論 文 の 内 容 の 要 旨

Thesis Summary

論文題目　SUSTAINABILITY ASSESSMENT OF BIOFUEL FEEDSTOCK OPTIONS IN GHANA
（ガーナにおけるバイオ燃料原料のサステナビリティ評価）

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Biofuel feedstock production has been promoted across different areas of Sub-Saharan Africa to boost socioeconomic development and energy security. However, biofuel crop production can have important implications for land use change, biodiversity loss, poverty alleviation, livelihoods and food security at the local level.

Ghana was one of the countries that experienced a large expansion of the biofuel crop jatropha between 2008 and 2013. Hundreds of thousands of hectares were allocated throughout the country to large-scale jatropha projects that were mostly foreign-led. By 2013, most of these projects had collapsed having had important environmental and socioeconomic impacts locally. Since then there have been scattered discussions regarding the future of biofuels in the country either using jatropha or other feedstocks such as sugarcane and oil palm. To inform such discussions it is important to understand what have been the drivers of the widespread jatropha collapse and the local sustainability impacts of different feedstock options.

However, despite some scattered literature, no study has undertaken a comprehensive assessment of the different reasons that led to jatropha collapse around Ghana or elsewhere in sub-Sahara Africa. Furthermore, few studies have adopted a holistic approach for the assessment of the local impacts of biofuel feedstock production across the three pillars of sustainability (environment, social, and economic), in Ghana or other parts of sub-Sahara Africa.

This study aims to assess the local sustainability impacts of different biofuel feedstock options that have either been promoted or hold potential for biofuel production in Ghana. The study specifically seeks to (a) understand the drivers of biofuel feedstock production in Ghana and map out the current institutional arrangements, (b) identify the reasons for the widespread collapse of the jatropha sector and document the land acquisition processes, (c) understand and quantify the local sustainability impacts of different feedstock options in Ghana, (d) identify and explain how different local conflicts emerge in areas of feedstock production, and the local acceptability of biofuels feedstock options in Ghana.

To address these complementary objectives, the study adopts a sustainability science approach to synthesize existing knowledge and frame the empirical assessment. A sustainability science approach is an appropriate analytical lens to tackle key questions about the sustainability of different biofuel options. In particular, this study adopts and modifies the space-time–impact–stakeholder framework, focusing on the local scale using various case studies. These

include six collapsed large jatropha plantation (in Kadelso, Ahinakom, Kobre, Lolito, Adidome and Kpachaa) and three operational feedstock projects: a large jatropha plantation (Yeji), a smallholder sugarcane project (Dabala) and hybrid oil palm project that contains a large core plantation surrounded by smallholders (Kwae).

For objective (a), an extensive literature review and policy analysis were undertaken to understand the structure of the biofuel sector in Ghana and the interactions between key stakeholders.

For (b), 21 expert interviews, six focus group discussions, three participatory community mapping exercises, and 201 rapid household surveys were conducted around the six collapsed jatropha projects to understand the drivers of jatropha expansion, institutional arrangement, land acquisition processes, reason of collapse and local sustainability impact.

For (c), a sustainability assessment framework was developed to quantify the local impacts of current operational feedstock production projects. The selected study projects reflected the main feedstock options (sugarcane, jatropha and oil palm) and modes of production (smallholder, plantation and hybrid systems) across the country's three agro-ecological zones. In total around 850 household surveys captured a series of social and economic impacts (food security, poverty, livelihood and energy poverty). Remote sensing analysis and ecological surveys were undertaken to assess key environmental impacts related to carbon stock change and biodiversity loss.

For (d), community perspectives were elicited through 80 local interviews and 15 focus group discussions to understand the different local conflicts related to feedstock production across the collapsed and operational projects.

Table 1 summarizes the major findings of each research objective. For objective (a), the study verifies the actual land acquired for biofuel projects, the amount of foreign direct investment for biofuel projects and the connections between the main stakeholders in the sector. For (b), the study identifies a number of reasons behind the failure of the jatropha sector such as poor business planning, poor land administration, low jatropha productivity, local community conflicts, and obstacles posed by civil society The findings indicate the systemic nature of the collapse as these factors often worked synergistically to catalyze the collapse of many jatropha projects in Ghana. However, land-related issues are central to almost all of these drivers of collapse, while the unconstructive involvement of chiefs during the land acquisition processes was a common theme behind the collapse of many projects.

For (c), the impacts of the collapsed projects show a significant increase in jobs and income were reported during the operational phase of these projects. At the same time, many of the communities reported a significant loss in availability of (and access to) different ecosystem services such as medicinal plants, wild food and fuelwood/timber due to loss of woodlands during land conversion to jatropha plantations. Following the collapse, there have been observed significant decreases in rural employment and income in all six sites. Loss of access to ecosystem services still persists due to ongoing restrictions to access the sites

Table 1: Summary of major findings across research objectives

Objective	Findings/Outputs
a: Institutional arrangements	• Verified and actual land size acquired for biofuel crop production across the country: 950,131 ha for 31 projects
	• Estimates of the total foreign direct investment for bioenergy projects
	• Map of the institutional arrangement and their linkages
b: Drivers of jatropha collapse	• Classification of drivers of jatropha collapse: five major reasons for the collapse of jatropha
	• The reasons for collapse vary considerably among individual jatropha projects
	• Land allocated for jatropha projects and considered as marginal, had multiple other uses that contributed significantly to the livelihoods of local communities
c: Sustainability impacts	• Livelihoods of local communities are negatively affects by the collapse of jatropha projects as employment and income generation were increasing substantially during the operation but declined rapidly after the collapse
	• Local community livelihoods are affected as multiple ecosystem services (i.e. non-timber forest products) have declined substantially during the operation of the jatropha projects and these services are yet to be restored after the collapse of the jatropha projects
	• Negative biodiversity impacts are associated with all operational feedstock production projects
	• Oil palm production has net carbon gains, while sugarcane and jatropha have net carbon debts
	• Workers in large-scale plantations (either oil palm or jatropha) have either the same or worse levels of income, poverty and food security than their respective non-involved groups.
	• Plantation approaches with a long history (i.e. oil palm) offer better social services for workers thereby improving workers' food security, energy access, and poverty levels
	• Outgrowers and smallholders (either oil palm or sugarcane) perform better than their respective non-involved groups in terms of income, poverty and food security.
d: Local conflict and future acceptability	• Land rights and payment of compensations are the key areas of conflicts in collapsed and operational feedstock projects
	• All plantation modes of production have land-related conflicts in terms of identification of beneficiaries and amount to be agreed for payment of compensations
	• Unconstructive roles of chiefs have led to several issues of mistrust and lack of transparency during land deals in several of the collapsed and operational projects
	• There are mixed responses on the future of jatropha but some communities would prefer oil palm and sugarcane to jatropha

For the operational projects, feedstock options (jatropha, oil palm, sugarcane), Table 2 summarizes the different Sustainability trade-offs for environmental impacts at landscape level and socioeconomic impacts at the community level. At the landscape level, most feedstock options impact negatively the environment in terms of carbon stock and biodiversity, albeit to different extents with a single exception of net carbon gain from oil palm. For socioeconomic impacts, feedstock producers in oil palm and sugarcane sites are better off than other groups in their respective sites in terms of food security, poverty and livelihood. In addition, workers are either worse off or at similar status with non-involved groups at their respective sites. Positive trade-offs are therefore observed for those involved in oil palm and sugarcane than jatropha. Plantation approaches with a long history (i.e. oil palm) offer better social services for workers thereby improving workers' food security, energy access, and poverty levels. Positive impacts are yet to be observed in the jatropha as the closely matched non-involved group reported better food security, energy access and lower poverty levels than jatropha permanent and seasonal workers.

Table 2: Synthesis of sustainability trade-offs based on the percentage change

Impact	Indicator	Kwae (Oil palm)			Dabala (Sugarcane)	Yeji (Jatropha)	
		Landscape					
Carbon stock change	Net carbon stock	+			-	-	
Biodiversity loss	Diversity index	-			-	-	
		Worker	Outgrower	Independent Smallholder	Smallholder	Permanent Work	Seasonal Worker
Food security	Food Consumption Score (FCS)	+	+	+	+	-	-
	Food Insecurity Access Scale (HFIAS)	+	+	+	+	N	-
	Coping Strategy Index (CSI)	+	+	+	+	+	-
Poverty	Multidimensional Poverty Index	+	+	+	+	-	-
Livelihood	Income	-	+	+	+	-	-
	Consumption expenditure	-	+	+	+	-	-
Energy Poverty	Multidimensional Energy Poverty	+	-	-	-	+	-

+ (Positive), - (negative), N (neutral)

For (d), plantation mode of production is characterized by land-related conflicts in terms of land rights disputes and compensation. While there is currently considerable skepticism among stakeholders about the future of biofuel feedstock production in Ghana (and especially of jatropha), there is still some interest especially for oil palm and sugarcane as reflected in community surveys and recent government policies. However, issues related to land rights can affect the social acceptance and viability of large-scale plantations. On the contrary, smallholder and out-grower systems will struggle without stable markets offered by large mills.

From a policy perspective, any interest in reviving the collapsed jatropha sector or promotion of other feedstock options must give considerable attention to; (a) addressing the impediments of land administration, (b) agro-ecological zone and proper site selection, (c) guidelines for certification, (d) understanding of sustainability trade-offs, (e) establishment of viable markets; and (f) improving community participation in project design.