Strengthening Indonesian Farmers’ Resilience Capacity of Disasters and Climate Change Through Development of Decision Support System: Challenges Lie Ahead

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Abstract. Farmers are the vanguard of national food providers. However, they still have not yet received much serious attention and assistance. This condition is exacerbated by unpredictable climate change. Therefore, it is crucial to have an analytics tool to assist farmers in resolving production problems with some variables such as soil condition, season, and plant species. Decision support system (DSS) in agriculture helps farmers in making decisions based on previous research results. However, DSS in some countries are available, but not widely used by the farmers. This study aims to analyze the possibility of developing DSS to increase the resilience capacity of farmers in Indonesia. The method used in this research was a literature study and descriptive analysis. The results showed that there is still a long way to go in achieving the robust DSS, referring to the quality of research results so far. To elaborate on this, it is necessary to make a research roadmap in this field by understanding the current research status. Moreover, DSS will be a form of contribution from researchers in providing reliable and updated public information packages for a better agricultural management.

1. Introduction
The population in Indonesia reached 270.20 million in 2020, with a population growth rate of around 1.25 per year for the last decade [1]. The biggest issue for this population growth is food security. Indonesia is an agrarian country, which most of the population works in the agricultural section. According to the Central Bureau of Statistics [2], the number of farmers in Indonesia in 2020 reached 33.4 million people, divided into food crops, horticultural, plantation, animal husbandry, fish farming, fishing, and forestry. Moreover, the Indonesian Department of Agriculture stated that agriculture occupies the most enormous number of labor for around 29.76% [3]. Indonesia has agricultural land for approximately 25 million Hectares which has degraded since 2010 [3]. With this condition, we should be able to become self-sufficient in rice and other commodities. However, the opposite has happened, we still import a lot to meet our domestic needs.

Farmers in Indonesia are the vanguard of national food security. They assist the government in fulfilling food needs for the entire population in Indonesia. Therefore, farmers in Indonesia must be considered carefully by the government to achieve food self-sufficiency. The level of success of farmers in food production is influenced by various factors such as social economics and the environment. Farmers in Indonesia face multiple problems such as the aging farmer phenomenon, lack of concern from the government, low level of education, and climate change [4]. The aging farmers
phenomenon happened because the agricultural sector is considered less prestigious, does not provide adequate income with a large risk of failure, and uses traditional technology [5, 6]. Some farmers in Indonesia have a low level of education, which makes them difficult to access technology. This issue made the farming activities less efficient, and as a result, they receive less yield that will worsen their wellbeing. As consequences, lots of farmers sent their youth to the city for school and get a decent living rather than become a farmer [6]. This phenomenon has made the agricultural sector in crisis.

The other biggest issue for the farmers recently is climate change. Human activities, such as burning fossils fuel, deforestation, and livestock farming, change the natural greenhouse gas emissions on the atmosphere, which cause the temperature rising on the earth surface [7]. This causes climate change. Agriculture, on the other hand, relies on the weather and climate [8]. The flood and drought have been unpredictable recently, while the sea surface is rising in some areas causing soil salinity worsen[9]. These conditions impacted plant development negatively and ruined the crop yield. If this condition continues, national food security would be in danger state. According to projections from Nelson, Valin, Sands, Havlík, Ahrammad, Deryng, Elliott, Fujimori, Hasegawa and Heyhoe [8], with an unchanging climate, the food production will be decreased by around 17%. The government should pay more attention to agriculture, as national food security relies on this matter.

Farmers need to adapt with the climate change. They need to receive valid information about climate change and alter their farming practices according to the risk posed by climate change [8]. Through this, they can optimize the positive impact and minimize the negative effect of climate change in farming[10]. Moreover, farmers need to make long-term planning for crops and daily basis decisions which require assistance to make it efficient on this recent condition. These included choosing the right crops for the recent climate, fertilizing, choosing the right pesticides and timing for applying, building the irrigation, sowing and harvesting timing, and changing the cropping pattern or intercropping [11,12]. According to Tripathi and Mishra [11], regardless of knowing the climate change, sometimes farmers do not respond to the impact of climate change because of some limitations such as incapacity, lack of knowledge, and data. In Indonesia, this is the gap that needs to be fulfilled to achieve a better agricultural practice in adapting the climate change.

Decision supporting system (DSS) is a part of computerized information system that help users in taking decisions and solving the problem by analyzing a big volume of data and accumulating information [13-15]. DSS could be in automated form, human-powered, or a combination of both forms [16]. DSS is used in various knowledge, for example, in medical to agriculture. As an example, the most common DSS we use in daily life is GPS route planning in our car or mobile phone. The program used real-time traffic inputs and data of possible roads, then analyzing them to find the best route and avoid congestion. DSS in agriculture, for example, has been used to aid farmers in choosing the right time to plant, determine the right plants for a different type of soil and the season [14,17,18]. In some countries, for example, Australia, India, the USA, Israel, and Italy DSS has been developed to help the farmer in taking decision [19]. An accurate and valid data collection is needed to build a well-targeted DSS. Moreover, DSS needs to be established in association and close discussion with end-user, hence the DSS could answer the farmers’ problems[18].

It is vital for the Indonesian government to provide a tool, such as decision supporting system, that could help farmers in making a decision for adapting the climate change. This tool should be based on recent research, easy to understand, feasible, and accessible for all farmers. This study aims to analyze the possibility of developing DSS to increase the resilience capacity of farmers in Indonesia. Developing DSS could help farmers in making decisions by providing scientific information packages based on the previous research results as a part of agricultural management.

2. Methods
The method used in this qualitative study is a literature study. Descriptive analysis is used in data analyzing for summarizing the data. Descriptive analysis is an important method in summarizing or describing data or phenomena which can explain and identify the causal effect [20]. In gathering the
data, a literature study is needed to have a deeper understanding of data, concepts, or phenomenon [21]. At first, we were looking for the development of DSS in Indonesia. Then the importance of DSS and the challenges of developing the DSS in Indonesia. We compared it with the agricultural public services approach in countries with advanced agriculture.

3. Results and Discussion
The exponential population growth, environmental insecurity, unpredictable climatic conditions are the problems we are facing now, which affect the stability in agriculture. Moreover, information and communication technologies play a big role in our daily life. With the emergence of efficient big data management, online analytical processing, and computational power, the decision-making process in agriculture should be more straightforward. However, there are some obstacles in information dissemination. Farmers often hard to find the correct information and data that could aid them in making decisions, while the available research information is hard to reach the farmers. DSS can bridge this problem, so that DSS can serve as a forum or data bank for research results also become the information and analysis center that helps farmers in making decisions because providing only information is not enough [22]. There are two main concepts on the decision-making model in agriculture, the cropping plan, and the crop rotation decisions. These decisions are crucial because they alter farm productivity and profitability in the short and long run [23]. In Indonesia, where agricultural practices are considered conventional and highly dependent on climatic conditions, adaptation to climate change is essential. Thus, a proper understanding of climate data and information is vital to support risk management and on-site decision-making.

3.1. The role of DSS in Agriculture
Making decisions for agricultural processes in the erratic seasons could be troublesome and daunting. Planting processes have many factors to be considered. There is a complex relationship between the unevenness of soil, climate, water, plants, the infestation of animals and microorganism [16, 24]. One misstep or flaw in judgement could lead to crop failure and disrupt sustainable agriculture. In making decisions farmers require experience, knowledge about the situation, and analysis [24]. Therefore, providing the reliability data and aiding in the analytical for decision making such as DSS become one of the agriculture research focus [16]. The first DSS for agriculture was Televise, developed for plant protection in Norway [13]. At that time, a computer was an uncommon object for personal use. However, DSS still became the focus for disseminating the information for agriculture. With the development of technology, it is hoped that DSS could reach all farmers and aid farmers in making the propitious decision.

Information is the determination key in decision-making. Accurate data and information will make decision-making more reliable. DSS in agriculture aid farmers in making decisions in farming by analyzing and integrating various data and information from the bank data [25]. In making decisions for planting crops, farmers need information about the type of soil they have and their suitability for crops, weather conditions during planting, information about plant pests and diseases in question-based on climatic conditions, irrigation, fertilizer doses according to plant growth stages and much other information [26]. This type information is already available through research conducted by government institutions, such as LIPI (the Indonesian Institute of Sciences), Ministry of Agriculture, and Ministry of Environment and Forestry. However, the dissemination of the information has not been able to reach the farmers. Thus, in the field, farmers only rely on knowledge and information provided from generation to generation, whereas in fact, this information is not sufficient in today's erratic conditions. DSS could aid farmers to minimize the negative environmental effect on the crops and increase yield [27].

DSS can also increase young people's interest in agriculture. As we know, agriculture in our country faces various problems, such as aging farmers and the stigma that farmers are poor [5]. Some farmers feel that being a farmer is not profitable and outdated. They often send their children to the city to get a proper education or to work. With the DSS, it is easier for farmers to make decisions in
planting to minimize losses and be free from the stigma of being poor [22]. Currently, almost everyone in Indonesia has access to the internet or mobile phones. This technology makes people could access almost all information regardless of their location. The Ministry of Communication and Information found that 89% of people in Indonesia or around 167 million people use smartphones [28]. If the DSS is an application on a smartphone, it will be easier to reach young people. This might make young people more interested in becoming a farmer or working in the agriculture sector. Moreover, this technology might also help the farmers in Indonesia in disseminating knowledge if the linear transfer of technology model is considered a failure, since the Farmers in Indonesia have a high social relationship [29].

In Indonesia, where the farmer’s level of education is still low, farm advisor is crucial. They also build a strong connection with the farmers and the agriculture in the specific area. Farm advisors help the farmers by demonstrating sustainable agriculture practices, providing information for farmers, and assisting the farmers throughout the agricultural practices. According to Jørgensen, Noe, Langvad, Jensen, Ørum and Rydahl [18], farmers prefer to use farm advisors rather than Crop Protection Online DSS. Farm advisors must ensure that the farmers are running their land as efficiently as possible. Hence, farm advisors also need DSS to aid the farmers in taking decisions using the latest data and information or disseminating the research results to farmers.

DSS is not only beneficial for farmers and farm advisors but also researchers. DSS for researchers provides more value because it makes easier to share the information. The results of research so far have only been provided through journals, seminars or dissemination, and research reports, which are difficult for farmers to achieve. This condition gives rise to a stigma that research is only useful for researchers but does not answer farmers’ problems. Dissemination of the results of the research itself, as we know, is less attended by farmers, also costs a lot of money. With the DSS, researchers can enter the results of their research in a data bank that can be used by DSS users. In aligning with the DSS, researchers have a ‘grip’ to carry out research so that later the results can be used for the DSS. In addition, it can also help researchers to answer what research is actually needed by farmers by looking at the trends in the DSS. This can help synergize between the needs of farmers and the researchers.

### 3.2. Implementation of Agriculture DSS on the other Countries

The global community has committed achieving the Sustainable Development Goals (SDGs) in 2030. Agriculture, on the other hand, is the determining factor for combating poverty, hunger, and malnutrition. Success in agriculture depends on many things, one of which is environmental conditions, government policies, and socioeconomic factors [30]. Environmental factors such as climate, soil condition, and pests are the controlling factors for crops. We are in the Anthropocene era, where the climate is changing, which makes the other factors unpredictable. In some countries, DSS has been developed as a tool to improve the farmers' adaptation and adaptive capacity. However, they have a different level of success and acceptance. To develop a proper and effective DSS, we need to delve it from other countries.

| Table 1. Implementation of DSS in developed and developing countries. |
|---------------------------------------------------------------|
| Developed Countries | Developing Countries |
| Availability | Almost all countries developed the agricultural DSS[31, 32] | Only some countries developed the DSS [16] |
| Focus | Broad range focus with transdisciplinary approach[33, 34] | Still limited in pest, agricultural production or climate and still in one or two scientific disciplines[35, 36] |
| Accessibility for farmers | Almost all farmers have access[37] | Only a few that have access[38, 39] |
| Farmers’ acceptance | In some countries, farmers are skeptical about the DSS and do not use DSS[40] | Farmers need the DSS, but only a few have access to the DSS[25, 38] |
3.2.1. Implementation of DSS in developed countries

DSS in agriculture is intensively developed globally. A lot of countries adopt the DSS as sustainable agriculture. The DSS in agriculture has a broad range of focus. Several scientific disciplines and competencies need to develop sustainable agriculture via a transdisciplinary approach for DSS could impact the society. In Australia, for example, they develop Agriculture 4.0 to assist farmers in taking feasible decisions and obtaining higher profits [33] and EXCLAIM DSS for estimating the impacts of climate change to habitat condition on wetlands by examining the possible scenarios of water management and climate change [41]. In Italy, researchers developed LANDS DSS for monitoring the main crop productions and forecasting the plant disease [31]. The other DSS for plants pest and diseases are NegFry, CLIMEX, SOPRA [32, 34, 42]. The Great Plains Framework for Agricultural Resource Management (GPFARM) DSS was developed in the US. The general purpose of GPFARM is as a whole-farm DSS for strategic agroecosystem sustainability evaluation across the US. However, not all implementation become successful. The DSS stumble upon an implementation problem, where the data and information successfully provided and the DSS is, but unused by the user, in some cases, farmers feel sceptical with the DSS [40]. As an example, in Sweden, many farmers have all the technology to DSS, but they do not use it in agricultural practice. The available information, data, and communications technology systems are not used to maximum potential [37]. Even though, in some cases, the DSS is not implemented by the farmer, the DSS is still used by the farm advisors.

3.2.2. Implementation of DSS in developing countries.

In developing countries, the opposite might happen (table 1). The DSS in some developing countries has not been established yet or the accessibility of farmers to the DSS remains troublesome [16, 38]. In some cases, the distribution and maintaining the program is expensive and needs a lot of investment [25]. In developing countries, such as Brazil, smallholder farmers are the most vulnerable communities. They do not have a stable income due to inconsistent access to markets [38]. Due to this, the Brazilian government develops a DSS to help accessing the markets [38]. On Africa, the AfricaRice is a mobile app DSS that guide farmers in managing rice plantation [35]. The TRF-DSS in Thailand aims to support data integration for farmers according to agricultural production and natural disaster management. In India, the accessibility to agricultural information is low; only 41% of farmers had access, which makes it harder for disseminating the information [39]. However, there are some DSS that has been used, such as The DSSAT, Krushi Samridhhi, or GeoSense DSS, which assist the rural farming community for better farming and management using location and environmental parameters [12, 36, 43].

Farmers usually passed their knowledge from generation to generation. This knowledge and traditional understanding are not sufficient because the agriculture practice is dynamic [44]. The learning through experience sometimes also inadequate and fail to acquire the same results; in the worst scenario, sometimes exacerbate the problems [45, 46]. Moreover, local knowledge might unsuitable for new problems in agriculture. Developing countries are faced with the problem of notable yield gaps, and that is the reason for the dissemination of agricultural information remains relevant [45].

3.3. Challenges in Developing DSS in Agricultural Sector in Indonesia

3.3.1. Requirement of multi-sector collaboration, strong commitment, and support.

The practice of agriculture in Indonesia is not only the domain of the Ministry of Agriculture, which oversees the agriculture and plantation sectors, but also the Ministry of Forestry with its agroforestry. Amid the anthropogenic era, especially those affected by climate change, the challenges are getting bigger. The problems faced by these two institutions that manage the agricultural sector are increasingly burdensome. In addition to these two institutions as implementing research activities, the involvement of the role of experts in the field of information technology (IT) is very crucial. The role of IT is very much needed in developing DSS tools which will later be launched to the public [47].
DSS development takes a long time; all information from research needs to be compiled into a data bank that can be used as a reference by farmers. Until now, the research data bank in Indonesia has not been created. So many research results are underutilized and seem not to be considered necessary. In fact, the results of this study can be used as a reference by farm advisers and field workers in responding to the needs of farmers on how agricultural models are more resistant to pests, more profitable, and in accordance with certain climatic conditions [14]. The creation of DSS is very important for an agrarian country like Indonesia, especially to increase the productivity of land that is increasingly being abandoned and the focus is changing on how to increase farmers' income levels [39]. In the development, DSS should be user-friendly, simple to use, and low cost to attract the farmers to use it [14]. The initiation of making this DSS is somewhat complex and involves a lot of parties. Bureaucratic traditions, tenacity, and commitment can be obstacles in the making of this DSS. DSS, which is actually a form of public service, is not necessarily attractive to policymakers, considering that this is a long-form of work and is far from a political selling point.

3.3.2. Requirement of high-quality disseminations.
The core input in DSS is research results. Moreover, to get a competent and reliable DSS, serious and in-depth research is needed in substance. Research that is not strong will give the wrong direction or be misleading. This will be dangerous and put farmers in a disadvantageous situation if followed. With the DSS, it will require researchers to make experimental designs and research ideas that can be accounted for and able to answer challenges at the farmer level. Thus, this will advance the quality of agricultural research in Indonesia.

However, the quality of research is not only focused on the quality of the researchers but also on non-technical factors such as administrative complexity, which is more difficult than the implementation of the research substance. Researchers and academics have complained about the administrative hassles, especially if the source of funds comes from the state budget. Non-technical factors that are closely related to this bureaucratic tradition are preventing researchers from getting in-depth and robust research results.

In relation to climate change, the Indonesian government is currently boosting the construction of dams. In Indonesia, there is still a lot of rainfall agriculture, which becomes a constraint when the climate becomes unpredictable. With this dam, it is hoped that the water availability factor will not become an obstacle in planting agricultural commodities. Thus, the direction of the research will not depend on the rainy season. Moreover, the existence of this dam will encourage agricultural innovations that are no longer constrained by the presence or absence of rain. This could minimize the effects of irregular rainfall on agriculture practice, which is caused by climate change.

3.3.3. Requirement of technology literate field advisors.
In general, DSS is the use of information through analyzing applications so that users can get the information needed from a data bank. Limited literacy of information technology at the farmer level still occurs in Indonesia. Therefore, it is necessary to maximize the role of the agricultural, plantation, and forestry advisors in disseminating the benefits of this DSS and assisting farmers in solving problems they face or making decisions about their farming businesses. Through DSS, the role of farm advisors will also become legitimate by farmers because they have materials that have been researched and reviewed to be disseminated to farmers. The existence of DSS will also facilitate the work of farm advisors in assisting and providing advice to farmers. The farm advisors who are already technologically literate will also become agents in increasing the technological literacy of the farmers so that they are able to operate the DSS independently. Farmers who are increasingly empowered will improve the quality of agriculture in Indonesia and can increase the prestige of farmers in youth [27]. This will also have an impact on the nation's independence which is getting stronger in the food sector. DSS in the agricultural sector should be started.
4. Conclusion
Indonesia has not developed DSS in agriculture. The DSS progress in Indonesia is still in the long run. As the proper data and information is the key of DSS, it is necessary to make a research roadmap, both in the agricultural, plantation, and forestry sectors, where all research applies high research standards by understanding the current research status. Moreover, it can enrich scientific data and be useful for the DSS database. DSS will be a form of contribution from researchers in providing reliable and updated public information packages for better agricultural management.

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