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論文内容の要旨

This thesis comes from the concern about food security in Indonesia under the impacts of climate variability and change. Indonesia is the world's fourth populous country, with more than 17,000 islands. The present study targets rice, the staple food of most of her population, and focuses on its availability, in particular production and distribution. The thesis starts with an overview of the following issues: (1) the historical and current socio-economic problems concerning rice production and distribution, (2) the observed and projected climate variability and change, (3) the way how the climate impacts exacerbate the exiting socio-economic problems concerning rice production and distribution, and (4) the recent policy responses of the Indonesian government.

With the above background, the present study has three research components. Firstly, it is aimed to understand the change in rice production and land use in North Sumatra and examine the combination of climate and socio-economic factors that have contributed to the land use conversion from rice production to oil palm plantation. It also identifies types of farmers' responses, and the variables that differentiate them. As publicly available data is limited, interviews with government officials and farmers, as well as focused group meetings with relevant agencies are conducted to identify the causes of changes in land use. North Sumatra is selected as the target area of this study because it is a significant producer of both rice and palm oil, where the competition for land use is fierce. The present study identifies four factors as affecting the change in land use: (1) climate conditions, (2) economic environment, (3) rice planting index, and (4) distance from palm oil enterprise estates. When unusual climate conditions were observed across North Sumatra such as in 2006, the rice harvest area substantially decreased. Economic conditions, most notably the price difference between oil

palm and rice, which incentivized land use conversion, also existed in common across the province. However, the remaining two factors: rice planting index and the proximity to palm oil mills; varied across regencies, which differentiated the rice farmers' response.

Secondly, the present study analyzes adaptive responses of rice distribution between Surabaya and Kupang, the provincial capitals of East Java and East Nusa Tenggara (*Nusa Tenggara Timur*, NTT) respectively. To this end, monthly inflation rates of food over the last ten years are analyzed between them. Price data is used as indicators of the adaptive responses on the premise that the market, if well integrated, should be able to adapt by providing price signals to direct flows of rice from surplus to deficit areas. Persistent price differences between locations imply weak supply responses to higher prices. The above two provinces are chosen as target sites since East Java has a surplus of rice while NTT has a chronic deficit, and the rice markets in the two provinces are one of the most strongly integrated pairs in the country. This study finds that the inflation rates are consistently higher in Kupang than Surabaya in January, the lean season in NTT, indicating seasonally weakening supply response to higher prices. The above findings suggest that, when and where seasonal factors are strong, government intervention for rice price stabilization, if it is centrally operated, is less effective. Instead, a more seasonally and geographically targeted intervention becomes necessary to mitigate climate impacts on rice distribution.

Thirdly, the present study aims to evaluate the pilot implementation of indemnity insurance for rice farmers in East Java, and assess the feasibility and scalability of weather index insurance if it would be applied in the same context. The potential problem of adverse selection is considered using historical data of monthly rice harvest failures at the pilot regencies. The feasibility of weather index insurance is considered on scatter plots between the historical data on rainfall and rice harvest failure by month at the pilot regencies. Locally observed rainfall data is used for this study, since this is the parameter on which weather index insurance is most frequently based. The issue of scalability of index insurance is considered on correlation coefficients of rainfall and rice harvest failures by month across all the regencies in the province. East Java is selected as a target province under the study because this is the place where the pilot insurance is actually conducted by the government. It finds that the pilot indemnity insurance is costly. Replacing it with weather index insurance, however, would bring about the problem of a basis risk. This problem is significant in the river basin, where floods are not only due to a particular weather parameter, on which index would be based, but also resulting from an interaction of multiple factors. This study also finds that, in the case of East Java, rice harvest failure is more area dependent than rainfall is, suggesting that a basis risk would potentially increase as the insured area geographically expands.

The above findings have important policy implications. The literature cautions that whether or not adaptation is successful is often dependent on scale (Adger *et al.*, 2005; Adger and Vincent, 2005; Osbahr *et al.*, 2010; Vincent *et al.*, 2013). In case of farmers, for example, who convert their land use from rice production to oil palm plantation, for them it may be considered as a good adaptation, as oil palm is more resilient to rainfall variability. The large scale of the conversions, however, is a threat to the food security of the society as a whole. Along with exhibiting a spatial dimension, adaptation also has a temporal dimension. In case of crop insurance, when farmers purchase insurance, they transfer production risk to the insurer. However, the risk transfer by itself does not address the underlying problems of climate and socio-economic impacts on rice production (Skees *et al.*, 2008). Unless these problems are addressed by other adaptation measures, the risks may become hardly insurable, and in the long run the insurance market may cease to function as the price asked by insurance companies becomes much higher than the price farmers are willing to pay (Charpentier, 2008).

The above observation indicates that the government countermeasures may face trade-offs between adaptation actions and other development priorities over different spatial and temporal dimensions. It presents the importance of evaluating the adaptation actions from other spatial and temporal scales to identify potential trade-offs and examine the sustainability of the proposed actions. This also underlines the importance of designing a coherent set of structural and non-structural response measures in consideration of the interaction of climate and socio-economic impacts.

This study also reveals the necessity for further research on the policy, institutional mechanisms and procedures for resolving the trade-offs between various adaptation measures, and between adaptation and other development priorities. In this context, criteria and indicators for assessing and prioritizing these trade-offs need to be developed.

論文審査の結果の要旨

インドネシアでは米が主食であるにもかかわらず慢性的に輸入が必要な状態になっており、食料安全保障のためにその確保を図る必要がある。そのため、本論文は、3つの視点から、インドネシアにおける米の生産・流通に対する気候及び社会・経済環境の影響とその対応策に関する評価を行ったものである。

第一に、米とパーム油双方の有力な生産地である北スマトラ州を対象にして、米作からアブラヤシ農園への土地利用変化とその要因を検討した。政府機関や農家との面接調査や統計データ等による多角的な分析により、土地利用変化には、①気候、②経済要因、③年間の米収穫回数、④パーム油製造所からの距離の4つの要因があること、このうち③と④の要因によって農民の対応に差が生じることを明らかにした。第二に、米の流通市場において気候及び経済影響に対する自律的な適応機能が存在するとした既往の研究に対して、米の供給元である東ジャワ州と受け手の東ヌサ・トゥンガラ州の間の流通を対象に、その妥当性を考察した。その結果、季節的な要因が強く働く状況の下で、政府の市場介入が一律的に実施された場合、その効果は限定的になる可能性があり、季節的・地域的な特性を十分に踏まえた介入の必要性を示唆する結論を得た。第三に、東ジャワ州の米農家を対象にパイロット実施された実損補填保険の結果を評価するとともに、天候インデックス保険導入の可能性を考察した。州内の県別に見た米の不作面積及び降雨量のデータを相関分析した結果、実損補填保険はコスト面で問題がある一方で、天候インデックス型に代替した場合にもリスクが生じることを明らかにし、保険のみでなく基盤整備を含む総合的な対策の必要性を指摘した。

本研究により明らかになった以上の点は、政策面での重要な示唆を与える。パームヤシへの土地利用転換は農家にとって望ましい適応と考えられるが、社会全体の視点から見れば食料安全保障への脅威となりうる。また、保険は、短期的に見ればリスクを保険業者に転嫁することができる一方、米生産への気候及び経済・社会影響に関する根本的な問題解決に取り組んだことにはならず、実体的適応策を行わない限り、長期的には、リスクの増大に伴って当該リスクがもはや保険の対象となり得なくなる恐れがある。以上のように、適応策相互、及び適応策と他の開発優先事項の間でトレードオフが生じる可能性を示した。このことから、適応策を複数の視点から評価し、トレードオフの可能性及び当該対策の持続可能性を検討することの重要性、さらにはインフラ施設及び非施設的な対応の双方から成る一貫性のある対策立案が必要であることも示した。

気候変動の影響は社会・経済的な要因との相互作用によって決まるため、適応策の設計にはこうした条件の考慮が不可欠であるが、この点に関する開発途上国における実証的な研究は極めて限られていた。本研究では、インドネシアにおける米の生産と流通への影響について現場のデータに基づいて実証的な研究を行い、それによって、米の生産・流通と気候、経済要因、米の生産性等の間に密接な関係があることを見いだした。さらに、適応策の一環として作物転換や農業保険などの検討を行い、その効果と限界やハード対策とソフト対策の融合の必要性を明らかにするといった新規性と有用性が高い知見を得た。インドネシアの米作は国の重要な政策分野であり、本研究の成果は今後の米作に関わる総合的な政策に対して重要な知見を提供するものであると判断される。以上を総合して、本論文は博士（工学）の学位論文として合格であると判定する。