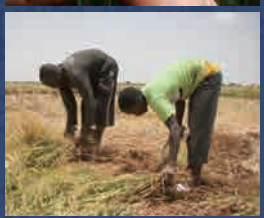

JICA Research Institute June 2013

The Coalition for African Rice Development (CARD) Progress in 2008-2013

The Coalition for African Rice Development (CARD): Progress in 2008-2013

June 2013
JICA Research Institute

Cover Photos:
Mika Tanimoto (largest photo)
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The Coalition for African Rice Development (CARD): Progress in 2008-2013

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Preface

African development depends heavily on the performance of the agricultural sector. As the World Development Report 2008 notes, agricultural development is essential for poverty reduction and food security in Sub-Saharan Africa (SSA). And a major cereal crop that has great potential to help achieve these goals is rice. In many countries in the region, rice consumption and imports have been increasing rapidly with population growth and urbanization, and yet there is ample room to improve the productivity of rice growing.

Based on this understanding, the Japan International Cooperation Agency (JICA) launched the Coalition for African Rice Development (CARD) initiative at the Fourth Tokyo International Conference on African Development (TICAD IV) in May 2008. A joint initiative with the Alliance for a Green Revolution in Africa (AGRA), CARD is a consultative group of donors, research institutions and other relevant organizations to work with rice-producing African countries. It is designed to help find medium- and long-term solutions for food security and poverty reduction in SSA by doubling the production of rice, one of Africa's major crops.

In parallel to CARD, the JICA Research Institute (JICA-RI) has been conducting, since 2009, a research project to empirically analyze how the CARD initiative serves to increase rice productivity per unit of land and reduce poverty. It aims to explore the potential of a rice Green Revolution in SSA by presenting micro-level evidence. The project is headed by Professor Keijiro Otsuka, National Graduate Institute for Policy Studies (GRIPS). The study covers Ghana, Mozambique, Senegal, Tanzania, and Uganda, the members of the first group of countries for the CARD initiative.

This volume is an interim report on the research project. It starts with a brief summary of CARD initiatives over the last five years, followed by an overview of the findings from the research, and four academic papers offering empirical analyses of the cases of three countries: Uganda, Tanzania and Mozambique. The cases underscore the rich potential for expansion in rice production while pointing to the remaining bottlenecks in adopting new and improved technologies to increase the rice yield.

I hope that the implications of this volume drawn from the research will serve as a solid base upon which effective strategies for enhancing the rice yield in SSA are developed, contributing to agricultural development, food security, and poverty reduction in Africa.

In concluding, I would like to express our sincere gratitude to Dr. Keijiro Otsuka (GRIPS), Dr. Takeshi Sakurai (Hitotsubashi University), Dr. Kei Kajisa (Aoyama Gakuin University), Dr. Yoko Kijima and Dr. Yuko Nakano (University of Tsukuba), for participating in the research project of JICA-RI.

Tokyo, June 2013
Hiroshi Kato
Director
JICA-RI

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Part 1

Five Years of the CARD Initiative —History, Achievements, and Further Challenges—

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The Coalition for African Rice Development initiative, or CARD, starting in 2008 at the 4th TICAD meeting, was launched jointly by the Alliance for Green Revolution in Africa (AGRA) and JICA. It is a partnership of African rice producing countries and development partners, with a shared target to double rice production in Sub Sahara Africa in 10 years.

This briefing note, written for the occasion of CARD's 5th anniversary at TICAD V, attempts to provide a short description of its history, its unique characteristics, achievements to date, and challenges ahead in the second half of the lifetime of the initiative.

BACKGROUND

How it was conceived

The idea of the initiative was conceived at a time when some signs of change in world food price trends were identified in late 2007, months before most food security-related actions were taken by development partners. The idea was initially discussed between Mr. Kenzo Oshima, then Senior Vice President of JICA, and Mr. Kofi Anan, former Secretary General of UN and then chairperson of the board of AGRA. The discussion was about a possible coordinated response by development partners to strengthen food security and to reduce poverty in Africa. The meeting was held at Mr. Kofi Anan's residence in Accra, Ghana, in December 2007, half a year prior to the Toyako G8 summit and TICAD IV meeting both scheduled for the middle of 2008.

Based on the agreement between Oshima and Anan, and with

consultation with The New Partnership for Africa's Development (NEPAD), JICA embarked on organizing a series of preparatory meetings participated in by experts from academia and development circles, where they analyzed the food demand-supply trends and discussed tangible options available for Sub Sahara Africa (SSA) as joint actions among like-minded partners.

Why Rice?

Experts recognized that rice development in Africa had not yet been sufficiently explored and its potential could be tapped by appropriately empowering producers and other stakeholders and by linking them up to the market. While regional production of other important staple crops such as maize, sorghum and cassava has increased steadily, matching the volume of local consumption, rice and wheat have shown a different pattern in supply-demand trend for the last few decades and the gap between production and consumption has been growing (Figure 1 a, b). Productivity of rice in SSA has been stagnating for a long time, in sharp contrast to Asia where the advancement of technologies enabled steady productivity improvement in the region (Figure 2 a, b). In addition, lessons of the Green Revolution in Asia and other regions told us that investment in infrastructure and capacity building of stakeholders, both public and private, along with the value chain of major staple crops made it possible to improve productivity and strengthen links between production and the market. These developments have not taken place in Africa.

Fig. 1-a Demand-Supply Balance of Maize in SSA

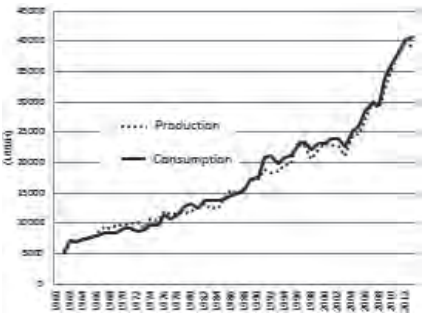


Fig. 1-b Demand-Supply Balance of Rice in SSA

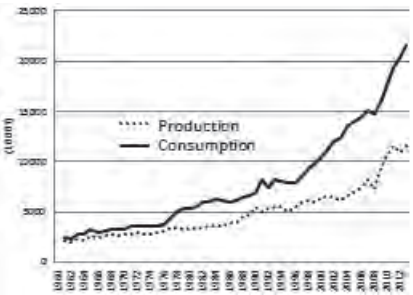


Fig. 2-a Trend of Cropping Area and Yield of Rice in Asia

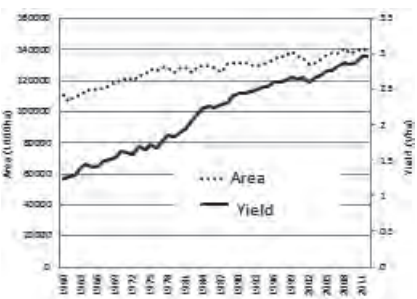
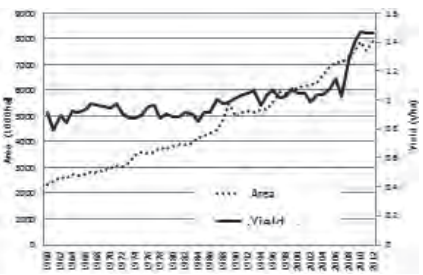


Fig. 2-b Trend of Cropping Area and Yield of Rice in SSA



JICA acknowledged the recommendation of the group of experts, and they jointly started the preliminary work of formulating the initiative, which focused on rice, one of the few commodities whose consumption-production gap in many countries in SSA has been widening, and a favorable environment for cropping was confirmed to exist widely across the region. It was a decision taken while many African countries were spending a large part of their foreign reserves on importing rice to meet increasing consumption demands in their countries. The supply gap as a percentage of whole rice consumption amounted to as high as 40% on average and even higher in some countries, with an inflated unit price in the global market since 2008.

Rice, as an entry point to revitalize agriculture

It must be noted, however, that initially, the idea of CARD focusing on a single commodity was not necessarily a comfortable one for some development partners. It was particularly so for multilateral development banks (MDBs) such as the World Bank and the African Development Bank, where the focus on a single commodity was perceived as unusual given their common business model geared to sector-wide programs and financing; their client governments usually looked for comprehensive approaches rather than ones focused on specified commodities.

With extensive discussion, however, partners found common ground by noting that rice development has been economically and politically, and in several cases, socially, important for the governments and agribusiness in the region because of rice's fast growing domestic market; and partners agreed not to miss the momentum that this crop was providing. At the same time, they understood that measures taken regarding rice would benefit other crops, too, such as strengthening of institutional and personal capacity for administration, research, extension and production. This was because in most African rice producing countries, those working in the rice value chain are involved in other important crops as well, unlike in many countries in monsoon Asia.

As a result of these discussions, MDBs decided to participate in the Steering Committee of CARD, recognizing rice production as one of the credible entry points to revitalize the agricultural sector as a whole.

STRUCTURE AND FUNCTION OF CARD

Simple structure of CARD Initiative based on Partnership

Following the announcement of the inauguration of CARD at the TICAD IV meeting in Yokohama in May 2008, seven development partners and 12 rice producing SSA countries listed in i) and ii) below jointly endorsed the overall target of the initiative: "doubling the rice production in SSA in 10 years" at the 1st CARD General Meeting (GM1) in Nairobi in November 2008. In numerical terms, the initiative envisaged that the baseline production of 14 million tons of rice (average in 2002-2006 FAO

statistics) would be doubled to reach 28 million tons in 2018. These 12 countries (group 1) accounted for about 85% of total production of rice in SSA as of 2008. They also agreed on the implementation guidelines of the initiative, and the working program of the initiative for the first year, at the GM1.

i) Africa Rice Center, AGRA, Forum for Agricultural Research in Africa (FARA), International Rice Research Institute (IRRI), JICA, Japan International Research Center for Agricultural Science (JIRCAS), NEPAD formulated the Steering Committee (SC). Food and Agriculture Organization (FAO, UN) joined soon after GM1. Three other partners, International Fund for Agricultural Development (IFAD), African Development Bank (AfDB) and The World Bank, all regular participants at the preparatory stage and at the first GM, joined SC at GM2 in May 2009.
ii) Cameroon, Ghana, Guinea, Kenya, Madagascar, Mali, Mozambique, Nigeria, Senegal, Sierra Leone, Tanzania, Uganda.

Participants at GM1 also endorsed a simple structure of the CARD initiative (Fig 3.). AGRA and JICA jointly supported a small but dedicated secretariat for the initiative, and Dr. Ngongi, then the president of AGRA and former Deputy Director General of WFP, was appointed first Secretary General of the Initiative. The Secretariat organized the General Meeting (GM), where all interested parties shared lessons and perspectives on rice development. The secretariat also served for the national task teams (later it was named as the national task force for NRDS) of 12 countries and a group of development partners who committed to support implementation of the Initiative. These committed development partners formulated the Steering Committee (SC) to coordinate activities among them to respond to the needs proposed and discussed in the GM by the 12 participating rice producing countries. Other development partners participating in GMs and other CARD events were bilateral and multilateral development organizations such as USAID, AFD and WFP, NGOs such as CRS and BRAC, and private foundations such as MBGF and the Aga Khan Foundation. They also contributed to the process when they share their experiences with the CARD members.

Expansion of coverage

After nearly a year of implementation of the initiative (formulation and analysis of the NRDS in 12 countries of the first group), SC members jointly started, at the GM3 in 2010, supporting the second group of 11 countries (group 2, listed in iii)) to enter the NRDS process (see next section).

Countries in the second group have various reasons for and interests in promoting rice development. Some of them needed to revitalize this staple crop as a foundation of their rural development in post-conflict situations, and others selected rice as one of the most promising crops for diversifying their production portfolio. With the additional 11 countries, a total of 23 participating countries cover more than 95 % of the total production of rice in SSA.

i) Benin, Burkina Faso, CAR, Côte d'Ivoire, DR Congo, Ethiopia, Liberia, Rwanda, The Gambia, Togo, Zambia

Fig. 3 Participants in CARD

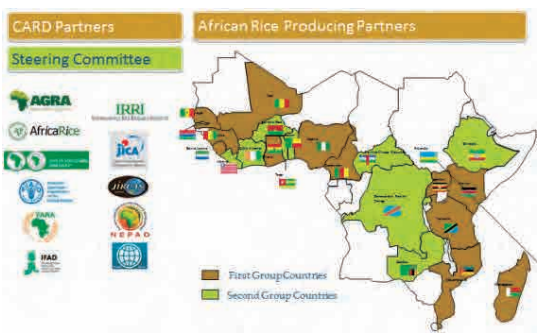
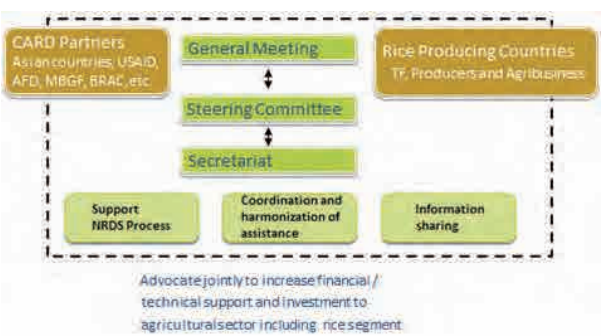


Fig. 4 Structure of CARD



ACHIEVEMENTS TO DATE

NRDS, country-owned process for rice development

The CARD initiatives defined themselves as a consultative group among African rice producing countries and bilateral and multilateral development partners to coordinate their investment in rice-related development programs. Based on the findings in the preliminary works, participants agreed to have a comprehensive information package of rice in their countries as a commodity and have a policy direction for rice development for their countries, as each of them had their own unique bio-ecological settings for production and socio-economic environment for rice industries. As a result, each rice producing country set up a task force (TF) to prepare an NRDS, which compiled all necessary information about the current status of rice development in the country and the potential for rice in the country, from both bio-physical and socio-economic viewpoints (the first step in Figure 5 below). Together with ARC, IRRI and JIRCAS, the Secretariat jointly prepared a format of the NRDS, and it worked together with FAO and JICA to sensitize the NRDS format to the TF members. The TFs started analyzing, with the participation of a wide range of stakeholders, the state of the rice value chain, and identified possible policy options to realize the best scenario for rice development to serve the country's strategy for food security and agricultural development. They also collated information regarding government- and donor-financed support in related areas and identified gaps where interventions were needed most to improve them (the second step in Figure 5). All NRDS documents and supporting material are open to the general public at the HP of the CARD initiative secretariat. NRDS documents must be revised from time to time, as 'living' document, to update them with new information and analyses. http://www.riceforafrica.org/new/

To improve their rice industry based on gap analysis, TFs and stakeholders jointly produced a prioritized list of possible interventions to strengthen their own systems (the third step in Figure 5). Each of the concepts of prioritized interventions must be tested through their mechanisms for sector strategy such as the CAADP Investment Plan (the fourth step in Figure 5). Practically all of the Development Partners in the CARD initiative are also supporting partners of CAADP and agreed to jointly support formulation and implementation of NRDS based on their own relative advantages and to look for any opportunity for

synergies among their interventions.

Science base for country strategy

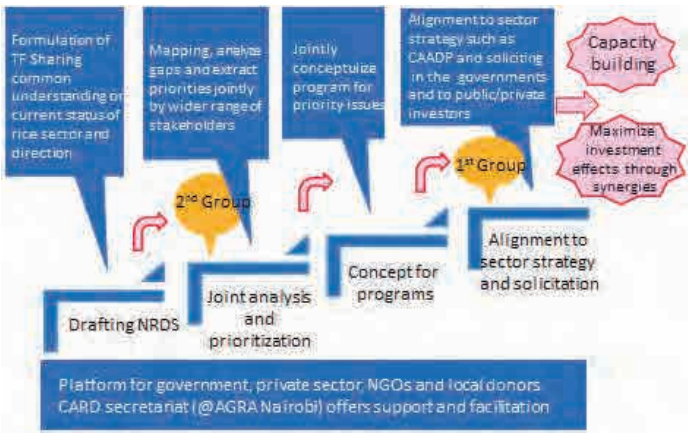
One of the common challenges for all participating countries at the entry point of the initiative was the lack of reliable statistics and base-line data for rice development. It is a natural consequence of prolonged underinvestment in the agricultural sector in the past decades, but CARD partners, particularly research institutions, worked on the capacity building of national research systems. As a major contribution in this area, JICA Research Institute and a group of researchers led by Professor Otsuka of GRIPS jointly started a base-line survey of rice in selected group-1 countries from 2009 and the interim products were shared with all interested parties at the seminar attached to GMs. This booklet contains a summary of the study.

Resources for implementation

It is not really possible to single out the additional expenditure specific for rice development under CARD as most of the financing partners, such as WB, AfDB, IFAD, have had sector financing. However, some funding programs dedicated to rice development have been launched in the period. They are, for example, GRiSPs, the CGIAR system-wide rice research program of which JIRCAS is also a member, and PHRD funding to complement the WAAP credit program mostly focused on rice. GAFSP or the Global Agriculture and Food Security Program has been in operation since 2011. It is a trust fund administrated by WB and funded by bilateral donors including Japan and a private foundation (MBGF) for both public and private windows. Over 60% of its allocated amount, totaling about USD 660 million to date, was distributed to projects in SSA countries including substantial rice-related development.

JICA has increased the number of rice-related interventions under CARD, including two new Yen loans for financing irrigation (Kenya and Tanzania), five new rice-based technical cooperation projects (Mozambique, Nigeria, Rwanda, Ethiopia and Cameroon) and a number of technical cooperation projects that have entered into new phases to further intensify their activities particularly in capacity building of stakeholders (Tanzania, Uganda, Mozambique, Ghana and Sierra Leone). (See the last section for a more detailed description of these projects.)

Fig. 5 Activity in each CARD country



Cases of collaboration for synergies

In the past five years, communications traffic among development partners and relevant government departments in rice producing countries has increased sharply. Although further improvement both in quality and quantity of cooperation is inevitable, partners now know others' relevant programs much better and much more in advance, and have captured more opportunities for exploring synergies in the specific countries or in various segments of value chains. Some cases of collaboration materialized / planned to date are shown in Figure 6.

Fig. 6 Cases of Collaboration On-going / Planned with Partners

Collectively support national NDRS TF team for technical/capacity building

ARC/IRRI/JIRCAS: Global Rice Science Partnerships/OGIAR
AfDB/ARC/JICA: Africa Rice Initiatives (Nerica seed multiplication in national systems/ Capacity development)
IRRI/PhilRice/JICA: Training for young researchers and core extension staff
IFAD/JICA: Planning joint works on promotion of S to S Cooperation
JIRCAS/JICA: Joint works on rice development in inland valleys in Ghana
USAID/JICA: Collaborative works on CD in irrigation systems in Tanzania
WB/JICA: Collaborative works on rice productivity and irrigation component with PPP
NEPAD/JICA: Alignment of NRDS with CAADP (training of NRDS TF)

- MOU on collaboration in food security including CARD-related activities with IFAD, WFP and BRAC
- Preliminary discussion started with KOICA on their participation in CARD
- G20 Agricultural Minister Meeting in June 2011 recognized CARD as a vehicle for rice development in Africa

ARGUMENTS FOR CARD

Funding mechanism or not

These settings made the CARD initiative unique among various systems of this kind in the development business as it is not a funding mechanism.

Development initiatives are often created to secure funds for specific development purposes accessible for a limited number of institutions. Some of them are said to have fallen into a trap with participants becoming excessively focused on fund raising. The CARD initiative deliberately avoided this trap and concentrated on the subject, i.e., strengthening of the national system capacity and making their proposal competitive and bankable. The initiative assumed that the responsibility of securing funding for the rice development projects/programs in each of the participating rice producing countries rests primarily with the countries themselves and secondly with each of the supporting members. Thus, each of the national TFs is made responsible to convince its fiscal authorities to allocate a reasonable share of the national budget to the relevant programs/projects, and planning authorities, to give higher priority to the credible rice-development programs/projects.

In other words, it was understood that fund raising for rice development is the joint task of all partners in CARD. Its members jointly make rice development programs/projects bankable and more relevant among competing projects/programs by making credible cases for them through science-based exercises. With a separate funding mechanism for a single commodity being unrealistic, interaction among NRDS TF and national focal points of CAADP became more important for each other. Thus, overall, the decision to make the initiative a platform for coordination and synergies, rather than a funding mechanism, can be judged as a wise one.

Alignment with sector development strategies ... CAADP and CARD need each other

All participants agree to make sure that NRDS fully aligns with the existing national development plans, such as Poverty Reduction Strategies, and particularly, the sector strategy such as CAADP Country Investment Plan (CIP) where applicable.

CAADP, or Comprehensive African Agricultural Development Programme, is a pan-African initiative launched by the Maputo Declaration at AUC Head of the States Submit in 2003. The Maputo Declaration re-defined the agricultural sector as the main engine of the development of the continent and the heads of states jointly agreed to increase the allocation of their own national budget up to 10% or more to agriculture and food security-related expenditure.

After several years of silence since the declaration, CAADP had renewed momentum in 2008 when there was a food price surge in many countries and development partners started supporting preparation of CAADP/CIP for each of the countries and committed to finance the CIP through bilateral and multilateral channels.

Often CIP is produced as a comprehensive shopping list for the sector, covering the whole range of possible interventions required, each item of which needs to be prioritized. By contrast, NRDS is prepared in such a way that it fits into a whole picture of sound sector development, typically that of CAADP/CIP, and in return, NRDS processes should offer a concrete, tangible and prioritized proposed intervention regarding the whole picture.

Progress of the CARD initiative has been welcomed by AUC/NEPAD, particularly the capacity building of national systems to work on the basis of analytical frameworks and in a participatory manner with a wide range of stakeholders. The CARD secretariat made a presentation about the Initiative at the CAADP partnership platform meeting in 2012, and NEPAD officials in charge of CAADP started communicating with the CARD secretariat in April 2013 to build up institutional engagement of the two initiatives for further concrete interactions.

JICA recognized the importance of CAADP CIP as a basis on which each of JICA's supported projects and programs are planned and implemented. In view of this, JICA will conduct a training course, targeting the focal CAADP country and CARD TFs, to help promote interaction among them and to produce a credible rice development program within CAADP CIP.

ELEMENTS PROMOTED BY CARD INITIATIVE

Partnership with emerging donors and Asian countries

The CARD Initiative has from the early stages encouraged new partnerships among African rice producing countries and emerging donors and Asian rice producing countries. Brazil, which started its institutional engagement with Africa for agricultural development in about 2005, used CARD meetings to learn about the demands and needs of African countries in this sub-sector. Likewise, Egypt, a decade-long partner of JICA through tripartite cooperation for capacity building in irrigation engineering and other related areas, expressed at various CARD meetings its policy to enhance its cooperation with African countries.

One particularly notable progress item observed is the partnership among African rice producing countries and their Asian counterparts. At GM2 in Tokyo in 2009, representatives of five Asian countries, Indonesia, Malaysia, Philippines, Thailand and Vietnam, were invited to share their experiences of rice development. Since then, the Initiative has provided a series of credible venues of dialogue among 23 African and 5 Asian countries. As an immediate outcome of the exercise, Indonesia sent a ministerial-level mission to Tanzania in 2010 to identify the concrete cases of cooperation in rice development between the two countries, and Thailand has strengthened its dialogue with some countries and moved toward project formulation on rice development in the last two years. Vietnam participated in JICA's technical cooperation project for small-scale irrigation in Mozambique with 5 to 6 long-term technical experts. The project is now in operation as a Mozambique-Vietnam-Japan tripartite cooperation undertaking.

JICA often goes on to facilitate communication and to support demand-resources matching. JICA's long-time commitment to agricultural development in Asian countries enables it to offer advice and information for best matching. Other SC members are also now interested in working on this venture and, for example, IFAD started funding study tours and matching exercises between African countries and Asian partners for rice development.

Key for the future of the rice industry ... Private sector

Another element that has been emphasized in the CARD initiative is

private sector investment in rice development. The global food price hikes in 2008, 2010 and onward stimulated private sector partners participation in agribusiness including rice development. In response to the growing interest of both public and private sectors, the CARD secretariat started proactively contacting private enterprises, including input industries (seed, fertilizer), farm operators, agro-machinery businesses and traders. It also set venues for dialogue among all interested parties. In 2012, the Secretariat started supporting six volunteer countries to extract policy elements jointly with private sectors and producers to promote agro-mechanization in rice development. Preliminary findings from the exercise were shared with all participants at the GM5 in 2013 for further discussion to develop mechanization action plans in each country. Also at GM5, private farm operators, mostly new-comers in SSA, were invited. They shared, with many other participants from both private and public sectors, their lessons and expressed their demands for policy adjustment needed for further investment.

In 2013, the exercise will be extended to the input business such as seed and fertilizer in some volunteer countries. These exercises will also be complimentary to on-going policy dialogue at the sector-wide level throughout the continent, such as the Cooperation Framework under G8 New Alliance.

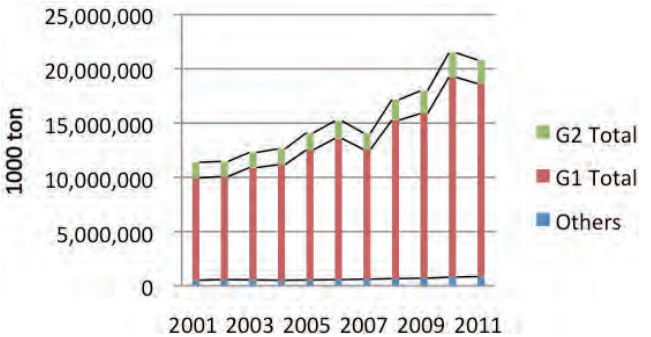
SOME FACTS ABOUT CARD

Trend in Rice production in SSA

The CARD secretariat summarized the current status of rice development in SSA at the GM5 in Senegal in February 2013.

Figure 7. shows break down of volume of paddy production in SSA by group in 2001-2011 based on FAOSTAT data.

Fig. 7 Paddy Production in SSA (2001-2011, FAOSTAT)

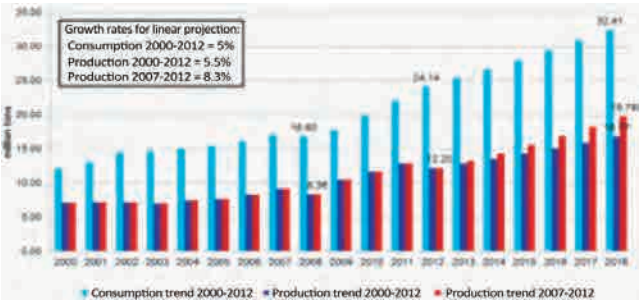


According to FAO STAT, production of rice (paddy) in SSA (a total of 39 countries where data is available) is 18 million tons (average of 2007-2011), an increase of 39% from the base line production of 13 million tons (average of 2002-2006). The area cultivated for rice increased from 17% to 9.2 million ha (average 2007-2011) from 7.8 million ha (average of 2002-2006).

A positive yield trend from 1.7t/ha in the base period to 2.0t/ha in the next 5-year period is observed. It is the fastest improvement of the yield in the past few decades in the region; however, it is still far too low compared with the yield level achieved in many Asian rice producing countries.

Figure 8, prepared by Africa Rice Center (ARC) for the GM5 based on USDA data, shows the projection of consumption and production in SSA toward 2018. ARC estimates that the CARD's target figure in 2018 can be achieved if the growth rate of production in the last 5 years is maintained in the coming years (about 8.3% per annum).

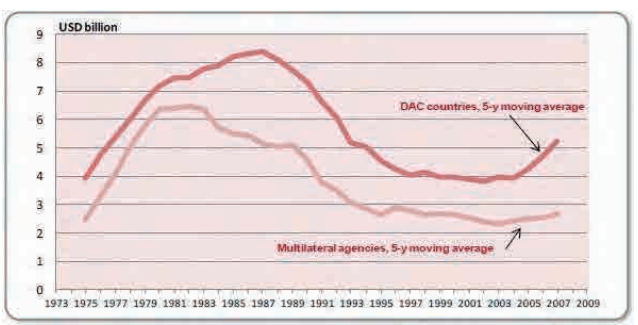
Fig. 8 USDA production and milled rice consumption (prod + imports) T2000-2012



Revive of investment in the agricultural sector including rice-related segments

World Development Report 2008 of the World Bank cautioned about the waning interest of both national governments and development partners in agricultural sector development. According to the OECD/DAC records, since the Maputo Declaration of CAADP in 2003, and encouraged by the global price hike of commodities including food/agricultural products, the trend of declining ODA investment in agriculture has been reversed (Figure 9 , OECD/DAC, Dec. 2011). MDBs, EU, USAID and other major sources of ODA finance expressed their commitment to support the sector and food security-related subjects in recent years and hope this upward trend would continue.

Fig. 9 Trends in aid to agriculture and rural development (ARD) 1971-2009, 5-year moving average commitments, constant 2009 prices



Impact of CARD initiative on JICA's own operation

While JICA has been supporting the administration of the initiative since it was launched, CARD has impacted JICA's operation in various ways. Firstly, this was the first ever wide-scale, multi-actor developmental initiative that JICA initiated and managed through the whole process. The process has presented JICA with enormous challenges, from structuring and leading the discussion for sound organizational design, to communication with members for building up the common ground of understanding, to managing efficient information, and to coordinating and accommodating the differentiated interests of participants. This has certainly been a capacity building exercise for JICA, and the lessons learned thus far will help improve the efficiency of the initiative's management and improve JICA's responses to other initiatives in which it may participate.

Secondly, through the process, JICA could refocus its advantage—a strong network of offices in the region—and take steps to better use this advantage. JICA's organization functioned well to support the Secretariat in sensitizing and mobilizing its counterparts in the relevant ministries and departments and helped to accelerate the in-country exercise of NRDS. This process was an additional burden for JICA's country offices, but the extra burden was well compensated for by better communication and widened coverage of the dialogue in related subjects. As most of the programs and projects are formulated on a country basis and beneficiaries of each intervention are defined country-wise, it often happens that the organizational scope tends to be limited likewise. However, the value chain approach adopted in CARD and extensive discussion in the related events and in-country consultation helped JICA's country-wise interventions become more flexible and wider in scope.

Thirdly, exercises of NRDS in countries and related dialogues accelerated the shift or widened the scope of JICA's intervention, which had tended to focus on production. Most of the rice-related projects formulated and implemented since the start of CARD in the past 4-5 years have components relating to post-harvest and market orientation. As a result, these interventions came to combine elements of productivity in the field with competitiveness in the market; projects in Ghana, Senegal, Uganda, Tanzania, and others are such examples. Althoughthishybridmodelis still young and JICA needs to accumulate

more data and experience, it is hoped these types of projects will contribute to fill the gap between producers and the market which is often left unattended.
Fourthly, CARD provided opportunities for interaction and mutual learning for all participants including JICA. Often staff in the country office and technical experts in the field of development partners devote themselves to their own specific country program or projects with defined terms of reference, but have had few opportunities to learn from other interventions. A series of CARD events offered venues where JICA personnel from various country programs could meet professionals of other institutions and discuss and exchange views on a wide range of subjects along the rice value chain. Deriving from these interactions, there will be more opportunities for synergies across programs and projects in the sector.

CHALLENGES FACING CARD IN THE SECOND FIVE YEARS

There are enormous challenges common to all CARD partners in the second five years.
Among others, as the author sees it, here are some of the most important issues to be dealt with in the forthcoming CARD events:

1. Quality of prioritized intervention for rice development in each country.
2. Scientific-based monitoring of performances of programs/ projects under the Initiative.
3. Strengthened coordination among partners for materializing synergies.
4. Public Private Partnership for input industry, mechanization and others.
5. Alignment with sector strategies and regional focus.

The nominal target of "doubling rice production in 10 years" is expected to be achieved by the end of the term of this initiative, but achievement is subject to stable local demand for rice, continued collaborative actions among partners, and the stable and continuous upward trend of resource allocation to this subsector. The real challenge, therefore, is still ahead of us. The partners working under the umbrella of the CARD initiative, including JICA, do not underestimate the magnitude of the difficulties.

But if this venture turns out to be successful, in five years we will be able to see, though with varying degrees in different countries, signs of contributions of rice production to people's improved food security, and the agricultural sector of some countries having been strengthened as an industry. Toward that end, JICA is determined to continue to work together with all partners, employing the various instruments it has at its disposal from human capacity building to economic infrastructure development.

How Promising Is the Rice Green Revolution in Sub-Saharan Africa? - Evidence from Case Studies in Mozambique, Tanzania, Uganda, and Ghana[1]

Keijiro Otsuka

1. Introduction

While the population continues to grow rapidly, the pace of area expansion has slowed down considerably in sub-Saharan Africa (SSA) due to the gradual exhaustion of uncultivated areas. On average, cultivated land per farming population has declined by about 40% since the 1960s and value added per worker now averages around 12% below 1980 levels. Investments in the development of new technologies have declined in recent years even though their adoption rates are low compared to other regions. In order to reduce widespread and persistent rural poverty in SSA, it is imperative to increase food production by increasing the productivity per unit of land.

We believe that what is urgently needed in SSA is a Green Revolution, which has successfully increased rice and wheat yields in tropical Asia over the last several decades. In Asia, small farmers actively adopted new improved technologies (David and Otsuka 1994), and there is no reason to assume that small farmers in SSA will not adopt new profitable technologies (Otsuka 2006; Otsuka and Kijima 2010). Yet the appropriate strategies to realize a Green Revolution in SSA are still unclear. Recent studies edited by Otsuka and Larson (2013), which compare the experience of the Asian Green Revolution with current grain farming in SSA, suggest that lowland rice is the most promising grain. This is essentially because high-yielding rice technology can be directly

1. This is a result of a research project being conducted at JICA Research Institute to empirically analyze how best the CARD initiative (See Chapter 2, Section 3) can serve to increase rice productivity and reduce poverty. I am heavily indebted to its members, namely Yoko Kijima, Kei Kajisa, Yuko Nakano, and Takeshi Sakurai. I would also like to thank JICA Research Institute for the intellectual and financial support it provided for this project.

transferable from tropical Asia to SSA (Estudillo and Otsuka 2012; Nakano et al. 2012).

This is illustrated by Figure 1, which compares changes in grain yields over time in India and SSA and their differences between the two regions. India is chosen for comparison because among Asian countries India is agro-climatically similar to SSA and, hence, cropping patterns are not so different (Tsusaka and Otsuka 2013a, 2013b).[2] Several important observations can be made. Firstly, grain yields were generally similar between India and SSA in the early 1960s before the Green Revolution began, which indicates that the difference in agro-climatic conditions alone cannot explain the large yield difference between the two regions at present. Secondly, the yields of sorghum and millet did not increase much even in India and the yield gap between the two regions is nil, which suggests that the potential of a Green Revolution in these crops is limited in SSA. Thirdly, the current yield gap is substantial in the case of wheat and rice, even though their yields increased appreciably in SSA. Since wheat can be produced primarily in a temperate zone, its potential production area is more limited than rice in SSA due to the dominance of a tropical climate. Thus, rice is likely to be critically important for the expansion of grain production in SSA. Furthermore, rice consumption has been increasing dramatically in this region in the past few decades. Lastly, the yield gap is only modest in maize, even though maize is the most important crop in SSA in both production and consumption. It is likely that the productivity gain in the maize sector in SSA from a technology transfer from Asia will not be large.

Although rice looks a promising crop from the aggregate data, micro-level evidence is needed to substantiate the argument that rice is the most promising crop in SSA. The first purpose of this study is to analyze the potential of a rice Green Revolution in SSA based on recently completed cases studies of rice-growing households in Mozambique, Tanzania, Uganda, and Ghana.[3] The second purpose is to draw up the

2. For example, sorghum and millet are grown in many countries in SSA but primarily in India in Asia. Analytically, however, a comparison between tropical Asia as a whole and SSA does not lead to major changes in our discussion (Estudillo and Otsuka 2012).

3. Senegal is also included in this project but the data collection has been delayed, so its analytical results will be reported later. Note, however, that according to our preliminary survey, the average irrigated rice yield in the Senegal River basin exceeds 5 tons per hectare, which is comparable to the irrigated yields in Asia.

implications of an effective strategy for a rice Green Revolution in SSA. We believe that, if successful, a rice Green Revolution can be a role model for Green Revolutions in other grains, particularly in maize production.

2. Is Asian Rice Technology Transferable to SSA?

Asian rice technology. Although the rice yield is still low in SSA, we should not overlook the fact that it has increased from 1.25 tons per hectare in the early 1960s to 1.8 tons per hectare in the late 2000s. In tropical Asia where lowland rice production dominates, the rice yield before the Green Revolution was 1.5 tons per hectare (see Figure 1).[4] Also, note that half of the rice area in SSA is upland, where the yield is substantially lower than in lowland paddy fields (Balasubramanian et al. 2007). Thus, it seems reasonable to assume that if new technology is not introduced and production is carried out under rain-fed conditions, the lowland paddy yield will range from 1.0 to 1.5 tons per hectare. We also hypothesize that the average rice yield has increased in SSA primarily due to the introduction of Asian-type improved rice technology.[5]

We focus on lowland rice, not upland rice, primarily because the prospect for a large improvement of the yield is much greater for lowland rice than upland rice. We also did not encounter upland rice, such as NERICA (new rice for Africa), in our study sites except in Uganda. Kijima et al. (2006, 2008, 2011) found that NERICA is potentially high-yielding but sensitive to rainfall and that the rate of discontinuation of NERICA adoption is also high, indicating that NERICA was grown in unsuitable areas or that sustainable management was not well understood by farmers. Also, the NERICA yield is exceptionally high in Uganda compared with other countries in SSA (Otsuka and Larson 2013). The tentative conclusion of this study is that upland rice is not particularly promising, even though there were great expectations for the impact of NERICA on the upland rice yield.

The Green Revolution in Asia is alternatively called the seed-fertilizer revolution because the engine of growth was the development and

4. Nearly half of the paddy fields were irrigated in Asia but the difference in yield between rain-fed and irrigated areas was not large before the advent of MVs.

5. This is consistent with the results of a review of rice farming in SSA by Balasubramanian et al. (2007).

diffusion of fertilizer-responsive, high-yielding modern varieties (MVs) of lowland rice (David and Otsuka 1994). It is also important to realize that paddy fields were bunded and leveled almost without exception in Asia when the rice Green Revolution began.[6] Bunding is needed to store water in the paddy fields to reduce weed growth, whereas leveling is necessary for even growth of rice plants and germination of directly broadcasted seeds. In other words, these production practices are essential for water and weed control and healthy growth of lowland rice plants. Draft animals or tractors are usually used for bunding and leveling, but they are often not used in SSA, as will be shown shortly. No less important than these production practices is straight-row transplanting, which provides space for weeding. Instead of transplanting, direct seeding can be adopted without sacrificing yield if paddy fields are bunded and leveled well and if herbicide is used. Herbicide, however, may not be available or may be too expensive, even if available in SSA. In the African setting, direct seeding is not generally recommended and transplanting is the generally preferred option. A major contribution of this study is to establish that these improved production practices are highly complementary to improved seed-fertilizer technology.

The case of Mozambique. Table 1 compares yields and production practices across rain-fed and irrigated areas in Mozambique (Kajisa and Payongayong 2011a, 2011b). Thirty-three villages in 9 districts in Zambezia and Sofara provinces in the Central region are chosen as representative rain-fed areas in this country, whereas the Chokwe irrigation scheme in the southern region is chosen as the irrigated study site. As in other countries in SSA, the irrigated area accounts for a small proportion of paddy area in this country. Furthermore, MVs are seldom adopted, chemical fertilizer is not used, and animal and tractor use is nil in rain-fed areas. Under such conditions, the rice yield is very low and unstable with the average being a mere 1.1 tons per hectare, which is consistent with our expectations. The yield per hectare is not very high in the Chokwe irrigation scheme either, mainly because the irrigation facilities are not well maintained. In fact, the top 20% of farmers, who receive adequate water, adopt MVs, and apply fertilizer, achieve a rate as high as 3.9 tons per hectare. Note that popular MVs are old MVs

6. There is no clear evidence on the prevalence of bunding and leveling in paddy fields in Asia in the 1960s and 1970s. My argument is based on interviews with rice scientists who worked in Asia in the 1970s.

developed in Nigeria (ITA312) in the late 1970s by crossing Asian MVs and African local varieties.[7] This clearly shows that there has been no attempt to transfer new Asian-type varieties to Mozambique. The yield could be higher if more modern improved MVs had been disseminated in Chokwe.

The case of Tanzania. The case of Tanzania is more revealing (Table 2). The three major rice growing districts with distinctly different production environments were chosen for this study. First, the average yield in rain-fed areas ranges from 1.6 tons per hectare in the Shinyanga region to 2.0 tons per hectare in the Morogoro region, which is much higher than in rain-fed areas in Mozambique. This relatively high yield in rain-fed areas in Tanzania can be attributed, at least partly, to some adoption of MVs, some chemical fertilizer application, and the adoption of some improved production practices. Second, the yields are considerably higher in irrigated areas. The adoption rate of MVs is very high in the Morogoro region, whereas chemical fertilizer use is high in the Morogoro and Mbeya regions. Note that there is no tradition of rice production in Tanzania, so even "traditional varieties" are imported improved varieties from abroad. This would explain why the yield is as high as 4.6 tons per hectare under irrigated conditions in the Shinyanga region, even though the adoption rate of MVs is very low. Third, the adoption rates of bunding and leveling are close to 100% in irrigated areas, which seems to help explain the considerably high yields in irrigated areas in Tanzania. Thus, it is clear that a combination of improved seeds, improved production practices, and irrigation leads to significantly high yields, resulting in a "mini" Green Revolution in this country.

The case of Uganda. The importance of improved production practices can also be clearly seen from the case study of basically rain-fed areas in the Eastern Region in Uganda (see Table 3), as reported by Kijima, Ito, and Otsuka (2011, 2012). Note that Bugiri and Mayuge were sites of a participatory rice training program offered by JICA, whereas no such training was offered in Bukedea and Pallisa. Also note that the demonstration of a simple irrigation scheme was implemented only in Bugiri. Roughly speaking, the difference between Bugiri and Mayuge is due primarily to the presence of irrigation in the former, whereas a major

7. To our surprise, C4, which was developed in the early 1960s by the University of the Philippines, Los Banos, was adopted in 22% of the paddy fields in Chokwe.

part of the difference between Burigi-cum-Mayuge and Bekedea-cum-Palissa is due mainly to the implementation of a rice training program in the former areas, even though some yield differences can be attributed to differences in agro-climate. In Bugiri, where Asian-type MVs are adopted in more than 40% of paddy fields, the yield and the number of improved production practices adopted are positively correlated, indicating that MVs and improved production practices are complementary. Considering that chemical fertilizer is not applied in Uganda, the yield of more than 4 tons per hectare is impressively high, indicating the high potential of rice yields in this country due to relatively high precipitation and fertile soil. It is likely, however, that such high yield is unsustainable, unless fertilizer is applied to maintain soil fertility.[8] The yield in Mayuge is reasonably high if all four improved production practices are adopted. In contrast, the yields are much lower and variable regardless of the adoption of improved practices in Bekedea and Palissa. Even if improved production practices are adopted, whether they are adopted properly can be questioned, as these areas were not covered by the training program. The average yield in these two sites is 1.8 tons per hectare, which is not low compared with other rain-fed areas in SSA. A critically important finding of the Uganda case study is that the rice training program encouraged the adoption of improved production practices and improved the profitability of rice farming (Kijima, Ito, and Otsuka 2012).

It must be pointed out that the rain-fed area in Uganda is located at the bottom of a valley. Although it is rain-fed, its production environment is favorable for lowland rice production, because the soil is fertile and moist. In my observations, such production environments are abundant in SSA, and most have been unused until recently. Probably for rice production such rain-fed area is more favorable than rain-fed areas in Asia, most of which are located in flat areas. The Northern Region in Ghana is another example of a rain-fed area at the bottom of a valley with mild slopes, which has huge potential to increase rice production.

8. In the Doho irrigation scheme located in the Easter Region, the rice yield is about 3 tons per hectare, even though double cropping of rice has been practiced for a few decades without chemical fertilizer (Nakano and Otsuka 2011).

The case of Ghana. The case study in Northern Ghana is unique in that it compares the rice farming performance between villages where the Lowland Rice Development Project (LRDP) was implemented and villages where no such project was implemented (deGraft-Johnson et al. 2012). Twenty project villages and 40 non-project villages were selected randomly for this study and in each village 20 rice-farming households were surveyed.[9] Out of 40 non-project villages, 20 are located within a 20-kilometer radius of any of the project villages and the other 20 are located beyond the 20-kilometer radius. The former are called "nearby villages" and the latter "remote villages." The LRDP, which was implemented from 1998 to 2003, was designed to promote the dissemination of MVs, chemical fertilizer use, bunding, leveling, and dibbling.[10] Aside from the practice of dibbling, the four technologies are essential components of Asian Green Revolution technology. Thus, in a sense, the purpose of LRDP was to transfer Asian Green Revolution technology to SSA. Transplanting was not recommended because this area suffers from floods and seedlings cannot survive under submerged conditions.

According to Figure 2, improved technologies were seldom adopted before the implementation of the LRDP. During the LRDP implementation period they were adopted primarily in the project villages, whereas they were diffused to nearby villages after the LRDP period, suggesting technology spillovers from the project to other villages. The adoption rates of new technologies are generally low in remote villages.[11] It is clear that the adoption rates of both MVs and chemical fertilizer are equally high, which indicates the strong complementarity between fertilizer-responsive MVs and fertilizer. Leveling is adopted by about half of the sample farmers at present, whereas bunding and dibbling are not widely adopted. Another important observation is that the rate of dis-adoption, i.e., adoption in the past but discontinuation later, is high for dibbling. According to our respondents, dibbling is highly labor-intensive, and this is the major reason for dis-adoption. Thus, we suspect that dibbling may not be appropriate technology in this region.

9. Reliable data were obtained from 545 households.

10. Dibbling is a crop establishment method in which seeds are planted in holes created by sticks. Dibbling is not needed, if paddy fields are well bunded and leveled so that broadcasted seeds are germinated well.

11. Socio-economic conditions are very similar between the project and nearby villages, whereas the remote villages are far from the capital city and endowed with large land areas.

Table 4 summarizes the technology adoption, paddy yield, labor use, and the factor share of labor. It is clear that the rice yield is lowest among non-adopters of new technology, which is 1.5 tons per hectare and falls in the expected range under rain-fed conditions without new technologies. The yield becomes higher as larger amounts of new technologies are adopted. It is interesting to observe that an average yield of 2.6 tons per hectare among full-package technology adopters is almost identical to the average lowland rice yield under rain-fed conditions in Asia in the late 1980s reported by David and Otsuka (1994). This indicates that the yield potential under rain-fed condition in SSA is not inferior to that in tropical Asia. While it is true that labor use per hectare becomes larger with increases in the adoption of new technologies, the factor share of labor tends to decline, which indicates that new technologies are not labor-using.

In sum, our case studies demonstrate large potentials to increase rice yields in SSA by disseminating Asian Green Revolution technology. Although we did not discuss in detail in this article, our case studies indicate that new technologies are not only productive but also profitable. In short, Asian rice Green Revolution technology is directly transferable to SSA.

3. Key Questions

Before recommending further dissemination of new technologies, we must ask a few key questions. The first question is whether the benefit of new technologies accrues to small farmers. If these new technologies are adopted primarily by large farmers, their contribution to poverty reduction is limited, because it is small farmers who suffer from poverty (Yamano, Otsuka, and Place 2011). The second question is what the major constraints are on the adoption of new technologies. In order to disseminate new technologies to wide areas, we have to remove such constraints.

Commonly our case studies do not find any significantly positive effect of farm size on technology adoption. In the case of Ghana, it has a negative and significant effect on the adoption of dibbling, which is highly labor-intensive. In both irrigated and rain-fed areas in Mozambique (Kajisa and Payongayong 2011a, 2011b) and Uganda

(Kijima, Ito, and Otsuka 2011), the effects of farm size on paddy yields are found to be negative, implying that the yield per hectare is higher on smaller farms. These findings are consistent with the negative correlation between farm size and yield widely observed in SSA recently (Larson et al. 2012), which can be explained by the higher intensity of family labor on smaller farms.[12] While the effect of farm size on rice income per hectare is negative and significant in Tanzania (Nakano and Kajisa 2012), no effect on profit is found in Uganda and Ghana (Kijima, Ito, and Otsuka 2012; deGraft-Johnson et al. 2012). Thus, there is no evidence that new rice technologies particularly favor large farms. On the contrary, they seem to be conducive to equitable distribution of income in rural communities in SSA by offering expanded work opportunities for family labor, which is a major resource of poor small farmers. This is consistent with the observations in Asia that the impacts of the rice Green Revolution technology are neutral with respect to farm size (David and Otsuka 1994).

While irrigation is found to be an important determinant of rice yield, there is no evidence that it is necessary for the adoption of new technology. Considering that rain-fed areas dominate in SSA, a critically significant finding of this study is that the improved rice technologies have significant impacts on the rice yields under rain-fed conditions. Judging from the results of studies in the rain-fed areas of Uganda and Ghana (Tables 3 and 4), it seems possible to increase rice yield by 50 to 100% by adopting the improved technologies. In order to increase the rice yield much further, irrigation is needed. Whether irrigation investment pays is an important issue to be examined carefully.

The finding that training activities with demonstration plots are effective in the dissemination of the new rice technologies in Uganda and Ghana suggests that a major constraint on the wider adoption of the new technologies is the farmers' lack of knowledge on new technologies. According to the case study in Ghana (deGraft-Johnson et al. 2012), the spillover effects of new technology adoption in the project villages on the adoption in non-project villages are significant in the case of bunding and leveling but not in the case of MVs and fertilizer applications. The authors argue that this is due to the fact that while the bunding and

12. Monitoring of hired labor in a spatially wide environment in agriculture is costly, so that the endowment of family labor relative to farm size is the critical determinant of crop yield (Hayami and Otsuka 1993).

leveling are visible and imitable, the know-how on appropriate cultivation of MVs with fertilizer cannot be easily copied. If this is true, it may be a good idea to set up a relatively small number of demonstration plots compared with the number of locations where training programs are offered.

Kijima et al. (2011) find that the dis-adoption rate of NERICA is very high (i.e., in the vicinity of 50%). This is either because NERICA was disseminated to unsuitable areas for production or because sustainable management was not well understood by farmers. Indeed, there is the indication that yields of NERICA decline over time due to the deterioration of self-produced seeds or soil quality. In either case, the major problem is that appropriate production knowledge of NERICA was not disseminated to rice farmers.

It is clear that the absence of an effective extension system is a major constraint on the rice Green Revolution in SSA. In Ghana, even though the LRDP was an effective program, similar programs have not been implemented for nearly 10 years. In Uganda, the geographical coverage of the training program is very small. It is worse in Mozambique where no extension program for rice farming has been carried out. Actually, there are a very small number of agricultural extension workers in SSA. Furthermore, only a few of them are knowledgeable about rice farming. Unless we invest in the capacity building of extension workers, the target of CARD (Coalition for African Rice Development), that is the doubling of rice production in ten years from 2008, may not be achieved.

Another possible constraint on technology adoption is the lack of credit. Kajisa and Payongayong (2011) argue that the lack of credit access leads to the insufficient application of chemical fertilizer as well as hired labor use in the Chokwe irrigation scheme in Mozambique. Similarly, Nakano and Kajisa (2011) report that the access to formal credit is an important determinant of fertilizer use, but not MV adoption in Tanzania. MV seeds can be self-produced and, hence, credit access is unlikely to be important in MV adoption. While improving access to credit is likely to be important to increase fertilizer application, it is also remarkable to realize that considerably high rice yields are achieved without functioning credit markets in our four study sites. Therefore, it seems fair to conclude that improved credit access is desirable but not essential for the improvement of rice yields in SSA. Furthermore, according to our

ongoing research in the Mwea irrigation scheme in Kenya, which is a large irrigation scheme consisting of 12,000 hectares with well-maintained facilities, rice yields are as high as 5 to 7 tons per hectare and credits are supplied not only by agricultural cooperatives but also by rice traders, as in many rice growing areas in Asia. It may well be that large demand for fertilizer induces the development of informal credit markets, where standing crops serve as the role of credit.

4. Concluding Remarks

The four case studies we have reviewed in this article clearly demonstrate that in order to realize the rice Green Revolution in SSA, high-yielding MV seeds, application of fertilizer, and the adoption of bunding and leveling are essential. We found that very high yields are realized in some irrigated areas in Tanzania and Uganda and reasonably high yields are achieved in some rain-fed areas in Tanzania, Uganda, and Ghana. Commonly in these areas, Asian type-MVs as well as bunding and leveling practices are adopted. These findings indicate that Asian rice technology can be *directly* transferable to SSA.[13] On the other hand, there are many areas in SSA where unimproved varieties are adopted, chemical fertilizer is not used, and paddy fields are not bunded and leveled. In such areas, the rice yield is low and ranges from 1.0 to 1.5 tons per hectare, which is close to rice yields in Asia before the Green Revolution. These observations strongly indicate that a strategic priority on the capacity building of extension specialists on rice and strengthening extension activities for rice production will be warranted, in order to realize a rice Green Revolution in SSA.

So far, however, inadequate resources have been allocated to the capacity building and extension. Unless more resources are allocated to these activities, the efforts to realize a rice Green Revolution in SSA are bound to fail.

Since MVs are fertilizer-responsive, once they are adopted, demand for fertilizer will increase, which, in turn, will increase the demand for credit. Similarly, since MVs are more productive under irrigated conditions, adoption of MVs will increase the demand for irrigation

13. Asian varieties, however, are susceptible to yellow mottle virus, which is unique to SSA. Thus, MVs tolerant to this virus must be developed urgently (Balasubramanian et al. 2007).

water. Thus, the benefit and cost of credit programs and irrigation projects must be carefully reassessed, while considering the large expected gains in productivity and profitability of rice farming in SSA.

We have been conducting research on lowland rice production partly because it is the most promising crop and partly because the success of the developing rice sector in SSA can provide a model for a successful Green Revolution in SSA. According to Otsuka and Larson (2013), profitable and productive maize technology is yet to be established. Indeed, although maize is the single most important crop in SSA, we seldom observed impressively high maize yields anywhere in SSA. It seems to us that the prerequisite for a maize Green Revolution is the development of truly profitable and productive maize seeds and farming practices for this crop. Once such technology is developed, it will trigger the change towards the maize Green Revolution in SSA. It is our hope that successful development of the rice sector can be a role model of the Green Revolution in other crops in this region.

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Table 1. Paddy yields and production practices in Mozambique

	Chokwe irrigation scheme	Rain-fed areas in central region		
		Bottom 1/3	Middle 1/3	Top 1/3
Yield per ha (tons)	2.1	0.3	0.8	2.2
Use of MVs (%)	92	0.0	0.0	3.0
Fertilizer use (%)	52	0.0	0.0	0.0
Plots with bund (%)	100	52	41	43
Animal use (%)	48	0	2	5
Tractor use (%)	55	2	5	2
No. of sample households	176	66	66	65

Table 2. Rice yields, the use of modern inputs and improved production practices by region and irrigation status in Tanzania

	Morogoro		Mbeya		Shinyanga	
	Rain-fed	Irrigated	Rain-fed	Irrigated	Rain-fed	Irrigated
Paddy yields (t/ha)	2.0	3.8	1.6	3.5	1.7	4.6
Modern inputs use						
Share of modern varieties (%)	17.8	87.5	0.0	2.1	1.9	13.1
Chemical fertilizer use (kg/ha)	11.7	40.4	10.7	31.7	0.9	0.0
Improved practices						
Share of bunded plots (%)	8.2	84.8	16.3	89.6	95.3	100.0
Share of leveled plots (%)	22.0	69.6	38.5	78.1	87.6	100.0
Share of straight row transplanting plots	4.4	47.8	3.8	22.9	6.4	0.0
No. of sample households	182	46	104	96	234	10

Table 3. Rice yields (ton/ha) according to the cultivation practices adopted in September 2008 – August 2009 in Uganda [a]

	All	Bugiri	Mayuge	Bukedea	Pallisa
4 practices	4.13	4.47	2.89	1.22	0.37
3 practices	3.20	4.15	1.89	---	1.54
2 practices	2.25	3.07	2.00	3.95	2.26
1 practice	1.81	2.30	1.91	1.89	1.38
Non-adopters	1.33	---	0.79 [b]	1.42	0.66 [c]
Fertilizer use	7.55c	7.55 [d]	---	---	---
Adoption of MVs (%)	19.6	43.8	40.0	5.0	1.6
No. of sample households	300	75	75	75	75

a. The numbers show the means for the rice yield in tons per hectare. The adoption of 4 practices means bunding, leveling, proper timing of transplanting, and straight-row planting.
b. Only 1 observation.
c. Only 3 observations.
d. Only 4 observations.

Table 4. Technology adoption, paddy yields, labor inputs, and factor share of labor in Northern Ghana

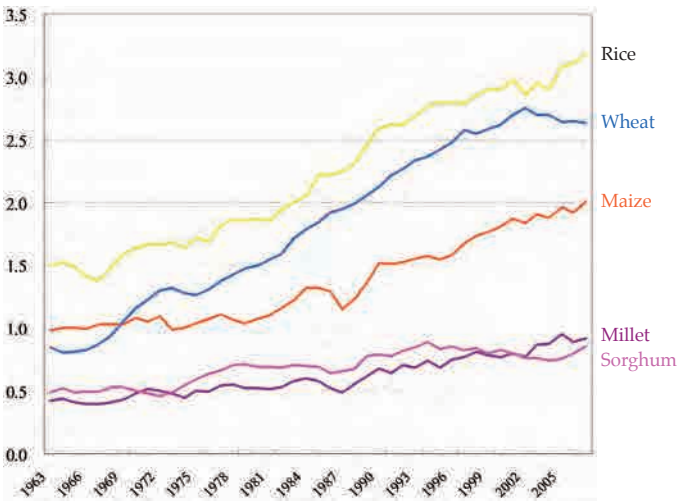
	No adoption	Partial adoption				Full adoption
		Modern inputs onlya	Some modern inputs	Modern inputs, bunding, and leveling	Some modern inputs, bunding and leveling	
No. of households (%)	63 (11.6)	78 (14.3)	349 (64.0)	37 (6.8)	84 (15.4)	47 (8.6)
Yield (ton/ha)	1.46	1.70	1.95	1.98	2.33	2.59
Labor (days/ha)	102	152	187	204	238	264
Factor share of labor (%)	61.5	62.6	54.6	52.8	49.5	47.6

a. Modern inputs refer to the adoption of MVs and chemical fertilizer application.
b. Factor share of labor is the total cost of labor divided by the total value of production.

Figure 1. Grain yields in India and SSA, 3-year moving averages.

Figure 1a. India

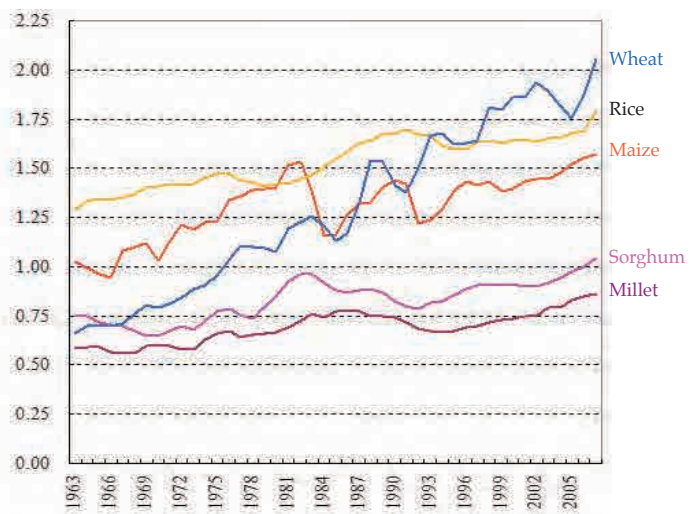
Yield (Ton/ha)



Source: FAOSTAT

Figure 1b. SSA

Yield (Ton/ha)



Source: FAOSTAT

Figure 2. Adoption of new technologies before, during, and after the Lowland Rice Development Project (LRDP) in Northern Ghana.