早稲田大学大学院アジア太平洋研究科

博士論文審査報告書

論 文 題 目

原題名 Original Title	High Yielding Variety Adoption, Technical Efficiency and Poverty Reduction for Rural Rice Farming Households under Rainfed Ecosystem:An Example of Eastern India
英訳 In Japanese	天水水稲生態系における農村部水稲生産者家庭の高収量品種の利用・技術効率と貧困削減：インドの東部地区を事例として

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1. Abstract of the Dissertation

This PhD dissertation covers the regional development in eastern India where the study areas— Giridih and Purulia—are located, by focusing on the patterns of agricultural development under rainfed ecosystem and poverty reduction among surveyed rural households. The dataset analyzed is drawn from a panel household survey, collected jointly by the International Rice Research Institute (IRRI) and Indian Statistical Institute (ISI) in Kolkata during the Kharif seasons in the time period between 1998-1999 and 2004-2006. The study area has been recognized as one of the poorest regions in the country and has drawn upon the long-term interests of development economists.

The agricultural development is investigated from the aspects of farmers' decision making regarding high yielding variety (HYV) rice adoption, and the technical efficiency of sampled rice farms and plots during the survey periods. In addition, the relationship between agricultural and non-agricultural development is discussed to understand the roles they played in rural poverty reduction. The study provides needed empirical evidence at both plot- and farm-level, allowing for gaps in the existing literature to be filled as well as highlighting the important areas for policy intervention.

The empirical results illustrate that potential high yield served as the main driver for farmers to adopt HYVs, since yield is significant for explaining farmer's choice. The 'subsistence pressure' is highlighted for small-scale farming households, thus cultivating a higher yielding rice variety becomes essential for their livelihood. The study identifies the important roles played by education, landholding size, the number of household members, share of production sold in the market, and share of non-agricultural income in affecting farmer's decision to adopt HYVs. In addition, the agroecological factors—soil quality, land types, and irrigation availability—also significantly influenced and constrained farmer's adoption choice.

The second part of the study estimate the degree of technical efficiency at farm- and plot-levels, separated for traditional varieties (TVs) and HYVs. Additionally, at a farm-level, the output growth decomposition analysis has been conducted, where the contributions of total factor productivity (TFP) are identified. The results from the analysis on stochastic frontier production function (SFPF) indicate that the sampled rice farms operated relatively close to the production frontier. The estimations at plot-level argue for lower technical efficiency scores for both TV and HYV plots when compared with the farm-level estimation, and the mean technical efficiency of HYV plots was higher than that of TV plots.

The last part of the study provides empirical evidence to the debate as to whether agricultural development is complementary or a substitute for non-agricultural development and poverty reduction. The finding supports the premise that growth in agricultural productivity and in the non-agricultural sector had a substitute relationship. However, in districts with a more developed non-agricultural sector (such as Giridih), the relationship tended to be more complementary.

2. Outline of the Dissertation and Summary of the Chapters

The chapter outline of the dissertation is as follows.

Chapter 1   Introduction

Chapter 2   Research Background

Chapter 3   Determinants of Small-scale Rice Farmer's Adoption of High-yielding Varieties under Rainfed Ecosystems in Eastern India: Using McFadden's Choice Model

Chapter 4   Estimation of Technical Efficiency and Output Growth Decomposition for Small-scale Rice Farms in Eastern India: A Stochastic Frontier Analysis

Chapter 5   Income Mobility and Pathways out of Poverty in Rural India: The Case of Giridih and Purulia

Chapter 6   Conclusions

Chapter 1 presents the background, research questions, hypotheses, and significance of the study. A large body of research argues for the importance of increasing agricultural productivity to achieve any pro-poor growth, as it can help rural residents overcome the unfavorable initial conditions and bring direct benefits to them by increasing their income and food security. With the wide-spreading Green Revolution, new agricultural technologies are diffused to rural farming households in the developing countries, which contributed greatly to improving agricultural productivity and reducing hunger in rural areas. However, there remains the concern that the success of the Green Revolution neglected the rainfed agriculture and left the regions under rainfed ecosystems behind.

Agricultural productivity growth is the primary focus of this study, which is examined empirically from two aspects: (1) the farmer's choice in adopting technical innovation—High Yielding Variety (HYV) rice, as well as (2) the farmer's potential of utilizing them—farmer's technical efficiency. In addition, an examination of the relationship between agricultural productivity growth and non-agricultural growth to rural poverty reduction becomes another focus of this study, to identify the most promising path out of rural poverty in the region. The study hopes to facilitate eastern Indian policymakers to properly identify their policy priorities in improving agricultural productivity and through this the income and living standards of the impoverished rural households

The main purpose and contribution of this dissertation is to identify what may contribute to the rural poverty reduction in rainfed regions of India. A unique data collected from eastern India can be used to conduct empirical analysis in a consistent manner on these issues. The data applied in the analysis were collected through a household survey conducted by the International Rice Research Institute (IRRI) and the Indian Statistical Institute (ISI) in Kolkata between 1998-1999 and 2004-2006. Nearly 600 farming households were surveyed in sixteen villages from the Giridih district of Jharkhand state and Purulia district of West Bengal state.   Eastern India is the most poverty-stricken region of the country where the rural population is mainly engaged in agricultural activities on rainfed lands

Because of the importance of these issues for pro-poor growth and rural development, the study can contribute significantly not only to academic literature but also to the discussions for policy formulation.

Chapter 2 presents the overview on the rainfed agriculture, especially on rice and rural poverty in India.

According to the global irrigated area mapping (GIAM) project, in 2000, the estimated area of global rainfed croplands totaled 1.75 billion hectares, which is 5.5 times the area of the total global irrigated croplands. India ranks first regarding both its extent (86 million

hectares) and its production value among all the rainfed agricultural countries. Rainfed regions are characterized with higher poverty rate, lower land and labor productivities, less per capita food consumption, lower level of infrastructural and social development when compared with the irrigated regions.

In eastern India, rice is the main crop that is grown and consumed by the local farming households. Rice production in the region covers 26.8 million hectares, accounts for 63% of the country's total rice croplands and meets 48% of the country's total production needs. Rice demand in India is predicted to exceed the supply and thus challenge people's food security in the near future due to the rapidly growing population.

Another particular concern of researchers and policymakers is the widespread extreme poverty across eastern India. The poverty rate of eastern Indian rural households is among the highest in Asia. Nearly all Indian states have experienced declines in poverty in recent decades. According to the National Family Health Survey (NFHS), the headcount rural poverty ratio has decreased from 37% in 1992-93 to about 29% in 2005-06. However, the states in eastern India have generally remained with high poverty incidence and have been less successful in poverty reduction. States like Bihar and West Bengal in eastern India ranked first and fifth place in 1998-99, and second and seventh place in 2004-05 among all the states in India.

Against these backdrops, it is critical to analyze the factors associated with the productivity increase in rice productions in eastern India, and the transition out of poverty.

Chapter 3 explores the high-yielding varieities (HYV) adoption patterns and the factors that influence the probability of adopting HYVs by small-scale rice farmers using the dataset collected in Giridih and Purulia district where, during the survey period, the adoption rate of HYV rice was relatively low. Categorizing all the reported rice varieties into traditional varieties (TVs), medium-duration HYVs and long-duration HYVs, this paper utilizes McFadden's choice model for empirical analysis.

The results indicate that the sampled farmers' decision-making processes were likely to be affected by a set of their socioeconomic and agroecological characteristics. Regarding the human capital attributes, contrary to previous studies finding significant and positive impacts of household head's age in HYV adoption, there is no evidence to support such arguments. The results indicate that education is significant for famer's choice, although the coefficient signs of the two education variables are opposite to each other. This is consistent with Rosenzweig's (1982) view on education's different influence on new technology adoption. He claimed that education may encourage adoption by lowering the learning cost, but it may also discourage adoption, as growing HYVs increases the opportunity cost of the farmer being employed in a more profitable, non-agricultural sector. According to previous empirical evidence, there is no single answer to the correlations between education and adoption

The results also show that farm size has negative and significant impacts on the farmer's HYV adoption. Smaller farms are more likely to adopt long-duration HYVs over TVs than larger farms. The results indicate that distance to the nearest local market does not significantly explain farmers' choices. However, the share of rice products sold in the market shows significant and positive impacts on the probability of adopting HYVs.   In the study area, farmers' agroecological differences played an important role in the adoption of HYVs. Results indicate that there is a greater likelihood of farmers growing long-duration HYVs if they possess more plots in medium and lowlands when compared with TVs. Irrigation

availability is also crucial to a farmer's decision. These results reflect the fact that, in the study area, unfavorable environments on upper lands and a lack of irrigation constrain HYV adoption.

Chapter 4 focuses on estimating the degree of technical efficiency of the sampled small-scale rice farmers over time using stochastic frontier analysis. It is important for policymakers to understand the technical efficiency of farmers which enables them to properly allocate policy priorities for the improvement of farmers' agricultural productivity and thus agricultural incomes. The estimations of technical efficiency are carried out at both aggregated farm-level, and disaggregated plot-levels where traditional varieties (TVs) and high-yielding varieties (HYVs) are differentiated. An empirical model of stochastic frontier production function (SFPF) with a sub-model of inefficiency effects is applied in order to assess the degree of technical efficiency and the determinants of technical inefficiency of the sampled rice farms. Additionally, the output growth decomposition analysis at farm-level identifies the contributions made by aggregated input growth, technical change and technical efficiency change to the total rice production growth during the survey period.

The estimation at an aggregated farm-level finds that the sampled rice farms are moderately technically efficient and operated relatively close to the production frontier. Only a small proportion of farms faces the severe issue of technical inefficiency. The estimations at a more disaggregated plot-level produced lower technical efficiency scores for both TV and HYV plots when compared with farm-level estimations. A difference in technical efficiency between TVs and HYVs is found in the study. The mean technical efficiency for HYV plots is higher than for TV plots.

The results indicate that the diffusion of technological innovation in rice production is not accompanied by an improvement in a farmer's ability to fully utilize them. Although a plausible increase in adopting HYVs is observed, the mean annual technical efficiency experiences a general decrease over time. The farm-specific reasons for technical inefficiency include the age of household heads, the highest educational attainment of household members, the size of landholding, the share of HYV plots, the share of non-agricultural income, the share of plots in various land types and the differences between the districts. Another non-negligible factor is the external environment, particularly the sufficiency of rainfall. Any unexpected environmental factor could put the production at risk, thus substantially decrease the technical efficiency. The production growth found that technical change (TC) plays a key role in increasing rice production, implying the importance of technological innovations. Therefore, how to facilitate the farmers to better implement the adopted new technologies, as well as increase their efficiency of utilizing the technologies, are open to discussion by policymakers and researchers.

Chapter 5 examines whether agricultural growth and non-agricultural growth are complementary or a substitute to poverty reduction. While some researchers argue that increasing agricultural productivity has helped to raise rural incomes and reduce rural poverty, others argue that growth in the non-agricultural sector has had an even more substantial impact on rural poverty reduction. Concrete empirical evidence of such debate has been relatively few and far between due to a lack of proper data, making it difficult to draw conclusions. The use of the IRRI data enables the reseachers to conduct such study. The study is conducted under the theoretical framework of structural transformation. It empirically estimates the correlation between agricultural growth and non-agricultural growth

and the roles they played in poverty reduction and also identifies the patterns of household income mobility and specific pathways through which the households escaped poverty.

The findings indicate that agricultural growth in general was a substitute to non-agricultural development and failed to contribute to poverty reduction in the study area. However, when taking district-specific effects into account, this relationship becomes reversed in Giridih district. The importance of non-agricultural sector development in facilitating agricultural growth and raising household income has been found in Giridih district.

Chapter 6 summarizes the findings from the empirical exercise in this dissertation. Combining the results of all three independent estimations, the dissertation attempts to respond to the main research question—Does the agricultural development in the form of farmer's HYV adoption and technical efficiency contribute to the rural poverty reduction during 1998/99 to 2004/06 in the rainfed agricultural ecosystem of eastern India?—and the three sub-research questions proposed in Chapter 1.

Regarding agricultural development, the study observes a general increasing trend in rice productivity and in farmers' HYV adoption, but a decreasing trend in technical efficiency for the sampled farming households during the survey period. Empirical results show the increasing HYV adoption is mainly driven by the consumption needs as well as the economic interests of the sampled households. According to a decomposition analysis, the technical change (TC) of HYV adoption is the primary contributor to the rice production growth during the survey period, while the importance of technical efficiency change is relatively small.

For the factors affecting the agricultural productivity growth, the study finds that higher education attainment is important in increasing farmers' HYV adoption, as well as decreasing their technical inefficiency. The smaller farms are found to be faster HYVs adopters and had higher technical efficiencies than larger farms. Larger proportion of rice plots cultivated in the lower land terrace where the soils are more fertile compared to others has significant impacts in increasing HYV adoption and technical efficiency when compared with plots in the upper lands.

It also needs to be noted that more involvement in the non-agricultural employment of the sampled farmers decreases their agricultural productivity, but also reduces their poverty. A larger share of non-agricultural income depresses the farm's technical efficiency, but significantly improved farmer's income level in the study area. In addition, more direct analysis confirms that agricultural productivity growth significantly increases the agricultural incomes, but it is a substitute to the non-agricultural growth and has no obvious impact on rural poverty reduction.

Based on these results, three policy recommendations can be offered: 1) more attention to human capital development; 2) tailored assistance taking into account of topographics features of the area; 3) expansion of irrigated areas; and 4) improvements in non-agricutlure employment opportunities in rural reas.

3. **Discussions of Oral Defense Examination**

After carefully reading the dissertation, the examination committee convened the oral defense examination on April 4, 2019. The examination lasted approximately two hours.

During the examination, the following points were raised. First point concerns with the

choice of the study areas.   This dissertation utilized a unique dataset gathered by IRRI and ISI.   Reviewers' comments suggest that provision of background information on how IRRI and ISI chose these locations as the study areas and more information on the rainfed rice cultivation are desirable. The second points were to make the notations of the equations more consistent with the explanations in the text and to make explicit differences in plot and farm-level analysis.

Examinee agreed to these two points and to revise the thesis accordingly.

4. Evaluation and the Result of Examination

The examiners find that this dissertation is well-written, and makes a number of contributions to the literature on rainfed agriculture in the context of developing countries. The dissertation makes use of the uniqueness of the dataset, which includes detailed information on plot level data, which are rare to find.   By using this unique data set coupled with appropriate empirical methodologies, the dissertation was able to analyze important issues on development in a consistent manner.

After careful assessment of the submitted dissertation, whose summary is presented in sections 1 and 2 of this report, the oral presentation of the dissertation, subsequent discussions and revisions made to the dissertation, the committee members came to a unanimous decision that Wei Wu, the author of the submitted dissertation, should be granted a Ph.D.

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