Bioentrepreneurship approach as a pillar to accelerate the integrated farming system implementation

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Abstract. The Integrated Farming System (IFS), as one of the bioeconomy models, operates with a variety of agricultural activities interaction to optimize benefits through the synergistic transfer of resources. In IFS, implementation of Integrated Crop Livestock Systems (ICLS) is more complicated than Mixed Crops System (MCS). The ICLS need to be operated by individuals who aspire to generate values through the creation or expansion of economic activity, by identifying and exploring new products, processes or markets. It has specific characteristics in strategy, competencies and management. It aligns with the entrepreneur aspect, which in agriculture is known as bioentrepreneurship. One strategy to achieve it is by implementing bioentrepreneurship approach. This study is intended to identify the aspects and elements of bioentrepreneurship and analysis in a case study. The analysis used radar charts that map the value of each element of the aspect of bioentrepreneurship based on its important values and real score. Analysis of bioentrepreneurship is divided into entrepreneurial orientation, entrepreneurial learning abilities, and entrepreneurial networking capabilities. Entrepreneurial orientation generally refers to autonomy, competitive aggressiveness, innovativeness, proactiveness, and risk-taking. Entrepreneurial learning capacity is related to knowledge and skills, collaboration, and culture of sustainable improvement, while entrepreneurial networking capability is about constructing bonding, bridging, and linking capability.

1. Introduction
Bioeconomy is a strategic approach to sustainable agribusiness development. It has a vital role in its characteristics as an integrated economic-ecological model [1], which is implemented in various models of Integrated Farming Systems (IFS). IFS is beneficial for soil health, weeds and pests control, and increases the efficiency of water use and its quality. From the economic aspect, IFS may improve the economy of small and marginal farmers as the production and cost increase, by optimizing resource utilization and recycling waste materials [2].

Despite its numerous advantages, the implementation of IFS in smallholder levels is still low. In IFS implementation, farmers have faced obstacles to integrating with the production system, agribusiness management requirements, and risk management. This condition requires the actors in IFS to have a willingness to innovate, which will accommodate risk-taking behavior for future benefits and sustaining a business, which is related to entrepreneurship behavior.
The entrepreneurial orientation construct combines entrepreneurial behaviour [3]. Its elements enable business units to identify and exploit opportunities for organizational revitalization and creating more customer values. Agricultural entrepreneurship shares many characteristics of generic entrepreneurship, but also has its distinct features due to the specific context of the agricultural sector [4]. The IFS needs specific characteristics in strategy, competencies and management that align with the entrepreneurship aspect, that in agriculture is known as bioentrepreneurship. The question is what are the main aspects of bioentrepreneurship that will support the development of IFS. This study is intended to discuss aspects of bioentrepreneurship that must be present in developing IFS.

2. Research Methods

2.1. Research approach
This study used a literature study to analyze the bioentrepreneurship aspects and its suitability in the IFS context. A case studies approach was carried out to investigate models, which sustain the formation of bioentrepreneurship.

2.2. Location and time of research
A case study is used to provide an overview of the application of the developed conceptual model. Case study observations were carried out in Kertasari District (2019) and Pangalengan District (2020), Bandung Regency, where coffee cattle integration was implemented. Data were obtained through in-depth interviews with representatives from the Forest District Society Board (Lembaga Masyarakat Desa Hutan - LMDH) Bumi Sangkuriang in Kertasari District dan Margamulya Cooperative (Koperasi Margamulya) in Pangalengan District. A survey on coffee cattle integration development was conducted involving 27 respondents.

2.3. Analysis Method
The analysis method used radar charts, which consists of the stages of determining the value of importance for each factor, assessing current conditions, and setting priority focus based on the most considerable gap value. The analysis used a 1-5 rating scale for the value of importance: 1=not important, 2=slightly important, 3=important, 4=fairly important and 5=very important; and the score of real condition: 1=poor, 2=fair, 3=good, 4=very good, and 5=excellent.

3. Results and Discussion

3.1. Integrated farming system
IFS operates with various interactions of agricultural activities to optimize benefits through synergistic resource transfers [4]. The model of IFS includes Mixed Crops System (MCS) and Integrated Crop Livestock Systems (ICLS). MCS is intercropping two or more plants in the same field in which plants are often planted in alternating rows or mixed in rows. ICLS is mixed crop-livestock farming that includes crops and livestock [5].

The MCS, also known as polyculture, inter-cropping, or co-cultivation, is a type of agriculture that involves planting two or more plants simultaneously in the same field. Farmers often use several types: (1) multiple cropping, by planting more than one type of crops on the same land for one year to obtain more than one crop; (2) companion planting, by planting more than one plant in one bed with other plants that complement physical and nutrient needs; (3) mixed cropping by planting more than one type of plants on a land simultaneously; (4) intercropping and interplanting, by planting more than one type of crops on one land simultaneously with regular rows; (5) alley cropping, by planting short-lived plants among annual plants; and (6) crop rotation, by planting different types of plants from different families in turn or rotation.

The MCS is an alternative pathway for sustainable agriculture. The main advantages of intercropping are production increase, more efficient use of environmental resources, lower damage caused by pests,
diseases and weeds, stability and uniformity of yield, soil fertility improvement, and an increase in nitrogen addition [6]. Significant benefits of the MCS include generating multiple sources of food, income and additional employment, hence the addition of net income per unit area, as well as time and inputs considerably [7]. The main issues in MCS are production risk, pests and crop diseases, and price [8].

The ICLS is a form of mixed production that utilizes crops and livestock in a way that they can complement one another through space and time. The backbone of an integrated system is the herd of ruminants that graze a pasture to build up the soil. The ICLS pursues the following goals: reducing incomplete nutrient cycles, following the rationale of industrial ecology, organizing land use and farming practices to promote ecosystem sustainability, and increasing farm resilience to adverse climatic and economic threats [9]. The ICLS program aims to optimize the utilization of local resources such as the use of straw as livestock feed and cow manure which can be processed into organic fertilizer to improve the soil nutrients [10].

Grazing livestock among estate crops such as rubber, oil palm, coffee, or coconut is one form of ICLS that is commonly found in Southeast Asia [11]. In Indonesia, palm cattle integration has been established on a national scale. Integration is increasingly developing in replanting areas. Farmers also implement ICLS individually.

ICLS is the potential to promote economic and social benefits [12]. The economic benefits are related to risk sharing, resilience, resource-use efficiency, whereas from the social point of view are related to management and workflow, social learning/empowerment, social acceptance of agriculture. However, the application of ICLS does not automatically bring benefits to farmers. The income earned by farmers who integrate cattle, coconut and cocoa are not significantly different from those who do not practice integration, because livestock farming is still operated traditionally, and no livestock products development [13].

There are four distinguished types of ICLS characteristics at the farm level according to spatial, temporal, and organizational coordination among farms [12]. Type 1, “global coexistence”, is exchanges of raw materials (grain, forage, straw) among farms through national or global markets. Type 2, “local coexistence”, is the relocation of raw materials exchanges among farms through a local economic organization such as an agricultural cooperative. Type 3 “complementarity”, is a direct exchange of raw materials between farms, and type 4, “synergy”, is a strong temporal and spatial integration between crops, pasture, and animals in farms.

The ICLS need to be operated by individuals who strive for generating values through the creation or expansion of economic activity, by identifying and exploring new products, processes or markets. It has specific characteristics in strategy, competencies and management [12]. It aligns with the entrepreneurship aspect, which in agriculture is known as bioentrepreneurship. Farmer-entrepreneurs see their farms as a business and passionate about their farm business and are willing to take calculated risks to make their farms profitable, and their businesses grow [14].

3.2. Bioentrepreneurship

The characteristics of the farmer can be identified based on land tenure, business orientation, technology adoption, and knowledge acquisition. Farmers generally own limited land with a self-sufficient orientation. In smallholder plantations, the business orientation is broader, but on a limited scale. Based on technology adoption, most of the farming is operated using a traditional approach with limited technical and managerial capabilities.

In general, problems in the development of IFS related to technical, social and economic factors [15]. Technical issues are related to the suitability of the production system with agro-ecosystem, whereas social problems are related to social conflicts due to community acceptance of livestock farming, while economic problems are related to increased income and added value. Social problems are also related to cultural and behavioural aspects where livestock farming is not the main business unit and low technology adoption [16], limited experience in livestock management, and lack of awareness of the impact of sustainable agriculture on the environment [17]. Furthermore, the farmer’s institution has not yet been developed, and the limited number of extension officers affects farmers’
knowledge in adopting the ICLS.

On the other hand, IFS is expected to advance the agricultural sector by utilizing the potential of local resources. IFS offer optimization of resource utilization rather than maximization of individual elements in the system [18]. The concept of integration of livestock with either estate, food, or horticulture crops is to put and manage livestock, without reducing plant activity and productivity. In these conditions, strengthening the entrepreneurial aspect of farmers will be a strategic way of developing IFS.

Bioentrepreneurship is the process of creating value from life science innovation. It is referred to as bioscience entrepreneurship, life science entrepreneurship or bioscience enterprise. Bioentrepreneurs seek to exploit life science innovation for commercial purposes [19]. There are similarities between bioentrepreneurs and entrepreneurs such as both must have an extraordinary idea to start and to raise investment. However, there are also some differences between the two. In bioentrepreneurs, starting a business based on an idea or invention from various fields of science faces a higher risk due to a dynamic aspect of science. Analysis of bioentrepreneurship is related to the entrepreneurial orientation [20], entrepreneurial learning capacity [21], and entrepreneurial network capability [22], as the main factors in developing a successful bioentrepreneurship.

3.2.1. Entrepreneurial orientation
Entrepreneurial orientation is a crucial concept when someone is crafting strategies in the hopes of doing something new and exploiting opportunities that other organizations cannot. It refers to the processes, practices, and decision-making styles of organizations that act entrepreneurially. Farmer entrepreneurship generally relates to a method of recombining agricultural resources innovatively to create opportunities for value creation that consists of five dimensions: (1) autonomy, (2) competitive aggressiveness, (3) innovativeness, (4) proactiveness, and (5) risk-taking [23]. Autonomy describes a condition someone has the freedom to develop an entrepreneurial idea and then tries to realize it. Competitive aggressiveness is the spirit to intensely and directly challenge competitors rather than trying to avoid them. Innovativeness is the desire to pursue creativity and experiments. Proactiveness is the willingness to anticipate and act on future needs rather than reacting to events after they evolve. At the same time, risk-taking describes behaviour to engage in bold rather than cautious actions.

3.2.2. Entrepreneurial learning capacity
Entrepreneurial capacity is the skill that individuals have to spot, recognize and absorb opportunities, as a necessary individual characteristic to become an entrepreneur. Entrepreneurial learning is often described as a continuous process that facilitates the development of essential knowledge for being effective in starting up and managing new ventures [21]. The collaborative model of professional development addresses capacity building within a framework of three pillars. The professional teaching pillar addresses teacher capacity, the community pillar addresses group capacity, and the spirituality pillar addresses vision capacity [24]. Entrepreneurial learning capacity is related to knowledge and skills, collaboration, and a culture of continuous improvement.

3.2.3. Entrepreneurial networking capability
The ICLS need to be organized beyond the farm level. Development of a collective agricultural system operated by a group of farmers, cooperatives, or associations can negotiate land-use allocation patterns and exchange materials such as manure, grain, and straw [12]. Farmer-entrepreneurs operate in a complex and dynamic environment. They are part of a larger group of people, including other farmers, suppliers, traders, transporters, processors and many others [14].

Entrepreneurial networking is related to social capital, as networks together with, shared norms, values and understandings that facilitate co-operation within or among groups [25]. Types of social capital can be viewed from: structure and cognitive; bonding, bridging, and connecting; strong and weak; and horizontally and vertically, and can be measured and analyzed at the individual and collective
level in terms of social perspectives and the micro and macro levels in terms of geographical perspectives [17].

Entrepreneurial networking capability is about constructing bonding, bridging, and linking capability. Bonding social capital describes the links between like-minded people or the reinforcement of homogeneity. Bridging social capital indicates the connections between heterogeneous groups. Linking social capital showed a possibility to reach out to unlike-minded people in different situations, thus enabling members to leverage a far more comprehensive range of resources than are available in the community.

3.3. Case study

The population growth in Bandung Regency generates numerous issues such as the increasing exploitation of land and water resources. Land conversion leads to an escalation of critical land. Critical land management is a strategy to reduce the sedimentation at the Citarum watershed by preventing erosion. Besides, forest management also runs within the community. Joint Forest Management (Pengelolaan Hutan Berbasis Masyarakat - PHBM) is a forest management system carried out jointly by Perum Perhutani and Forest Village Communities (Masyarakat Desa Hutan) with stakeholders. It based on the principle of sharing so that both have a common interest in achieving sustainable functionalities and benefits of forest resources.

Researchers, extension officers, and community leaders carried out determining the values of the importance of the entrepreneurial factors. It was based on the opinions regarding the sustainability of ICLS, which was influenced by regional conditions and farmers’ characteristics. The factors of competitive aggressiveness, innovativeness, risk-taking, collaboration, and internal group bonding have a “5” score. Competitive aggressiveness will encourage coffee farmers to maintain the flavour and improve the quality as the coffee in Bandung Regency has obtained a Geographical Indication (GI) certificate and widely distributed. Arabica coffee from Priangan, West Java is branded as Java Preanger Arabica Coffee (Kopi Arabika Java Preanger/KAJP). Based on the GI, the KAJP distribution is divided into two variants or regions, namely KAJP Bandoeng Highland and Soenda Mountain. Wide distribution with the same GI brand has the opportunity to build competition among actors.

Innovativeness and risk-taking behaviour are considered necessary because ICLS is an expansion of agricultural activities viewed from the economic scope. Farmers who generally grow vegetables then, for ecological reasons, switch to coffee and are directed to adopt ICLS for developing a bio-industrial system. Collaboration in capacity building is an essential factor as participatory knowledge transfer is considered more effective and sustainable among farmers. Bonding or strengthening of farmers groups is the fifth important factor that determines the success of implementing ICLS. The establishing of farmers groups, which begins with the reforestation program, needs strengthening so that it is not a mere formality.

Assessment of conditions in the field was carried out through in-depth interviews with chairpersons and representatives of LMDH Bumi Sangkuriang and Margamulya Cooperative. LMDH Bumi Sangkuriang was founded in 2016 with 100 members. Upon the distribution of coffee seeds, horticulture farmers in Perhutani’s areas have gradually switched to planting coffee. PHBM is a forest resource management system with a collaborative synergy between Perum Perhutani and forest village communities to achieve sustainable functions and optimal benefits of forest resources. Growing vegetables on slopes cut the land contour, which interferes with the reforestation and rehabilitation activities causes erosion and surface runoff, and pollution due to the high use of pesticides. Therefore, efforts have been taken to shift from horticulture to estate crops which have a strong root system and have good economic values for the communities, such as coffee.

The Margamulya Cooperative was founded in 2014 with 200 members. The coffee agribusiness activity at the Margamulya Coffee Producers Cooperative is the processing center of coffee purchased from members of several farmer groups. The coffee plantation is grown on their land and Perhutani’s land. Cooperative members who are members of farmer groups send coffee as raw material to the
The cooperative then provides coffee seeds and organic fertilizers processed from coffee skins for coffee farmers.

An assessment of the farmer’s condition related to the implementation of coffee cattle integration was carried out by giving a value of 1-5 for each factor. A radar chart is used for mapping based on the importance and performance values. Gap analysis is performed to see factors with high importance but low conditions or performance. The elements of innovativeness and risk-taking have the most significant gap (Figure 1). The result of the analysis will guide us to develop strategies for accelerating the implementation of coffee cattle integration.

**Figure 1.** Bioentrepreneur elements mapping of coffee cattle integration in Bandung Regency.

The implementation of coffee cattle integration is still limited. As many as 55% of farmers who own sheep, with a total of 2-3 heads per household, have an average of about three years of experience or since the coffee cattle integration program was established by the local government. Cattle management carried out individually with a cattle pen around the house, reduce the benefit of integrated farming. Colony model allows optimum livestock management, which is not highly welcomed by farmers. This condition shows a low level of high risk-taking behaviour.

The feed given by farmers in the form of grass causes a low index of livestock growth. The coffee berries skin is a potential raw material for complete feed. The colony model in cattle management is an approach to optimize the use of an enormous amount of coffee berries skin by communal processing. Utilization of animal manure as organic fertilizer is not optimal, 72.22% of respondents use it for fertilizer but without processing, and even 11.11% of respondents throw it away. Coffee berries skin is used for fertilizer was 47.06 % unprocessed, and 35.29% did not practice it, while for animal feed, all respondents did not use coffee berries skins as a complete feed ingredient. It means the innovativeness aspects of farmers is still low.

Strategies that can be taken to accelerate the implementation of ICLS is making demonstration plots and assisting farmers. Through the making of the demonstration plot, innovativeness aspect will be developed in farmers. At the same time, assistance is needed to raise awareness and encouragement to farmers to strengthen business and manage risks that arise from business expansion in coffee cattle integration.
4. Conclusions
The IFS needs to be operated by a new mindset and approach to optimize in reaching their potential benefit. It needs specific characteristics in strategy, competencies, and management that align with the entrepreneurship aspect, which in agriculture is known as bio-entrepreneurship. The elements of bioentrepreneurship are divided into entrepreneurial orientation, entrepreneurial learning abilities, and entrepreneurial network capabilities. Entrepreneurial orientation generally refers to autonomy, competitive aggressiveness, innovativeness, proactiveness, and risk-taking. Entrepreneurial learning capacity is related to knowledge and skills, collaboration, and culture of continuous improvement, while entrepreneurial networking capability is about constructing bonding, bridging, and linking capability.

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