development and the speed of innovation to increase the added value of a product which will ultimately have an impact on improving people’s welfare, as well as increasing regional and national competitiveness. The stakeholders in an Innovation Cluster members are usually grouped into industry, research institutions, professional associations, industry, sectoral expertise, government (central and regional), financial institutions and institutions/innovation bodies that carry out their roles with innovation tools. Relevant institutions can occupy the same position and role and there is no relationship with the level of interest of the actors. A particular role can be carried out by any competent entity, depending on the economic level of a particular value chain relationship.

The innovation cluster is not merely a concept, but can also be a national platform in the context of knowledge-based (national and regional) economic development. Collaboration in the innovation cluster model is a collaboration with sharing of roles and responsibilities according to the competencies and expertise of each cluster member. For this reason, it is very important to identify the role of each cluster member in the early stages of developing an innovation cluster. The identification of roles is based on the main duties, competencies and expertise of each cluster member.

The development of innovation clusters can also be used to develop broad-based industries and focus on superior products that have the opportunity to have high international competitiveness both in the domestic and global markets. The geographical scope of innovation clusters can vary greatly, from spanning just one village or one of the roads in an urban area to covering a sub-district, province, or networking between provinces. An innovation cluster can also transcend national boundaries, reaching several neighbouring countries (e.g. Singapore, Malaysia, Thailand, and Vietnam).

3. Results and Discussion
The Indonesian seaweed innovation cluster model is a new paradigm in developing, increasing the added value and competitiveness of Indonesian seaweed. Schematically, the Indonesian Seaweed Innovation Cluster can be seen in Figure 2 below.
Some understanding of elements in the Indonesian seaweed innovation cluster are as follows: (1) Upstream-downstream industry, is a group of economic actors that provide raw materials, process seaweed into products or services (½ finished products, finished products until final product) with high market value. (2) Research Institutions are institutions that carry out activities systematically, according to scientific principles and methods, to produce science, technology and innovation; (3) Professional and Industry Associations are groups of people or industries with the same profession, expertise, competence or profession; (4) Sectoral Expertise Group is a group/collection of institutions/people who have expertise in certain fields; (5) Government (central and regional) means ministries, non-ministries, district/city or provincial governments; (6) Financing Institutions are bank and non-bank financial institutions, grants/grants, assistance, ventures, and other financing institutions; (7) Innovation Tools are innovation tools (policies) implemented by institutions or agencies to strengthen innovation systems.

The stages of the development of the Indonesian Seaweed Innovation Cluster basically consist of 5 (five) generic stages, namely: (1) Initial development initiative activities; (2) Establishment of institutional/management cluster of Indonesian seaweed innovation system; (3) The making of an Indonesian seaweed innovation cluster master plan model; (4) Implementation of innovation system clusters (integration, synchronization and synergy of joint programs) for the development of Indonesian seaweed; (5) Monitoring, evaluation, and improvement.

The organizing stage in the development of Indonesia's seaweed innovation system cluster is a very important stage, because it is a process for designing management structures, grouping and organizing and dividing functions and activities among cluster members, so that the goals of cluster development can be achieved effectively and efficiently with resources that are owned and in the surrounding internal and external environments. In designing the management of Indonesian seaweed innovation clusters, the most important factor is that the management structure is built to give all cluster members a similar position, making them equal, rather than being a superior/subordinate structure. In the cluster management structure, the function of top management is only as a coordinator whose main task is to harmonize and synergize all activities that have been mutually agreed upon, so that they can be carried out properly based on the objectives, budgetary resources and time.
Figure 3. The identification of technology needs, supply chain and value chain in the development of Indonesian seaweed innovation clusters

The general objectives of developing the Indonesian Seaweed Innovation System Cluster are: (1) Encouraging collaboration and synergy of the roles and functions of the ABG + C (Academic, Business, Government plus Community) innovation actors, in an effort to develop, improve and give added value to the competitiveness of Indonesian seaweed; (2) Increasing the capacity of innovation through collaborative R&D; (3) Increasing access of cluster members, especially industries, to relevant experts/expertise; (4) Improving the international orientation of cluster members (companies and knowledge providers), (5) Building an environment that encourages the development and application of knowledge as a foundation for entrepreneurship, investment, innovation and change.

3.1. Determinants of the Successful Development of Indonesian Seaweed Innovation Clusters

The development of Indonesian seaweed innovation clusters is not an easy task; in order that the development of these innovation clusters can be successful, in accordance with the shared goals they are built on, attention must be paid to the determinants of the success of innovation cluster development. Some determining factors that hinder success in the development of Indonesian seaweed innovation clusters, especially in the initial initiation stage of development, are: (1) In conducting initial initiation activities, the innovation cluster initiator does not involve competent institutions; (2) Collaboration that is built is not permanent, there is no MOU and PKS, so the commitment of the innovation cluster members is still low; (3) Carrying out activities oriented only to the project, not to the sustainability of activities due to the benefits gained from each of the agencies involved in activities; (4) Initial initiation activities to determine the focus and locus of activities are not attended by the top management authorized as policy makers, but by ordinary staff; (5) The division of tasks and authority is not based on the competency of the institution/member of the innovation cluster, but is done only based on individual interests, so that the success of the given task is very limited; (6) Problem analysis is not conducted holistically, but rather in accordance with specific (individual) interests, and only partially, so the results of the analysis of the problem are not in accordance with the actual conditions; (7) Failure to implement a monitoring and evaluation system and a clear timeframe,
so that if a problem occurs, it won’t be known from the beginning/early on, and therefore solutions won’t be sought; (8) Identification of the activities to be carried out not be based on priorities and the greatest leverage, so that very important and priority activities are not carried out from the beginning or at worst are not carried out at all.

3.2. The Impact of Innovation Cluster Development

The positive impact at the beginning of the development of an innovation cluster is that cluster members who collaborate and participate in programs and activities within the cluster, especially the private sector/business and the community, will have a broadened access to science and technology. By collaborating, science and technology information that are generated from research activities will be readily obtainable from universities and R & D institutions, enabling the flow of knowledge. R & D institutions and universities will also be able to obtain information on the technology needs of the private sector/business and the community more easily, in order to conduct research according to user needs. Ultimately, the expected impact of the development of Indonesian seaweed innovation clusters is the development of industries that can process seaweed into end products in Indonesia; thus, the added value of seaweed that has only been enjoyed by Indonesian seaweed importing countries, can be shifted to Indonesia. And another impact of the increase in added value will be an increase in the purchase price of seaweed so that seaweed cultivators become more prosperous.

4. Conclusion

The Indonesian seaweed innovation cluster is a systemic way to encourage all stakeholders associated with seaweed in Indonesia to collaborate, synergize and commit to developing added value and competitiveness of Indonesian seaweed. The Indonesian seaweed innovation cluster will be designed in such a way as to stimulate innovative activities by increasing intensive interaction, use of shared facilities, exchange of knowledge and expertise that contribute effectively in the dissemination and acquisition of technology, business networks and information dissemination. The Indonesian seaweed innovation cluster is a form of innovation network, which serves as a vehicle to build a process of interaction, linkages and partnerships between innovation actors, and to dynamize the flow of knowledge, innovation, diffusion, and learning as strategic initiatives to strengthen innovation. Like it or not, an Indonesian seaweed innovation cluster must inevitably be built if Indonesian seaweed really wants to develop, gain added value and become highly competitive.

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