



System thinking for policy modeling fits youth's unwillingness as paddy farmers

Miranda Romaully Br. Sitanggang^{1*}, Sadik Ikhsan², Nuri Dewi Yanti², Yudi Ferrianta²

¹*Doctoral Program of Agriculture Science, University of Lambung Mangkurat, Banjarbaru, Kalimantan Selatan, Indonesia*

²*Magister of Agriculture Economics, University of Lambung Mangkurat, Kalimantan Selatan, Indonesia*

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Abstract

South Borneo, with its wetlands, is used as a substitute for Indonesian wetland paddy production during the dry season as part of the government's strategy to ensure paddy sufficiency during the fast cyclical season in paddy centers on the islands of Java and Sumatra. However, this effort has been hampered by the imperative of preserving the wetland environment's sustainability and the younger generation's declining interest in paddy farming. The central and provincial governments have pursued farmer regeneration, but there is no evidence of its success in paddy farmer regeneration. Indications of the occurrence of aging farmers indicate that the problem of farmer regeneration, particularly among paddy farmers, requires a comprehensive system capable of resolving lengthy and complex issues. The research aims to examine the aging farmer phenomenon in South Borneo. Eviews software is used to analyze the secondary data obtained. The findings indicated that farmer aging is a reality in South Borneo. However, efforts to reverse aging through farmer regeneration are strange and time-consuming. Thus, System Thinking must be applied to determine the root cause of the issue and the critical nature of involving all parties or subsystems, including the sustainability of the wetland environment through the use of native wisdom, as shown in the Causal Loop Diagram. This diagram could be used to make policy models for the younger generation interested in working as paddy farmers.

* **Corresponding Author:** Miranda Romaully Br. Sitanggang ✉ 1940511320012@mhs.ulm.ac.id

Introduction

There are two fundamental theories of systemic change: one that seeks to amplify success by anticipating and planning ways to overcome potential barriers to success, and another that seeks to improve an existing situation by planning to sustain and build on progress over time (Senge and Sterman, 1992; Stroh, 2015; Hynes *et al.*, 2020). We are confronted by an ever-more complex and interdependent system. The system is constantly evolving and is not in a stable state or on the verge of achieving one. Thus, forecasting cannot be based on historical extrapolation or isolated analysis of individual or corporate behavior. By treating these individual systems as intra- and interconnected, systems thinking fully considers these interconnections.

This approach, which could be implemented using agent-based modeling, network analysis, and machine learning, can provide a more holistic view of these diverse cross-effects. The population of Indonesia in 2019 was recorded at around 268.1 million people. In 2024 the population is estimated to be 280.4 million people. Thus during the period 2019-2024, the population of Indonesia increased by about 12.3 million people. So more consumption is needed of about 1.4 million tons of paddy, assuming a consumption rate of 114 kg/capita/year. By 2050, the population of Indonesia will be 311 million. Problems will arise if food production cannot meet food needs due to the increasing population, namely food shortages (Trisia *et al.*, 2016).

Agricultural households dominate the form of agrarian units in developing countries (Toader and Roman, 2015). Farmworkers have the most negligible income, while those who earn from non-agriculture are higher welfare, especially if they have diverse incomes (Davis *et al.*, 2017). Therefore, it needs the government's attention to improve the welfare of farmers so that they do not get out of the agricultural sector. In addition, agriculture human resources face severe problems because the age of farmers is getting older without being balanced with regeneration, which is feared to threaten the sustainability of

agriculture, especially paddy commodities in Indonesia which means also threatening the country's food independence. Changes in the aspirations of rural young people, especially the educated, consider farming to have a low status, high risk, less guarantee of stability and continuity of income, average narrow land tenure, or difficult access to land (Bezu and Holden, 2014; Susilowati, 2016). It needs a strong push for them to work in the agricultural sector with socialization and education related to agricultural innovation and technology to improve the status of farmers and anticipate climate change (Widiyanti *et al.*, 2018). The younger generation's response with the support of engineering and finance, agricultural profits, and sustainability shows an interest in becoming young entrepreneurs (Pelzom and Katel, 2017). Collaboration between farmers is expected to attract young people working in agriculture (Almgren, 2018). Minimizing uncertainty helps succession and attracts young people to become farmers. Behavioral approach with endogenous succession cycle model and structural modeling technique, showing economic factors, namely payments received as farmers and non-economic, among others motivation, involvement in decision making keeps young people on the farm (May *et al.*, 2019). The position of youth in agriculture also determines decision-making (Andersson Djurfeldt *et al.*, 2019). Career incentives in agriculture need to be considered to attract fresh graduates from agriculturally educated students (Unay-Gailhard *et al.*, 2019). We need a plan to socialize younger generations to want to farm as more farmers from non-farm backgrounds enter into agriculture with a desire to practice agriculture (Carolan, 2018).

As a developing country, agriculture in Indonesia is still dominated by farming families (Toader and Roman, 2015). Because it does have difficulties to realize, especially facing the younger generation with a strong interest in technology and innovation, changing the perception of young people about agricultural (Boström, 2012; Toader and Roman, 2015; Nhamo and Chikoye, 2017; Magagula and Tsvakirai, 2020).

The development of the issue of farmer regeneration which was then widely researched prompted the government to start then paying more attention to farmers' regeneration programs in 2016. The number of farmers in Indonesia in 2019 is as many as 33.1 million people, whereas millennial farmers are only 2.7 million people or only 8.16% (BPS, 2020). The data illustrated that young people's interest in pursuing agriculture is still shallow. This condition needs to be thought about more deeply for better farmers' regeneration programs. It is necessary to get a solid and intelligent young generation interested in moving into agriculture to replace aging farmers.

Indonesia's paddy self-sufficiency program places South Borneo as one of the supporting centers of national paddy producers by utilizing its wetland resources. Wetlands become an alternative to paddy barns because, during the dry season, the paddy fields in dry plains experience a famine. The wetland area with paddy planting based on local wisdom turned out to do a great harvest.

For agri-food sustainability, policies involving the young generation and agriculture require research into the future engagement of young people with agriculture by framing the agri-food sector broadly and emphasizing the critical role of agribusiness rather than by focusing exclusively on crop and livestock production. Additionally, we require research that elucidates what young people are doing, where they are doing it, and why they are doing it in relation to youth policy (Anyidoho *et al.*, 2012). Policies should assist young people who intend to farm and those who would farm if they had a better chance (Ruiz Salvago *et al.*, 2019). The research aims to analyze the aging farmer phenomenon in south Borneo and open decision-makers' insights to make suit policies for regenerating paddy farmers with a system thinking approach.

Materials and methods

Study area

This study focuses on South Borneo, Indonesia, with wetlands areas for alternate paddy center production,

especially during the dry season in central paddy production in Java. The provincial government needs to know the situation regarding human resources in rice crop farming. The research site is a wetland with vulnerable properties, so it needs a prudent policy to keep it sustainable.

Study design

The study is designed to analyze the aging conditions of farmers and the relatively slow process of farmer regeneration or to prove the formal decline of young farmers in South Borneo with the ADF test using the Eviews program. Agricultural development policies require a model that can accommodate the younger generation's desire for the sustainability of paddy farmers. This model is also keeping the sustainability of wetlands based on local wisdom. Paddy's agribusiness model is suitable for use with the systems thinking approach within subsystems apart. The causal loop diagram was produced from the system thinking approach using Powersim software.

Results and discussion

Aging farmer phenomenon

Indonesia is the agrarian country with the most jobs in the agricultural sector. As the economic structure changed, employment in manufacturing and services experienced such rapid growth that jobs in the agricultural sector began to be abandoned by the younger generation. This phenomenon is a logical consequence of economic development that is already underway,

The progress of development outside the agricultural sector is often a benchmark for the progress of a nation. The number of people working on farms is declining due to changing employment structures. This condition unwittingly threatens or sacrifices the agricultural sector. Therefore, the social-economic behavior of paddy crop subsectors in Indonesia needs to be monitored and continuously analyzed to anticipate unwanted changes.

Paddy Productivity of South Borneo is 2.75 Tons/Ha, still below the national productivity of 5,135 tons/ha.

Paddy production centers in Indonesia are East Java, West Java, Central Java, South Sulawesi, North Sumatra, South Sumatra, Lampung, South Borneo, West Borneo, and West Sumatra. Paddy production amounted to 2,415,285 tons, while the highest in East Java with 13,125,414 tons in 2018 ("InaAgrimap - Home," n.d.). Although at the eighth position, South

Borneo's role is quite significant because it becomes a paddy producer when the main center of paddy is experiencing a famine. If the distribution is smooth, it will maintain the stability of the national paddy price. This role needs to be maintained so that it is interesting to research agricultural sustainability, especially paddy crops in South Borneo.

Table 1. ADF Test results data of people working in the agricultural sector from 2011-2020.

Information	Age50+	Ages 30-49	Ages 15-29
ADF statistical test	-0.277986	-5.257202	-2.159381
The Critical value 1%	-4.800080		
The Critical value of 5%	-3.791172		
The critical value of 10%	-3.342253		

Data of workers in three main sectors, agriculture, manufacturing, and services in South Borneo, indicates a decrease in the number of people working in agriculture. The central government continues to work with various programs to increase the number of farmers. Although there is an increase, the interest of young people working in agriculture is more promising crops such as horticulture than rice crops because rice plants require heavier and dirtier work with unsatisfactory results.

This condition cannot be allowed or ignored because improving conditions with complex problems have been around long enough, requiring holistic thinking. Problem-solving policies early on need to be taken and it takes a long time to change things.

The development of the labor force working in the agricultural sector based on three age groups can be seen in the graph Fig. 1. The 15–29-year-old labor decreased from 2011 - 2020, and the ages of 30-49 years showed a slight decrease in a chart, The age of 50 years up shows an increase that means the aging of farmers. Biologically farmers are indeed aging, which can be explained by seeing farmers aged 30-49 who are reduced because the age of 49 who entered 50 years moved without any significant additions from farmers aged 29 years who entered the age of 30 years. Farmers aged 15-29 who continue to decline show farmers' regeneration is not going as expected.

To determine whether the data contains roots or exhibits a trend, a formal stationary data test using the ADF test is required. The ADF test results are summarized in Table 1. ADF calculated for those aged 50 years or more is -0.277986, which is greater than the critical value of 1%, indicating that the null hypothesis (H_0) cannot be rejected, indicating that there is indeed a trend or increase in the workforce aged over 50 years. The same thing occurred in the age group of 15-29 years, with ADF calculated values exceeding the critical values of 1% by -2.159381. It is unable to reject the null hypothesis (H_0), which implies an actual decline in the number of young generation farmers in that region.

The chart for farmers aged 30-49 years demonstrates a slightly decreased tendency to reject H_0 , as the ADF count of -5.257202 is negative or less than the critical value of 1%.

This indicates that the data are stationary and thus that farmers aged 30-49 do not decline.

Based on the research results, there is an increase in more than 50 years of farmers. On the other hand, young farmers are declining, and adult farmers remain. If left unchecked, the aging conditions of South Borneo farmers will threaten the availability of food or food adequacy from their products in the future.

Table 2. Employment structure (%) in South Borneo 2012-2019.

Information	2012	2013	2014	2015	2016	2017	2018	2019
Agriculture	42	40	39	36	35	33	31	30
Manufacturing	18	17	16	16	15	17	10	19
Service	41	42	45	48	50	49	59	51

Source; BPS South Borneo, 2020.

The aging of farmers means that the regeneration of farmers does not run satisfactorily. The younger generation is less interested in struggling with jobs in the agricultural sector, especially paddy farmers. Data on the state of the labor force in the subsector of food crops, especially paddy, is not yet available. Still, conditions that occur in agriculture can be widely used as a proxy approach to see the picture of the behavior of paddy farmers.

The Ministry of Agriculture is currently building big data farmers based on crops cultivated with the "Simluhtan (Agricultural extension information system)" portal. However, the data does not describe series data of death or in and out of farmers. Furthermore, it is expected that the data series will be available for better decision-making.

Agricultural Census data per 10 years as 2003, 2013, and 2018 inter-census survey data (SUTAS) were used to look at the condition of paddy farmers in South Borneo. The number of agricultural households in 2003 was 470,884 KK (head of the family), then decreased to 432,328 KK in 2013, so the government made efforts to increase farmers, and SUTAS 2018 results show an increase 472,067 KK. Unfortunately, paddy farming households continued to decline from 321,288KK in 2003 to 309,792 KK in 2013 and 302,892 KK in 2018. There was a reduction in paddy farming households by 5.73% from 2003 to 2018, or a decrease of 0.38% per year. From 2013 to 2018, the decline was 2.23% or 0.44% per year, which indicates a faster average decline per year.

The younger generation seems more interested in working in the service sector, seen from the blue graph, which tends to increase, while those working in the agricultural sector tend to decline (Fig. 2). The

employment structure once dominated by the agricultural sector has undergone a shift. The service sector is increasingly in demand while the agricultural sector is abandoned. In 2012 agriculture and service sector drew about 40% contributed to the structure of existing employment, but in 2019 the service sector, up to 51%, has replaced the agricultural sector with only 30%. Manufacturing tends to be stable because factory growth in South Borneo is not too rapid (Table 2).

Indonesia is still busy with paddy self-sufficiency efforts, so opportunities for paddy exporters are still far from being realized. The role of South Borneo as an alternative paddy production center in the dry season is due to the type of wetlands that dominate paddy fields in South Borneo. South Borneo's contribution averages about 3% of national paddy production (BPS South Borneo, 2019). Based on the food security agency report, there is a paddy surplus. Reports of surplus paddy often make us complacent, thus ignoring the reduced regeneration conditions of farmers Fig. 3 shows the growing need for rice while its original production increased shows a decline since 2017. Rice fields fluctuate but tend to increase with the number of farmers who continue to decline. This condition indicates an increase in rice productivity per person but decreases per land area.

This condition shows that existing farmers cannot cultivate increasingly large land because of labor shortages or reduced efficiency. Furthermore, rice farming requires technological changes to manage land to be more productive. If the land area becomes more economical in scale, then more modern tools are possible to apply in South Borneo. The agribusiness paddy system 4.0 can be applied to the sustainability of wetlands and adopting local wisdom.

System thinking for regeneration paddy farmer

Avoiding the phenomenon of icebergs where significant problems are often not seen on the surface, it is necessary to anticipate by paying attention to the behavior of human resources that leave the agricultural sector, especially paddy crops. However,

unfortunately, the right strategy is not pursued to overcome it early on. The efforts to overcome significant problems will not give satisfactory results, even until it is too late to overcome them. Need holistic consideration or system thinking to solve it (Hynes *et al.*, 2020).

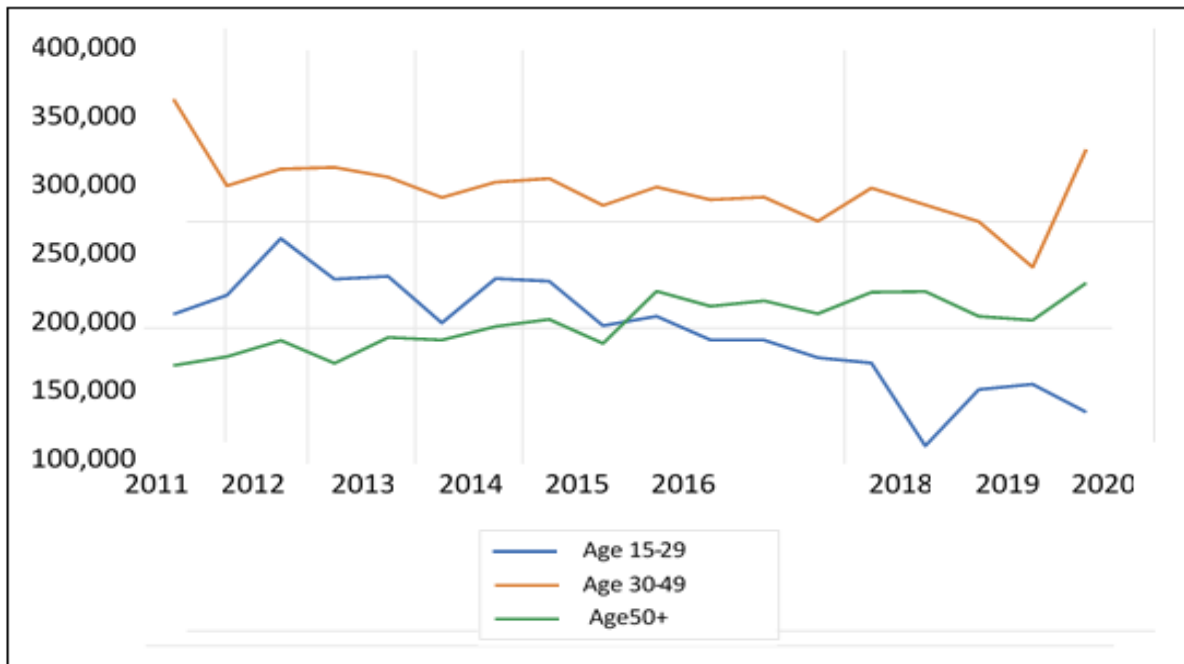


Fig. 1. Labor Force working in the agricultural sector based on age group.

Systems thinking is an approach to solving problems by seeing that everything affects each other and understanding how systems work with behavioral patterns. Systems thinking underlies the concept of system modeling (Senge and Sterman, 1992; Stroh, 2015). For example, the thinking system considers the phenomenon of low farmer regeneration in South Borneo as a problem that aims to solve the problem. Modeling this system will help solve the problem, treat symptoms, and find the problem's root.

Looking at the results of ADF tests, the trend of the young farmers is decreasing, and adult farmers are relatively constant, then in the next ten years, adult farmers will enter old age. If the younger generation is no longer interested in paddy crop farming, regeneration will be challenging to realize.

The regeneration of paddy farmers has been realized for quite a long time. However, efforts and programs

that have been running have not increased the number of young people working in agriculture, especially paddy farmers. The role of "System Thinking" is needed to parse problems in a comprehensive system to explain phenomena and solutions to solve comprehensively. An issue that has been long enough and has not found a theoretically encouraging solution needs to be looked at with system thinking theory. Considering the involvement of all stakeholders related to the paddy agribusiness system to see the problem thoroughly.

Paddy farmer's regeneration issue is a problem that requires a system thinking approach in South Borneo. Decisions made by simply seeing a decrease in the number of young farmers do not necessarily solve the problem. Requires deep attention to the behavioral patterns and system structures that lead to a lack of interest in young people becoming paddy farmers to cope.

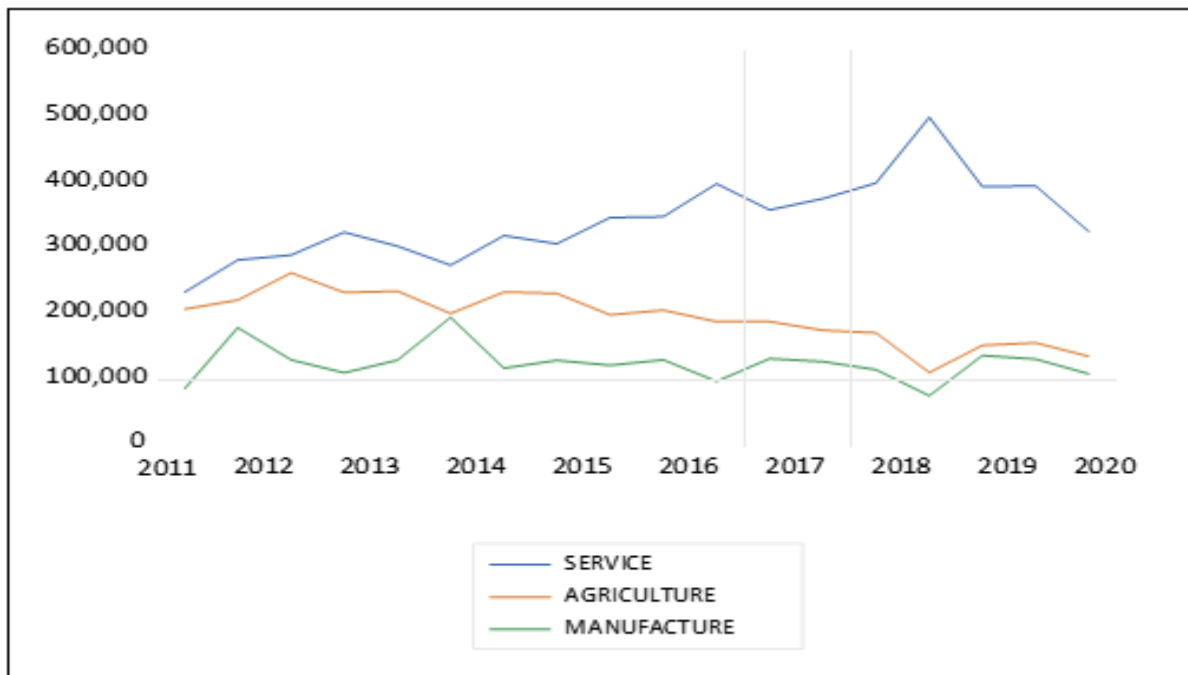


Fig. 2. The workforce composition of 15–29-year-olds working in the service, agriculture, and manufacturing sectors.

The phenomenon of low farmer regeneration has the structure and behavior that organizes it into a system. Therefore, modeling of this phenomenon is made closer to actual conditions. Based on the Focus Discussion Group results, the elements that make up the structure and behavior were obtained.

This research produced the Causal Loop Diagram (CLD) as a conceptual model to comprehensively see farmer regeneration (Fig. 4). As a result, CLD has become the basis for policymakers to decide on a suitable model to overcome the regeneration of paddy farmers in South Borneo.

The CLD depicts the phenomenon of regeneration of paddy farmers in South Borneo. The elements that influence and structure the behavior of the regeneration model with consideration of the three pillars of environmental sustainability; social, economic and environmental. Also, based on the agribusiness concept for modern agriculture within five subsystems and technology 4.0.

Wetland is a land that is easily damaged if not wise in managing it. The unique nature of wetland is considered so that the damage to existing land does

not increase. The local hereditary wisdom of ancestors needs to be transferred to the younger generation to pay more attention to the sustainability of wetland. The government needs to identify local wisdom of rice cultivation to be socialized to the younger generation. Socialization and education take time, or there is a delay in getting the expected results.

The use of wetlands for paddy farming requires a clear legal basis from the government without damaging the function of wetlands as a buffer for the life of flora and fauna around it. The hydrological function of the wetland is as an aquifer for biodiversity. Wetland land management needs to be careful not to incur environmental costs that are greater than expected benefits. Efforts to support young farmers by giving wetland access must be considered and should not penetrate wetland conservation areas.

It is worth considering planting a type of paddy suitable for wetlands. This type of paddy wetland is better for health because it has a relatively higher glycemic index than dryland rice types. This type of rice is good for a healthy diet.

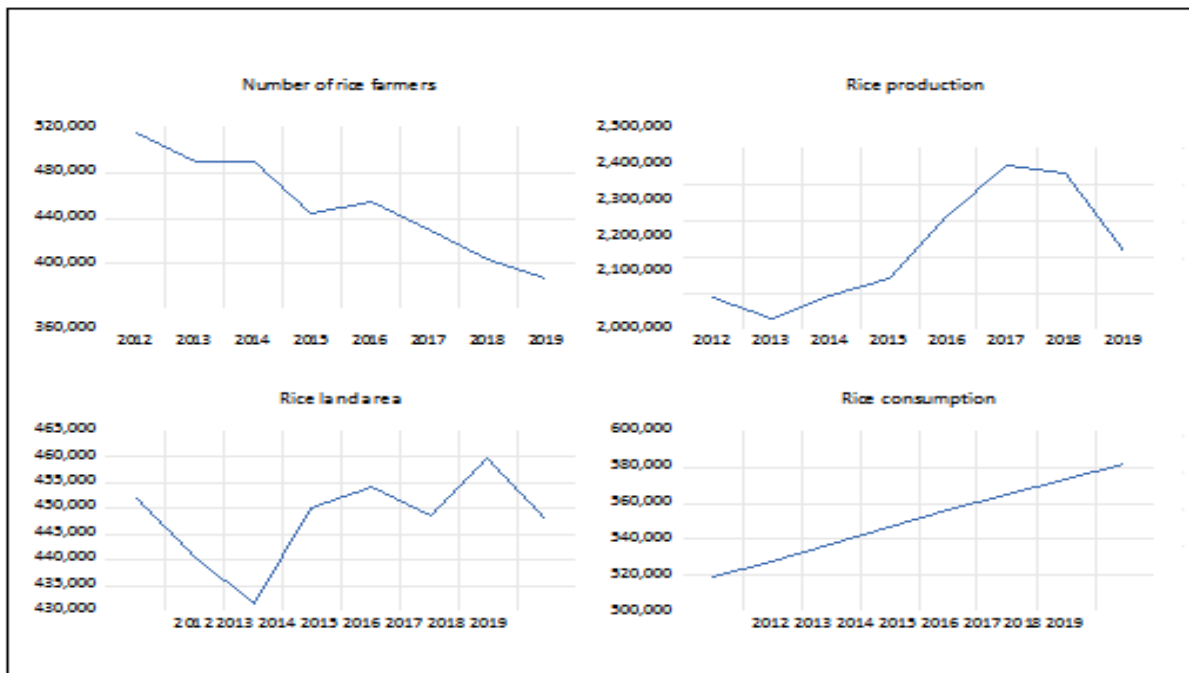


Fig. 3. Tend of total farmers, paddy production, paddy land area, and paddy consumption in South Borneo.

Social considerations for the sustainability of rice agribusiness in wetlands are related to human resources like paddy farmers. Agricultural education, especially rice crops, needs to be given from an early age so that the results will be better in instilling a sense of pride in working in rice crop farming. The government needs to support the agricultural education curriculum from an early age. The regeneration process takes a long time to instill concepts and foster interest.

Rice farm employment needs to be changed to compete with manufacturing and service sector jobs. The rice farming sector with the concept of agribusiness will adopt technology 4.0 so that modern agriculture can cause interest and passion for young people to work in it. All parts in the agribusiness subsystem can be integrated with rice cultivation by carrying technology 4.0 in all subsystems. However, the use of mechanization using technology 4.0 needs to be wise because wetlands can not bear the burden of equipment or machinery that is too heavy, so it needs modifications in order to be appropriate for wetland paddy cultivation.

The agricultural extension needs to increase its capacity to educate the younger generation with

commensurate technological capabilities. Local governments need to facilitate young people who desire to engage in agriculture with more challenging patterns. Universities can produce graduates who are interested in becoming modern paddy farmers.

Career incentives in rice agribusiness will increase if technology 4.0 is well adopted. Thus increasing prestige compared to conventional rice farming. Rice agribusiness start-ups can be a model of business forms that attract young people.

The younger generation is very interested in working in a start-up with a working team that has a passion for a common goal. The apps used were even found that adjusting wetland conditions would be challenging for young people to get involved.

Increasing the number of young farmers interested in paddy farming has been a challenge for the government and those who feel the importance of maintaining and improving paddy crop subsectors to appeal to the younger generation. It takes time and deep thought to produce a model of agriculture that successfully attracts the younger generation's interest as an iceberg phenomenon that needs to be solved with the next problem-less solution.

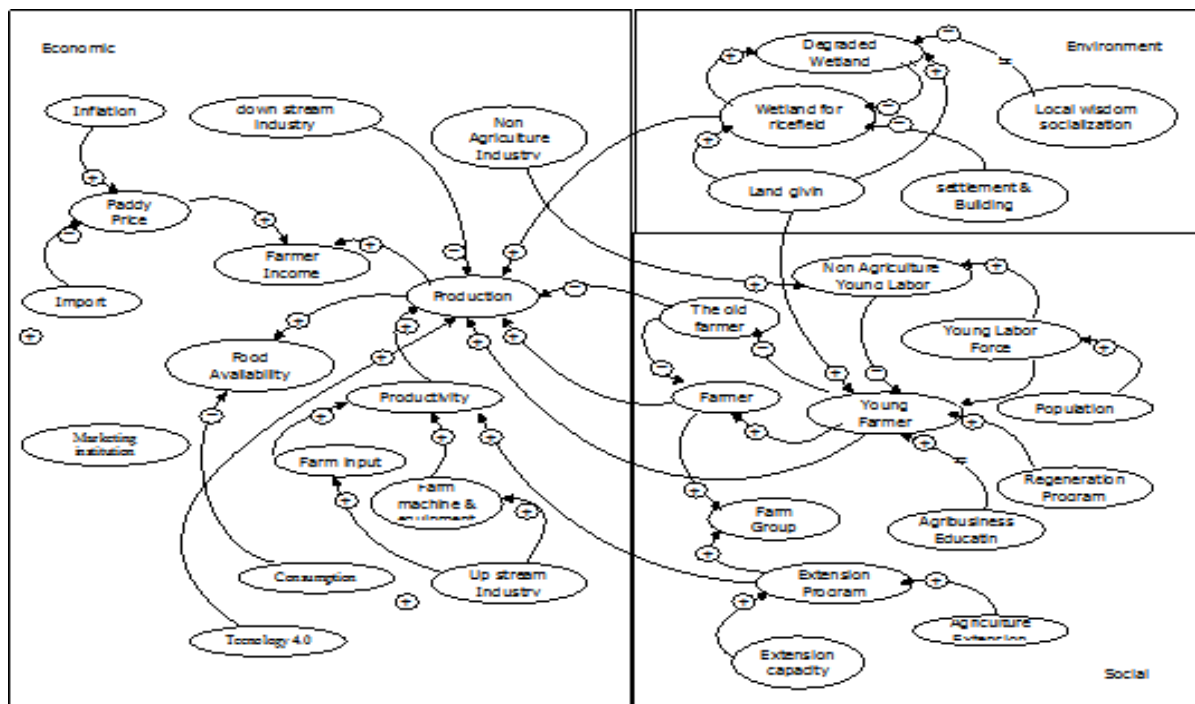


Fig. 4. Causal Loop Diagram (CLD) of paddy farmer regeneration in South Borneo,

The rice agribusiness system is an integrated subsystem. Without rice farmers in the farm subsystem, other subsystems will not exist. The rice farming business that is following the wishes of young people needs to be started soon so that in the future, it becomes a job that is in demand by the younger generation. Based on the mindset of this system, the government can determine the right programs and budgets to attract young people working in paddy agribusiness later. It needs a more profound analysis using a dynamic systems approach to suppress more applicable decision-making technically. Research using dynamic systems in agriculture has been done (Saysel *et al.*, 2002), but this has still never been done for the regeneration of paddy farmers. This research will be the next job for the researchers.

Conclusion

ADF tests of the increase in the number of old farmers and the decrease in the number of young farmers prove scientifically that this phenomenon occurs. Decision-makers can start preparing policies to support the regeneration of paddy crop agriculture. The practical implications of this research can be a consideration for early decision-makers with system thinking that the problem of aging farmers in south

Borneo cannot be ignored, especially considering that paddy production still meets food needs. Especially with the role of South Borneo as one of the centers of paddy production. The Causal Loop Diagram will open up new perspectives in decision-making for successful paddy farmer regeneration efforts. Local governments can unite cross-sectoral to support the successful regeneration of paddy farmers. By involving all subsystems and considering the three pillars of environmental sustainability using technology 4.0 that adopts local wisdom, the results will be more promising. Agricultural development in companies can attract the younger generation with careful consideration using dynamic system analysis for the following research. The development of agricultural companies while paying attention to the wetland sustainability of the three pillars, with social aspects need to be considered.

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