Water Management and Crop Production in Semi-arid and Arid Environments

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1 Progress of desertification

Today, in the world, many areas totaling 3.6 billion ha as large as 100 times the area of Japan are being threatened by desertification. Many people living in such areas are afflicted with it and, it has become a global issue that may eventually affect the ecosystems of the earth itself.

The situation in the sub-Saharan region of Africa is particularly serious. The discussion here will be focused on agriculture and rural development in the arid and semi-arid regions of Africa.

2 Rural development in Africa

In farming villages of the arid and semi-arid regions of Africa, villagers make a living mainly by cattle grazing and production of cereals with rainwater. Grazing is a major means of farming when precipitation is less than 400 mm. With an increase in rainfall, the ratio of crop production will increase. Grazing and crop production are mixed together up to 800 mm, above which crop production becomes a core, resulting in the change in the raising of domestic animals from grazing to livestock. Naturally, even in regions with precipitation less than 800 mm, irrigated cultivation utilizing water of oasis, wells, rivers, lakes and marshes can be observed. The need for technical cooperation will remain also high in the future.

However, most of the inhabitants depend upon an amount of rainfall that changes considerably with the seasons and years for their livelihood and soil deterioration is caused by inappropriate water control, overgrazing and excessive cultivation. Thus, they are falling into the vicious circle of exhaustion of natural resources, means of earning their livelihood, and poverty.

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Table 1 Livelihood patterns classified by precipitation

Amount of precipitation/ water resources (Note 1)	Pattern of livelihood (Note 2)	Methods for livelihood (Note 4)	Conditions and features (Note 5)	Issues to be considered	Remedies (Note 6)
Less than 400mm	1.Grazing, stock-farming type	Grazing (long-distance movement)	Extensive jointly-owned land	Decrease and deterioration of natural environmental resources, Deterioration of quality of livestock, Lack of watering places, Decrease in the amount of grass and deterioration of quality	Restoration of natural resources, Installation of watering places at proper intervals
400~800mm	2. Grazing, semi- crop production type	Grazing + subsistence crops	High dependence on livestock, Large land, Jointly owned land, Watering places, Natural grass	Decrease in natural environmental resources, Unstable precipitation, Lack of watering places, Decrease in the amount of natural grass and deterioration of quality	◎Restoration of natural environmental resources: Promotion of forest establishment (Raising seedlings of trees and fruit trees, and distribution) ◎ Prevention of soil erosion (Creation of grass-grown belts, planting covering vegetation, etc.) ◎ Pastureland: Improvement of seedlings of grasses and increase of grass density Livestock: Improvement of livestock species (Improving species, artificial insemination, etc.) Arable land : Equalizing cultivated land, Increasing soil fertility
	3. Crop production, semi-stock farming type (Note 3)	3-1. Subsistence crops + (grazing)	Land area: small~medium, Dependence on cultivation: small~medium, Fertile land	Unstable precipitation, Decline of productivity of land	◎ Prevention of soil erosion (Creation of grass-grown belts, Planting covering vegetation, Equalizing farm land, etc.) ◎ Farm land: Storage of rainwater (Distribution of water, methods for percolation), Increase of soil fertility Stock feed: Diversification of feed, Introduction of high-quality grass, Introduction of fodder trees
		3-2. Subsistence crops + cash crops & / or commercial crops) + grazing	Land area: small~medium, Dependence on farming cultivation: Medium~large, Fertile land, Market access	Unstable precipitation, Decline of productivity of land, Unfavorable market access	◎ Prevention of soil erosion (Creation of grass-grown belts, Planting covering vegetation, Equalizing farm land, etc.) ◎Stock feed: Introduction of high-quality grass, Introduction of fodder trees. Market access: Improvement of access roads, Improvement of transportation means

More than 800mm	4. Crop production (+ livestock) type	4-1. Subsistence crops	Land area: small, Dependence on farming medium~large, Fertile soil, Supplementary livestock raising, Market access	Unstable precipitation, Decline in productivity of land, Unfavorable market access	◎ Prevention of soil erosion (Creation of grass-grown belts, Planting covering vegetation, Equalizing farm land, etc.) ◎ Farm land: Storage of rainwater (Distribution of water, Methods for percolation), Increasing soil fertility. Stock feed: Diversifying feed, Introduction of high-quality grass, Introduction of fodder trees.
		4-2. Subsistence crops + (Cash crops & / or commercial crops) (Suburban type)	Land area: small, Dependence on farming cultivation: large, Market access	Unstable precipitation, Decline in productivity of land, Unfavorable market access	◎ Prevention of soil erosion (Creation of grass-grown belts, Planting covering vegetation, Equalizing farm land, etc.) ◎ Farm land: Storage of rainwater (Distribution of water, Methods for percolation), Increasing soil fertility. Market access: Improving access roads, Improving transportation (Dissemination and guidance on intensive agricultural technologies)

Note 1 Patterns of livelihood are classified by precipitation, However, the amount of rainfall is not an absolute numerical value. The boundary numerical values vary with the conditions of the countries.

Note 2 The patterns of livelihood are classified according to rates of dependence associated with major types of livelihood.

Note 3 Crop production, semi-livestock type exists in an extensive range of rainfall regions the regions are indicated by oblique lines.

Note 4 Subsistence crops and commercial crops vary with the countries, regions, precipitation and altitude above sea level (temperature).

Note 5 Land area, one of the conditions, is a relative account.

Note 6 In remedies, the dissemination of and guidance on agricultural technologies are important for all of them, and, these deemed particularly important are denoted by ( ).

Note 7 The order of priorities is shown by ◎.

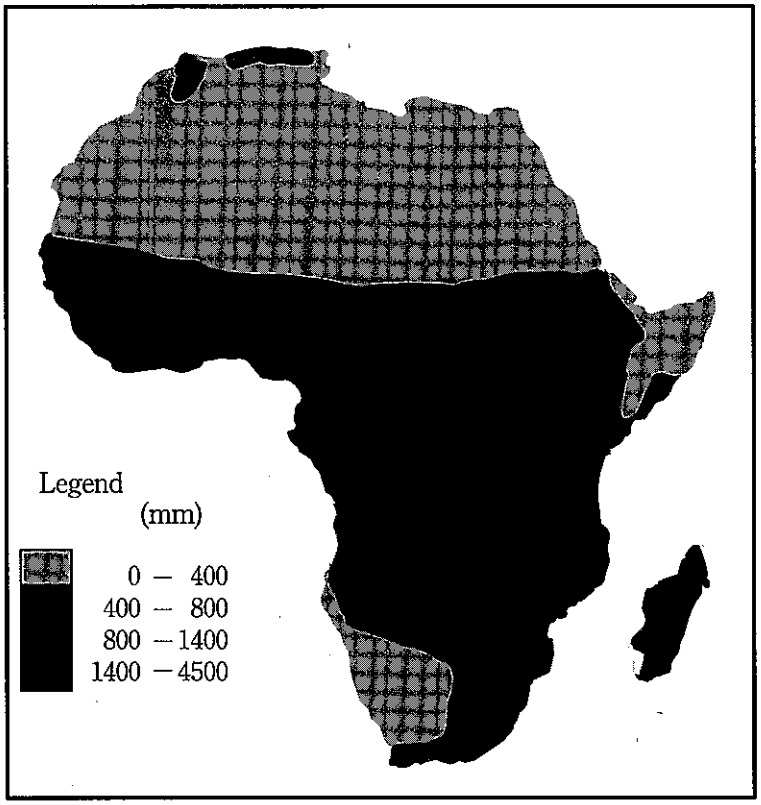


Fig. 1 Average annual precipitation in Africa.

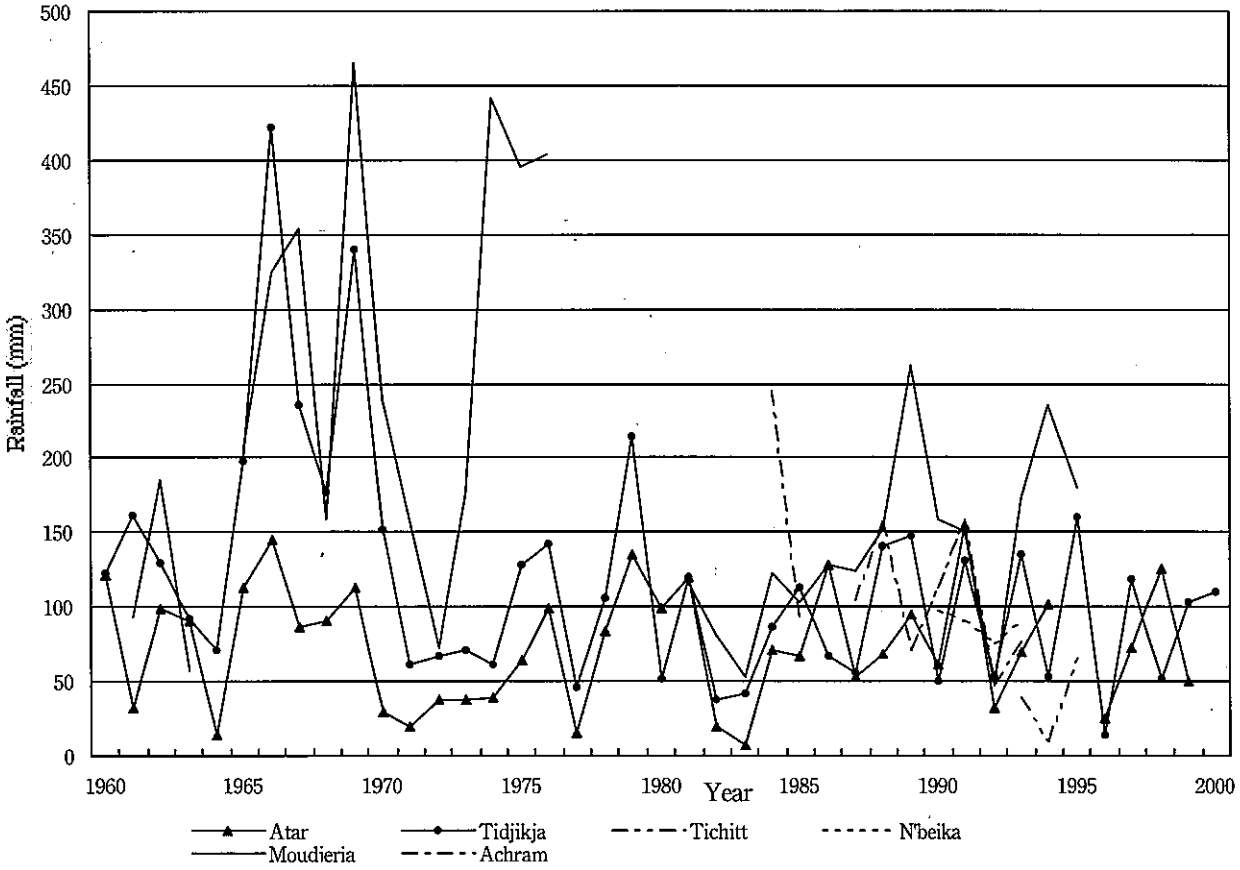


Fig. 2 Yearly changes of precipitation in Mauritania.

3 Roles and activities of JICA

The Japan International Cooperation Agency (JICA) is a governmental organization dealing with mainly technical cooperation and studies and implementation of grant aid among Japan's ODA.

Table 2 Performance of Japan's ODA for Africa

(from FY1952 to FY1999)

Region	Project-type cooperation (number of projects)	Development Study (number of projects)	Experts	Training Participants	JOCVs	Equippement Supply (million yen)	Government Loans (100million yen)	Grant Aid (100million yen)	Remarks
Western Africa (Dry)	3	62	164	1,356	682	2,601	422	2,065	Niger, Burkina Faso, Mali, Gambia, Senegal, Mauritania
Western Africa (Wet)	14	56	821	3,816	1,003	6,348	2,848	2,177	Guinea-Bissau, Guinea, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon
Eastern Africa	40	116	2,317	7,503	2,363	16,238	2,404	3,167	Eritrea, Ethiopia, Somalia, Kenya, Uganda, Rwanda, Burundi, Tanzania
Southern Africa	13	124	783	3,462	2,336	8,902	2,537	2,958	Mozanbique, Malawi, Zambia, Zimbabwe, Madagascar, South Africa, Botswana, Namibia, Angola, Lesotho, Swaziland
Central Africa	0	2	12	282	0	276	6	313	Centaral Africa, Chad, D.R.of Congo

JICA initiated cooperation for agriculture in Africa in the 1970s. At the beginning, it was centered on irrigated rice cultivation based on the experience gained in Japan and cooperation in Asia. Cooperation in irrigated rice cultivation for Lower Moshi in Kilimanjaro province of Tanzania has been successful in producing 6 tons per hectare while overcoming various difficulties.

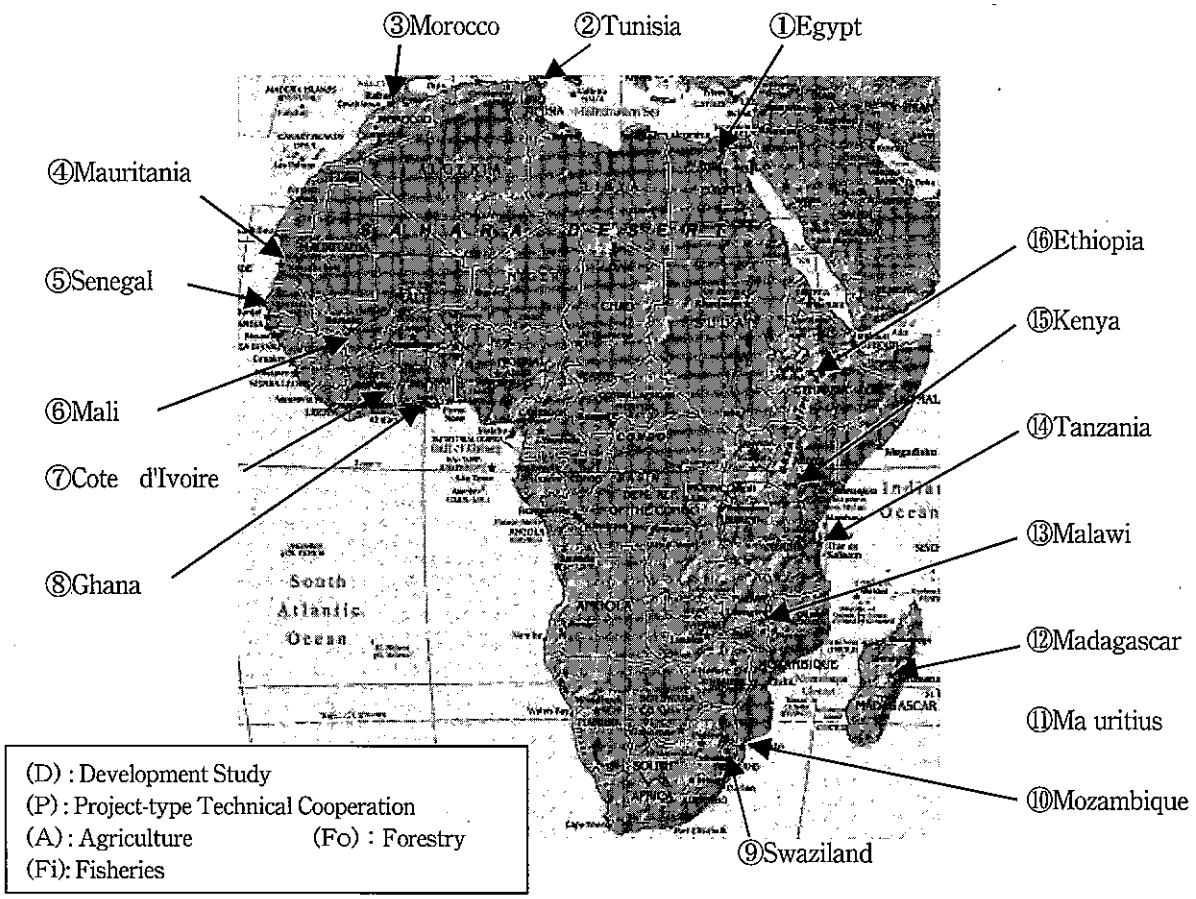
The consumption of rice in Africa is rapidly increasing, centering on western Africa and thus the volume of import is also rising. In terms of yield per unit area, however, rice yield is higher than that of other cereals if the conditions are favorable. For these reasons, cooperation in rice cultivation will be the core of Japan's cooperation for Africa in the coming years. However, in the case of irrigated rice cultivation, areas with a reasonable use of water are limited and improvement of paddy fields is costly. Similarly, rainfed rice is also important but in this case, too, there is a limit in the areas suitable for cultivation.

Table 3 Performance of Japan's ODA for agriculture, forestry and fisheries sector in Africa

(from FY1952 to FY1999)

Region	Project-type cooperation (number of projects)	Development Study (number of projects)	Experts	Training Participants	JOCVs	Government Loans (100million yen)	Grant Aid (100million yen) 1977 to 1999	Remarks
Western Africa (Dry)	1	14	45	242	114	0	669	Niger, Burkina Faso, Mali, Gambia, Senegal, Mauritania
Western Africa (Wet)	4	13	246	792	146	241	526	Guinea-Bissau, Guinea, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon
Eastern Africa	10	15	539	1581	562	196	748	Eritrea, Ethiopia, Somalia, Kenya, Uganda, Rwanda, Burundi, Tanzania
Southern Africa	0	11	277	692	318	0	799	Mozanbique, Malawi, Zambia, Zimbabwe, Madagascar, South Africa, Botswana, Namibia, Angola, Lesotho, Swaziland
Central Africa	0	0	0	58	0	6	44	Centaral Africa, Chad, D.R.of Congo

In recent years, cooperation has been promoted in each sector of agriculture, forestry and fisheries in addition to irrigated rice cultivation. Projects currently implemented are listed in Fig. 3.



①Egypt
(P) Water Management Improvement Project in the Nile Delta(A)
②Tunisia
(P) Fisheries Training Project in Mahadia (Fi)
③Morocco
(P) Training Center Project for Agricultural Mechanization (A)
(P) Fisheries Technical Training Project (Fi)
④Mauritania
(D) Study on the Development for the Oasis Zone (Fo)
(D) Study for the Fisheries Resources Management Plan (Fi)
⑤Senegal
(P) Integrated Community Forestry Development Project (Fo)
⑥Mali
(D) Study on the Prevention of Desertification in the Southern Region of Segou (A)
⑦Cote d'Ivoire
(P) Farming System Improvement Project for Small-scale Irrigated Agriculture (A)
⑧Ghana
(D) Master Plan Study on Fisheries Development (Fi)
(P) Small-scale Irrigated Agriculture Promotion Project (A)
⑨Swaziland
(D) The Study on Rehabilitation and Reclamation of Degraded Lands in the Upper Middlevelt (A)
⑩Mozambique
(D) The Study on the Development of the Resettlement Area for Demobilized Soldiers and Mine Laborers from South Africa(A)
⑪Mauritius
(P) Coastal Resources and Environment Conservation Project (Fi)
⑫Madagascar
(P) Aquaculture Development Project in the Northwestern Coastal Region (Fi)
⑬Malawi
(P) Project on Aquaculture and Technical Development of Malawian Indigenous Species (Fi)
⑭Tanzania
(D) Verification Study on Small Scale Horticultural Development Project for Poverty Alleviation of Farmers in the Coastal Region (A)
(D) Study on National Irrigation Master Plan (A)
(D) Support Program on Rural and Agricultural Development (A)
(D) Master Plan Study on Fisheries Development (Fi)
(P) The Kilimanjaro Agricultural Training Center Project(A)
⑮Kenya
(D) Master Plan on Integrated Rural Development Project in Baringo Semi-Arid Land Area (A)
(P) Social Forestry Extension Model Development Project for Semi-arid Areas (Fo)
⑯Ethiopia
(D) Study on Meki Irrigation and Rural Development Project in Oromia Region (A)

Fig. 3 Projects being implemented in Africa (as of August 2001).

For the cooperation activities in the arid and semi-arid regions that largely cover sub-Saharan Africa,

attention should be paid to fundamental patterns of livelihood of the people living in those regions. What is important is an approach to gradually improve their livelihood. Many governments of Africa have low national budgets and they depend upon foreign assistance for their budgets for development. However, presently many aid agencies are reducing the volume of assistance, concentrating their resources on education and health sectors, thus reducing assistance in agricultural development. Accordingly, in considering the rural development of Africa, a micro-level approach should be adopted, whereby farmers themselves improve their livelihood based on the resources and skills they can acquire by themselves. JICA also considers that cooperation rooted in such a micro-level approach should be emphasized.

Next, the project being implemented by JICA in the Baringo province of Kenya is taken for example.

A large number of integrated rural development projects have been implemented by various donors since 1980s, but many of them have failed to achieve their objectives. One reason is that inhabitants' participation in a project is insufficient. The other is that too many components are incorporated into a project under the name of integration. As a result, the project becomes too large for the inhabitants and also coordination among the administration authorities responsible for implementation becomes difficult. Against this background, in the JICA project this time, the inhabitants are involved from the onset of planning. In individual projects, selection of those that can be implemented at the level of the inhabitants is adopted.

4 Master Plan Study on Integrated Rural Development Project in Baringo Semi-Arid Land Area in the Republic of Kenya

JICA initiated studies on a rural development plan for the semi-arid region of Baringo province of Kenya, starting in September 1998 and ending in December 2001. Baringo Province is located in the central western part of Kenya, which is classified as semi-arid zone. Chronic water shortage prevents the development of the main activities in this region, namely, agriculture and cattle grazing. Many problems are also involved, that is, educational level, knowledge on health, hygiene and nutrition, status of women, no opportunity of earning an income from other sources than agriculture, environmental deterioration and conflicts among tribes. In order to address these issues, it is necessary to promote sustainable agriculture and grazing based on appropriate water control. It is also important to address such issues as improvement of soil and forest management, establishment of infrastructure in terms of both hardware and software to meet the needs of the people living there and, moreover, promotion of health and hygiene knowledge. The objective of this study is that the inhabitants address these issues by themselves and to prepare a master plan for suitable regional development basically by the inhabitants under administrative assistance. Simultaneously, a pilot project is being implemented to verify the suitability of the plan.

1) Outline of the Baringo district

Natural conditions

Annual precipitation	600~700mm
Average temperature	28℃
Prolonged drought	At 10~15-year intervals
Short drought	At 3~4-year intervals
Area	1,244 km^2 (grazing land 85.4%)

Inhabitants and population

Agro-pastoralists		
Population	54,000 people	
Livelihood	Grazing	Cattle, Goat

Farming Maize (production 1.7 ton/ha)
Ratio of self-sufficiency in cereals 43%
Small-scale industries (bee culture, fisheries, handicrafts)

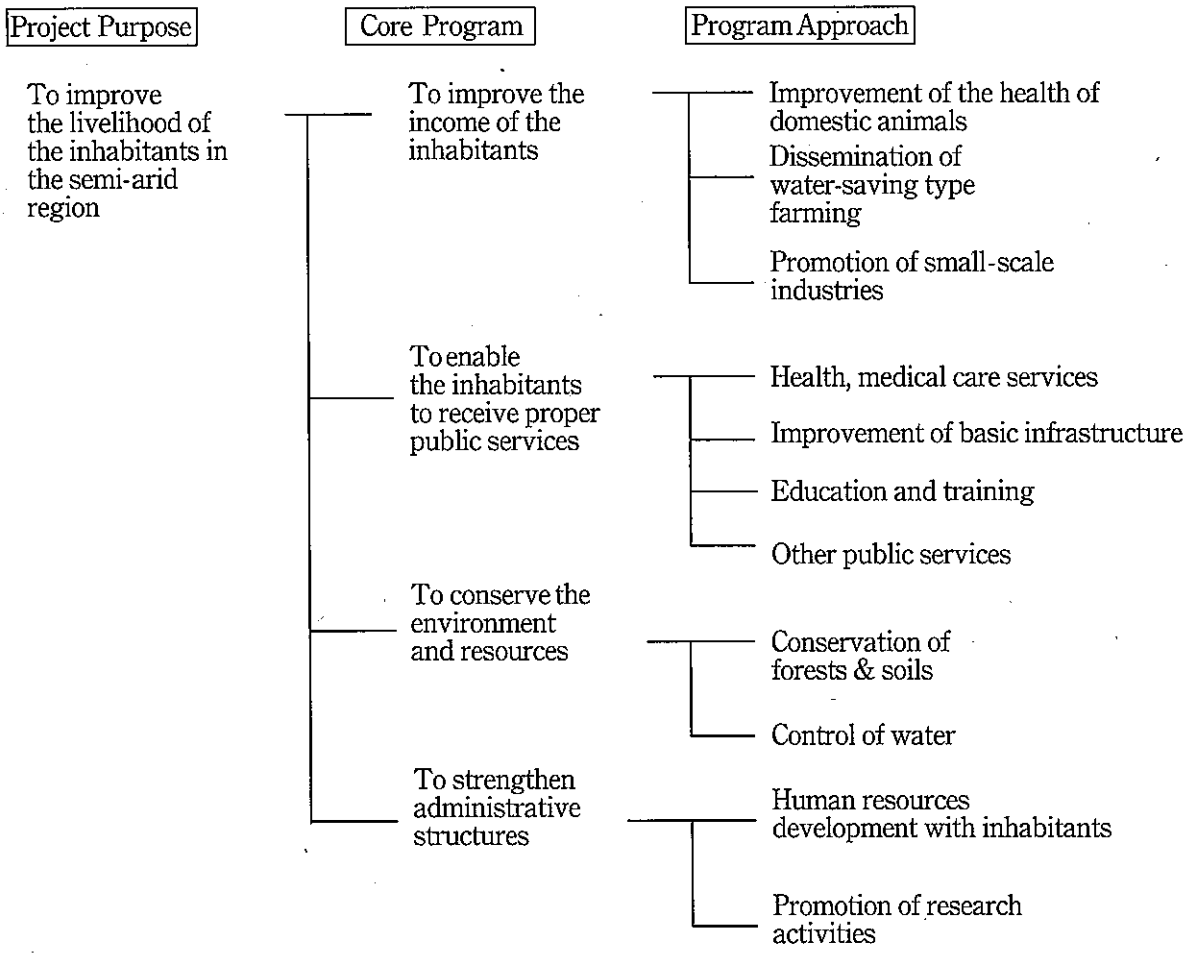
2) Results of the study on inhabitants

Local consultants, using some of PRA methods, conducted interviews with the inhabitants in 7 villages. Major problems raised by the inhabitants were as follows.

Shortage of safe drinking water
Shortage of water for irrigation
Water and land resources control
Cultivation and timber-felling in a basin
Illness
Inadequate hygienic facilities
Inadequate school facilities
Shortage of employment for young people
Low income
Food shortage
Conflicts with other tribes (theft of domestic animals)

3) Master plan

Based on the studies on the existing conditions, analyses and future predictions of the aforementioned



target region, studies on opinions of the inhabitants through PCM and on the basis of administrative opinions on the Kenyan side, a draft master plan was formulated. The framework is outlined below.

4) Implementation and evaluation of the pilot project

In the draft master plan, 76 projects have been proposed under high priority target and 4 core programs. While the study on inhabitants' opinions was in progress, especially active groups of inhabitants expressed their eagerness for implementing some of those projects by themselves, serving as a core. These were implemented as pilot projects over a period of two years, during which the inhabitants played a major role. The implemented projects and a brief evaluation are outlined below.

Improved cooking oven	Decrease in firewood consumption by 63% Decrease in time for dinner preparation from 90 min to 40 min.
	Water is needed for maintenance of the kitchen range
Improvement of rainfed agriculture	Harvest 2.4-fold Crop diversification
	Dissemination to other districts
Improvement of bucks	Increase in weight of a young goat from 1.8 kg to 3.0 kg
	Results varied with tribes
Dip for animal hygiene	Important for livestock hygiene but drugs are costly
Rehabilitation of a farm pond	Period of water storage in a reservoir extends from 2- month to 4-month a year
	Progress is not seen in the maintenance by inhabitants
Small-scale irrigation	Lining of stone walls Increase in irrigation efficiency by installing a divide
	Expansion of cash crops
	Expansion of cropping areas
Land leveling	Costly
Multipurpose building	Strengthening of the solidarity and leadership of women' groups
	Arrangement of business for selling souvenirs, honey, etc.
Rural water supply	Reducing the distance for drawing water by an average of 2 km
Strengthening of youth polytechnic	Increase in enrollment from 17 to 34 people
	Increase in income by rental of instruments and sales in the showroom
	Running the school is impossible only by school fees
Improvement of health station	Equipment such as microscopes, etc. is used
	Running cost depends on the Ministry of Health
Observation of successful undertakings	

5) Lessons and future development

The implementation of the participatory pilot projects was successful as expected. This will be reflected on the final master plan. Problems rather lie in the sustainability and dissemination of each project. For the dissemination, inhabitants' observation of successful undertakings has been effective. As for the improved cooking oven and the improved rainfed agriculture, dissemination can be seen among the inhabitants. However, in the case of health and medical care and education such as polytechnic education, administration on the Kenya side regards them as a unified sector, thus coordination is a difficult.

As for the sustainability, periodical monitoring and some follow-up will be needed.

Also, when listening to the opinions of only the inhabitants, one can see that their request for water may be exaggerated. In arid and semi-arid regions, the inhabitants experienced a severe "water" famine many times in the past. It is natural that the request for "water" will come up first. However, it is important to have both inhabitants and the administration side understand that things shall not be solved by "water" alone. To develop water resources that withstand severe drought, naturally the construction costs incurred by the excavation of deep wells and the construction of dams in a river in which water does not dry up throughout a year will be exorbitant. The expectation for the development of water resources that can not be controlled at the level of the inhabitants in farming villages will be too high, possibly resulting in the inhabitants being disappointed by the aid agency for not realizing it. Much careful response is essential to discuss matters with the inhabitants on how to realize the request for drinking water and irrigation water. The question from here is how to fill the gap between a bottom-up approach on the part of the inhabitants and top-down approach on the part of the administration. Practically, what becomes ever more important is to strengthen the organizing power of the inhabitants and to reinforce the capacity of staff on the part of administration who are in direct contact with the inhabitants.

5 Other examples

In the regions of Meki in Ethiopia, Segou in Mali and oasis area in Mauritania, projects in which the preparation of master plans for suggesting future directions of the regions are combined with the implementation of pilot projects by the participatory method are being successful.

6 Research on a method for rural development in Africa

JICA has actually conducted participatory rural development studies in which the inhabitants played a major role in the stages from planning of a project to its implementation as mentioned above. Thereby, while referring to actual examples of the various donors and NGOs, JICA has been conducting studies and research for three years since 1999 to develop a method for rural development in Africa.

Developmental efforts at the grassroots level, namely, inhabitants which play a major role in the development, have been observed in rural development in Africa. Also, each of the donors, by considering the community function in existing villages, has tended to implement cooperation in which the inhabitants actively participate from the initial stage of development. From these viewpoints, it is appropriate to mention that "rural development" is not only aimed at increasing the production of agriculture, forestry and fisheries but also at improving health and education, namely, the living standards of the people in farming villages. Thus, development needed for maintaining and improving the livelihood of the people in villages in Africa should be conceived at a micro-level. Thereafter, what is important is to draft a realistic plan and implement it in conformity with macro-level agricultural policies. And, as pointed out in the example of Baringo in Kenya, coordination is also important, particularly among sectors that are indispensable for rural development, such as education, health and medical care.

In this project, the results of the studies are compiled as guidelines.

The whole composition of the guidelines is as follows. At first, patterns of livelihood in a village are considered. Then, the village is analyzed based on the conditions of 5 resources. Thereby, issues for development can be understood and then a development project is implemented. Figure 3 is given as a relevant flow chart.

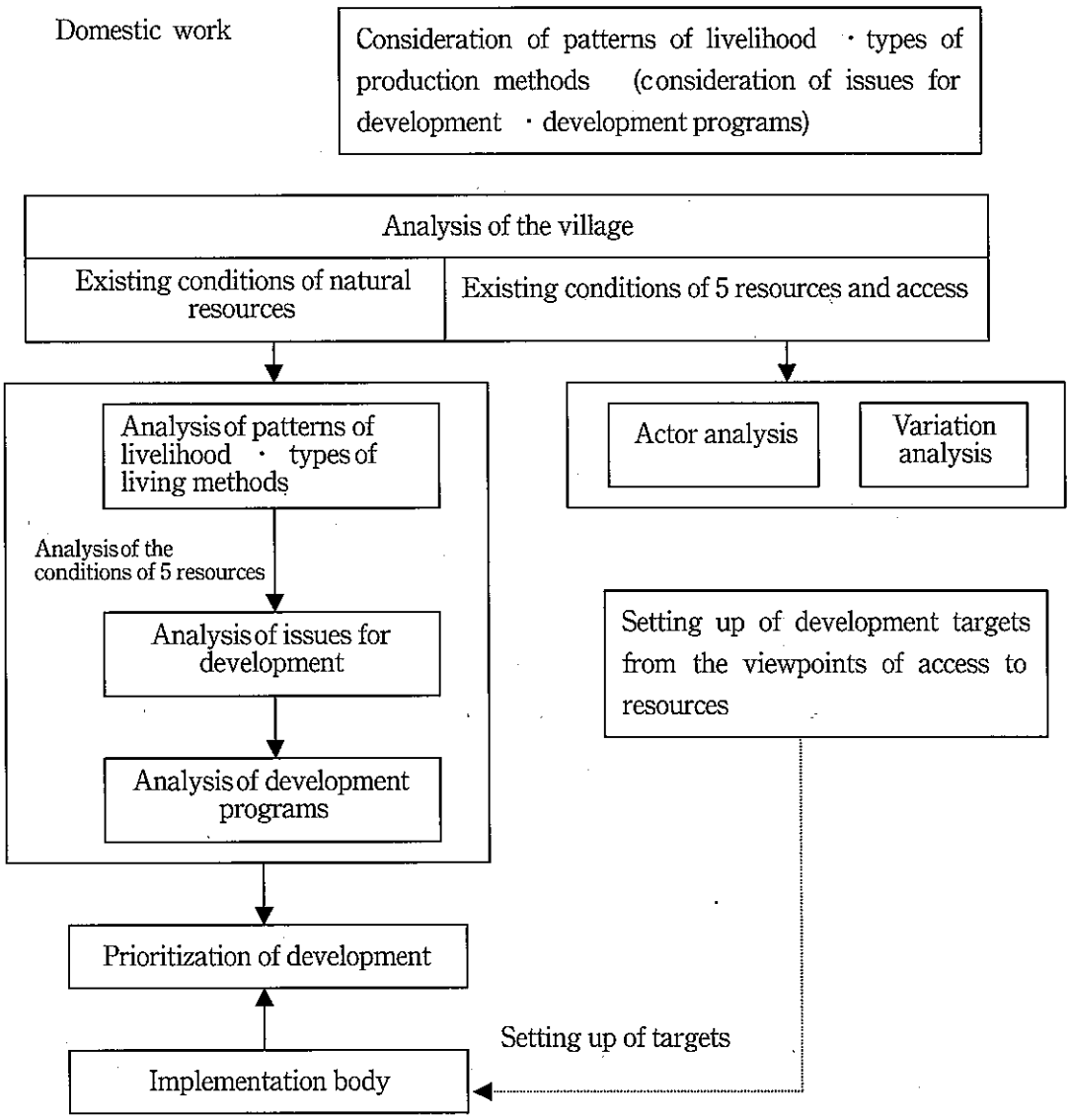


Fig. 4 Guidelines.

The "patterns of livelihood" here are those previously given in Table 1. Table 1 shows examples of issues and areas of improvement in the respective patterns of livelihood.

And the "5 resources" include natural, social, human, physical and financial resources analyzed in reference to the strategy adopted by the Department for International Development (DFID). The contents are given in the following table.

Table 4 Five resources

Natural resources	:	Natural resources, that can be used for livelihood, for example, land, water, wild animals and plants, and environmental resources.
Social resources	:	Social setup that plays a role in promoting cooperative activities among people at a community level and serves as a supporting base for them to make a living. Various factors in encouraging social participation such as networks, a sense of attachment to a group and reliable relations, etc. belong to this category.
Human resources	:	Technology, knowledge, physical strength and health necessary for training and maintaining the ability of the people to choose various ways for earning a livelihood.
Physical resources	:	Equipment and tools that can be used for fundamental social · economic infrastructure and for people to earn a livelihood.
Financial resources	:	Financial resources that enable people to choose various ways for making a living, for example, savings, providing credits, periodical remittance, and pensions. Depending on the cases, it also includes other forms of capital that can be converted into cash, such as precious metals and livestock.

7 Conclusion

"Water" is the most important resource for arid and semi-arid regions and it is the major element for the people to select a method of living. However, solution of the issue of "water" does not result in the solution of all the problems. A project aimed at addressing a water problem may lead to the exhaustion of water resources due to excessive use of irrigation water and the deterioration of soils associated with salt accumulation. The appropriate management of water resources is indispensable.

Accordingly, the water resources should be considered as one of the natural resources and one of all the resources existing in the district, including social resources. Thus, this issue should be handled within the framework of participatory rural development.

On the other hand, the demand for developing and disseminating appropriate techniques that can be utilized by the inhabitants will become increasingly important, for example, for the improvement of livestock, increase of productivity in subsistence crops and improvement of afforestation techniques. In addition, it should be directed to the development of human resources.

From this point of view, several examples of development studies, which JICA is implementing, will provide instructive lessons. Also, we are convinced that the "guidelines" will serve as a direction in the implementation of cooperation for farming villages of Africa in the future.