the expansion of rainfed agricultural land has its limit, urgent promotion of irrigated agriculture with a high productivity is required.

The climatic environment and associated rainfall patterns greatly influence agricultural production. Though the annual rainfall in North, Central and South Regions amount to 400 to 700 mm, 1,000 to 1,500 mm and 2,000 to 2,500 mm respectively, these rainfall concentrate in the wet season with a duration of four months in North to eight months in South, and after the wet season, dry spells continue in a long duration. This situation is a big limitation to rainfed crop yield. Vagaries of weather, particularly the timing of rainfall, limit the profitability of rainfed crops. Consequently, irrigation is not only essential for crop production, but can also reduce crop risks particularly in the dry season.

In Nigeria, agriculture production mostly come from the wetlands where it is expanding along rivers. However, pressure has been directed gradually to the development of hilly land adjoining wetlands to secure more food for the increasing population. The forest and weedland in hilly land which occupies 90 percent of agricultural land with an area of 39 million ha have been converted to farm land through shifting cultivation . The rapid expansion of farm land by shifting cultivation has caused such serious problems as the degradation of water resources bearing capacity of the river basin and soil, expansion of desert and increase of sediments in rivers. Consequently, FGN has limited the shifting cultivation to conserve the land, and has planned to increase agricultural production through the improvement of rainfed agriculture and introduction and expansion of irrigated agriculture.

5.1.3 Classification of Irrigation Systems

Crop production in Nigeria greatly depends on the rainfed areas through the utilization of rainfall in the wet season and residual moisture after flood recession in the dry season. Consequently, the irrigated agriculture has been practiced in the wetlands using easily accessible shallow aquifer and surface water. According to the study of the World Bank, the irrigable wetlands is estimated at 2 million ha. Irrigated agriculture is classified in terms of irrigation technology, executing agencies and project scale as follows:

- Irrigation Technology

Irrigated systems are categorized as traditional or modern irrigation. For the former, traditional water lifting devices such as shadouf and calabash are used to lift water into the land. While such devices are low in cost and depend mostly on farmer's labor for construction and operation, their irrigation potential is limited to small plots. Water lifting by such devices is laborious, and the irrigated area is limited to 0.1 ha per shadouf. The latter is irrigation method using modern facilities which requires a relatively high technology for the operation. However, this method needs big investment and high returns. At present, the World Bank estimates that out of about 900 $\times$ 10^3 ha of irrigated area, 80 percent practice traditional irrigation, while the remaining 20 percent practice modern irrigation.

- Executing Agencies

At present, there are the public sector schemes by the RBDAs under the FMWRRD administration and by the State Ministries and the private sector schemes by the State ADPs mostly under the coordination of FMANR. These schemes are categorized as modern irrigation. The former consist of large, medium and small-scale projects, most of which have the upstream reservoirs, while the latter is the farmer-owned and -operated small-scale irrigation in the wetlands.

The public sector schemes have been implemented since 1970s with the construction of water source facilities such as storage dams and pumping stations for an irrigable area of 320 $\times$ 10^3 ha. However, the downstream construction of canal systems and on-farm facilities has reached only 70 $\times$ 10^3 ha corresponding to 22 percent of the total irrigable area. On the other hand, the private programs managed by farmers themselves has been provided with much supporting services through ADP management unit. The program is based on the premise that a combination of factors comprising of the right technology, effective extension, access to physical inputs, adequate marketing and other infrastructures, are essential to get agriculture moving and to improve productivity in order to raise the living standards of rural dwellers. The less investment and quick returns in this program compared with that of public sector schemes has been highly favored by small farmers, and accordance with the survey executed by FACU the irrigation achievement of 150 $\times$ 10^3 ha has been made through the active support of the World Bank as shown Table 5.1.4.

- Project Scale

Public irrigation projects have been developed by the eleven RBDAs under FMWRRD and SIDs under State governments. Both agencies have engaged in irrigation projects of various scales which reflect the project characteristics. On the commencement of the NWRIS, the scale of public irrigation projects was tentatively classified into the following categories at a National Workshop for the NWRMP held in December 1993 in Abuja.

Classification	Planned Service Area
Large	more than 1,000 ha
Medium / Small	less than 1,000 ha

Above classification was reviewed based on the result of NWRIS, and the detail is described in para. (3) of 5.4.1 in Chapter 5.

5. 1. 4 JICA-NWRIS and Database

Since the technical data related to public irrigation projects in Nigeria are very scarce in the FMWRRD and scattered in different agencies, the NWRIS of public irrigation projects was carried out in 1992 / 93 by five domestic consulting firms under the contract between and supervision of the JICA Team. Items surveyed included location, executing agency, planned, developed and irrigated areas, water source facility, canal dimension, etc. In addition, a series of the site surveys and the discussions with the Government agencies concerned have been carried out, and this has led towards the supplement to the above-mentioned NWRIS. The final inventory of public irrigation projects thus established is compiled in Vol. Three "Water Resources Inventory Survey".

It may be noted that during the course of the NWRMP Study, any inventory of the private irrigation schemes has not been prepared due to the lack of information except for those of the ADPs and NFDP. As is explained in paras (1) and (2) of 5.1.3, there would be a considerable number of the private irrigation schemes on personal or individual basis without any Government intervention, and the field reconnaissance has identified some of those private schemes where local farmers of the entrepreneurship with a statutory or

customary right of land occupancy are taking water from the rivers to irrigate their own land on the small scale less than 30 ha. It is thus considered that this type of the private irrigation is likely to occupy a leading role in the water resources development and use at this stage; however, due to the lack of its inventory, no account is made on the water demand at intakes for the present and also the NWRMP as is explained in paras. 5.2.4 and 5.4.9 respectively.

Virtually, it is considered that the water demand for this type of the private irrigation would be great in total, and the customary water rights for this should be properly protected with the official security of supply that will be increasingly essential as the water abstraction progresses during the course of the NWRMP. This is crucially connected to the enforcement of the Section 3 of the 1993 Water Resources Decree; therefore, it is recommended that an inventory work for this irrigation scheme on nationwide basis should be carried out as quickly as possible, and the water rights as classified into each river and lake should be legally registered for future implementation of any water resources projects. It may be mentioned that many of the private irrigation schemes particularly in the wetlands would be included in the service area of the proposed public irrigation projects as the NWRMP is implemented.

The observations and findings derived from the JICA-NWRIS and related database are described below:

(1) Existing Public Sector Schemes

(a) Achievement of Existing Irrigation Projects Nationwide

Data collected in NWRIS were in many cases incomplete and inaccurate due to lack of technical data in each agency. Thus, planned irrigation areas in existing public irrigation projects, which have canals and water source works such as dam, intake facility and pumping station completed or under construction, are evaluated taking into account the amount of available reservoir water based on reservoir inflow, active reservoir capacity, release water for downstream users, reservoir loss, etc. As a result, the irrigation area of 468×10^3 ha planned by the agencies would be reduced to 320×10^3 ha corresponding to 68 percent of planned area estimated as shown in following table and Table 5.1.1. The evaluation result regarding to the planned irrigation area in major projects is tabulated in Table 5.1.2.

Waterworks	No. of Project	Planned Irrigation Area (ha) ① Estimated by Agencies	② Evaluated by JICA	②/① (%)
Dam	66	276,200	196,000	71
Pump/Others	116	191,800	124,000	65
Total	182	468,000	320,000	68

In accordance with the survey result, large and medium/small irrigation projects, consisting of 182 units and covering service area of 320×10^3 ha, are planned under the existing water source works. The outline of these irrigation projects is shown in the Water Resources Inventory Survey and their distribution by HA is shown in Table 5.1.2.

In many irrigation projects, especially the large irrigation projects, irrigation canal system and on-farm facilities are not completed sufficiently. Out of total planned area of 320×10^3 ha, the developed area where most of the irrigation canal system are completed is only about 97×10^3 ha and the area of 223×10^3 ha is still undeveloped due to the absence of irrigation canal system. On the other hand, out of the area of 97×10^3 ha developed with canal system, 70×10^3 ha is actually irrigated and the remaining area of 27×10^3 ha is left in non-irrigated status due to non provision of on-farm facilities. Accordingly the achievement rate of the irrigated area against the planned area is as low as 22%.

Project Scale	No. of Project	Irrigation Area (1,000 ha) Planned	Canal System Developed	Canal System Undeveloped	Irrigated
Large	75	280	82 (29%)	198 (71%)	58 (21%)
Medium/Small	107	40	15 (38%)	25 (63%)	12 (30%)
Total	182	320	97 (30%)	223 (70%)	70 (22%)

(b) Regional Distribution of Existing Irrigation Projects

The irrigation project status in each region is summarized as follows;

North-West Region (HA-I)

There are 19 units of irrigation projects covering a planned area of 60,000 ha in this region. The large irrigation projects of Zobe, Bakolori, Middle Rima Valley and Zauro Polder covering 44,700 ha in total occupy a large part of the planned area. These large area, however, have not been developed yet, except for Bakolori project with an area of 23,000 ha.

The total developed and irrigated area are only 10,000 ha (17%) and 8,000 ha (13%) respectively. It can be said that the achievement of irrigation project is very low in the region due mainly to the projects being large in scale.

North-East Region (HA-VIII)

There are 35 units of irrigation projects with a planned area of 90,000 ha in this region. Out of the 90,000 ha, 65,000 ha are covered by the large scale projects of KRP I, KRP II, Hadejia Valley, Gari and South Chad. The irrigation projects developed with canal system are KRP I (14,000 ha) and South Chad (22,000 ha). The Hadejia Valley project has just completed its irrigation system and is about to commence irrigated agriculture. KPR II project, covering an area of 40,000 ha and to be irrigated by Tiga and Challawa Gorge dams, is not planned in detail yet and JICA Team estimated that the project can irrigate only an area of 4,000 ha from Tiga dam. South Chad and Baga projects, with a total planned area of 87,000 ha, are to be irrigated by pumping water from Lake Chad. However, the project faces the problem of a lowering lake, water level and it seems water is inadequate to irrigate such a large planned area.

Large irrigation projects with irrigation area of 1,000 to 2,000 ha, such as Jakarade, Tomas, Watari, etc., have been partially developed and are now under irrigation.

As to the irrigation status of the region, the total developed and irrigated area are only 44,000 ha (49%) and 27,000 ha (30%) respectively. Achievement ratio of the irrigation projects in the region is remarkably low due to delay of implementation of irrigation system and the inadequacy of water from Lake Chad.

Central-West Region (HA-II)

Although there are 39 units of irrigation projects, the total planned area is estimated to be only about 55,000 ha. Most of the large projects have an area of less than 3,000 ha, and small projects with area less than 500 ha. The projects with large area of more than 4,000 ha are Bacita (5,700 ha) which has already been developed and is under irrigated agriculture and Kontagora (12,400 ha) and Omi (4,100 ha) which are under construction.

The developed and irrigated area are estimated at 14,000 ha and 12,000 ha respectively. Achievement ratio of the developed and irrigated area excluding Kontagora and Omi projects, are 36 percent and 31 percent respectively.

Central-East Region (HA-III and IV)

Although the Central East region occupies a large catchment area of about 232,000 sq.km and has rich water resource, the planned area is small and is estimated at about 40,000 ha. The large irrigation project of Savannah (12,000 ha) occupy a large part of it. Other irrigation projects are formed with the planned area less than 2,000 ha. The Dadin Kowa project has its irrigation service area of 4,000 ha for upland development, and the project with dam is expected to have irrigation beneficiary area of 38,000 ha, however there is big limitation of available land at the downstream of dam, while Kiri project has about 6,000 ha developed out of the planned area of 12,000 ha. The developed and irrigated area in the region are 17,000 ha and 12,000 ha respectively and their achievement ratio excluding Dadin Kowa project, are 42 percent and 30 percent.

South-East Region (HA-V and VII)

The water source of most irrigation projects in this region are from pumping stations and intake facilities and only four (4) projects out of 35 existing irrigation projects with planned area of 30,000 ha, have dam facilities.

Notable pump irrigation project is the Lower Anambra with an irrigated area of 3,000 ha. Although it is already in operation, the irrigation water supply has not been carried out smoothly due to the breakdown of the

pumping station. In addition, the Ilushi, Ejule Ogebe, Peremabiri and Mbiabet projects which are also large scale pump irrigation projects with an area of 2,000 to 3,000 ha are also not in operation as their pump facilities are not installed completely. Instead, a few self-moving type hydro-flow pumps are placed for irrigation water supply for spot areas of 100 to 300 ha. As a result, the irrigation achievement ratio of the region is low.

South-West Region (HA-VI)

The South-West region has 24 units of irrigation project with a planned area of 45,000 ha, of which the irrigation water supply for an area of 38,000 ha comes from storage dams. Notable large scale dam irrigation projects of Middle Ogun and Lower Ogun occupy 24,500 ha, however their irrigation plans have not yet been formulated. The developed and irrigated area of remaining 22 units are very small and is estimated at 3,000 ha. Consequently, the achievement ratio of irrigation project is only seven percent which is the lowest among the other five regions.

(2) Private Sector Programs

Since the beginning of 1975, FMANR was involved in irrigation development in funding, partly with World Bank support, the agricultural development programs carried out by the 30 States through their ADPs. ADPs have begun to provide the supporting services with the promotion of farmer owned and managed irrigation, notably in wetland areas, and the provision of extension services to farmers on RBDA and SID public sector irrigation schemes. Technical experts working in these projects who are familiar with successful development in low-cost, simple technologies for exploiting shallow groundwater developed in South Asia, made great efforts to apply this technology. They introduced low-cost tubewell drilling and irrigation by pumps into the traditional wetland farming areas with very encouraging results. The key results of these activities were: (a) the introduction of supplementary irrigation in the wet season which significantly reduces the risk of crop failure in drought years, and (b) the potential for introducing a dry-season crop. Initially, the success rate of good yielding tubewells (sustained dry-season yield of at least 20 g.p.m.) was less than 50 percent. This was primarily due to inadequate understanding and definition of the shallow aquifers in the wetlands. The "Staff Appraisal Report on National Fadama

Irrigation Project" (WB, February 1992) indicates that based on the shallow aquifer survey and other studies, FACU has estimated that in the middle and northern States about 3.14 million ha are available in the wetlands out of which about 2.06 million ha are potentially irrigable using three types of small-scale irrigation techniques as introduced hereinafter;

Lift Irrigation by Direct Pumping

For lift irrigation, the farmers place their pumps on the borders of rivers, lakes and shallow-dug wells to irrigate small plots normally within 100 m of the water source. Small water channels may sometimes be necessary to maintain access to water when its level subsides. In order to avoid major land leveling, small basins (of 1m×2 m or less) are used to contain and manage the water. Water distribution is through crude unlined field ditches or PVC pipes. Fields are irrigated only in daylight, once or twice a week, and pumps are usually removed for safekeeping at night. Pumping units are portable, self-priming centrifugal pumps driven by 3 to 5 HP petrol engines.

Pumping from Shallow Aquifer

Shallow Tubewells by Washboring: Washbore technology is simple and low-cost (N750/well compared to N4,500/well for drilled tubewells), but its application is limited to areas where aquifers are at depth of less than 7m and overlain mainly by coarse or moderately coarse textured materials.

Shallow Tubewells by Drilling : Rotary or percussion (bailer) rigs have to be used wherever washboring is not feasible because of the depth of aquifer or the resistance of overlying materials. The bailer is simple and inexpensive and can be made locally, and steel pipes are used as casing. It can drill up to 15 m and provides good stratigraphical information. The major disadvantage of this method is the slow rate of penetration.

Controlled Flooding

While irrigation makes the wetlands productive in the dry season, flooding and water recession have been the basis for a very active agriculture in extensive natural depressions and oxbows. Water retained in these locations sometimes last into the dry season which provided habitat for fish, birds and

other wildlife. This generally uncontrolled flooding of the wetlands has diminished largely as a result of the construction of upstream dam projects. It is, however, possible to rehabilitate the functions of some of the wetland depressions by improving water inflow channels and providing control structures to retain water at desired level. This would also help to rehabilitate fishing activity affected by the dams. The cost of excavating channels and building structures for controlled flooding is about ₦2,200 per ha and involves mostly local material and labor. This has to be properly coordinated with the operations of the upstream dams which are managed by RBDAs,

Among the three types of small-scale irrigation techniques described above, the lift irrigation has the largest potential (1.03 million ha), shallow tubewells have the second largest (0.87 million ha) and the controlled flooding has the smallest (0.17 million ha). The potential for the extensive irrigation schemes operated by RBDAs is only 320,000 ha, compared with the total of about 2 million ha for small-scale activities in the wetlands.

Existing projects conducted by ADPs since 1975 reach about 150,000 ha, consisting of 95,000 ha by lift irrigation, 40,000 ha by shallow tubewells and 15,000 ha by controlled flooding, and the projects are mainly located in northern States of Kano, Bauchi, Sokoto and Borno as shown in Table 5.1.4.

It may be noted that additional information of the projects to be included in Vol. Three "Water Resources Inventory Survey" have been pointed out in the comments from some RBDAs on the draft Final Report, for instance, the following from the B - O RBDA:

- Ewora, Elemi, Erusu, Imoga, Ogbesse, Abavo, and Illah-Ebu, being related with the large-and medium-scale dams.
- Ojirami, Ikpoba, Ukhun and Aparics, in relation with the small-scale dams.

These, however, are not compiled in Vol. Three because there are no information of these projects on location and scope of works and service area. In general, there would be the cases like the above because of the inherent defectiveness on the database and inventory preparation in each Government agency. It is proposed that there is a considerable room for improvement in this simple work under the strong direction and coordination of the Department of

Planning, Research and Statistics in cooperation with other relevant Departments, and the Water Resources Inventory included in this Final Report should be updated with additional information. It is also considered that new projects not included in the present Inventory could be implemented through revision of the NWRMP when these projects are well-qualified in meeting the requirements and conditions to be given for the potential projects under NWRMP that are later described.

5.2 CURRENT SITUATIONS

5.2.1 Current Status of Existing Public Irrigation Projects

The public sector projects have been suffering from a number of technical, financial, institutional and human resource weakness. Although the available irrigation water developed by the storage dams and pumping stations is capable of irrigating 320×10^3 ha, the actual irrigated area is only 70×10^3 ha corresponding to a low achievement ratio of 22 percent. The salient features of existing public irrigation projects are as follows;

(1) Incomplete Projects

(a) Ambiguous Scope of the Project Service Area

The JICA Team evaluated the net irrigable area of the existing projects at 320×10^3 ha. However, the proposed area as determined by such agencies as RBDA and SID through NWRIS was 468×10^3 ha. The reason of the discrepancy in proposed area is that the irrigable area might be roughly shown without examination of the relation between water availability and irrigation demand, and also difference in the delineation of service boundary.

(b) Inadequacy of Project Feasibility Study

The review of previous project feasibility study reports indicates that the majority either do not have or have ill-prepared topographical map, soil and land classification survey, existing agro and socio-economic survey and so forth which are pre-requisite in project planning. It is suggested that the feasibility

of large-scale project should be prepared based on international procedures as already established.

In addition, the guideline and criteria on cropping patterns, irrigation method and water demand, and project benefits (financial and economic) which consist the main parts of project study shall be prepared at least on regional level to promote the quick preparation of project planning in more consistent manner.

(2) Completed Projects with Problems

(a) Improper OM of Project Facilities

The water management in canal and on-farm level based on rotational irrigation scheduled by irrigators groups is not carried out smoothly. As to the project facilities, there are problems of the shortage of canal water conveyance capacity by gravity, facility deterioration or already damaged, reduction of conveyance capacity by silting and weed growth and so on which need urgent rehabilitation.

(b) Slow Progress in Irrigated Agriculture

The success of irrigated agriculture depends on the adequate provision of agricultural extension services and the vigorous activities of Water Users Associations (WUAs). The agriculture extension is in a state of transition from the RBDA to the ADPs, while coordination between the two is generally insufficient. Although the WUAs are being organized in existing projects, it does not seem that they become functionable to play a practical role in OM.

The land lease system which admit farmer's land occupancy right on seasonal basis only under various tenancy arrangement becomes a big constraint for the enhancement of farmers intention in project area, and the seasonal plot distribution procedures cause the constant delays in starting cropping operations which are hampering the smooth operations of irrigated agriculture.

(c) Rise in Social Problems

Most large-scale projects have created serious social problems on 1)the land lease system with a short lease term and inequity among lessees, and 2) inadequate compensation and resettlement to families displaced by the construction of reservoirs and other infrastructures. FMWRRD needs to review closely the matter of tenure arrangements, compensation and resettlements on the RBDA irrigation projects and the related issues of in equity between irrigation farmers, and the RBDA clients and other farmers.

5.2.2 Build-Up Process of Irrigated Agriculture

The planning, design and construction of public sector programs are being implemented by public agencies without the farmers' participation. This fact leads to the delay in expected outputs and cause the following problems which prevent the appropriate agricultural production in irrigated agriculture:

- It takes a long period to select the beneficiaries of the project.
- The beneficiaries have not enough knowledge on farming practice in irrigated agriculture due to the lack of opportunity to receive necessary training from public extension agencies which are under capacity.
- The proper water management and maintenance at on-farm level needs co-operative works by irrigators. However, the delay in the establishment of WUAs prevents the proper achievement.

For the proper achievement of target yield, FMWRRD shall take necessary action to facilitate farmers' participation from early stage of project formulation and pay more attention for a campaign of irrigated agriculture. With proper coordination to the FMWRRD, the FMANR shall provide necessary extension services and make efforts to establish WUAs before the completion of project facilities.

5. 2. 3 New Dimensions of Farmers-Conducted NFDP

FGN has requested the World Bank loan of US$67.5 million equivalent to finance the National Fadama Development Project (NFDP) for developing wetlands (flood-plains) by introducing small-scale irrigation. The project would be implemented mainly in Bauchi, Jigawa, Kano, Kebbi and Sokoto States, which have pioneered fadama development under the earlier Bank funded Agricultural Development Projects (ADP). It would also initiate wetland development in other eligible States.

One of the successful components of the World Bank-assisted Agricultural Development Projects (ADPs) in Nigeria since 1975 is the development of small-scale irrigation which is much cheaper than large-scale irrigation in the wetland through the introduction of low-cost petrol driven pumps in line with various types of drilling technologies to draw shallow groundwater. It is needless to say that the rapid spread of small-scale irrigation is the major source of agricultural growth and poverty alleviation for small farmers. In turn this source of growth could increase the productivity of land and reduce the need for extending land use to feed the growing population, hence, will help in protecting soils, forests and environment.

The NFDP plans to install 50×10^3 shallow tubewells in the wetlands over a period of four years (1992 to 1995) which would create the capacity for irrigating a maximum of about 100×10^3 ha of wetland, out of which at least 50×10^3 ha would come under irrigation during the project life. The project would focus only on the wetlands which [1] are presently cultivated during the wet season, [2] have shallow groundwater for irrigation and [3] are not in use by livestock herders within an overall framework of the transition steps for fulfilling the goal of accelerated agricultural growth based upon environmentally, financially and institutionally sustainable wetland development. This project has been designed as the first necessary transition step in the provision of needed services and capital.

According to FACU information, FGN has started to make preparation of a second phase project for the wetland development with possible loan assistance from the World Bank. The proposed area is about 120×10^3 ha consisting of 76×10^3 ha by lift irrigation, 34×10^3 ha by shallow tubewells

and 9×10^3 ha by diversion works and controlled flooding in a four year period from 1995 to 1998. The distribution of proposed area is shown in Table 5.1.4.

5. 2. 4 Water Demand at Intakes

Water demands of existing public irrigation projects (320×10^3 ha) and private irrigation projects (150×10^3 ha) are estimated by modified Penman method under the following assumption:

- Irrigated crops : Rice and other cereal (see Table 5.2.1)
- Cropping pattern : See Figure 5.2.1 and 5. 2. 2
- Irrigation intensity :
  - Public irrigation project : Wet season 100%, dry season 50% to 70%
  - Private irrigation project : Wet season 80%, dry season 50%
- Effective rainfall : 70% of average rainfall
- Irrigation efficiency : 50 %

Water demands of existing public irrigation projects is estimated at 3,650 MCM, out of which 780 MCM corresponding to 21 percent of total demands is utilized for the operation of irrigation area with system fully developed as shown in Table 5.2.2 (1). While, water demands of private irrigation projects are estimated at 1,310 MCM as shown in Table 5.2.2 (2).

Total water demands of existing irrigation projects consisting of above projects reach 5,000 MCM, of which 2,600 MCM corresponding to 53 percent of total water demand is required for the operations of irrigation projects in HAs I and VIII, as shown in Table 5.2.2.

The more detailed description are given in APPENDIX 5 - 1.

5.3 PRESENT PROBLEMS AND NEEDS

5.3.1 Wholesale Import of Modern Technology

The JICA Team considers that the investment policies for irrigation should be aimed to urgently increase the domestic production of food to further reduce inflationary and balance of payments pressures. Since the economic situation during the period of the 1970s - 80s was caused by the combination of the appreciated value of Naira and high domestic inflation, it is understood that the capital investment with a high proportion of imports would not only have a high output-capital ratio, but also a high output-to-tradeables (capital and recurrent) ratio. In this way, longer-run balance of payments problems could be reduced by making efficient use of necessary tradeable inputs, and this approach would help to ensure the optimum utilization of scarce financial resources.

The technology employed on the FGN-funded public sector irrigation projects already constructed has a number of unattractive features in the light of this analysis. Aside from a facet with much reliance on inappropriate imported technology and the "room for grandiose or prestige projects", the capital costs in relatively import-intensive nature is not a major problem in the short-run; however, not only is there a long lag between investment and increase in production, but also more damaging from the viewpoint of long-run self-sufficiency, it appears to involve a high commitment to recurrent tradeable inputs particularly mechanical operations. The significance of this finding is that there is the danger of relying on the continued use of imported or tradeable inputs for production being contributive to budget deficits and inflationary pressures, and great attention should be devoted to finding more appropriate (less import-intensive and higher productivity) means of managing the large-scale public irrigation schemes so far constructed. Furthermore, in view of the manpower and other constraints and the need for time to evolve suitable management techniques, further development should be examined in the light of achieved levels of productivity. At any rate, under the current economic dilemma that is linked with a weak exchange rate and a high domestic inflation which are expected to persist, careful approach needs to identify appropriate technology to be employed on irrigation schemes by scrutinizing proposed designs of projects in the light of actual conditions in the country and of ensuring the optimum utilization of scarce financial resources. At the same

time, the local manufacture of equipment and materials relevant with the irrigation operations should be encouraged to operate within the national industrialization policy.

5.3.2 Technical Problems in Public Sector Projects

In accordance with the site survey by the JICA Team and the Inventory Survey, the existing irrigation projects generally have the following problems;

(1) Irrigation Planning

Although the net irrigation area of about 320,000 ha has the available irrigation water developed by the storage dams and pumping stations, the actual irrigated area is only 70,000 ha corresponding to a low achievement ratio of 22 percent by reasons given hereinafter. The expected agricultural production and benefit have not been achieved yet, accounting to great losses in the national economy. It is very important and of urgent necessity to consolidate the existing irrigation projects and to accelerate the irrigated agriculture in order to recover the large investments already made on water resources development projects.

Several of the existing irrigation projects are planned using the sprinkler system, and the related equipment have already been procured. However, RBDAs and farmers cannot manage the sprinkler irrigation system due to the lack of technical knowledge and the high maintenance cost of the equipment. These sprinkler systems should be converted to gravity irrigation system, such as the border, furrow and basin, whenever practicable.

The gravity irrigation system shall be principally applied due to its lower construction and operation costs and easy maintenance as compared with the pumping system. However, several projects are planned with pumping system, when there is no sufficient head available for gravity system from the storage dam. Some irrigation projects have drainage problems caused by rainfall and excess irrigation water, as these projects are planned and implemented without proper drainage plan.

Some projects with available water sources, have no proper irrigated agricultural plan, so that feasibility studies shall be carried out urgently based on the detailed and accurate survey data in the service area. Otherwise, the project implementation, the detailed design and construction, could not be carried out properly. Attention shall be paid particularly to the following in the course of irrigation plan formulation for the existing projects;

- Preparation of the topographical map with scale of 1/5,000 having contour interval of 1.0 m for the service area (among others, to carry out a careful study for gravity irrigation system).
- Review of the land use plan based on soil survey.
- Review of the hydrological analysis for reservoir inflow and effective rainfall for irrigation.
- Review of the irrigation requirement for the proposed cropping pattern.
- Review of the available reservoir water for irrigation through a detailed reservoir operation study.
- Review of the limitation and scale of irrigation area based on the available reservoir water.
- Review of the water allocation plan for each irrigation zone, sector and block.
- Review of the preliminary design for canal system taking into account the gravity diversion irrigation system and proper canal structures.
- Establishment of the institutional plan for operation and maintenance by the public sector and water users' group.
- Estimation of the construction cost and project benefit.
- Project economic evaluation and environmental impact assessment.

(2) Design and Construction of Canal System

Although irrigation canal systems have been completed in some projects, irrigated agriculture has not progressed yet due to the deficiencies in the design and construction of canal systems. The major deficiencies and their effects on the water management are the following;

- Canal water level is designed lower than the elevation of farm land, hence pumping would be necessary for irrigation.
- The side slope in the earth canal section is designed with a little steeper slope of 1.0 to 1.5, which causes slope sliding.
- The check gates to control the canal water level are not installed properly taking into account the hydraulic gradient of canal flow. The irrigation water diversion at turnouts are inadequate to cope with the diversion discharge variation based on irrigation requirement in the service area.
- The concrete lining of the canal is damaged in some portions. This is caused by the uplift and back pressure of the groundwater, especially during the maintenance period when there is no water in the canal. Installation of flap valves at canal lining and collecting drain along the canal are necessary to drain out groundwater and lower its water level.
- In the North zone, the canals are designed with a little shallower depth and larger width, so that high evaporation losses from canals take place.

(3) Operation and Maintenance

The operation and maintenance of irrigation systems have the following problems;

- The water diversion management in some projects cannot be smoothly performed due to the fact that canal systems are not properly planned, designed and constructed as mentioned above.
- Trained staff and equipment to operate and maintain the canal systems are insufficient due to the lack of OM fund.
- The water diversion management at turnout level to meet the irrigation requirement for the service area is rather difficult due to non-existence of the Water Users Association (WUA) in service areas to cooperate with OM staff.
- Although the government has set up regulation to collect the irrigation fee and to use such fee for the OM expenses, farmers are delinquent in paying the fee.
- The inflow to the canal from the reservoir does not always correspond to the irrigation demand of service area, so that surplus or shortage of irrigation water takes place at the canal and service area.

The following are the existing irrigation projects which seem to have some problems according to the sample survey conducted by JICA Team;

Bakolori Project

- Actual irrigated area of 4,000 ha against total irrigable area of 23,000 ha.
- Some damage in the concrete lined canal caused by back pressure of groundwater level.
- Destruction of pump house due to the uneven settlement of the foundation.
- Clogging of tertiary canal by dense weed.
- Inundation in the paddy field due to the lack of drainage canal system.
- Non operation of sprinkler system thus necessitating conversion to surface irrigation.
- Absence of OM equipment.

Zobe Project

- Irrigated agriculture is not practiced except in the pilot scheme of 100 ha due to lack of irrigation canals.

Zauro Polder Project

- Inundation of the area due to the seepage through dike foundation and improper drainage canal.

Swashi Project

- Canal water level is lower than farm land elevation.

Kano Project

- Water-logging in the field due to the improper maintenance of drainage system.
- Increased water demand due to the expansion of paddy field.

- Lack of O/M staff and equipment.

Baga Project

- Water shortage due to low water level in Lake Chad.
- Damaged canal due to the embankment constructed with sandy material.

Baga Project

- Water shortage due to low water level in Lake Chad.
- Clogging of intake canal by dense weed.
- Poor maintenance of canal due to insufficient O/M equipment.

Tungan Kawo Project

- Lower water level of canal compared with farm land elevation and necessity of pump irrigation due to improper canal design.

Tada Shonga Project

- No irrigated area due to the lack of canal system and polder dike.

Doma Project

- Operation problem of sprinkler system makes conversion to surface irrigation necessary.
- Transformer for pumping station is yet to be installed.

Lake Geriyo Project

- Inundation in the field due to lack of polder dikes.
- Difficulty of water management due to lack of turnout gates.

- No spare parts for pumping equipment.
- Defected pump.
- Collapse of irrigation earth canal due to the piping through embankment of sandy material.
- Difficulty of water management due to the broken check gates.

(4) Improvement for Existing Irrigation and Drainage Systems

In order to accelerate irrigated agriculture and obtain quick returns, the following counter measures for existing irrigation and drainage systems shall be taken so as to ameliorate the problems.

(a) Formulation of Proper Water Diversion Plan

In order to carry out proper water diversion from canal system to service area, the water diversion plan will be formulated by O/M office one or two months before the irrigation season. Accounts will be taken in respect of the available reservoir water condition, the cropping pattern requested by farmers group, and the irrigation requirement of each service unit. This will eliminate the over or under-irrigation problems during irrigation season.

(b) Improvement of Water Management of Canal Systems

In order to divert the canal water to service area to meet the irrigation requirement, the following consideration will be required:

- Installation of the staff gages at the canal turnout to monitor the water level.
- Proper operation of the turnout and check gates in accordance with irrigation diversion requirements.

(c) Improvement of Canal Systems and Pumping Equipment

- Rehabilitation and improvement of the defective canal system having leakage problems, insufficient head, uncontrolled water

level without proper check gates, scouring at the downstream of drop and cross structures, sedimentation in the canal, sliding of canal slope, dense weed growth in the canal, etc.

- Rehabilitation of the deteriorating pumping equipment, and provision of the spare parts.
- Concrete lining of the existing earth canals with sandy soil.

(d) Improvement of Drainage System

It is general that a little attention is paid to drainage improvement in existing irrigation projects. This fact indicates farmer's low interest of OM of drainage canal and leads the low yield of irrigated crops in the existing irrigation projects. More attention shall be paid to drainage improvement to increase the productivity. The following study shall be made for the improvement:

- Hydrological study; rainfall analysis, runoff estimation raising from project area and out of project area.
- Study for design drainage capacity of project facility; allowable inundation depth and period in paddy and upland crop field, continuous rainfall amount and catchment area.
- Hydraulic study of related river; design high water level of river.
- Study of project facilities; drainage canal, polder dike, pumping station, drainage sluice gate and regulation pond of drainage water.

On the other hand, major observation as to drainage improvement are as follows:

- The water logging problem has taken place in existing public irrigation projects, especially in large-scale projects with large dams upstream of service area such as Bakolori and KRPI projects. This problem is caused by not only the insufficient drainage capacity but also improper water management. The rehabilitation of drainage canal system and improvement of water management and OM works shall be carried out.
- In the lower basins of the Anambra and the Imo of the South East region, inundation problems in farm land by heavy rainfall in the wet season have taken place due to poor drainage facilities. The

rehabilitation and new construction of drainage systems are needed.

- The Niger Delta belonging to Delta and Rivers States have much rainfall in the wet season, and it is very difficult to make farm cultivation in the wet season. Consequently, rainfed agriculture in the dry season utilizing retained soil moisture after recession of flood has been operated. However, when long-lasting dry period occurs, the water shortage for the crop production in the dry season has taken place. For the improvement of agricultural production in this region, drainage facilities such as polder dike for prevention of invasion of river flood and runoff coming from adjacent area, and drainage system to drain out the excess water within the project area by pumping stations with dual purpose - irrigation and drainage.

(e) Strengthening of Operation and Maintenance of Canal System by Public Sector

- Formulation of OM organization with sufficient staff.
- Training of operation staff and gate keepers.
- Monitoring of canal water level fluctuation.
- Periodic check of gates and pumps.
- Delineation of responsibility for canal management by the public sector and farmers groups.
- Provision of OM equipment.

(f) Improvement of On-farm Management

- Consolidation of farm plot including land leveling for surface irrigation taking into account the length and slope on the border and furrow irrigation.
- Consolidation of on-farm facility such as farm ditches, farm drains and farm roads.
- Establishment of water utilization management methods on farm level taking into account the rotation irrigation method, irrigation hour per day, irrigation water per unit time, etc.

- Formulation of water users groups such as Water Users Association (WUA) for irrigation block of 200 to 400 ha and Farmers Irrigation Group (FIG) for area of 20 to 40 ha.

(g) Improvement of Irrigated Agricultural Practices

In order to increase the agricultural productivity by irrigation, the following steps will be performed by farmers cooperatives and supported by public sector:

- Supply of agricultural input such as seeds, fertilizers, herbicides and farm machinery. The supply method will depend on the crops, cropping pattern and crop calendar.
- Strengthening of extension services to improve cultivation practices by providing demonstration farms.
- Provision of agricultural credits with low interest rates.
- Formulation of farmers cooperatives to manage agricultural input and marketing of products.

(h) Collection of Irrigation Fee

The government has set up the regulation to collect the irrigation fee of 500 Naira/ha/season under irrigated agricultural area. This fee is important to cover the OM expenses of public sector schemes. However, farmers response to payment is poor, so that OM work by public sector has not been implemented properly. The establishment of adequate measures to improve the collection rate of the fee shall be of an urgent necessity.

5.3.3 Insufficiency in Government Supporting Services

In spite of the government policy to assist small farmers, the farmer in the public irrigation project cannot achieve the target income because of the lack of knowledge in irrigated agriculture, difficulty in procurement of agricultural inputs, insufficient government extension service etc. It is necessary to tackle the following problems for full achievement of target agricultural income.

(1) Extension Services

Agricultural supporting services to irrigation farmers are provided by State agencies, principally by the ADPs which provide extension and adaptive research services, and by their associated farmers' supply corporations (as well as the private sector - except for fertilizers) for fertilizer, agricultural chemicals and equipment. RBDAs used to have their own extension staff but this service was discontinued owing to the reorganization of RBDAs in 1986, although some agricultural personnel are retained in some of the RBDAs. Few ADP staff are trained in irrigation agronomy and only a limited amount of the currently restricted national research effort is made for irrigation oriented subjects. Both extension and research work for irrigated agriculture need to be improved for farmers on public sector schemes and those owning and operating their own irrigation equipment. It is critically important, therefore, that closer linkages are developed between RBDAs and ADPs to ensure adequate services to clients of the former.

(2) Input Supplies and Tractor for Hire Services

Irrigated farmers suffer as others do from the problem of irregular fertilizer supplies (partially as a consequence of an unsatisfactory subsidy policy and dependence on State monopolies), poor supplies of quality seeds, and very serious problem of timely cultivation due to inefficient public sector tractor for hire. Solution to such problems is vital to the development of a sound irrigated agriculture where water must be complemented by other essential inputs, and to justify the high investment costs.

5.3.4 Lack of Farmers' Initiatives in Irrigation Development

RBDAs have been extra generous to their irrigation farmers by providing them heavily subsidized cultivation and harvesting services in addition to almost free water, as well as crop transportation and marketing services at less cost. This paternalism has been justified on the grounds that farmers need encouragement to take up irrigation and are too poor to pay for services and inputs. Such paternalism have affected adversely to the sound growth of farmers' initiatives in irrigation development.

In general, the successful operations of an irrigation system depends upon the active involvement of the supposed beneficiaries not only in project selection and planning/design stages but also in the performance of OM functions. This obviously calls for a share of activities between the project authority and the farmers from the highest hierarchy to the lowest level. For example, while the former concerns itself with OM of dam and main canals, the farmers organization can maintain the distribution canals, collect the irrigation fees and fines, resolve conflicts and provide extension and farmer training. A big effort of the State ADPs under the FMANR administration should be paid on the establishment of sound WUAs with a strong initiatives in irrigation development.

5.3.5 Inherent Problems of Large-Scale Irrigation Project

Although large scale irrigation projects with area of between 1,000 and 5,000 ha and medium/small projects of less than 1,000 ha seem to be properly implemented and managed, large scale irrigation projects of more than 10,000 ha with large scale dams could not attain the target benefit, and the economic and financial returns from irrigated agriculture is unfavorable. It seems that these projects face following problems;

(1) High Capital Cost

Large irrigation projects including water source works such as large scale dams and pumping facilities have been constructed with high project cost corresponding to over US$15,000 per ha as quoted in the Irrigation Sub-Sector Review (FAO/WB-CP 1992). In other developing countries, irrigation projects are generally implemented with the cost per ha less than US$5,000 to 6,000, otherwise the project could not attain the economical return for irrigated agriculture.

The high cost for the large irrigation project may be caused by the following reasons;

- Proper feasibility study prior to project implementation was not carried out, especially on the scale of irrigation area and reservoir

dam, socio-economical condition of project service area, project cost estimation, project evaluation including economic evaluation, etc.

- Construction works are awarded on the contractor finance basis which normally have high interest rates and the construction costs are usually much higher than those through competitive bidding.

Capital cost of existing major projects is shown in Table 5.3.1.

(2) Slow Development

The large scale project takes a long period to achieve the project target in irrigated agriculture, even if the waterworks and irrigation system are already completed, because of the following reasons;

- Consolidation of farm land and preparation of on-farm facilities normally carried out by the farmer will be delayed if technical and financial support by government to farmers are not provided. This government support cannot be extended in a short period for the project covering a large irrigation area.
- It takes a long period to set up water allocation and distribution rule from irrigation system to farm plot area. Generally, upstream service area takes much water and downstream suffers from water shortage.
- It takes also a long period to set up farmers' organization and cooperatives in a large service area. Irrigation water management and extension services by government are difficult without farmers' institution.
- It is rather difficult to carry out efficient and effective extension services and training of irrigation practice to a large number of farmers scattered in a large service area.

(3) Slow Achievement to Target Yield

It generally takes five to six years after completion of the project to achieve the target yield proposed by irrigated agricultural plan due to the following reasons;

- It is necessary to supply agricultural input, such as quality seeds, fertilizer, chemicals, agricultural equipment etc. in order to carry out effective irrigated agriculture and achieve the target production. The agricultural input supply based on demand and schedule could not be properly carried out without setting up agricultural credit to farmer and market system to distribute the input with government support. It takes a long period to set up the above system in a large irrigation service area from the viewpoint of government institution and finance.
- Progress in farmer's technology for irrigation and agriculture practice is slow because extension service staff cannot cover a large irrigation service area within a short period of time.

(4) Poor Water Management

Water management in the large irrigation project consists of reservoir water operation, water distribution in canal system and water use on farm level. This water management is very complicated and could not be achieved within a short period.

In reservoir water management, the reservoir operation rule shall be set up taking into account reservoir inflow, reservoir evaporation losses, irrigation demand, both in wet and dry season, etc. Hydrological observation is carried out at damsite to judge accurate reservoir inflow and outflow measurement to control and make proper irrigation water release.

In irrigation canal system, the distribution management to divert irrigation water at canal turnout based on the irrigation demand which fluctuates on a 10-day basis will be carried out in coordination between government OM staff and farmer's organization. This water management in the large irrigation area is rather complicated and difficult and cannot be achieved without trained OM staff.

Water management on farm level to use water effectively could be achieved by the farmers under the guidance of the OM staff. Preparation of farm plot, land leveling irrigation method etc, shall be guided by OM staff. This training for farmers could not be carried out without proper planning and preparation for large irrigation service area.

(5) Underestimation of Volume and Value of Production without Project

Existing large irrigation project area covers wetland and rainfed agricultural area which has reasonable agricultural productivity. The volume and value of the present agricultural product (without project) seems to be estimated at low level in the feasibility study. As a result, the project is implemented under misjudgment of project economy. Economical evaluation in the feasibility study shall be carefully performed taking into account the benefit without project and with project.

(6) Resettlement for Reservoir and Service Areas

Large resettlement for reservoir construction and service areas is required for the large irrigation project. Therefore, loss of assets by the implementation, countermeasures and cost for resettlement, impact on environment, etc. shall be carefully studied in the feasibility study. Since the large irrigation project located in the North zone has large wetland at downstream of the project area, the influence to wetland area by project shall be studied carefully, because many of the farmers have been engaged in this traditional irrigated agriculture.

Large irrigation project by their nature have many problems and it is difficult to achieve irrigated agriculture successfully if it is not adequately planned and designed. It is recommendable, therefore, to suspend the project implementation temporarily and to thoroughly review and find solutions to the problems besetting large-scale irrigation in the country.

(7) Land Tenure Arrangement

RBDAs and SIDs have generally run into difficult problems. In all but scarcely populated areas, most large irrigation projects have created serious land tenure problems. The project facilities in large irrigation project were built on farmers land on condition that fully mechanized farming is to be introduced. Under this concept, land consolidation works with large-scale soil movement are implemented and considerable large farming-scale soil movement are implemented and considerable large farming plots with the larger area than average holding area of individual farmer are devised. Thus, big disadvantage are brought to the farmers displaced by the construction of

project facilities and those rejected from farming in the project areas. In this situation it is much more difficult to control cropping and levy adequate charges to cover operation and maintenance and certainly not charges to cover the huge increase in value of the land under irrigation. On-farm works shall be implemented considering relevant plot size and land occupancy right of individual farmer, and on-farm works with land consolidation are not required and land leveling shall be adopted as a plot arrangement. The alternative of promoting schemes in under populated areas should be carefully examined before implementation. Fully mechanized farming is unlikely to prove sustainable or economic, and irrigation is more likely to succeed in areas with high population pressure where the labour for cultivation by hand is available.

5. 3. 6 Wetland Development Downstream of Existing Reservoirs

(1) Change in Land Use of Wetland

(a) Land Use before Dam Construction

Because of relatively high soil moisture and fertility, the wetland is a prized area in developing the floodplain agriculture where farmers are able to grow one crop (rice or maize) during the rainy season and then plant the dry season crops on the margins of flooded wetland utilizing the residual soil moisture to secure the second harvest. The rich natural vegetation that provided forage for resident and transient livestock population was converted to agricultural crops. As more and more wetland was cleared and planted, competition for land has increased between livestock owners and settled farmers. The conversion of wetland to cropland has continued to date where a point have been reached wherein most wetlands have been fully converted to wet season rainfed agriculture while a small amount is used for dry season irrigated cropland.

Even before their conversion to agriculture, the wetland was important in household economies. Construction materials and fuelwood were extracted for local use, and reed and grasses were harvested for roofing materials and household items. Hunters and trappers harvested wildlife population for bush meat, and women gathered herb for food, medicine and

ornaments. At present time, very little natural vegetation and precious little wildlife remains in the densely-populated wetland.

Many wetlands retained open water into the dry season as a result of the fairly impermeable underlying soils. In this open water body covering tens of hectares, trapped fish and prolific invertebrate population prospered on the rich aquatic vegetation. As water is lost through percolation and evaporation, fishermen, women and children are able to take advantage of large fish yields using primitive fishing gear, and these fish, usually sun-dried and sold at local markets to supplement household income or used for family consumption.

(b) Post-Dam Land Use

During the past decades, the Federal Government has promoted an extensive program of dam construction to support large-scale irrigation on the wetland and adjacent upland. However, the irrigation development in these downstream areas did not occur at expected rates, and most of the reservoirs are currently not utilized for irrigation. The ecological changes within these highly productive wetlands after dam construction are far-reaching, mostly with adverse environmental, social and economic effects.

The dams have significantly altered the wetland hydrology. Recent changes in river regimes as brought about by dams and/or by cyclic or semi-permanent changes have drastically reduced the area, depth and duration of annual floodings; thus, this has affected communities which depended upon these ponded wetlands for fishery and cultivable wetlands, and also has reduced the habitat area for migratory birds and other wildlife. In particular, the recession agriculture on the wetland has been seriously curtailed both in respect to the area under cultivation and the market-value crops being planted; for instance, in some places where farmers cultivated the wet season rice, they are presently obliged to cultivate Guinea-corn or millet due to the reduced flood water and the consequent loss of residual soil moisture.

The reservoirs effectively trap a greater part of the sediments that were formally deposited on the wetlands during the flood period. The flood water no longer spreads the same amount of enriched silt over the cropland, thereby reducing the natural maintenance of soil fertility. As it is difficult to

purchase more fertilizer in order to avoid reduced yields, crop production and values are reduced.

Since water released from the reservoirs is carrying less suspended load, it is more erosive, and the river channels have been cut deeper in the downstream stretches resulting in the increased channel bed erosion or river scour. This scouring lowers the river level relative to the land, thus, flood water does not spread as far laterally with a consequent reduction of the water depth in flooded depressions. This reduction in area and depth also limits the amount of lateral fish migration and duration of open water in the floodplain depressions. The lower river level also have detrimental effects on groundwater levels. At lower river level, lateral groundwater movement is towards the river which would cause more rapid flood recession than it would have occurred before the rivers were not regulated by dams and reservoir. The river channel has become so deeply scoured in some places that it is possible to observe the groundwater falling from beneath the wetland to the river surface during the dry season. This premature draining of groundwater to the river reduces the amount of residual soil moisture available for dry season cropping.

(2) Position of Existing Reservoir Upstream of Wetland

At present, a large proportion of the water resources in the drought-prone areas of the North and Central regions are trapped in reservoirs, and water that could be used for downstream irrigation is greatly reduced by evaporation. An essential idea is that water resources development in the form of dams does not necessarily have to be linked with large-scale irrigation development. In other words, the position of dam and water storage may be justified by a number of effects of which irrigation is just one, and irrigation does not have to be exclusively on a large-scale basis. When linked to the possibilities for improved rainfed, water control or supplementary irrigated small-scale agriculture in areas free from flooding, it is possible that with suitable development assistance particularly access and infrastructure as well as with lower capital cost and commitment to tradeable inputs, the expansion of agricultural production by these methods might exceed that actually achieved on large-scale projects. Where competition for water or land is likely to arise, careful examination of the alternatives will be required.

The dam construction program will continue to radically alter the hydrological regimes downstream with both positive and negative effects on downstream water users. It is apparent that the loss of flood water has adversely affected Hadijia-Nguru and Birnin Kebbi farmers. On the other hand, wetlands no longer subject to variable flooding can be used for other rainfed crops. When large areas of the large-scale irrigation schemes come under cultivation, conflicts over water are likely to increase. When water is diverted for downstream areas, the resources will have to be allocated to those whose livelihoods are damaged. One possibility for compensation may be to pass stored water downstream in the dry season as regulated river flow for use in small-scale irrigation and flood-related livelihoods. The possible benefits from flood control and regulated river flows in the dry season in wetlands have not been fully explored. It may be noted that the farmer owned and managed small-scale irrigation in wetlands has many advantages in comparison with the large-scale public ones, particularly short lead time, low commitment to tradeable recurrent inputs, low skilled manpower requirements, rural employment effects, and land management.

(3) NFDP Downstream of Existing Reservoirs

The more than 90 percent of beneficial areas of 50×10^3 ha of the on-going World Bank assisted NFDP initiated in 1992 are located in the wetlands at Chad and Sokoto-Rima basins in North region and several large-scale dams such as Tiga, Challawa Gorge, Jibiya, Zobe, Goronyo, Bakolori, etc. had been constructed at the upstreams of the beneficial areas. The proposed wetland development should be assessed with due consideration of river basin management including the establishment of an appropriate plan to regularly release a part of the water stored in the major dam as river maintenance and to avoid the rapid change of the present wetland ecological systems and support the sustainability of small-scale irrigation.

(4) Future Perspective

It has been observed that the braided river systems in the wetlands have been developed for a long time as a result of the geological process establishing the topographical features, the runoff discharge, the quantity and character of sediment load and the composition of bed and bank materials, and

also have absorbed a great part of the upstream floods into the wetlands for local water use, percolation for shallow groundwater recharge and evaporation.

There has been moves before to improve the main river channels within the wetlands. The schemes to improve the Hadejia river as suggested by both IWACO (1985) and Chifana (1985) were aimed at reducing the losses to non-returning distributaries and bank overflow during the period of high flows. The IWACO plan consisted of the construction of a new river channel that would shorten the length of the Hadejia river by 50 percent, while Chifana perceived the need for a remodeled channel for the Hadejia river (Hadejia to Geidam) and additionally suggested that the Hadejia river between Wudil and Hadejia and the Katagum (Jama'are) river downstream of Katagum should be improved in order to reduce the current water losses.

When these schemes at a great expense are implemented in a stretch, an expected outcome would be to succeed in moving some of the present wetland activities to downstream areas where considerable fund each year would be required to maintain the production. The JICA Team considers that these schemes may be one of the final solutions and measures to protect the wetlands with major irrigation services in the most integrated and effective modes from major dams in the upstream. However, a gradual transition process from the present stage via, the NFDP typed irrigation to the final status may take an assumed period of more than fifty years. The above mentioned schemes should be properly designed to achieve this gradual transition process not only for the main remodeled channel but also for appurtenant structures in order to take all water users into consideration at each of the transition processes including the groundwater recharge, small-scale irrigation, wetland cultivation, livestock raising, fisheries or wildlife conservation in line with the well-coordinated reservoir operations in the upstream dams.

Reference is made to the historical perspective of irrigation development in Japan. It is said that major development of irrigation started in the flood plains four hundred years ago when the local landlords began to make investment to increase their revenues. When modern technology was introduced about 100 years ago, the public sector schemes undertook some of the irrigation projects similar to such indigenous irrigation systems as mentioned above. Immediately after World War II, the Government of Japan introduced a positive policy for the expansion and further modernization of all

the existing irrigation systems by applying the refined technology to overcome the food deficiency at that time. Many storage dams had been constructed to achieve full irrigation for the existing projects where the development of the so-called, "Water societies had reached a maturity level". Under this situation, by the 1970s, the chronic food shortage in Japan had been basically solved and then turned to the surplus stage. When reviewing the historical perspective on irrigation in Japan, it may be understood that the subject item "Proper Phasing of Irrigation Project Implementation" has been ingeniously incorporated for long-term development. It may be referred that the Southeast Asian Countries are accepting the above-mentioned concept to phase the irrigation development through many technical cooperation programs under the Government of Japan.

At present, everyone can observe a vast extent of the irrigated farmland as fully consolidated for large-scale farm mechanization work. While watching the process of irrigated agricultural development to be made from now on in the on-going Hadejia Valley Irrigation Project that is close to completion, it may be stressed that it should take longer years to achieve a full development of irrigation on the wetlands by mobilizing the sophisticated technology that may be extended with a main point to provide the appropriate channelization works mitigating the major ecological and environmental impacts in line with a gradual transition process planning.

5.3.7 Environmental Management

(1) General

Irrigation projects cause environmental problems and impacts in irrigation service area in accompany with a change in hydrology, construction of project facilities. Since general environmental problems and impacts related to irrigation development are discussed in Chapter 11, some of the major problems and impacts, waterlogging and salinization of soils in irrigated area, and irrigation development in wetland, are briefly discusses below:

(2) Waterlogging and Salinization of Soils

It is of the worldwide issues that the greatest technical causes of decreasing the production on many irrigated projects or failure of large areas

are waterlogging and salinization of soils especially in arid and semi-arid areas. The waterlogging is not an inevitable result of irrigation, but due to excessive water supply into systems which have finite natural drainage capacities and cause the groundwater level to rise until a new equilibrium is reached. The sources of excess water input may include the seepage from unlined canals and on-farm ditches, the deep percolation on irrigated lands, and the rainfall. After waterlogging occurs, the soil salinity increases as the plants extract pure water and the evaporation from soil surface leaves the dissolved solids in the soil that are present in irrigation water. In the humid areas, the waterlogging occurs due to excess rainfall and may not be associated with salinity. A special problem in some coastal areas is the reclamation of acid-sulfate soils.

Monitoring the change in water tables from the beginning of a new project is essential in implementing any corrective action before the soil damages occur and many also enable the prediction of whether small-scale drainage will be adequate to prevent localized waterlogging problems, or whether a large-scale system will be needed. For new irrigation projects, an integrated design of the irrigation and drainage systems along with operating practices may minimize irrigation development and management costs, as is explained in para (1) of 5.4.1 "General Strategies and Priority". And also, the farmers should be involved in the development and OM of effective waterlogging and salinity control measures.

Waterlogging can be corrected by reducing excess water input and increasing natural drainage capacities by vertical (well) and horizontal drainage (pipe drain). Once soil salinity is increased to a level that affects the plant growth, salinity should be leached from the soil. Since the pipe drainage cost is typically high, the installation of drains may often be postponed until no alternative remains for increasing or maintaining soil productivity. On large irrigated projects with small topographic gradients, disposal of drainage effluent is a major problem. Because of increasing competition for good quality water, the saline drainage water is diverted into evaporating ponds.

Technology is well-established for designing, constructing and managing drainage systems, while some adaptive research may be needed where local materials are used and where unique local soil problems exist. With existing irrigation system in Nigeria, it is anticipated that the increased drainage will almost invariably be required to maintain adequate soil productivity. The main question is a matter of when such drainage systems should be constructed. In this occasion, pilot drainage projects in waterlogged and salinized areas need to be established to verify design and effectiveness of materials, demonstrate the effect of drainage on productivity, and train the personnel in OM of the drainage systems.

(3) Wetland

- Impact of Irrigating Existing Arable Land

  No new wetland clearing will take place with the criteria for farmer selection that only wetland currently under cultivation is eligible for pumps and tubewells to be supplied through the project. There is also the groundwater monitoring system to indicate the sustainable limit for the expansion of wetland irrigation and the environmental assessment to determine if there are other ecological and social limits to sustainable wetland development.

  It is unlikely that the introduction of irrigation into the wetland which has long been under continuous farming and supports little or no native vegetation would have any profound ecological impact. However, expanding wetland irrigation in the dry season is likely to intensify the conflicts between livestock owners and farmers. The traditional methods of resolving the conflicts between pastoral livestock herders and settled farmers may break down if wetland irrigation expands too rapidly and will cause an increase in civil actions. Since many of the livestock incursions on irrigated land stems from locally owned livestock, the local mechanism for compensating damage work may adjust to keep serious conflicts to a minimum.

- Soil and Water Contamination

  Soil salinization or other degradation as a result of the wetland irrigation has yet to occur. However, increased capital requirements of farmers and the pressure to repay loans in irrigated crop production may increase the use of yield-increasing pesticides and fertilizers. These residues could enter the surface water and shallow groundwater systems, and therefore the groundwater monitoring on nitrates, pesticide degradation

products and faecal bacteria is essential. While there could be an increase in incidence of water-borned diseases for surface water irrigation, the development of groundwater irrigation is unlikely to be associated with such problems because the scheme leaves no free-standing water to support diseases or their vectors.

- Fish and Wildlife Impacts

  While major impact on fish population is likely to have occurred with the upstream dam construction which have reduced the areas of annually flooded fadama basins, some impact on resident fish population may occur as a result of the drawdown of the river systems from direct pumping from rivers and also of additional contributions to aquifer recharge. A program of the fadama basin rehabilitation through controlled flooding would make a positive contribution in re-establishing the role of these basins in aquifer recharge and also provide the opportunity to re-establish the fishery that existed previously as well as to enhance this through the introduction of aquaculture techniques.

  Recent concern has been expressed about the effects of wetland irrigation on migratory waterfowl and other water birds. Attention has been paid to Hadejia-Nguru wetland in Jigawa State where the Hadejia Wetlands Game Reserve is located and this project will not affect this wetland. When there is significant expansion of irrigated arable agriculture outside the present boundaries of land use, there may be other areas that are threatened and they should be protected.

5.4 NWRMP TOWARDS THE YEAR 2020

5.4.1 General Strategies and Priority

(1) General Strategies

The main problem facing the public sector schemes is that while FGN spent large funds in building many dams for irrigation mostly in the dry north during the oil boom period, the related downstream development has proceeded far more slowly with very limited funds to complete them in the subsequent continuing years because of financial difficulty. Thus a large proportion of the water resources is only trapped in reservoirs and evaporating without giving any benefits while significant damages have been given to the traditional water users in the downstream wetlands inviting adverse changes in their ecological context. Probably, none of the investments made so far have been economical, and even if past investments are taken as sunk cost, it will remain difficult to keep the completion cost to sufficiently low levels to ensure acceptable economic returns, because of poor operation and maintenance (OM) of the facilities as well as the problems of social issues, tenure arrangement, land acquisition, agro-allied services and cost recovery that are currently prevailing in existing irrigation projects.

The JICA Team has observed during the field visits that a fundamental change in the way of thinking about the sequence and phasing of irrigation development particularly in the large and medium-scale projects may be required. In this regard, the key word is the capability of local farmers to absorb and accept such irrigation practices who will be the only beneficiaries from the public sector investments, more particularly, this may be converted to "Development and Maturity Level of Water Society in the Irrigation Service Area". Even when the pilot demonstration farms are quite functional, the farmers still have no knowledge on irrigated agriculture. It would then be equal to an act of misbudgeting to first start the construction of dam, as this would only lengthen the gestation period in accrual of the full benefit from such investment.

It is one of the ideas that when an irrigation scheme with components such as storage dam, diversion weirs and canal system, the first undertaking would be to construct a river intake and the subsequent upper part of the

irrigation canal system in order to allow as early as possible the local farmers for wet season supplemental irrigation. In accordance with the progress of farmers proficiency in irrigated agriculture, the next work is to construct a diversion weir and extension of the canal system. In the later stage when the development and maturity level of water society in the service area is close to a full extent, a storage dam will be constructed for full dry season irrigation. The phasing for the implementation of irrigation development as mentioned above would be quite essential for the public sector schemes to obtain the quickest return of the huge investments so far made. Needless to say, the design of this irrigation project in an entire scope should be completed prior to long-term implementation.

Some important items to develop the public irrigation schemes under the FMWRRD as a departure from the current practices are described in a general manner in para. 12.4.4 of Chapter 12 "Strategic Issues in Project Undertakings" as well as para. 12.2 of Chapter 12" Decentralization, Privatisation and Users Participation" and summarized below:

- The present situation indicates that the public irrigation schemes are being undertaken by both the RBDAs and the State Governments without any clear division for implementation. In view of rather unfavorable irrigation performances of the State schemes with insufficient manpower, it is recommended that all of the public schemes be carried out by the RBDAs in a consistent way, and the State Irrigation Department be best merged with the ADPs for their strengthening. In this respect, reference is made to para. (3) of 12.4.4 in Chapter 12.
- With a view to achieving the partial commercialization policy, the RBDAs will be responsible for delivering the irrigation water to the farm turnouts with the amount and timing as required by the farmers in connection with the appropriate costing arrangement. On the other hand, the subsequent provision and OM of the terminal service network with a standard coverage of 30 ha each will be the responsibility of the Water Users Association (WUA) in line with the agro-allied services to be carried out by the State ADPs. In this respect, it is critically important that closer linkages are developed and established between RBDAs and ADPs to ensure adequate agro-allied services for the clients of the former.
- Comprehensive review on the fact that the ability and initiative of both the Government officials and small farmers have been underestimated, has revealed a drastical change in initiating and

implementing manner for any irrigation development. In particular, attention has been paid to the official procedures of initiating a public project. It is proposed that when a project is preliminarily identified, the Government campaign will take place for farmers in line with the land tenancy arrangement suitable for development, and the several persons qualified will file a petition requesting that such project is to be executed by the FMWRRD. After this, a feasibility study will be carried out; to this end, a WUA covering the area will be set up for the project implementation. This may be one of the items to be included in the regulations under the Water Resources Decree.

- To date, little attention has been paid to the provision of adequate drainage function within the irrigation area. It is common that the drainage facilities may function to improve the on-farm water management for crop productivity and reduce the occurrence of not only the water-based infections but the rural environmental problems as a whole. Generally speaking, the farmers at an initial stage would not be aware of the seriousness of this problem and would be reluctant to grant the necessary land for drains through their fields. However, drains will be included in the design of on-farm works and could be constructed if they become convinced of the need for them.

- It is generally recognized that small-scale public irrigation projects with a concept that the communities develop and operate most activities of the projects themselves although technical assistance is often necessary during survey, design, construction and OM which can fulfill many local water needs and affect sustainable agricultural development in several ways:

  - Well-designed projects may lessen the vulnerability of agricultural activities and the risk of soil and water degradation.
  - Small-scale irrigation enables the use of renewable energy sources where suitable.
  - The rates of expansion of small-scale irrigation can be controlled being consistent with locally available water resources.
  - Small-scale programs can be efficient and amenable to cost recovery and thus can operate reliably with private as well as public OM services and provide inexpensive and cost-effective extensions to irrigated production by small farmers whose

aggregated output is a key factor in the economic development for a particular area.

- When properly implemented in combination with irrigation, the large water consumer, and such others as water supply for humans and animals, soil conservation and flood spreading, the small-scale water programs can generate employment, promote equity, improve health standards and help to slow or prevent migration to urban areas. As a matter of fact, the small-scale irrigation projects need to be based upon better design and far better institutional coordination, with a key focus upon participation at the local level in all stages of planning, implementation and management, including the following:

  - To develop more effective institutional coordination to integrate the development of agricultural and water supplies and soil and water conservation.
  - To enhance the capability of farmers in the implementation and OM of water programs through enlarging the local capability with more flexible design approaches, training and appropriate funding.
  - To adapt and disseminate appropriate technologies suitable for small plots of land and low-cost irrigation practices for small and marginal farmers.
  - To provide stronger representation and support to small farmers including development of more effective production and marketing environment particularly for credit and agricultural inputs required.
  - To enhance the roles of NGOs and private sector in promoting small-scale projects; viz. (1) encourage NGOs to improve coordination and increase their support along with positive assistance to NGOs to improve their managerial and technical skills through trainings: (2) expand opportunities and improve the performance of the private sector; and (3) improve collaboration between public and private sector agencies to ensure standardized programs in credit and technical assistance.
  - To monitor performance, evaluate success and failures and identify constraints to provide feedback and disseminate lessons learned.

- In conclusion, the experience and knowledge to be derived from the implementation of small-scale public irrigation projects in the above-mentioned manner will be a great asset to complement future proper development of the larger public projects.

(2) Priority

Although the scale of the existing public irrigation projects in NWRIS was tentatively classified into the large scale with the area of more than 1,000 ha and medium / small with the area of less than 1,000 ha, the scale of proposed irrigation projects toward the year 2020 is classified into the large scale for the area of more than 3,000 ha, the medium for the area between 500 ha and, 3,000 ha, and the small for the area of less than 500 ha.

The above scale classification is set up the following idea;

- In accordance with the survey at the sites and study on the map with scale of 1 to 50,000 by JICA Team, a number of medium and small scale irrigation projects covering the area of 200 to 3,000 ha were identified in the tributary basins related to the proposed water sources projects.
- Irrigation projects with area of less than 500 ha (Small) could be easily planned with the pre-feasibility study, implemented quickly by the force account of RBDA with participation of beneficiaries, and managed smoothly by responsibility of beneficiaries.
- Irrigation projects with the area of 500 to 3,000 ha (Medium) would be planned with the simplified feasibility study to be executed by RBDA in accordance with the planning guideline and criteria prepared by RBDA, implemented with medium-scale-contractors under supervision of RBDA, and managed by RBDA with participation of the beneficiaries.
- Irrigation projects with the area of more than 3,000 ha (Large) should be planned with the complete and detailed feasibility study including many surveies and investigation works, implemented with the large and competent contractors under severe supervision of RBDA, and managed carefully with OM office provided by RBDA.

Needless to say, the priority should be given to the quick realization of existing but incomplete public schemes and the steady growth of private irrigation schemes mostly over the wetlands, while the proposed new public

schemes mainly composed of small- and medium-scale in association with the proposed water resources development would need a considerable time for preparation towards full implementation by around 2005.

Attention has been paid to an assumed rate of expanding the private schemes at 20 to 30×10^3 ha per year, most of which will be converted later for inclusion into the proposed public irrigation schemes taking advantage of the increased farmers' familiarity to and experience in irrigated agriculture and also the quick return from public investment. Realizing that private irrigation is always practiced ahead in the implementation over public schemes, a close coordination between the FMWRRD and the FMANR should be vigorously promoted.

5. 4. 2 Irrigation Growth Scenario

(1) Available Materials for Examination of Irrigation Subsector Growth

It would be imperative that the irrigation subsector growth to be given during the NWRMP period should be discussed within the crop subsector growth from the perspectives of food demand and supply in the drive for the attainment of self-sufficiency in the production of most crops. Toward this end, three major sources of future growth such as population growth and its effect on expansion in area under cultivation, effect of technological change and of an increased input use on yield and irrigation can be examined to estimate the growth in the crop as well as total agricultural output from these sources of growth.

Virtually, the above examination is not a direct task as imposed on the JICA Team; however existing materials made available to the Team as given below have been reviewed for an orientation and approach to the subject item:

- FMAWRRD. 1992. A Perspective Plan for Agricultural Development in Nigeria: 1990 - 2005
- NISER. 1985. Nigerian Food Balance Study: 1985 - 1995, prepared for Federal Ministry of National Planning
- World Bank. 1989. Nigeria: Strategy for Agricultural Growth

- World Bank. 1991. Nigeria: Strategy for Food and Nutrition Security.
- World Bank. 1992. Nigeria: Irrigation Sub-Sector Review

Major understandings as made through the review of existing available documents are summarized in para. 2.5.1 with the titles of (1) Food Insecurity, (2) Factors Affecting the Food Security, (3) Food Imports, (4) FMAWRRD Perspective Plan (1990-2005), and (5) in next clause with the title of World Bank Medium - Term Projection (1990-1994). The first three publications provide special background information on the need of future agricultural growth, while the latter two are related to the perspective of crop sub-sector growth in terms of supply and demand. The FMAWRRD perspective (1990-2005) gives the output of most crops at the annual growth rate of 4 to 6 percent with the average of 5.1 percent for all food crops that seems to be arbitrary without taking any detail on the future growth by relevant sources. On the other hand, the World Bank estimates that the agricultural production would grow at 3.9 percent per annum during the 1990-94 period and its comprehensive efforts are undertaken as recommended, a detail of which is described below:

(2) Summary of World Bank Medium-Term Projection (1990-1994)

Reference is made to the World Bank materials such as (1) "Nigeria: Strategy for Agricultural Growth" (Report No. 7988-UNI, 1989) (2) "Nigeria: Strategy for Food and Nutrition Security' (Report No. 9040-UNI, 1991) and (3) "Nigeria: Irrigation Sub-Sector Review" (Report No, 89/91 CP-NIR 45 SR, 1992), from which major analyses and the subsequent recommendations are summarized below:

- It is clear that the Nigerian agriculture has a high potential in line with the strategy for its growth involving (1) fine-tuning of the economic policy framework, (2) development of a strong focal point for sectoral policy analysis and strengthening of policy implementation capacity, (3) specifications to improve agricultural services, and (4) reorientation of and increase in public expenditure for agriculture.
- Assuming that the key constraints as mentioned above are removed, three distinct sources of growth depending upon

incentives, availability of technology and inputs, and infrastructure are pointed out:

- Increase in the cultivated area and labor input as a result of the population growth at the annual rate of 3.3 percent. This rate may be compared with the 1.7 percent between two population census of 1963 and 1991.
- Increase in the yields of rainfed crops as a result of modern inputs such as varieties and fertilizers.
- Increase in production by bringing more area under irrigation which helps the food security in two ways: (1) bringing new and marginal land under assured cultivation, and (2) reducing the dependency on rainfall to fluctuate a great deal.

- The 1989 report shows that under the most optimistic scenario when all the sources of growth are efficiently tapped, it would be possible for agriculture production to increase at the rate of 3.9 percent per annum during the 5-year period of 1990 - 94 which should be viewed as the outer limit attainable through the recommended actions.

Various Sources of Potential Growth, 1990 - 94

(Unit: % per annum)

Sources of Growth	Region			
	North	Central	South	Total
Land and Labor*	0.8	2.7	0.8	1.1
Yield per ha	0.9	1.1	2.0	1.5
Irrigation	1.9	3.4	-	1.3
Overall	3.6	7.2	2.8	3.9

Note: * ..... The annual growth rate of rural population is taken at 3% in Central region and 2% in North and South regions, which may lead to expansion in the cultivation area in Central while adding to production by relieving the labor constraints in other regions.

Potential Rates of Growth under Different Scenarios

(Unit: % per annum)

Scenario	1990	1991	1992	1993	1994	Overall
Growth with Existing Programmes	2.1	2.1	2.1	2.1	2.1	2.1
Medium Adoption of New Technology*	2.6	2.8	3.1	3.2	3.3	3.1
Accelerated Adoption of New Technology**	2.8	3.2	3.7	4.0	4.3	3.9

Note: * ..... Continuation of existing programs with additional effort that will give an adoption rate on average 1-2% per annum for new technology and exploitation of 25% of total fadama potential at the rate of 40,000ha a year.

** ... Accelerated adoption rate rising to 3%, 5% growth rate for fertilizer consumption and exploitation of 50% total fadama potential at the rate of 80,000 ha a year.

A 3.9 percent growth rate as envisaged would represent a high jump over the past growth rates achieved in the 1960s and 1970s. It is achievable with the following reasons:

- Recent macro-economic reforms have created the right kind of incentive structures; hence the 2 to 3 percent growth achieved during the pre-oil period (1960 - 70) would be easily achieved when the price distortions were not there.
- Significant productivity gains are currently possible because of the availability of proven technologies.
- Over and above this growth, small-scale irrigation, although it will take longer, is a newly realized key source of growth.
- Exploitation of these new sources of growth may depend upon concerted efforts on adaptive research extension, roads, markets and related infrastructure financial services and so forth.

Using the potential growth rates for individual crops, the supply of various food crops for the year 1995 is projected against the demand for consumption by assuming that population and per capita growth at 3.3 and 3 percent per annum respectively.

(Unit: 10^3 ton)

Crop	1995 Supply	1995 Demand			FMAWRRD-Perspective Plan
		Human	Industrial	Total	1995 Supply
Maize	2,709	1,356	904	2,260	1,946
Millet	3,690	3,568	396	3,974	5,087
Sorghum	5,524	4,483	1,921	6,524	4,616
Rice	801	1,112	0	1,112	1,153
Wheat	30	2,546	0	2,546	683
Cassava	2,748	1,792	316	2,108	16,883
Yam	2,445	1,424	0	1,424	11,533
Groundnuts	1,018	1,183	0	1,183	
Beans	1,079	967	0	967	
Total	20,069	18,528	3,587	22,065	41,901

The above table shows that the supply can meet the human consumption demand at aggregate level. There may be substantial surplus or shortfall in supply for individual crops. The consumers, however, can substitute maize and cassava for other staples since rapidly growing supplies of these crops will bring down their relative prices. Similarly, the increasing relative prices of wheat, millet and sorghum, the domestic production of which will fall short of demand, will also induce imports of these crops.

(3) Interpretation of World Bank Medium-Term Projection (1990-1994)

The World Bank's growth rate of 3.9 percent per annum under the most optimistic scenario that may be viewed as the outer limit attainable through recommended actions is divided by source into 1.1 percent for land and labor, 1.5 percent for yield and 1.3 percent for irrigation. The growth rate for irrigation is also subdivided by region into 1.8 percent for North and 3.4 percent for Central. Taking into account the 3.9 percent annual growth for agricultural production based upon the annual growth of total population at 3.3 percent (1990-94) that may be compared with the actual rate of 1.7 percent for the period of 1963-91, the World Bank perspective may be interpreted thus;

- Due to the population growth and continuation of present programs only, the overall growth at 2.1 percent per annum may come only from the expansion of cultivation area and relaxation of labor constraints.
- Overall for the crop sector, in the beginning 1990 to 91, 2-3 percent growth rate would be attainable at best. After that if comprehensive efforts are undertaken as recommended, the growth rate would increase and approach a 3-4 percent annual rate.
- The Central region will grow at the fastest rate of 7.2 percent, while the Southern region at the lowest rate of 2.8 percent, although all regions will grow at a rate faster than the population growth.
- Without investment in irrigation, the Northern region will grow only at the rate of 1.7 percent per year. Important source of growth for the North is irrigation especially from wetland scheme that alone can give about 2 percent increase of output. This should be accelerated particularly due to the recent Sahelian drought.
- The World Bank report mentions that about 1.3 percentage of the overall growth rate (3.9 percent per annum) come from the accelerated exploitation of 50 percent of total wetland potential at the rate of 80,000 ha per annum, and at least 50 percent is allocated to rice and maize. The report continues that assuming that in next 10 years all of the potential for small-scale schemes are exploited and 6 ton per ha of the annual grain production from double cropping is achieved, 800,000 ha will generate about 2.4 billion Naira worth of agricultural produce at the price of 500 Naira per ton for rice and maize. This irrigation would be of low-cost, private scheme with the shortest gestation period.

(4) Irrigation Area Proposed for the NWRMP Period

There would be many uncertainties relevant to future agricultural growth particularly in the NWRMP period up to 2020. In the projection of irrigation growth proposed for the NWRMP period, the JICA Team follow the same scenario of the World Bank but with a newly estimated population growth rate of 2.6 percent per annum by the JICA Team instead of 3.3 percent per annum as estimated by the World Bank. The total potential growth rate coming from three sources is estimated at 2.9 percent, of which irrigation sector bear the potential growth of 0.5 percent as shown below;

Source of Growth	Potential Rates of Growth	
	World Bank Medium-Term Projection (1990-1994)	NWRMP
Land and Labor	1.1	0.9
Yield per ha	1.5	1.5
Irrigation	1.3	0.5
Overall	3.9	2.9

Based on the potential rates of growth in NWRMP period, the proposed areas to be irrigated by year 2020 is estimated at $1,500 \times 10^3$ ha and the detailed procedure is shown below;

a) Present Agricultural Production (P_1)

Present agricultural production in 1991 is expressed by following equation:

$$P_1 = \{2\alpha h + (1-\alpha)i\}Ae$$

where:

A : Net agricultural land in 1991 ($=17,700 \times 10^3$ ha)

α : Land use rate of irrigation area ($= \frac{220 \times 10^3 \text{ ha}}{17,700 \times 10^3 \text{ ha}} = 0.012$)

h, i: Cropping intensities in irrigation area ($=1.3$) and rainfed area ($=1.0$)

e : Yield in rainfed area (ton/1,000 ha)

Area	Land use rate	Cropping intensity	Cropping area	Yield in 1991 (ton/1,000 ha)	Agricultural Production
Irrigation	α	h	$A\alpha\ell$	2e	$2\alpha hAe$
Rainfed	$1-\alpha$	i	$A(1-\alpha)i$	e	$(1-\alpha)iAe$

$\therefore P_1 = 1.019Ae$

b) Required Agricultural Production in 2020 (P_2)

$P_2 = \{1 + (\text{overall potential rate} = 0.029)\}^n \times P_1$

where n : number of years upto 2020 = 29

$\therefore P_2 = 2.291 P_1 = 2.335 Ae$

c) Agricultural Production by Irrigation in 2020 (P_{21})

$P_{21} = (\text{contribution rate of irrigation sector}) \times P_2$
$= 0.5/2.9 \times P_2 = 0.403 Ae$

d) Required Irrigation Area in 2020 (A_2)

$A_2 = P_{21}/e'k$
where
e' : Yield of irrigated area in 2020
$e' = (\text{yield in 1991}) \times \{1 + (\text{growth rate of irrigation})\}^n$

$\therefore e' = 2e \times (1 + 0.015)^{29} = 3.08e$

k : Cropping intensity in 2020 (= 1.6)

$\therefore A_2 = 0.403Ae/(3.08e \times 1.6)$
$= 0.082A$
$= 0.082 \times 17{,}700 \times 10^3$
$= 1{,}450 \times 10^3$
$\fallingdotseq 1{,}500 \times 10^3$ (ha)

The proposed area to be irrigated by year 2020 is estimated with many assumption introduced from scarce database. Accordingly, MOA should, at the earliest, execute food balance study toward 2020 considering the population growth rate, food consumption per capital, etc., and clarify the burden of irrigation sector for food security taking into account the distribution of irrigation area recommended in this NWRMP. In addition, full use of the study result shall be made for the next updating of NWRMP in 2000.

5.4.3 Transformation from the Government-Conducted to the Self-Reliance Mode in Project Implementation

(1) General

Irrigation project implementation in public sector have been depending heavily on public agencies, and farmers within a project area have received various subsidized services at less than normal cost from public agencies.

This paternalism prevents successful irrigated agriculture in Nigeria. It is urgently needed to transform project implementation mode from the government-conducted to farmers self-reliance mode through the upgrading of farmers' participation in the implementation. For this purpose, the following countermeasures are needed;

- Vigorous campaign on irrigated agriculture bringing out high income generation and job creation shall be made by public agencies.
- Project implementation shall be commenced only when farmers' requests for the implementation are submitted to public agencies.
- Proposed beneficiaries shall participate in public sector programs at the planning and implementation stages.
- OM for project facilities shall be carried out by WUAs as much as possible under the guidance of RBDAs.

(2) Strengthening of Irrigation Execution Services

Increases in the future production of irrigated agriculture will be subject to the positive actions required to transfer existing technology for efficient water use at the farm level and to support its implementation. Urgent action is required to educated and train extension staff, strengthen water management research under irrigated conditions, monitor and evaluate irrigation project performance, and establish effective demand management procedures and water pricing policies. More particularly, the following actions should be worked out:

(a) Develop and strengthen irrigation extension services and provide appropriate irrigation management training at all levels including water users:

- educate and train extension staff in irrigation water management principles and practices and associated agronomic and cultural practices;
- establish or strengthen irrigation technical support infrastructure, train extension staff in establishing demonstration plots on farmers' fields, and provide adequate transport facilities to enable extension staff to interact with farmers and project officers; and
- train lead farmers in effective and economic irrigation management practices.

(b) Promote exchange of information among farmers, extension workers, design engineers and researchers so that research and new design approaches meet the changing needs of farmers and the farmers fully understand the relevance of new and improved technology. In this regard it is recommended that action be taken to:

- create opportunities for increased interaction among farmers, extension workers and researches through organized visits of farmers and extension workers to research stations and the researchers to farmers' fields; and
- hold regular field events' for the participation of design engineers, extension workers and farmers to enable exchange of knowledge and information among the participants.

(c) Enhance design, operation and maintenance of irrigation projects by training of relevant professionals and members of water users' organizations:

- initiate training for operation and maintenance personnel during the construction phase of new projects and during rehabilitation of existing projects to prepare them for project operations;
- train system designers and operators in effective and economic approaches to modernizing irrigation and drainage systems and in effective and economic maintenance technology including principles of preventative maintenance; and
- develop operation and maintenance criteria, taking into account the cost, manpower availability and requirements and social and

environmental protection needs. Ensure that the criteria are taken fully into account in the design of irrigation systems.

(d) Review, develop and implement water pricing policies, establish effective demand / supply management procedures and cost recovery mechanisms for operation and maintenance of irrigation projects:

- establish manageable water demand and pricing systems which will minimize excess water application and reduce drainage requirements and costs; and
- ensure that new or rehabilitated irrigation projects will have adequate resources for sustained operation and maintenance.

(e) Establish monitoring, evaluation and feedback systems for all existing and future irrigation projects to improve performance of water deliveries and maintenance of distributary systems and watercourses, and to control groundwater levels to increase crop yields and social and economic benefits:

- train project managers in use of monitoring, evaluation and application of feedback techniques to improve irrigation performance and to reduce operating costs;
- identify meaningful irrigation component performance parameters, establish required measurements including their accuracy and sampling frequency and establish a management information system to assist real-time project management decision-making and scheduling of major maintenance operations; and
- link project performance with operation and maintenance costs and agricultural production.

(3) Strengthening of Agricultural Extension Services

In any event, each scheme should contain the blend of inputs and services necessary to ensure a sustained increase in productivity for the beneficiaries. Particular attention should be given to the appropriate balance between the directly productive and indirectly productive elements in a scheme. The balance should reflect the level of services proposed for the sector on a national basis, the most economic means of providing such services, and

restrictions on the resources that can be used for this purpose. This program may cover the following studies.

(a) Assessment of the adequacy of existing support services and facilities for various schemes within the Program area, and recommendation of the required improvement in adaptive research, extension, training, credit, input supply, processing and marketing, and transportation and distribution together with the provision of details of staff deployment levels and budgetary allocations needed to strengthen an overall support facility.

(b) In association with the selected priority schemes in productive sector and the availability of investment and operational credit facilities, the provision of detailed scope of a credit program including credit delivery system, required investment estimate for associated schemes, implementing arrangement inclusive of terms and conditions of loans, and annual lending program.

(c) In line with the assessment on the role of women in farm and household activities in the Program area, the identification of their needs, interests and constraints, and the formulation of strategies and approaches for integrating women into the Program development plans including the training which might integrate matters of concern to women into the Program.

(4) Project Implementation Procedures

The project shall be implemented in accordance with the following procedures;

- The FMWRRD and the FMANR-ADP shall make preliminary explanation of identified irrigation projects through pre-feasibility study and campaign of irrigated agriculture and necessity of farmers' participation for the implementation of the projects, and several farmers qualified will file a petition requesting that such projects is to be executed by the FMWRRD. The agencies shall prepare the demonstration farm to show the advantage of irrigated agriculture to the farmers.
- After this, a feasibility study will be carried out by the FMWRRD, and if a project is feasible, the implementation program will be prepared and the public notice and active campaign of the project to the farmers by the FMWRRD in cooperation with the FMANR.

The establishment of WUA covering the area shall be promoted by the public agencies for the project implementation.

- After the completion of detailed design by the FMWRRD, the construction of project facilities will be carried out by the RBDA under the coordination with the FMANR and WUA. The alignment of main, secondary and or tertiary canals, location of farm turnout and layout of on-farm facilities will be decided with a beneficiaries' participation including provision of their man-power input to the construction works. On the other hand, WUA shall discuss water charges to be collected by the RBDA.
- The layout of on-farm facilities will be worked out by WUA with the technical assistance of the RBDA and extension services by the FMANR-ADP and shall obtain the consent of the beneficiaries.

  The construction of on-farm facilities will be implemented under the beneficiaries' collective responsibility, and if necessary, farmers credit for the construction shall be prepared with an assistance of the FMANR-ADP.
- The construction works for the on-farm facilities shall be completed along with those by the RBDA, and the water management test at the on-farm level will be carried out under the guidance of the RBDA and the FMANR-ADP.
- After the establishment of WUA, Agricultural Cooperative Society (ACS) which deal with collective procurement of agricultural inputs, tractor service, cooperative shipment, arrangement of farmers credit, etc. shall be organized with the support of the FMANR-ADP.
- Even the project facilities belong to the RBDA, they shall be operated and maintained by WUA as much as possible and weeding and simple repair for the facilities shall be borne by the beneficiaries. A success in OM of these facilities depend on the extent of farmers' understanding that these facilities are for the beneficiaries or WUA. The RBDA and the FMANR-ADP shall devote themselves wholly to play a role of a supporter to enlight the beneficiaries.

5.4.4 BMR for Existing Public Sector Systems

The balanced modernization and rehabilitation (BMR) for the existing canal system including on-farm facilities will be comprised of the repair and

improvement works for the canal system to maintain canal function and the proper water management works to deliver irrigation water effectively.

(1) Rehabilitation Works in Existing Canal Systems

The existing public sector systems with actual irrigated area of 70,000 ha have already defective facilities that needs immediate rehabilitation. The RBDAs shall carry out the rehabilitation works in accordance with the following procedure;

(a) Execution of detailed inventory survey for defective irrigation and drainage system

(b) Formulation of rehabilitation plan including detailed design work for relevant structures and construction plan.

(c) Classification of rehabilitation works to be executed by the RBDAs or contractor.

(d) Provision of construction equipment and materials for the works to be executed by RBDA force account.

(e) Order of the works and their supervision by the RBDAs.

(2) Establishment of Water Management in Canal System

Poor water management in canal system including on-farm facilities has brought the water shortage and excess water at on-farm level. The following countermeasure shall be taken by the WUAs and the RBDAs;

(a) Formulation of irrigation schedule on irrigation division such as zone, sector, block and field turnout in accordance with proposed cropping pattern by the WUAs prior to irrigation season.

(b) Execution of distribution water management in canal system by monitoring water level and discharge in canal and opening degree of regulator and turnout gate in order to adequately supply irrigation water to meet the irrigation schedule.

(c) Control of reservoir water taking into consideration the balance between storing water during night time and releasing water during day time.

(d) Establishment of rotational irrigation method at on-farm level to use the distributed water effectively.

(3) Introduction of Surface Irrigation

As described in 5.3.2, some existing projects with a sprinkler system have faced OM problems due to the lack of technical knowledge and maintenance of the equipment. These sprinkler systems shall be shifted to surface irrigation systems such as the border, furrow and basin which can be more easily managed by farmers at low operation cost.

For the successful achievement of above, water management training programs for OM staff and water users shall be prepared.

(4) Adoption of Water-Conserving Technology

An important element in any strategy to conserve water will be incentives for adopting technologies and management approaches that increase the efficient use, allocation, and distribution of water. Such technologies and management approaches will make it easier to conserve water, to increase the efficiency of water use and conveyance, and to reuse wastewater. As water scarcity and waste disposal problems become more acute, adopting and improving water conservation practices, wastewater reuse systems, and overall approaches to reduce pollution will become increasingly important.

Although the water resources in Northern zone consist of HA I and VIII is in the almost development stage, the need of water use for domestic water supply and agriculture and fisheries activities has been increasing year by year. Accordingly, it is recommendable that irrigation sector in Northern zone which is major water user shall be adopted micro-irrigation technology including drip irrigation for cropping of cash crop such as beans and orchard to conserve limited and exhaustible water resources and to prevent salinization of soils. And for farmers' easy procurement, FMANR shall take necessary arrangement such as agricultural credit and encouragement of domestic manufacture of required irrigation equipments of micro-irrigation.

5. 4. 5 Implementation of On-Going Public Sector Projects

The implementation of on-going public sector projects which have been characterized by incomplete canal systems covering the service area of 250,000 ha as shown below, shall be carried out urgently.

unit : 1,000 ha

Area	Hydrological Area								
	I	II	III	IV	V	VI	VII	VIII	Total
1. Service area	60	55	25	15	20	45	10	90	320
2. System completed	8	12	10	2	5	3	3	27	70
3. System uncomplete	52	43	15	13	15	42	7	63	250
3.1 Partially developed	10	14	11	6	6	3	3	44	97
3.2 Undeveloped	42	29	4	7	9	39	4	19	153

Among the uncompleted projects, about 39 percent have their irrigation plan already studied and their irrigation systems such as main and secondary canals partially developed. Therefore, more irrigated agriculture could be realized rapidly through the completion of the remaining partially developed system.

However, the remaining 61 percent of uncompleted projects, especially the large-scale irrigation projects such as Kano II, Middle-Rima Valley, Zauro Polder, Middle and Lower Ogun, etc., do not have their feasibility studies for the service areas. Implementation of there projects shall be scheduled with the condition that the feasibility studies and detailed design work will be finished upto the year of 2000, so that their systems could be constructed up to year 2005.

Moreover, since the large-scale irrigation projects in the North region would have reduced water-availability a rising from a decrease in reservoir inflow and an increase in water allocation to wetland, the irrigation plan shall be set up in coordination with the study on Integrated Water Management for Existing Dams described in Chapter 4.

5. 4. 6 Implementation of Proposed Public Sector Projects

The stable irrigated agriculture in Nigeria requires storage dams as a dependable water source facility due to less river runoff in the dry season.

Thus, in the formulation of newly proposed irrigation projects, those with storage dams shall be classified with a higher priority than those with pumping stations. However, where there are no potential damsites but river runoff is sufficient even in the dry season, the irrigation projects with pumping stations or creek systems shall be planned. The latter are mainly at the Central and the South regions. The number and area of proposed projects are 1,400 and 800×10^3 ha respectively, and 88 percent of proposed area is to be irrigated by dams. These three categories of projects is described hereafter:

Item	With Dam	With Primary Pump	With Creek System	Total
Number	1,080	285	35	1,400
Area (1000 ha)	705	85	10	800

(1) Irrigation Component of Medium and Small Dams Projects

As described previously, the public sector projects have been suffering from a number of weaknesses. Especially, large-scale projects have many problems such as high capital cost, slow development, slow attainment of target yield, poor water management, poor project viability and serious environmental impact. Therefore, it is advisable to defer immediate implementation of large-scale irrigation projects until after the irrigated agriculture through medium- and small-scale projects covering the service area of 500 to 3,000 ha and less than 500 ha respectively shall be well under way. However, medium and small-scale irrigation projects by dams with multipurpose components such as irrigation, water supply, mini-hydropower, fish culture, etc. can be implemented so as to secure increasing food demand. The irrigation projects with dams shall be formulated by the following criteria and procedure;

(a) Plan Formulation and Project Implementation

Plan Formulation

- Service areas shall be selected taking into consideration the operation and management of project facilities such as dams and canal systems. Therefore, the service areas shall be selected near damsites, and be irrigated by gravity system as much as possible. In case pumping stations are needed, only projects having a small

portion of service area to be served by pumping station or by the use of low lift pumps.

- Depression and swamp area in the service area shall be joined with irrigation canals linked by dams and they will be used as village ponds for domestic water, village garden irrigation, fish culture and reforestation.
- Project formulation shall be made under close coordination among public agencies related to irrigation, water supply, fish culture and reforestation.
- Establishment of the WUAs in the project area at the early stage of project planning shall be promoted for easy understanding and active participation of the beneficiaries.

Project Implementation

- Project shall be implemented basically by the RBDAs, and the labor from beneficiaries shall be mobilized as much as possible for the construction of small-scale facilities such as irrigation canal systems and village ponds under the RBDAs guidance.
- Standard and criteria for detail design on irrigation canals and village ponds shall be prepared by Department of Irrigation and Drainage (DID) with the coordination of National Water Resources Institution (NWRI), and they shall be applied for the design of project facilities to simplify and standardize the design works at each RBDA.
- The equipment and material centers for the construction works by force account mode shall be established at each RBDA. They will be used for the rehabilitation and OM works as well as construction works of project facilities.

(b) Identification of Proposed Irrigation Projects with Dams

The JICA Team has identified proposed irrigation areas up to the year 2020 and reference is made to para. 4.4.4. of this Sector Report which reflect the study made by using topographical maps with a scale of 1:250,000, 1:100,000 and 1:50,000 covering of about 60 percent of the whole land of Nigeria. The study result includes the location of dams and available storage water for irrigation. The irrigable areas are estimated based on the available storage water of proposed dams and unit irrigation requirement discussed in para.

5.2.4. As a result, 1,080 units of irrigation projects comprising of 260 units with large/medium dams and 820 units with small dams covering total service area of 705×10^3 ha are proposed toward the year 2020 for the Public Irrigation Program.

(c) Distribution of Proposed Irrigation Projects with Dams

The regional distributions of service area identified above are eight percent in the North region, 70 percent in the Central region and 22 percent in the South region with average irrigation area of 2,600 ha, 2,100 ha and 1,000 ha in the projects with large/medium dams respectively, and of 300 ha in the projects with small dams as shown below and Table 5.4.2.

	Region			
	North	Central	South	Total
1. Number of Proposed Projects				
Large/Medium Dam	15	165	80	260
Small Dam	70	500	250	820
Total	85	665	330	1,080
2. Proposed Irrigation Area (1000 ha)				
Large/Medium Dam	40	340	80	460
Small Dam	20	150	75	245
Total	60	490	155	705
Distribution (%)	8	70	22	100
3. Average Irrigation Area (ha/project)				
Large/Medium Dam	2,600	2,100	1,000	-
Small Dam	300	300	300	-

This study indicates the following regional conditions;

- The surface water in the North region has been generally developed already by the existing large dams and only little potential for water resources in limited basins are left.
- The Central region still has big potential for development mostly in medium and small-scale irrigation projects. The water and land resources are hardly not developed yet.
- The South region also has an abundant water resources, but has a limited land resources for agriculture due to its large population.

Consequently, the small-scale irrigation with a service area of less than 500 ha are proposed mainly in the North and South regions, and the medium- and small-scale projects proposed in the Central region.

The major areas to be developed by irrigation projects with dam are the wetlands, where irrigated agriculture is operated by individual farmers through traditional and modernized irrigation methods, extending along the tributaries of the Niger and Benue rivers and upper tributaries of the South region as shown in Table 5.4.3.

(2) Proposed Public Irrigation Projects with Primary Pump and Creek System

The main rivers and their major tributaries located mainly in the Central and South regions have a river runoff even in the dry season. The irrigation projects with primary pump are proposed for the wetlands of 85,000 ha which extend along such rivers as Niger and Benue and their major tributaries as according to the topography and present land use shown below.

HA	Major Basin to be developed by Proposed Pump Irrigation Project	Proposed Area (ha)
I	Along Niger river	5,000
II	Kampe, Upper Kaduna and Gurara	10,000
III	Taraba, Lower Donga and Pai	5,000
IV	Ankwe, Mada and Akini	10,000
V	Anambra and Mamu	15,000
VI	Ogun, Oyan, Oshun, Shasha and Silko	10,000
VII	Okpanku, Lower Cross and Imo	30,000
VIII	–	0
	Total	85,000

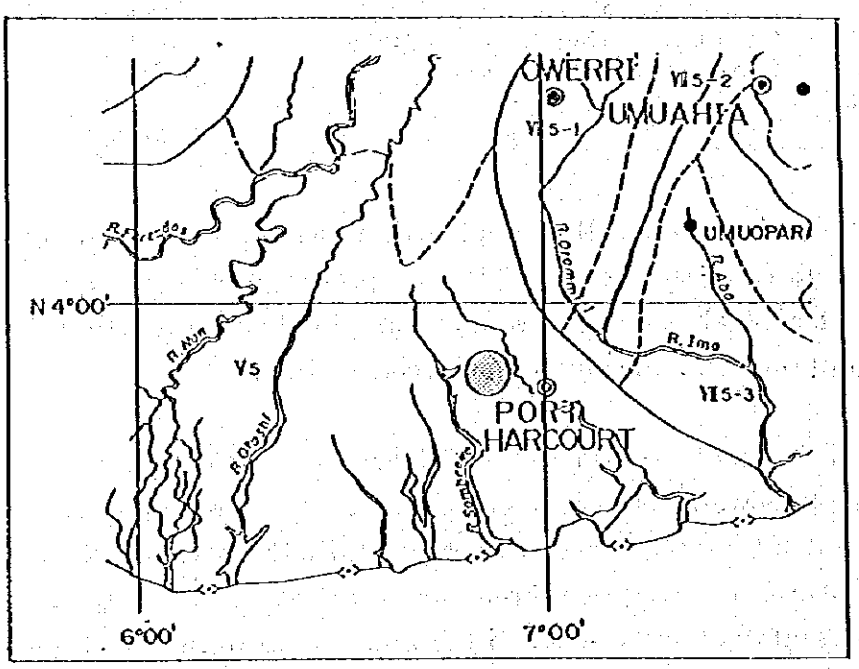
Since it is generally accepted that the primary pumping irrigation requires high OM cost, a typical case of a project may be considered to take a service area of 300 ha on average and a pumping head of less than 10 m taking into account the economic and financial constraints.

The present situations of the Niger Delta including the water and land environment as well as the development status are described in some detail in para. 7A.1.2 of Chapter 7, Sector Report. While there are fertile soils suitable for agriculture, invading flood from adjoining rivers and inundating by high intensity rainfalls have prevented the progress in agricultural development. This is against the common views that the deltas all over the world have been thoroughly developed for their wealth of resources for centuries. Virtually, it would not be possible in this NWRMP Study to establish a scope of work for the flood and erosion control in the Niger Delta because of the lack of topographical

maps and systematic data collection networks; therefore, any plan for irrigated agriculture is not compiled in the NWRMP with reference to para. (3) of 7B.3.2 in Chapter 7.

In general, the coastal creak areas may provide some of the irrigation projects with polder dike for protection from tributary flood and primary pump for both function of irrigation and drainage. This type of the project would be of a small-scale with a service area of 300 ha according to the field reconnaissance. There may be the possibility to develop the coastal creek irrigation projects along the belt of the Gulf of Guinea; however, the field reconnaissance has identified that most promising area for this development in a collective manner may be the New Calabar river basin as shown in the figure below where a total irrigable area of 10,000 ha has been tentatively taken up for inclusion in the NWRMP. It is recommended that a series of the coastal creek irrigation projects should be identified and prepared in connection with the mapping work for relevant river basin at a scale of 1 : 5,000.

Proposed Coastal Creek Irrigation Project
- New Calabar River Basin Project -



(3) Project Costs of Public Sector Projects

Project costs for existing and proposed public sector projects are estimated simply based on the following method;

{Service area to be improved or developed (ha)} × {Approximate unit cost}

The unit cost of rehabilitation for existing canal system, construction for new canal system in existing and proposed projects and pumping station are estimated at ₦ 6,000/ha, ₦ 31,000/ha and ₦ 30,000/ha respectively at the price level in the beginning of 1994 under the following assumption;

- Unit cost for canal system include construction cost of project facilities, other cost for OM equipment, right of way, administration, consultant and survey work. Excluded are on-farm facilities.
- Unit cost for rehabilitation include the cost of construction works and preparation works for the implementation.
- Unit cost for pumping station include the cost of the pump with a total lift of around 15m.

The project cost for canal systems of the existing projects of 320×10^3 ha and the proposed projects of 1,400 units covering 800×10^3 ha will be 38 billion Naira as shows in Table 5.4.4.

(4) Project Evaluation of Proposed Public Projects

Unit development cost including the allocated dam costs for the proposed small and medium-scale public irrigation projects is estimated at 61,000 to 74,000 Naira per ha as shown below:

Region	Unit Development Cost (₦/ha)	
	Public Irrigation Project	
	With Dam	With Pump
North/Central	73,900	61,000
South	72,300	61,000

Based on the above project costs, the proposed public irrigation projects as evaluated by region in para. 2.7.3 of Chapter 2 of Volume Two "Sector

Report" have special features and different characteristics by region as introduced hereinafter;

(a) North Region

The North region has a limited water resources for subsequent development due to scarce rainfall and existing water resources projects to a large extent, while effective rainfall for crops is also in minimum amount. Consequently, as much water is required for crop irrigation, the crops to be introduced in the service area may be those having less consumption of water such as maize and beans with low market price. As a standard, the planned cropping intensity is 150 percent comprising of 10 percent in rice and 140 percent in upland crops. The expected economic rate of return (ERR) might be about 10 percent. Thus, irrigation development in this region has its economic disadvantage, the area to be developed may be focused only on the areas where irrigation development is positive with the possibility of developing the water resources and obtaining the users participation to a greater extent.

(b) Central Region

This region has rather much rainfall than that of the North region. Consequently, much profitable crops could be introduced in a project with a cropping intensity of 180 percent comprising of 55 percent in rice and 125 percent in upland crops. The expected ERR for proposed project may range from 10 to 14 percent. Thus, the proposed projects will be promoted as there are no constraints for irrigation development in technical term.

(c) South Region

The South region has abundant water resources compared with the other two regions because of long periods of the rainy season with much rainfall. Thus, high cropping intensity of 180 percent comprising of 160 percent in rice and 20 percent in upland crops could be introduced in the irrigation projects. The expected ERR could reach 14 percent and more. Therefore, the proposed projects will be economically attractive and shall be promoted if there are no constraints in the land acquisition.

5.4.7 Implementation of NFDP Expansion

There are considerable wetlands in the lower basins of major rivers, in which the irrigated areas under private sector programs could reach 150×10^3 ha. This farmer-owned and -operated programs have a high development potential toward the year of 2020 with a rapid progress because of the easy realization of quick return from the projects with less investment.

The private sector programs shall be promoted from the following reasons;

- The agriculture production of existing public sector schemes which require additional construction works, will start only after the year 2000. For food security, the private sector programs, especially NFDP downstream of existing reservoirs, shall be hastened by utilizing the already available reservoir water until the completion of on-going public projects. In order to secure released water for the wetlands to be irrigated, an implementing agreement on the water-allocation between the RBDAs and the WUAs shall be prepared.
- It is essential for farmers to have experience in irrigated agriculture through private sector programs for the enhancement and upgrading of farmers' technology in irrigated agriculture.

The total available area including newly proposed area of 600×10^3 ha under this program by the year 2020 will be 750×10^3 ha, of which 370×10^3 ha will be shifted to the public sector schemes, bringing the service area by year 2020 to 380×10^3 ha. The project cost will be 7.8 billion Naira at the unit development cost of 13,000 Naira per ha. The final area will be mainly concentrated over the large wetlands in the North and Central regions as show below.

Private Sector Program	Hydrological Area (HA)								unit (10^3 ha)
	I	II	III	IV	V	VI	VII	VIII	Total
Existing Area	35	10	0	3	1	0	3	98	150
Proposed Area	68	146	90	74	32	43	53	94	600
Total	103	156	90	77	33	43	56	192	750
Final Area in 2020	75	40	30	15	10	10	10	190	380
Project Cost (10^6N)	884	1,898	1,170	962	416	559	689	1,222	7,800

5.4.8 Strengthening of Inter-Government Coordination For Supporting Services

At present, the supporting services by public agencies to the beneficiaries within the project area especially in the public sector are in a poor state mainly because of the withdrawal in providing supporting services by the RBDAs, insufficient activities of the SIDs and low capacity of the State ADPs, as well as the lack of coordination among these agencies.

The ADPs shall bear the responsibility to provide supporting services for beneficiaries in a consistent way, and the SIDs shall be merged with the ADPs for their strengthening.

There is a need to have strong inter-government coordination between the DID under the FMWRRD and the DOA under the FMANR on the development strategy of irrigated agriculture including areas to be developed, crops and irrigation method to be introduced and the implementation schedule. Moreover, demonstration farms for irrigated agriculture shall be consolidated by the ADPs under the administration of the DID in line with above strategy of coordination between both ministries. The State ADPs under the guidance of the DOA shall provide extension services through demonstration farms and utilization of TV system including the following items to farmers' representatives;

- Optimum farm size based on cropping pattern
- Arrangement and operations of on-farm facilities such as tertiary canal, farm ditch, tertiary drain, farm drain and farm road
- Information as to agricultural research and development
- Cultivation method including plowing, harrowing, ridging, land leveling, etc. by agricultural equipment
- Irrigation practice at on-farm level including irrigation demand, irrigation interval, rotation irrigation etc.
- Application method of agricultural inputs such as fertilizer, agricultural chemicals, seeds, etc.
- Harvesting and processing method of agricultural product