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学位論文全文に代わる要約
Extended Summary in Lieu of Dissertation

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学位論文題目：
Title of Dissertation

An Analysis of Climate Change Adaptation through Sago Palm Development in South Sulawesi, Indonesia: Policies, Strategies and Challenges
(気候変動が社会経済にもたらす影響および対応策の分析～インドネシア南スラウェシのサゴヤシ開発を事例として～)

学位論文要約：
Dissertation Summary

Over the long-term, global climate change is projected to have negative impacts on agricultural productivity in Indonesia. Assuring food security in Indonesia is a fundamental challenge that the government and community face. Recent analyses indicate that some successes have been achieved, but food insecurity gaps still exist, with implications for more concerted investments in local food resources to achieve better results. Indonesia has a great potential food supply from a local resource that is more tolerant of variable climate change such as sago palm (Bantacut, 2014; Girsang, 2014) and tubers. Haryadi (2013) argued that supporting local food is an important means of improving food independence within the framework of the Indonesian food security system and the stated commitment from government to increase national food security through local resources (Figure 1). Therefore, the local government has the authority to identify potential local food and strengthen their food security with political support from the national government.

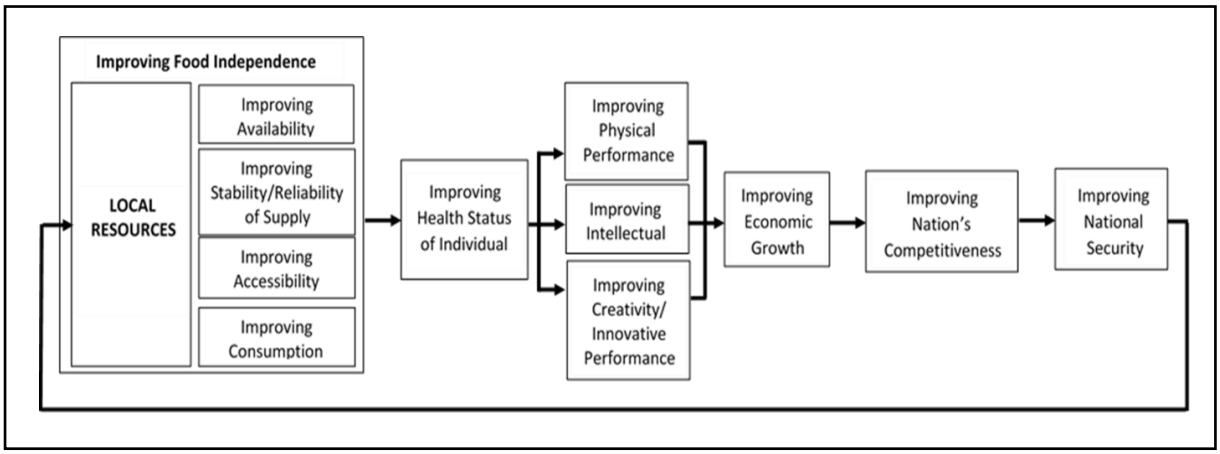

Figure 1 Framework of national food security through indigenous food diversification

This study focuses on sago palm as an alternative for local food adaptation in Indonesia. *Metroxylon sagu*, known widely as sago, is a tropical crop containing a large amount of starch in its trunk with average productivity four times that of paddy rice (Ishizuka *et al*., 1995). Sago palm has been recognized as one of the oldest plants consumed by human beings (Ave, 1977). It is a potentially beneficial alternative crop because its production is not significantly influenced by climate (Bantacut, 2014). It can play an important role in promoting food security because it contains carbohydrates in a higher proportion than rice; 84.7 gram carbohydrate per 100 gram for sago starch compared to 80.0 gram carbohydrate per 100 gram for rice (Ministry of Health, 1979). It also produces four times more starch as rice (100-200 kilograms per palm), which is enough to feed a family for one month (Loreto *et al*., 2004). Sago palm is also excellent for greenbelt vegetation and acts as an effective means to sequester carbon thus potentially helping to mitigate climate change (Osozawa, 1998). Compared with paddy fields, sago palm is environmentally friendly because it conserves soil and water, acts as a buffer zone for flood and sea water intrusion, and stands of sago have the capability of self-regeneration (Flach, 1983). In addition to being tolerant of tropical acidic soil and preventing soil erosion via a root system which can trap silt, it also has the ability to endure intense insolation, typhoon strength winds, drought, and prolonged flooding (World Food Programme, 2015). A case study conducted in the Philippines showed that sago palm experienced limited damage, only 12% from the Haiyan typhoon in 2013 (Nishiyama *et al*., 2014). Therefore, sago palm could contribute to Indonesia's food security, particularly when agriculture comes under increasing pressure from changing climate patterns.

This study examines the status, challenges and motivating factors to promote sago palm for climate change adaptation at the national and local level in Indonesia through the action research approach. Even though many researchers have worked on the physiology and utilization of sago, very few researchers have investigated the possibility of sago palm cultivation as a climate change adaptation tool. Furthermore, a farmers' willingness to plant sago palm and the determinant factors influencing a farmers' adoption behavior to promote sago palm cultivation are also examined to give a comprehensive view on sago palm development in Indonesia.

Sago has a very long historical record as a food in Indonesia. It has been consumed as a traditional staple food and it was an important commodity in the past. It was first mentioned in European texts in the 13th century by Marco Polo as one of the typical foods in Western Sumatera (Polo, 1930) and later it was again described three centuries later along with millet and rice as a common food in Sumatera (Ruddle *et al*., 1978). Wallace (1869) also mentioned that sago was one of the small tributes for the Sultan of Tidore during the 18th century, demonstrating that sago was an important commodity in the past. However, nowadays, sago has been replaced with the cultivation of rice and other crops. The shifting social culture aspects of sago cultivation are particularly

influenced by political power. This occurs because the food is a vehicle for provoking change in policy areas based on political economy and interest groups (Reynolds, 2010). The domination of Javanese political power in the centralized Indonesian political system emphasized rice production as the main part of national food security. Java is well documented as being the primary rice producer; 61.1% in 1955, 57.8% in 1960 and 55.3% in 1970 (Afiff & Timmer, 1971). The combination of the rice revolution in the 1960s-1980s, the national transmigration program in the 1990s, the "rice for the poor" program in the 2000s, and the paddy pledge program in 2015 caused a great deal of change in Indonesian food habits and created the impression that sago was a food type associated with the poor as eating rice is a kind of status symbol, while sago was associated with poverty.

Table 1 summarizes the SWOT analysis of sago development at the national level. This study also showed that sago palm has a great potential for supporting economic and food security, but it has not yet been chosen as a priority crop at the national level. Sago exports only amounted to 196,000 US dollars in 2013, far below other crops such as palm oil (17.7 billion US dollars), rubber (6.9 billion US dollars), coffee (1.17 billion US dollars) and cacao (1.51 billion US dollars). Furthermore, the national sago palm program was only 420 thousand US dollars or 0.05% of the total state budget of the Ministry of Agriculture during 2012-2014, a relatively small amount compared with expenditures promoting and developing other annual crops.

Table 1. SWOT analysis

Strengths	**Weaknesses**
Comparative advantage as a staple food and the production is not significantly influenced by climate.	Sago palm has a long life cycle and takes 8-10 years to harvest; longer than other crops.
Supports local economies by providing jobs and income.	Traditional approach of farming with lack of information to develop best practice and limited capacity to create plantations.
Existence of sago-based culture in the local area.	Inferior production methods leading to low quality product.
Favorable weather and land conditions for sago production.	Lack of support for sago as a crop with minimum financial system and promotion for the sago industry.
Opportunities	**Threats**
Increased sago production and area.	High competition between other crops such as palm oil, cassava, rubber, corn and sweet potato.
Increased health benefits of sago palm among customers.	International market demand is vulnerable due to potential economic crisis
Sago advanced industry development.	Lack of mainstream recognition of sago palm into climate change adaptation programs.
Market expansion opportunities.	

According to historical analysis of policy framework, the Indonesian government recognized that climate change was a trigger of "developing food security crisis" and issued Law 18/2012, National Action for Climate Change Adaptation (RAN-API) in 2014, and Government Regulation 17/2015 to tackle the situation. Therefore, promoting sago palm as a strategy to adapt to climate change appears also to be a good option for the purpose of food security, despite there being no specific sago development policy aimed at cultivating and developing it into a main food resource and industry. Sago palm is specifically mentioned only in two regulations; Ministerial Regulation P.19/2009 for exploring sago palm as a non-timber forest product and Ministerial Regulation 43/2009 for the acceleration of the diversification program based on local resources to support 36 agricultural commodities including sago palm. Despite having been created, those policies lack clarity and are sometimes hindered by a lack of political will and face difficulty in coordinating institutions and interested stakeholders. Minimum interest in local food adaptation approaches (i.e. sago palm) that can create climate-resilient agricultural may contribute to national insecurity. Therefore, the national government has a significant responsibility in changing the perception of sago, actively integrating sago palm into a climate change adaptation framework as well as promoting sago cultivation by allocating subsidies and financial institutions.

An appreciation of local tradition and cultural practices associated with sago cultivation as a part of climate change adaptation is still an unfamiliar approach for Indonesia. Therefore, for further investigation 3 Regencies; Luwu Utara, Palopo, and Luwu of South Sulawesi Province were examined to provide a better understanding of the current state of the sago palm as a local resource, as well as demonstrating the value of it in the context of local climate change adaptation. The Analytic Hierarchy Process (AHP) was used to investigate the level of priority of local government to support sustainable development and adaptation to climate change at the local level. Based on the weights of the criteria at this level, Knowledge Management and Capacity Building (KMCB) was ranked as the highest criteria followed by Economic Resilience (ER) and Ecosystem Resilience (ECR). These three criteria accounted for 70.4% of the overall weights being compared. In contrast, the lowest criteria were Monitoring and Evaluation (ME), Planning and Budgeting (PB), Infrastructure Protection (IP) and Health and Settlement (HS). The λ max was 7.738 and the IR value was 0.093 which satisfied the 0.10 threshold (Table 2). Positive correlations have been found with criteria such as education level, experiences of past conditions, social customs (De Wit, 2006; Leith & Haward, 2010) and environmental interaction (Fatorić & Morén-Alegret, 2013) which evolve different adaptation strategies that may be necessary for responding to climate change. Thus, this result also supports the Institutional Analysis and Development (IAD) framework of Bisaro & Hinkel (2016), who mentioned that adaptation action is characterized by biophysical conditions,

community attributes and institutions (Figure 2). In brief, considering that significant resources are allocated for emergency and reconstruction activities, conserving sago as part of a climate change adaptation policy could be a cheaper option because it is already a part of community life.

Table 2. Ranking of various criteria of sustainable adaptive development to climate change at the local level

Rank	Criteria	Weight
1	KMBC	0.327
2	ER	0.218
3	ECR	0.158
4	HS	0.115
5	IP	0.084
6	PB	0.056
7	ME	0.041
$\lambda max = 7.738$	IR = 0.093	

In the three regencies investigated, sago palm still plays an important role in providing income and food for the local community. However, a drastic change has happened due to the expansion of other profitable crops during late 1990s-2000s. Sago production has also decreased significantly by 87% from 2006 to 2013. Several local actions have been attempted to revive sago palm, for example through the “Gerakan Ayo Tanam Sagu” or “Let`s Plant Sago” and sago palm community service programs by Ehime University (Japan) in collaboration with Hasanuddin University (Indonesia), however, these actions were not sustainable as they were independent actions without adequate support from local government. Therefore, a small sago palm development initiative called The Sago Palm Restoration Project by Ehime University was implemented through a triple helix (University-Industry-Government) collaboration. This project was funded by the Japanese Ministry of Education, Culture, Sport, Science and Technology with a total budget of 14.3 million Yen (126,400 US Dollar). So far, gaining the support of local government for sago palm can be seen as one of the positive outcomes. The local government included sago palm into the Regional Medium-Term Development Plan (RPJMD) 2016-2020 as an alternative crop to help adapt to climate change. They are also drafting a local regulation (PERDA) regarding the protection of existing sago palm stands. Until now, there was no institution in the 3 regencies with the capacity to estimate the possible impact of climate change and therefore no specific policies that support climate resilient

livelihoods have been proposed. However, the enthusiasm to support sago palm for sustainable and climate-friendly development is also an encouraging step. Indeed, a strong commitment by local government is essential for policies promoting sago palm to remain competitive with other policy directives in a comprehensive view on sustainable development.

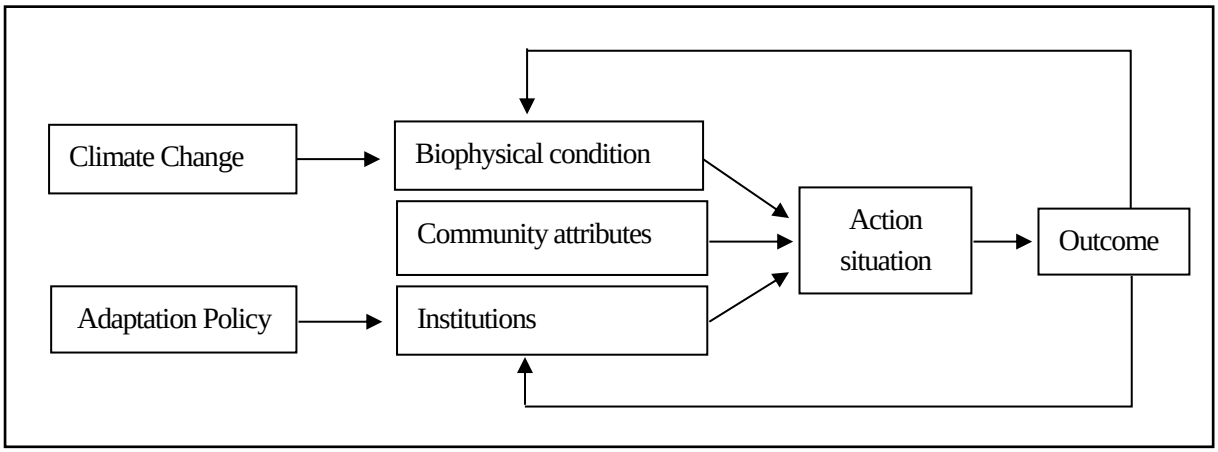

Figure 2 A framework for adaptive governance analysis

One critical aspect of developing sago palm cultivation is the smallholder; hence, the determinant factors influencing farmers' adoption behavior to promote sago palm cultivation need to be explored. Sago farmers, especially in South Sulawesi, are still using conventional practices in sago processing and do not know how to cultivate sago palm efficiently. The transformation of sago starch extraction by smallholders started before the 1970s. At that time, local people extracted sago for their self-consumption using manual tools. By the end of the 1970s, a rasping machine with diesel power had been introduced to extract sago. Between 1980s-1990s, water pumping was adopted for the washing process to get better starch. In 2012, a locally developed rasping machine using a washing process with a better pump and mechanical squeezing had been introduced improving the efficiency of starch extraction. Nowadays, sago smallholders are categorized into 3 types based on technology adoption: (1) technology transition between traditional to small-scale, (2) small-scale technology and (3) semi-mechanized technology.

The result of this investigation shows that (1) knowledge of an integrated cultivation system of sago, (2) access to information and training, and (3) internal motivation, followed by (4) work experience and (5) size of the sago area are the most important factors influencing farmers' willingness to plant sago palm (Table 3). This result can be used to promote sago cultivation in Indonesia. Furthermore, this study also found that technology,

information, and market access issues limit the development of sago palm cultivation by smallholders, in addition to the application limit set by the government. Indeed, the cultivation of sago palm cannot be accomplished by one person alone. Success requires active participation by the government, industry, academia, and farmers.

Table 3. Results of logit regression model

Variables	***β***	**S.E**	**Sig.**	***Exp(β)***
AGE	-1.109	0.880	0.208	0.330
WE	2.596	1.439	0.071*	13.415
SA	3.890	1.430	0.007***	48.898
EO	0.352	1.162	0.762	1.421
HE	1.462	1.608	0.363	4.313
KNO	5.464	1.639	0.001***	236.078
IT	-4.055	1.724	0.019**	0.017
IM	3.527	1.841	0.055*	34.039
EM	1.266	2.413	0.600	3.548
Constant	-8.447	3.223	0.009***	0.000
L_0 = -2 Log likelihood (initial)		122.603		
L_1 = -2 Log likelihood (final)		44.214		
Cox and Snell R-Squared		0.510		
Nagelkerke R-Squared		0.758		
Hosmer and Lemeshow Test		0.978		

*Significant at 10%, **Significant at 5%, ***Significant at 1%

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