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Chapter 3
Towards Smart Farming in Indonesia: Issues, Challenges, and Opportunities

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1. Introduction

In this chapter, I would like to share with you some ideas about Smart Farming issues. Like all researchers at present, our work at the Faculty of Agricultural Research in Kyoto has been hindered by the COVID 19 pandemic, especially in relation to our fieldwork, and we are presently seeking ways to conduct smart farming research in Indonesia remotely.

I would like to discuss the issues, challenges and opportunities to work on smarter farming in developing countries, not only Indonesia, but in rural areas in developing countries to be exact. This report is founded on quite a wide interdisciplinary background from engineering, industrial management, and also factory-based manufacturing, holistically from the perspective of a system modeler.

In my research work I take care of all the factors that are related to the focus objective and try to solve related problems dynamically as a whole.

2. General Background

First, I would like to highlight the fragile nature of humankind. We know climate change, rising global population or widening inequality especially economic equality, and recently the global pandemic has brought concern about the fragile future of humankind.

Thus, our fragile future is dependent on all those compounded issues that worsen each other, and are expected to worsen our supporting system also. It's not only about the task of dealing with what is in front of our eyes, but also about what effort we need to make to sustain our future.

Among critical concerns about our future at the local, regional and global level, one of them is food security. Food security, including agriculture as its foundation has become a major issue all over the world. When we talk about climate change, rising global population, widening inequality and global pandemics, the root problem of everything is food security. If we cannot eat, how do we work? How do we move? How do we think? And if we talk about food security, then we talk about agriculture as its foundation. And when we talk about agriculture, we mostly talk about rural areas, because rural areas are the place or the location in which most agricultural activities are conducted.

However, rural areas are experiencing numerous critical sustainability issues. The primary issue is rapid urbanization and the next is the recent trends concerning the shifting interests of the younger generation. In the past, the younger generation in rural areas was expected to carry on doing farming activities. Dr. Iqra Anugrah in his chapter mentioned how they should make a kind of solidarity economy, but then the younger generation's interest is shifting from agriculture to non-primary industries, and this will also lead to further urbanization. This could be physical urbanization, or just conceptual urbanization. That is, they still stay in rural areas, but their minds, their work, and activities are all focused in urban areas. So, they only stay physically in the countryside, but everything they do is for the sake of urban areas.

Another important issue is the aging and declining of rural populations, not only due to urbanization, but also because the average

age, which is higher in rural areas, is compounded by rapid urbanization, and the movement of younger people to the cities. The resulting average age in rural areas will be much higher, and so the population will eventually decrease. It has happened in developed countries already, but we also expect it to happen in developing countries in the near future.

We know that currently almost half of the global population already lives in the worlds large cities and in the next few decades, we expect that to increase to 70% or 80%. However, when we talk about food security, we are largely talking about rural areas. So, how do we feed all those billions of people? If we leave the rural areas and rural agriculture to somehow run themselves that will not be sustainable.

We know that this is inevitable, but we still keep pursuing urbanization and city development. There is nothing wrong with it, but when we do this development we leave rural areas behind, which means that we are cutting the very foundation of city sustainability in the future, which is food security.

So, especially in less developed economies like Indonesia, we expect stronger challenges compared to rural areas in developed economies. This is due to the fact that compared to developing countries, we have a lack of resources and limited knowledge that will compound each other and produce less sustainability, or we could say a weaker foundation for a sustainable future, because of the lack of resources and limited tolerance.

These are the basic facts that we have to deal with and in fact, in developed countries the younger generation accounts for the largest proportion of the population, because life expectancy is much higher than in developing countries. However, the birthrate in developing countries is much higher than in developed countries and because the large corporations employ the younger generations, and they have been shifting their interest to non-primary industries, so we have a much bigger problem than ever.

So we have a workforce, but that workforce does not want to sustain our rural agriculture. And that's a much bigger problem, we have to feed them, but they do not want to produce things that will feed themselves.

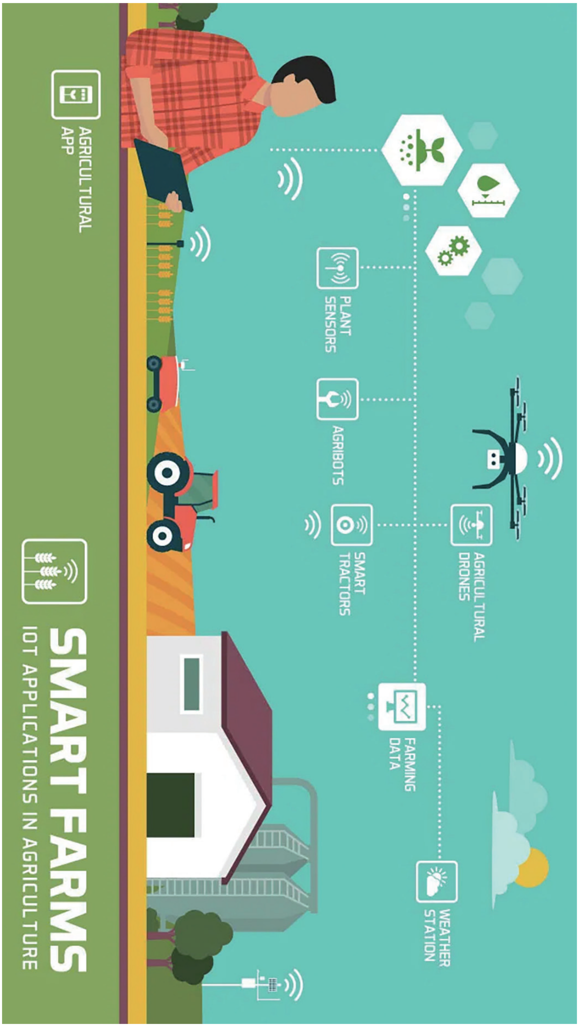

Figure 1. Smart Farms: IOT Applications in Agriculture

Source:
https://www.insidetelecom.com/the-new-frontier-of-smart-farming-powered-by-5g

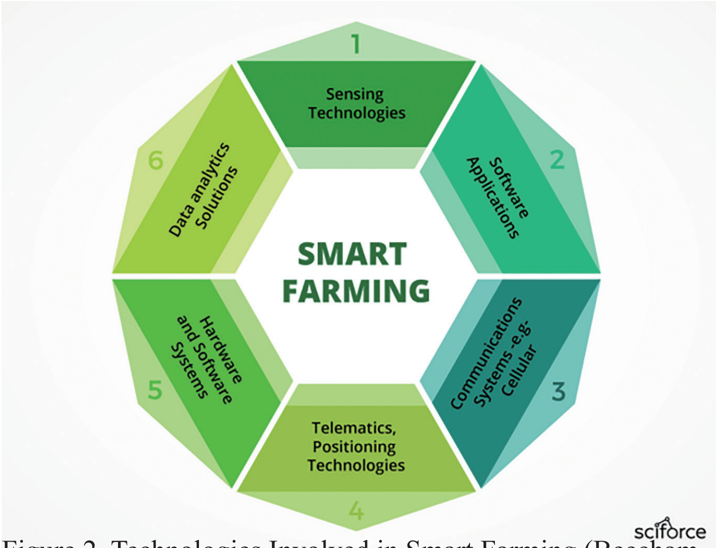

Figure 2. Technologies Involved in Smart Farming (Beecham Research)
Source: https://medium.com/sciforce/smart-farming-or-the-future-of-agriculture-359f0089df69

2. What is Smart Farming?

Recently, Smart Farming, or Digital Agriculture as it is called in the West, has begun to attract attention from the stakeholders of rural agriculture, especially because it requires less labor, is able to do automated scheduling, and can provide us with data-driven decision making, and so on. We expect smart farming to address the low availability of human resources in rural agriculture. We have fewer human resources for rural agriculture but that is when smart farming can address the issue.

Technically speaking, smart farming combines two things. The first is the devices, and the second the brain behind the devices. We call the devices the Internet of Things, or IoT devices, and the brain behind the devices we call data-driven artificial intelligence.

The combination of these two things can take the form of for example, automatic farm machinery for fertilizer, like a fertilizing mechanism that is attached to drones.

In the diagram we can see drones and plant sensors, and there are agricultural robots related to smart tractors that will take care of the lands of the farm and all the data from them is collected and connected to a weather station so that it will provide us with information for when we should plan our rice project.

Consequently, if we want to apply smart farming, there are factors in the agricultural sector that will affect or be affected by smart farming or smart farming systems in general. So, if we want to understand how smart farming will affect or be affected by agricultural sectors, we have to understand the transformation that it will bring. This transformation may go beyond technological development. People tend to think that smart farming is always about technologies, about the technical nature of the IoT devices, etc., but then we have not been able to evaluate the bigger impact of smart farming on the whole society. My point is that it is not about farm or farming activities, but that it can bring transformation to the whole agricultural system and to the whole rural society.

So by understanding this transformation, we can make sure that smart farming will bring a sustainable agriculture and also for example sustainable rural areas.

3. The Perspectives of Understandings

In order to understand the issues, challenges, or opportunities, which affect or are affected by smarter farming in rural agriculture, we need an understanding of systems thinking. Theoretically, systems thinking offers an integrated perspective to understand the complexities of both transformational requirements and the things that will affect smart farming and the impact on things that will be affected by smart farming in every part of rural agriculture and its related systems such as a societal system or an ecological system or an industrial system around the smart farming, all through a holistic lens.

In that sense, the transformation can be observed through two different lenses, the first is systemic and the second is systematic. Systemic transformation refers to changes that happen to almost all components of the observed system and in systemic transformation, we try to understand changes that have happened to all the components. So, we have a rural agricultural system, we have a societal system, we have an ecological system surrounding the smart farming. If we try to understand it systemically it means we have to understand the facts about the whole farming system and other related systems.

Systemic transformations refer to changes that happen to almost all components of the observed systems. Meanwhile, systematic transformations attempt to discover how smart farming brings changes that occur in a staged manner from one factor/actor to other related parts of the system. So if we talk about systemic transformation, we are talking about how those changes happen gradually, step by step, (a) affecting (b) and so on.

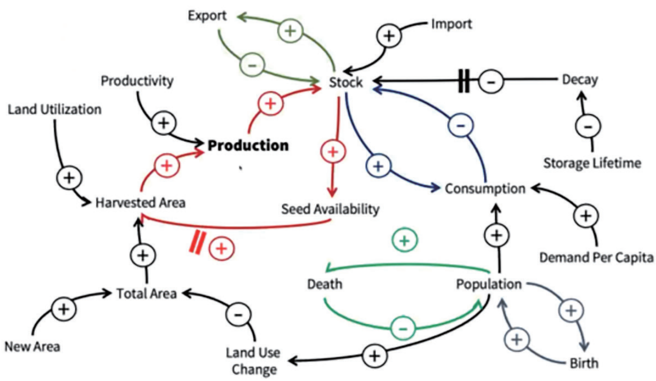

Figure 3. Understanding How an Agricultural System Works
Source: Author

This diagram shows how a production system works. This example is of onion production. If we talk about the production and consumption of onions, we have to include all these things. So the stock will affect exports, the stock will be affected by imports, consumption will affect the stock and so on. In the same way, if we want to talk about smart farming, we have to talk about them all.

So, then, in general, the systemic and systematic transformation to smart farming can occur at three different levels.

1) Routine level. Here we have to focus on scheduled activities like routine farming activities

2) Macro-level. Here, we focus on aggregated structures, what you can call a helicopter view.

3) Micro-level. Here we focus on heterogenous and autonomous actors, on some micro-interaction between actors involved in some smart farming whether they are farmers or non-farmers or the families of the farmers or intermediaries and so on. Then, if we want to observe the impact of smart farming, we have to observe all the those impacts at three different system levels.

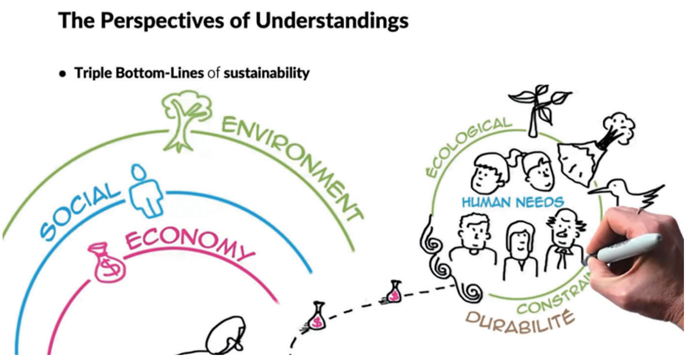

Figure 4. Triple Bottom-Lines of Sustainability
Source: https://www.lshtm.ac.uk/aboutus/introducing/environmental-sustainability/sustainability-resource-centre

In addition, the systemic and systematic transformations due to smart farming should be approached from the triple bottom-lines of sustainable development (economic, environmental, social). It is purposed to ensure the correct perspectives of those transformations in the fields.

4. Issues, Challenges, and Opportunities

Looking at the perspectives above, probable transformations triggered by or affecting smart farming implementation in rural areas in less developed countries are provided in Table 1.

System transformations affecting and affected by smart farming implementation can be divided into three categories.

Table 1.

Systems Level	**Transformations**		
	Economic [E]	Environmental [V]	Social [S]
Routine [A]	[1] Investments for smart farming devices [2] Internet connection costs [3] Fuel costs of devices [4] Labor costs [5] Utility costs [6] Irrigation maintenance costs [7] Transportation costs for harvested products [8] Building maintenance costs [9] Transportation maintenance costs [10] Maintenance costs of devices	[1] Emissions emitted by smart farming devices [2] Emissions emitted by internet infrastructures [3] Emissions emitted by transportations [4] Weather forecasts [5] Animal disruptions [6] Fertilization	[1] Labor forces [2] Community meetings

Macro [B]	[1] Investments for recharging facilities [2] Investments for adequate internet infrastructure [3] Investment for faster postharvest processing [4] Investment for adequate storage volume [5] Aggregated loans required [6] Liquid savings [7] Running costs of smart farming devices [8] Return-of-Investment of smart farming devices [9] Value depreciations of smart farming devices	[1] Emission per mass of products [2] Projected land abandonments [3] Climate models [4] Risks of natural hazards [5] Water control [6] Plot productivity (yield)	[1] Projected immigration [2] Projected emigration [3] Effects of urbanization [4] Projected birth [5] Projected deaths [6] Regional demands of products [7] Demands for exogenous experts [8] Media exposure [9] Disaster recovery plan [10] Community education
Micro [C]	[1] Negotiation for financing schemes [2] Pricing mechanism [3] Cooperative investment of smart farming devices [4] Price sharing between farmers [5] Financial incentives from authorities [6] Loan payment	[1] Farm extensification [2] Weather models [3] Emissions emitted by transportations for community meetings [4] Harvest failures [5] Plot irrigation [6] Soil nutrition	[1] Projected numbers of active farmers [2] Cooperative usages of smart farming devices [3] Labor demands [4] Local demands of products [5] Cooperative water arrangements [6] Indigenous agents-of-change [7] Exogenous experts [8] Disaster response training

Source: Sianipar, 2021

1. Economic Transformations

Looking at the probable economic transformations at three system levels, the biggest expected challenges for rural farmers in less developed countries are the large investments required for providing smart-farming devices. As a large-scale technological investment, smart farming requires a cautious calculation of financial risks for smaller-scale farmers. In that sense, there are opportunities to negotiate more flexible financing schemes, or collaborative investment in smart farming devices to reduce risks for individual farmers. Besides, meeting the running costs of sophisticated smart farming systems would expectedly bring additional challenges to farmers' financial situation such as avoiding any default in loan payments. Therefore, shared uses of the devices can be an alternative way to reduce the running costs, and eventually the maintenance costs.

For example, today smart devices will be used by farmer A and the next day by farmer B and so on. Then the investment or the running costs can be spread. It can be shaped by them and we can relate to what Dr. Iqra Anugrah mentioned in the first chapter about sustaining all the activity going on in rural areas by doing it collectively. Shared use will also lead to reducing maintenance costs for individual farmers, so then we go to environmental transformation.

2. Environmental Transformations

Furthermore, environmental transformations at routine, macro, and micro levels are expected to bring different dimensions to smart farming implementation. Basically, the primary concern is the added emissions produced by smart farming devices, including those emitted by faster postharvest processing and larger volumes of products being processed. So it is not only about how we can buy the devices or how we can repay the loan but we have to deal also with emissions. In fact, the shared uses suggested above may also be useful in reducing prorated emissions per mass of agricultural products being traded.

Nevertheless, besides the immediate emissions from the devices, we must consider the things that are taken care of by the device, for example, fertilization. We know that smart farming can work much faster, and much more precisely, that is why we sometimes call it precision agriculture, but then it will require more inputs such as fertilizers.

However, more intensive fertilization will add another form of environmental impact, which requires an expanded life-cycle assessment of the smart farming systems. In fact, farm extensification may help in offsetting the emissions by producing better yields per farm plot.

Moreover, land abandonments due to existing labor problems before smart farming implementation will be another issue to address. Land abandonment may occur because of the aging and declining population before smart farming was introduced. So, when we apply smart farming we have to deal with those abandoned lands and make them active farm plots. Smart farming may also reduce the abandonments due to its capability to work on a larger size of lands compared to conventional (non-smart) machineries and manual labor.

Then, hazard risks due to animal disruptions, weather conditions, and/or reduced water levels can possibly be overcome by applying more sensors that can be integrated into the farm-wide smart farming systems.

3. Social Transformations

Social transformations at the three system levels will deliver additional understanding of the larger impacts of smart farming implementation to the whole rural society and beyond. At the routine level, the full/semi-automated principles of smart farming are expected to reduce the daily labor forces required to run rural agriculture.

In addition, there should be more active community meetings to ensure the smooth running of the smart farming systems between farmers and plots. Those meetings should, for example, establish an agreement on the arrangement of the routing of the devices to avoid any accidents. Farmers need to hold meetings to establish agreement on the arrangement of device routes, where to store the devices in a centralized position, a schedule for use by the farmers and also the routes taken by those devices. They need to be moved from the storage to the farm, but this will use for example, public roads. So, by using a range of scheduled routing, it means we can avoid accidents for example, because sometimes things that we call ‘smart’ are not so smart, some accidents may still happen, and by thinking ahead we can help to prevent them.

As another example, the community meetings can decide the arrangements for the shared uses of smart farming devices and irrigation systems. Besides, the rural population is expected to affect and be affected by smart farming systems due to the significantly reduced labor demands but also lesser increases in demand for highly-skilled operators.

In such a situation, younger generations can be attracted to be the high-skilled operators since they have been growing in today’s information era. If urbanization virtually diminishes the chances of recruiting local young people, exogenous experts can be introduced.

It follows that all the above-mentioned opportunities to install more sensors for hazards, animals, weather, water, etc., will require proper planning, training, and education for local people to build their capacities in responding to the outputs of the sensors and develop data-driven decisions based on the information gathered.

5. Implications and Insights

This brief description of my division’s research has attempted to raise issues, challenges, and opportunities that are expected to affect or be affected by the application of smart farming systems. By considering these transformations, we can make a summary of the implications. If we try to implement smart farming in rural areas in less developed countries, we can divide the implications into two types; two managerial implications and four policy implications.

1. Managerial Implications

In terms of managerial implications, smart farming requires transformed farm management that can apply more data-driven decision-making processes. In other words data-driven management that will make use of big data obtained through smart farming sensors or devices. So, by doing data preparation and management, we can precisely analyze what we should do. That's the first managerial implication.

The second managerial implication is more active community meetings to establish the proper arrangements for smart farming systems that involve multiple farmers working together and also dealing with the impacts on public facilities such as increased road use and noise levels.

2. Policy Implications

On the other hand, smart farming brings more cautious policy implications to ensure smooth investment, running, and maintenance of smart farming systems. In terms of policy implications, we can consider the basic financial incentive, but it's not only about financial incentives. Other policies may go beyond financial incentives for those issues.

We know that smart farming will help us to produce better yields, but then, where should we sell the excess production? So, we have to search for new markets. Here, for example, the government may take care of the searches for additional markets to cope with increased yields due to faster and larger processing scales of smart farming. In this way the government may act as an intermediary to access those human assets.

The third policy implication is about knowledge transfer. We have to make sure that smart farming will not leave local people behind. So we have to make sure that local people can take care of at least the basics of the new smart farming system. Policies may also cover training and education for local people to catch up with technological advances brought by smart farming, with the possible introduction of exogenous experts to pass on the necessary knowledge.

Then the last policy implication is offering an incentive for younger people. We know that younger people have more capabilities in related works or IP-related control or operation. If we can promote incentives for the younger generation to get involved as highly skilled operators and decision-makers, then we can create an incentive for them to stay in the villages in rural areas to take care of smart farming. In this way they can fulfill their capabilities or capacities in highly-skilled operations or jobs, but they are still supporting rural agriculture.

In this chapter I have attempted to instill the understanding that if we talk about technology, we do not only talk about the technology by itself, but also about things that will affect the implementation of that technology and be affected by the implementation of the technology. For smart technology to be used not just for profit, but as Dr. Fitrio Ashardiono insisted in his editorial, for the sustainability of agriculture and rural life, it must be introduced in close collaboration and cooperation with the rural society, with a focus on the younger generation.

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Chapter 3: Towards Smart Farming in Indonesia: Issues, Challenges, and Opportunities

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