Form 3

Abstract of Thesis

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Title	Environmental Evaluation of Agro-Product Supply Chain: Indonesian Palm Oil and Japanese Green Tea Case Studies (農産物サプライチェインの環境評価:インドネシアのパーム油と日本の緑茶を例にして)

Abstract of Thesis

The growing global demand for agricultural product has driven the increasing production by exploring natural ecosystem and using agricultural chemicals. On the other hand, the demand itself creates economic opportunities. Therefore, the environmental evaluation of agricultural product by considering supply and demand is necessary. The general objective of this PhD thesis is to develop a dynamic supply-demand model to analyze potential environmental impacts resulting from the agriculture sector, using two case studies of the Indonesian palm oil (IPO) and the Japanese green tea (JGT). Palm oil is a representation of agricultural product that exploring natural ecosystem to meet the growing demand. While, Green tea is for using the pesticides to meet the growing demand. More specifically, the following descriptions are the stages of study to meet the general objective.

Chapter 2 analyzes the moratorium policy (MP) on new concessions for use of forest and peatland areas under reducing emissions from deforestation and forest degradation (REDD-plus) cooperation in Indonesia by focusing on one economic sector that relies on forest conversion and use for its business activities. The developed model is used to clarify the impact of MP on the environment and the economy of Indonesia using a case study of the palm oil industry sector. A scenario-based approach is conducted to extrapolate two basic scenarios of with and without the MP. Three scenarios describing the implications of the moratorium policy were examined in this study. The model has demonstrated that the MP helps to reduce CO2 emissions from deforestation. However, the reduction is temporary or only to halt temporary environmental degradation. The environmental degradation may arise again to the next period after the MP finished. On the other hand, the IPO industry will experience a breakdown effect in the palm oil production capacity. In addition, the breakdown effect last sufficiently long compared to the period of the MP, within a minimum of 10.5 years. This depicts the Indonesia should be prepared to weather the economic slowdown as the result of MP implementation since many economic sectors in Indonesia that rely on the forest.

Chapter 3 clarifies and estimates the historical environmental loads generated by each production supply chain of the IPO industry. In particular, significant focus is placed on Greenhouse Gas (GHG) emissions during the period 2004-2014. The model focused on estimated GHG emissions derived from land use changes and energy use based on fossil fuel and waste utilization. Based on the practical application of the model, the IPO industrial sector generated net GHG emissions of approximately 0.868 Tg CO2eq per year during the period 2004-2014. The model demonstrated that plantation production chains also serve as an important source of carbon sequestration for the palm oil industry. Until 2014, carbon sequestration in the production chain contributed to reduce the Global warming potential (GWP) by nearly one-third based on total GHG emissions as a result of the IPO industry activities. Therefore, the GHG intensity of palm oil actually decreased over time. Furthermore, we found that the GHG emissions from fossil fuel-based energy are lower than the waste fuel-based energy within the production supply chain boundary. The cumulative difference was approximately 15×10-3 Tg CO2eq for one decade.

Chapter 4 continues developing the model for assessing other agricultural products and environmental issues. The developed model is used to clarify and estimate the exposure pathways of pesticides on tea plantations using a case study of Shizuoka Prefecture, Japan, and an improvement to the Japanese good agricultural practice (GAP) is proposed. Although JGT is well known product but it cannot enter some countries due to the MRL values of some pesticides are still higher than the Codex Alimentarius Commission (CAC) or

European Union (EU). Despite the studies to quantify and determine the pesticide residue and maximum residue limits (MRL) values for tea are generally performed through supervised field trial, this study use modeling for the estimation. Two pesticides, Azoxystrobin and Clothianidin, were analyzed using the model for a given set of circumstances. The results indicate that the implementation of a fixed preharvest interval (PHI) time, which is a crucial provision in the GAP, is not appropriate. The reason for this is that the dissipation rates of pesticides in tea leaves vary with the timing of the pesticide application and are influenced by factors specific to the plantation area. The dissipation rates are 1.5-3.9 days for Azoxystrobin and 3.8-9.5 days for Clothianidin. This study also clarifies that incorporating plantation-area-specific factors, such as temperature, in the GAP guidelines are essential to ensure that pesticide residues are lower than the desired level. Furthermore, to produce good-quality and safe green tea, the GAP should provide detailed and precise guidelines for the timing of pesticide application and formulation of the dosage treatment. These guidelines should be determined by considering specific provisions for the harvest times of fresh tea leaves.

Chapter 5 conducts a preliminary comparative study on the environmental load between IPO and JGT in order to investigate the key environmental issue in both agricultural products that probably have a significant impact on human health. Although IPO and JGT have different key environmental issues, both issues culminate on human health and eventually have fallen as global trade barriers. Land use change (LUC; i.e., forest conversion) associated with the GHG emissions has served as a key issue for the IPO. Total disability adjusted life year (DALY) resulted from the GHG emissions of LUC and energy use in whole production supply chain of palm oil industry in Indonesia is about 6418310 DALYs. Instead of LUC, the important issue in JGT is more to the pesticide residue in its final product that is measured by MRL value, which it is not a concern yet in the palm oil. Although MRL for pesticide residue are not measuring the level of toxicity, it is crucial to make sure that the pesticides are applied according to the GAP which ensures the food safety for consumer.

By the studies, Chapter 6 concludes that to minimize the environmental impact from agricultural product due to exploring of natural resources, the governance of LUC should be priority handled in order to reduce the environmental degradation. The MP is only an initial measure for the governance of LUC. The critical analysis for further policy and strategy which prepared during MP period is necessary. Furthermore, to minimize the environmental impact from agricultural product due to the use of pesticides or agricultural chemicals, GAP should provide detailed and precise guidelines on the timing of pesticide applications, formulation of dosage treatments considering specific provisions for the harvest times. Thus, incorporation of factors specific to individual plantations for the GAP guidelines and the PHI that is not implemented at fixed days, are essential to maintain pesticide residues under the desired levels. Moreover, developing the model which is able to directly compare the environmental impact of various agriculture products by using the same impact category, such expressed in DALY, are good for the future work.

様式７

論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

世界的な農産物供給増大に伴う環境影響を，特にサプライチェインを通じて評価する必要性が高まってきている．本論文は，特徴的な２つの農業生産物を取り上げ，システムダイナミクスの手法に基づき作物のサプライチェインを通じた環境評価を可能とする手法の構築と２つのケーススタディをとりあげて手法の適用性の検討している．

第１章では農業生産物のサプライチェインを通じた環境影響評価に関する先行研究を整理するとともに本研究の枠組みを設計している．

第２章では，インドネシアにおけるパーム油生産を取り上げて，森林伐採一時凍結を通じた生産面積の制御による効果をシステムダイナミクスによって評価するモデルを構築するとともに，この政策が導入されることによる効果を定量的に把握するモデルを構築している。

第３章では，第２章で構築したモデルを発展させて，パーム油の生産から廃棄処理過程までを含めたサプライチェイン全体からの環境影響に関し，温室効果ガス発生量を指標にして，土地被覆の変化，アブラヤシの生産過程，輸送過程，パーム油生産過程，発生した廃棄物の処理過程を通じて定量化している。

第４章では，構築したモデルを日本で生産される緑茶に適用し，害虫防除に使用される農薬の評価を行っている．代表的な農薬として，クロチアニジンならびにエトキサゾールを取り上げて，茶葉への残留特性を明らかにしている．農業生産工程管理に従って農薬を使用した際の残留レベルを経時的に推算を可能としており，このことから最大残留基準を満足する栽培技術に関する知見を得ている．

第５章では，インドネシアで生産されるパーム油による温室効果ガス発生による環境影響と日本における緑茶生産に伴う残留農薬による環境影響を比較し，対応の優先順位を考察することの必要性を議論するとともに，そのために導入の必要な指標として障害調整生命年の可能性を議論している．

第６章では，ケーススタディの結果をまとめるとともに，パーム油生産に関しては，森林伐採一時凍結政策について，緑茶生産については農業生産工程管理の含意についてリスク管理の観点で考察しており，多くの有用な知見を得ている．

以上のように、本論文は環境・エネルギー工学の発展に寄与すること大である．

よって本論文は博士論文として価値あるものと認める．