

Agricultural Reform in Africa — With Special Focus on Taiwan Assisted Rice Production in Africa, Past, Present and the Future Perspectives —

アフリカの農業改革 — 特にアフリカの稲作振興に対する台湾の
国際協力の過去、現在、そして将来展望に焦点を当てて-

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ABSTRACT Africa is the largest continent in the Southern Hemisphere. It has enormous ecological diversity, embracing two temperate zones, two subtropical zones and a tropical region. This geographical situation allows people in Africa to grow diversified crops. The 655 million Africans are largely agriculturally based. The main foods consist of the coarse grains (sorghum, millet, maize), wheat, rice, root and tuber crops (yam, cassava, sweet potato, potato, and taro); Asian rice is the preferred cereal and now replaces the indigenous African rice species.

In order to solve the food problem of the increasing population, efforts have been made to increase rice production in most African countries. Republic of China on Taiwan has been one of the countries which extended technical assistance to Africa to help increase rice production. During the past 39 years, through the Committee of International Technical Cooperation and International Cooperation and Development Fund, Republic of China on Taiwan devoted a large number of Chinese specialists and technicians in overseas service across six geographical regions. Taiwan's agricultural cooperation projects in Africa began in 1961 with agricultural technical mission sent to Liberia. In the following years, 23 missions were stationed in Africa, though some were withdrawn later. As of May 1, 2001, eight missions are still operating in African countries.

During the past 39 years, the agricultural technical missions in Africa reclaimed a total of 28,631 hectares of rice fields in 24 African countries. They also built a total of 2,784 Km of irrigation canals and a total of 1,524 km of drainage canals, which enabled to irrigate a total of 18,244 hectares of rice fields in 24 countries. This infrastructure building in the past years played an important role to promote the ability of rice production in the African countries.

In this paper, a special focus is placed on the Taiwan assisted rice production in 13 African countries, including Burkina Faso, Chad, Central African Republic, Cameroon, Benin, Gambia, Guinea-Bissau, Cote d'Ivoire, Liberia, Malawi, Mauritius, Niger and Senegal. Taiwan model of rice production in Africa, with regards to the past achievements and difficulties encountered in technology transfer, and the perspectives of future cooperation in rice production between Republic of China on Taiwan and African countries are discussed.

Key words: African rice cultivation / Agricultural Technical Mission / extension work / International Cooperation and Development Fund / land reclamation / seed multiplication / tidal irrigation scheme / technology transfer (アフリカ稲作 / 農業技術協力 / 普及 / 国際合作発展基金会 / 水田開発 / 種籾生産 / 潮汐灌漑システム / 技術移転)

During the period between 1950-1965, the Republic of China (ROC) on Taiwan was greatly benefited by the aid of the US, which laid the foundation for economic growth. After enjoying considerable economic growth, the ROC on Taiwan started to think about how to help other developing countries. Taiwan currently maintains extensive international economic cooperation programs. Taiwan's most widely celebrated international economic cooperation programs are the Agricultural Technical Missions, with a history of thirty-nine years in some sixty nations. This unprecedented program for agricultural cooperation was initiated on the purpose of helping friendly nations to increase food production to feed the ever-increasing populations. It also aimed to transfer the technology of agriculture production to small farms.

The first Agricultural Technical Missions began in the early 1960s in Africa under a program entitled Operation Vanguard. Starting from November 1972, all official technical assistance programs were transferred to the Committee of International Technical Cooperation (CITC), a semi-autonomous agency financed by the ROC government. The CITC was reorganized into the International Cooperation and Development Fund (ICDF) in July 1996.

After receiving a request for technical assistance from a country, the ROC would first send a survey team of experts to visit the country to assess feasibility of technical cooperation. The recommendations for possible areas of cooperation would then be drafted by the study mission. The recommended proposal would then be written in the form of an "Agreement" or a "Memorandum of Understanding (MOU)" which will be signed by representatives of both countries. A sum of budget for project operation, together with an agricultural technical mission would then be sent to the cooperating country from Taiwan through ICDF. Generally speaking, agricultural project is performed in four steps: (1) field experimentation, (2) field demonstration, (3) transfer of technology through training, and (4) extension of selected varieties of crops and methods of culture. Special emphasis is given to promote the production of rice, corn, sorghum, fruit tree, and vegetables.

In this paper, a special focus is made on the Taiwan assisted rice production in 13 African countries, including Burkina Faso, Benin, Central African Republic, Chad, Cameroon, Gambia, Guinea-Bissau, Cote d'Ivoire, Liberia, Malawi, Mauritius, Niger and Senegal. The impact of Taiwan assisted rice production on cooperating countries, and factors contributing to the success or failure were analyzed. The future perspectives of technical cooperation in rice production between the ROC on Taiwan and the African countries are also discussed.

Geographical and Agricultural Situations in Africa

Africa is the largest continent in the southern hemisphere: it spans across the equator from 37 degrees north latitude to 35 degrees south latitude and covers 70 degrees in longitude at its widest point. It has enormous ecological diversity, embracing two temperate zones, two subtropical regions and a tropical zone. It covers 30.27 million square kilometers of land mass including the immense Sahara desert, several large lakes, vast savannas, timber land, bottom land, tropical rain forests, and mangrove swamps.

The 655 million Africans are largely agriculturally based. The caloric sources consist of coarse grains (sorghums, millets, maize), wheat, rice, root and tuber crops (yam, cassava, sweet potato, and taro). Asian rice is the preferred cereal and it now replaces indigenous African rice species. Rice also

brings in cash income for the farmers. Industrial crops include cocoa, coffee, cotton, rubber, and sugarcane. Most farm families keep livestock. Local industries are generally associated with exportable commodities.

Likewise, limited cropland on one hand, and poor soils on the other handicap Africa. Rainfall is unreliable most years, adding instability to food production. While irrigation projects have been implemented in many countries in recent decades, their benefits cannot cope with the increasing demand for more food on limited croplands. Government authorities have given high priority to food production. Nearly one half of the 54 independent nations are devoting one quarter of their national budget to agriculture and two-thirds allow the local market to set food prices. However, improved health has led to a rapid rise in human population. With scarce croplands, the competition for land has encouraged the migration of able-bodied workers to urban areas. These developments have further strained efforts to increase food production.

Thus, Africa presents great challenges and at the same time, offers magnificent opportunities for Taiwan agriculturists and other technologists to transfer their expertise and experience of rice culture to their African friends in a genuine effort to enhance their livelihood. The Taiwan assisted rice productions in 13 African countries in the past 39 years are described in the following paragraphs. Activities of some other African nations, due to limited space, were not included in this paper.

Scope and Method of Agricultural Technical Cooperation

In the early days of CITC, enhancing rice production by using improved varieties and adopting the modern methods of cultivation was the primary goal. Production of rice was soon expanded to include many locally important food crops (sorghum, maize, soybean, and sweet potatoes), vegetables, and fruit trees. The process of local adoption of new crops involved a series of experiments to determine the best-suited varieties, planting dates, cultural and pest control methods. The work was soon extended to build necessary infrastructures such as irrigation systems, storage houses and land reclamation, etc.

The number of countries cooperating with Taiwan grew from 2 in 1961 to the accumulated number of 68 until 1996. 2,094 experts and technicians under 105 mission worldwide at various times were involved. The accumulated number of specialists during the period of 1961-1996 totaled 11,799. Currently 301 experts under 39 missions are working in 34 countries in Africa, Central America, South America, the Caribbean, Middle East, Asian Pacific and European areas.

Past and Present Status of Taiwan Assisted Rice Production in African Countries

Burkina Faso (BF)

The first phase of ROC-BF cooperation began in May of 1965 and ended in September of 1973. The initial activities included: surveying of project sites, planning irrigation facilities that would improve water use efficiency, land reclamation, experimental planting of rice, field demonstration, training of local extension workers and farmers, and extension of farming techniques to new settlers. Four

Table 1. Projects in Burkina Faso (Upper Volta)

| Location | Project | Duration | Reclaimed acreage (ha) | Settled farmers families | Farm family members |
|----------|--|--------------|---------------------------|--------------------------------|---------------------------|
| Boulbi | 1. Land reclamation 2. Develop irrigation systems for paddy rice cultivation | 4/65-8/69 | 87 | 250 | 1,000 * |
| Louda | 1. Land reclamation 2. Develop irrigation systems for paddy rice cultivation | 12/66-6/70 | 120 | 465 | 1,860 * |
| Kou | 1. Land reclamation 2. Building a dam at upper stream of Kou River 3. Construct irrigation infrastructure 4. Move farmers to upstream zones of the Black Volta | 1/67-9/73 | 1,260 | 913 | 5,480 ** |
| Bagre | 1. Land reclamation 2. Irrigation canal construction to take water from Bagre water reservoirs 3. Move farmers to the newly reclaimed land | 1/96-12/2000 | 1,150 | 1,100 | 4,400 *** |
| Total | | | 2,617 | 2,728 | 12,340 |

* Calculated based on 4 persons/family.

** Actually recorded number.

*** Targeted by the end of 2000.

projects were implemented in successive stages covering 2,167 ha of projected land area (Table 1).

(A) Boulbi and Louda areas

The main operations were to rehabilitate and strengthen the rock-filled earthen dams built during colonial days, line the irrigation channels with concrete, add lateral canals, build drainage channels, and add farm roads. Rice, coarse grains, beans and cotton was planted on the new land. Field trials of introduced rice varieties led to the selection of better-adapted and more productive varieties under proper fertilization. The acreage of rice culture extension at Boulbi and Louda areas totaled 213.70 ha, with a total production of 2,475 metric tones of rice during the period of 1965-1970.

(B) Kou project area

At the Kou project area, the site was selected to make best use of the abundant water flow of the Kou River. A diversion dam with a water inlet was built below the Diordougou Village. Water channels consist of 11 km of canals, 10 km of laterals, 11 km of sub-laterals and 73 km of branched sub-laterals. Farm roads measuring 15 km with 84 km of side roads were constructed. The facilities served 1,260 ha of reclaimed land. Of the three project areas, this is the largest reclamation operation, serving 913 families and 5,480 people. Rice yields of above 5 t/ha were obtained on the 1,260 ha of reclaimed land. Through the above efforts, rice yields were raised to 12 t/ha on a double-cropping system, raising production level by nearly 20 times. As the result of extension work done by the Taiwanese mission, a total of 12,058.21 tons of rice was produced from the Kou area covering 2,078 ha of land.

The total income earned from the selling of rice amounted to 278,707,641 CFA, which brought 134,123 CFA for each farmer. This unprecedented project, greatly increased farmer's income (calculated by French journalists at US\$871 per farmer), and farmers were able to built rice milling plants and market places. They were also able to buy motorcycles, radios, and furniture. Some built new houses; and others bought draft cattle. The writer (Hsieh 2001) made his second visit to the Kou project site in June 2001, and impressed by its sustainable operation of rice production by the local farmers for 30 years. Phase- I of the ROC-BF cooperation ended in September of 1973.

(C) Bagre area

The second -phase of the ROC-BF collaboration was resumed in 1994. Both countries were anxious to continue the fruitful cooperation of the earlier years. Before a formal agreement was drawn up, ROC sent a team headed by the writer (Hsieh 1994) to survey the Bagre area for an irrigation-and-reclamation scheme. Further field visits and studies by the ROC delegations have agreed to honor the host country's desire to increase annual production from 40,000 to 70,000 tones.

The Nakanbe River will help to improve the irrigation capabilities at the Bagre dam in Kenkodoko County. The dam was designed to irrigate 30,000 ha, but the gravity-fed irrigation water serves only 80 ha, and crop yields are low. The host country needs to develop 3,000 ha of irrigated land in order to attain the production goal of a 30,000-ton increase. After careful work, the mission initially developed 1,150 ha of land on the Right Bank of the river in 2001 (Table 2). The ROC mission is in the process of taking over the unfinished work by a consortium of eleven international organizations, to develop 2,165 ha of abandoned land on the left bank of Nakanbe River this year (2001). Currently, a rural development plan has been made for the local government to develop the newly reclaimed Bagre area into a community center. The project will include the establishment of new villages, schools, health centers, etc. (Table 3). In addition to irrigated rice, the phasse II project includes the improvement of

Table 2. Land reclamation project of ROC-ATM at Bagre area of Burkina Faso (1996-2000)

| Year | 1996 | 1997 | 1998 | 1999 | 2000 | Total |
|--------------------------------------|------|------|------|------|------|-------|
| Length of main irrigation canal (km) | 1.5 | 3.5 | 4.0 | 4.0 | 2.5 | 18.0 |
| Reclaimed acreage (ha) | 23 | 227 | 300 | 300 | 150 | 1,150 |

1. Expected annual rice production 10,000 MT.

2. Expected No. of households benefited 1,000

3. Expected No. of population benefited 7,000

Table 3. Rural development plan for newly reclaimed Bagre area in Burkina Faso

1. Establishment of new village:
Ten villages (about 100 households each) will be established to accommodate a total of 1,100 households of new immigrants from other districts.
2. One Farmer's Association will be established at each village
3. Infrastructure building
 - (1) Establishment of four primary school to accommodate 1,440 children.
 - (2) Three Health Centers will be established.
 - (3) Ten warehouses will be built.
 - (4) Numerous underground wells will be dug to supply drinking water.
 - (5) Road construction.
 - (6) Reforestation will be enforced.

Table 4. Taiwan assisted upland rice extension work in Burkina Faso between 1996-2000

| Year | 1996 | 1997 | 1998 | 1999 | 2000 |
|--------------------------|-------|-------|-------|-------|-------|
| Reclaimed acreage (ha) | 300 | 500 | 800 | 1,000 | 1,150 |
| No. of farmers benefited | 1,200 | 2,000 | 3,200 | 4,000 | 4,000 |

1. Expected acreage of extension: 3,600 ha.

2. Expected Annual production of rice: 9,000 Mt.

upland rice (Table 4).

Chad

In April 1964, the ROC signed an agricultural technical cooperation agreement with Chad, and sent a team of specialists to help improve agricultural production in May 1965. The members of the mission increased to 43 in 1972 with the expanded extension work.

Phase I (1965-1972)

Irrigation facilities were built to irrigate an area of 350 hectares. They included 3,667 m of main canal, 5,500 m of lateral canal and 16,800 m of sub-lateral canal. A total of 46 checking gates of irrigation canals and 57-drainage conduit were also built during the years 1965-1972. Farm demonstrations and extensions were conducted primarily on two demonstration farms, one in Fresson on five hectares of land, and one in Doba on four hectares of land. A training center was built at Doba, and 500 hectares of highland was reclaimed with local farmers. A total of 1,347 farmers received training organized by the ROC mission. An average of 6 t/ha of rice was produced as the result of extension work.

Phase II (1997-Present)

The new mission's work is targeted on the development of upland rice production on the 2,000 hectares of dry land, and 500 hectares of paddy rice on the irrigated land. A deep underground well was dug and irrigation facilities were constructed to irrigate the land based on rotational system of irrigation. Training programs for extension farmers are organized from time to time by the mission. Seeds of rice will be further multiplied for the increasing need of farmers in Chad. The targeted annual production of rice is 15,000 tons. It is expected that the continued service of the ROC mission will allow an increase in job opportunities for 5,000 households.

Cameroon (1964-1971)

A ten-member mission was sent to Cameroon in November 1964 to help develop agriculture with a special emphasis on rice production. The mission introduced rice varieties from Taiwan and began testing their adaptabilities and field potential in 1965. Field demonstrations and extension work were conducted to teach farmers to grow the selected high yielding varieties of rice. During the period of 1966-1970, a total of 2,317 farm households were under the extension for rice production, covering a total acreage of 1,128.34 hectares. Annual production of rice in those areas was 617.4 tons in 1966 and increased to 3,136.8 tons in 1970. The total production of rice in the area under this extension program totaled 7,021.24 tons during the period between 1966-1970.

Central African Republic

In June 1965, the ROC signed an agreement on agricultural technical cooperation with the Central African Republic (CAR), and sent an agricultural technical mission in January 1969. As a first step, the mission built irrigation facilities on the barren lands of Bangui, Sakae, Bozoum, Bambari and Alindao. A total of 24.4 km of irrigation and drainage canals was built over a 4-year period (1969-1973). Eight pumping stations and 4 dams were constructed during that time. Extension work for rice culture expanded 186.89 hectares. A total of 554 farmers and 43 local extension officers received training over the 4-year period.

Benin (Dahomey) (1963-1973)

Agricultural cooperation between Benin and the ROC began in March 1963. In April 1966, a new agreement was signed. The ROC agreed to send technicians to reclaim land for growing rice, and also to train farmers in Benin. In 1963, the mission began the work of land reclamation at 6 sites (Zou, Cove, Natitingo, Malanville, Mono, Godemey and others). The largest piece of reclaimed land was situated at Zou with 540 hectares, followed by Malanville with 516 hectares. The total acreage of reclaimed land increased to 1,289 hectares by the end of 1973.

The ROC mission introduced several varieties of rice from Taiwan to Benin for trials. Under the irrigated condition, the average yield of rice was 4-5 t/ha in both first and second crops. This figure was two times higher than the yields of pre-mission times. Demonstrations and extension work were concentrated in the reclaimed area covering 774 hectares. A total of 1,574 trainees including 58 local extension workers and 1,516 farmers received training organized by the mission during the period of 1963-1964. Financial difficulties and poor cooperation between Benin's Ministry of Economic Affairs and Ministry of Agriculture hindered the extension work.

The Gambia

Phase I (August 1966-December 1974)

In August of 1966, the ROC signed an agreement on technical cooperation with the Gambia; an agricultural technical mission was then dispatched to the Gambia in June 1967, to help boost rice production. Up to 1974, the mission members increased to 38. Crop experimentation and demonstration took place in Sankuli Kunda, Sapu, and Yord Beri Kun. Taichung Sen 2 yielded 7.1 tons/ha to 7.8 tons/ha with an average of 7 tons/ha. Based on the results of the fertilizer experiments, the mission recommended 12 bags of urea (46%) and 2 bags of compound fertilizer NPK (15-15-15) per hectare. During the period between 1966 - 1974, 1,644 hectares of rice were cultivated through the mission's extension service (Table 5).

During the period between 1965-1974, the mission trained 5,490 farmers and 186 agricultural staff members in rice production technology and the maintenance of farm machinery such as power tillers, water pumps, power sprayers, rice milling machines, etc. The mission also helped to establish the Rice Growers' Association, through which the harvested rice could be sold on the market.

Phase II (November 1995-Present time)

After the restoration of diplomatic ties between the ROC and the Gambia, a five-member delegation

led by the writer (Hsieh 1995) visited the Gambia in September 1995. The delegation found out that the national rice production dropped drastically from 29,610 tons in 1983 to 12,500 tons in 1993 which was a 125% reduction in total rice production. The delegation agreed to send another agricultural technical mission to help boost rice production to former levels, and also to ensure the sustainability of rice production.

Since November 1995, the ROC-ATM received funding from the ROC-ICDF to improve infrastructures at Jahally/Pacharr, as well as land development at Sapu and Sukuta. In addition, various activities such as rice breeding; screening for promising rice varieties, and training has also been conducted.

Rice extension work

The ROC-ATM provided a total of 3,040 bags of chemical fertilizers worth about D 570,000 to the farmers, in the dry season of 1999. The mission prepared 6,000 bags of fertilizer worth about D 1,123,200 for the farmers to use in the wet season. In addition, the mission provided 25 sets of power tillers and 6 sets of tractors to help prepare farmers' rice fields.

Land Development

The mission is presently reclaiming 30 ha of swampland at Sapu. The mission and the Kuntaur Agriculture Station jointly selected the land in Sukuta for development. The mission also spent about D10,530,000 to purchase additional equipment in January 1999.

The ATM was very pleased to convert about 340 ha of pump irrigated land to tidal irrigation land in Jahally and Pacharr. The cleaning of irrigation canals at Pacharr and Jahally enabled nearly 700 ha of land for rice growing under the tidal irrigation system in the dry season. More farmers are now able to grow rice all year round under this tidal irrigation practice.

Screening for promising rice varieties

Mr. Chen-Chang Chen, a rice breeder from Taiwan Agricultural Research Institute introduced more than 800 lines or cultivars of rice from Taiwan to the Gambia for trial at Sapu Branch Station of the National agricultural Research Institute. The promising varieties have been multiplied through a seed production program. More than 50 tons of certified seeds can be produced in each crop season to support at least 1,000 ha of extension rice field

Soil fertility analysis for optimum fertilizer application on the rice fields

Under funding from the ICDF, the Taichung District Agricultural Improvement Station in cooperating with the National Agricultural Research Institute of the Gambia to carry out a research project on soil survey and soil analysis on the major rice fields in the Gambia. This 2-year project produced the following results:

- * Soil maps of the major rice fields in the Gambia had been made.
- * The practical formula of fertilizer application for lowland and upland rices in the Gambia has been worked out.
- * Ideal rice based cropping systems have been established.

Development of tidal irrigation scheme to promote rice production

Tidal irrigation depends on the Atlantic tide movement which pushes the water through the inlet gates

Table 5. Paddy rice extension, the Gambia, 1966-1974

| Starting date | Site | Extended acreage (ha) | Farm families settled |
|---------------|----------------------|-----------------------|-----------------------|
| Dec. 1966 | MacCarthy province | 410.0 | 2,918 |
| Dec. 1966 | MacCarthy province | 184.0 | 257 |
| Nov. 1968 | MacCarthy province | 184.8 | 1551 |
| Dec. 1968 | Bathurst province | 232.4 | 1,073 |
| Oct. 1969 | Lower river city | 104.0 | 242 |
| Aug. 1970 | Lower river province | 103.6 | - |
| June 1971 | MacCarthy province | 86.8 | 860 |
| July 1971 | MacCarthy province | 222.0 | 1,260 |
| June 1966 | MacCarthy province | 116.8 | 610 |
| Total | | 1,644.4 | 8,771 |

Table 6. Potential area for tidal swamp development in the Gambia

| Type of swamp | Total acreage (ha) | Cultivated in 1983 | Potential for development (ha) |
|------------------------|--------------------|--------------------|--------------------------------|
| Seasonally fresh water | 66,742 | 8,944 | 57,798 |
| Ever fresh water | 5,720 | 1,844 | 3,876 |
| Total | 72,462 | 10,788 | 61,674 |

Source: Soil and Water Management Unit, Banjul.

or small creeks to both banks of the Gambia River and distributes the water into the rice fields. Seasonally- fresh -water tidal areas and ever-fresh water areas are two potential areas for rice production. At present, about 57,798 ha of the seasonal-fresh- water area and 3,876 ha of ever- fresh-water area can be developed for rice culture (Table 6). As the result of surveys made in 1997, six locations covering a total of 600 ha of land were identified to be good for rice production under the "tidal irrigation scheme". The ROC government provided a sum of US\$833,333.00 for purchasing of heavy equipment (tractors etc.) and fuel for land reclamation. As a result of land reclamation in Sapu and Sukuta of the CRD in 1999, a total of 100 ha of newly developed land was eligible to grow rice.

In the dry season of 1997, a total of 1,100 ha land in Jahally/Pachrr adopted the tidal irrigation method. The yields of rice increased from 2.5 t/ha to 5 t/ha. In the dry season, Wassu/Kuntaur farm (320 ha) adopted the tidal irrigation, increased its rice yield from 1 t/ha to 5 t/ha. In the dry season of 1999, the extension farms in Jahally/Pacharr planted a total of 320 ha of rice fields using tidal irrigation with good results (Table 7). The surrounding farmers were encouraged to plant rice using similar methods on 880 ha of farm.

As the results of efforts made by both the government of the Gambia and the ROC-ATM, total production of rice in the Gambia increased to 24,493 tons in 1997 which was two times higher than that of 12,500 tons in 1993. Rice production in the Gambia continued to increase to 26,636 tons in 1998, and reached to the highest record of 31,653 tons in 1999. Even though the Gambia still needs to import 60,000-80,000 tons of rice every year to meet the ever-increasing population (1.3 million). Post harvesting loss due to the traditional methods of milling is quite serious; the mission is now helping the farmers to establish rice-milling centers by providing milling machines.

Table 7. Estimated yields and additional profits after adoption of tidal irrigation methods (1998 dry season, and wet season, 1999 dry season)

| Year | Extension farm | Area (ha) | Yield t/ha | | | Additional Yield (ton) | Dallas' increase | US\$ |
|-----------------------|----------------|-----------|------------|---------|---------------------|------------------------|------------------|------------|
| | | | *Before | **After | Increase difference | | | |
| 1998 Dry Season | Kuntaur | 210 | 1.0 | 4.97 | 3.97 | 833.7(1) † | 1,458,975 | 121,581.25 |
| | Wassu | 110 | 1.0 | 5.26 | 4.26 | 468 † | 820,050 | 68,337.50 |
| | Small Scale | 70 | 1.15 | 4.78 | 3.63 | 254.1 † | 444,675 | 37,056.25 |
| | J/P | 155 | 2.5 | 5.0 | 2.5 | 387.5 † | 678,125 | 56,510.42 |
| 1998 Wet Season | Kuntaur | 181.2 | 1.0 | 3.5 | 2.5 | 453 † | 792,750 | 66,062.50 |
| | Wassu | 176.8 | 1.0 | 4.5 | 3.5 | 618.8 † | 1,082,900 | 90,241.67 |
| | Small Scale | 103.2 | 1.15 | 3.5 | 2.35 | 242.5 † | 424,375 | 35,364.58 |
| | J/P | 147 | 2.5 | 4.5 | 2.0 | 294 † | 514,500 | 42,875.00 |
| 1999 Dry | Kuntaur | 151 | 1.0 | 4.5 | 3.5 | 528.5 † | 924,875 | 77,072.91 |
| | Wassu | 176 | 1.0 | 4.5 | 3.5 | 616 † | 1,078,000 | 89,833.33 |
| | J/P | 320 | 2.5 | 6.5 | 4.0 | 1,280 † | 2,240,000 | 186,666.66 |
| | RIDEP | 110 | 2.0 | 5.5 | 3.5 | 385 Δ | 673,750 | 56,145.83 |
| | Wassu | 13 | 1.0 | 4.8 | 3.8 | 49.4(2) Δ | 121,030 | 10,085.83 |
| Total | | 1923.2 | | | | | 11,254,005 | 937,833.73 |

Exchange Rate=1 US\$: 12 Dallas

** After Project Implementation

(2) Aromatic Rice - D2.45/kg

† Tidal Irrigation

* Before Project Implementation

(1) Ordinary Rice - D1.75/kg

Δ Pumping Irrigation

Guinea - Bissau

After signing an agreement on agricultural technical cooperation between the ROC and Guinea-Bissau, a 12- member agricultural technical mission was dispatched to Guinea-Bissau in September 1990. The mission was withdrawn after separation of diplomatic relations in 1998. During the 8-year stay in Guinea-Bissau, the ROC mission worked on a 5-year project targeted to develop 5,000 ha of land for rice production. This was a very ambitious project.

Land reclamation

The mission began to reclaim abandoned land in 1991. By 1996 a total of 743 hectares of land in Bafata and Mansoa regions were successfully reclaimed. In this reclaimed land, a total of 20.5 km of irrigation canals and a total of 18 km of drainage canals were built

Due to financial limitations and lack of support from the local government, to reach the primary goal of reclaiming 5,000 ha of land seemed to be not easy. Under this situation, the mission decided to apply the method used in the Dara region (Dara model) to other regions. The So-called "Dara model" is to guide farmers to reclaim the land with their own hands, without using the expensive machinery. The land reclamation of the Dara district took only six and half months to complete and ready for rice culture.

By the end of 1997, the reclaimed land increased to 3,707.5 hectares. The main characteristic of "the Dara Model" was primarily that it was economical. The cost was about US\$ 200 for one hectare of land. Secondly, during the first year, farmers were provided with free seeds, free fertilizers, and free pesticides; however, starting from the following year, all costs of rice culture were paid by the farmers themselves. Thirdly, Farmers followed the simple farm management practices formulated by the

mission and were able to get good harvests (4-5 t/ha). They usually earned the profits 5-8 times higher than what they earned from the traditional ways of farming (0.8-1 t/ha). This was really a very successful project in Africa.

Seed multiplication

Rice seeds were in great demand; therefore, seed multiplication was one of the essential tasks for the ROC mission. The amount of rice seeds produced at Balata totaled 45.9 tons in 1994-1995 and 72 tons at Carantaba in 1995-1996.

Training of farmers

Training courses were organized by the ROC mission regularly with regards to methods of land reclamation; methods of rice cultivation, methods of fertilization, methods of pest control and farm management. A total of 3,681 farmers received training in 1996.

Extension work for rice production

Extension work was targeted for 5,000 hectares of rice field in five years. In 1993, the extended areas totaled 877 hectares with a total of 1767 households. The area produced a total of 3,040 tons of rice in 1993. The average yield of rice ranged from 3 tons to 5 tons per hectare. This yield was 5-8 times higher than that produced by traditional ways of shifting culture. By the end of 1997, the area increased to 3,707.5 hectares. The rice production was increased tremendously through this method of production. In recognition of the ROC mission's achievement in rice production, the farmer renamed a village in the Dara region to Wu-tzeun (Mr. Wu's Village) to honor Mr. Wu's contribution to rice production in Guinea-Bissau.

Cote d'Ivoire

The Cote d'Ivoire and the ROC signed an agreement on agricultural technical cooperation in September of 1962. The headquarters were set up at Bouake and Korhog in 1966. The number of technical personnel rose from 14 in 1963 to 160 in 1966, making the Cote d'Ivoire the largest mission abroad at that time. The mission activities ended in March 1983, after the severing of diplomatic ties between the Cote d'Ivoire and the ROC.

Table 8. Average yields of rice in the Cote d'Ivoire (1964-1973)

| | Paddy rice (kg/ha) | Upland rice (kg/ha) |
|------------------------|--------------------|---------------------|
| Pre- ROC-ATM operation | 870 | 450 |
| 1964 | 5,581 | - |
| 1965 | 5,110 | - |
| 1966 | 6,000 | 2,500 |
| 1967 | - | - |
| 1968 | 6,999 | 2,000 |
| 1969 | 3,779 | 912 |
| 1970 | 3,939 | 1,628 |
| 1971 | 3,375 | 1,510 |
| 1972 | 3,200 | 1,776 |
| 1973 | 2,875 | - |

Source: Committee of International cooperation 1987.

Table 9. Rice propagation and supply in the Cote d'Ivoire (1968-1982)

| | Seed propagation | | Seed supply | |
|-------|------------------|----------------------|----------------------|----------------------|
| | Acreage (ha) | Amount produced (kg) | Amount supplied (kg) | % of produced amount |
| 1968 | 2.30 | 2,800 | 1,140 | 40.7 |
| 1969 | 1.20 | 3,347 | 840 | 25.0 |
| 1970 | 16.81 | 38,413 | 25,743 | 67.0 |
| 1971 | 27.65 | 60,151 | 10,175 | 16.9 |
| 1972 | 35.20 | 121,774 | 57,009 | 46.8 |
| 1973 | 34.80 | 119,117 | 94,507 | 79.3 |
| 1974 | 37.29 | 112,753 | 95,374 | 84.6 |
| 1975 | 40.00 | 121,412 | 119,050 | 98.0 |
| 1976 | 40.00 | 131,448 | 124,875 | 95.0 |
| 1977 | 40.00 | 112,719 | 110,464 | 98.0 |
| 1978 | 40.00 | 122,407 | 65,163 | 53.1 |
| 1979 | 38.00 | 27,755 | - | - |
| 1980 | 48.80 | 85,990 | - | - |
| 1981 | 44.40 | 118,191 | - | - |
| 1982 | 22.00 | 65,120 | 28,300 | 43.0 |
| Total | 468.45 | 1,243,397 | 732,640 | 58.9 |

Source: Agricultural Technical Mission, Cote d'Ivoire.

Table 10. Acreage of rice demonstration and extension farms in Cote d'Ivoire (1963-1972)

| Year | Number of farmers households | Acreage of field under extension program | | | Annual production (Mt) |
|-------|------------------------------|--|------------------|-----------------|------------------------|
| | | Paddy rice (ha) | Upland rice (ha) | Total area (ha) | |
| 1963 | 5 | 1.20 | - | 1.20 | 13 |
| 1964 | 220 | 46.00 | - | 46.00 | 310 |
| 1965 | 2,515 | 601.24 | - | 601.24 | 4,540 |
| 1966 | 9,560 | 2,387.00 | - | 2,387.00 | 12,560 |
| 1967 | 10,533 | 5,327.00 | 406.99 | 5,734.58 | 10,266 |
| 1968 | 14,312 | 8,461.98 | - | 8,461.98 | 17,785 |
| 1969 | 15,795 | 5,949.06 | 3,053.32 | 9,002.38 | 22,138 |
| 1970 | 20,626 | 6,752.44 | 929.97 | 7,682.41 | 21,497 |
| 1971 | 25,926 | 8,332.34 | - | 8,332.34 | 34,562 |
| 1972 | 24,956 | 6,472.08 | - | 6,472.08 | 23,804 |
| 1973 | 4,487 | 2,126.35 | - | 2,126.35 | 7,644 |
| Total | 128,935 | 46,457.28 | 4,390.28 | 50,847.56 | 155,119 |

Source: Committee of Technical Cooperation (1987).

Rice production was the primary task of the mission. Prior to the mission's arrival, the average yield of paddy rice was 870 kg/ha and 450 kg/ha for upland rice. This was primarily due to lack of irrigation supply and good varieties of rice.

Construction of irrigation facilities

During the period of 1966, the ROC mission constructed a total of 1,000.83 km of irrigation canals, 619.87 km of drainage canals and 161 dams.

Yield trial of newly introduced varieties of rice

The mission introduced several varieties of rice from Taiwan and the Philippines and tested for their

adaptability and yielding potential in the Cote d'Ivoire. Ten promising varieties were selected for extension to farmers. The varieties of Tainan 8, Kaohsiung 27, Kaohsiung 10 and Taichung Native 1 yielded 3.3-4.4 t/ha depending on the availability of irrigation water. The figure was 4-6 times higher than the yields of local varieties (870 kg) (Table 8).

Rice seed multiplication project

The total amount of certified rice seeds produced between 1968-1982 was 1,243.4 tons, 58.9% of which was supplied to farmers for growing (Table 9).

Field demonstrations and extension work

In the early years, the mission's work was to culture paddy rice in the north, and to grow both paddy and upland rices in the central part of the country. In the east and southwest, upland rice is grown. Technology transfer for rice culture from Taiwan to the Cote d'Ivoire was the main task of the mission (Table 10).

Liberia

An eleven-member agricultural technical mission was dispatched to Liberia after signing an agreement on agricultural technical cooperation in November 1961. The agreement was renewed in 1965, 1967, and again in 1970. In response to the request of the host country to expand the activities of technical cooperation, the member of the ROC-ATM increased from 11 in 1961 to 60 in 1973. The mission had to be withdrawn after a separation of diplomatic ties in 1977.

With the reestablishment of diplomatic ties between the ROC and Liberia, a new mission consisting of 10 members were sent to Liberia from Taiwan in February 1990. The mission had to cease operations in May 1990 because of civil war in Liberia. After the civil war ended, a new mission was sent to Liberia again in November 1997, to rehabilitate the destroyed farming facilities during those 7 years.

Phase I (1961-1977)

The initial task was to conduct yield trial of crop varieties, including rice. A new rice variety, Chianan 3, produced 4,700 pounds of rice per acre, breaking the previous record for a dry season rice yield. The results of experiments indicated that Taichung Native 3, Kaohsiung 27, IR-5, IR-20 and IR 22 performed very well under the environmental conditions of Liberia.

A total of 2,498 farmers participated in various training courses in rice production organized by the Taiwanese mission. Extension work on rice production covered a total of 7,257 hectares of rice fields, in Faya, Gbana, Chiehn, Cape Mount and Gdedin. Under the instruction of the ROC mission, farmers could harvest 12,096 pounds / acre of rice per year. This amount was 18 times higher than the yield of rice by the traditional shifting system of agriculture. Each farmer's household could earn an amount of 210-286 dollars from each acre of land. This mission also implemented the ROC-Basa project, reclaiming 500 hectares of land for rice culture.

Phase II (September 1998-Present)

Goals of the 5-year project (1998-2003)

1. 2,050 ha. of upland rice extension.
2. 260 ha. of paddy rice extension.
3. Seed multiplication on 93 hectares of land to produce enough rice seeds for extension.

4. Increase job opportunities for 5,000 farming households to improve the livelihood of 25,000 people who suffered during the civil war.
5. Efforts are to be made to achieve the goal of producing 4,600 tons of rice annually.

Due to the severe damage of infrastructures, farm roads, and irrigation facilities by the civil war, the execution of the project is rather slow.

Malawi

The ROC-Malawi technical cooperation began with the arrival of a 12-member of ROC Agricultural Mission in the Karonga Province of Northern Malawi in December 1965. The team planted 2 ha of demonstration fields and obtained rice yield of 7 t/ha by growing Taiwan variety, a figure that was nine times greater than the yield of a local variety, Faya. The results greatly impressed the local authorities. Upon their urging, the working sites were increased to 12 during the years between 1965-74.

Land reclamation and irrigation infrastructure building

In order to expand the area of rice culture, the mission began reclaiming lands located at Kapora, Mwentiete, Wovwe, Bua, Domasi, and Tangazi / Mouna etc. The area reclaimed during 1965-1985 totaled 2,288.29 hectares. Domasi was the largest single piece of land reclaimed with a size of 500 hectares, and Tangazi/Mouna came to next with an area of 400 hectares. Following the land reclamation, various irrigation facilities, including waterways, Dam and drainage systems were built to facilitate gravity irrigation. The area of reclaimed land with completed irrigation facilities totaled 2,188.29 hectares during 1976-1986.

Field demonstrations and extensions of rice production for farmers

Between 1965 and 1968, demonstration sites were located in Chirumba, Kaporo, and Njaca. The work fell into four categories: establishing, managing and the extending the demonstration farms, implementing irrigation facilities, and training farmers in paddy rice culture. Between 1965-1985, the extension work by the 29 members of the ROC mission covered a total area of 2,288.29 hectares, which was the entire area of reclaimed land by the mission. The extension work was aimed to increase rice production for domestic use as well as for exportation. Blue Bonnet was selected to be the most productive variety among the tested varieties of rice introduced. It yielded 8 tons/ha in the Domasi extension farm in 1972, and 5.3 tons/ha on the farmer's field in Domasi. The rotational irrigation scheme developed in Taiwan was widely practiced to maximize water use.

The Taiwan assisted farm machinery centers

To facilitate rice production, farm machinery centers were established in Malawi in 1978. Eighty-farm machines were donated to 11 farm machinery centers by the ROC government through the ROC mission in 1978. The mission's machinery expert organized training courses with regards to handling and maintaining the machines. The trained technicians worked at 11 centers to maintain the machinery. Ten machines in 1978, increased to 80 machines to serve an area of 1,056.60 hectares of rice fields in 1985.

Establishment of seed multiplication systems in Malawi

With a joint effort, a seed multiplication system was established in 1978. The ROC mission produced stock seeds, which were distributed to the selected progressed farmers to reproduce the certified seeds.

The certified seeds are sold to ordinary rice farmers for planting. The ROC mission maintained an area of 2-40 hectares of fields for stock seed production and 25-57 hectares for production of certified seeds.

The Taiwan assisted rice production in Malawi up to 1995

The reclaimed area at Domasi became a model for present-day rice production. The writer (Hsieh 1996) visited Domasi in 1996, and was impressed by its sustained operation of rice production with assistance of two rice experts from the ROC mission. In 1975, it expanded rice culture to cover 5,000 ha. of land. The southern areas became the main rice regions in Malawi.

Inputs of the mission, coupled with government efforts, greatly boosted rice production. The rice production area under the mission's supervision soon grew to 5,470 ha. The quantity of rice turned over to governmental agencies was 4,461 tones in 1966. The amounts available for export grew each year by two to five times a year except in years of draught. The amount reached 23,030 tones in 1974. The rice export to South Africa then greatly boosted Malawi's foreign currency exchange.

During the dry season of 1994 and wet season of 1995, a total of 18,665.00 tons of rice were produced from an area of 7,027 hectares of fields under the assistance of the ROC mission, through extension work jointly conducted with local extension specialists. This accounted for one third of total rice production in Malawi on 8% of the cultivated land. This is another success story for rice production in Africa

Performance of reclaimed land after transferring it from the ROC mission to Malawi

Reclaimed land is usually handed over to the host country after it operates normally in rice production. It is a common phenomenon that the performance of field management will degrade gradually after an assisting unit leaves the farm, and sustainability becomes a big problem. At present, only Domasi farm (500 ha) continues to be served by the ROC mission regularly, and other reclaimed farms have been handed over to the local governments. According to a recent survey, the performance of transferred farms tended to degrade gradually due to a lack of support from the local government in terms of supplies such as fertilizer, pesticides and other expenses. Some are close to stopping operation. Yielding capacity has declined due to lack of money to repair irrigation facilities, road, etc. However, the majority of the rice fields are maintained with fairly good conditions such as those in Limphasa, Mpamantha, Niala, Domasi, Dedza, Bun, Nkhate, etc.

Mauritius

An agricultural technical mission was sent to Mauritius to improve rice production and inter-crop farming after the signing of a technical cooperation agreement between Mauritius and the ROC. Mission activities ended in October 1974. During the period between 1969-1971, the ROC mission established a half-hectare demonstration farm in Belle Vae for the experimentation of crops. Based on the results of the experiment, the mission recommended a high- yielding variety (6.8-10 t/ha) for farmers to grow there.

Niger

ROC-Niger collaboration began in 1964. Initial efforts focused on developing rice cultivation in the

Daijikina village of Tillabery State where government officials owned farms and were willing to cooperate. After one year, effective land reclamation activities were extended to cover 116 ha of land. Installation of irrigation facilities, mainly with the opening of channels and setting up of water pumps, increased the water supplies of vital water. Rice yields with introduced IR varieties rose to 4 t/ha.

The next project was to develop 1,000 ha of rice land in the Saga area. The operations consisted of developing both irrigation and drainage facilities along the Niger River close to Niamey at four sites: (29,007 total meters), Tillabery, Saga, Kolo and Tera. A water reservoir was planned for Tera, an area, which suffers from chronic water shortage. Other efforts included experimental plantings of introduced varieties of rice

Up until to 1974, reclaimed land totaled 970 ha in the Saga area. Five hundred ha were added to other areas. Over 3,000 farm families were taught to use improved cultivation practices and modern rice varieties. Trained workers were estimated at 8,620. The use and maintenance of modern farm machineries was also an important component in the training program.

Senegal

Following the signing of an agreement on agricultural technical cooperation between Senegal and the ROC, in 1963, an eight-member agricultural technical mission was sent to Senegal to help develop local agriculture. The agreement was renewed to enlarge the scale of technical cooperation in rice production. The number of specialists increased from eight in 1964, to 56 in 1972.

Phase I (1964-1973)

Land reclamation and irrigation facilities

As the first step of the technical cooperation, the mission started building up various irrigation facilities on the abandoned lands near Dakar. After completion of 300 meters of irrigation canals and 200 meters of drainage canals, a land of 88.5 hectares could be irrigated for rice production. The work continued in the following years, and by 1973 a total of 34,330 meters of irrigation canals together with a total of 19,908 meters of drainage canals were built in the northern and southern parts of Senegal. In addition to this, 18 pumping station and 650 meters of riverbank were built. The water taken up by the pumping stations could irrigate a total of 817.32 hectares of reclaimed land. A total of 4,362 concrete drying grounds were set up to dry the harvested rice grains under sunshine in Goundomp and seven other locations.

Yield trials of newly introduced rice varieties

Various varieties of rice introduced from Taiwan and other sources were tested at Dakar in 1964. The yield trials of rice were continued at the selected locations every year there after. Taichung Sen 2 and Kaohsiung 138 produced 10 t/ha and 7 t/ha in the 1st and second crops respectively on the experimental field under special care during the growing seasons.

Extension work for rice culture

The extension work was generally carried out by the mission together with the local extension officers. During the period of 1967-1973, a total of 3,870 farmer's 293-extension agents received training on rice culture, regularly organized by the mission. A total of 1,876.48 hectares of rice fields were under the extension service of the ROC mission. A total of 6,338 farmer's households benefited

Table 11. Target of the ROC-ATM's work in 1999

| | |
|---|----------|
| 1. Reclamation in southern Senegal | 400 ha |
| 2. Upland rice culture in new and old plantations | 750 ha |
| 3. Seed multiplication in southern Senegal | 14 ha |
| 4. Replanting rice on the abandoned paddy field in northern Senegal | 2,000 ha |
| 5. Total | 3,164 ha |

from the extension service during the period of 1967-1973.

Phase II (1996-Present)

The ROC and Senegal resumed diplomatic ties with Senegal in 1996. Based on an agreement signed by both countries in July 1996, the ROC immediately dispatched a new Agricultural Technical Mission (ATM), consisting of 14 staff members to Senegal. The mission set up its headquarter in Ziguinchar and began to work the major rice producing zones at Casamance, Ziguinchou, Bignona, and Kolda. Since the departure of the ROC-ATM in 1973, rice production of some of the extension fields gradually declined and some others, even abandoned rice culture due to lack of supporting resources. Therefore, the 1999 target of mission work was to help farmers replant rice in the 2000 hectares of abandoned lands (Table 11).

Field demonstration and seed multiplication

At Kolda, three newly chosen varieties, Taichung Sen 10, IR64, and Sahell 108 were subjected for field demonstration on 1 hectare of land. 24 tons of seeds were produced from a 50ha of fields to supply the needs of 350 hectares of rice field.

Extension of upland rice in southern Senegal

Reclamation of lands on both sides of the Casamance River from Ziguinchor to Kolda was made during the period between January-June 1999. Field demonstrations for the selected varieties were made during the 2nd crop (July-Dec.) of 1999. Each farmer was allocated with 0.25 hectares of reclaimed land together with free seeds (70 kg/ha), free fertilizer (200 kg/ha of composite fertilizer N:P2O5:K2O=15:15:15), free urea (100 kg/ha) and free pesticides. Small farm tools (sickles, hoes etc) were donated to farmers, while power tillers and grain threshers were on rent basis. The upland rice yield increased to 4 t/ha, which is 3.3 times higher than the amount (1.2 /ha) produced previously. The extension work for upland rice was carried out in an additional 400 hectares of land in 2000.

Extension of paddy rice

St.-Louis in northern Senegal is the main region for extension of paddy rice. The deep-water-direct sowing method introduced by the mission solved the problems of soil salinity, bird damage of sown seeds, and weed control. The newly introduced Taichung-sen 10 from Taiwan produced 5-6 t/ha of rice, which is 25% higher than the previous yield of 4-5 t/ha. The extended area increased to 3,000 hectares, which exceeded greatly the planned area of 1,800 hectares in 1999. With the newly introduced variety Taichung sen 10 and deep water direct sowing method, the yield of rice in the northern part of Senegal became stable at a level of 5-6 t/ha. It is hoped that the total production of rice on a 70,000-hectare land will be further increased in the future.

Table 12. Acreage of reclaimed and cultured land and number of farmers trained by the ROC-Agricultural Technical Missions in the African countries (1961-2000)

| Country | Acreage of reclaimed land (ha) | Acreage of cultivated land (ha) | No. of farmers trained |
|--------------------------|--------------------------------|---------------------------------|------------------------|
| Botswana | 158.57 | 95.01 | 252 |
| Burkina Faso | 2,617.23 | 3,473.00 | 5,660 |
| Cameroon | 329.53 | 1,637.39 | 772 |
| Central African Republic | 368.98 | 1,056.11 | 775 |
| Chad | 411.32 | 904.53 | 1,756 |
| Dahomey(Benin) | 780.00 | 1,067.90 | 1,621 |
| Gabon | 832.33 | 1,240.92 | 571 |
| Gambia | 470.00 | 1,683.00 | 8643 |
| Ghana | 216.32 | 161.35 | 374 |
| Guinea-Buissau | 3,707.50 | 3,707.50 | 3,681 |
| Ivory Coast | 9,669.95 | 50,958.33 | 3,384 |
| Lesotho | 0 | 180.14 | 3,314 |
| Liberia | 1,325.32 | 9,801.22 | 2,790 |
| Libra | 12.00 | 12.00 | 102 |
| Malagasy | 523.40 | 476.47 | 97 |
| Malawi | 1,474.86 | 5,418.26 | 1,295 |
| Mauritius | 3.00 | 68.58 | 291 |
| Niger | 1,590.50 | 1,123.75 | 8,620 |
| Rwanda | 1,188.65 | 994.22 | 4,246 |
| Senegal | 100.48 | 1,929.36 | 3,870 |
| Sierra Leone | 630.31 | 1,443.93 | 1,307 |
| Swaziland | 112.65 | 160.62 | 0 |
| Togo | 801.85 | 2,122.15 | 3,124 |
| Zaire | 1,506.58 | 9,861.62 | 6,482 |
| Total | 28,831.33 | 99,577.36 | 63,027 |

Evaluations of Taiwan Assisted Rice Production in Africa

Limitation of irrigation water provisions for rice culture

Africa has enormous ecological diversity, embracing two temperate zones, two subtropical regions, and a tropical zone. Central African countries like Burkina Faso and Niger are very dry; therefore mostly low yield upland rice (1-1.5 t/ha) is grown. Meanwhile, in the coastal Western Africa (Senegal, the Gambia, etc.) abundant water during rainy seasons (August-October) created deep-water swamps. The deep-water rice grown in this area produces 1.5 t/ha of rice only.

Although there is plenty of water in the Niger River and Malawi Lake, the countries do not have enough funds to construct irrigation facilities for rice production. Farmers have to use the limited underground water from the artificial deep wells for irrigation. To solve this problem, the countries constructed many irrigation facilities with financial support from the World Bank, FAO, UNDP, IFAD, and the US. England, France, Japan, ROC and other countries. The common problems faced in most African countries are the sustainability of the projects after the termination of funds from the donating countries. For instance, in the past, the European Colonial Development Cooperation (CDC) reclaimed the Jahally/Pachrr area with pumping stations in the Gambia. In 1970 it was able to produce 5-6 t/ha of rice under the aid project. However, after the evacuation of the CDC from the Gambia, the condition gradually deteriorated in terms of the maintenance of pumping station and irrigation facilities. The yield of rice has dropped sharply from 5-6 t/ha to 3-4 t/ha, and even stops growing in some areas, because of poor management. This has also been the case in the northern part of Senegal,

Table 13. Irrigation facilities constructed by the ROC-Agricultural Technical Mission in the African countries (1961-2000)

| Country | Irrigation canal (m) | Drainage canal (m) | Dam | Pumping station | Acreage of irrigated land (ha) |
|--------------------------|----------------------|--------------------|-----|-----------------|--------------------------------|
| Botswana | 6,650 | 3,701 | 5 | 10 | 44.40 |
| Burkina Faso | 89,345 | 57,860 | 1 | 0 | 2,446.96 |
| Cameroon | 28,611 | 16,282 | 36 | 1 | 209.07 |
| Central African Republic | 35,957 | 7,787 | 4 | 18 | 153.30 |
| Chad | 69,609 | 34,900 | 0 | 4 | 578.00 |
| Dahomey(Benin) | 62,690 | 83,480 | 2 | 6 | 782.00 |
| Gabon | 39,265 | 44,872 | 0 | 27 | 257.49 |
| Gambia | 130,322 | 20,083 | 1 | 172 | 1,372.38 |
| Ghana | 13,068 | 11,538 | 1 | 1 | 108.12 |
| Ivory Coast | 1,000,828 | 619,865 | 161 | 0 | 5,475.41 |
| Lesotho | 26,803 | 11,907 | 7 | 8 | 133.15 |
| Liberia | 93,136 | 139,235 | 10 | 5 | 844.70 |
| Libya | 1,000 | 0 | 0 | 1 | 2.00 |
| Malagasy | 12,599 | 16,250 | 7 | 1 | 189.97 |
| Malawi | 132,172 | 149,680 | 1 | 4 | 1,382.74 |
| Mauritius | 783 | 920 | 0 | 0 | 3.00 |
| Niger | 680,730 | 44,666 | 0 | 25 | 1,569.00 |
| Rwanda | 164,120 | 122,253 | 0 | 0 | 820.51 |
| Senegal | 34,330 | 19,908 | 10 | 18 | 817.32 |
| Sierra Leone | 18,106 | 11,056 | 6 | 12 | 116.62 |
| Swaziland | 16,683 | 9,737 | 0 | 2 | 103.20 |
| Togo | 48,200 | 33,660 | 3 | 8 | 284.34 |
| Zaire | 78,572 | 64,003 | 8 | 12 | 550.00 |
| Total | 2,783,579 | 1,523,643 | 263 | 335 | 18,243.68 |

Malawi, and in other African countries. Sustainability of the established systems of rice culture is a big challenge for people in these African countries.

To cope with this problem, the ROC Agricultural Technical Mission for many years began by rehabilitating the abandoned land as the first step of technical cooperation. Our engineers built small dams, pumping stations, irrigation and drainage canals over the years. For example, 160 technicians from Taiwan built 161 dams, 1,000.23 km of irrigation canals, and 619.0 km of drainage canals, which irrigated a total of 5,475.41 hectares of rice field in the Cote d'Ivoire, in the past years. In Niger, the ROC mission built 25 pumping stations to take water from the Niger River through newly constructed 680.73 km of irrigation canals and 44.67 km of drainage canals to the newly reclaimed rice field of 1,569.90 hectares of rice fields. In Malawi, the ROC mission built one dam, and four pumping stations as well as 132.17 km of irrigation canals to irrigate the newly reclaimed 1,382.74 hectares of rice fields. In the Gambia, the ROC mission constructed 171 pumping stations to take water from the Gambia River to irrigate a total of 1,372.38 hectares of rice field through 130.32 km of irrigation canals.

In Burkina Faso, in addition to finishing the construction of one dam, irrigation facilities were also established to irrigate the reclaimed lands of 1,298.92 hectares in 1965-1973 (by 49 technicians). The ROC mission reclaimed a total of 1,200 hectares of abandoned desert land with irrigation and drainage facilities at the Bagre project site from 1996, to present time.

A total of 335 pumping stations, 263 dams, 2,783,579 m of irrigation canals, and 1,523,436 m of drainage canals constructed by the ROC missions has contributed greatly to rice production in 23 African countries in the past 39 years (Table 12 & 13).

Vast abandoned lands in Africa need reclamation before they can be used for rice production

For many years, most African countries needed to reclaim their vast area of desert land into cropland. For instance, 86.57 percent of lands in Swaziland need to be reclaimed before it can be used to grow crops.

Land reclamation is usually the first step of work, after the arrival of a technical mission to a host country. Land reclamation needs technology, funding, and manpower. The ROC sent a total of 83 mission members to finish reclaiming a total of 1,325.32 hectares of abandoned land in Liberia between 1961-1977. In the Cote d'Ivoire, a total of 160 technicians were sent to help reclaim an area of 9,669.95 hectares during 1963-1983. This was the largest human power sent to Africa from Taiwan, for the work of land reclamation and other activities in the ROC's technical assistance history. The total area of reclaimed land in the African countries by the ROC-ATM has increased to 28,831.33 hectares in the past 39 years (Table 12). We have experienced some difficulties in the course of carrying out land reclamation work, primarily due to the lack of close cooperation from the host country, in terms of working attitudes of local officers and equipment supply. However in Burkina Faso, the positive attitude of government officials and field workers helped a great deal in accelerating the construction work of irrigation facilities.

A Simple Economical Measure should be Developed for the Use of Farmers

The case in Senegal

In St. Louis and Fleune areas of northern Senegal, the 7,000 hectares of rice land developed by the multilateral assistance program (England, France, U.S.A., Japan etc.) through the Triangle Land Development Cooperation in the early years had to stop operation in 50% of the reclaimed land for many years. This was due to expensive land reclamation costs, and farmers lacked fund for farm investment. There are also other reasons: (a) salinity of land; (b) bird damage to the sown seeds; and (c) weeding requires too much labor and time. Because of these, the farmers eventually had to stop rice culture for many years.

To cope with this problem, the ROC mission devised a very simple "deep-water-direct-sowing-method", after a series of experiments conducted on an experimental farm at St. Louis. The adoption of deep-water-direct sowing helps dilute soil salinity inhibits the growth of weeds and prevents the sown seeds from being eaten by birds. This labor saving method can give yields of 5-7 t/ha, in comparison with 4.5 t/ha yielded from the conventional way of rice planting. . Because of this, a total of 2,000 hectares of abandoned land returned culturing rice using this simple method. The high yielding variety Taichung-Sen 10 introduced from Taiwan is the major rice variety cultured with this simple method in northern Senegal today.

In the dry areas of southern Senegal (Bignona, Ziguinchor and Kolda), in addition to Taichung Sen 10, IR 64, and Sahell 108 are recommended for culture under the rain-fed conditions (800-1,200 mm of rain fall only). Because of early planting of the drought- resistant varieties, the rice yielded 4 t/ha. This is 3 times higher than the 1-2 t/ha yielded by the previous practice of planting of an old upland variety. As a result of extension work, a total of 3,000 hectares of rain-fed upland are now practicing this method of early planting. The Taiwan mission provided free seeds and free fertilizer at the initial

year of replanting rice. The acreage of rice at rehabilitated land continues to increase. Broken rice has been a big problem in this area. The traditional way of milling causes 30-50% of broken rice, which is no commercial value. The ROC mission provided several sets of small milling machines for farmers to use. As the results, the rate of broken rice is now reduced to 25%. This helped farmers a lot, to increase the market value of rice, and gives farmers more incentives to grow rice in that abandoned field. The ROC mission spent an amount of US\$1,800,933 for this project in 1996.

The case in the Gambia

In 1996 the ROC mission studied the economy of pump and tidal irrigation systems in the Central River Division (CRD). The result of the survey indicated that the pump irrigation system is very costly in terms of equipment and fuel consumption. In contrast to this, tidal irrigation system costs much less. Therefore the ROC mission decided to help farmers to convert 400 hectares of pump irrigated rice field into tidal irrigation field in Jahally/Pacharr. As a result of this shift, an amount of US\$25,000 could be saved annually from the cost of fuel and other expenses. More importantly, the yield of rice could be increased from 1 ton/ha to 5 ton/ha under this newly adopted tidal irrigation system. In fact, during the dry season of 1999, the extension farm in Jahally/Pacharr was able to increase the yield of rice as much as 6 tons/ha.

In addition to the low cost, an important characteristic of tidal irrigation is that it permits year-round cultivation with simple technology. Although the tidal irrigation is considered to be very advantageous, however one should not forget to pay more attention to the following matters in the course of practicing the tidal irrigation.

- (1) Farmers should collaborate each other to maintain the structures and to clean the irrigation and drainage channels
- (2) Water users need to work closely as a group. Appointed individuals must be "on call" in case of high tides occur at night, so that an appropriate measure can be taken immediately to prevent overflow of water into the rice field.
- (3) Farm machinery may be used for land preparation and harvesting. However, animal traction should be used on the muddy low land where machinery operation is difficult.

There are more than 5,000 hectares of tidal lands available for double cropping of rice in the Gambia. Of this, about 1,800 ha of land is already used for rice production. If the rest of land is fully utilized to produce rice at a level of 4t/ha, the total output of rice could reach 40,000 tons annually, based on double cropping. In addition to this, there are about 60,000 ha of seasonal fresh water area in which only a single crop could be grown during the rainy season. If 20,000 ha are planted annually, yield of rice may reach up to 80,000 tons. If these two types of lands (ever-fresh-water area and seasonal fresh water area) are used properly, yields may reach 120,000 tons annually. This will be more than the amount of annual requirement of 80,000-90,000 tons. The excess amount of rice then could be exported to other countries in the future.

- (4) Farmers are in short of capital for operation of their farms.

Loans from local banks are usually very expensive. In Senegal, the rate of a loan could be as high as 20-25%. To solve this problem, the ICDF extended low interest loans (3.5-6%) to the needy farmers in African countries. The ROC-ICDF's loans are extended to farmers through local cooperatives or banks. Loans through the ROC mission are interest free. The mission could only

recover 25-50% of the loaned funds. This situation will hinder the smooth operation of micro-lending systems now operating in several African countries.

- (5) The education levels in Africa are generally low, and the majority of farmers are non-educated.

This situation will affect the effectiveness of technology transfer. With the help of the local officers to serve as interpreters, the ROC mission was able to train a total of 63,027 farmers in 24 African countries in the past years (Table 12).

Other difficulties we have experienced include: (1) the high cost of imported chemical fertilizer and pesticides, (one bag of fertilizer costs US\$ 30-40 in Senegal and Liberia). (2) Lack of milling factories; farmers depend on traditional ways of hand milling. The high temperature and high humidity cause the stored brown rice to germinate quickly. Germinated rice seeds have no commercial value. To solve this problem, the ROC mission is providing the small imported milling machines for farmers. Marketing of rice in competition with the imported cheap low-grade rice is also a problem.

CONCLUSION

The main point of Taiwan's agricultural assistance program is technology transfer. The technology of rice production is transferred through a hands-on process, learning through practicing. Taiwan's teams of experts normally begin by selecting a piece of uncultivated land or desert for reclamation. At the same time, various kinds of rice are then introduced from Taiwan and other countries for adaptability trials. The methods of rice culture are then tested with the selected varieties at the demonstration fields. A special feature of the Taiwan's agricultural cooperation program is that team members are involved in every step of the cultivation process, from land preparation, rice planting, fertilizer and pesticide applications, irrigation, and drainage as well as harvesting, milling, and packing of milled rice. They work together side by side with the local counterparts and farmers on every detail of the operation and share with them the joy of harvest and the despair of failure. This "hands-on" approach is different from many foreign programs, which give financial support only and are seldom involved in other steps of rice production.

The "hands-on" approach, together with financial support, will ensure that the funds are well spent according to the original plans of land reclamation, construction of irrigation facilities, and extension work. The spirit of working together with the local farmers, not only develops a close partnership and friendship with farmers, but also enhances the efficiency of work. The naming a village name to "Wu-Tzuen"(Wu's Village) in commemoration of Mr. Wu's contribution in rice production in Guinea-Bissau is a good example of this friendly cooperation.

A successful rice production assistance program requires transferring appropriate technologies to a country. Free chemical fertilizers, free seeds and free pesticides in the initial year stimulated farmers' incentives to work harder. When yields of rice increased after adopting new measures, it will encourage farmers to continue culturing rice in following crop seasons. When farmers were able to pay the costs of fertilizers and other farm supplies on their own; the subsidies from the mission are terminated. In this way, the sustainability of rice culture by farmers will be maintained, as modeled in Burkina Faso, Senegal, and the Gambia. At times however, this model of rice culture did not sustain, because the farmers did not have enough money to cover the costs of field operations. Micro-loan programs from the ICDF thus offered to help solve the problem. 70% of loans were returned in

Senegal, while only 20-25% of loans was recovered in the Gambia. This is a problem, which needs to be solved.

Field demonstration and extension work are the keys to successful rice production. Demonstration plots are usually set up in the major rice growing areas. The majority of farmers can easily see the performance of newly adopted varieties of rice with their own eyes. This is a very useful way of transferring technology to farmers, especially those who could not read and communicate in common national language. Training courses with regards to the use of fertilizers, pesticide, and handling of agricultural tools, etc. were often accompanied with activities held at the demonstration farms. More than 55,288 farmers received this kind of training organized by the Taiwanese mission in 23 African countries in the past. This training will be continued by every ROC mission operating in the African countries. The extension officers in the host counties often were not very cooperative in this matter unless they were well paid by the mission. This situation slows down or prevents continuation of this kind of activity after the mission leaves the country.

The Taiwan assisted rice production has been very successful in most of the cooperating countries especially in Burkina Faso's Valle Du Kou project and Bagre project and rice projects in the Cote d'Ivoire, Niger, Liberia, etc. The halting of a mission is really a sad event that we do not want to see. For instance, the ROC mission at one point was close to accomplishing the goal of reclaiming a land project of 5,000 hectares in Guinea-Bissau. We had to stop operations suddenly, even after finishing 3,500 ha of land reclamation in Guinea-Bissau. This was a very unfortunate event for farmers in that country. The same is true in the cases of the Cote d'Ivoire and Niger, where the scales of rice production projects were even larger.

It is felt that the existing agricultural cooperation programs should be strengthened by the financial resources and co-financing of projects of the ROC and other countries like Japan. The host country will hopefully facilitate the success of a project just like the on-going rice production project in Burkina Faso, the Gambia and Senegal. With co-financing and the cooperation of two or more parties, we may not only be able to enlarge current programs, but also further expand current production operations to post-harvesting treatments and the marketing of rice.

Perspectives of the Future

The ICDF itself has periodically sent officers to the rice production project sites and evaluated the field mission approaches, activities, difficulties faced, and accomplishments. In the interest of seeking continuous improvements, African regional meetings for joint planning and assessment were held in the Gambia in May 2000. As a result of this introspective review, we have drawn up the following measures for further improvement.

Bilateral cooperation should be developed on a project-specific basis to address key problems confronted by the host nation in agriculture and associated developments within a certain time limit. The project should be within the realm of our expertise and the host nation's available resources. Project plans should follow scientific and management standards.

Technology transfers and extensions should be strengthened and expanded by moving from simple to complex programs and providing aid to local farmers and technical cadres. The missions should make the best use of the local organizations. Strengthening collaboration among field missions in a

region will make full use of resources and increase the sharing of expertise and experience. Multilateral cooperation, such as that with FAO, the World Bank, and Japan, can be expanded to good advantage. Assistance to a friendly nation may be expanded to cover countrywide planning of its agricultural economy, from which appropriate areas of cooperation may be selected to suit ROC capabilities and matching the resources of the host country.

Mission staff should be carefully selected and upgraded from well-qualified resources in the ROC. Mission leaders should have higher academic and scientific qualifications. In this connection, the members of the mission have been regularly sent back to receive "on-the-job training" at the Tropical Research Institute, National Pingtung University of Science and Technology. They should have a Master of Science (MS) education and have taken professional and leadership courses for at least two years. After finishing their studies, they will be sent back to cooperating countries around the world, including Africa. We find that this type of "on-the-job training" is very useful for our field experts working in foreign countries.

On-location research by the mission has been expanded to a joint research program between the local research institutions and the research institutions in Taiwan. Currently, a research project on soil analysis in relation to yielding capacities of rice in the Gambia is under joint execution by the Taichung District Agricultural Improvement Station and the National Agricultural Research Institute of the Gambia. We find that this type of "on-location research" helps to develop new technologies, which can be better adopted in that specific country. The Taichung District Agricultural Improvement Station will conduct similar types of joint research in Liberia and Chad, and the research stations in the host countries to solve the problems encountered in the course of rice production. Increased participation of mission staff in international workshops and conferences, regionally coordinated programs, and related activities will broaden the mission's vision. The increased amount of foreign aid will accelerate the activities of international cooperation.

With these refinements in strategy and modes of operation, the ICDF can look forward to many new frontiers of international cooperation, extending from production to related market-oriented activities such as the processing of local products for market. Fruitful returns can be assured from the improved measures. Meanwhile, the ICDF will seek improvements to upgrade the efficiency of its operations. Our efforts are directed to improving our missions of sharing expertise with our friends on a partnership basis and by staying dynamic in our changing world.

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謝順景 アフリカの農業改革—特にアフリカの稲作振興に対する台湾の国際協力の過去、現在、そして将来展望に焦点を当てて—

アフリカは南半球で最も大きな大陸である。南端と北端の2つの温帯地域とそれに連なる2つの亜熱帯地域に挟まれた熱帯地域を包含し、極めて多様な生態環境を有する。この地理的条件により、アフリカの人々は多様な作物を栽培する。6億5500万人の大部分は農業に従事している。主要食物はソルガム、ミレット等の雑穀類、とうもろこし、小麦、大麦、米、それにヤム、キャッサバ、サツマイモ、ジャガイモ、タロイモ等の根塊茎作物から成る。アジア稲は大変好まれている穀物であり、現在では、在来のアフリカ稲にとって代わっている。

人口増加による食糧問題を解決するために、ほとんどのアフリカの国々が稲の生産増に尽力している。稲の生産増を助けるために、台湾はアフリカへ技術援助を行った国の一つである。ここ39年間、国際技術合作委員会および国際合作発展基金を通して、台湾は多数の専門家および技術者を世界の6つの地域に派遣した。台湾のアフリカにおける農業合作計画は、1961年に農業技術協力隊をリベリアに派遣して始まった。翌年、23の協力隊（合作隊）チームがアフリカ各地に配置されたが、後にそのうちいくつかは撤退した。2001年5月1日現在、8つの協力隊チームがアフリカ諸国で活動している。

この39年間で、アフリカの農業技術協力隊チームは24カ国全体で28,631 haの水田を開墾した。同時に18,244 haの灌漑水田に導水するため、全体で2,784 kmの灌漑用水路と1,524 kmの排水用水路も建設した。このような稲作基盤の整備はアフリカ諸国の稲生産力を向上させるのに重要な役割を果たした。

本報告では、アフリカ13カ国（ブルキナファソ、チャド、中央アフリカ共和国、カメルーン、ベニン、ガンビア、ギニアビサウ、コートジボアール、リベリア、マラウイ、モーリシャス、ニジェール、セネガル）における台湾の稲生産技術援助に焦点を当てた。アフリカにおける稲作技術協力におけるこれらの台湾モデルの過去の成果と技術移転時の諸問題を考察して、今後の技術協力の展望を述べた。