近畿大農紀要　28：65～75（1995）
Mem. Fac. Agr. Kinki Univ.　28：65～75（1995）

A Study on Technology Transfer of Paddy Cultivation in the Kilimanjaro Region, Tanzania*

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1 Introduction

Tanzania has a peasant economy, much like most Sub-Saharan countries. Agriculture contributed to employment of about 82.3% of the population in 1987 and to 82.8% of foreign currency earnings in 1986 [FAO[1]]. Agricultural production occupied 52.8% of GDP in 1990 [BUREAU OF STATISTICS[2]]. More important, this peasant economy naturally contributes to people's existence through production of food crops. However, since the beginning of the 1980s in particular, Tanzania has been facing food problems and importing a lot of cereals, spending

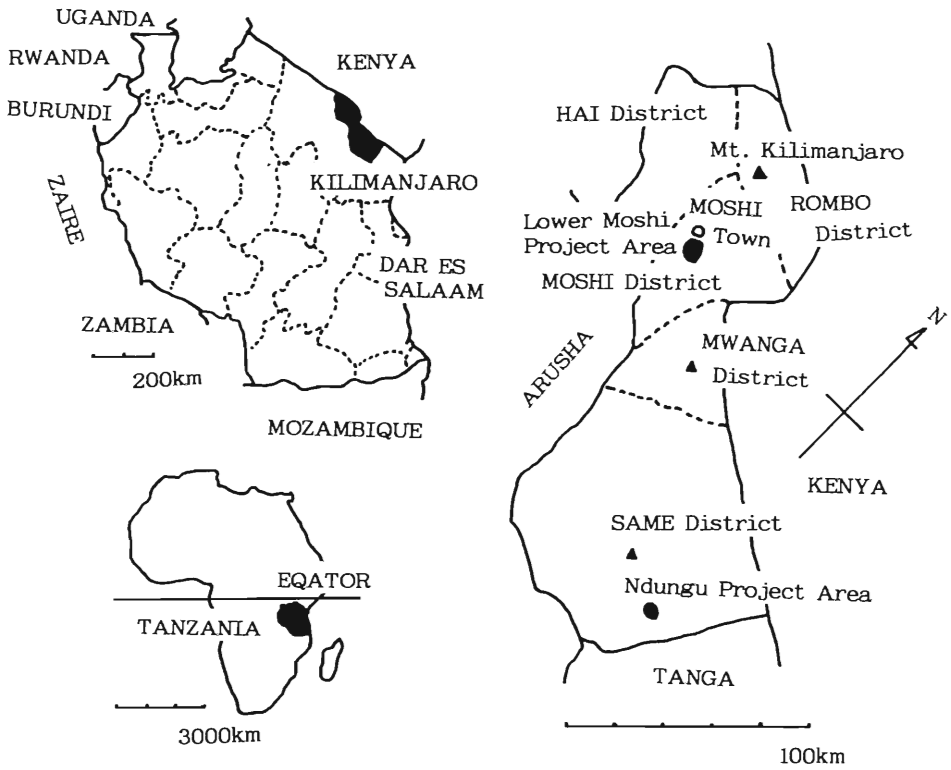

Fig. 1　Location of the Lower Moshi Project Area

* This investigation in 1989, 1991 and 1992 was supported by the Grant in Aid for Scientific Research of the Japanese Ministry of Education and Culture, No. 01041046 and No. 04041050. And Researches were carried out under the permission of the Tanzania Commission for Science and Technology, and the collaborating with the Sokoine University of Agriculture.

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scarce foreign holdings or depending on donated food to do so. Therefore, an increase in food production is an urgent task.

For this purpose, appropriate technology transfer is desired as well as a re-evaluation of traditional agriculture [RICHARDS[3]]. In gneral, technology transfer is carried out with the assistance of developed countries. The Japanese goverment began technical assistance in regard to irrigated paddy farming in the Kilimanjaro Region, Tanzania. This scheme is called the Lower Moshi Project (LMP). Location of the LMP is shown in Fig. 1.

In regard to the Official Development Assistance (ODA) of Japan, these is a lot of criticism [SUMI[4], MURAI[5]]. The LMP is also criticized severely. Although there is an irrelevant comment that food problems became more serious due to the change from traditional maize cultivation to modern paddy cultivation [MURAI et al[6]], criticism that a technological system depending on agricultural input from foreign countries is not sustainable is worthy of noting [SAKAMOTO[7]]. On the other hand, there is an affirmative view that the LMP is an example of success [KATSUKI[8]]

Whether we regard the LMP as a success or not lies in our evaluation of irrigated paddy cultivation. Thus this paper examines 1) the performance of paddy cultivation and problems to be solved in the LMP, and 2) conditions for the establishment of paddy cultivation. In order to examine these two points, this paper first explains the history of the LMP and the details of assisted technology of irrigated paddy cultivation. Then, it analyzes economic performance on the basis of data collected in interviews with villagers. Third, it points out problems with or negative impact on the sustainability of paddy farming.

2 History of the Lower Moshi Project

Former president Nyerere announced the Arusha Declaration in 1967, which showed the direction of national development based on "ujamaa", which means families, and agricultural village communities. This policy called "Ujamaa" socialism aimed at a decentralized society. In alignment with this policy, the Second 5-year Plan for 1969 74 defined the strategy for national development by regional development for which regional governments are responsible and with assistance of the Northern Countries to specified regions.

In 1970, the Government of Tanzania requested the Government of Japan to assist in the settlement of an integrated development plan for the Kilimanjaro Region. In response to this request, the Japan International Cooperation Agency (JICA) started preliminary research for the project from 1974, and submitted the Report on the Kilimanjaro Integrated Development Plan in 1977 which showed a variety of projects with regard to agriculture, small scale industry, water resources development, education, etc.

In 1978, feasibility studies were carried out, and resulting report listed 38 projects. Both Goverments agreed to select 6 high priority projects from these results. These projects were as follows: 1) Lower Moshi Agricultural Development Project, 2) Mkomazi Valley Area Irrigation Project, 3) Development, Extension and Agricultural Technique, 4) Promotion of Agricultural Mechanization, 5) Establishment of the Kilimanjaro Industrial Development Center (KIDC), and 6) Kilimanjaro Transmission and Distribution Network Project. In this year, both Goverments signed the Records of Discussion (R/D), and construction of facilities such as buildings, head-works and canals began.

The construction of Kilimanjaro Agricultural Development Center (KADC) and KIDC finished in 1981. KADC is the core of technical training for farmers and extension workers. In 1981, R/D was extended to 1986 to continue the preparation of fields suitable for paddy farming under a new controlling organization, Kilimanjaro Agricultural Development Project (KADP). The first phase was from 1981 to 1986.

The first phase was succeeded by the second phase in 1986, when water began to be used at

partial plots. The preparation for paddy fields and farm infrastructure, including irrigation and drainage networks, was finished completely by 1987. The second phase aimed at the technology transfer of paddy cultivation, agricultural mechanization and water management techniques. In 1991, the Kilimanjaro Project entered its final stage which will continue until 1993. In addition, planning for the Kilimanjaro Agricultural Training Center (KATC) started in 1994.

In the Agricultural Policy of Tanzania in 1983, the Government of Tanzania put high priority on promotion of irrigated agriculture as a long term policy [MIZUNO[9]]. The Kilimanjaro Region is given a position of preferential investment because about 28% of arable land, that is 45, 100 ha, is already irrigated in the Kilimanjaro Region, whereas no more than 4% of arable land in the nation is irrigated [JICA[10]]. However, such irrigation is small scale and is controlled by traditional systems, mainly in the mountain areas. The Regional Goverment wants to practice modern and large scale irrigated farming. Therefore, it is expected that the LMP will become a leading project. The new plan for KATC was made with the intention to expand irrigated paddy cultivation on the national level.

3 Structure of technology of irrigated paddy cultivation

There are 4 villages, Chekereni, Mabogini, Oria and Rau, in the LMP area, and about 2,000 farmers including land holders living outside these villages who are concerned with the LMP. Most of these farmers migrated from mountain areas, which were exploited in the 18th century, owing to population pressure. Generally, rainfall is little and uncertain in the lowland, ranging from 300 to 500 mm per year. Before the LMP, farmers practiced basically rainfed agriculture of maize and sunflower, and they could not expect stable yields. They often suffered from hunger because of accidental droughts. On the other hand, demand for rice exceeds supply in the Moshi, Hai and Rombo Districts (Table 1).

For these reasons, the local goverment of the Kilimanjaro Region focused on increase and

Table 1. Supply and Demand of Main Food by District (1985/86)

(unit : tons)

District	food	yield	amounts required	surplus
MOSHI urban		—	5,460	−5,460
MOSHI rural	maize	46,374	23,393	22,981
	rice	6,399	7,209	−810
	banana	322,800	335,560	−12,760
HAI	maize	55,362	13,752	41,610
	rice	600	4,245	−3,645
	banana	210,000	197,156	12,844
ROMBO	maize	12,649	12,224	425
	rice		3,781	−3,781
	banana	107,260	175,108	−67,848
MWANGA	maize	4,090	5,775	−1,685
	rice	495	1,778	−1,283
	banana	66,240	82,827	−16,587
SAME	maize	4,000	12,731	−8,731
	rice	9,600	3,940	5,660
	banana	3,250	182,617	−179,367

Source : REGIONAL AGRICULTURE DEVELOPMENT OFFICE, Annual Progress Report (1986) for the Agricultural Sector in Kilimanjaro Region, Moshi, Tanzania (1987)

stabilization of food production by irrigation. The LMP was expected to solve this problem, with establishment of irrigation facilities and technical guidance.

The LMP's targeted area is 2,300 ha, among which 1,100 ha is paddy field. The main purpose of the LMP is to stabilize food production and to improve the peasant economy through diffusion of irrigated paddy farming into the tropical semi-arid areas. Though irrigation was intended for upland crops, this has not been provided due to water shortage.

As shown in Table 2 and Fig. 2, the LMP constructed irrigation facilities and developed paddy fields. Water sources are the Njoro and Rau Rivers, where headworks were set up, not dams. A standard paddy field called a plot is 0.3 ha (30 m by 100 m). Each field has an irrigation and a drainage canal, and each faces a road. This method is quite the same as Japan's. Technical guidance goes into three areas: paddy culture, water management and agricultural machinery. Japanese experts were dispatched to each area, and they were involved in technical development for paddy farming in the tropical zone. Established technology includes selection of appropriate varieties of paddy, making standards for paddy cultivation and schedules for water distribution,

Table 2. Japan's Assistance Results Concerning the LMP

items	remarks	amount (100 million yen)
loan	paddy field, irrigation facilities	33.0
grant	KADC, KIDC	20.0
	post harvest facility	5.5
KR2	tractors, spare parts, chemicals	49.4*
	vehicles, implements	2.4
local cost	trial farm, pilot farm	1.0
	engineer training, public relations	0.8

Source: JICA, Research Report for Evaluation of the Kilimanjaro Agricultural Development Project in Tanzania, Tokyo, Japan (1991)

Note: * is on E/N base, and includes other regions.

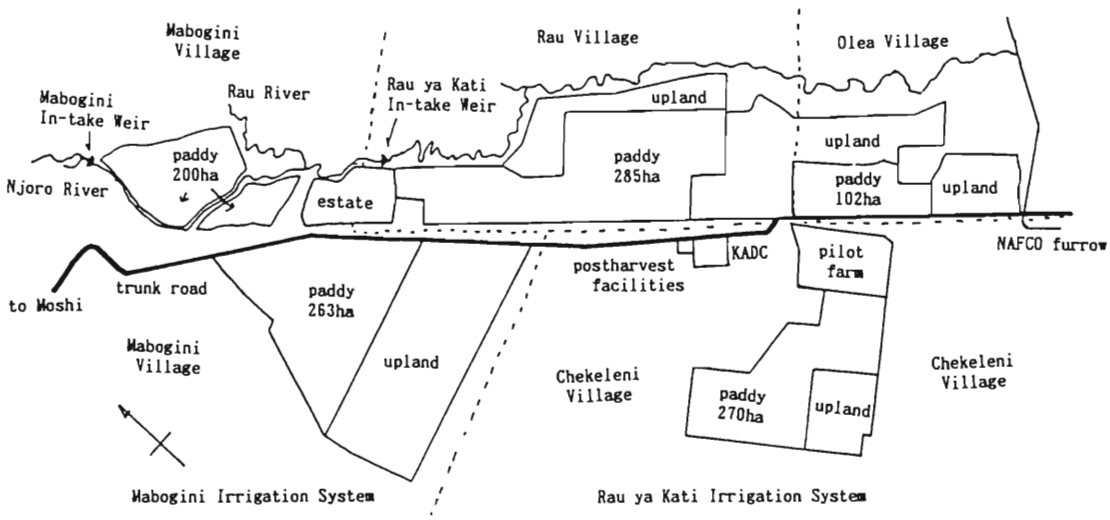

Fig. 2 Map of the Lower Moshi Project Area

and establishing methods of cultivation. It is notable that these techniques were developed on an on-farm basis through a coalition of Japanese experts and local staff.

On-farm development and construction of irrigation and drainage facilities were done by OECF Loan of Japan. The total amount of the loan was 3,300 million yen with interest of 1.5%. The technical guidance by Japanese experts was performed under Japan's Grant Aid. Grants for constructtion of KADC, KIDC and post-harvest facilities reached 2,500 million yen. In addition, tractors, spare parts, agricultural chemicals and so on were donated to increase food production.

Paddy farming of the LMP is operated, in a sense, in a Japanese style characterized by transplanting in straight lines, puddling by tractors, and applying artificial fertilizers and chemicals. Puddling is provided by the tractor hire service section of the KADP. This is because soil structure is very solid and it is difficult to cultivate by hand or ox-drawn plow. The main artificial fertilizers are "UREA" and "TSP". Diazinon, smithion and others are used as chemicals.

The recommended varieties of paddy were IR20, IR36, IR54 and IR56, which are so-called hybrid varieties. Among these varieties, farmers preferred IR54, because its husk fall off easily by hitting sheaves on the ground only twice. For this reason, only IR54 is grown in the LMP area at the moment.

High yield varieties including IR54 need much input such as fertilizers, chemicals and water [BROWN[11]]. In fact, according to the cultivation manual of KADP, IR54 needs more than twice the nitrogen fertilizers of the native varieties [HORIBATA[12]., 1992]. Fertilizers and chemicals are distributed through the Kilimanjaro Native Co-operative Union (KNCU) and the Tanzania Farmers Association (TFA). However, their supply is not sufficient and tends to be delivered late. In addition, they are rather expensive for small farmers in particular. In 1989, UREA was 1,000 Tshs (about 1,000 yen) per bag. TSP was 650 Tsh., and diazinon was 700 Tsh. Therefore, fertilizers and chemicals are not necessarily applied according to instruction in the manual. Nevertheless, avarage yields of paddy have been very high as will be mentioned later.

In contrast, water is a restrictive factor. The water flow of the Njoro and Rau Rivers is relatively stable, but it is not enough to irrigate all the project area at once. Real water requirements in depth is larger than that of the plan. Furthermore, water demand is becoming greater at the area upstream of both rivers, where modern paddy farming is expanding. Meanwhile, political pressure forced the paddy cultivation of a large area, at least 1,100 ha as the first plan. Therefore, KADP thought out a triple cropping system in 1988, instead of a double cropping system (Fig. 3). A triple cropping system means that paddy fields are rotated once in

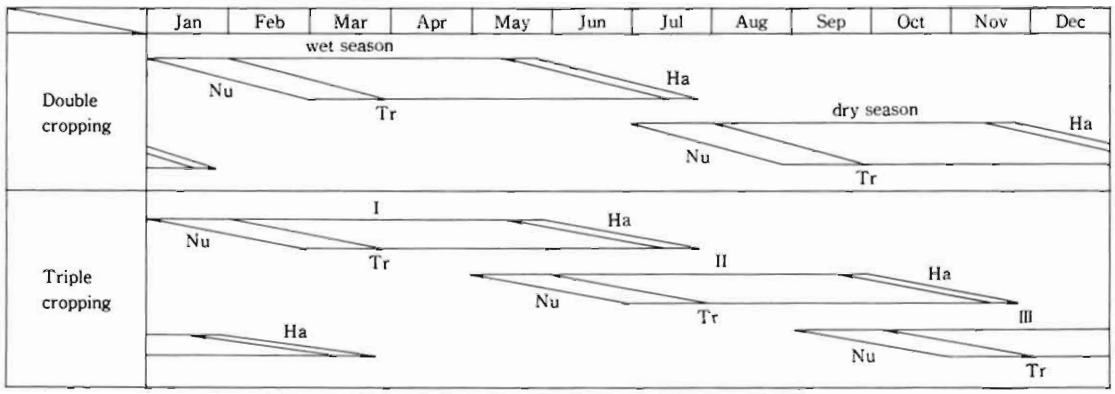

Fig. 3 Cropping Pattern of Paddy
Legend Nu : Nursery Tr : Transplanting Ha : Harvesting
Source : Compiled from KADC

a year with the LMP area divided into three. Under this system, paddy is not planted continuously in each field. By adoption of a triple cropping, it became possible to cultivate about 1,500 ha per year.

4 Economic performance by types of farmers

4-1 Types of farmers

The LMP is generally evaluated with high praise or at least with affirmation [YOSHIDA[13], KATSUKI[8,14]]. The greatest reason lies in achievement of high yield in the LMP area, compared with the national average. As shown in Table 3, since the beginning of paddy farming, average yield in the LMP (paddy base) continues at around the 6 ton mark, which far exceeds the national average of 2.4 tons per ha [PLANNING AND MARKETING DIVISION[15]]. This level is much higher than the targeted yield, 2.5 tons, in 1989. Although the yield level fell a little in 1988 and 1989, it showed an upward tendency again after 1990, and reached the 8 ton mark, the highest yield, in the second season in 1990. Such a high land productivity mainly owes to the adoption of IR varieties.

A high yield of paddy causes an increase in food supply and achieves great significance from

Table 3. Yields of Paddy

(unit : tons, tons/ha)

	total yiends	yearly average
1985 (dry)	744	7.02
Total & yearly ave.	744	7.02
1986 (wet)	1,017	7.59
1986 (dry)	3,410	6.49
Total & yearly ave.	4,427	7.04
1987 (wet)	3,075	6.70
1987 (dry)	3,519	6.69
Total & yearly ave.	6,594	6.695
1988 (I)	3,358	7.19
1988 (II)	2,936	5.69
1988 (III)	2,677	6.14
Total & yearly ave.	8,971	6.34
1989 (I)	2,489	4.60
1989 (II)	3,572	6.18
1989 (III)	2,584	5.68
Total & yearly ave.	8,645	5.49
1990 (I)	3,145	5.47
1990 (II)	5,207	8.44
1990 (III)	2,656	5.64
Total & yearly ave.	11,008	6.52
1991 (I)	2,652	7.11
1991 (II)	2,708	6.10
1991 (III)	3,278	7.30
Total & yearly ave.	8,638	6.84

Source : Compiled from KADC (Collected by T. HORIBATA)

Table 4. The Numbers of Farmers by Types of Paddy Cultivation (1992)

(unit : households)

block	Pure land-owner I	Dependent on laborer II	Family labor + laborer III	I + III	II + III	I + II + III	total
MS 2 — 3	11	1	33	9	1		55
MS 3 — 1	9	3	22	3		1	38
MS 6 — 1 c		2	3	2	1		8
MS 7 — 1	9	2	33	4	4		52
RS 1 — 8	1		11		1		13
RS 4 — 3	26	16	61				103
合 計	56	24	163	18	7	1	269

Source : Interview with farmers and counter parts of KADP

Table 5. The Numbers of Farmers by Residence (1992)

(unit : households)

block	Mabogini	Rau	Chekereni	Pasua	Mandaka	Moshi	Uru	Kibosho	others	Other Region
MS 2 — 3	41		1	2	8				2	
MS 3 — 1	28	1		2	2			1	1	3
MS 6 — 1 c	2						5		1	
MS 7 — 1	26	1		1		3	17		3	1
RS 1 — 8		13								
RS 4 — 3	1	2	73			5		10	5	7

Source : Interview with farmers and counter parts of KADP

the viewpoint of national economy. On the contrary, farmers in the LMP have gained fairly more cash income than expected. However, the economic effect is not the same for all farmers and is different according to the type of farm management.

Farmers in the LMP area can be classified into 5 types by whether they hold paddy fields or not and whether they hire agricultural laborers or not. Those are 1) land-owners with non-cultivation, 2) land owners using agricultural laborers, 3) family farms holding land, 4) tenant farmers using agricultural laborers, and 5) tenant farmers depending on family labor.

According to Table 4, pure land-owners who aim at taking only land rent occupy 21% of registered farmers in the researched 6 blocks*. Most of them are living outside of the LMP area. Their residences are generally villages in the mountain areas, but some farmers are living in other regions and even in Kenya (Table 5). Farmers wholly depending on agricultural laborers, those of the second type, are similar to so-called commercial farmers. Of all types, farmers partially using agricultural laborers occupy main position. Farmers of this type basically depend on family labor and may well be called family farms. However, pure family farms are fewer than expected. The reason why tenat farmers, such as type 4, can employ agricultural laborers lies in the economic condition that it is possible for them to gain profits even in such a case.

* In the LMP area, 70 to 100 plots (1 plot is 0.3 ha) make up 1 block, where a block leader has a responsibility to collect tractor fees and water charges, and to distribute water.

4-2 Economic performance of paddy farming

Table 6 shows an income estimation per plot in 1989 according to 5 types of farmers. Gross income is calculated by multiplying average yield of 25 bags (75 kg per bag) by sale price per bag, which was different for open markets and for government purchase. Cash expenditures are composed of tractor fees (1,510 Tsh.), water charges (510 Tsh.), material costs such as fertilizers, chemicals, bags etc. (5,025 Tsh.) and wages paid for agricultural laborers (17,150 Tsh.). As working time is unknown, self-employment wages are not included in costs.

According to a trial calculation using these assumptions, income is the highest in family farms which hold land and sell paddy to an open market. Of all types, working time is the longest in this type. Farmers of type 2 come next to those of type 3. Even tenant farmers wholly depending on agricultural laborers can gain a fairly large sum of income if selling to an open market. This fact creates the economic conditions for the birth of pure land-owners. Although land rent was 3,000 Tsh. per plot in 1987, it reached 2,000 Tsh. in 1989. Pure land-owners get high profit without cost.

Any type of farmers practicing paddy cultivation enjoyed fairly high economic performance in 1989. At that time, the minimum wage of governmental officials was about 2,500 Tsh. Compared with that, paddy cultivation was much more profitable.

Although I do not show the same estimate in 1992 as in Table 6, economic performance of paddy cultivation became increasingly high. In 1992, the minimum wage of governmental officials went up to 3,500 Tsh. per month, while income from paddy farming per plot in the case of sale to a free market by type of farmers increased as follows: 1) income of pure land-owners was 30,000 Tsh., 2) land-owners using agricultural laborers, 95,565 Tsh., 3) family farms holding land, 129,115 Tsn., 4) tenant farmers using agricultural laborers, 65,565 Tsh., and 5) tenant farmers depending on

Table 6. Estimate of Profitability of Paddy Cultivation by Types of Farmers (the first season in 1989)
(unit : Tsh)

types of farming	gross income	primary cost	surplus
land holders			
I pure land owner	20,000		20,000
II employed laborers			
case A	75,000	24,195	50,805
case B	36,750	24,195	12,555
III family farming			
case A	75,000	7,045	67,955
case B	36,750	7,045	29,705
tenant system			
IV employed laborers			
case A	75,000	44,195	30,805
case B	36,750	44,195	▲7,445
V family farming			
case A	75,000	27,045	47,955
case B	36,750	27,045	9,705

Source: Based on interview with farmers

Note: Case A indicates sale to open market, where the price just after harvesting is Tshs 3,000. Case B indicates sale to official route, the price of which is Tshs 1,470. Gross income is calculated on the assumption that yield is a 25 bag per plot yearly average.

family labor, 99,115 Tsh.

Reasons for high economic performance are the high price of rice in the free market, low tractor fees and water charges, outstanding redemption money of on-field work and so on. However, low tractor fees, which do not include depreciation costs, cannot only cover the running cost for tractors but also causes difficulty of tractor maintenance.

Farmers do not sell all the paddy but consume some part of the yield as food. Where paddy fields are smaller, the proportion of self-consumption is higher. As some small farmers can not get enough money for their living, there occurs cases in which they rent out their land and work as agricultural laborers. In this way, they can gain both rental fee and wages.

As mentioned above, paddy cultivation has three aspects: cash crops, food crops and labor opportunities for small farmers. For these aspects of paddy farming, farmers in the LMP give an affirmative evaluation to Japan's technical cooperation for paddy farming on the whole.

5 Evaluation of technology transfer for paddy farming

The first aims of the LMP were 1) diffusion and establishment of paddy cultivation, 2) an increase in food production, and 3) economic improvement of farmers. As far as the LMP area, the last two have been realized on the whole. Moreover, it became clear that irrigated paddy cultivation has a good impact on the environment. For example, salinization, which damaged production in a certain part of the LMP area at the beginning, has almost been solved because water flow washed away salts. Furthermore, paddy fields contribute to soil conservation. Soil erosion is almost nonexistent in the paddy fields compared with the surrounding upland fields.

Paddy cultivation in the Japanese style is expanding outside of the LMP area, as the high profitability of paddy farming is becoming known. Farmers neighboring the LMP area or in the LMP area have exploited paddy fields newly in Pasua, Mandaka and Kahe areas or have changed their traditinal paddy farming to modern farming. Their total area is reaching 1,000 ha. Such a regional expansion of paddy cultivation is evidence that the LMP is playing a sufficient role as a pilot project.

As can be seen from the above facts, the LMP has achieved the first aim considerably. However, it cannot be predicted whether irrigated paddy farming will continue after Japan's assistance has finished. Of course, economic incentives to continue this paddy farming will be kept strong for a while. Some new problems occur concerning paddy cultivation, however. Thus, it is impossible to know whether paddy cultivation can be sustained, as long as those problems are not solved.

First, water competition is severe. There are custom water rights in both the Njoro and Rau Rivers. Should the economic value of water became far higher, it will be quite difficult to coordinate water use among related villages. In addition, the authority in charge of a given water right of the LMP is different from that for custom water rights. Thus, governmental intervention is necessary from a legal point of view. Otherwise, a water users association will be required, whose membership is given to all farmers using the same river system, and which has an order for water use. However, this method would need a long time to become effective.

Second, there are some problems which are obstacles to the sustainability of paddy cultivation such as a decline in fertility due to a lack of fertilizer input and loss of variety's nature due to self-breeding. These are not only technical problems but also structural problems owing to a mismatch of socio-economic conditions. Therefore, it is necessary to reexamine adaptiveness of Japanese style paddy farming to socio-economic conditions in Tanzania in order to deal with these problems thoroughly.

Third, there is a warning that blood flukes and malaria mosquitos could increase, though I did not confirm this. It is recommended, therefore, to practice comprehensive research into environmental impacts of paddy farming, including protection of soil erosion and so on, on the basis of

fact not prediction.

Last, economic gaps among farmers and villagers are growing. From the outset, acreages of land holdings are different among farmers in the LMP area except those in Chekereni. In addition, some big farmers who have accumulated economic power have purchased paddy fields. Here we can see the appearance of a classification which goes against the philosophy of the "Arusha Declaration". Moreover, a bigger gap develops between villages with water and those with no water. This gap has the danger of causing crimes and social unrest. Further, an economic gap between farmers practicing paddy farming and the urban poor and needy will be a problem. The price of rice at public markets is steadily rising ahead of the purchasing power or the poor and needy. There exists a dilemma of antinomy that the high price of rice, which improves the economic condition of farmers in poverty makes worsens the living standard of the urban poor and needy.

There remain other problems such as management of post harvest facilities, financial difficulties of KADP, and payment of moneys collected from farmers to the National Treasury, develoment of human resources, in particular, responsible leaders engaged in management and control work, and so on.

It is strongly necessary to solve problems mentioned in this section and to establish irrigated paddy cultivation in the future, because economic performance of paddy cultivation is so good. Cooperation for paddy cultivation should focus on this point.

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タンザニア・キリマンジャロ州における灌漑稲作の技術移転に関する研究

池上甲一

要　約

発展途上国，とりわけサブ・サハラ・アフリカ諸国の多くは，小農経済に基礎をおく農業国でありながら，依然として食料問題に直面している。そこで，食料問題を解決しようと，各種の農業技術移転が図られている。

本稿は，日本の技術協力の下に，タンザニア・キリマンジャロ州において実施されている灌漑稲作の到達点と現段階における諸問題、およびその安定的な持続性を確保するための条件を検討する。この課題を解明するために，まず灌漑稲作プロジェクトの導入経過とその技術構造の特質を明らかにし，次いで灌漑稲作の経済的成果を分析する。これらの分析を踏まえて，灌漑稲作が定着するために考慮されるべき諸問題を検討し，最後に定着のための条件を探る。

キリマンジャロ州の灌漑稲作プロジェクトの目的は，熱帯半乾燥地帯に灌漑稲作を導入し，それによる食料問題の解消と小農経済の向上におかれている。この基本目的からみると，灌漑稲作プロジェクトは今のところ大きな成果をあげている。プロジェクト地域の農民は全体として，灌漑稲作から基礎的食糧の確保と現金収入の増大という２つの効果を得ている。さらにプロジェクト周辺地域へも灌漑稲作は急拡大している。

しかし，そのような成果の現れは一様ではなく，農民のタイプによって異なっている。また水を入手可能な村とそうでない村との格差も大きくなっている。さらに，これに関連して，水をめぐる紛争が激化しつつあるという問題が指摘できる。つまり，共同水利の経験が乏しい地域で，どのようにして水利秩序を形成するのかという課題が重要である。この問題は結局，技術移転と社会構造との接合可能性に帰することができる。移転しようとする技術の構造と社会構造との不整合はしばしば見られる問題であり，時には技術移転の成否を左右する。それゆえ，農業援助においては，技術構造と社会構造との整合性が十分に考慮されるべきである。