MAIN TEXT

CHAPTER 1 PURPOSES, SCOPE AND SCHEDULE OF THE STUDY

1.1 Background and Purposes of the Study

In West Africa, the consumption of rice as one of the main staple food has considerably increased in recent years, particularly in urban areas. At the same time, many countries in the region have lost the opportunity of increasing rice production, despite the potential of meeting the increasing demand for rice with domestic production because of the influx of cheap imported rice at a cost of more than US$1 billion a year. Meeting the increasing demand with domestic rice has become an urgent task for West African countries not only to improve the income of farming households, to create employment opportunities in rural areas but also to save foreign exchange. In order to achieve this task successfully, research and extension of appropriate technologies enabling the effective use of local resources are essential in addition to the improvement of marketing mechanism. However, the tight fiscal situation makes the implementation of these measures quite difficult for West African countries.

With rich experience of providing cooperation for rice farming in Asia over a long period of time, Japan has accelerated cooperation for rice farming in Africa as a part of the assistance programs based on TICAD II held in 1998. Various efforts are being made, including research cooperation to enhance the productivity of rainfed rice cultivation and technical cooperation to improve small-scale irrigated cultivation with the participation of farmers. Some examples of such cooperation are the development of New Rice for Africa (NERICA) varieties under five year cooperation between WARDA and JIRCAS, the Small-Scale Irrigated Agriculture Promotion Project in Ghana assisted by JICA, the Integrated Inland Valley Bottom Development Project with Farmer Participation by JICA and the Project for Supporting Development of Small-Scale Rice Farming Groups in Côte d'Ivoire by AICAF. An urgent task is for Japan to examine possible measures of cooperation to meet the rapidly increasing demand for rice, taking the results and lessons of the preceding cooperation efforts into full consideration.

The primary purpose of the Study is to assess the present situation of the research and extension of rice cultivation technologies based on the findings of field studies conducted in three countries, i.e., Italy (FAO), Côte d'Ivoire and Guinea. The Study will also incorporate the comments of the Study Group, consisting of experts on rice production and consumption in West Africa (JICA, JBIC, JIRCAS, international organizations, universities, media and NGOs). The second purpose of the Study is to propose the desirable direction for Japan's international cooperation in agricultural research and extension in West Africa. It is also hoped to present the recommendations for TICAD III as one of possible roles to be played by Japan for agricultural development in Africa. For technical extension, in particular, it is essential to diffuse the necessary and available/affordable technologies for farm households under the existing socioeconomic conditions in West African rural areas.

1.2 Scope and Schedule of the Study

The Study consisted of the study in Japan and the field study.

1.2.1 Study in Japan

(1) Analysis of Existing Reference Materials

Using existing reference materials, the present situation and future prospects of the rice supply and demand in West Africa were outlined while the present situation and issues of cooperation by Japan and other donors for the research and extension of rice farming were examined.

(2) Study Group Meetings

The members of the Study Group consisted of those with experience and knowledge concerning rice farming in Africa. The Study Group met three times during the study period to discuss the present situation and issues of the research and extension of rice cultivation technologies, focusing on West Africa, where rice is becoming more important as the staple food. The Study Group also examined possible international as well as Japanese cooperation to attain self-sufficiency in rice. The issues were examined not only from the viewpoint of developing and extending rice farming techniques/technologies but also from the viewpoint of rural development, particularly the improvement of farm income and gender equality.

1.2.2 Field Study

The field study was conducted in Côte d'Ivoire and Guinea for a total period of three weeks in August 2002. In addition to assessing the agricultural policies and rice supply and demand situation in these countries, the field study focused on 1) NERICA, 2) inland valley bottom farming system and 3) SG2000's activities, all of which have positive implications for the expansion of rice farming in West Africa in the future. In Côte d'Ivoire, WARDA, an international research institute under the Consultative Group for International Agricultural Research (CGIAR), was visited to learn the present situation and issues of the extension of their research results, including those related to NERICA varieties. NERCA is widely seen as the key to the future productivity improvement of rice cultivation in Africa. In addition to the situation and future prospects of rice cultivation in inland valley bottom fields, the Farmer Participatory Varietal Selection Research (PVS), which aims at transferring improved varieties to farmers more effectively, and other efforts were also studied. In Guinea, the study mainly focused on the intensive rice cultivation promoted by SAA under the program of self-sufficiency in rice, which is given the highest priority by the government. Through these studies, the present situation and issues of rice production in the two countries were identified and concrete methods to overcome the constraints for an increased self-sufficiency rate were examined from the viewpoint of agricultural research and extension.

1.3 Study Group Members

Chairman

Dr. Kunio Takase	Advisor, International Development Center of Japan (IDCJ)

Members

Mr. Mitsuya Araki	President, International Development Journal (IDJ)
Dr. Ryoichi Ikeda	Director, Biological Resources Division, Japan International Research Center for Agricultural Sciences (JIRCAS)
Dr. Shoichi Ito	Associate Professor, Faculty of Agriculture, Tottori University
Mr. Shiro Okabe	Former Director General, UN/ESCAP CGPRT Center
Mr. Yuzo Kobayashi	Operation Department, Association for International Cooperation of Agriculture and Forestry (AICAF)
Dr. Yoko Takagi	International Research Coordination Officer, Japan International Research Center for Agricultural Sciences (JIRCAS)
Mr. Teiji Takahashi	Director, Liaison Office in Japan, UN/Food and Agricultural Organization (FAO)
Ms. Mihoko Tamamura	Director, UN/World Food Programme (WFP) Office in Japan
Mr. Noboru Nagaoka	Editorial Writer, Asahi Shimbun
Ms. Yoshimi Nagamine	Deputy Director, News Analysis and Commentary Department, Yomiuri Shimbun
Dr. Kazuo Hanzawa	Professor, School of Bioresource Science, Nihon University
Dr. Shinsuke Horiuchi	President, International Development Associates Ltd.
Mr. Iwao Matsumoto	Former JICA Expert
Dr. Tetsuo Matsumoto	Professor, International Cooperation Center for Agricultural Education (ICCAE), Nagoya University
Dr. Shoichi Mizutani	Professor, Faculty of Agriculture, Utsunomiya University
Mr. Masataka Minagawa	Head of Finance and Administration, Sasakawa Africa Association (SAA)
Mr. Masao Miyazaki	Engineer/Advisor, Division 3, Sector Strategy Development Department, Japan Bank for International Cooperation (JBIC)
Mr. Ryusuke Yoshimura	Executive Vice President, Association for International Cooperation of Agriculture and Forestry (AICAF)
Dr. Toshiyuki Wakatsuki	Professor, Faculty of Life and Environmental Science, Shimane University

1.4 Study Team Members

Name	Assignment	Affiliation
Kunio Takase	Team Leader	Advisor, IDCJ
Satoko Emoto	Coordinator	Senior Economist, IDCJ
Toshiyuki Wakatsuki	Rice Farming in West Africa	Professor, Faculty of Life and Environmental Science, Shimane University

1.5 Work Schedule

(1) Preparatory Study in Japan

- Collection and analysis of relevant information: May - July 2002
- Analysis of the situation of rice supply and demand in West Africa: June 2002
- First Meeting of the Study Group: June 18, 2002

(2) Field Study Schedule

Month	Date		Activities	Stay
August	12	Mon.	Narita 09:55 → Rome 16:20 (AZ 785)	Rome
	13	Tue.	Discussions on rice cultivation and food supply and demand situation in Africa with SPFS, GIEWS, etc. at the FAO Headquarters	Rome
	14	Wed.	Rome 08:50 → Paris 10:55 (AZ 318) Paris 13:55 → Abidjan 18:05 (AF 702) Discussions on the schedule with a JICA expert (Mr. Kohei Ajiro)	Abidjan
	15	Thu.	(Holiday) Move to Grand-Lahou; visit to CFMAG (discussions and tour of the facilities); move to Abidjan	Abidjan
	16	Fri.	Reporting to and discussions at the JICA Office; courtesy visit to the Japanese Embassy, ANADER, MINAGRA and PNR	Abidjan
	17	Sat.	Discussions with Japanese experts involved in agricultural cooperation in Côte d'Ivoire	Abidjan
	18	Sun.	Move to Gagnoa	Gagnoa
	19	Mon.	Visit to farms planted with NERICA varieties (a farmer assisted by ANADER and a seed production farm of WARDA) guided by the staff of ANADER's Gagnoa Zone Move to Bouaké; visit to ANADAR's Central Regional Office Visit to WFP-assisted PBF sites in Foro-Foro and Soungourou guided by the staff of WFP and ANADAR's Central Regional Office Discussions with a WFP expert (Dr. F. Nagumo)	Bouaké
	20	Tue.	Visit to a site (Lokapli) of the Irrigated Agriculture Development Project in the North-Central assisted by JICA, guided by PNR Visit to NERICA CBSS farms assisted by ANADER/WARDA Visit to a WFP-assisted PBF site in Pronou Discussions with a WFP expert and WARDA researchers	Bouaké
	21	Wed.	Move to Yamoussoukro Visit to PNR's seed farm and seed selection and storage facilities Visit to the Yamoussoukro office and model site (Anongblin) of the Farming System Improvement Project for Small-Scale Irrigated Agriculture (PASEA) assisted by JICA; return to Bouaké; team meeting	Bouaké
	22	Thu.	Discussions with the Director General and researchers of WARDA Move to Abidjan	Abidjan
	23	Fri.	Visit to FAO and WFP Takase and Wakatsuki: Discussions with MINAGRA's Cabinet, Directorate General of Rural Development, CNRA, ANADER and PNR Emoto: Visit to PNR (data collection) and UNDP Reporting to and discussions with Japanese experts at the JICA Office Abidjan 22:05 →	On board
	24	Sat.	→ Paris 06:10 (AF 703); team meeting	Paris
	25	Sun.	Paris 11:00 → Conakry 15:20 (AF 766) Discussions on the schedule with SG2000's Country Director	Conakry

	26	Mon.	Move to Labé (by air) Greeting of the participants (MAE, SG2000 and local community representatives) at Labé Airport Move to Popodora to visit SG2000's soil improvement project site Move to Dara to visit a potato and arrowroot cultivation project site using phosphate rock (a project assisted by Winrock International, SG2000 and WFP) Move to Segne to visit a NERICA farm Move to Timbi Madina to visit a NERICA seed farm and other facilities of IRAG's Bareng Agricultural Experimental Station Move to Dalaba	Dalaba
	27	Tue.	Move to Tolo to visit the Tolo-Mamou National Agricultural School Move to Kilissi to visit a NERICA CBSS seed farm Visit to the Kilissi Agricultural Experimental Station to observe a NERICA farm and post-harvest processing machinery, etc.	Conakry
	28	Wed.	Reporting to and discussions with the Minister of Agriculture and Livestock (attended by representatives of FAO, SG2000, etc.) Reporting to and discussions with the Ambassador and First Secretary at the residence of the Japanese Ambassador to Guinea Conakry 22:00 →	On board
	29	Thu.	→ Paris 06:00 (AF 767) / Paris 13:15 →	On board
	30	Fri.	Takase and Emoto: → Narita 07:45 (AF 276) Wakatsuki: → Kansai 08:10 (AF 292)	

(3) Post-Field Study Work in Japan

- Compilation of the Back-to-Office Report: September 2- 9, 2002
- Second Meeting of the Study Group: September 12, 2002
- Preparation of the Draft Final Report: Mid-September - October 3, 2002
- Third Meeting of the Study Group: October 8, 2002
- Preparation of the Final Report: Mid-October 2002 - March 2003

CHAPTER 2 SITUATION SURROUNDING RICE FARMING IN WEST AFRICA

2.1 Development Strategies and Problems in 40 Years of African Development

Beginning around 1960, a series of African countries became independent, which provided a major turning point for the African continent to revive itself free from colonial rule that lasted for several hundred years. However, their independence was greeted by a combination of adverse impacts caused by dictatorships in terms of politics, a planned economy in terms of economy, ethnic conflicts in terms of society, desertification and environmental destruction in terms of nature and falling prices of primary products in terms of international economy. Meanwhile, Africa has received the highest level of ODA per capita in the world since 1981. Despite receiving ODA, the amount of which is more than six times higher than that received by South Asia, which is poorer than Africa, the real GDP growth per capita and the food production index in Africa have remained almost in negative territory. As repeated changes of the aid strategy of donors have proven futile, there is a real need to learn from the lessons of 40 years of African development without prejudice in order to formulate more viable measures for the 21st century.

	Development Strategy	Problems
1960	Independence of African countries (better positioned than Asian countries)	Proxy battlefield of the Cold War (no time for political and economic independence)
1970	President McNamara's Nairobi Speech to eliminate poverty (30-40% of World Bank loans for rural development)	Top-down approach (development led by large investment in infrastructure)
1980	Structural Adjustment Program (SAP) (emphasis on macro-economy)	Absence of a safety net (discard of the poor)
1990	Shift to free market economy (falling prices of primary products)	Destruction of agriculture and the environment (successive occurrences of conflicts)
2000	Propensity to human development (preparation of the New Partnership for African Development, or NEPAD)	Allocation of 74% of ODA to education, health, debt service, peace, governance (and only 7% to agriculture)[1]

[1] OECD, *Geographical Distribution of Financial Flows to Aid Recipients,* 2001.

2.2 Major Donors' Strategies for African Agriculture and Rural Development

The end of the Cold War in 1990 was immediately followed by "aid fatigue" among European countries and the United States and the aid efforts of these countries shifted towards Eastern Europe and the former Soviet Union. Japan has taken an initiative to hold a series of the Tokyo International Conference on African Development (TICAD I in 1993 and TICAD II in 1998), but the global climate toward TICAD III in 2003 is not necessarily bright. The latest African development strategies of major donors in the 21st century, i.e., the G8, the World Bank and FAO, are outlined below.

(1) Kananaskis G8 (June 26 and 27, 2002)

Following the "Tokyo Action Program" agreed in TICAD II, the G8 will increase aid for Africa in line with the New Partnership for African Development (NEPAD) prepared by African countries, taking the following points into consideration.

1) The emphasis of aid will be placed on those countries that have achieved positive results in terms of good governance, rule by law, investment in human resources, economic growth and poverty reduction. Only humanitarian aid will be provided for countries that ignore the interests and dignity of the people. The selection of countries will be based on the mutual assessment process of African countries.

2) The G8 believes that more than half of the increased aid portion (US$12 billion) expressed at the International Conference on Financing for Development held in Monterrey, Mexico in March 2002 will be directed to Africa.

3) The priority ranking of concrete aid subjects is topped by 1) promoting peace and security, followed by 2) strengthening of institutions and governance, 3) fostering trade, investment, economic growth and sustainable development, 4) implementing debt relief, 5) expanding knowledge (education of women and information communication technologies), 6) improving health and confronting HIV/AIDS, 7) increasing agricultural productivity and 8) improving water resource management. Agriculture is given very low priority.

(2) The World Bank's Strategy for Agriculture and Rural Development Strategy in Africa (From Action to Impact, July 2002)

1) Most of the least developed countries in the world (70%) are concentrated in Africa. Given the threat posed by AIDS, urgent cooperation for NEPAD is necessary to achieve the target for millennium development by 2015. It is a fact that World Bank loans for agriculture and rural development to Africa considerably fell from 23% (US$1 billion; 23 new projects) of the entire loan amount in 1990 to 10% (US$224 million; 8 new projects) in 2000. Future improvement in this aspect is required.

2) The priority themes for the World Bank are 1) PRSP/HIPC, 2) credit for poverty reduction, including non-rural areas, 3) government's decentralization, 4) communities self-reliant development, 5) multi AIDS programs, 6) agricultural

research and extension, 7) natural resource management, 8) global environment, 9) education and health, 10) water management, 11) infrastructure, 12) land reform, and 13) post-war restoration.

(3) FAO's Comprehensive Africa Agriculture Development Programme for NEPAD (CAADP, May 2002)

CAADP requires investment of US$240 billion (US$ 17.2 billion/year)[2] to achieve the following four targets in the 14 years from 2002 to 2015. Under the current state of fund distribution, however, achievement of the Millennium Goals by 2015 is almost impossible.

1) Land and water development (US$37 billion) and their operation and maintenance (US$31 billion)

2) Increase of food production and reduction of hunger (US$8 billion)

3) Development of infrastructure and marketing (roads, inputs, markets and storage) (US$89 billion) and their management (US$37 billion)

4) School meals for 100 million pupils (US$38 billion)

2.3 Historical Changes of Chronically Undernourished Population in Developing Countries

(1) In August 2002, FAO published World Agriculture: Towards 2015/2030 Summary Report (97 pages) which was a culmination of its full-scale mobilization of staff members with accumulated knowledge and information. This report objectively describes the future prospects of the agricultural, animal husbandry, forestry and fisheries sectors while taking the global economic environmental and trade in the next 30 years into consideration. The report states that it simply aims at describing the future as it is likely to be, not as it ought to be. As such, it should not be considered to represent the goals of an FAO strategy.

(2) The report warns that food imports by developing countries will multiply by three - five times in the next 30 years, unless the current absence of political will, fund shortage and insufficient efforts for environmental conservation and poverty reduction surrounding the present agriculture, forestry and fisheries are immediately modified. The report concludes that to halve the number of undernourished persons by no later than 2015, one of the targets set under the Millennium Goals, is far from being reached and may not even be accomplished by 2030.

[2] This is a huge sum even when compared with the US$67 billion for the "15 Year Program for Doubling Rice Production in Asia" (involving 15 Asian countries, excluding China and Japan), which was proposed by Saburo Okita and Kunio Takase in 1976 was eventually achieved at the end of the 1980s with the support of the World Bank, ADB and the Trilateral Commission.

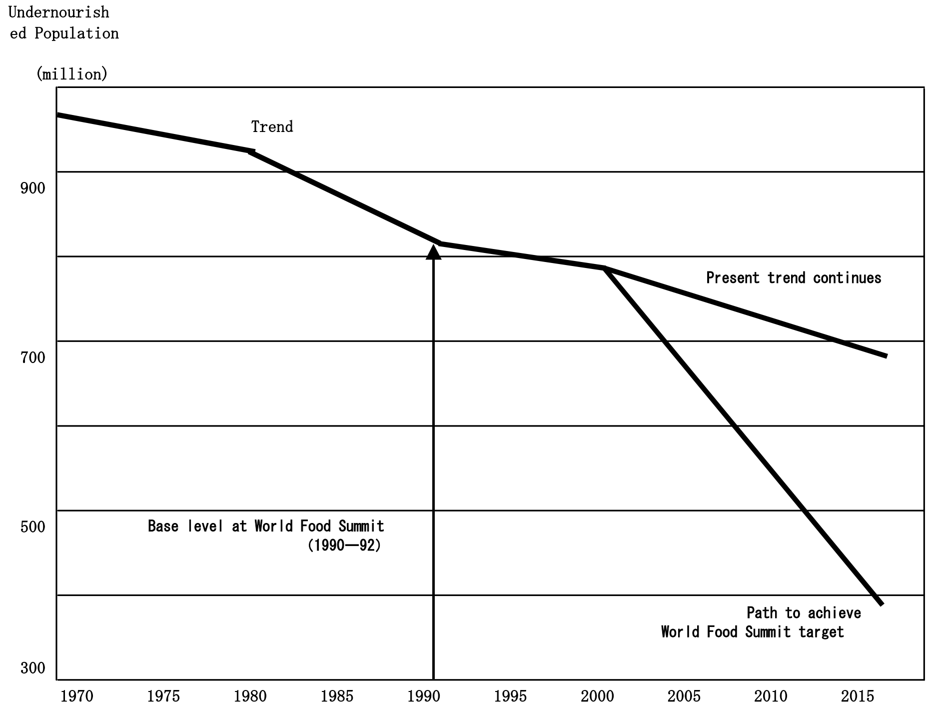


Figure 2-1 Historical Changes and Prospects of Chronically Undernourished Population in Developing Countries

Notes:

1. Target adopted at the World Food Summit in 1996 to reduce the undernourished population by half by 2015.
   800 million (base year: 1990 – 1992) → 400 million (target year: 2015)
2. According to FAO's *Statistics of Food Insecurity in the World 2001*, if the present declining trend of the undernourished population continues (reduction by 6 million people a year), it will take more than 60 years to achieve the World Food Summit target.

Source: "World Agriculture, Forestry and Fisheries" (in Japanese), September Issue, 2002.

2.4 Lessons from the World Summit on Sustainable Development (WSSD) in Johannesburg

(1) It is highly significant that the World Summit on Sustainable Development (WSSD), which placed more emphasis on development than environment, was held in South Africa, taking the opportunity of 10 years since the UN Conference on the Environment and Development (Earth Summit) in 1992 (UNCED in Rio de Janeiro, Brazil).

(2) From August 26 to September 4, 2002, delegates from 191 countries/areas attended the Summit together including Presidents/Prime Ministers from 104 countries. From Japan, some 1,000 persons were in attendance, including Prime Minister Junichiro Koizumi, Foreign Minister Yoriko Kawaguchi, Environment Minister Hiroshi Oki and about 500 NGO representatives. As of September 4, the United Nations announced that the number of registered participants for the Summit stood at 21,340 (9,101 government officials, 8,227 NGO representatives and 4,012 press personnel). On August31, a side event featuring NERICA rice, representing hope for Africa, was held at the Japan Pavilion for the tasting and discussions on this rice variety.

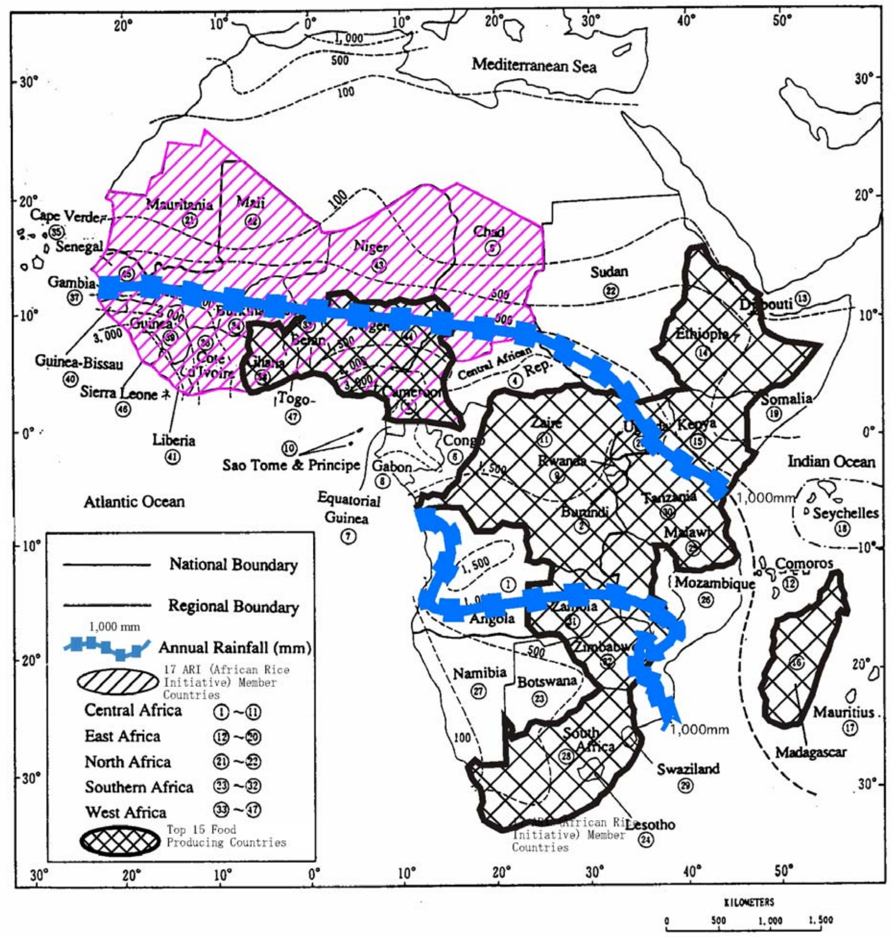
(3) On September 6, 2002, the Asahi Shimbun carried its general assessment in its editorial entitled "Far from Celebration".
"Throughout the Summit, there were repeated demonstrations by poor people. Their pressing sentiments were evident by their placards carrying such messages as 'water and jobs', 'fair trade' and 'simple development rather than sustainable development'. Even though the Implementation Plan was finalized, concrete measures included in the draft either disappeared or were changed to ambiguous expressions every time one country or another raised an objection. No promises were made for increased aid by developed countries or the export promotion of products from developing countries. This tendency was aggravated by the arrogant behavior of the United States. In addition to opting out of the Kyoto Protocol, President Bush failed to attend the Summit. Nevertheless, <u>the Implementation Plan does indicate certain direction to be followed despite unsatisfactory contents</u>. Even though it lacks legally binding force, it can be useful as an action plan once the number of countries genuinely committed to it increases. If developed countries really hope to see the self-reliant development of developing countries, they must seriously consider the 'revision of their trade rules' and 'liberalization of their domestic markets for the products of developing countries' while paying careful attention to environmental issues."

(4) According to the report of the NGO Proposal Forum, "the representative of Ethiopia revolted against the Chairman's draft wording to give precedence to the World Trade Organization (WTO) over environmental regulations. Following seconding by Norway and Kiribati, etc., the clause containing 'while ensuring WTO consistency' was dropped as a result of the domino effect, marking a decisive moment when the domineering, invincible armada called WTO was defeated for once". Meanwhile, the Johannesburg Summit meant "development prior to the environment" for Africa. The African side insisted on a decision on "the time limit to achieve the target of 0.7% of the GNP" but was forced to accept the need for "good governance" instead. There were some positive outcomes, including urged cooperation between developed countries and developing countries for the "10 Year Reform Plan for Production and Consumption" and "the promise for comprehensive negotiations to aim at the phased withdrawal of export subsidies for the agricultural products of developed countries". In addition, it is highly significant that a consensus was achieved regarding the realization of the "Millennium Development Goals (2015)" adopted by the UN general meeting in 2000. A new concept of "reducing the gap between the rich and the poor" was appreciated as the basic foundations for development in the 21st century.

2.5 Distribution of Major Food Producing Countries in Africa

(1) <u>The characteristic of agriculture in Sub-Saharan Africa</u> lies with the emphasis on commodity crops for export (coffee, cocoa and cotton) as remnants of the colonial economy with insufficient efforts being made for food production. According to UNDP/World Bank data, the main food crops in Africa in 1989 were maize (41% by weight ratio of all food crops), potatoes (20% based on conversion to one-fifth of the real weight), sorghum (15%), millet (10%), rice (9%) and wheat (5%). The top 15 countries in Africa in terms of food production are marked by grids in Figure 2-2.

(2) In terms of rice production, the high-ranking countries are Nigeria, Côte d'Ivoire, Tanzania, Mali, Zaire, Senegal and Cameroon, indicating the leading status of West African countries. According to recent FAO data, the West African share of rice production is 65% for 1998, 65% for 2015 and 61% for 2030. As shown in Figure 2-2, rice production appears to gradually spread to the whole of Africa with West Africa playing a central role given the geographical scope of the area with annual rainfall of 1,000 mm spreading between 10°N and 15°S.



Source: -A Strategy to Develop Agriculture in Sub-Saharan Africa and a Focus for the World Bank
-UNESCO Atlas of World Water Balance

Figure 2-2 Distribution of Top 15 Food Producing Countries and ARI Member Countries in Sub-Saharan Africa

2.6 NERICA (New Rice for Africa): Its Merits and Limitations

(1) In the 1990s, NERICA (New Rice for Africa) was developed after several years of research by WARDA (17 member countries) of which the headquarters is situated in Côte d'Ivoire. NERICA is a general term given to rice varieties developed through interspecific hybridization between African cultivated rice (*Oryza glaberrima*) which is highly resistant to diseases and pests and Asian rice (*Oryza sativa*) which is high

yielding and some 3,000 varieties have so far been developed.[3] However, only 10 or so varieties, including NERICA 1 through 7, have reached the stage of steady properties and can be cultivated at the farm level. Because of the hybrid character, only sterile varieties were produced in the early years, but Dr. Monti Jones, a Sierra Leonean breeding scientist working for WARDA, successfully developed the technology to create high-yielding varieties in 1994 using a biotechnology he had learned in China.

(2) Although NERICA varieties were developed by WARDA, the development efforts involved agricultural research institutes in the world including Asia, South America, North America and Europe. The Government of Japan, the Rockefeller Foundation of the United States and international organizations, including UNDP also financially supported. As a result, it has become possible to create genetically stable varieties that can be cultivated by ordinary farmers. Apart from the financial contribution to WARDA, the Government of Japan has dispatched experts through JICA and JIRCAS, etc. As announced by Prime Minister Koizumi and Foreign Minister Kawaguchi at WSSD held in Johannesburg, Japan will maintain its policy of assisting the development of NERICA varieties and the promotion of their extension.

(3) NERICA varieties that can currently be cultivated by farmers have the following characteristics.

1) NERICA varieties typically mature 90-100 days, earlier by 30-40 days compared to native varieties. The early maturity is a significant advantage for upland rice cultivation dependent on unreliable rainfall.

2) With low fertilizer application, experiments have produced a yield level of 1.3-1.5 tons/ha compared to the average yield of native varieties of 1 ton/ha, suggesting a 30-50% increase of the yield. The reasons for this increase of the yield are believed to be the better competitiveness against weeds, stronger resistance to diseases, pests and poor soil fertility compared to native varieties.

3) The protein content tends to be 20-30% higher than that of native varieties, implying a positive contribution to the better nourishment of poor farmers and their dependents.

4) When a current yield level of 3-4 tons/ha or higher in tropical Asia is aimed at, lowland varieties are required. However, there is currently no suitable NERICA variety for this purpose.

(4) At present, NERICA varieties are cultivated in several West African countries, including Côte d'Ivoire, Guinea and Gambia. According to SG2000, NERICA extension activities are most active in Guinea and NERICA is cultivated most widely there as a result, though there is no data on the cultivation area or yield.

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[3] Takagi, Y., Tsunematsu, H. and Iwanaga, M., "Latest Trends of Development of Rice Varieties in West Africa: Development and Extension of NERICA", *International Agricultural and Forestry Cooperation (Kokusai Noringyo Kyoroku)*, Vol. 25, No. 1/2, April/May Issue, 2002, pp. 12 – 19 (in Japanese).

2.7 African Rice Initiative (ARI) and Future Prospects

(1) On March 27, 2002, 17 African countries formed a consortium to extend the NERICA research results and the first meeting of the Steering Committee was held at WARDA on June 27 and 28, 2002. The permanent members of this committee are representatives of seven pilot countries (Côte d'Ivoire, Gambia, Guinea, Mali, Nigeria, Togo and Benin), the Forum for Agricultural Research in Africa (FARA), the ARI Secretariat and WARDA (two members) and UNDP (as an observer). Other members that rotate every two years are representatives of one non-pilot country, one NGO and one farmer organization. Representatives of donors may freely attend the committee meetings as observers.

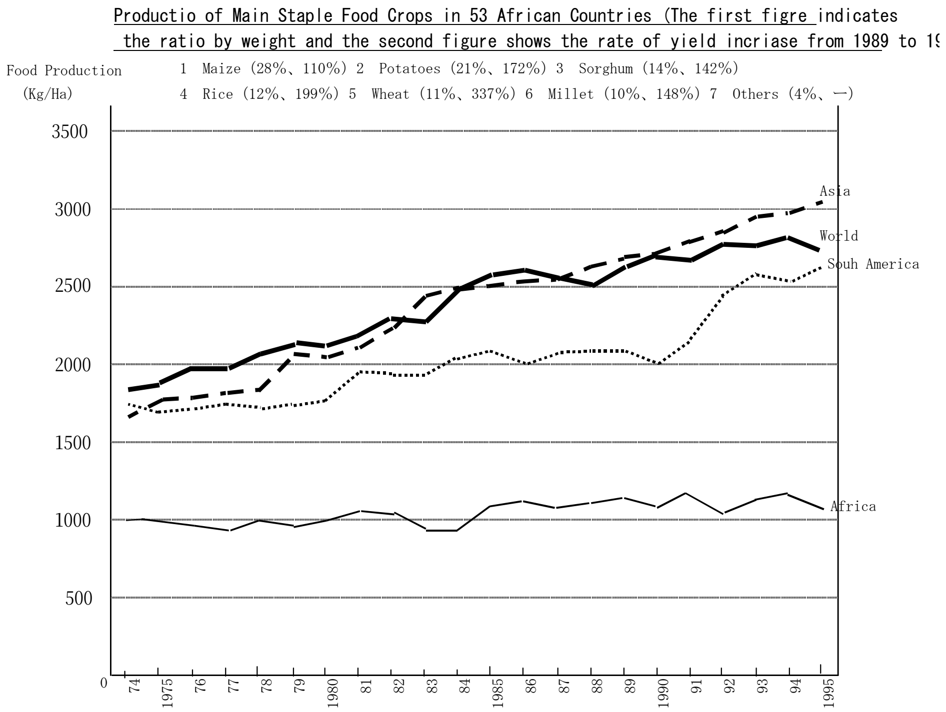
(2) As activities under ARI cover both the "research" and "extension" fields, research institutes and agricultural extension organizations in each member country should consult with one another to decide the national ARI coordinator to attend the Steering Committee as the representative of the country. It is planned to select the secretary for ARI in February or March 2003. ARI is not the main activity of WARDA, i.e., non-core program, and constitutes an independent initiative. However, its activities are closely linked to WARDA as they reflect the research results of WARDA. Further details of ARI's relationship with the broader activities of WARDA will be discussed at the second meeting to the Steering Committee to be held in June 2003.

(3) The Steering Committee of ARI is assigned to review the ARI activities up to the previous year and to plan and decide the activities and budget for the current year. Japan, UNDP, the World Bank, the Rockefeller Foundation, AfDB, etc. have already come forward as donors. When ARI was first launched, the budget size for the first five years (2002-2006) was US$15.2 million. At the first meeting of the Steering Committee, however, an enlarged budget of US$ 75.3 million was presented to increase the number of pilot countries and to expand its scope to include Central, East and South Africa in addition to West Africa.

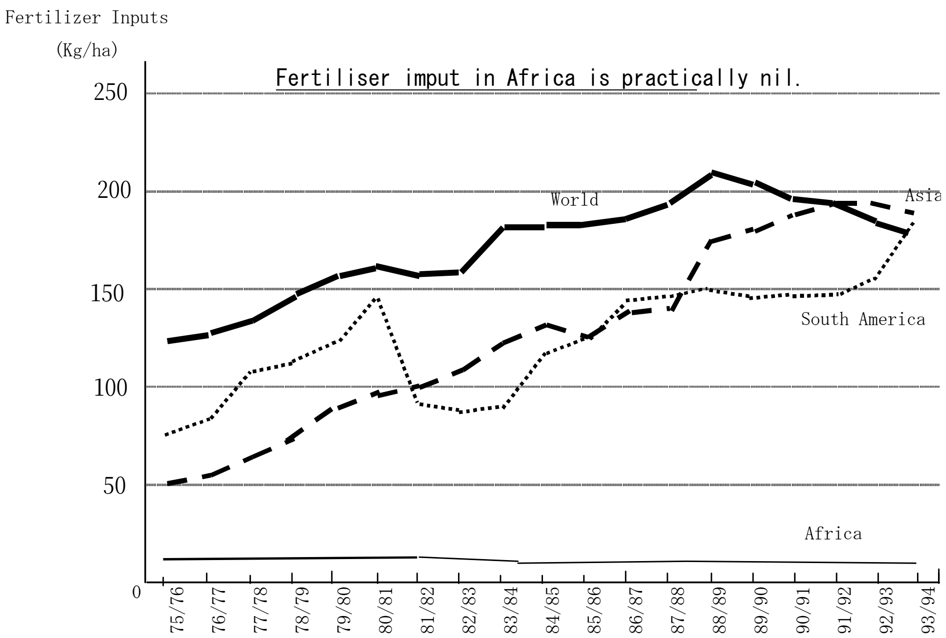
(4) The research achievements of WARDA so far include the development of NERICA seeds for upland and the development of methods to allow farmers to select varieties of their choice (Participatory Varietal Selection or PVS and Community-Based Seed Production System or CBSS). However, as described in 2.8 and 2.9 in detail, hardly any development efforts have been made in regard to two of the three elements for "an increased rice yield", i.e., "fertilizer" and "water management". In the meantime, there is a strong prospect of new varieties for rainfed and irrigated lowland. When such a prospect is taken into consideration, a substantial part of the responsibility to promote "extension" projects is likely to fall on individual countries. It appears to be crucial for ARI to play a bridging role in the interim period.

2.8 Global Comparison of Food Production and Fertilizer Utilization

As NERICA varieties have only been established as new rice varieties for upland so far, the achievement of a "self-sufficiency in rice in West Africa" will require an increased yield through extension activities, including the provision of fertilizer and water management and the prevention of environmental destruction caused by slash and burn agriculture. At present, fertilizer input in Africa is practically nil (Figure 2-3).



Source: FAO, *Production Yearbooks*, 1977-1993 and 1996.

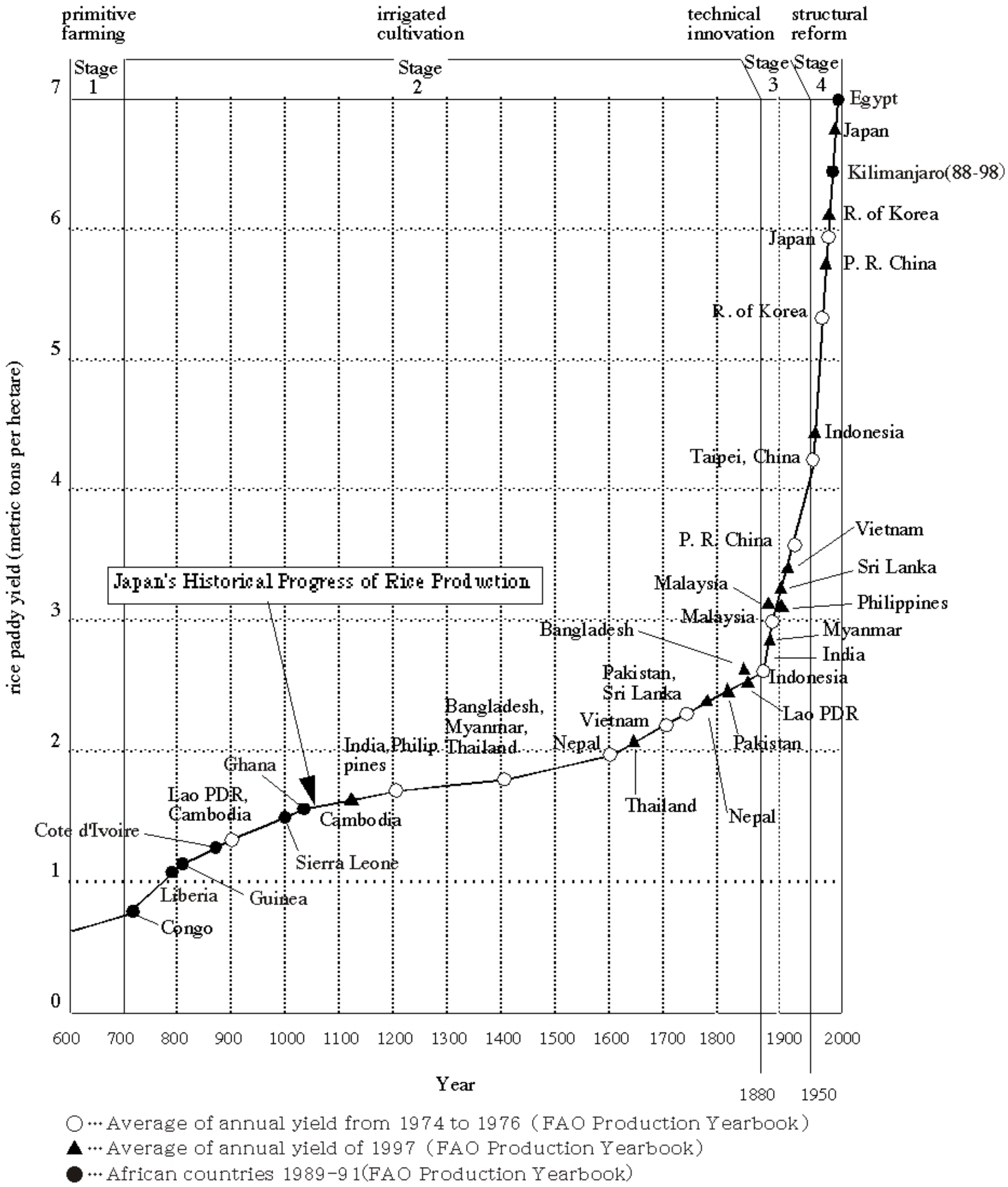


Source: FAO, *Production Yearbooks*, 1978-1995.

Figure 2-3 Global Comparison of Food Production and Fertilizer Input

2.9 Historical Background of Rice Production

Figure 2-4 compares rice production in Japan over 1,400 years and the current situation in Asian and African countries. The first stage is primitive farming (the yield per hectare is 1.0 ton), the second stage is irrigated cultivation (1.0-2.5 tons), the third stage is cultivation with fertilizer and irrigation (2.5-4.0 tons) and the fourth stage is post-agrarian reform cultivation (4.0-6.0 tons). West African countries are in the transitional stage from primitive farming to irrigated cultivation, suggesting the possibility of a substantial increase of the rice yield with technological innovations in terms of variety, irrigation and fertilizer.



Source : The chart was supplemented by the Study Team by adding FAO data published in its Yearbooks to: Takase, K. and Kano, T., "Development Strategy for Irrigation and Drainage" in the Asian Development Bank, Asian Agricultural Survey, 1969, p.520.

Figure 2-4 Rice Yields in Asia and Africa: Comparison with Historical Path of Rice Production in Japan

CHAPTER 3 CURRENT SITUATION AND PROSPECTS OF RICE SUPPLY AND DEMAND IN WEST AFRICA

3.1 Characteristics of the World Rice Market

The world rice production has been almost consistently increasing since the 1960s, primarily because of the increased yield per hectare rather than expansion of the production area (Figure 3-1). The introduction of high yielding varieties, associated with the provision of modern inputs, such as chemical fertilizers and pesticides, irrigation development and mechanization, in the late 1960s to the 1980s substantially increased the rice production in Asia, which is the world's principal rice production and consumption region. Meanwhile, the world demand for rice has undergone structural changes. Eating habits in Asian countries, which produce and consume some 90% of the rice produced throughout the world (Figure 3-2) and thus have major impacts on the world rice market, are said to have been changing with economic growth to the extent that the per capita consumption rice in Asia shows a declining trend.[1]

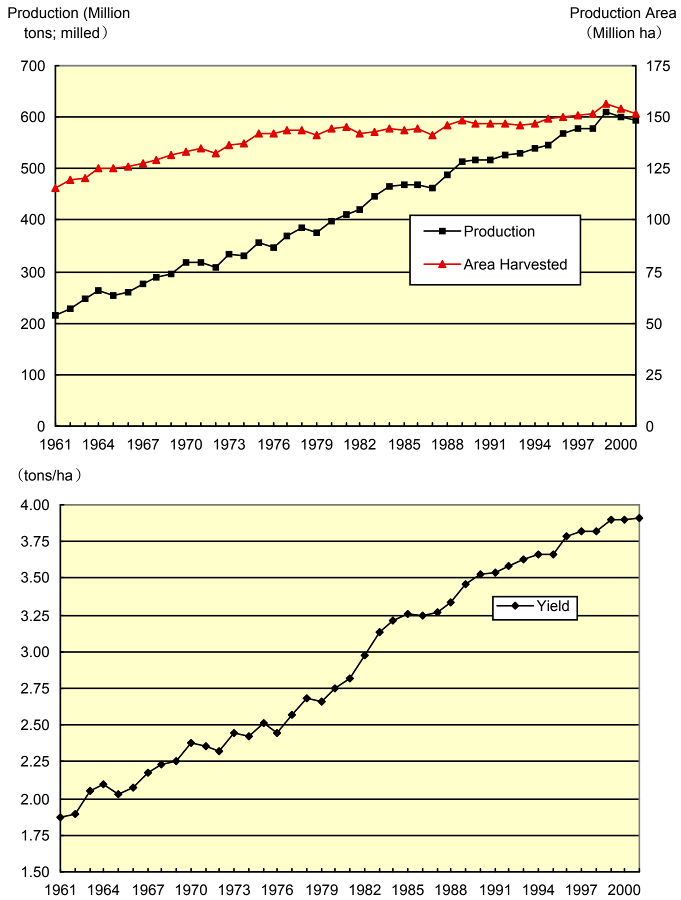


Figure 3-1 Trends of World Rice Production, Area Harvested and Yield (1961-2001)

Data Source: FAOSTAT Database (http://apps.fao.org/).

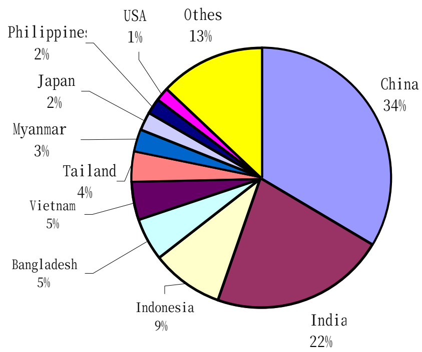
[1] For the structural changes of the world rice supply and demand, see Ito, S. and Ota, K., "Changing Global Rice Economy" in *Food White Paper*, edited and published by the Food and Agricultural Policy Research Center and distributed by Rural Culture Association, March 1998. This section owes to "Developing Global Rice Economy: Diagnosis of Changes Over the Last 40 Years" (in Japanese) listed in the Home Page of Assoc. Prof. Shoichi Ito, Tottori University (http://worldfood.muses.tottori-u.ac.jp/keizai).

Lower rice consumption in Asia inevitably increases the volume of exportable rice from Asia to the world market.

(1) Major Rice Producing Countries (Average for Period from 1990/91 to 2001/02)

(Unit: 1,000 tons)

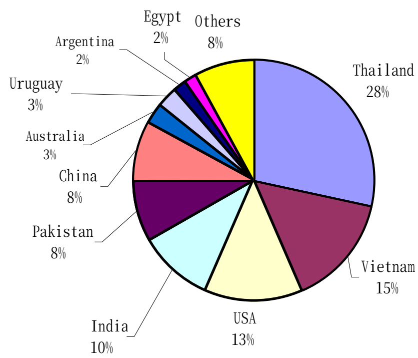
Rank	World Total	558,028
1	China	188,334
2	India	122,198
3	Indonesia	49,380
4	Bangladesh	29,387
5	Vietnam	26,545
6	Thailand	21,977
7	Myanmar	15,489
8	Japan	12,320
9	Philippines	10,803
10	USA	8,194
	Others	73,402



(2) Major Rice Exporting Countries (Average for Period from 1991 to 2002)

(Unit: 1,000 tons)

Rank	World Total	19,884
1	Thailand	5,712
2	Vietnam	2,897
3	USA	2,638
4	India	2,013
5	Pakistan	1,658
6	China	1,579
7	Australia	577
8	Uruguay	538
9	Argentina	353
10	Egypt	326
	Others	1,593



(3) Major Rice Importing Countries (Average for Period from 1991 to 2002)

(Unit: 1,000 tons)

Rank	World Total	19,884
1	Indonesia	1,718
2	Iran	1,056
3	Brazil	818
4	Saudi Arabia	783
5	Nigeria	733
6	EU	726
7	Philippines	667
8	Bangladesh	653
9	Iraq	607
10	Japan	560
11	Senegal	537
12	Malaysia	525
13	South Africa	478
14	China	473
15	Côte d'Ivoire	427
	Others	9,123

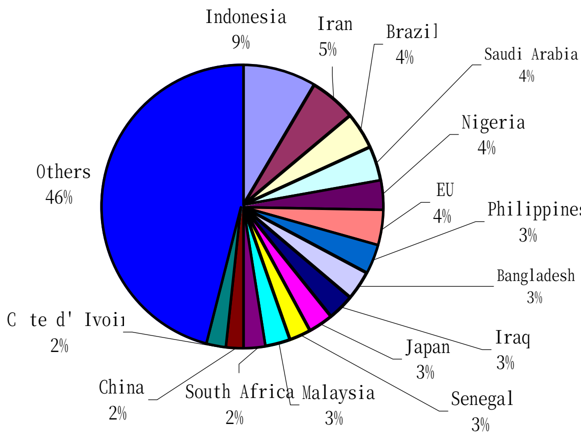


Figure 3-2 Major Rice Producing, Exporting and Importing Countries in the World

Data Source: USDA/Economic Research Service, *Rice Situation and Outlook Yearbook*, RCS-2001, November 2001, pp. 87-88.

The world rice market has traditionally been regarded as a "volatile and thin market" where the small proportion of the traded volume to the production volume makes the market vulnerable to impacts of changing weather, policies and other factors. In fact, the ratio of the traded volume of rice to the production volume from the 1960s to the 1990s was an average of 4-5%, which was extremely smaller than the corresponding figures for other major grains in the world, such as wheat, maize and soybeans (Figure 3-3). For this reason, a price hike can easily occur when extraordinary weather reduces production and increases imports in leading producing and consuming countries (China, India, Indonesia, etc.). It has been pointed out that a small trading volume in the international market makes it more difficult to reflect the real supply and demand situation, resulting in a tendency for rice to be traded at a higher price. However, comparison between the rice price from the 1960s to the 1990s and the prices of other crops in terms of real prices shows that the fluctuation range of the rice price was overwhelmingly large in the 1960s and 1970s but subsequently decreased in the mid-1980s, indicating considerable stabilization of the rice price (Figure 3-4).

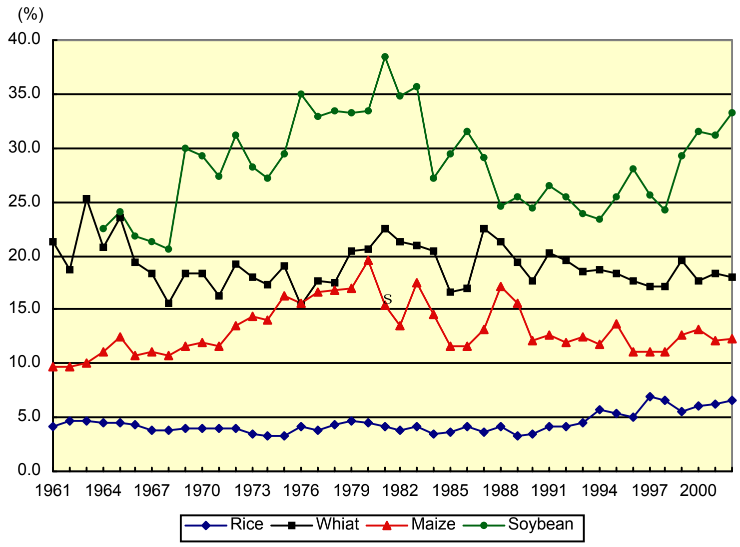


Figure 3-3 Worldwide Export Ratios of Grains and Soybeans (1961 – 2002)

Data Source: USDA, PS & D View, May, 2002, as cited in *World Food Statistics*, Shoichi Ito, Faculty of Agriculture, Tottori University (http://worldfood.muses.tottori-u.ac.jp).

The results of the statistical comparative analysis of the price fluctuations of rice, wheat, maize and soybean over the last 40 years by Ito show that the rice market, which used to show the characteristics of a volatile and thin market fin the 1960s-1970s, has not necessarily been a "thin market" in recent years.[2] To be more precise, even though the ratio of the trade volume to the production volume is still relatively small, the range of price fluctuation has greatly narrowed. The reasons for this narrowing range of the price fluctuation of rice are: 1) the speedier conveyance of more accurate information regarding a production shortage or excess in any part of the world to other parts of the world because of the tremendous improvement of information technologies; 2) the much faster transportation of a large amount of food due to the development of infrastructure and the innovation of transportation technologies; and 3) the availability of alternatives for consumers due to the growing variety and increased supply of food.

[2] Ito, S., "Developing Global Rice Economy", op. cit., Chapter 3.

Another important trend in the world rice market over the last 40 years has been the substantial real price decline of rice. The price of rice in 2000 was approximately one-third of the price in the early 1960s (Figure 3-4). During this period, the real prices of wheat and maize also dropped by some 50% and their decline was smaller than that of rice. One reason for this was that the productivity increase resulting from improved production technologies made it possible to produce rice at a lower cost. However, the fact that rice production in developed countries has been maintained or even expanded with subsidies, resulting in a decline of the real price in the world market, should not be ignored.[3] The international price of rice continued to decline in 2001 and the export price of rice (100%, milled, Grade B) in Bangkok reached its record lowest level at US$ 170/ton in April 2001 (Figure 3-5).

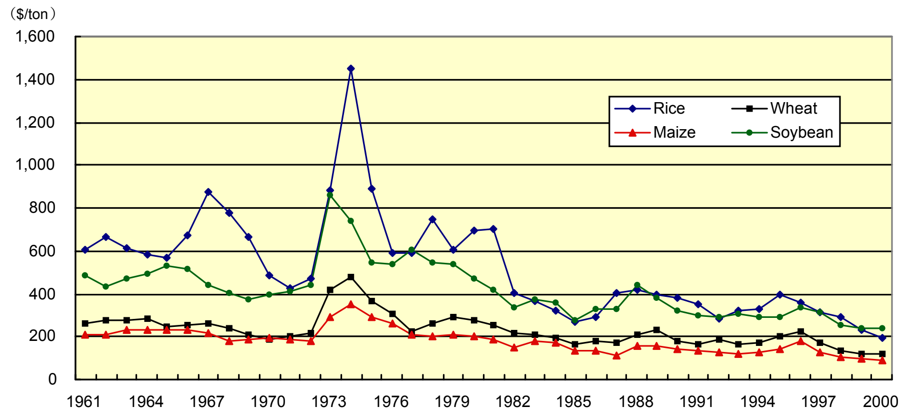


Figure 3-4 Trends of Real Prices of Rice, Wheat, Maize and Soybean in the World (1961 – 2000)

Note: The prices for rice are Bangkok, 5% broken, milled; for wheat, No. 1, Hard Red, US Gulf; for maize, Yellow No. 2, Chicago; for soybean, US (Rotterdam). The real prices were calculated on the basis that the CPI in 2000 is 100.

Source: IMF, *International Financial Statistics Yearbook*, 1999; USDA WASDE Report, WASDE-364, July 12, 2000. Data were obtained from USDA for rice for 1986 onwards and for others for 1999 onwards, as cited in Ito, S., *World Grain Statistics*, the National Association for Food Promotion, 2001, p. 37.

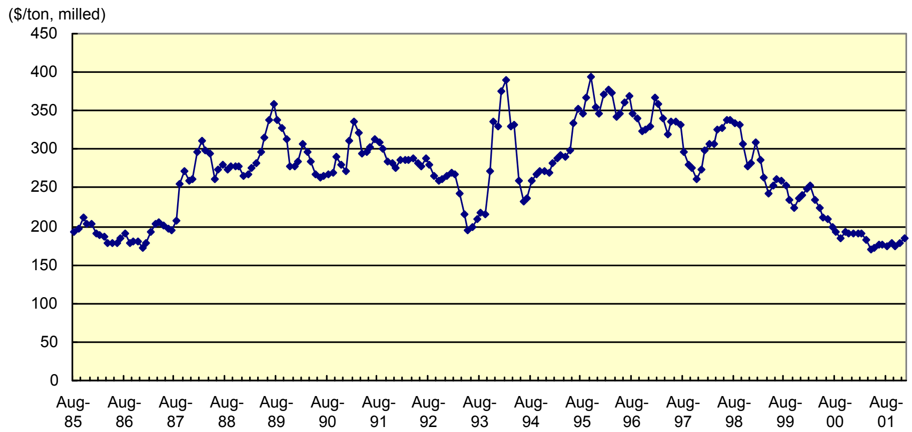


Figure 3-5 Trends of Export Price of Rice in Bangkok (100% Grade B; August 1985 – December 2001)

Data Source: Weekly price reports, US Embassy in Bangkok, as cited in USDA/Economic Research Service, *Rice Situation and Outlook Yearbook*/RCS-2001/November, 2001, pp. 71 – 76.

[3] In regard to the continuous increase in the world production of major grains even after the mid-1980s despite a substantial decline of their real prices, Ito points out that it should not be ignored that the production of grains was maintained and even increased due to subsidies for producers, as typically seen in the United States as well as other countries. See Ito, S., *World Grain Statistics*, op. cit., p. 38. (In Japanese)

The sluggish rice price in recent years reflects the lowered consumption in Asia, which is traditionally the principal rice consuming region, against the background of increasing world production. Until the mid-1980s, a decline of the per capita consumption of rice was only recorded in Japan, Taiwan, Malaysia, Singapore and Thailand. However, China, Korea and Sri Lanka have recently been added to the list and there have also been signs of a decline in India.[4] In those Asian countries where production adjustment falls short of the declining consumption, the rice supply tends to become excessive, making it necessary for them to seek an outlet in the international market. In addition, the market liberalization in individual countries has favored exports. For example, Vietnam, which resurfaced as an exporting country in the international market at the end of the 1980s, passed the United States in the late 1990s to become the second largest rice exporting country in the world after Thailand (Figure 3-2). India also increased its rice exports in the mid-1990s, exporting an annual average of 2 million tons of rice in the 1990s. Even though the annual level of world rice trade fluctuates from one year to another, there has been an overall increasing trend (Figure 3-6). Meanwhile, the importance of West Africa as a rice importing market has been growing.

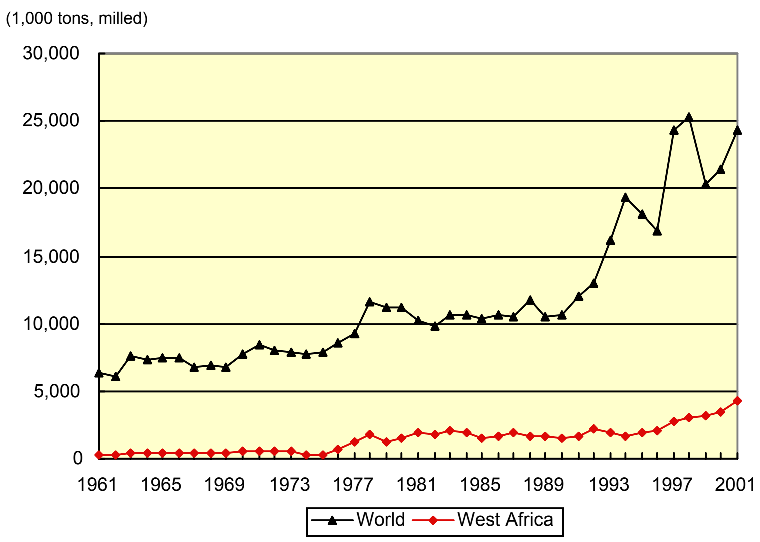


Figure 3-6 Rice Imports in the World and West Africa (Milled Basis, 1961 – 2001)

Note: West Africa here means 18 countries: Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo (Cape Verde is not included in the 17 WARDA countries dealt with in Chapter 4).

Data Source: USDA, PS & D View, May, 2002; USBC, *International Data Base*, December 1998; as cited in Shoichi Ito, Faculty of Agriculture, Tottori University, *World Food Statistics* (http://worldfood.muses.tottori-u.ac.jp).

3.2 Subsidies for Rice Production and Export

The development of rice cultivation in West Africa is considerably affected by trends of the international market price of rice. The recent situation in which the international price has been sluggish because of the relatively abundant or excessive rice supply in exporting countries is favorable for consumers in West African rice-importing countries but is disadvantageous for local rice producers. During the field study in Côte d'Ivoire and Guinea, the Study Team members heard repeated complaints by government officials and rice producers that "local producers cannot effectively compete with low priced imported rice".

[4] Ito, S., *World Grain Statistics*, op. cit., p. 67.

Meanwhile, rice production throughout the world has the aspect of being sustained or even increased by subsidies for producers. In regard to agricultural subsidies, developing countries demanded a reduction of such subsidies provided by developing countries on the grounds that "agricultural subsidies in rich countries are harming poor farmers in developing countries" at the World Summit on Sustainable Development held in Johannesburg from late August to early September 2002. Although developed countries did not give a clear answer to this demand[5], it is significant that this problem was clearly pointed out at a summit discussing the sustainable development of developing countries, including those in Africa, prompting a promise by developed countries to make efforts to solve the problem in the coming years.

Typical examples of subsidies for rice production can be seen in Japan and the United States. The policy of subsidizing rice production in the United States, where rice has traditionally been produced as an export crop, is more important from the viewpoint of analyzing the impact of such a policy on the international market. The conventional price policy for rice and other grains in the United States combines two-stepped price support (i.e., target price and loan rate), income support, farm reserves, production adjustment and crop insurance.[6]

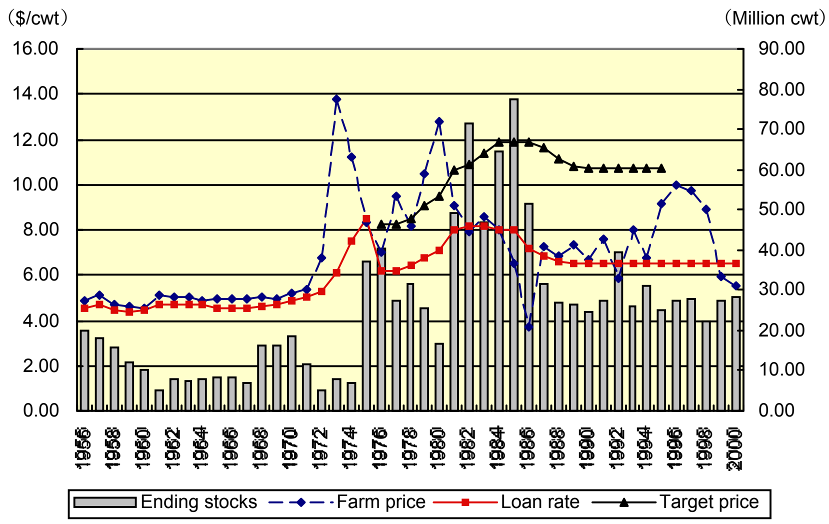


Figure 3-7 Changes of Ending Stocks, Farm Price, Loan Rate and Target Price of Rice in the United States (1956 – 2000)

Notes: 1) CWT is 100 pounds (rough basis); 2) The figures for 2001 are estimates; and 3) The target price was abolished under the 1996 Agricultural Law.
Data Source: Economic Research Service/USDA, *Rice Situation and Outlook Yearbook*, RCS-2001, November, 2001, p. 54.

The basics of price support lie with the loan rate. As the loan rate was originally determined to maintain the international competitiveness of US agricultural products, it did not significantly exceed the international price. When the market price fell below the loan rate, producers could deliver agricultural products used as collateral for loans to the Commodity

[5] See *International Herald Tribune*, August 29 2002, p. 4 and 2.4 (4) of this report.
[6] For the price support and supply-demand adjustment of agricultural products in the United States, see Itsumi, K. and Mochida, K., "Outline of American Agricultural Policies" in Itsumi, K. and the Central Union of Agricultural Cooperatives, eds., *Agriculture in the United States*, 1984, Part 1, Chapter 3, pp. 57-62. For the 1996 Agricultural Law and recent subsidy systems, see Ito, S., "Developing Global Rice Economy", op. cit., Chapter 4.

Credit Corporation (CCC) to avoid repayment of both the principal and interest. CCC, however, ended up with a huge amount of stock. Meanwhile, fiscal expenditure rose as the government paid the difference between the target price, which functioned as income deficiency payment, and the loan rate to compensate for the shortfall in addition to compensation in the form of a loan. This problem became apparent in the 1980s when the market price began to fall below the loan rate.[7] In the early 1980s, government stock accounted for more than half of the total stock. In the 1986 crop year when the market price became the lowest since 1956, i.e., US$3.75 per 100 pounds of rough rice (paddy), the loan rate and the target price were set at US$7.20 and US$11.90, respectively, and thus the deficiency payment reached US$4.70 (Figure 3-7 above). This means that the amount of subsidy combining a loan and a deficiency payment was more than double the market price.

Such price support has conventionally required producers to participate in production adjustment (reduction of the planting area). The mechanism whereby subsidies are paid in accordance with the volume of production tends to encourage producers to plant high yielding varieties so that they can ensure their income level even if market prices are unfavorable. As a result, the production has not fallen to the same extent as the reduction of the area planted (Figure 3-8). In the United States, the yield of rice has shown a marked increase in the last 40 years and an increase of the yield was observed even around 1990 when the market price leveled off.[8] While the development and extension of new high yielding varieties form the background for this increase, the fact that the price support system induces an increase of the yield has remained the same throughout this period.

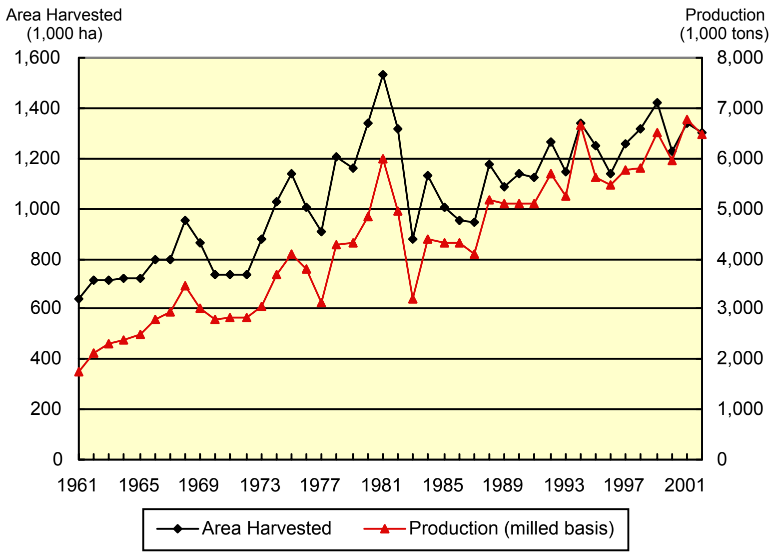


Figure 3-8 Trends of Area Harvested and Production of Rice (Milled Basis) in the United States (1961 – 2001)

Data Source: USDA, PS & D View, May, 2002; as cited in Shoichi Ito, Faculty of Agriculture, Tottori University, *World Food Statistics* (http://worldfood.muses.tottori-u.ac.jp).

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[7] The move by Thailand to abolish the export levy to lower the export price of Thai rice formed the background for the decline of the market price. An increase of stock occurred as the export offensive by Thailand snatched the international market from the United States.

[8] The increase of the yield per hectare was most noticeable in California. Economic Research Service/USDA, Rice Situation and Outlook Yearbook, RCS-2001, November 2001, p. 49.

Under the 1996 Agricultural Law, the target price, deficiency payment and policy of reducing the production area were abolished and production flexibility contract payment by which a fixed amount is paid regardless of market price fluctuations was introduced for the purpose of systematically reducing subsidies. Meanwhile, export expansion policies, including marketing loans, were maintained. The marketing loan system was originally introduced under the 1985 Agricultural Law to counteract the substantial lowering of the export levy by Thailand to boost rice exports. Under this system, whenever Thailand lowers the export price of rice, the United States releases rice at the international price to the market from the government stock. It is designed to increase rice exports by the United States through a government subsidy to fill the gap between the international price and the domestic market price. The sluggish nature of the international rice price since the second part of the 1980s can be partly attributed to such export promotion policy of the United States.

The 1996 Agricultural Law sets the annual ceiling for payment: up to US$40,000 per farmer for a production flexibility contract payment and US$75,000 for a deficiency payment by a marketing loan. However, the ceiling was recently raised to US$80,000 for the former and US$150,000 for the latter, totaling US$230,000 to support producers against the sluggish prices of agricultural products.[9] In the case of a producer running more than one business, the total subsidy ceiling is US$460,000. When farmland is sufficiently large, each family member can be registered as an independent producer to receive a larger subsidy. Companies or cooperatives formed by many producers also receive a large subsidy. This tendency appears to be particularly strong in the rice industry, where a small number of rice millers and cooperatives have a large market share. In the 2000/2001, the top three beneficiaries of crop subsidies were two companies and one cooperative, all of which were mainly engaged in rice production. Riceland Foods Inc. (located in Stuttgart, Arkansas), the top beneficiary, received more than US$200 million in two years (Table 3-1). Within the United States, there has been long-standing criticism that the subsidy system originally designed to support small-scale farm households most benefits the largest farms and that this situation is still continuing under the 1996 Agricultural Law which aims at strengthening competitiveness through the liberalization of production.

Table 3-1 Top 10 Commodity Certificate Subsidy Recipients in the United States (2000 – 2001)

Rank	Name	Location	Commodity Certificate, Total in 2000 and 2001 (US$ 1,000)	Crops for Subsidy
1	Riceland Foods Inc.	Stuttgart, AR	220,821.86	Rice, maize, wheat and soybeans
2	Producers Rice Mill Inc.	Stuttgart, AR	77,184.52	Rice
3	Farmers Rice Coop.	Sacramento, CA	35,917.54	Rice
4	Dimmitt Agri Industries	Dimmitt, TX	2,228.51	Maize, wheat and sorghum
5	Wilder Corporation	Havana, IL	1,433.67	Maize, wheat, soybeans and others
6	Panola Co.	Newellton, LA	1,313.85	Maize, wheat, sorghum and soybeans
7	Tyler Farms	Helena, AR	1,284.68	Maize, rice, wheat, sorghum and cotton
8	River Garden Farms Co.	Knights Landing, CA	1,254.38	Maize, rice, wheat and sorghum
9	Stallings Farms	Blytheville, AR	1,172.76	Maize, rice, wheat, sorghum and cotton
10	Bobby Roark & Sons Partnership	Lake Village, AR	1,140.55	Maize, rice, wheat, sorghum and cotton

Source: EWG Farm Subsidy Database (http://www.ewg.org/farm/certificate.php?stab=US).

[9] EWG Farm Subsidy Database (http://www.ewg.org/). This database points out that tens of thousands of "paper farms" have been set up to circumvent the subsidy payment ceiling.

Another US policy capable of affecting rice cultivation in West Africa is food aid, including the provision of export credit. The main component is food aid known as PL 480 (Public Law 480) or Food for Peace. Since its launch in 1954, PL 480 has been playing a significant role in the food aid provided by the United States. At the beginning, its main purpose was to dispose of excessive agricultural commodities. This was later changed to assisting developing countries experiencing food shortages after its revision to become the Food for Peace Law. Even after this revision, however, it has the objective of developing the export market for US agricultural products through aid as it was originally intended. It has been pointed out on the one hand that the tremendous growth of rice consumption in Africa since the 1970s has been assisted by the US food (rice) aid. But on the other hand, it is likely the case that the US strategy of developing markets through food aid forms the background for such growth. The export of rice under food aid and other export programs accounted for approximately one-third of the total exports from the United States in the mid-1970s (Table 3-2). Although its relative importance has been declining since 1990, as much as 200,000-600,000 tons of rice is still exported a year under export programs.

Table 3-2 US Rice Exports by Program and Share of Export Programs 1/

Fiscal Year	PL 480 2/	Section 416(b)	Global Food for Education	Food for Progress	CCC Exports for African Relief	Total Exports Under Food Aid	EEP 3/	Total Exports Under Export Programs 4/	Exports Under Non-Export Programs	Total Exports	Share of Export Programs of Total Exports
	US$1,000										%
1975	747	0	0	0	0	747	0	747	1,467	2,214	34
1976	509	0	0	0	0	509	0	509	1,374	1,883	27
1977	676	0	0	0	0	676	0	676	1,585	2,261	30
1978	502	0	0	0	0	502	0	502	1,695	2,197	23
1979	442	0	0	0	0	442	0	442	1,891	2,333	19
1980	500	0	0	0	0	500	0	500	2,359	2,859	17
1981	320	0	0	0	0	320	0	320	2,677	2,997	11
1982	332	0	0	0	0	332	0	332	2,444	2,776	12
1983	429	0	0	0	0	429	0	429	1,780	2,209	19
1984	366	0	0	0	49	415	0	415	1,797	2,212	19
1985	500	0	0	0	5/ 180	500	0	500	1,408	1,908	26
1986	411	0	0	0	0	411	23	434	1,803	2,237	19
1987	370	60	0	0	0	430	28	458	1,954	2,412	19
1988	338	29	0	0	0	367	120	488	1,637	2,125	23
1989	355	0	0	0	0	355	20	375	1,875	2,250	17
1990	276	0	0	0	0	276	0	276	2,225	2,501	11
1991	210	4	0	0	0	214	76	290	2,126	2,416	12
1992	229	0	0	16	0	245	358	603	1,676	2,279	26
1993	199	0	0	137	0	336	278	614	2,096	2,710	23
1994	222	0	0	10	0	232	46	279	2,155	2,434	11
1995	196	0	0	14	0	209	113	322	3,441	3,763	9
1996	179	0	0	12	0	191	23	214	2,613	2,826	8
1997	115	0	0	14	0	129	0	129	2,431	2,560	5
1998	183	0	0	11	0	194	0	194	3,116	3,310	6
1999	515	0	0	45	0	561	0	561	2,505	3,066	18
2000	216	147	0	31	0	394	0	394	2,913	3,307	12
2001 6/	144	0	32	29	0	205	0	205	2,953	3,158	7

1/ Exports (program and non-program) reported on a product-weight basis. 2/ Titles I, II, and III. 3/ Export Enhancement Program. Sales, not actual shipments. 4/ Adjusted for estimated overlap between CCC export credits and EEP shipments. 5/ Estimated. 6/ Based on shipment data through November 2001.

Source: Food aid data for fiscal years 1975 through 1991 are from the Economic Research Service "Data Base". Food aid data from fiscal 1992 through 2001 are from the Foreign Agricultural Service and the Farm Service Agency. As cited in Economic Research Service/USDA, Rice Situation and Outlook Yearbook/RCS-2001/November 2001, p. 90

As mentioned in Section 3.1, the international price of rice is currently at its lowest level in history. In theory, a fall of the market price should result in a fall of production. In reality, however, rice production in the United States has shown an increasing trend despite some fluctuations from one year to another, largely stimulated by the availability of subsidies. Even though the US share of the international rice market has declined to the 10% level in recent years, the rice industry in the United States which has historically developed as an export industry can considerably influence the international market as long as the export expansion policy through marketing loans, etc. is maintained. Meanwhile, Thailand, Vietnam, etc., where rice is mainly cultivated in low land areas, cannot easily adjust the planting area in response to price fluctuations even if the international price of rice remains sluggish. Moreover, the leveling off of the domestic and regional consumption force these countries to attempt further export expansion to other regions. Markets such as West Africa where the rice consumption has been increasing are becoming more important for rice exporting countries. Meanwhile, rice producers in West Africa, the productivity of which is as low as an average of 1.5 tons/ha (milled basis), are facing harsh international competition as they have to battle against imported rice (milled) of which the price is less than US$200/ton.

3.3 Rice Supply and Demand Trends in West Africa

For 20 years from the early 1960s to the early 1980s, the productivity of rice production in West Africa remained virtually unchanged at 1.0-1.2 tons/ha on a milled rice basis without recording a substantial increase in the yield (Figure 3-9). During the same period, the area harvested only increased from 1.6 million ha in 1960 to 2.5 million ha in 1980. In the 1980s, however, the area harvested rapidly increased, partly because of market liberalization in many countries, recording an increase of 2 million ha in 20 years from 1980 to reach 4.5 million ha in 2001. Even the US Department of Agriculture, which carefully monitors agricultural data throughout the world, is said to have hardly recognize such tremendous growth from the 1980s to the 1990s and had to retroactively modify the data up to 1990 in late 1997.[10] Although the increased yield partly contributed to the production increase from the late 1980s onwards, the expansion of the area harvested has been principally responsible for the increased rice production in the last 40 years.

Meanwhile, rice consumption in West Africa has rapidly increased since the 1970s (Figure 3-10). This increase has been caused by a rapid increase of the per capita consumption, the background of which has been the rapid growth of the urban population due to the advancement of urbanization in this region.[11] While rice has traditionally been the staple food in some parts of West Africa, the rapid increase of rice consumption, particularly in urban areas, has been brought about by the facts that it can be stored for much longer than other grains or potatoes, can be easily transported and is easy to cook or process. The population growth in urban areas has also been a contributory factor. Any shortage of the domestic supply to meet the increasing demand for rice has been supplemented by imports, resulting in a steady increase of imports to a record-breaking 3.4 million tons in 1998 (milled basis). As mentioned in Section 3.1, even though the international price of rice has been leveling off at a

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[10] Ito, S., "Developing Global Rice Economy", op. cit., Chapter 4. The large discrepancies in the USDA data on rice production in West Africa between 1989 and 1990 may well be explained by such modification. In the USDA data, for example, the area harvested in 1989 was 3.1 million ha compared to 3.5 million ha in 1990. The rice production on a milled basis was 2.4 million tons in 1989 and 4.3 million tons in 1990.

[11] FAOSTAT Database (http://apps.fao.org/).

low level in recent years, the import value of rice in West Africa in 1998 was still a massive US$1 billion (Figure 3-11). To expand domestic rice production to meet the increasing demand, or at least to examine the feasibility of such a strategy, has become an urgent task for West African countries from the viewpoints of improving the income of farmers, creating employment opportunities in rural areas and saving foreign currencies.

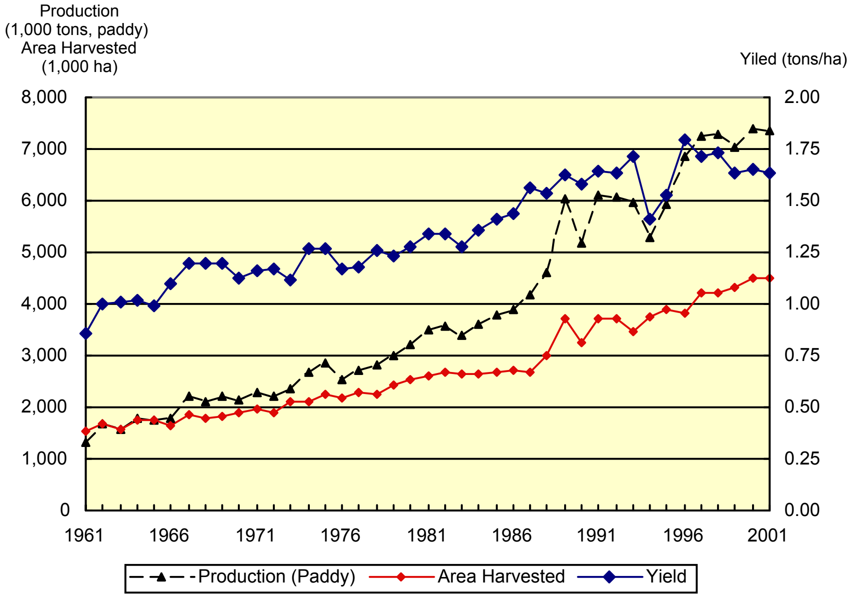


Figure 3-9 Rice Production (Milled Basis), Area Harvested and Yield in West Africa (1961 – 2001)

Note: West Africa here means 16 countries, i.e. Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo.

Data Source: FAOSTAT Database (http://apps.fao.org/)

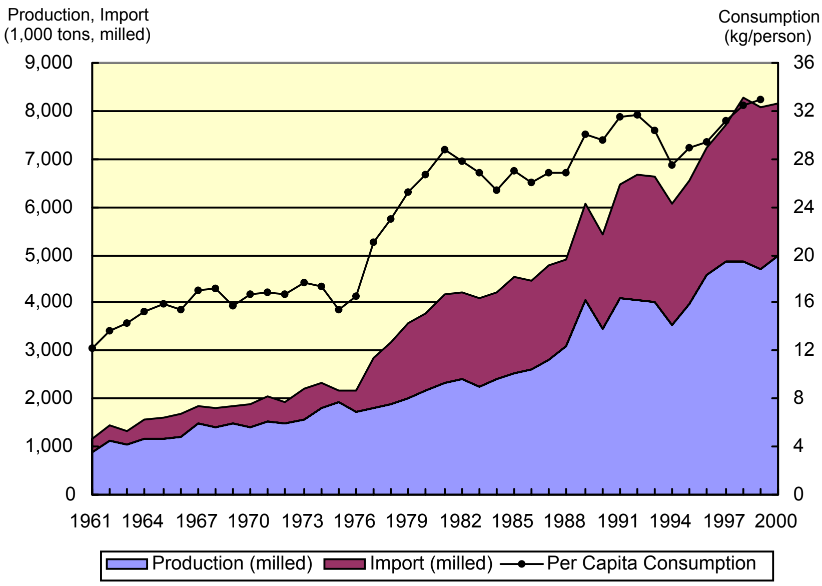


Figure 3-10 Trends of Rice Production Volume, Import Volume and Per Capita Consumption in West Africa (Milled Basis, 1961 – 2000)

Note: The production on a milled basis is calculated by multiplying the paddy production by 0.66972.

Data Source: FAOSTAT Database (http://apps.fao.org/)

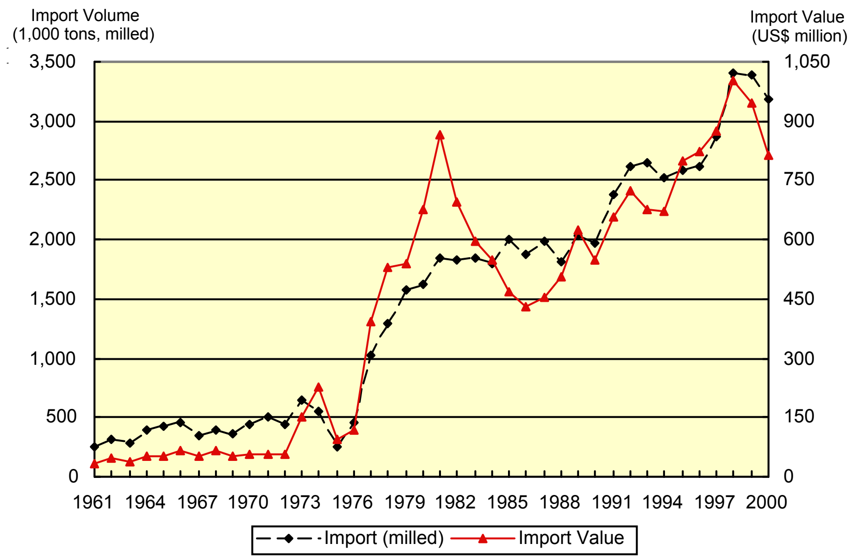


Figure 3-11 Trends of Import Volume and Import Value of Rice in West Africa (Milled Basis, 1961 – 2000)

Source: FAOSTAT Database (http://apps.fao.org/).

Further background for the increased rice imports to West Africa in the 1970s was the fact that US food aid during this decade primarily focused on such West African countries as Nigeria, Senegal, Côte d'Ivoire and Liberia.[12] Even though West African countries are no longer the main destinations of rice exports from the United States, the "strategy to develop markets through food aid" can be said to have been successful in the sense that West Africa has become an important market for the world rice trade. Ironically, however, the main rice exporting countries to West Africa today are Thailand and Vietnam, both of which are rivals of the United States.[13]

The main rice consuming countries, i.e., countries with a large demand defined as the total volume of domestic production and imports, in West Africa are Nigeria, Côte d'Ivoire and Guinea (Figure 3-12). These countries are also leading rice producing countries. Meanwhile, Senegal is another main consumer but its demand is mainly met by imports. Sierra Leone's average annual consumption per capita in 1996-1999 of 93 kg was overwhelmingly high compared to other West African countries, though it often exceeded 100 kg in the 1970s and the 1980s. During these two decades, Liberia's rice consumption per capita was as high as 110-130 kg a year. In contrast, the annual rice consumption in Nigeria and Côte d'Ivoire continued to increase even during the 1990s and thereafter.

[12] USDA, *Agricultural Statistics*; Miyakawa A., "Rice Cultivation" in *Agriculture in the United States*, op. cit., Part 2, Chapter 5, pp. 320-321.
[13] FAOSTAT Database (http://apps.fao.org/).

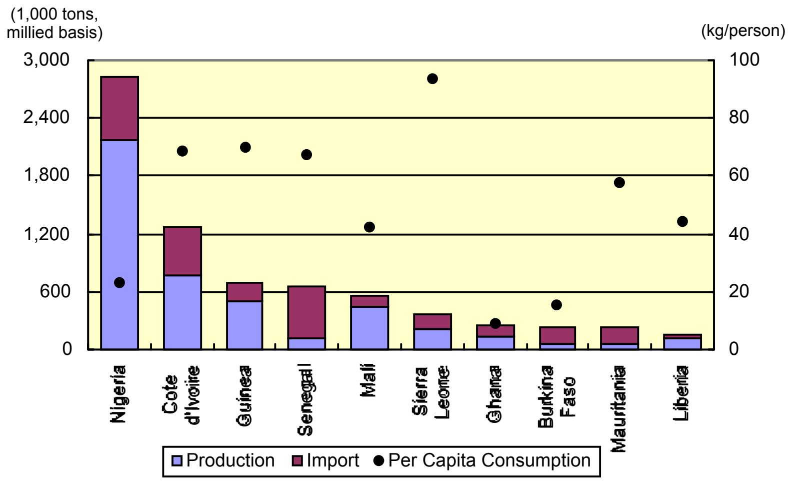


Figure 3-12 Major Rice Consuming Countries in West Africa (Milled Basis, Average for 1996 – 2000)

Note: The "Per Capita Consumption" is the average for 1996 through 1999 based on FAO data "Per Capita Supply/Year".
Source: FAOSTAT Database (http://apps.fao.org/)

3.4 Rice Supply and Demand Prospects in West Africa

According to *World Agriculture Towards 2015/2030* published by the FAO in August 2002, rice production (milled basis) in West Africa is expected to increase from 9.22 million tons in the base year of 1998 (average for 1997-1999) to 11.65 million tons in 2015 and further to 17.09 million tons in 2030 (Table 3-3). In comparison, the total demand (milled basis) is expected to increase from 11.51 million tons in 1998 to 19.16 million tons in 2015 and 28.37 million tons in 2030. As the expected demand increase will outstrip the production increase, the self-sufficiency rate will decline from 63% in 1998 to 60% in 2030. It will, therefore, be necessary to import the portion of the demand that cannot be met by domestic production and the import will increase from 4.4 million tons in 1998 to 7.51 million tons in 2015 and 11.27 million tons in 2030. As a result, West Africa will account for slightly more than one-fifth of the world import of 52.52 million tons (compared to its share of 13% in 1981).

Table 3-3 FAO Projection for Supply and Demand of Main Grains in West Africa (2015, 2030)

(1) Rice (milled basis; 1,000 tons)

	Food	Feed	Other	Demand	Import	Export	Balance	Production	Sufficiency
1997/1999	10,085.6	31.1	1,395.1	11,511.8	4,401.3	15.9	-4,385.4	7,223.2	0.63
2015	17,188.6	50.5	1,921.6	19,160.7	7,507.5	0	-7,507.5	11,653.2	0.61
2030	25,852.3	80.7	2,433.9	28,366.9	11,274.8	0	-11,274.8	17,092.1	0.60

(2) Wheat (grain; 1,000 tons)

	Food	Feed	Other	Demand	Import	Export	Balance	Production	Sufficiency
1997/1999	2,890.8	18.3	316.3	3,225.4	3,212.4	104.3	-3,108.1	102.9	0.03
2015	5,264.9	20	387.8	5,672.7	5,493.0	0	-5,493.0	179.6	0.03
2030	8,400.6	30	476.5	8,907.1	8,630.0	0	-8,630.0	277.1	0.03

(2) Maize (1,000 tons)

	Food	Feed	Other	Demand	Import	Export	Balance	Production	Sufficiency
1997/1999	5,784.1	1258.1	2,007.0	9,049.2	231.4	23.9	-207.5	8,932.9	0.99
2015	10,150.9	2,410.6	2,815.2	15,376.7	423.9	0	-423.9	14,952.7	0.97
2030	14,900.9	4,922.0	3,568.8	23,391.7	718.1	0	-718.1	22,673.5	0.97

Note: West Africa here means 16 countries, i.e. Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo.

Data Source: Obtained during a visit to Global Perspective Studies Unit, Economic and Social Department (in charge of preparing *World Agriculture: Towards 2015/2030*), FAO on August 13, 2002.

While the total demand and import of wheat and maize are expected to increase more prominently than rice, the expected maize import in 2030 is some 700,000 tons, approximately one-tenth of the rice import (about 7.5 million tons on a milled basis) due to the high self-sufficiency rate. As the self-sufficiency rate of wheat in West Africa is traditionally low due to the difficulty of domestic cultivation in the region, the import volume will be larger than that of rice. The potential for rice cultivation in West Africa seems to be greater than the FAO projection for 2030, i.e., production area of 6.63 million ha and a yield of 2.6 tons/ha, depending on the intensity of development efforts. There appears to be a strong necessity to exceed such projection as the per capita consumption of rice, which is greater than that of other grains, is expected to increase continually (Figure 3-13).

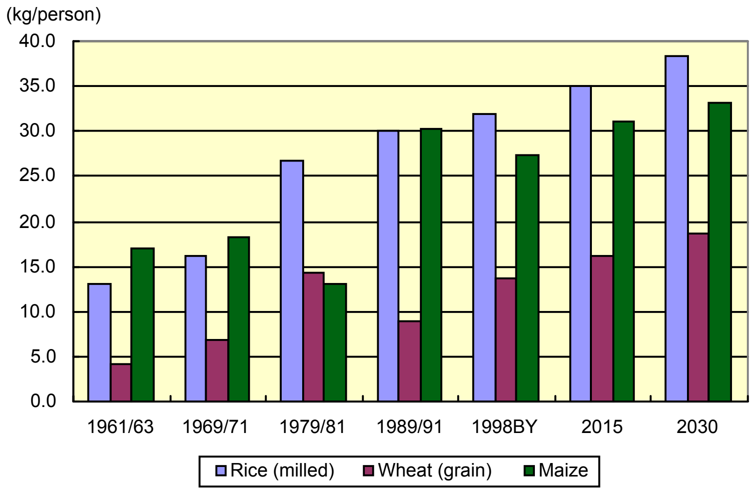


Figure 3-13 Changes and FAO Projection of Annual Per Capita Consumption of Main Grains in West Africa (1961/63 – 2030)

Note: West Africa here means 16 countries, i.e. Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo.

Data Source: Obtained during a visit to Global Perspective Studies Unit, Economic and Social Department (in charge of preparing *World Agriculture: Towards 2015/2030*), FAO on August 13, 2002.

CHAPTER 4 TRENDS OF RICE CULTIVATION AND DIRECTION FOR COOPERATION IN WEST AFRICA

4.1 Rice Ecology in West Africa

Rice cultivation in West Africa has traditionally been an extension of upland farming. The topography of West Africa is dominated by peneplains that are very flat with few undulations. There are many areas where the natural topography provides dipped areas which are ideal for the collection of water and the cultivation of rice without the deliberate development of paddy fields (*sawah*)[1]. Typical examples are a rice growing area near Abakaliki in southeast Nigeria and rainfed lowland areas in Sierra Leone. In areas like these, rice has long been cultivated without clear distinction between lowland (*sawah*-based) rice cultivation and upland rice cultivation. However, following the pioneering technical cooperation activities of Taiwanese teams regarding to wide-spread and intensive *sawah* (paddy) based farming for some 10 years in the 1960s and 1970s, the number of rice farmers who are consciously conducting water management has been steadily increasing throughout the subsequent 30-40 years.[2] Such management involves the introduction of bunding, leveling, construction of dams, dykes and weir and extension of water canals. Consequently, there are now many types of rice cultivation in terms of water management, ranging from upland rice cultivation to irrigated lowland rice cultivation (i.e., *sawah*-based). Figure 4-1 summarizes the various types of rice ecology observed in West Africa. It, however, excludes deep water cultivation on flood plains in the Sahel Zone and rice cultivation in coastal mangrove belts (observed in such countries as Guinea, Guinea Bissau and Nigeria).

4.1.1 Rainfed Upland

Rainfed upland rice fields depend on direct natural precipitation in definition. Rice is cultivated without the artificial supply of water in areas where the amount of available water does not exceed the annual rainfall level because of the natural topography, unlike lowland areas. As shown in Table 4-1 and Table 4-2, upland rice cultivation accompanying shifting cultivation, on slash and burn, accounts for a large proportion of the rice growing areas in West Africa. In Nigeria and Côte d'Ivoire, there is a small number of large-scale upland rice plantations which are run by companies. The cultivation areas of both upland rice based on shifting cultivation and rice cultivated as an agricultural business have little increased in the last 20 years because of soil degradation and other reasons described below. In the past, shifting cultivation did not cause any serious environmental problems in terms of soil and water conservation as slash and burn sites existed as small spots in secondary forests due to the long fallow period of more than 10-15 years. In recent years, however, the fallow period has been shortened to 3-5 years or less, making the regeneration of forests practically impossible. Fallow bush has now further deteriorated to become alang-alang (*Imperata cylindrica*) grassland while iron stone outcrops are observed due to soil erosion. There has been a progressive expansion of barren land where neither farming nor forest restoration with a long fallow period can be hoped for. Together with the advancement of desertification in semi-arid areas, the severity of environmental destruction in the wet forest zones described

[1] The explanation for the term "sawah" is found in Section 4.3.4 (2).

[2] Hsieh, Sung-Ching, "Agricultural Reform in Africa – With Special Focus on Taiwan-Assisted Rice Production in Africa, Past, Present and Future Perspectives", *Tropics*, Vol. 11, No. 1, pp. 33-58, 2001.

above is increasing. The area of such barren land resulting from human causes is particularly large in Guinea which saw a huge inflow of refugees due to civil wars in Sierra Leone and Liberia for more than 10 years since the 1990s and in Côte d'Ivoire, where upland rice cultivation and plantations have been expanded. It is estimated that some 2 million ha of land has become barren in each of Côte d'Ivoire, Guinea and Nigeria, totaling some 6 million ha with some 10 million ha of barren land in entire West Africa in the last 20 years due to upland rice cultivation (see Table 4-10).

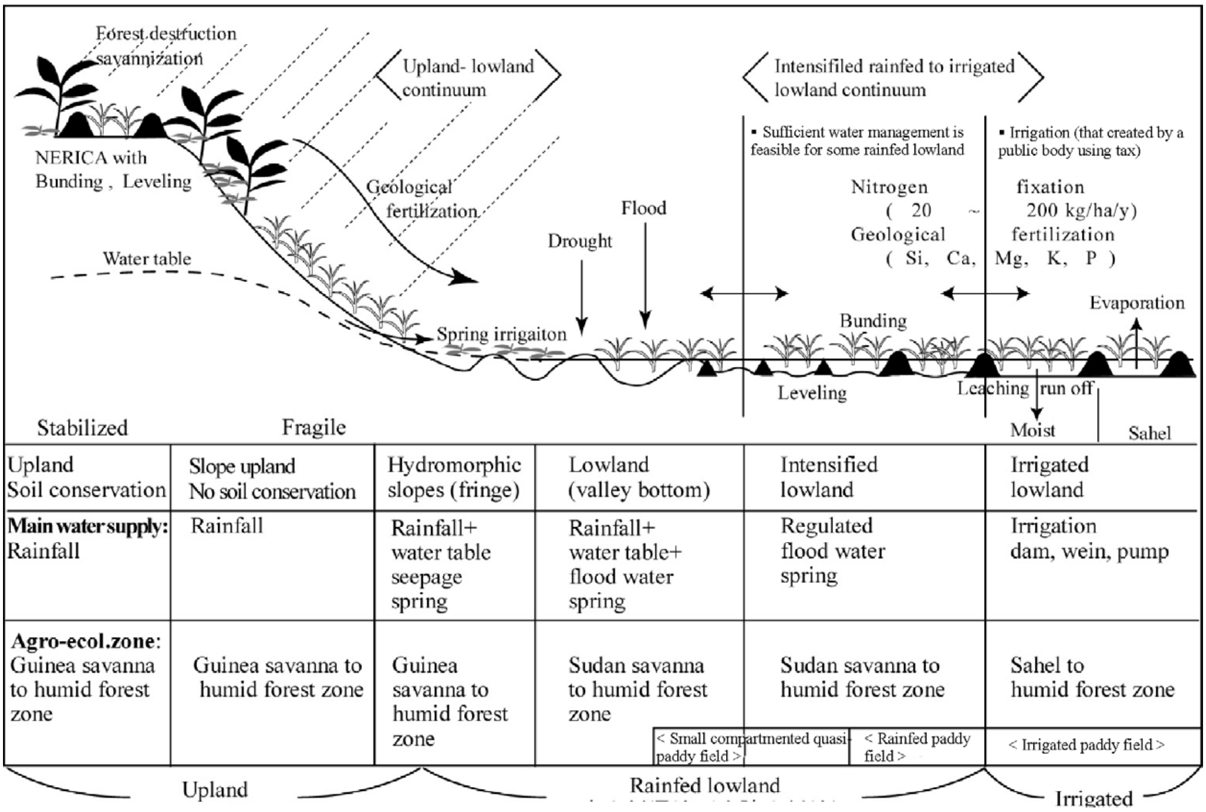


Figure 4-1 Various Types of Rice Ecology in West Africa (Excluding Deep Water Rice and Mangrove Rice Cultivation)

Source: Defoer, T., Wopereis, M. C. S., Jones, M. P., Lançon, F. and Erenstein, O., "Challenges, Innovation and Change: Towards Rice-Based Food Security in Sub-Saharan Africa", Article presented at 20th session of the International Rice Commission, Bangkok, July 23-25, 2002, pp. 1-25. Substantially revised by the Study Team.

Upland rice production sites with shifting cultivation are not compartmented by ridges, etc. and are, in many cases, sloping. The cultivation of upland rice, including other crops, in a sustainable manner at these sites is impossible due to the certainty of progressive soil erosion and degradation. Sustainable cultivation requires at least fertilizer application (the fertilizer application efficiency at upland farmland, even with conservation measures, is usually around 30%) and fertilizer application requires some levels of soil conservation measures, such as the existence of ridges, compartmentation or some degree of leveling work. At most slash and burn upland rice cultivation sites in West Africa where even such minimum improvement of farmland is not conducted, the fertilizer application efficiency is almost nil. Nevertheless, the improvement of infrastructure by means of introducing ridges and leveling the land is impossible and unnecessary at the present stage. If resources to conduct such improvement are available, they should preferentially be used for the development of lowland *sawah* fields of which the level of sustainability of intensive farming is far higher than upland because of the much more favorable ecological environment. Even so, there are some areas in West Africa where upland farmland has been improved to the level of allowing useful fertilizer application because of the topographical conditions or through the use of traditional farming methods (for example, the farming method called the Tabade system observed near Labe on the Guinea Highland; see Chapter 6 for a more detailed description). Therefore, if ecology is not suitable for the development of lowland sawah systems, we should not neglect rainfed upland fields. Rural development should be done in an integrated manner, including both lowland and upland, in appropriate balance depending on the local ecology.

Table 4-1 Rice Cultivation in West Africa Based on WARDA Data (1980-1984)

Country	Surface area under rice cropping (1000ha)						Paddy production (1000 ton)	Paddy yield (t/ha)
	Rainfed upland	Rainfed lowland	Irrigated lowland	Mangroves	Deep water	Total		
Nigeria	336	92	98	12	73	610	1,209	2.0
Guinea	256	163	27	82	16	545	451	0.8
Côte d'Ivoire	321	26	21	0	0	368	402	1.1
Sierra Leone	265	104	0	23	0	395	406	1.0
Mali	7	0	45	0	79	130	146	1.1
Liberia	207	13	0	0	0	220	278	1.3
Ghana	60	5	5	0	0	71	63	0.9
Senegal	0	46	17	3	0	66	115	1.7
Guinea Bissau	26	30	3	70	0	129	108	0.8
Chad*	0	0	6	0	36	42	97	2.3
Burkina Faso	0	26	4	0	0	30	39	1.3
Niger	0	0	6	0	15	21	42	2.0
Togo	11	3	1	0	0	14	15	1.1
Mauritania	0	0	4	0	0	4	13	3.3
Cameroon*	0	0	18	0	0	18	70	3.9
Gambia	3	13	1	3	0	21	35	1.7
Benin	1	7	0	0	0	8	8	1.0
West Africa	1,493	528	256	193	224	2,693	3,496	1.3

*As Chad and Cameroon were not the members of WARDA during this period, the figures were estimated based on the data provided by the following sources and FAO statistics.

Sources: WARDA, *Rice Statistics Yearbook, 6 Edition*, 1986; and Association for International Cooperation for Agriculture and Forestry, *Basic Statistics of Developing Countries (Africa I)*, 1985/86. (In Japanese)

Given the current situation in West Africa, the conversion of slash and burn shifting cultivation sites to permanent and sustainable upland rice fields is difficult. At farming fields of WARDA and those of key agricultural experiment stations in West African countries, the farming infrastructure has been improved by means of bunding (terracing), leveling, etc. to prevent soil erosion and it is possible to turn these fields into sustainable upland rice cultivation sites with the appropriate application of organic matters and fertilizer (stabilized rainfed upland rice in Figure 4-1). The sustainable cultivation of NERICA rice is only possible with such infrastructure improvement and fertilizer application. Moreover, at those sites of which the topography permits commercially large-scale mechanized farming as in the case of Cerrado in Brazil, sustainable upland rice cultivation may be possible with a combination of appropriate soil conservation measures and fertilizer application. Sustainable commercially mechanized upland rice cultivation with sufficient soil conservation efforts has so far not taken root in West Africa. Meanwhile, cultivation techniques presupposing such infrastructure improvement cannot be extended to farmers in West Africa, most of which are engaged in small-scale upland rice cultivation and of which the poverty is illustrated by their need to conduct shifting cultivation.

Table 4-2 Rice Production in West Africa Based on WARDA Data and Paper Presented by Lanacon and Erenstein

Country	Surface area under rice cropping (1,000 ha)						Paddy production (1,000 tons)	Paddy yield (tons/ha)
	Rainfed upland	Rainfed lowland	Irrigated lowland	Mangroves	Deep water	Total		
Nigeria	510	894	298	17	119	1,838	3,290 (2,081*)	1.8
Guinea	476	250	36	95	51	908	712 (261*)	0.8
Cote d'Ivoire	463	94	41	0	19	617	1,230 (828*)	2.0
Sierra Leone	269	100	8	20	8	405	340 (-66*)	0.8
Mali	10	51	89	0	144	294	670 (524*)	2.3
Liberia	85	33	11	0	0	129	222 (-56*)	1.7
Ghana	35	39	13	0	0	87	195 (132*)	2.2
Senegal	2	37	38	7	0	84	165 (50*)	2.0
Guinea Bissau	14	19	7	35	3	78	126 (18*)	1.6
Chad	3	25	3	0	32	63	96 (-1*)	1.5
Burkina Faso	2	20	8	0	3	33	94 (55*)	2.8
Niger	0	4	19	0	10	33	79 (37*)	2.4
Togo	22	5	4	0	0	31	76 (61*)	2.5
Mauritania	0	0	25	0	0	25	91 (78*)	3.6
Cameroon	0	2	16	0	0	18	65 (-5*)	3.6
Gambia	2	8	1	5	0	16	31 (-4*)	1.9
Benin	4	3	1	0	0	8	23 (15*)	2.9
Total	1,897	1,584	618	179	389	4,667	7,505 (4,111*)	1.6

* Difference between the production volumes in 1999 and 1980/84.

Sources: WARDA, The African Rice Initiative (ARI): NERICA Consortium for Security in Sub-Saharan Africa, pp.40, 2000.
Lançon, F. and Erenstein, O., "Potential and Prospects for Rice Production in West Africa," Sub-regional Workshop on Harmonization of Policies and Coordination of Programmes on Rice in the ECOWAS Sub-region, Accra, Ghana, February 25-28, 2002, pp. 20.

From a fairly long-term perspective, it may be possible to transfer Japanese experience in technical cooperation at Cerrado in Brazil to West Africa. Since the ecological conditions of West Africa resemble those of Cerrado in Brazil where these successful technology transfers have contributed to agricultural development. Given the socioeconomic conditions as well as the conditions of human resources, however, it appears difficult that the direct transfer of Japanese technology cooperation to West Africa based on the experience of agricultural development in Cerrado.

4.1.2 Rainfed Lowland

Rice cultivation here takes place at sites where the amount of available water exceeds the annual rainfall level due to the topographical condition of lowland. However, rainfed upland and rainfed lowland are located on a toposequence. In this report, rice cultivation at a site where the groundwater level does not reach the ground surface is classified as rainfed upland rice cultivation while rice cultivation on land below that point is classified as rainfed lowland rice cultivation. Rice is cultivated on such land with different levels of water management depending on the experience and skill of the rice farmers. As shown in Figure 4-1, the different features of this land include lower land just below upland and further lower land, including flood plains. Rainfed lowland can be classified into the following three categories based on the topography and type of development even though it is difficult to draw clear boundary lines between them.

(1) Hydromorphic Slope (Fringe)

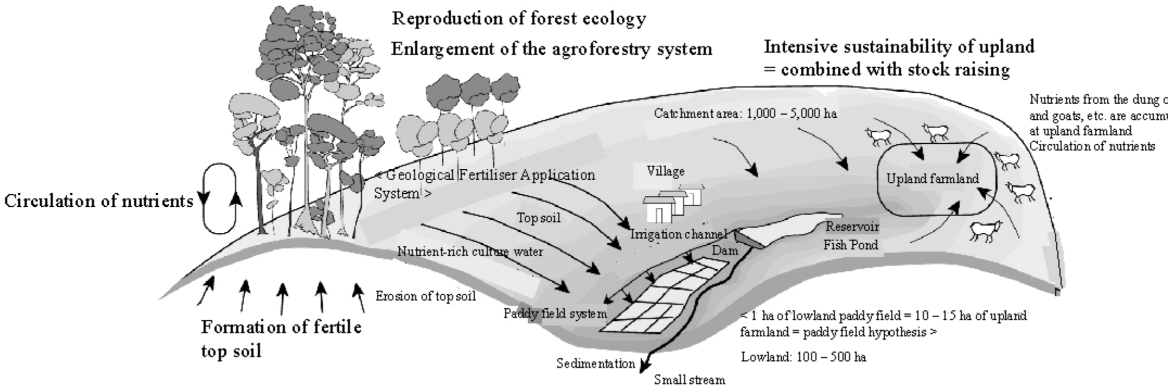
In the case of hydromorphic slopes in a groundwater fluctuation area, it is possible to gain access to seepage and spring water in addition to rainwater and groundwater. In such a case, multiple block irrigation is possible. Such multiple block irrigation in the form of small compartment quasi-*sawah* fields is widely observed in inland small lowland areas near Bida in Nigeria using spring water. Spring water is also observed in small lowland areas near Ashanti in Ghana and is used for fishponds and *sawah* fields, though most farmers in these areas cultivate rice using the naturally flat ground without creating *sawah* fields. The ground is not entirely flat as undulations of up to 1 meter, including those caused by anthills, are observed (Figure 4-1). Therefore, the common local practice is for rice to be cultivated at sites with an irregular mixture of droughty land, which is constantly dry due to the shortage of water, and flood land where the standing water or deep water condition is dominant.

At hydromorphic slopes, seepage water is used for irrigation as the water table rises during rain. When there is no rain, the water table rapidly becomes lower, making rice cultivation similar to upland rice cultivation. As these slopes are most liable to soil erosion from the topographical point of view, the soil fertility tends to be lower than that of upland let alone lowland. NERICA varieties that are supposed to be highly resistant to drought and poor soil may demonstrate their true value for this type of rice ecology. However, NERICA varieties, which are currently only upland rice varieties, appear to suffer from various physiological disorders when cultivated under submerged water as illustrated by a NERICA variety cultivated at *sawah* fields at Grand Lahou, Côte d'Ivoire, where 30% has failed to bear grains. It is, therefore, hoped that new varieties suitable for cultivation in rainfed lowland areas (cultivation at lowland paddy fields) will be developed.

(2) Inland Valley Bottom

Sustainable rice cultivation nearly every other year is possible in lowland areas without any attempt at water control or in small lowland areas with no flooding because of the small catchment (watershed) area (as in the case of the transitional forest zone in Ghana) as water which gathers at lowland carries nutrients (geological fertilization in Figure 4-1 and Figure 4-2). This is a great advantage over upland rice cultivation which requires a fallow period of 5-15 years to restore the soil fertility.

The size, microtopography and river flow rate of an inland valley bottom plain vary depending on the annual rainfall, size of the catchment area and geological as well as topographical conditions. When the catchment area is small (approximately less than 500 ha for a tropical forest belt, less than 2,000 ha for a transitional forest zone, less than 3,000 ha for the savannah in Guinea or less than 5,000 ha for the savannah in Sudan), it is rare for the water flow of a river to continue for more than half of the year with flooding of inland valley bottom lowland seldom being observed. Normally, the width of an inland valley bottom plain does not exceed several hundred meters and the flood discharge does not exceed several tons per second. When a catchment area is larger than the above case, the flow of river water continues for 6-10 months with flooding to a certain extent. In inland valley bottom lowland areas, high ground which almost acts as natural levees are formed near a river channel and such topographical differentiation as back swamp and slopes descending from the upland can be observed. The flood discharge may reach 10 tons/second in some cases.



The formation and erosion of fertile top soil in forests and its sedimentation as lowland paddy field soil creates "a sustainable catchment area agroforestry system" resulting from the water cycle, constituting an ecological engineering technology and intensifying the geological fertiliser application process in the catchment area. As a result, the sustainable production capacity of 1 ha of paddy field is boosted to be almost equivalent to 10-15 ha of upland (paddy field hypothesis).

Figure 4-2 Conceptual Drawing showing Relationship Between Forest and *Sawah* (Paddy) Field System in Catchment Area

In the case of small lowland areas situated in a catchment area of up to the above-mentioned size, the development of infrastructure for water control (development of an irrigated *sawah* field system) is possible based on joint work by a village-level farmers group with some assistance provided by an engineer of a public organization. In the history of *sawah* field development in the Yayoi Period, *sawah* based rice cultivation starting in Japan about 3,000 years ago, was made possible by weirs constructed across small rivers.[3] This is the simplest way of creating a *sawah* field system in tropical Africa where the technical level is similar to that of Japan in the Yayoi Period and which has no previous experience of *sawah* rice cultivation (a demonstration example is shown in 4.3.4). One difference is that while rocks and stones to build weirs were readily available in Japan and Asia, the use of woods, plastic sandbags, concrete and cemented blocks or similar will be essential in West Africa. Given the very gentle gradient of lowland, the creation of leveled *sawah* fields is relatively simple. However, accurate surveying to ensure water distribution throughout the system is essential. This latter requirement, in fact, makes it difficult for farmers to develop irrigated *sawah* fields by themselves even in rainfed lowland areas. When farmers have no previous experience of paddy fields, technical assistance at the early stage of development is necessary. Nevertheless, paddy fields can be developed relatively easily with the self-help efforts of farmers in rainfed lowland areas.[4] West Africa as a whole is estimated to have the potential for the development of some 9 million ha of *sawah* fields in small lowland areas (inland valley bottom areas).[5]

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[3] Honma, T., *Mechanism of Nation Building in Japan: Relationship Between Sawah Field Development and Population Increase*, Tokyo: Sankai-do, 1998. (In Japanese)

[4] Wakatsuki, T., Otoo, E., Andah, W.E.I., Cobbina, J., Burt, M.M. and Kubota, D., eds., *Integrated Watershed Management of Inland Valleys in Ghana and West Africa, Ecotechnology Approach, Final Report for JICA/CRI-CSIR Ghana Joint Study Project*, CRI, Kumasi, Ghana and JICA, Tokyo, 2001.

[5] Windmeller, P.N. and Andriesse, W., eds., *Inland Valley in West Africa: An Agro-Ecological Characterisation of Rice-Growing Environment*, II.RI Publication 52, Wageningen, the Netherlands. Hirose, S. Wakatsuki, T., *Restoration of Ecological Environment and Regeneration of Rural Areas in West African Savanna*, Tokyo: Association of Agriculture and Forestry Statistics. (In Japanese) Hirose, S. and Wakatsuki, T. eds., *Restoration of Inland Valley Ecosystems in West Africa*, Tokyo: Association of Agriculture and Forestry Statistics, 2002.

When the size of a catchment area is 10,000 ha or larger for a tropical forest zone, 50,000 ha or larger for a transitional forest zone, 50,000-100,000 ha for the savannah zone in Guinea or 100,000 ha or larger for the savannah zone in Sudan, flood plains are well developed and water management is impossible without large-scale civil engineering work to sufficiently control flooding. Compared to rainfed lowland areas where leaching and erosion are more prominent than sedimentation, these large catchment areas see the reverse situation where sedimentation is more prominent than leaching and erosion, resulting in a high level of soil fertility. However, the development of *sawah* fields in the case of this type of topography does not command high priority in terms in terms of cost and sustainable management under the present economic conditions because large-scale sophisticated irrigation work is required. Even so, the total development potential in West Africa is estimated to be some 9 million ha, which is similar to that of rainfed lowland areas.[6] While the development cost under conventional ODA schemes is inevitably high, it is believed that the current cost (US$20,000 per ha of irrigated paddy field) can be reduced to less than one-tenth with the full technology transfer, i.e., localization or making independent development technologies to allow development to be conducted solely by local engineers, extension workers and farmers groups in West Africa.

There has been little effort so far to localize *sawah* field development technologies to support the self-help efforts of local engineers, extension workers and farmers groups in West African countries. However, as *sawah* field farming in West Africa now has a history of more than 30 years and both the qualitative and quantitative levels of farmers, extension workers, agricultural engineers and researchers have much improved, the implementation of even fairly large-scale participatory projects is feasible. This situation is demonstrated by the ongoing development of paddy fields in Côte d'Ivoire under the Food for Work program carried out by WFP.

(3) Intensified Rainfed Lowland

As mentioned above, the self-reliant development of *sawah* fields in small lowland areas by farmers or farmers groups has been making much progress throughout West Africa in recent years. Different levels of irrigation systems have been created by farmers, including irrigation using a small pump costing some US$500 (or the use of a pumping service provider) without the construction of a weir or water canal, irrigation using spring water, irrigation by means of water harvesting where outflowing water from upland is guided to rainfed *sawah* fields, use of a simple weir made of wooden piles and soil or grass and irrigation canals constructed by farmers over more than several kilometers to intercept rainwater without a weir. Moreover, the manual leveling of fields is often observed along ridges of various forms and sizes. In short, rice cultivation at lowland *sawah* fields appears to be spreading all over West Africa with various levels of water control.

It is unclear what proportion of the so-called rainfed lowland rice cultivation area of some 1.6 million ha (Table 4-2) is currently accounted for by intensified rainfed lowland rice cultivation. Assuming that it is one-third of the total area, the area under intensified rainfed lowland rice cultivation is approximately half a million ha. An increase of this figure to the

[6] Hirose, S., and Wakatsuki, T., op. cit.

one million ha level is believed to be possible with the provision of technical support for such self-reliant efforts of farmers to improve already irrigated *sawah* fields. The reason for this optimism is the fact that the total area of intensified rainfed lowland rice cultivation has increased by some 400,000 ha in the last 15 years based on the spontaneous efforts of farmers and local governments without strategic support for *sawah* system development. It is, therefore, inferred that a further increase to one million ha level in the short period of the next 5-10 years is feasible based on the introduction of effective technologies under strategic support for the development of lowland *sawah*. Compared to the ARI's target of expanding the cultivated area with NERICA varieties by 200,000 ha in five years, the perceived expansion of intensified rainfed lowland rice cultivation will make a better contribution to a continual production increase of rice. In this sense, it may be a good idea for the ARI's activities not to focus exclusively on the extension of NERICA rice production.

4.1.3 Irrigated *Sawah* Fields

(1) Small-Scale Irrigated *Sawah* Development and Large-Scale Development

The cost of large-scale development (the area of a single development unit is assumed to be 1,000 ha or larger) and small-scale development (the assumed area of a single development unit ranges from several tens of hectares to several hundred hectares) is compared in a comprehensive manner, mainly referring to the development cost, etc. of past Japanese ODA projects in Lower Anambra (Nigeria), Lower Moshi (Tanzania) and small-scale projects in Lokapli in Côte d'Ivoire, where reservoirs were used to irrigate *sawah* fields, small rehabilitation projects in Ashaiman and Okyereko in Ghana and other areas in Niger, Senegal, etc. In Table 4-3, the cost of the eco-technology type small lowland irrigation system (inland valley bottom farming method) is also compared with the cost of upland rice cultivation with the slash and burn shifting cultivation method. As the inland valley bottom farming method relies on the self-help development of farmland by farmers, the single unit area of development varies from less than 1 ha to a maximum of several tens of hectares. As such, this type of irrigated *sawah* field development is much smaller than the conventional small-scale development of irrigated *sawah* fields with Japanese ODA.

The calculation results of the FAO for irrigated *sawah* field projects, including those of the World Bank and others, put the unit development cost at US$10,000-15,000/ha for large-scale projects, US$3,000-5,000/ha for the rehabilitation of large-scale project sites and US$3,000-4,000/ha for small-scale projects. However, most small projects used for this calculation, such as an informal scheme for rainfed lowland (*fadama* or inland valley bottom) in Nigeria and irrigation for vegetable cultivation, do not involve the development of infrastructure and land consolidation for *sawah* fields. Even in the case of large-scale development projects of the World Bank and others, *sawah* fields are often not properly developed, though weirs, pumps and water canals are provided to a certain extent. The development of *sawah* fields is left to the self-help efforts of farmers. When standard irrigated *sawah* fields are properly developed as in the case of Japanese projects, the cost per hectare exceeds US$10,000 under the present ODA scheme. In fact, the development cost of irrigated *sawah* field projects implemented by Japanese assistance is estimated to be US$20,000-30,000/ha regardless of the project scale even though there is a small margin of error depending on the scope of cost calculation.

Large-scale *sawah* field development in West Africa so far has been costly, partly because it has aimed at demonstrating modern *sawah* rice cultivation, including mechanization. Despite such a high cost, the development has been significant to show the essence of modern *sawah* rice cultivation to West African countries. Its positive effect is illustrated by the progress of rice cultivation in West Africa in the last 30-40 years to reach its present state. In the long history of rice cultivation in Asia, farmers were accustomed to small-scale irrigated *sawah* fields and have been able to integrate their accumulated experience and skills over the years to create more efficient large-scale irrigated *sawah* fields. In contrast, the lack of a tradition of rice cultivation in West Africa has meant a lack of accumulated experience and skills at the level of farmers. Consequently, large-scale projects inevitably incur a high cost (Table 4-3).

Table 4-3 Comparison of Development Cost, Economy, Maintenance, Willingness of Farmers to Participate, Sustainability, etc. in Various Types of Rice Cultivation in West Africa

(Unit: US$/ha)

Rice Cultivation Type	Large-Scale Irrigation	Small-Scale Irrigation	Eco-Technology Type Small Lowland Irrigation (Inland Valley Bottom Farming Method)	Conventional Slash and Burn Rice Cultivation Techniques
Development Cost (US$/ha)	20,000 – 30,000	3,000 – 30,000	3,000 – 4,000	20 – 30
Income (US$/ha) 1)	1,000 – 2,000	1,000 – 2,000	1,000 – 2,000	100 – 300 2)
Profit (US$/ha)	Loss-making	Loss-making – 1,000	1,000	100 – 200
Maintenance Cost	High	Medium – Low	Low	None
Operating Cost (US$/ha)	Medium – High (300 – 600)	Medium (200 – 400)	Medium (200 – 300)	Low (10 – 20)
Farmer Participation	Low	Medium – High	High	High
Background of Farmers	New settlers	Old and new settlers and indigenous farmers	Old settlers and indigenous farmers	Old settlers and indigenous farmers
Ownership of *Sawah* (Paddy) Field Development	Government	Government and farmers	Farmers	Farmers
Contents of Technology Transfer	Intensive rice cultivation technology with high inputs, including machinery	Intensive rice cultivation technology with medium to high inputs, including small machinery	Eco-technology type development, including small machinery and rice cultivation technology with medium inputs	Rice cultivation technology with low inputs
Ease of Adaptation to Technology	Requires a long time and was difficult to establish in the past	Can be established in a short to medium period with relative ease	Can be established in a short to medium period; technology transfer through demonstration and OJT	Transfer of technology on a minor scale
Sustainability of Technology	Low	Low – High	High	Medium
Environmental Impacts	High	Low – Medium	Low	Medium

1) In Nigeria, due to pump damage, only one crop (not two crops as scheduled) was possible. In Mali, due to deficient water fertilizer and seed technology, yield was only 2 tons/ha until recently. Large irrigation systems in Senegal, Cameroon and Nigeria have rarely harvested due to inadequate management. Milled rice is sold at a price of $200-300/ton, thus total maximum income is $2,000/ton, based on 7 tons/ha milled rice for two crops. Vegetable production in the second crop with small irrigation is normally more profitable.
2) Average harvest is 1 ton/ha of paddy (or 0.6 - 0.7 ton/ha of milled rice), and total income seldom reaches $300/ha.

Because of no tradition on sawah based irrigated rice farming in Sub-Saharan African countries, the accumulation of technological know-how and experience was not enough for large-scale irrigation projects. Therefore, operation and maintenance and water distribution and field water control were poor, resulting in lower water use efficiency and smaller irrigated area than the original plan. Thus, planned merits of large-scale were not realized. These are the major reasons of expensive large-scale projects. In Asia, on the contrary, since farmers and engineers have long and appropriate technological know-how for irrigation, large-scale irrigation schemes can offer more flexible and sustainable water supplying system, thus the sustainable and cost-effective production than small-scale projects. These are the basic socio-economical and cultural differences in irrigation between Asia and Sub-Saharan Africa.

Because of the high development cost of large-scale irrigated *sawah* fields and the difficulty of transferring maintenance technologies, small-scale development is given high priority today. However, the simple smallness of a project does not necessarily guarantee its sustainability. The unit cost of small-scale irrigated *sawah* field development conducted by Japan in West Africa up to the present is still too high as in the case of large-scale projects. Instead of introducing the conventional small-scale irrigation method which has so far been used by Japanese ODA, a low cost, small-scale irrigation method while maintaining the quality of the conventional method, i.e., high level of infrastructure development for the irrigated *sawah* field system, should be studied and developed, taking the participation of farmers into consideration.

Sawah field farming in West Africa has a history of more than 30 years and the qualitative as well as quantitative levels of farmers, extension workers, agricultural engineers and researchers have substantially improved as described earlier. Consequently, the sustainable maintenance of large-scale *sawah* field development sites is not as difficult as was previously the case. The achievements of an irrigated *sawah* field project of the Office du Niger in Mali, which covers an area of 50,000 ha, support this view (Table 4-4). Under this project, the yield up to the 1980s was 2 tons/ha while the production declined from 90,000 tons in the early years to 60,000 tons, a level which remained the same for many years. However, the yield rapidly improved to 5 tons/ha in the 1990s and the production is now approaching 300,000 tons/year. The long sluggish period appears to have been a preparatory period for the subsequent establishment of sawah based rice cultivation.

Behind this success lays model irrigated *sawah* rice cultivation of more than 1,000 ha at Valle du Kou in Burkina Faso implemented by a Taiwanese team 35 years ago and long-lasting cooperation and technology transfer by China, the Netherlands, etc. When Wakatsuki visited the project site in 1998, he witnessed the sealing of bund (*aze-kiri* in Japanese) of *sawah* fields by pairs of farmers to minimize the water leakage from each *sawah* field. While ridging is taken for granted in Japan, it has been necessary in West Africa to improve the technical level of water management for every *sawah* field of each farmer. These conscious efforts have made fertilizer application and the planting of a high yield variety viable, constituting a breakthrough for the Green Revolution.

Accordingly, it has become possible to create a large irrigated area by shifting the development strategy to the development of large-scale *sawah* fields at low cost or a cost of an appropriate level. Such a change of the development strategy together with the progress of research and development efforts will presumably make it fully viable to achieve the sustainable large-scale development of irrigated *sawah* fields let alone small-scale development. Under the present socioeconomic situation, however, it must be noted that the promotion of small-scale development and inland valley bottom development "on an ultra small-scale" based on the WFP method or the participatory type described later commands higher priority.

Table 4-4 Progress of Large-Scale Irrigated Rice Fields Under Office due Niger in Mali

Year	Planting area (ha)	Production of paddy (ton)	Yield (ton/ha)		Number of farm households	Area of rehabilitation (ha)	Farm households headed by women	Planting area per household	Fertilizer application volume (ton)	
									Urea	Ammonium phosphate
73/74	40,139	83,128	2.1		3,672			10.93		
74/75	40,774	86,000	2.1		4,153			9.82		
75/76	39,916	90,000	2.3		4,367			9.14		
76/77	39,567	94,400	2.4		4,542			8.71		
77/78	37,946	101,000	2.7		4,751			7.99		
78/79	36,557	95,000	2.6		4,863			7.52		
79/80	35,104	62,314	1.8		4,985			7.04		
80/81	35,589	69,290	1.9	Long	5,107			6.97		
81/82	36,96	65,992	1.8	stag-	5,236			7.05		
82/83	35,181	56,524	1.6	nant	5,484	450		6.42		
83/84	36,920	64,663	1.8	period	5,741	1,773	13	6.43		
84/85	38,154	64,086	1.7		6,665	3,778	15	5.72		
85/86	39433	82,957	2.1		8,490	5,886	17	4.64		
86/87	39,910	88,011	2.2		9,282	7,898	16	4.3		
87/88	42,125	98,194	2.3		9,972	9,617	20	4.22		
88/89	43,352	97,796	2.3		9,459	9,880	23	4.58		
89/90	44,251	106,593	2.4		9,621	10,872	31	4.6		
90/91	43,872	143,938	3.3		9,973	12,452	41	4.4		
91/92	44,435	180,909	4.1		10,465	14,637	53	4.25		
92/93	44,843	208,541	4.7		10,864	16,870	56	4.13	5,533	5,533
93/94	45,442	222,634	4.9		11,159	18,455	84	4.07	5,492	3,440
94/95	44,950	290,978	4.6		11,842	19,190	106	3.8	5,940	4,055
95/96	46,407	232,206	5.0		13,235	20,790	168	3.51	7,071	3,931
96/97	47,984	246,112	5.3		13,767	22,170	209	3.49	8,508	4,379
97/98	49,314	267,186	5.5		15,441	29,106	236	3.19	7,591	4,034

Devaluation of FCFA (93/94)
Source: Office du Niger, 1998.

(2) Rehabilitation or Development of New *Sawah* Fields?

One of the most important findings of this study is that irrigated *sawah* fields, the expansion prospect of which has been practically ruled out by WARDA and others, have, in fact, recorded a high growth rate in terms of the cultivation area and production volume compared to other forms of rice cultivation in the last 15 years (Table 4-5). This fact appears to suggest that preference for the rehabilitation of past ODA irrigation projects because of the high cost of new development and the difficulty of sustained maintenance, i.e., the common understanding of irrigated *sawah* field development in West Africa typically held by the FAO, is lagging behind the actual progress of rice cultivation in the region. In other words, it is now time for strong support for the low cost development of new *sawah* fields based on the self-help efforts of farmers rather than simple rehabilitation.

However, appropriate rehabilitation is important to get originally expected effectiveness of the investment for securing rice self sufficiency in this region. Since the cost effectiveness of rehabilitation is generally higher than new projects, priority should still be given to rehabilitation projects in this region. Therefore, it will be important to support both rehabilitation and cost-effective new projects in appropriate balances. It is hoped that Japanese consultants and construction companies with ODA experience will come up with a new high cost-benefit performance as well as an appropriate profitable method which can meet the challenge of creating several thousand to tens of thousand hectares of irrigated *sawah* fields at a low unit cost of several thousand dollars per hectare instead of creating 100-1,000 ha at a unit cost of several tens of thousands of dollars per hectare. The development of *sawah* fields based on the Food for Work program of WFP in Côte d'Ivoire[7] and the integrated development of inland valley bottom areas with the participation of farmers in Ghana[8] are pursuing this direction.

Table 4-5 Comparison of 1984 of WARDA's Strategic Plan in 1988 for Target Year of 2000 and Actual Results in 1999: Area, Yield and Production by Different Ecological Systems in West Africa

Ecological System for Rice Cultivation	Area (1,000 ha)	Area (%)	Yield (tons/ha)	Production (1,000 tons)	Additional Data		
1. Case with changed area and unchanged yield for the target year of 2000 in comparison with the 1984 survey data							
Rainfed Upland	2,160	59	1.0	2,160			
Rainfed lowland	760	21	1.4	1,064			
Irrigated *Sawah* (Wet)	185	5	2.8	518			
Irrigated *Sawah* (Sahel)	155	4	2.8	434			
Mangrove Swamp	193	6	1.8	347			
Deep Water Area	190	5	0.9	171			
Total	3,643	100	-	4,694			
2. Case with changed yield and unchanged area for the target year of 2000 in comparison with the 1984 survey data							
Rainfed Upland	1,490	57	1.3	1,937			
Rainfed Lowland	530	20	2.5	1,325			
Irrigated *Sawah* (Wet)	119	5	3.5	416			
Irrigated *Sawah* (Sahel)	112	4	3.5	392			
Mangrove Swamp	190	7	2.2	418			
Deep Water Area	190	7	0.9	171			
Total	2,631	100	-	4,659			
3. Case with changed area and changed yield in comparison with the 1984 survey data: (1990-2000 targets of WARDA)*					Production Increase Rate in 1984 -1999	Absolute Increase (1,000 tons)	(%)
Rainfed Upland	2,160	59	1.3	2,808	190%	1,318	43
Rainfed Lowland	760	21	2.5	1,900	250%	1,150	37
Irrigated *Sawah* (Wet)	185	5	3.5	647	190%	314	10
Irrigated *Sawah* (Sahel)	155	4	3.5	542	170%	228	7
Mangrove Swamp	193	6	2.2	425	120%	83	3
Deep Water Area	190	5	0.9	171	100%	0	0
Total	3,643	100	-	6,493	190%	3,093	100
4. Estimate for 1999 actual results**							
Rainfed Upland	1,897	41	1.0	1,897	130%	407	10
Rainfed Lowland	1,584	34	1.8	2,854	380%	2,104	52
Irrigated *Sawah* (Wet)	438	9	3.0	1,314	390%	981	24
Irrigated *Sawah* (Sahel)	180	4	4.5	810	260%	496	12
Mangrove Swamp	168	4	1.8	302	90%	-40	-0
Deep Water Area	305	7	0.9	275	160%	104	3
Total	4,572	100	-	7,452	220%	4,052	100
5. 1984 survey data (WARDA)							
Rainfed Upland	1,490	57	1.0	1,490			
Rainfed Lowland	530	20	1.4	750			
Irrigated *Sawah* (Wet)	119	5	2.8	333			
Irrigated *Sawah* (Sahel)	112	4	2.8	314			
Mangrove Swap	190	7	1.8	342			
Deep Water Area	190	7	0.9	171			
Total	2,631	100	-	3,400			

Note: WARDA targets for an increased production volume of rice (paddy) for the period from 1990 to 2000 (*) were 43% for rainfed upland, 37% for rainfed lowland and 10% for irrigated *sawah* fields. However, the actual results (**) showed an increase rate of 10% for rainfed upland, 52% for rainfed lowland and 24% for irrigated *sawah* fields.

Source: Computed by Wakatsuki by using data in the WARDA Strategic Plan 1990 – 2000 (1998) and data in Table 4-1 and Table 4-2 while referring to data in Lançon and Erenstein (2002) and Defoer, T., et al (2002).

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7 Nagumo, F., "Hand-Made *Sawah* Field Development in Progress in Côte d'Ivoire, West Africa", *International Cooperation* of *Agriculture and Forestry*, Vol. 25, No. 4/5, July/August, 2002, pp. 42-50.

8 Wakatsuki, T., "Small-Scale Inland Valley Bottom Development Allowing Autonomous Development in West Africa", *Bulletin of Agricultural Engineering Society*, Vol. 70, November 2000, pp. 999-1004. (In Japanese)

(3) High Sustainability of and Possibility of Contribution to Environmental Restoration by Irrigated Lowland *Sawah* Fields

Throughout the Study, it was strongly felt that the significance of the high ecological sustainability of *sawah* fields and its reasons were not well known among the people concerned. Figure 4-2 shows the mechanism of this high and long-term ecological sustainability of paddy fields. While it is fairly well-known that weeds can be controlled by means of water control, the fact that the nitrogen fixation volume of soil microbes under submerged watered cultivation system (50-80 kg/ha/year in Japan and 20-200 kg/ha/year in the tropics depending on the level of soil fertility and water management) is comparable with the nitrogen fixation amount of leguminous plants is not widely known. Rainfed upland farming has no option but to rely on the use of leguminous plants and/or animal dung, etc. The above-mentioned advantage of the *sawah* field system in lowland areas through water management is not properly understood. Moreover, geological fertilization through i) the sedimentation of fertile topsoil eroded by water flowing from upland to lowland and ii) the accumulation of highly nutritious water at lowland is important for the maintenance of the long-term sustainability of the lowland *sawah* field system.

When the unit yield of upland slash and burn rice cultivation is compared to that of lowland *sawah* rice cultivation, the latter (2.5 tons/ha) is approximately 2.5 times higher than the former (1 ton/ha) under the condition of no fertilizer application. With standard fertilizer application, the yield of *sawah* rice increases to 5-6 tons/ha. In contrast, fertilizer application is not a viable option for rainfed upland rice cultivation because of its low efficiency unless infrastructure or land consolidation is provided to a certain degree by means of soil erosion prevention measures, etc. In addition, the planting of rice in rainfed upland areas based on the slash and burn method of farming must be followed by a fallow period of at least 4-5 years to allow restoration of the soil fertility, i.e., for the sustainable 1 ha of upland rice cultivation based on slash and burn, 4 - 5 ha of upland are necessary. In comparison, repeated cultivation is possible at paddy fields as they have a mechanism to restore the soil fertility by geological fertilization (Figure 4-2) in the catchment area and cultivation under submerged condition of water. When these two types of cultivation are compared for a long period of 10-plus years, which are necessary to sustain a complete cycle of slash and burn cultivation, taking the above facts into consideration, the difference in sustainable productivity can be more than tenfold, i.e., yield difference (2.5) times difference of required area for sustainable production (4-5 times). Accordingly, the development of 1 ha of *sawah* field enables the conservation or regeneration of 10 ha or more of forest area. *Sawah* fields can, therefore, contribute to not only increased food production but also conservation of the forest environment as well as soil and water conservation in the catchment area, resulting in the enhanced sustainability of an intensive lowland *sawah* field system. Furthermore, they can contribute to the alleviation of global warming and other global environmental problems through the fixation of carbon to forests and forest soil.