While associated extension services shall be provided to individual farmer to establish farmer's organization such as WUA and farmer's cooperative. These farmer's organization would provide the following extension services:

- Provision and operation of agricultural credit
- Procurement of agricultural inputs such as seeds, fertilizers, chemicals, agricultural equipment and man power
- Sales promotion of agricultural products

5.4.9 Water Demand at Intakes

Irrigation water demand at intake in 2020 for the irrigation service area of $1,500 \times 10^3$ ha including existing and proposed projects is estimated at 16,750 MCM comprising water demand of 13,470 MCM in public sector and 3,280 MCM in private sector as shown in Table 5.4.5 and 5.4.6, and as summarized below.

Sector	Existing		Proposed		Total	
	Area (10^3 ha)	Demand (MCM)	Area (10^3 ha)	Demand (MCM)	Area (10^3 ha)	Demand (MCM)
Public	320	3,650	800	9,820	1,120	13,470
Private	150	1,310	230	1,970	380	3,280
Total	470	4,960	1,030	11,790	1,500	16,750

5.4.10 Implementation Program

(1) Rehabilitation Works in the Existing Public Canal System

Rehabilitation works in the existing canal system covering a service area of 70,000 ha will be carried out by the RBDAs. The works are planned to be completed by the year 2000.

(2) Additional Construction Works in On-Going Public Sector Projects

There exists on-going public sector projects covering a total service area of 250,000 ha. Of this, about 100,000 ha comprising of individual project with service area of more than 3,000 ha each have not formulated their irrigation plan or construction plan. Proper feasibility study and detailed design work for these irrigation systems are required prior to their construction. It takes seven to eight years to complete the irrigation system taking into account two years for the feasibility, two years for the detailed design, one year for tendering work and four years for construction. Consequently, the construction work will be implemented during the year 2001 to 2005.

Projects required F/S and D.D.		Projects required D.D.	
Project	Area to be studied (ha)	Project	Area to be studied (ha)
Middle Rima Valley	5,300	Bakolori	17,000
Zauro Polder	11,200	Tada Shonga	3,200
Ilushi	5,000	Doko	3,000
Middle Ogun	12,000	Savannah	6,000
Lower Ogun	12,000	Mokoloki	2,900
KRP II	4,000	Igbere	3,000
Gari	4,200	KRP I	7,000
Total	53,700	Total	42,100

The remaining on-going projects covering 150,000 ha mainly comprise of individual projects with a service area of less than 3,000 ha, and those which have their construction plans worked out could be implemented immediately during the period from 1996 to 2000.

(3) New Public Projects

The service area of newly proposed public projects reaches 800×10^3 ha and these projects will be implemented after the implementation of the existing projects including large-scale projects which require large investment. The projects with dams, primary pumping stations and coastal creek system shall be implemented in the following manner;

- The proposed irrigation projects are classified in accordance with the size of service area in large, medium and small-scale. These service areas are defined at more than 3,000 ha, 500 to 3,000 ha and less than 500 ha respectively. Among the projects with dams

covering a service area of 705×10^3 ha, about 45 percent of the whole area belong to medium and small scale projects. For the quick yield of the irrigated agriculture outputs, the medium and small scale project will be implemented prior to large scale irrigation project during the period of 2001 to 2010. After the completion of medium and small scale projects, when the detailed feasibility studies are completed and the pre-conditions to start the projects inclusive of overcoming of the various problems as stated in para. 5.3.5 are met, the implementation of large-scale projects could be started.

- The proposed dam projects with main objective of wetland irrigation will take a multipurpose function to upgrade the rural infrastructure for future development in conformity with National Perspective Plan including the objectives to achieve the rural water supply, mini-hydropower and fisheries.
- The projects with primary pump and coastal creek system will be implemented only after the year 2001 with an average development rate of 30,000 ha during the succeeding five years.

The implementation program is shown in Table 5.4.7.

(4) Private Irrigation Programs

Under the private irrigation programs, the service area of 600×10^3 ha is proposed. This program shall be implemented with the appropriate coordination between the FMWRRD and the FMANR and will be commenced in 1996 at a development rate of 20,000 to 30,000 ha per year. The project area will be converted to the public irrigation schemes with priority. The implementation program is shown in Table 5.4.8.

5.4.11 Future Overview in Irrigated Agriculture

It may be noted that the irrigation projects can contribute greatly to the increased incomes and agricultural production as compared with the rainfed agriculture. In addition, the irrigation is more reliable and allows for a wider and more diversified choice of cropping patterns as well as high-valued production, in other words, irrigation can help make yield-increasing innovations a more attractive investment proposition, but this does not

guarantee the crop yield increase. As is examined in para.5.3, the overall performance of existing irrigation projects has been disappointing because of poor scheme conception, inadequate construction and implementation, and ineffective management. The mediocre performance of the irrigation sector is also contributing to many socio-economic and environmental problems; however, these problems are neither inherent in the technology nor inevitable as is often argued.

As is stressed in para. 2.6.3 of Chapter 2, Sector Report, the water resources sector in Nigeria is currently in the "Expansionary" phase, and it is anticipated that in line with the NWRMP, the positive implementation of meidum-and small-scale irrigation projects will be carried out; as a result, the water resources sector in many river basins may enter into the "Mature" phase towards the end of NWRMP period, the year 2020, and thereafter. In this future, as high levels of the costly inputs are added to farmland to sustain the yield increases, the security and efficiency of irrigated agriculture will become more important to the farming in Nigeria. Water will no longer be plentiful and cheap, and it will be scarce, expensive to develop and maintain and valuable in use. the high-cost water, however, will be an incentive to use water more efficiently, because the single most important factor limiting the adoption of proven irrigation and drainage technology is the low cost of water. Moreover, if farmers have the opportunities for high-value uses and can make profits, both of the Government and the farmers will invest in irrigation.

This water dilemma to produce more in a sustainable way with less water may point to the need for demand management mechanisms to reallocate existing supplies, encourage more efficient use and promote more equitable access. In future, the competition among agriculture, cities and industry for limited water supplies will constrain the development efforts in Nigeria. Despite the water shortages, the misuse of water will be widespread: small communities and large cities, farmers and industries will also mismanage the water resources. Surface water quality will be deteriorating and groundwater will be polluted with the aquifer overdraft; cities will be unable to provide adequate drinking water and sanitation facilities; waterlogging and salinization will be diminishing the productivity of irrigated lands; the decreased water flows will reduce the hydro potential, pollution assimilation, and fish and wild habitats. At first glance, most of these water problems will not appear to be directly related to the agricultural sector. As the competition,

conflicts, shortages, waste, overuse and degradation of water resources grow, the policy-makers will look increasingly to agriculture as the system's safety valve.

In general, the agriculture is not only the largest water user in terms of volume, it is also a relatively low-value, low-efficiency and highly subsidized water user. These facts may force the Government to rethink the economic, social and environmental implications of large-scale public funded and operated irrigation projects. Once established, the irrigation projects become some of the most heavily subsidized economic activities. Despite these huge investments and subsidies, the irrigation performance indicators are falling short of the expectations for yield increase, area irrigated and technical efficiency in water use. It is usually said that as much as 60 percent of the water diverted is wasted, and this excess water is causing the waterlogging and salinity. Moreover, the stagnant water and poor drainage is escalating the incidence of water-related diseases. In future, the agriculture will often be unable to compete economically for the scarce water. The urban cities and industries can afford to pay more for water and earn a higher economic rate of return from a unit of water than does agriculture. Under this circumstance, the agriculture will be obliged to give up water for the conversion of high-value uses in the urban and industry sectors. In this occasion, the irrigators in some areas will be asked to pay for the water they receive including the full cost of water delivery and payment for polluting the water resources.

The irony is that the irrigated agriculture is expected to produce much more for the food security in future while using less water than it uses as it is, in other words, encouraging the innovations in water-saving technology. In the water resources sector, various demand-side policy measures can help shape the decisions that encourage the water-use efficiency; however, while appropriate policies and regulations are necessary for the improved water productivity, a variety of additional water-saving measures are required in the irrigation sector, an essential component of the sustainable agricultural development. Some water-saving measures involve taking more advantage of the scientific, engineering and technological advances in soils, plants and irrigation practices, as is examined in para. 5.4.5 of this Chapter. Other measures focus on administrative and managerial reforms to improve efficiency, including the decentralization of public irrigation agencies and a

greater reliance on the farmer-owned and-operated irrigation, both of which are examined in para.12.2 of Chapter 12 of the Sector Report.

Para. 2.6.3 of Chapter 2 of the Sector Report indicates that the current emphasis on macroeconomic policy reforms and economic liberalization in Nigeria would have several important implications for the irrigation sector. One of the most important is that the era of large direct and indirect subsidies will be nearly over, and moreover, the recognition of the value of water and the high cost of turning of a water source works into a service delivered to a farm will make the water sector a prime target for further policy reforms; nevertheless, the irrigation sector will remain a resource-hungry one in this transitional period, and the irrigation to be successful will consume large quantities of the capital and foreign exchange and tie up the scarce skilled personnel.

Like many of the public sector personnel, the irrigation managers should take a fine line between the tighter control of finance, the need for more positive and active leadership and the better planning of resources allocations, on the one side, and the contradictory need for more ideas from participating farmers, on the other. While the financial pressures are likely to be the dominant influence, the irrigation sector as a public agency will still rely upon the budget allocations to obtain the financing for project implementation. As the private sector disciplines may be applied in the irrigation sector, the policy-makers will find that: (1) the agencies become more supportive of the farmers' own efforts and less inclined to make all key decisions before informing the farmers or their groups accordingly; (2) the management seeks more consensus or priorities, more information about the basis of decisions and a common view of external factors affecting management; (3) the irrigation schemes seek and receive more autonomy; (4) the financial responsibility and accountability of irrigation managers increase; and (5) the managers shift focus from their government depending upon the amount of finance generated by irrigation service fees.

Following are some of the issues to emerge in the "Mature" phase:

- The national water resources politics will be shifting from "Projects" to "Policies", and this trend is likely to continue and even accelerate.

- Water may become a test-bed for the economic reform, liberalization and accountability.

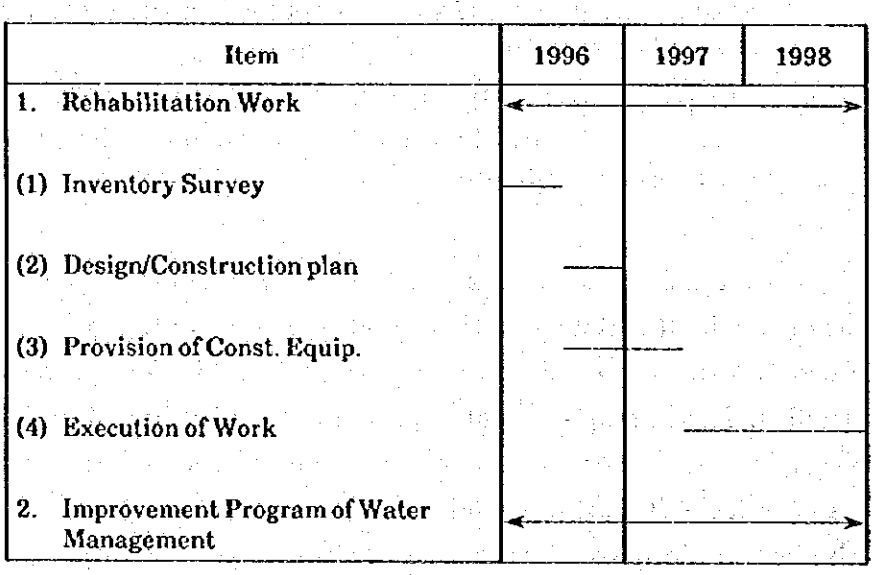
- Given the water scarcity and its value to urban societies and industries, the water resources sector will be less dominated by irrigation, and its multipurpose use will be more widely acknowledged.
- Irrigation is a service with users; it is not a production industry.
- At the level of the irrigation scheme, the process of water policy formulation, assessment and appraisal needs to include more open groups that are the representatives of political, technical, managerial and most importantly water users associations.
- These policy groups will be consulted before the policy selection and then provide the feedback and adjustment in the light of their experience.
- The policy groups will identify the options consistent with the national policy framework, as opposed to the measures to protect and satisfy special irrigation interests.
- The goal is to identify a broader range of the water policy options, to have less "policy by crisis" management and more resilience in the face of outside pressures.

In conclusion, the irrigation that is an essential component of the sustainable agricultural development and faces the challenges confronting the public and private sector economic activities will allow for the better and more diversified choices in cropping patterns and the cultivation of high-value crops. Successful irrigation is a crucial determinant of the future development in Nigeria because of its influence on the supply and price of food. As the debate over the water policies sharpens, it is increasingly important that the agricultural policy-makers help shape the nature of the debate and influence the policy decisions.

5. 5 NATIONAL WATER MASTER ACTION PLAN TOWARDS THE YEAR 2000

5. 5. 1 Preparation and Implementation of BMR Program for Existing Public Sector Systems

The water management in existing canal system is not well operated due to the defective facilities and poor institutional arrangement of public agencies and farmers. The rehabilitation works including inventory work of existing canal facilities, preparation of detailed design and construction plan, provision of construction equipment and the implementation will be achieved by the year 1998. On the other hand, the improvement program of water management in canal system including that at on-farm level shall be progressed with a sufficient coordination between the FMWRRD and the FMANR. Work schedule for the above study is as follows:



5. 5. 2 Implementation of On-going Public Sector Projects

(1) Implementation Method

The service area of on-going public sector projects reach 250,000 ha. Out of which, medium and small scale projects with a service area of less than 3,000 ha cover 90,000 ha. These projects shall be implemented urgently after

completing the detailed design. The remaining 160,000 ha belonging to large scale project such as Middle Rima Valley, Zauro Polder, Ilushi, Middle Ogun, Lower Ogun, KRP II, Gari, etc. shall be progressed into the detailed design stage after completion of their feasibility studies.

(2) Work Schedule

Work schedule for the study and implementation of above projects will be as follows:

Item	1996	1997	1998	1999	2000	2001~05	Service Area (ha)
1. Medium/Small-scale Project							90,000
Detail Design							
Construction							
2. Large-scale Project							
a) With Pump/others							
Feasibility Study							60,000
Detailed Design							
Tendering							
Construction							
b) With Dam							
Feasibility Study							100,000
Detailed Design							
Tendering							
Construction							

5. 5. 3 Preparation of Public Sector Projects

(1) Preparation Method

The medium and small scale irrigation package program with reservoir dam, diversion dam and pumping station as a water source facility will be prepared by the year 2000 aiming to implement the program after the year 2000. One model river basin with priority for the preparation of the program will be firstly selected by each RBDA, although the JICA Team

proposes tentatively selected basin at each RBDA, such as Danzaki, Gbako Awun, Kilange, Katsina-Ala, Mamu, Upper Ogun, Osse and Aya basins as described in para. 4.4.4 of this Sector Report. The preparation work of the program after selection of the model basin will be carried out by recruiting the consultants.

(a) Pre-Feasibility Study

The pre-feasibility study for the basin with a catchment area of about 10,000 sq.km will be made for the following purpose prior to the feasibility study:

- Analysis of the potential surface water resources.
- Identification of a number of the proposed water source facilities and summarization of their outline.
- Study of the potential water resources and the available water to be developed by the proposed water source facilities.
- Study of potential irrigation projects and summarization of their outline.
- Selection of the representative irrigation projects with different scale for the consecutive feasibility study.
- Formulation of survey and study items for the feasibility study.

(b) Feasibility Study

The feasibility study of representative projects selected through the pre-feasibility study will be carried out. The representative projects will be composed of three to five projects with the service area of medium and small scale, less than 3,000 ha. The study will be made with the international feasibility level including hydrological analysis, water source facility plan, preliminary design, cost estimation, environment impact assessment, project evaluation, etc.

(c) Formulation of Package Program

In accordance with the feasibility study result, the package program is formulated with the following manner;

- Outline of all potential irrigation projects identified in pre-feasibility study will be reviewed based on the data of the feasibility study for the representative projects.
- Irrigation projects to be implemented with priority are selected based on the above reviewing result and taking into account the project and budget size, project economy, urgency of each sub-project, etc.
- Package program will be implemented with budget scale of 600 to 800 million Naira, which will cover the medium and small scale projects of 10 to 15 units and irrigation area of 8,000 to 10,000 ha in total.
- Package program will be classified and sub-divided into the sub-package program consisting of three to five projects. The implementation period of the sub-package program will need three years.

(2) Work Schedule for the Study

Work schedule for the study of the package program are given below:

Item	1996	1997	1998	1999	2000
1. Study of Model Basin with Priority	←	—	—	→	
(1) Pre-Feasibility Study	—				
Data collection and review	—				
Site Survey	—	—			
Analysis and Study					
(2) Feasibility Study		—			
Topo-Survey		—			
Soil survey		—			
Socio-economic survey					
Analysis and study		—	—		
(3) Preparation of Implementation				—	
2. Additional Basin Study			←	—	- -

5. 5. 4 Preparation and Implementation of NFDP Expansion

The expansion of NFDP will be made to the existing rainfed area in the wetlands. The FMANR has a responsibility for the development of this private sector program and will carried out the following preparation for the expansion with a campaign for irrigated agriculture to stimulate farmers participation to the program:

(1) Hydrological and Hydro-geological Survey in the Proposed Area

- Maximum water level of related river and continuous inundation period
- Fluctuation of groundwater level and yield of groundwater

(2) Standardization of Project Facilities

- Intake facilities, distribution canal and on-farm facilities
- Tubewell and pump

(3) Guidance to related Farmers

- Operation method of project facilities
- Establishment of Fadama Users Association (FUA)

The implementation of the program will commence at the beginning of the year 1996 since above preparation may be set up previously by the FMANR, and will continue by the year 2020 with a development rate of 20,000 to 30,000 ha per annum.

5. 5. 5 Guideline for Irrigation Planning and OM of Public Sector Projects

The rehabilitation works under OM office and planning of the proposed irrigation package program will be mainly carried out by the year 2000. In order to carry out the above study and works smoothly and properly, the guideline is prepared as shown in Appendix 5.2 and 5.3.

It is necessary that the NWRI in Kaduna shall emphasize to formulate the more detailed guideline for the planning and design and to level up the irrigation engineering through staff training. It is also needed to request the foreign technical aid to fulfill the above work in the NWRI.

5. 5. 6 Implementation Program

The implementation program for the study and works by the year 2000 is summarized in the chart given below:

Item	1996	1997	1998	1999	2000	2001~05
1. Rehabilitation Works						
2. Implementation of On-going Public Sector Projects						
(1) Medium/Small Scale Pro.						
(2) Large-scale Pro. with Pump						
(3) Large-scale Pro. with Dam						
3. Preparation of Public Sector Program						
(1) Model Package Program						
(2) Second Package Program						
4. Preparation and Implementation of NFDP Expansion						

Medium / Small scale irrigation project shall be referred in para.4.5.2 of Chapter 4.

5. 5. 7 Priority Programs for Consideration by External Agencies

Careful consideration has been made for the needs and categories to be assisted by the external agencies, and the priority has been given to two programs on the technical cooperation basis which should be implemented at an early period of the National Water Master Action Plan period by 2000. Provisional Terms of Reference on two programs are given below:

(1) Water Resources Management Program in the Upper Hadejia

Ref. para. 2.3.2 (2) (a), of Chapter 2, and 3.2.2 (2) (b) & 3.3.2(1) of Chapter 3 of this Sector Report.

(2) Preparation of Medium / Small Dams Package Programs

Ref. para.: (3) of 3.2.2 of Chapter 3 of this Sector Report.

TABLE 5.1.1 PLANNED IRRIGATION AREA EVALUATED BY JICA IN EXISTING PUBLIC PROJECTS

Hydrological Area (HA)	Water Works	Number of Project	Planned Irrigation Area		Actual Irrigated Area	
			Collected Data in NWRIS (ha)	Evaluated Area by JICA	Area (ha)	Achievement Ratio
I	Dam	10	58,900	52,000	6,000	12
	Pump/Others	9	7,000	8,000	2,000	25
	Subtotal	19	65,900	60,000	8,000	13
II	Dam	13	26,300	23,000	2,000	9
	Pump/Others	26	31,300	32,000	10,000	31
	Subtotal	39	57,600	55,000	12,000	22
III	Dam	6	56,700	19,000	8,000	42
	Pump/Others	7	6,600	6,000	2,000	33
	Subtotal	13	63,300	25,000	10,000	40
IV	Dam	4	4,100	4,000	0	0
	Pump/Others	13	10,700	11,000	2,000	18
	Subtotal	17	14,800	15,000	2,000	13
V	Dam	1	300	0	0	–
	Pump/Others	15	19,900	20,000	5,000	25
	Subtotal	16	20,200	20,000	5,000	25
VI	Dam	11	35,400	38,000	1,000	3
	Pump/Others	13	11,000	7,000	2,000	29
	Subtotal	24	16,400	45,000	3,000	7
VII	Dam	3	2,500	2,000	0	0
	Pump/Others	16	7,300	8,000	3,000	38
	Subtotal	19	9,800	10,000	3,000	30
VIII	Dam	18	92,000	58,000	16,000	28
	Pump/Others	17	98,000	32,000	11,000	34
	Subtotal	35	190,000	90,000	27,000	30
Total	Dam	66	276,200	196,000	33,000	17
	Pump/Others	116	191,800	124,000	37,000	30
	Subtotal	182	468,000	320,000	70,000	22

TABLE 5.1.2 EVALUATION OF IRRIGATION AREA IN EXISTING MAJOR PUBLIC PROJECTS

HA	Project	Water Source Facility	Available Reservoir Water (MCM)	Unit Water Demand (m^3/ha)	Irrigation Area		
					Agency Planned (ha)	JICA Estimated (ha)	JICA Evaluated (ha)
HA-I	Jibiya	Jibiya Dam	37	9,600	3,500	3,900	3,000
	Zobe	Zobe Dam	50	9,600	8,200	5,200	5,200
	Bakolori	Bakolori Dam	227	9,600	23,000	23,600	23,000
	Middle Rima Valley						
	Wurno/Zauro Polder	Goronyo Dam	170	9,600	17,000	17,700	17,700
	Swashi Valley	Kubuli Dam	42	9,600	2,700	4,400	2,700
HA-II	Kontagora	Kontagora Dam	141	11,400	11,200	12,400	12,400
	Guzan	Guzan Dam	10	11,400	1,500	900	900
	Kpada	Kpada Dam	8	11,400	1,500	700	700
	Kangimi	Kangimi Dam	22	11,400	1,600	1,900	1,900
	Tungan Kawo	Tungan Kawo Dam	13	11,400	800	1,100	800
HA-III	Savannah	Kiri Dam	182	13,400	12,000	13,600	9,600
	Dadin Kowa	Dadin Kowa Dam	900	13,400	38,000	67,200	4,000
	Balanga	Balanga Dam	38	13,400	4,000	2,800	2,800
HA-IV	Doma	Doma Dam	12	11,600	2,000	1,000	1,000
HA-VI	Middle Ogun	Ikere Gorge Dam	300	14,600	12,000	20,500	12,000
	Lower Ogun	Oyan Dam	175	14,600	12,000	12,000	12,000
	Sepeteri	Sepeteri Dam	51	14,600	400	400	400
HA-VII	Gari	Gari Dam	40	9,600	4,100	4,200	4,200
	Tomas	Tomas Dam	22	9,600	1,100	2,300	2,300
	Jakara	Jakara Dam	19	9,600	2,000	2,000	2,000
	Challawa	Challawa Dam	120	9,600	12,500	12,500	12,500
	Watari	Watari Dam	18	9,600	1,700	1,900	1,900
	Tiga	Tiga Dam	250	9,600	40,000	26,000	26,000
	Galala	Galala Dam	14	9,600	2,500	1,500	1,500
	Baga	Pump	–	–	20,000	–	1,000
	South Chad	Pump	–	–	67,000	–	22,000

TABLE 5.1.3 DISTRIBUTION OF EXISTING IRRIGATION PROJECTS

Hydrological Area (HA)	Large Project				Medium/Small Project				Total				Achievement Ratio ③/① (%)
	No.	Irrigation Area (1,000 ha)			No.	Irrigation Area (1,000 ha)			No.	Irrigation Area (1,000 ha)			
		P.A.	D.A.	I.A.		P.A.	D.A.	I.A.		①P.A.	②D.A.	③I.A.	
I	9	56	9	7	10	4	1	1	19	60	10	8	13
II	16	46	10	9	23	9	4	3	39	55	14	12	22
III	7	23	10	9	6	2	1	1	13	25	11	10	40
IV	7	12	5	1	10	3	1	1	17	15	6	2	13
V	7	18	5	4	9	2	1	1	16	20	6	5	25
VI	11	40	2	2	13	5	1	1	24	45	3	3	7
VII	3	5	1	1	16	5	2	2	19	10	3	3	30
VIII	15	80	40	25	20	10	4	2	35	90	44	27	30
Total	75	280	82	58	107	40	15	12	182	320	97	70	22

Remarks:
1) P.A. : Planned Area (planned net irrigation area)
2) D.A. : Developed Area (area with completed irrigation canal system)
3) I.A. : Actual Irrigated Area (area carrying out irrigated agriculture)

TABLE 5.1.4 EXISTING AND PROPOSED PRIVATE SECTOR PROGRAMS IDENTIFIED BY FACU

	State	Potential Irrigable Wetland (ha)	Existing Area (ha)				Proposed Area in NFDP (ha)						Remarks
			D.P.	D.W.&C.F.	T.W.&W.B.	Total	Phase I	Phase II				Total	
							T.W.&W.B.	D.P.	D.W.&C.F.	T.W.&W.B.	Sub-Total		
NW	Sokoto	} 180,000	9,000	700	11,300	21,000	5,000	6,500	1,000		7,500	12,500	- D.P. : Direct pumping
〃	Kebbi		4,400	–	4,500	8,900	7,000	8,000	2,000		10,000	17,000	- D.W.&C.F. : Diversion
〃	Katsina	20,500	1,600	1,600	1,800	5,000	600	2,000		1,200	3,200	3,800	works & controlled flooding
NE	Kano	53,000	28,500	–	2,000	30,500	6,500	12,500	1,000		13,500	20,000	- T.W.&W.B. : Tubewell &
〃	Jigawa	79,000	26,000	3,200	4,000	33,200	3,500	9,000	3,500		12,500	21,000	washbore
〃	Yobe	125,000	–	–	2,000	2,000	1,700	2,200	100	6,000	8,300	10,000	- Phase I : 1993-1996
〃	Borno	125,000	–	–	2,200	2,200	1,600	2,200	100	6,000	8,300	9,900	- Phase II : 1995-1998
〃	Bauchi	181,000	24,300	–	9,500	33,800	15,000	16,500	1,000		17,500	32,500	
CW	Niger	200,000	400	5,600	–	6,000	0	1,000	–	1,500	2,500	2,500	Data Source : FACU
〃	Kwara	230,400	100	–	70	170	0	1,500	–	1,000	2,500	2,500	
〃	Kaduna	75,000	–	–	2,500	2,500	1,200	3,200	200	1,700	5,100	6,300	
〃	Kogi	150,000	1,000	–	–	1,000	0	550	150	1,800	2,500	2,500	
〃	Abuja	19,900	–	–	–	–	1,000	2,500	–	1,000	3,500	4,500	
CE	Adamawa	350,000	–	–	–	–	0	550	–	1,950	2,500	2,500	
〃	Taraba	360,000	–	–	–	–	0	550	–	1,950	2,500	2,500	
〃	Plateau	66,500	–	–	3,000	3,000	1,300	2,500	–	2,500	5,000	6,300	
〃	Benue	57,000	–	–	–	–	600	1,550	–	950	2,500	3,100	
SW	Oyo	26,800	–	–	–	–	0	300	–	450	750	750	
〃	Ogun	N.A.	–	–	–		0	300	–	450	750	750	
〃	Oshun	25,900	–	–	–	–	0	300	–	450	750	750	
〃	Lagos	N.A.	–	–	–	–	0	100	–	450	550	550	
〃	Ondo	18,500	–	–	–	–	0	300	–	450	750	750	
〃	Edo	74,000	–	–	–	–	0	300	–	450	750	750	
〃	Delta	100,000	–	–	–		0	300	–	450	750	750	
SE	Anambra	55,000	–	1,300	–	1,300	0	300	–	450	750	750	
〃	Imo	40,000	–	1,300	–	1,300	0	300	–	450	750	750	
〃	Rivers	10,000	–	–	–	–	0	200	–	350	550	550	
〃	Enugu	12,200	–	900	–	900	0	300	–	450	750	750	
〃	Abia	N.A.	–	600	–	600	0	300	–	450	750	750	
〃	Akwa Ibom	N.A.	–	–	–	–	0	100	–	900	1,000	1,000	
〃	Cross River	55,000	–	200	–	200	0	200	–	350	550	550	
	Total	2,689,700	95,300	15,400	42,870	(153,570)	50,000	76,400	9,050	34,100	119,550	169,550	

TABLE 5.2.1 DIVERSION WATER REQUIREMENT OF IRRIGATION PROJECT

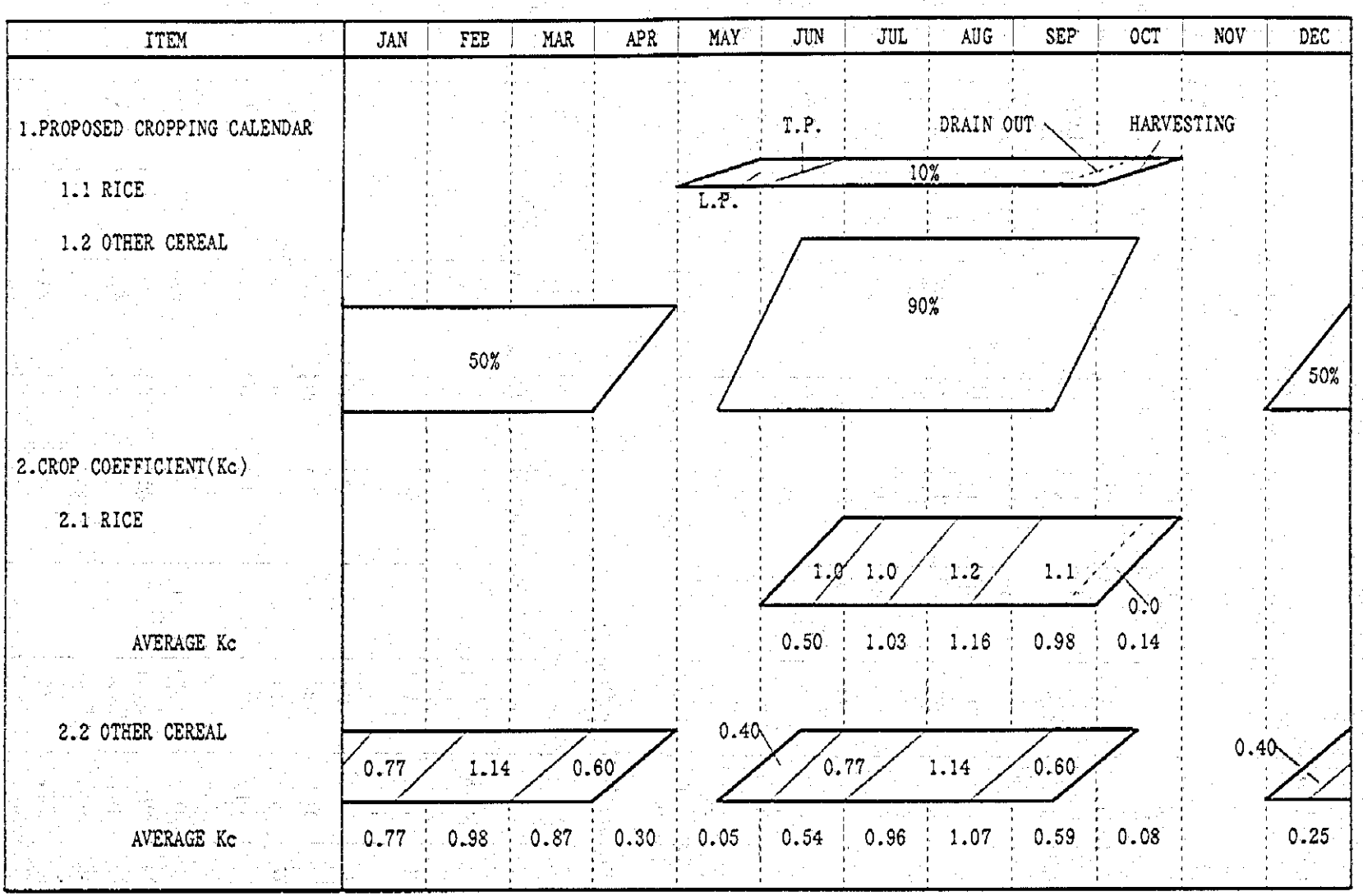
a) Public Irrigation Projects

HA	Season	Net Irri. Water Requirement (mm)		Crop Intensity (%)		Seasonal Net Irri. Water Req. (mm)	Diversion Water Requirement		
		Rice	Other Cereal	Rice	Other Cereal		Wet (mm)	Dry (mm)	Total (mm)
I	Wet	664	116	10	90	170			
	Dry	–	610	0	50	310	340	620	960
II	Wet	141	0	30	70	40			
	Dry	913	540	25	55	530	80	1,060	1,140
III	Wet	225	13	30	70	80			
	Dry	1,002	614	25	55	590	160	1,180	1,340
IV	Wet	140	19	30	70	60			
	Dry	909	529	25	55	520	120	1,040	1,160
V	Wet	50	0	90	10	50			
	Dry	852	464	70	10	640	100	1,280	1,380
VI	Wet	151	0	90	10	140			
	Dry	786	422	70	10	590	280	1,180	1,460
VII	Wet	26	0	90	10	20			
	Dry	853	471	70	10	640	40	1,280	1,320
VIII	Wet	683	137	10	90	190			
	Dry	–	587	0	50	290	380	580	960

b) Private Irrigation Projects

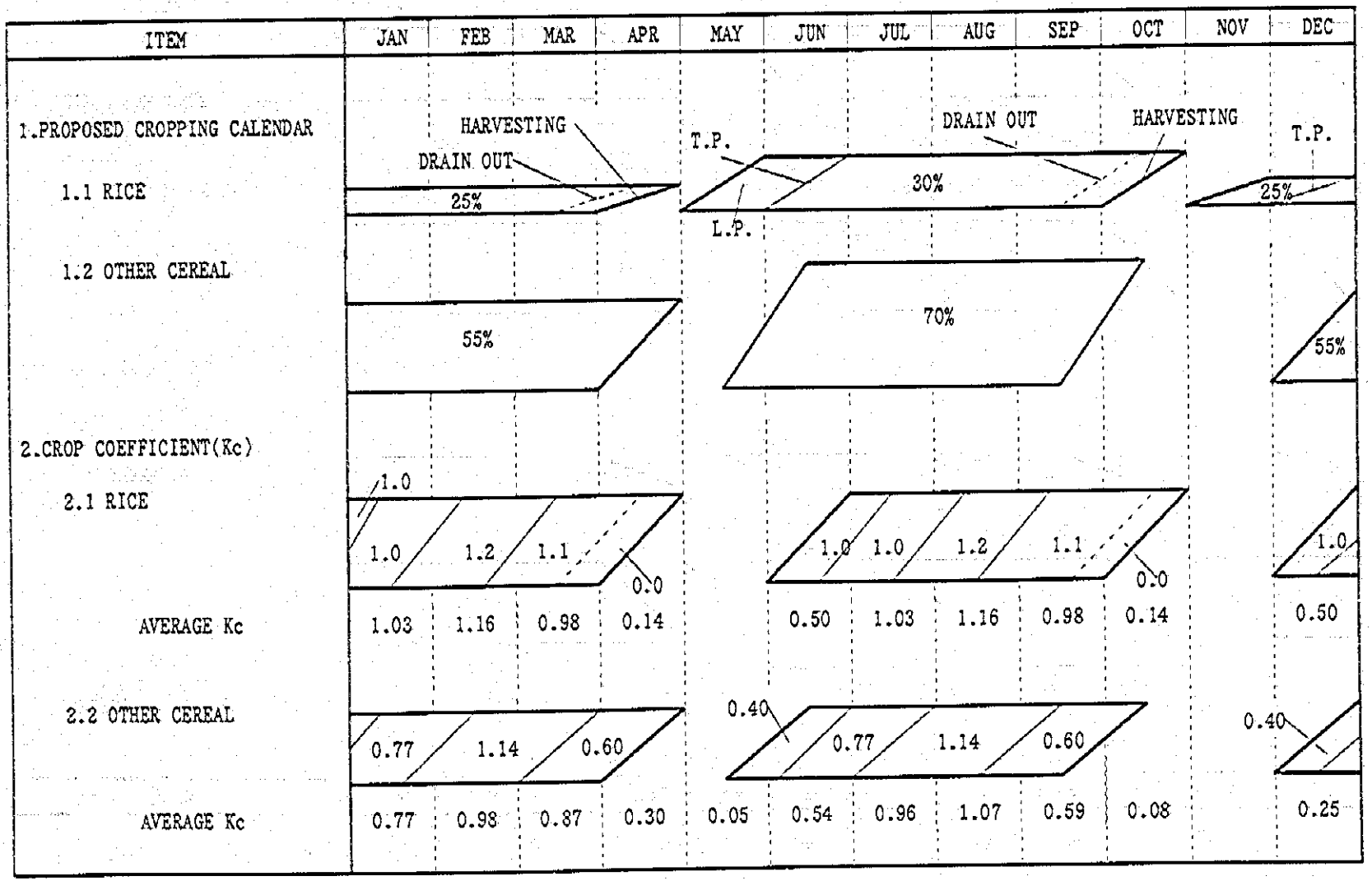
HA	Season	Net Irri. Water Requirement (mm)		Crop Intensity (%)		Seasonal Net Irri. Water Req. (mm)	Diversion Water Requirement		
		Rice	Other Cereal	Rice	Other Cereal		Wet (mm)	Dry (mm)	Total (mm)
I	Wet	664	116	10	70	150			
	Dry	–	610	0	50	310	300	620	920
II	Wet	141	0	80	0	110			
	Dry	913	540	0	50	270	220	540	760
III	Wet	225	13	80	0	180			
	Dry	1,002	614	0	50	310	360	620	980
IV	Wet	140	19	80	0	110			
	Dry	909	529	0	50	260	220	520	740
V	Wet	50	0	80	0	40			
	Dry	852	464	0	50	230	80	460	540
VI	Wet	151	0	80	0	120			
	Dry	786	422	0	50	210	240	420	660
VII	Wet	26	0	80	0	20			
	Dry	853	471	0	50	240	40	480	520
VIII	Wet	683	137	10	70	160			
	Dry	–	587	0	50	290	320	580	900

FIGURE 5.2.1 (1) PROPOSED CROPPING CALENDAR AND RELEVANT FACTORS IN PUBLIC IRRIGATION PROJECTS (HA-I & VIII)



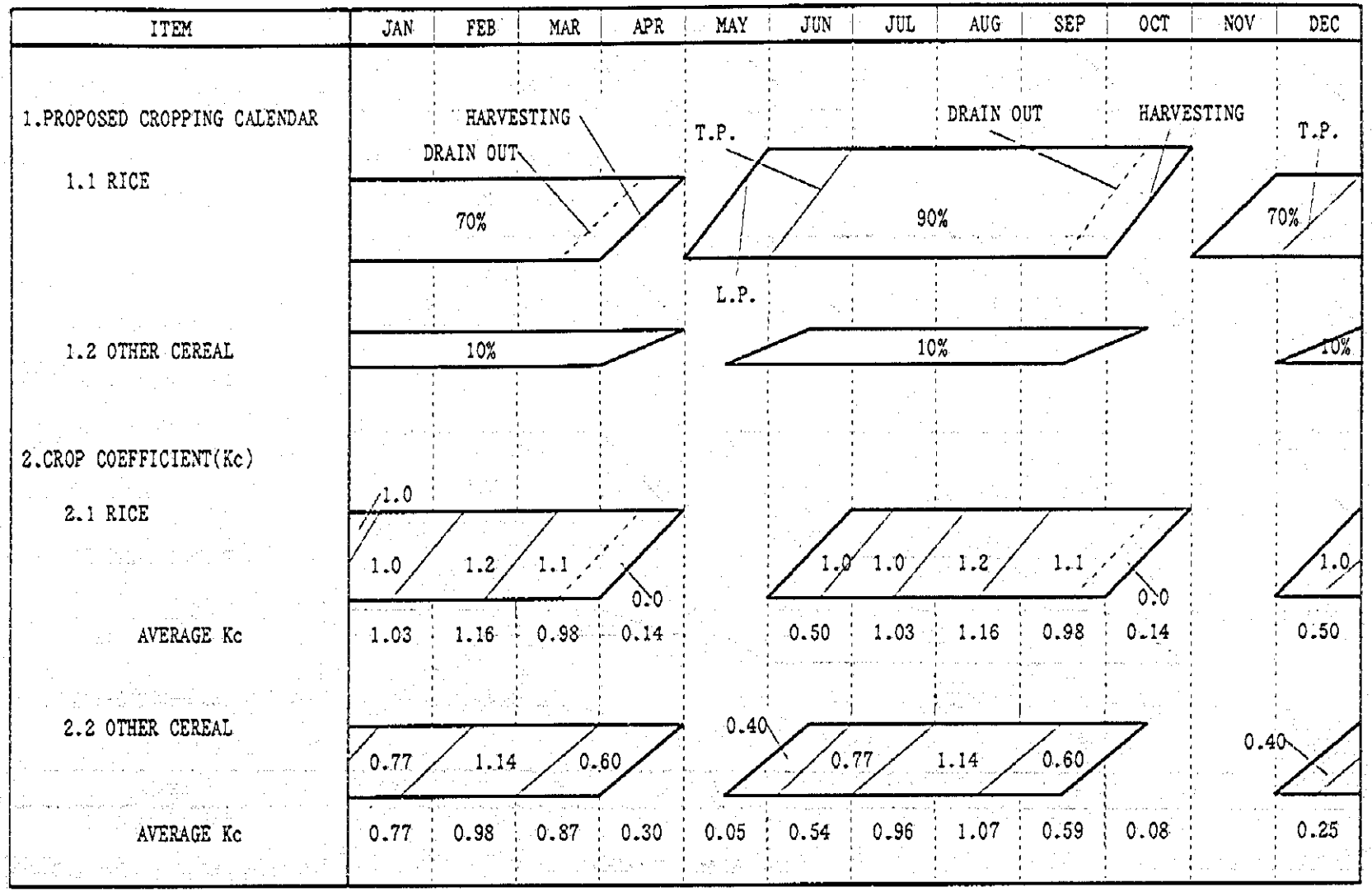
REMARKS : L.P.=LAND PREPARATION
T.P.=TRANCE PLANTING

FIGURE 5.2.1 (2) PROPOSED CROPPING CALENDAR AND RELEVANT FACTORS IN PUBLIC IRRIGATION PROJECTS (HA-II, III & IV)



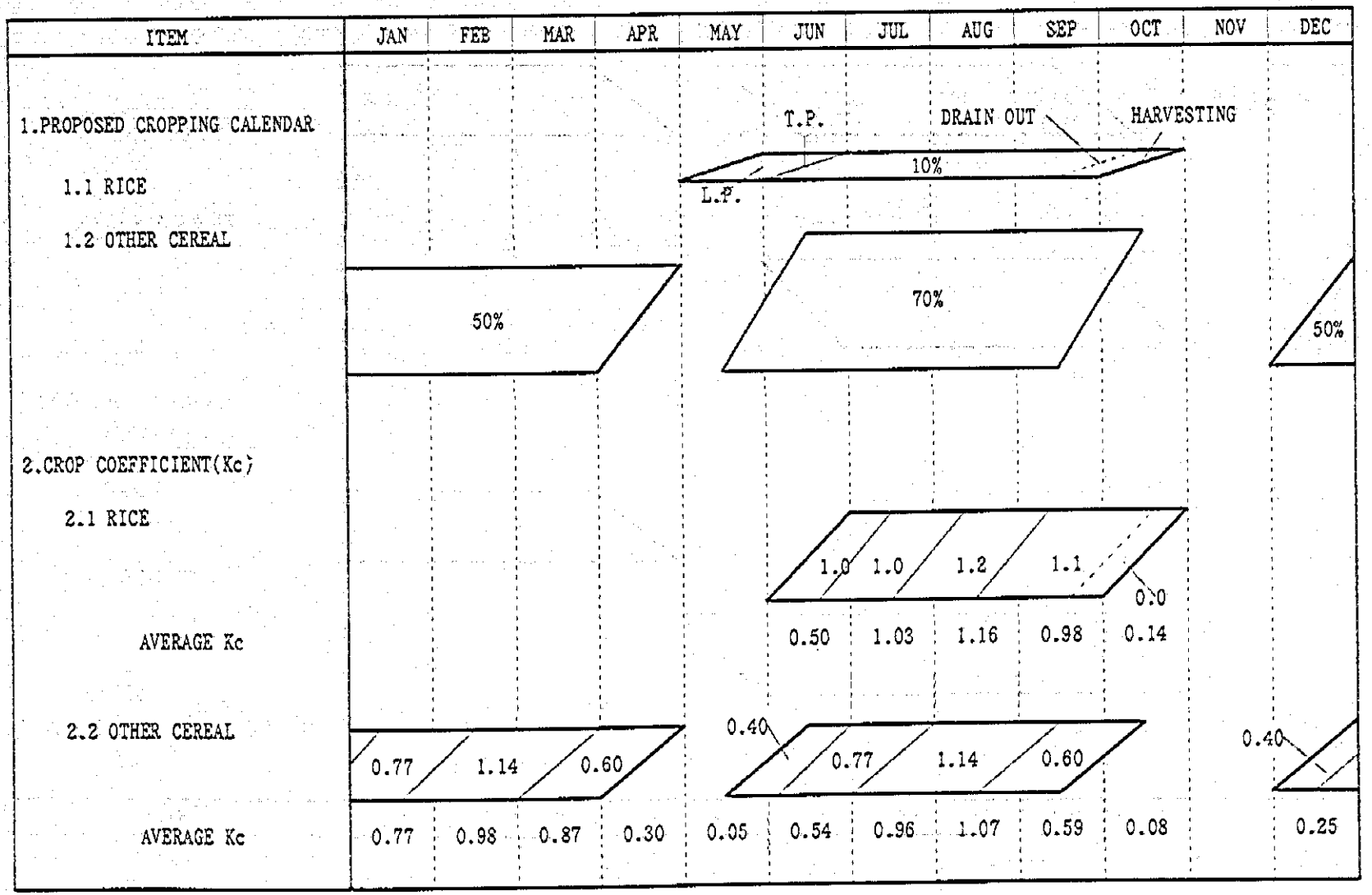
REMARKS : L.P.=LAND PREPARATION
T.P.=TRANCE PLANTING

FIGURE 5.2.1 (3) PROPOSED CROPPING CALENDAR AND RELEVANT FACTORS IN PUBLIC IRRIGATION PROJECTS (HA-V, VI & VII)



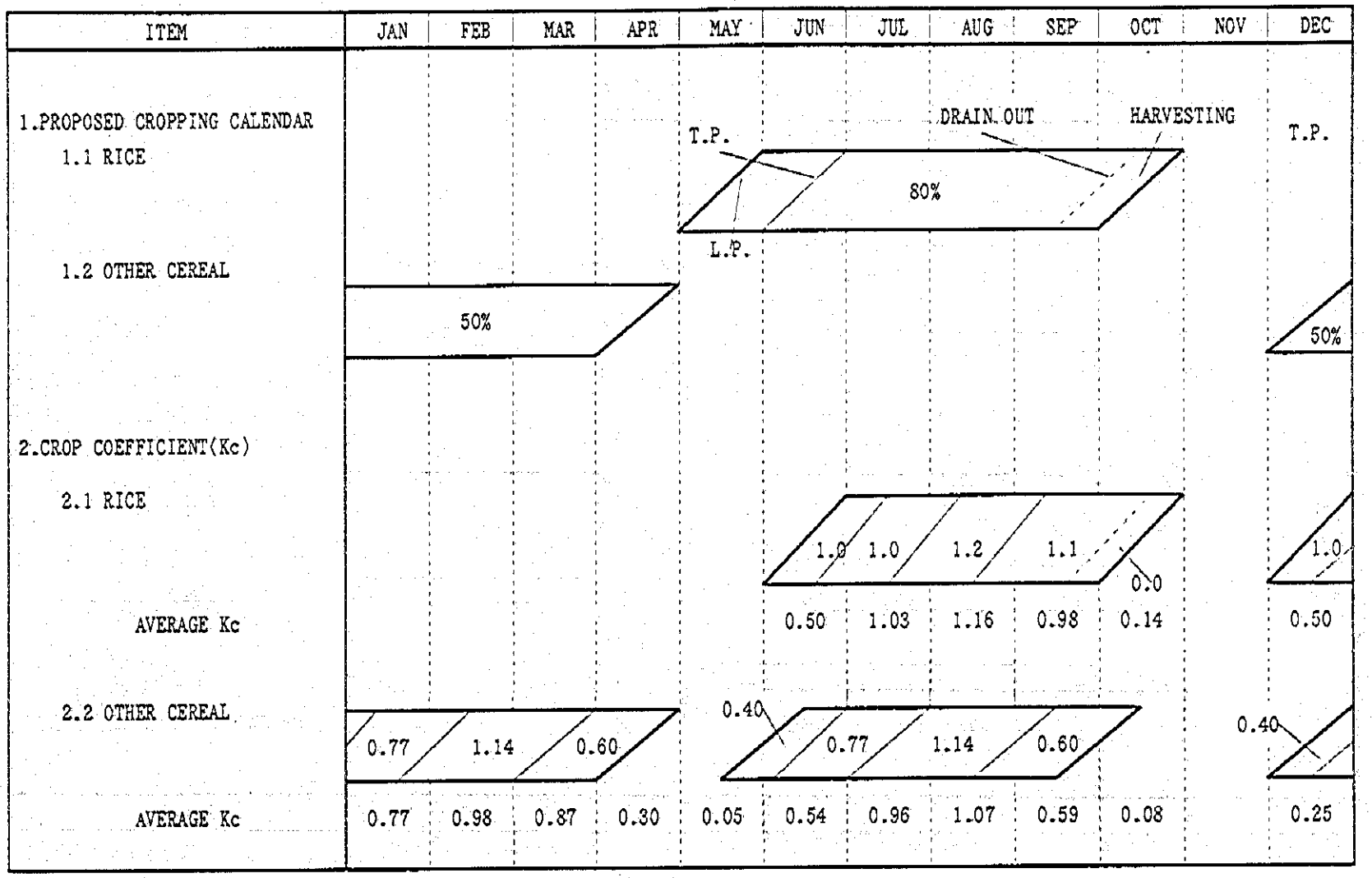
REMARKS : L.P.=LAND PREPARATION
T.P.=TRANCE PLANTING

FIGURE 5.2.2(1) PROPOSED CROPPING CALENDAR AND RELEVANT FACTORS IN PUBLIC IRRIGATION PROJECTS (HA-I & VIII)



REMARKS : L.P.=LAND PREPARATION
T.P.=TRANCE PLANTING

FIGURE 5.2.2(2) PROPOSED CROPPING CALENDAR AND RELEVANT FACTORS IN PUBLIC IRRIGATION PROJECTS (HA-III, IV, V, VI & VII)



REMARKS : L.P.=LAND PREPARATION
T.P.=TRANCE PLANTING

TABLE 5.2.2 (1) IRRIGATION DEMAND OF EXISTING PUBLIC IRRIGATION PROJECTS

HA	Annual Unit Water Rep. (m^3/ha)	Facilities Completed		On-going		Total	
		Area (1,000 ha)	Demand (MCM)	Area (1,000 ha)	Demand (MCM)	Area (1,000 ha)	Demand (MCM)
I	9,600	8	80	52	500	60	580
II	11,400	12	140	43	490	55	630
III	13,400	10	130	15	210	25	340
IV	11,600	2	20	13	150	15	170
V	13,800	5	70	15	210	20	280
VI	14,600	3	40	42	620	45	660
VII	13,200	3	40	7	90	10	130
VIII	9,600	27	260	63	600	90	860
Total	–	70	780	250	2,870	320	3,650
%	–	22	21	78	79	100	100

TABLE 5.2.2 (2) IRRIGATION DEMAND OF EXISTING PRIVATE IRRIGATION PROJECTS

HA	Annual Unit Water Rep. (m^3/ha)	Existing	
		Area (1,000 ha)	Demand (MCM)
I	9,200	35	320
II	7,600	10	70
III	9,800	0	0
IV	7,400	3	20
V	5,400	1	10
VI	6,600	0	0
VII	5,200	3	10
VIII	9,000	98	880
Total	–	150	1,310

TABLE 5.2.3 IRRIGATION DEMAND OF EXISTING IRRIGATION PROJECTS

HA	Public Sector		Private Sector		Total	
	Area (1,000 ha)	Demand (MCM)	Area (1,000 ha)	Demand (MCM)	Area (1,000 ha)	Demand (MCM)
I	60	580	35	320	95	900
II	55	630	10	70	65	700
III	25	340	0	0	25	340
IV	15	170	3	20	18	190
V	20	280	1	10	21	290
VI	45	660	0	0	45	660
VII	10	130	30	10	40	140
VIII	90	860	98	880	188	1,740
Total	320	3,650	150	1,310	470	4,960

TABLE 5.3.1 CAPITAL COST OF MAJOR EXISTING PUBLIC IRRIGATION PROJECTS

Project	Irrigation Area (ha)	Water Source Works	Mode of Irrigation	Project Cost ($/ha)	Evaluated Term
Bakolori	23,000	Dam	Gravity (8,000ha) and Sprinklers (15,000ha)	24,500	1990
KRPI	14,000	Dam	Gravity	12,200	1990
Balanga	1,800	Dam	Gravity	3,700	1990
Kontagola	11,000	Dam	Piped Network	6,200	1988
LAIP	3,850	Pump	Primary pumping with gravity	8,500	1987

Data Source; Irrigation Sub-Sector Review, FAO/WP-CP, 1992

TABLE 5.4.1 NUMBER AND AREA OF PROPOSED PUBLIC IRRIGATION PROGRAM

Proposed Projects	Unit	Hydrological Area (HA)								
		I	II	III	IV	V	VI	VII	VIII	Total
1. Number of Projects										
1.1 Under Dam										
Large/Medium Dam		15	75	40	50	10	40	30	0	260
Small Dam		50	230	110	160	35	100	115	20	820
Sub-Total		65	305	150	210	45	140	145	20	1,080
1.2 Under Pump and Others										
Primary Pump		15	35	15	35	50	35	100	0	285
Coastal Creek		–	–	–	–	35	–	–	–	35
Sub-Total		15	35	15	35	85	35	100	0	320
1.3 Total		80	340	165	245	130	175	245	20	1,400
2. Service Area										
2.1 Under Dam										
Large/Medium Dam	1000 ha	40	170	100	70	15	30	35	0	460
Small Dam	1000 ha	15	70	30	50	10	30	35	5	245
Sub-Total	1000 ha	55	240	130	120	25	60	70	5	705
2.2 Under Pump and Others										
Primary Pump	1000 ha	5	10	5	10	15	10	30	0	85
Coastal Creek	1000 ha	–	–	–	–	10	–	–	–	10
Sub-Total	1000 ha	5	10	5	10	25	10	30	0	95
2.3 Total	1000 ha	60	250	135	130	50	70	100	5	800

TABLE 5.4.2 IRRIGATION AREA UNDER PROPOSED MEDIUM AND SMALL DAMS PROJECTS

	Hydrological Area (HA)								
	I	II	III	IV	V	VI	VII	VIII	Total
1. Available Water for Irrigation (MCM)									
Large/Medium Dam	430	1,930	1,310	800	200	500	470	0	5,640
Small Dam	135	830	395	575	140	405	465	55	3,000
2. Unit Irrigation Requirement (10^3 m^3/ha)									
	9.6	11.4	13.4	11.6	13.8	14.6	13.2	9.6	–
3. Proposed Irrigation Area (10^3 ha)									
Large/Medium Dam	40	170	100	70	15	30	35	0	460
Small Dam	15	70	30	50	10	30	35	5	245
Total	55	240	130	120	25	60	70	5	705
4. Number of Project									
Large/Medium Dam	15	75	40	50	10	40	30	0	260
Small Dam	50	230	110	160	35	100	115	20	820
Total	65	305	150	210	45	140	145	20	1,080

TABLE 5.4.3 MAJOR BASINS TO BE DEVELOPED IN PROPOSED IRRIGATION PROJECTS WITH DAMS

Region	Major Basin/Area to be developed	Remarks
North West	Gulbin Ka, Danzaki and Malendo	Southern river basins
North East	Yedesaram	Southern river basins
Central West	Oshun, Awun and Gbako, Karami and Galma	Tributaries of Niger and Kaduna rivers
Central East	Mayo Ine, Belwa, Kilange, Hawal, Mada, Shemankar, Ankwe and Katsina-Ala	Tributaries of Benue river
South West	Ogun and Oshun	Upper basins of both rivers
South East	Aboine and Aya	Tributaries of Cross river

TABLE 5.4.4 PROJECT COST FOR PUBLIC IRRIGATION PROJECTS

Water Source Facility	Unit	Hydrological Area (HA)								
		I	II	III	IV	V	VI	VII	VIII	Total
1 Service Area										
1.1 Existing Project										
(1) Completed	1000 ha	8	12	10	2	5	3	3	27	70
(2) On-going										
Under Pump and Others	1000 ha	6	22	4	9	15	5	5	21	87
Under Dam	1000 ha	46	21	11	4	0	37	2	42	163
Sub-Total	1000 ha	52	43	15	13	15	42	7	63	250
1.2 Proposed Project										
Under Pump and Others	1000 ha	5	10	5	10	25	10	30	0	95
Under Dam	1000 ha	55	240	125	125	25	60	70	5	705
Sub-Total	1000 ha	60	250	130	135	50	70	100	5	800
1.3 Total	1000 ha	120	305	155	150	70	115	110	95	1,120
2 Unit Development Cost										
(1) Rehabilitation	N1,000/ha	6	6	6	6	6	6	6	6	–
(2) Canal System	N1,000/ha	31	31	31	31	31	31	31	31	
(3) Pump and Others	N1,000/ha	30	30	30	30	30	30	30	30	
3 Project Cost										
3.1 Existing Project										
(1) Rehabilitation	Mil. N	48	72	60	12	30	18	18	162	420
(2) Canal System	Mil. N	1,612	1,333	465	403	465	1,302	217	1,953	7,750
(3) Pump and Others	Mil. N	180	660	120	270	450	150	150	630	2,610
Total	Mil. N	1,840	2,065	645	685	945	1,470	385	2,745	10,780
3.2 Proposed Project										
(1) Canal System	Mil. N	1,860	7,750	4,030	4,185	1,550	2,170	3,100	155	24,800
(2) Pump and Others	Mil. N	150	300	150	300	750	300	900	0	2,850
Total	Mil. N	2,010	8,050	4,180	4,485	2,300	2,470	4,000	155	27,650
3.3 Ground Total (3.1+3.2)	Mil. N	3,850	10,115	4,825	5,170	3,245	3,940	4,385	2,900	38,430

TABLE 5.4.5 IRRIGATION WATER DEMAND TOWARD THE YEAR 2020

Description	Unit	Hydrological Area (HA)								
		I	II	III	IV	V	VI	VII	VIII	Total
1 Irrigation Area										
(1) Public Irrigation										
Existing	1000 ha	60	55	25	15	20	45	10	90	320
Proposed	1000 ha	60	250	130	135	50	70	100	5	800
Sub-Total	1000 ha	120	305	155	150	70	115	110	95	1,120
(2) Private Irrigation										
Existing	1000 ha	35	10	0	3	1	0	3	98	150
Proposed	1000 ha	40	30	30	12	9	10	7	92	230
Sub-Total	1000 ha	75	40	30	15	10	10	10	190	380
Total	1000 ha	195	345	185	165	80	125	120	285	1,500
2 Irrigation Water Demand										
(1) Public Irrigation										
Unit Requirement	1000 m^3/ha	9.6	11.4	13.4	11.6	13.8	14.6	13.2	9.6	–
Existing Demand	MCM	580	630	340	170	280	660	130	860	3,650
Proposed Demand	MCM	580	2,850	1,740	1,570	690	1,020	1,320	50	9,820
Sub-Total	MCM	1,160	3,480	2,080	1,740	970	1,680	1,450	910	13,470
(2) Private Irrigation										
Unit Requirement	1000 m^3/ha	9.2	7.6	9.8	7.4	5.4	6.6	5.2	9.0	
Existing Demand	MCM	320	70	0	20	10	0	10	880	1,310
Proposed Demand	MCM	370	230	290	90	50	70	40	830	1,970
Sub-Total	MCM	690	300	290	110	60	70	50	1,710	3,280
(3) Total Water Demand	MCM	1,850	3,780	2,370	1,850	1,030	1,750	1,500	2,620	16,750
(4) Proposed Total Demand	MCM	950	3,080	2,030	1,660	740	1,090	1,360	880	11,790

TABLE 5.4.6 (1) IRRIGAITON AREA AND ITS WATER DEMAND TOWARD THE YEAR 2020

(1/3)

SHA	Area of Public Irrigation									Area of Private Irrigation			Irrigation Demand				
	Existing Projects			Proposed Projects					Total	Existing	Proposed	Total	Public Irrigation		Private Irrigation		Total Demand
	Completed ①	On-going ②	Sub-Total ③=①+②	Medium/ Large Dam ④	Small Dam ⑤	Pump/ Diver. ⑥	Coastal Creek ⑦	Sub-Total ⑧=④~⑦	⑨=③+⑧	⑩	⑪	⑫=⑩+⑪	Unit Demand ⑬	Total Demand ⑭=⑨×⑬	Unit Demand ⑮	Total Demand ⑯=⑫×⑮	⑰=⑭+⑯
	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000m³/ha)	(MCM)	(1,000m³/ha)	(MCM)	(MCM)
1) HA-I																	
101	1	4	5	0	2	0	0	2	7	2	1	3	9.6	67	9.2	28	95
102	0	6	6	5	0	0	0	5	11	2	4	6	9.6	106	9.2	55	161
103	0	1	1	9	2	0	0	11	12	2	4	6	9.6	115	9.2	55	170
104	4	19	23	1	0	0	0	1	24	4	3	7	9.6	230	9.2	64	295
105	1	6	7	0	0	0	0	0	7	6	6	12	9.6	67	9.2	11	178
106	0	0	0	0	2	0	0	2	2	6	6	12	9.6	19	9.2	110	130
107	0	11	11	0	0	0	0	0	11	3	2	5	9.6	106	9.2	46	152
108	0	0	0	0	3	0	0	3	3	3	2	5	9.6	29	9.2	46	75
109	0	0	0	8	0	0	0	8	8	2	1	3	9.6	77	9.2	28	104
110	0	1	1	9	2	4	0	15	16	3	2	5	9.6	154	9.2	46	200
111	1	1	2	4	0	0	0	4	6	2	1	3	9.6	58	9.2	28	85
112	0	0	0	0	0	0	0	0	0	0	0	0	9.6	0	9.2	0	0
113	0	1	1	4	2	1	0	7	8	0	3	3	9.6	77	9.2	0	0
114	1	2	3	0	2	0	0	2	5	0	5	5	9.6	48	9.2	46	94
Sub-Total	8	52	60	40	15	5	0	60	120	35	40	75	–	1,160	–	690	1,850
2) HA-II																	
201	0	2	2	0	5	0	0	5	7	0	0	0	11.4	80	7.6	0	80
202	0	0	0	0	5	0	0	5	5	0	0	0	11.4	57	7.6	0	57
203	1	11	12	0	5	0	0	5	17	0	0	0	11.4	194	7.6	0	194
204	0	0	0	25	5	1	0	31	31	0	2	2	11.4	353	7.6	15	369
205	6	6	12	5	5	0	0	10	22	0	2	2	11.4	251	7.6	15	266
206	0	1	1	4	5	0	0	9	10	0	0	0	11.4	114	7.6	0	114
207	1	2	3	19	5	0	0	24	27	3	2	5	11.4	308	7.6	38	346
208	1	8	9	8	5	2	0	15	24	1	4	5	11.4	274	7.6	38	312
209	0	1	1	6	5	0	0	11	12	1	2	3	11.4	137	7.6	23	160
210	0	1	1	0	5	0	0	5	6	0	0	0	11.4	68	7.6	0	68
211	0	1	1	24	5	1	0	30	31	0	4	4	11.4	353	7.6	30	384
212	0	3	3	8	5	4	0	17	20	1	1	2	11.4	228	7.6	15	243
213	0	0	0	0	5	0	0	5	5	1	2	3	11.4	57	7.6	23	80
214	3	7	10	43	0	0	0	43	53	3	2	5	11.4	604	7.6	38	642
215	0	0	0	22	5	0	0	27	27	0	2	2	11.4	308	7.6	15	323
216	0	0	0	6	0	2	0	8	8	0	7	7	11.4	91	7.6	53	144
Sub-Total	12	43	55	170	70	10	0	250	305	10	30	40	–	3,480	–	300	3,780
3) HA-III																	
301	0	0	0	11	5	0	0	16	16	0	3	3	13.4	214	9.8	29	244
302	0	1	1	14	5	0	0	19	20	3	3	13.4	268	9.8	29	297	

TABLE 5.4.6 (2) IRRIGAITON AREA AND ITS WATER DEMAND TOWARD THE YEAR 2020

(2/3)

SHA	Area of Public Irrigation									Area of Private Irrigation			Irrigation Demand				
	Existing Projects			Proposed Projects					Total	Existing	Proposed	Total	Public Irrigation		Private Irrigation		Total Demand
	Completed ①	On-going ②	Sub-Total ③=①+②	Medium/ Large Dam ④	Small Dam ⑤	Pump/ Diver. ⑥	Coastal Creek ⑦	Sub-Total ⑧=④+⑤+⑥+⑦	⑨=③+⑧	⑩	⑪	⑫=⑩+⑪	Unit Demand ⑬	Total Demand ⑭=⑨×⑬	Unit Demand ⑮	Total Demand ⑯=⑫×⑮	⑰=⑭+⑯
	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000m³/ha)	(MCM)	(1,000m³/ha)	(MCM)	(MCM)
303	7	6	13	14	2	0	0	16	29	0	2	2	13.4	389	9.8	20	408
304	0	4	4	0	3	0	0	3	7	0	4	4	13.4	94	9.8	39	133
305	2	2	4	0	0	0	0	0	4	0	2	2	13.4	54	9.8	20	73
306	0	0	0	0	0	0	0	0	0	0	0	0	13.4	0	9.8	0	0
307	0	0	0	20	5	0	0	25	25	0	4	4	13.4	335	9.8	39	374
308	0	0	0	0	2	2	0	4	4	0	2	2	13.4	54	9.8	20	73
309	0	0	0	2	3	0	0	5	5	0	2	2	13.4	67	9.8	20	87
310	0	0	0	2	2	0	0	4	4	0	2	2	13.4	54	9.8	20	73
311	1	2	3	22	3	3	0	28	31	0	3	3	13.4	415	9.8	29	445
312	0	0	0	2	0	0	0	2	2	0	0	0	13.4	27	9.8	0	27
313	0	0	0	0	0	0	0	0	0	0	0	0	13.4	0	9.8	0	0
314	0	0	0	8	0	0	0	8	8	0	3	3	13.4	107	9.8	29	137
Sub-Total	10	15	25	95	30	5	0	130	155	0	30	30	-	2,080	-	290	2,370
4) HA-IV																	
401	0	2	2	17	5	0	0	22	24	1	1	2	11.6	278	7.4	15	293
402	0	0	0	4	3	1	0	8	8	0	0	0	11.6	93	7.4	0	93
403	1	2	3	11	7	2	0	20	23	1	2	3	11.6	267	7.4	22	289
404	0	0	0	10	3	0	0	13	13	1	1	2	11.6	151	7.4	15	166
405	0	4	4	13	7	1	0	21	25	0	0	0	11.6	290	7.4	0	290
406	0	3	3	4	5	0	0	9	12	0	4	4	11.6	139	7.4	60	169
407	1	1	2	9	10	3	0	22	24	0	3	3	11.6	278	7.4	22	301
408	0	0	0	7	5	3	0	15	15	0	0	0	11.6	174	7.4	0	174
409	0	1	1	0	5	0	0	5	6	0	1	1	11.6	70	7.4	7	77
Sub-Total	2	13	15	75	50	10	0	135	150	3	12	15	-	1,740	-	110	1,850
5) HA-V																	
501	0	1	1	6	5	0	0	11	12	0	2	2	13.8	166	5.4	11	176
502	4	4	8	4	0	4	0	8	16	1	3	4	13.8	221	5.4	22	242
503	0	6	6	2	0	0	0	2	8	0	2	2	13.8	110	5.4	11	121
504	1	1	2	3	5	7	0	15	17	0	2	2	13.8	235	5.4	11	245
505	0	3	3	0	0	4	10	14	17	0	0	0	13.8	235	5.4	0	235
Sub-Total	5	15	20	15	10	15	10	50	70	1	9	10	-	970	-	60	1,030
6) HA-VI																	
601	0	0	0	0	0	0	0	0	0	0	0	0	14.6	0	6.6	0	0
602	1	35	36	14	5	2	0	21	57	0	3	3	14.6	832	6.6	20	852
603	1	2	3	0	2	0	0	2	5	0	0	0	14.6	73	6.6	0	73

TABLE 5.4.6 (3) IRRIGAITON AREA AND ITS WATER DEMAND TOWARD THE YEAR 2020

(3/3)

SHA	Area of Public Irrigation									Area of Private Irrigation			Irrigation Demand				
	Existing Projects			Proposed Projects					Total	Existing	Proposed	Total	Public Irrigation		Private Irrigation		Total Demand
	Completed ①	On-going ②	Sub-Total ③=①+②	Medium/ Large Dam ④	Small Dam ⑤	Pump/ Diver. ⑥	Coastal Creek ⑦	Sub-Total ⑧=④+⑤+⑥+⑦	⑨=③+⑧	⑩	⑪	⑫=⑩+⑪	Unit Demand ⑬	Total Demand ⑭=⑨×⑬	Unit Demand ⑮	Total Demand ⑯=⑫×⑮	⑰=⑭+⑯
	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000 ha)	(1,000m³/ha)	(MCM)	(1,000m³/ha)	(MCM)	(MCM)
604	0	2	2	4	2	1	0	7	9	0	0	0	14.6	131	6.6	0	131
605	0	1	1	6	3	2	0	13	14	0	2	2	14.6	204	6.6	13	218
606	0	1	1	2	5	2	0	9	10	0	0	0	14.6	146	6.6	0	146
607	0	0	0	0	3	2	0	5	5	0	2	2	14.6	73	6.6	13	86
608	0	0	0	4	5	1	0	10	10	0	2	2	14.6	146	6.6	13	159
609	1	0	1	0	0	0	0	0	1	0	0	0	14.6	15	6.6	0	15
610	0	1	1	0	3	0	0	3	4	0	1	1	14.6	58	6.6	7	65
Sub-Total	3	42	45	30	30	10	0	70	115	0	10	10	–	1,680	–	70	1,750
7) HA-VII																	
701	0	0	0	9	7	0	0	16	16	0	0	0	13.2	211	5.2	0	211
702	1	1	2	8	8	5	0	21	23	0	1	1	13.2	304	5.2	5	309
703	0	0	0	14	7	0	0	21	21	2	1	3	13.2	277	5.2	16	293
704	0	0	0	0	3	0	0	3	3	0	3	3	13.2	40	5.2	16	56
705	1	1	2	2	5	10	0	17	19	1	2	3	13.2	251	5.2	16	266
706	1	5	6	2	5	10	0	17	23	0	0	0	13.2	304	5.2	0	304
707	0	0	0	0	0	5	0	5	5	0	0	0	13.2	66	5.2	0	66
Sub-Total	3	7	10	35	35	30	0	100	110	3	7	10	–	1,450	–	50	1,500
8) HA-VIII																	
801	0	0	0	0	0	0	0	0	0	0	0	0	9.6	0	9.0	0	0
802	2	6	8	0	0	0	0	0	8	12	8	20	9.6	77	9.0	180	257
803	0	3	3	0	0	0	0	0	3	3	2	5	9.6	29	9.0	45	74
804	14	9	23	0	0	0	0	0	23	6	5	11	9.6	221	9.0	99	320
805	0	3	3	0	0	0	0	0	3	15	12	27	9.6	29	9.0	243	272
806	0	0	0	0	0	0	0	0	0	3	2	5	9.6	0	9.0	45	272
807	1	19	20	0	0	0	0	0	20	25	25	50	9.6	192	9.0	450	642
808	0	0	0	0	0	0	0	0	0	0	0	0	9.6	0	9.0	0	0
809	0	1	1	0	0	0	0	0	1	25	25	50	9.6	10	9.0	450	460
810	0	0	0	0	0	0	0	0	0	7	5	12	9.6	0	9.0	108	108
811	1	2	3	0	0	0	0	0	3	0	0	0	9.6	29	9.0	0	29
812	8	15	23	0	0	0	0	0	23	0	0	0	9.6	221	9.0	0	221
813	0	3	3	0	0	0	0	0	3	0	5	5	9.6	29	9.0	45	74
814	1	2	3	0	5	0	0	5	8	2	3	5	9.6	77	9.0	45	122
Sub-Total	27	63	90	0	5	0	0	5	95	98	92	190	–	910	–	1,710	2,620
Total	70	250	320	460	245	85	10	800	1,120	150	230	380	–	13,470	–	3,280	16,750

TABLE 5.4.7 IMPLEMENTATION PROGRAM FOR PUBLIC IRRIGATION PROJECTS

Project Program	Unit	Implementation Schedule					
		1996-2000	2001-2005	2006-2010	2011-2015	2016-2020	Total
1. Implementation Area							
1.1 Existing Project							
(1) Rehabilitation	1000 ha	70	–	–	–	–	70
(2) Canal System	1000 ha	150	100	–	–	–	250
(3) Water Source Facilities							
Under Pump and Others	1000 ha	87	–	–	–	–	87
Under Dam	1000 ha	–	–	–	–	–	0
1.2 Proposed Project							
(1) Canal System	1000 ha	–	140	180	220	260	800
(2) Water Source Facilities							
Under Pump and Others	1000 ha	–	5	30	30	30	95
Under Dam	1000 ha	–	135	150	190	230	705
1.3 Service Area							
Imple. Area in Sub-Period	1000 ha	220	240	180	220	260	1,120
Service Area							
at End of Sub-Period	1000 ha	220	460	640	860	1,120	–
2. Unit Development Cost	N1,000/ha						
(1) Rehabilitation	6						
(2) Canal System	31						
(3) Pump and Others	30						
3. Project Cost							
3.1 Existing Project							
(1) Rehabilitation	Mil. N	420	–	–	–	–	420
(2) Canal System	Mil. N	4,650	3,100	–	–	–	7,750
(3) Water Source Facilities							
Pump and Others	Mil. N	2,610	–	–	–	–	2,610
Total	Mil. N	7,680	3,100	0	0	0	10,780
3.2 Proposed Project							
(1) Study	Mil. N	100	400	560	670	780	2,510
(2) Implementation	Mil. N	–	4,080	5,890	7,020	8,150	25,140
Sub-Total	Mil. N	100	4,480	6,450	7,690	8,930	27,650
3.3 Ground Total (3.1+3.2)	Mil. N	7,780	7,580	6,450	7,690	8,930	38,430

TABLE 5.4.8 IMPLEMENTATION PROGRAM FOR PRIVATE IRRIGATION PROJECTS

Service Area and Project Cost	Unit	Implementation Schedule						
		Present	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020	Total
1. Implementation Area								
1.1 Existing Project								
Present Service Area	1000 ha	150	–	–	–	–	–	0
1.2 Proposed Project								
New Provision Area	1000 ha	–	100	150	150	100	100	600
1.3 Inclusion in Public Projects	1000 ha	–	50	60	100	80	80	370
1.4 Service Area at End of Sub-Period	1000 ha	150	200	290	340	360	380	–
2. Unit Development Cost	N1,000/ha							
Lift/Tubewell Irrigation	13							
3. Project Cost	Mil. N	–	1,300	1,950	1,950	1,300	1,300	7,800

APPENDIX 5-1 ESTIMATION OF DIVERSION WATER REQUIREMENT

(1) Potential Evapo-transpiration

Potential evapotranspiration (ETo), generally recognized as fairly reliable index in calculating consumptive use, can be determined by a number of methods, such as the evaporation measurement with evaporation pan and the application of empirical formula based on the climatological data. In the project, the ETo values are estimated on the monthly basis, based on the climatological data obtained from The National Atlas prepared by FGN in 1978 by applying Penman Method.

The Penman Method is the most complete theoretical approach, showing that consumptive use is inseparably connected to incoming solar energy. The formula representing the potential evapotranspiration is shown below;

$$ETo = CW.Rn(1 - W) \cdot f(u) \cdot (ea - ed)$$

radiation term aerodynamic term

Where;

ETo	=	potential evapotranspiration in mm/day
W	=	temperature-related weighting factor
Ru	=	net radiation in equivalent evaporation in mm/day
f(u)	=	wind-related function
(ea-ed)	=	difference between the saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air, both in mbar
C	=	adjustment factor to compensate for the effect of day and night weather conditions

According to the above equation, the monthly ETo valves are calculated and its result is tabulated in Table A.1.1.

(2) Cropping Pattern

According to NWRIS, major crops in Nigeria are sorghum, millet, oil crops, maize, rice, wheat, etc. in North zone, maize, sorghum, rice, oil crops, millet, etc. in Central zone, and maize, sorghum, rice, etc. in Southern zone. Among such crops, rice, maize wheat, and vegetables such as chillies, tomato, onion are irrigated crops. Rice / rice and rice / other cereal and vegetable are the predominant cropping pattern. For the estimation of irrigation water demand in NWRMP, rice and maize are adopted as a representative one of other cereal, and the zonal cropping patterns, cropping intensity and average crop coefficient considering cropping calendar are assumed as below table:

Cropping Pattern and Cropping Intensity

Zone	HA	Public Program				Private Scheme			
		Wet Season		Dry Season		Wet Season		Dry Season	
		Rice	Other Cereal	Rice	Other Cereal	Rice	Other Cereal	Rice	Other Cereal
North	I & VIII	10	90	0	50	10	70	0	50
Central	II, III, IV	30	70	25	55	80	0	0	50
South	V, VI, VII	90	10	70	10	80	0	0	50

(3) Diversion Water Requirement and Water Demand

Diversion water requirements are estimated by the following equation:

$$DWR = (ET\,crop + Pe + LP - Re)/IE$$

where;

DWR : diversion water requirement
ET crop : crop evapo-transpiration
Pe : percolation loss
Re : effective rainfall
IE : irrigation efficiency
LP : water for land preparation

The estimated annual net requirement are shown in Table A.1.2 and the diversion requirements are shown in Table 5.2.1.

TABLE A.1.1 (1) REFERENCE CROP EVAPOTRANSPIRATION (SOKOTO)

Station	State	Item	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Dutsin-Ma	Sokoto	Lat 11.5													
		Rainfall (1/2)	754	0	1	4	14	73	95	181	231	144	12	0	0
		E-Rainfall	527	0	1	3	9	51	67	126	162	100	8	0	0
	Data	Mean Tempera. (F)		75	79	85	90	89	85	80	78	79	82	80	75
		Mean Tempera. (C)		24	26	29	32	32	29	27	26	26	28	27	24
	Data	n (Sunshine hour)		9	9	9	8	9	9	8	6	8	10	10	9
	Data	RHmean		20	15	20	32	52	60	75	80	73	57	25	25
	Table 5	ea	(1)	29.8	33.6	40.1	47.6	47.6	40.1	35.7	33.6	33.6	37.8	35.7	29.8
		ed	(2)	6.0	5.0	8.0	15.2	24.8	24.1	26.8	26.9	24.5	21.5	8.9	7.5
	Fix	f(u2)	(3)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Table 9	w	(4)	0.73	0.75	0.77	0.8	0.8	0.77	0.76	0.75	0.75	0.77	0.76	0.73
	Table 10	Ra	(5)	12.8	13.9	15.1	15.7	15.7	15.5	15.5	15.6	15.2	14.4	13.3	12.5
		Rns	(6)	6.1	6.6	7.1	6.8	7.1	7.0	6.6	5.8	6.6	7.3	6.8	6.0
		Rnl	(7)	2.9	3.0	2.8	2.0	1.5	1.5	1.2	1.0	1.3	1.9	2.9	2.7
	Table 11	N		11.6	11.8	12	12.3	12.6	12.7	12.6	12.4	12.1	11.8	11.6	11.5
	Table 13	f(T)		15.4	15.9	16.5	17.2	17.2	16.5	16.1	15.9	15.9	16.3	16.1	15.4
		f(ed)		0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
		f(n/N)		0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.5	0.7	0.9	0.9	0.8
		Rn	(8)=(6)-(7)	3.3	3.6	4.3	4.8	5.6	5.5	5.4	4.8	5.3	5.4	3.9	3.3
	Table 16	C	(9)	0.86	0.91	0.91	0.95	1.03	1.06	1.06	1.04	1.06	1.06	0.91	0.91
		Rs		8.2	8.8	9.4	9.0	9.5	9.4	8.8	7.7	8.8	9.7	9.1	8.0
		RHmax		30	23	30	48	78	90	113	120	110	86	38	38
	Fix	Ud/Un		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Fix	Ud		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
		ETo (mm/day)	(10)	4.8	5.7	6.4	6.7	7.0	6.5	5.5	4.6	5.4	6.4	5.6	4.9
		ETo (mm/month)	2,082	145	170	192	201	209	194	164	139	162	191	168	148

Remarks) Estimation of reference crop water requirement is based on "Crop Water requirements" of FAO Irrigation and Drainage Paper 24. Table 5, 9, 10, 11, 13, 16 come from the same paper.

TABLE A.1.1 (2) REFERENCE CROP EVAPOTRANSPIRATION (KANO)

Station	State	Item	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Kano Met.	Kano	Lat 12.0													
		Rainfall (1/2)	684	0	1	0	8	41	93	182	241	96	22	0	0
		E-Rainfall	479	0	1	0	6	29	65	127	169	67	15	0	0
	Data	Mean Tempera. (F)		70	75	83	87	86	83	78	77	79	80	77	71
		Mean Tempera. (C)		21	24	28	31	30	28	26	25	26	27	25	22
	Data	n (Sunshine hour)		8	9	8	8	9	8	7	6	8	9	9	9
	Data	RHmean		20	20	22	32	50	60	73	80	73	53	25	25
	Table 5	ea	(1)	24.9	29.8	37.8	44.9	42.4	37.8	33.6	33.6	33.6	35.7	31.7	26.4
		ed	(2)	5.0	6.0	8.3	14.4	21.2	22.7	24.5	26.9	24.5	18.9	7.9	6.6
	Fix	f(u2)	(3)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Table 9	w	(4)	0.70	0.73	0.77	0.79	0.78	0.77	0.75	0.74	0.75	0.76	0.74	0.71
	Table 10	Ra	(5)	12.8	13.9	15.1	15.7	15.7	15.5	15.5	15.6	15.2	14.4	13.3	12.5
		Rns	(6)	5.7	6.6	6.6	6.7	7.1	6.5	6.1	5.7	6.6	6.8	6.4	6.1
		Rnl	(7)	2.6	2.8	2.4	2.0	1.7	1.4	1.2	0.9	1.3	1.9	2.7	2.8
	Table 11	N		11.5	11.7	12	12.4	12.7	12.8	12.7	12.5	12.1	11.8	11.5	11.3
	Table 13	f(T)		14.8	15.4	16.3	17	16.7	16.3	15.9	15.6	15.9	16.1	15.6	15
		f(ed)		0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
		f(n/N)		0.7	0.8	0.7	0.7	0.7	0.7	0.6	0.5	0.7	0.8	0.8	0.8
		Rn	(8)=(6)-(7)	3.1	3.8	4.2	4.7	5.4	5.1	5.0	4.8	5.3	4.9	3.7	3.3
	Table 16	C	(9)	0.85	0.91	0.91	0.95	1.03	1.06	1.02	1.02	1.06	1.06	0.91	0.91
		Rs		7.7	8.8	8.8	9.0	9.5	8.7	8.1	7.6	8.8	9.1	8.5	8.1
		RHmax		30	30	33	48	75	90	110	120	110	80	38	38
	Fix	Ud/Un		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Fix	Ud		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
		ETo (mm/day)	(10)	4.4	5.4	6.0	6.6	6.8	6.0	4.9	4.5	5.4	6.1	5.3	4.7
		ETo (mm/month)	1,988	132	163	180	198	203	181	148	136	162	183	159	142

Remarks) Estimation of reference crop water requirement is based on "Crop Water requirements" of FAO Irrigation and Drainage Paper 24. Table 5, 9, 10, 11, 13, 16 come from the same paper.

TABLE A.1.1 (3) REFERENCE CROP EVAPOTRANSPIRATION (NIGER)

Station	State	Item	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Kontagora	Niger	Lat 10.5													
		Rainfall (1/2)	1.112	1	3	26	50	136	160	198	249	211	73	2	1
		E-Rainfall	778	1	2	18	35	95	112	138	174	148	51	2	1
	Data	Mean Tempera. (F)		74	77	82	82	79	76	74	74	75	77	75	73
		Mean Tempera. (C)		23	25	28	28	26	24	23	23	24	25	24	23
	Data	n (Sunshine hour)		9	9	8	7	8	7	5	4	6	8	9	9
	Data	RHmean		20	20	40	52	70	80	80	80	80	65	42	25
	Table 5	ea	(1)	28.1	31.7	37.8	37.8	33.6	29.8	28.1	28.1	29.8	31.7	29.8	28.1
		ed	(2)	5.6	6.3	15.1	19.7	23.5	23.8	22.5	22.5	23.8	20.6	12.5	7.0
	Fix	f(u2)	(3)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Table 9	w	(4)	0.72	0.74	0.77	0.77	0.75	0.73	0.72	0.72	0.73	0.74	0.73	0.72
	Table 10	Ra	(5)	13.2	14.2	15.3	15.7	15.5	15.3	15.3	15.5	15.3	14.7	13.6	12.9
		Rns	(6)	6.3	6.7	6.7	6.3	6.6	6.0	5.1	4.8	5.7	6.5	6.5	6.2
		Rnl	(7)	2.9	2.8	1.9	1.4	1.4	1.1	0.9	0.8	1.1	1.6	2.3	2.7
	Table 11	N		11.6	11.8	12	12.3	12.6	12.7	12.6	12.4	12.1	11.8	11.6	11.5
	Table 13	f(T)		15.2	15.6	16.3	16.3	15.9	15.4	15.2	15.2	15.4	15.6	15.4	15.2
		f(ed)		0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
		f(n/N)		0.8	0.8	0.7	0.6	0.7	0.6	0.5	0.4	0.5	0.7	0.8	0.8
		Rn	(8)=(6)-(7)	3.5	3.9	4.8	4.8	5.2	4.9	4.2	4.0	4.7	4.9	4.2	3.5
	Table 16	C	(9)	0.86	0.91	0.92	1.03	1.06	1.02	0.98	0.98	1.02	1.06	1.00	0.85
		Rs		8.4	9.0	8.9	8.4	8.8	8.0	6.9	6.4	7.6	8.7	8.7	8.3
		RHmax		30	30	60	78	105	120	120	120	120	98	63	38
	Fix	Ud/Un		0.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Fix	Ud		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
		ETo (mm/day)	(10)	4.8	5.6	5.8	6.0	5.5	4.5	3.8	3.6	4.3	5.4	5.4	4.6
		ETo (mm/month)	1.780	145	169	173	180	165	134	113	108	129	162	163	139

Remarks) Estimation of reference crop water requirement is based on "Crop Water requirements" of FAO Irrigation and Drainage Paper 24. Table 5, 9, 10, 11, 13, 16 come from the same paper.

TABLE A.1.1 (4) REFERENCE CROP EVAPOTRANSPIRATION (ADAMAWA)

Station	State	Item	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Yola	Adamawa	Lat 9.2													
		Rainfall (1/2)	1,069	1	0	12	54	123	154	204	227	202	92	1	0
		E-Rainfall	748	1	0	8	38	86	108	143	159	142	64	1	0
	Data	Mean Tempera. (F)		79	83	89	90	86	82	80	79	80	82	80	78
		Mean Tempera. (C)		26	28	32	32	30	28	27	26	27	28	27	26
	Data	n (Sunshine hour)		9	9	8	8	8	7	6	5	6	9	9	9
	Data	RHmean		27	26	36	44	62	75	78	78	77	70	47	32
	Table 5	ea	(1)	33.6	37.8	47.6	47.6	42.4	37.8	35.7	33.6	35.7	37.8	35.7	33.6
		ed	(2)	9.1	9.8	17.1	20.9	26.3	28.3	27.8	26.2	27.5	26.5	16.8	10.8
	Fix	f(u2)	(3)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Table 9	w	(4)	0.75	0.77	0.8	0.8	0.78	0.77	0.76	0.75	0.76	0.77	0.76	0.75
	Table 10	Ra	(5)	13.4	14.3	15.3	15.6	15.4	15.2	15.2	15.5	15.3	14.7	13.7	13.1
		Rns	(6)	6.4	6.8	6.7	6.7	6.6	6.0	5.6	5.3	5.7	7.0	6.6	6.3
		Rnl	(7)	2.6	2.6	1.9	1.6	1.3	1.0	0.9	0.8	1.0	1.5	2.1	2.5
	Table 11	N		11.6	11.8	12	12.3	12.6	12.7	12.6	12.4	12.1	11.8	11.6	11.5
	Table 13	f(T)		15.9	16.3	17.2	17.2	16.7	16.3	16.1	15.9	16.1	16.3	16.1	15.9
		f(ed)		0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
		f(n/N)		0.8	0.8	0.7	0.7	0.7	0.6	0.5	0.5	0.5	0.8	0.8	0.8
		Rn	(8)=(6)-(7)	3.8	4.2	4.8	5.1	5.3	5.0	4.6	4.4	4.8	5.5	4.5	3.8
	Table 16	C	(9)	0.95	0.95	0.95	1.00	1.06	1.02	1.01	1.00	1.01	1.06	1.03	0.95
		Rs		8.5	9.0	8.9	9.0	8.7	8.0	7.4	7.0	7.6	9.3	8.7	8.4
		RHmax		41	39	54	66	93	113	117	117	116	105	71	48
	Fix	Ud/Un		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Fix	Ud		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
		ETo (mm/day)	(10)	5.6	6.1	6.5	6.7	6.2	5.0	4.5	4.2	4.6	5.9	5.9	5.4
		ETo (mm/month)	2,004	168	183	196	202	187	150	136	127	139	176	176	163

Remarks) Estimation of reference crop water requirement is based on "Crop Water requirements" of FAO Irrigation and Drainage Paper 24. Table 5, 9, 10, 11, 13, 16 come from the same paper.

TABLE A.1.1 (5) REFERENCE CROP EVAPOTRANSPIRATION (OSHUN)

Station	State	Item	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Oshogbo	Oshun	Lat 7.8													
		Rainfall (1/2)	1,327	3	31	80	117	182	201	158	159	216	145	30	4
		E-Rainfall	929	2	22	56	82	127	141	111	111	151	101	21	3
	Data	Mean Tempera. (F)		79	81	83	81	80	78	76	75	77	78	79	79
		Mean Tempera. (C)		26	27	28	27	27	26	24	24	25	26	26	26
	Data	n (Sunshine hour)		7	8	7	6	6	6	4	3	4	6	7	7
	Data	RHmean		78	72	77	82	82	85	85	80	90	83	83	78
	Table 5	ea	(1)	33.6	35.7	37.8	35.7	35.7	33.6	29.8	29.8	31.7	33.6	33.6	33.6
		ed	(2)	26.2	25.7	29.1	29.3	29.3	28.6	25.3	23.8	28.5	27.9	27.9	26.2
	Fix	f(u2)	(3)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Table 9	w	(4)	0.75	0.76	0.77	0.76	0.76	0.75	0.73	0.73	0.74	0.75	0.75	0.75
	Table 10	Ra	(5)	13.6	14.5	15.3	15.6	15.3	15	15.1	15.4	15.3	14.8	13.9	13.3
		Rns	(6)	5.6	6.4	6.2	5.8	5.6	5.5	4.7	4.3	4.8	5.6	5.7	5.5
		Rnl	(7)	1.2	1.3	1.0	0.9	0.9	0.9	0.7	0.6	0.7	0.9	1.1	1.2
	Table 11	N		11.7	11.8	12	12.3	12.4	12.5	12.4	12.3	12.1	11.9	11.7	11.6
	Table 13	f(T)		15.9	16.1	16.3	16.1	16.1	15.9	15.4	15.4	15.6	15.9	15.9	15.9
		f(ed)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		f(n/N)		0.6	0.7	0.6	0.5	0.5	0.5	0.4	0.3	0.4	0.6	0.6	0.6
		Rn	(8)=(6)-(7)	4.4	5.1	5.2	4.9	4.8	4.6	3.9	3.7	4.1	4.6	4.6	4.3
	Table 16	C	(9)	1.02	1.06	1.04	1.04	1.02	1.02	0.98	0.98	0.98	1.02	1.03	1.02
		Rs		7.5	8.5	8.3	7.7	7.5	7.4	6.2	5.7	6.4	7.4	7.6	7.3
		RHmax		117	108	116	123	123	128	128	120	135	125	125	117
	Fix	Ud/Un		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Fix	Ud		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
		ETo (mm/day)	(10)	4.3	5.4	5.2	4.7	4.5	4.2	3.4	3.4	3.4	4.3	4.3	4.3
		ETo (mm/month)	1,538	130	161	155	140	134	125	102	103	102	128	129	128

Remarks) Estimation of reference crop water requirement is based on "Crop Water requirements" of FAO Irrigation and Drainage Paper 24. Table 5, 9, 10, 11, 13, 16 come from the same paper.

TABLE A.1.1 (6) REFERENCE CROP EVAPOTRANSPIRATION (ENUGU)

Station	State	Item	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Enugu	Enugu	Lat 6.5													
		Rainfall (1/2)	1,593	6	9	57	106	228	207	241	260	296	167	16	0
		E-Rainfall	1,115	4	6	40	74	160	145	169	182	207	117	11	0
	Data	Mean Tempera. (F)		79	82	84	83	81	79	78	78	78	79	81	79
		Mean Tempera. (C)		26	28	29	28	27	26	26	26	26	26	27	26
	Data	n (Sunshine hour)		7	7	6	6	6	5	4	3	4	5	7	7
	Data	RHmean		63	65	72	77	78	80	80	80	85	82	77	67
	Table 5	ea	(1)	33.6	37.8	40.1	37.8	35.7	33.6	33.6	33.6	33.6	33.6	35.7	33.6
		ed	(2)	21.2	24.6	28.9	29.1	27.8	26.9	26.9	26.9	28.6	27.6	27.5	22.5
	Fix	f(u2)	(3)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Table 9	w	(4)	0.75	0.77	0.77	0.77	0.76	0.75	0.75	0.75	0.75	0.75	0.76	0.75
	Table 10	Ra	(5)	13.9	14.8	15.4	15.4	15.1	14.7	14.9	15.2	15.3	15	14.2	13.7
		Rns	(6)	5.7	6.0	5.8	5.7	5.6	5.0	4.6	4.2	4.8	5.2	5.8	5.6
		Rnl	(7)	1.4	1.3	0.9	0.9	0.9	0.8	0.7	0.6	0.7	0.8	1.1	1.3
	Table 11	N		11.8	11.9	12	12.2	12.3	12.4	12.3	12.3	12.1	12	11.9	11.8
	Table 13	f(T)		15.9	16.3	16.5	16.3	16.1	15.9	15.9	15.9	15.9	15.9	16.1	15.9
		f(ed)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		f(n/N)		0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.3	0.4	0.5	0.6	0.6
		Rn	(8)=(6)-(7)	4.3	4.8	4.8	4.8	4.7	4.2	3.9	3.7	4.1	4.3	4.7	4.3
	Table 16	C	(9)	1.02	1.04	1.02	1.02	1.02	1.00	0.98	0.98	1.00	1.01	1.02	1.02
		Rs		7.6	8.1	7.7	7.6	7.5	6.6	6.1	5.7	6.4	6.9	7.7	7.5
		RHmax		95	98	108	116	117	120	120	120	128	123	116	101
	Fix	Ud/Un		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Fix	Ud		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
		ETo (mm/day)	(10)	4.9	5.4	5.1	4.8	4.6	4.0	3.7	3.5	3.7	4.0	4.6	4.7
		ETo (mm/month)	1,592	147	163	153	144	137	119	111	106	111	0121	139	141

Remarks) Estimation of reference crop water requirement is based on "Crop Water requirements" of FAO Irrigation and Drainage Paper 24. Table 5, 9, 10, 11, 13, 16 come from the same paper.

TABLE A.1.2 NET IRRIGATION REQUIREMENT (1)

HA- I

	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)		194	164	139	162	191	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		97	169	161	154	27	
② Percolation		60	120	120	106	14	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	232	289	281	260	41	1,178
⑤ Effective rainfall	51	67	126	162	100	8	
⑥ Net irrigation Requirement	24	165	163	119	160	33	664
2) Other Crops							
ETo (Reference Crop Evaporation)	209	194	164	139	162	191	
Kc (Crop coefficients)	0.05	0.54	0.96	1.07	0.59	0.08	
① ETcrop	10	105	157	149	96	15	
② Per-Irrigation	40	40	–	–	–	–	
③=①+②	50	145	157	149	96	15	612
④ Effective rainfall	51	67	126	162	100	8	
⑤ Net irrigation Requirement	0	78	31	0	0	7	116

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)							
Kc (Crop coefficients)							
① ETcrop							
② Percolation							
③ Land preparation							
④=①+②+③							
⑤ Effective rainfall							
⑥ Net irrigation Requirement							
2) Other Crops							
ETo (Reference Crop Evaporation)		148	145	170	192	201	
Kc (Crop coefficients)		0.25	0.77	0.98	0.87	0.3	
① ETcrop		37	112	167	167	60	
② Per-Irrigation		80	–	–	–	–	
③=①+②		117	112	167	167	60	623
④ Effective rainfall		0	0	1	3	9	
⑤ Net irrigation Requirement		117	112	166	164	51	610

TABLE A.1.2 NET IRRIGATION REQUIREMENT (2)

HA-II

	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)		134	113	108	129	162	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		67	116	125	126	23	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	172	176	185	179	30	818
⑤ Effective rainfall	95	112	138	174	148	51	
⑥ Net irrigation Requirement	0	60	38	11	31	0	141
2) Other Crops							
ETo (Reference Crop Evaporation)	165	134	113	108	129	162	
Kc (Crop coefficients)	0.05	0.54	0.96	1.07	0.59	0.08	
① ETcrop	8	72	108	116	76	13	
② Per-Irrigation	40	40	–	–	–	–	
③=①+②	48	112	108	116	76	13	474
④ Effective rainfall	95	112	138	174	148	51	
⑤ Net irrigation Requirement	0	0	0	0	0	0	0

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)		139	145	169	173	180	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		70	149	196	170	25	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	175	209	256	223	32	
⑤ Effective rainfall	2	1	1	2	18	35	
⑥ Net irrigation Requirement	73	174	208	254	205	0	
2) Other Crops							
ETo (Reference Crop Evaporation)		139	145	169	173	180	
Kc (Crop coefficients)		0.25	0.77	0.98	0.87	0.3	
① ETcrop		35	112	166	151	54	
② Per-Irrigation		80	–	–	–	–	
③=①+②		115	112	166	151	54	
④ Effective rainfall		1	1	2	18	35	
⑤ Net irrigation Requirement		114	111	164	133	19	

TABLE A.1.2 NET IRRIGATION REQUIREMENT (3)

HA-III

	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)		150	136	127	139	176	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		75	140.08	147.32	136.22	24.64	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	180	200	207	189	32	883
⑤ Effective rainfall	86	108	143	159	142	64	
⑥ Net irrigation Requirement	0	72	57	48	47	0	225
2) Other Crops							
ETo (Reference Crop Evaporation)	187	150	136	127	139	176	
Kc (Crop coefficients)	0.05	0.54	0.96	1.07	0.59	0.08	
① ETcrop	9	81	131	136	82	14	
② Per-Irrigation	40	40	–	–	–	–	
③=①+②	49	121	131	136	82	14	533
④ Effective rainfall	86	108	143	159	142	64	
⑤ Net irrigation Requirement	0	13	0	0	0	0	13

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)		163	168	183	196	202	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		82	173	212	192	28	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	187	233	272	245	35	1,047
⑤ Effective rainfall	1	0	1	0	8	38	
⑥ Net irrigation Requirement	74	187	232	272	237	0	1,002
2) Other Crops							
ETo (Reference Crop Evaporation)		163	168	183	196	202	
Kc (Crop coefficients)		0.25	0.77	0.98	0.87	0.3	
① ETcrop		41	129	179	171	61	
② Per-Irrigation		80	–	–	–	–	
③=①+②		121	129	179	171	61	661
④ Effective rainfall		0	1	0	8	38	
⑤ Net irrigation Requirement		121	128	179	163	23	614

TABLE A.1.2 NET IRRIGATION REQUIREMENT (4)

HA-IV

	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)		134	113	108	129	162	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		67	116.39	125.28	126.42	22.68	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	172	176	185	179	30	818
⑤ Effective rainfall	95	93	148	170	162	57	
⑥ Net irrigation Requirement	0	79	28	15	17	0	140
2) Other Crops							
ETo (Reference Crop Evaporation)	165	134	113	108	129	162	
Kc (Crop coefficients)	0.05	0.54	0.96	1.07	0.59	0.08	
① ETcrop	8	72	108	116	76	13	
② Per-Irrigation	40	40	–	–	–	–	
③=①+②	48	112	108	116	76	13	474
④ Effective rainfall	95	93	148	170	162	57	
⑤ Net irrigation Requirement	0	19	0	0	0	0	19

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)		139	145	169	173	180	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		70	149	196	170	25	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	175	209	256	223	32	970
⑤ Effective rainfall	2	0	0	4	22	42	
⑥ Net irrigation Requirement	73	175	209	252	201	0	909
2) Other Crops							
ETo (Reference Crop Evaporation)		139	145	169	173	180	
Kc (Crop coefficients)		0.25	0.77	0.98	0.87	0.3	
① ETcrop		35	112	166	151	54	
② Per-Irrigation		80	–	–	–	–	
③=①+②		115	112	166	151	54	597
④ Effective rainfall		0	0	4	22	42	
⑤ Net irrigation Requirement		115	112	162	129	12	529

TABLE A.1.2 NET IRRIGATION REQUIREMENT (5)

HA-V

	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)	137	119	111	106	111	121	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		60	114	123	109	17	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	165	174	183	162	24	783
⑤ Effective rainfall	127	130	175	167	211	115	
⑥ Net irrigation Requirement	0	35	0	16	0	0	50
2) Other Crops							
ETo (Reference Crop Evaporation)	137	119	111	106	111	121	
Kc (Crop coefficients)	0.05	0.54	0.96	1.07	0.59	0.08	
① ETcrop	7	64	107	113	65	10	
② Per-Irrigation	40	40	–	–	–	–	
③=①+②	47	104	107	113	65	10	446
④ Effective rainfall	127	130	175	167	211	115	
⑤ Net irrigation Requirement	0	0	0	0	0	0	0

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)	139	141	147	163	153	144	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		71	151	189	150	20	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	176	211	249	203	27	941
⑤ Effective rainfall	11	0	4	6	40	74	
⑥ Net irrigation Requirement	64	176	207	243	163	0	852
2) Other Crops							
ETo (Reference Crop Evaporation)	139	141	147	163	153	144	
Kc (Crop coefficients)		0.25	0.77	0.98	0.87	0.3	
① ETcrop		35	113	160	133	43	
② Per-Irrigation		80	–	–	–	–	
③=①+②		115	113	160	133	43	564
④ Effective rainfall		5	3	8	41	51	
⑤ Net irrigation Requirement		110	110	152	92	0	464

TABLE A.1.2 NET IRRIGATION REQUIREMENT (6)

HA-VI

	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)		125	102	103	102	128	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		63	105	119	100	18	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	168	165	179	153	25	765
⑤ Effective rainfall	127	141	111	111	151	101	
⑥ Net irrigation Requirement	0	27	54	68	2	0	151
2) Other Crops							
ETo (Reference Crop Evaporation)	134	125	102	103	102	128	
Kc (Crop coefficients)	0.05	0.54	0.96	1.07	0.59	0.08	
① ETcrop	7	68	98	110	60	10	
② Per-Irrigation	40	40	–	–	–	–	
③=①+②	47	108	98	110	60	10	433
④ Effective rainfall	127	141	111	111	151	101	
⑤ Net irrigation Requirement	0	0	0	0	0	0	0

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)		128	130	161	155	140	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		64	134	187	152	20	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	169	194	247	205	27	916
⑤ Effective rainfall	21	3	2	22	56	82	
⑥ Net irrigation Requirement	54	166	192	225	149	0	786
2) Other Crops							
ETo (Reference Crop Evaporation)		128	130	161	155	140	
Kc (Crop coefficients)		0.25	0.77	0.98	0.87	0.3	
① ETcrop		32	100	158	135	42	
② Per-Irrigation		80	–	–	–	–	
③=①+②		112	100	158	135	42	547
④ Effective rainfall		3	2	22	56	82	
⑤ Net irrigation Requirement		109	98	136	79	0	422

TABLE A.1.2 NET IRRIGATION REQUIREMENT (7)

HA-Ⅶ

	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)	137	119	11	106	111	121	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		60	114	123	109	17	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	165	174	183	162	24	783
⑤ Effective rainfall	160	145	169	182	207	117	
⑥ Net irrigation Requirement	0	20	5	1	0	0	26
2) Other Crops							
ETo (Reference Crop Evaporation)	137	119	111	106	111	121	
Kc (Crop coefficients)	0.05	0.54	0.96	1.07	0.59	0.08	
① ETcrop	7	64	107	113	65	10	
② Per-Irrigation	40	40	–	–	–	–	
③=①+②	47	104	107	113	65	10	446
④ Effective rainfall	160	145	169	182	207	117	
⑤ Net irrigation Requirement	0	0	0	0	0	0	0

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)	139	141	147	163	153	144	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		71	151	189	150	20	
② Percolation		30	60	60	53	7	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	176	211	249	203	27	941
⑤ Effective rainfall	11	0	4	6	40	74	
⑥ Net irrigation Requirement	64	176	207	243	163	0	853
2) Other Crops							
ETo (Reference Crop Evaporation)	139	141	147	163	153	144	
Kc (Crop coefficients)		0.25	0.77	0.98	0.87	0.3	
① ETcrop		35	113	160	133	43	
② Per-Irrigation		80	–	–	–	–	
③=①+②		115	113	160	133	43	564
④ Effective rainfall		0	4	6	40	74	
⑤ Net irrigation Requirement		115	109	154	93	0	471

TABLE A.1.2 NET IRRIGATION REQUIREMENT (8)

HA-Ⅷ

	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)	203	181	148	136	162	183	
Kc (Crop coefficients)		0.5	1.03	1.16	0.98	0.14	
① ETcrop		91	152	158	159	26	
② Percolation		60	120	120	106	14	
③ Land preparation	75	75	–	–	–	–	
④=①+②+③	75	226	272	278	265	40	1,155
⑤ Effective rainfall	29	65	127	169	67	15	
⑥ Net irrigation Requirement	46	160	145	109	198	24	683
2) Other Crops							
ETo (Reference Crop Evaporation)	203	181	148	136	162	183	
Kc (Crop coefficients)	0.05	0.54	0.96	1.07	0.59	0.08	
① ETcrop	10	98	142	146	96	15	
② Per-Irrigation	40	40	–	–	–	–	
③=①+②	50	138	142	146	96	15	586
④ Effective rainfall	29	65	127	169	67	15	
⑤ Net irrigation Requirement	21	73	15	0	28	0	137

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
1) Rice (Wet)							
ETo (Reference Crop Evaporation)							
Kc (Crop coefficients)							
① ETcrop							
② Percolation							
③ Land preparation							
④=①+②+③							
⑤ Effective rainfall							
⑥ Net irrigation Requirement							
2) Other Crops							
ETo (Reference Crop Evaporation)		142	132	163	180	198	
Kc (Crop coefficients)		0.25	0.77	0.98	0.87	0.3	
① ETcrop		36	102	160	157	59	
② Per-Irrigation		80	–	–	–	–	
③=①+②		116	102	160	157	59	593
④ Effective rainfall		0	0	1	0	6	
⑤ Net irrigation Requirement		116	102	159	157	54	587

APPENDIX 5 - 2 GUIDELINE FOR PLANNING OF IRRIGATION PROJECT

1. PRE-FEASIBILITY STUDY

Pre-feasibility study shall be performed at the model river basin with the priority at each RBDA.

(1) Data to be Collected

(a) Aerial photograph and the map of 1 to 50,000 scale

(b) Hydrological data in the basin or the adjacent basin

(c) Socio-economic data including administrative boundary, number of villages, total population and household, farmers' population and household at present and their movement on the LGA basis.

(d) Soil and land use

(e) Agricultural data including crop area, cropping intensity of major crops and yield of crops per unit area on the LGA basis.

(f) Existing water resources projects including location and outline

(g) Crop water requirement, diversion water requirement and drainage requirement per unit area based on the existing irrigation project report.

(h) Construction cost for the irrigation and drainage canals and on-farm work from the existing irrigation project report.

(2) Preparatory Work for the Study in the Office

(a) Division of the basin into the several tributary basins with the catchment area of 1,000 to 2,000 km^2 on the map of 1 to 50,000 scale and measurement of their catchment area.

(b) Study for the basin salient feature such as the basin topography and geology, tributary system, land use, socio-economy, etc.

(c) Study for hydrological condition such as aerial rainfall and evaporation, annual average runoff, sediment transport, peak flood

discharge, etc. Preparation of the guideline for the specific yield of annual average runoff (mm), peak flood discharge ($m^3/see/km^2$) and sediment transport (m^3/km^2) in order to estimate approximate available surface water.

(d) Study for water demand in service area and present water use under the existing water resources projects.

(e) Finding of the proposed water source facilities such as dam, pumping station, etc. and service area on the map of 1 to 50,000 map.

(f) Measurement of catchment area on the map of 1 to 50,000 scale.

(g) Approximate estimation for the river runoff at proposed water source facility site based on the catchment area and the specific runoff yield.

(h) Approximate estimation for the available river runoff at the proposed site.

(i) Drawings of the location, catchment area, reservoir area, damsite, etc. for the existing and proposed projects on the map of 1 to 50,000 .

(3) Site Survey Work

The following survey is carried out for the downstream service area where the proposed water source facilities such as dam and pumping station have a possibility to be constructed. The survey is made on the basis of a map of scale 1:50,000 and aerophotos.

(a) Topographical and geological condition at water source site

(b) Hydrological condition by observation and interview to local people

- Water level and runoff fluctuation at water source site
- Flood and inundation damage in the service area

(c) Present water utilizing conditions at the farm land by rainfall inundation and streams

(d) Selection of canal alignment and location of the weir and pumping station to be related with the reservoir

(e) Consideration of the irrigation method newly introduced at the terminal

(f) Soil and present land use

The survey at the representative places in the service area is only made in accordance with collected data. When the unsurveyed soil is found at the field survey, such soil conditions are assumed by observation survey.

(g) Village socio-economic survey at the service area by questionnaire

The interview with the chief of the village and farmers will be made at a representative village in each sub-hydrological area. Subjects to be interviewed consist of history of village, relationship of village people, socio-economic conditions, agriculture, livestock and fishery conditions, problems and difficulty in villages, and necessity of development. The information collected in the interview will help the selection of the proposed project with the first priority.

(h) Selection of gaging station site for the surface water observation

(i) Beneficial intention survey for the project

(j) Environmental survey in the related area

(4) Data Analysis and Study in the Office Work based on Collected Data and Site Survey

(a) Hydrological analysis for monthly rainfall, evaporation and runoff at water facility site and the service area

(b) Study of the dimension of water source facility

(c) Water demand study in the service area

Water demand for irrigation is estimated based on crop water requirement, effective rainfall, percolation rate and irrigation efficiency. The standard water demand at each region shall be prepared taking into account the following items.

Crop Water Requirement

Crop water requirement is estimated by the crop to be introduced and evapotranspiration estimated by the modified Penman formula based on the meteorological data such as temperature, mean humidity, mean maximum humidity, mean wind velocity, mean wind velocity in daytime and night and mean cloudiness.

Effective Rainfall

The value of effective rainfall differs by crop water requirement in paddy/upland crop field, field conditions, and rainfall amount/intensity in the cropping calender. The effective rainfall shall be estimated on the daily basis and it will range from 70 to 80 percent of monthly rainfall.

Percolation Rate

Percolation is divided into two types, namely horizontal and vertical. Their percolation rates are affected by many factors, such as texture of soil, depth of top soil, groundwater level, etc. In principle, percolation rate should be determined by actual measurement.

Irrigation Efficiency

The irrigation efficiency consist of the following three kind efficiencies :field irrigation efficiency (Ea), efficiency on-farm ditches (Eb) and water delivery efficiency (Ec). Total efficiency is obtained by multiplication above three efficiencies ranging from 50 to 90 percent in accordance with adapted water distribution system and skillfulness of water management.

(d) Available runoff water for the service area

(e) Potential irrigation area by the proposed water source facility

Potential irrigation area is estimated by the available water at the water source facility site and unit water demand in service area.

(f) Land Use and Agro-Economy

The following items shall be analyzed on the small sub-hydrological area basis to clarify the necessity and urgency of irrigation

development taking into consideration the relation between the existing irrigation area and proposed area:

- Land use and population: all areas, area of paddy field, upland crops and other land, population and its density, population growth, farm population and household, average cultivation area per unit household, farm population density, etc.
- Annual change of land use: all areas, area of paddy, upland and other lands of the specified past years and recent year, and annual changing ratio of land use.
- Relation between land use and land classification: land classification of paddy field (5 classes), present land use for paddy and upland crops and their comparison, and the comparison of cultivation area and aerial rainfall in the small sub-hydrological area.
- Productivity of major crops: cropped area, farm household, cropping intensity, harvested ratio and yield per unit area.

(g) Selection of Service Area

The following area shall be selected with priority:

- Area where the implementation of irrigated agriculture is strongly requested by farmers
- Area with a suitable tenure arrangement for irrigated agriculture
- Area to be located near the water source facility

(h) Approximate project cost based on the acreage of service unit

(i) Project evaluation

- Economic and financial analysis of project economy
- Environment impact

(5) Selection of the Representative Projects for the Feasibility Study

In accordance with the above study, four to five representative projects will be selected for the feasibility study with the following conditions:

- Projects consisting of the medium and small scale as the representative size
- Projects with priority from view point of the project economy
- Projects without environmental problem
- Projects with easy condition for the survey and study such as accessibility to project site

2. FEASIBILITY STUDY

The feasibility study shall be performed for the above selected representative projects based on the international standard. In the implementation of feasibility study, the particular attention shall be paid for the following items:

(1) Survey and Investigation Works

(a) Preparation of aerial photo map of 1:10,000 scale covering the water source facility site and service area

(b) Hydrological observation of rainfall and river discharge in the service area and at water source facility site with a installation of hydrological station.

(c) Soil survey at the area which has been indicated as the area with soil problem in the pre-feasibility study.

(d) Survey of present land use and land classification in each sub-project based on the map of scale 1:10,000 newly prepared

(e) Detailed agro-economical survey in terms of items studied in pre-feasibility study.

(2) Hydrological Analysis

(a) Runoff analysis on daily basis by preparation of the runoff model at proposed water source facility site.

(b) Design flood capacity analysis for spillway of dam and weir based on the unit hydrograph

(3) Irrigation Water Demand Study

(a) Formulation of cropping pattern including crops to be introduced, cropping calender and cropping intensity.

(b) Estimation of irrigation water requirement on 10 days basis taking into account potential evapotranspiration, crop factor, effective rainfall, soil percolation rate and irrigation efficiency.

(4) Water Source Facility Plan

(a) Water operation study on 10 day basis for more than 20 years.

(b) Formulation of water operation rule of water source facility.

(c) Estimation of available river runoff in wet and dry season and also in wet and dry year.

(5) Preliminary Design of Canal and Appurtenant Structures

(a) Definition of proposed irrigation area

- Establishment of irrigation division such as service unit, block and zone.
- Formulation of irrigation water diagram

(b) Hydraulic and structural analysis

(c) Construction plan and cost estimation

- Construction method and schedule on the contractor basis for medium-scale project or force account basis of RBDA for small-scale project
- Cost estimation preparing the bill of quantity

(6) OM Plan

(a) OM organization, equipment and OM cost in public agency

(b) OM organization of WUA for beneficiary

(7) Environment Impact Assessment (EIA)

(a) Resettlement problem in the related area

(b) Other ecological problem by the construction of project facilities

The procedure of EIA may be referred to Chapter 11 of the Sector Report for detail

(8) Project Evaluation

(a) Economical and financial analysis for the project cost

(b) Evaluation of farmer income generation and job creation

(c) Evaluation of environment impact

APPENDIX 5-3 GUIDELINE OF OPERATION AND MAINTENANCE OF IRRIGATION CANAL SYSTEM

1. OPERATION OF IRRIGATION CANAL SYSTEM

(1) Establishment of Division of Irrigation Service Area

Irrigation project area is subdivided into the following areas in accordant with their acreage of irrigation area for the operation of canal system:

	Area (ha)	Responsible OM Staff
Service Unit	20 to 40	Water Master (WM)
Irrigation Block	200 to 400	- ditto -
Zone	1,500 to 3,000	Zonal Officer

The OM office under a manager will carry out the water management of irrigation canal system by OM staffs such as Water Masters (WMs) who control farm turnout at the head of service unit and Zonal Officers who control a several WMs in their jurisdiction.

While, Farmers Irrigation Groups (FIGs) are established as a farmers' organization at each service unit and the terminal facilities in service unit are consolidated by them. Water users Association is also farmers' organization and comprises several FIGs.

(2) Request and Allocation Procedures of Irrigation Water

The present procedures of request and allocation of irrigation water are not properly made because of the reasons that i) Irrigation area and schedule to be requested by the farmers can not be estimated accurately by Water Master (WM), ii) Estimation of irrigation water by Irrigation Blocks and Zones can not be made quickly and accurately, iii) Exact allocation of irrigation water on the weekly basis at each check and head gate is very hard, and iv) Allocation of irrigation water at each block and zone in considering an effective

rainfall is not properly made. And these facts have caused shortage of irrigation water and inundation in the downstream area.

In order to execute proper water management for supplying irrigation water to the service area, the followings are proposed to improve the procedures for request and allocation of irrigation water.

(a) Preparation

- The irrigation flow diagram in the canal system shall be prepared and te Irrigation Block (IB) covering about 10 service unit shall be formulated in taking into account the area commanded by major check and head gates and division/zone boundary.
- The service area to be irrigated is accurately estimated on the turn-out basis, Farmers Irrigation Group (FIG) basis, by using cadastral maps and summarized on the IB basis. This work will be made by the Water Master (WM) coordinating with WUA, FIG and farmers. This area becomes the base for request and allocation of irrigation water.

(b) Plan for Request and Allocation

- The request and allocation plan of irrigation water shall be prepared about one month before starting cropping season in each main canal system. WUA shall prepare the irrigation area and make schedule by FIG or the member farmers to submit to the Water Master (WM). WM shall check the schedule to make adjustment and shall arrange the schedule by WUA and summarize it on the IB basis.
- The irrigation area and schedule on the IB basis shall be submitted to OM Office by WMs. OM office shall estimate promptly and accurately the irrigation requirement on the IB basis for the major check and head gates by using computer. The OM office shall adjust the estimated irrigation requirement taking into account the available effective rainfall and storage water conditions in reservoir, diversion dam and pumping station before starting cultivation.
- In accordance with the above estimation and adjustment, the OM Office manager shall determine the allocation plan of irrigation water supply to IB and outflow from reservoirs, diversion dams and pumping stations, and give instructions to each District manager

or Zonal officer. This allocation plan is prepared on the weekly basis.

- The District manager or zonal officer shall give instructions to WM and WUA so as to keep the above allocation of irrigation water according to the expected irrigation schedule in the cropping season.

(c) Actual Operation for Request and Allocation

- Actually, the procedures for request and allocation of the irrigation water shall be followed in the manner as specified in the plan on the weekly basis.
- The operation may be revised slightly to the plan because of some differences in conditions by actual irrigation area, delay in irrigation schedule by farmers, delay in irrigation water to reach farm areas due to defect of irrigation canals or misoperation of in gate operation, conditions of rainfall available, storage condition in the reservoir, etc.
- These variable factors are carefully studied on the weekly basis by OM office with collected data and information available, and then the final water allocation will be made by OM Office manager and given to each District manager or zonal officer.
- The control of irrigation water supply will be practiced by check and head gate keepers under WM according to the instruction on the water allocation.

(d) Estimation Method

- The estimation of irrigation water allocation will be made by computer.

(3) Operation of Canal System

Irrigated agriculture would not be realized without adequate operation of canal system. The proper allocation and delivery of water can be achieved by adopting the following activities:

- To practice the correct discharge measurement,

- To set the gate opening rate in corresponding to programmed diversion requirement, and
- To execute monitoring and checking of canal flow.

(a) Check of Water Flow

Following distribution control of irrigation water in the canals is very important works for the OM Offices;

- To schedule gate operation works,
- To compare discharges between programmed and measured at the specific points in the canals, and
- To adjust the gate opening rate at the problem sites with large difference in flow rate.

The discharges measurement for gate operation will principally be practiced by automatic water level recorders or staff gages, and periodical calibrations also are needed to maintain the correct relationship between water level and discharge.

(b) Water Distribution Control

As a general rule, the water distribution control by setting the gate opening rate should be done in taking into account its stream characteristics, and weekly irrigation water requirement at the check and head gate points in corresponding to farming activities on lateral basis should be decided and instructed to the operators in advance by OM Offices. And then, the gate operators can adopt easily correct opening rate for the designated gates.

(4) Water Management at On-farm Level

Water management at on-farm level should be practiced under the chief of FIG and WUA to conform with the proposed distribution schedule and irrigation rule. The basic rule for water use at the on-farm level is shown as follows;

- Executions of irrigation water supply in accordance with the planting stage of crops,
- Strict observance of the rotational irrigation schedule,

In connection with the improvement of water management at on-farm level, the existing on-farm facilities such as farm ditches, farm drains and farm roads should be improved under the support by the OM Offices.

2. MAINTENANCE OF IRRIGATION CANAL SYSTEM

Maintenance and repair works of irrigation system are inseparable from operations activities. It embrace basically, some major elements of irrigation system management. Without maintenance, operation cannot be efficiently implemented.

Most of failure in the irrigation system, especially in the implementation of water management can be attributed to poor maintenance of irrigation facilities. Eventually, these lead to low water utilization and to a loss of expected benefits from huge government investments.

As much as possible, the original design capacity of canals must be retained. To do this, plan for repairs, needed improvements and other related activities shall be undertaken properly. However, some activities like routine maintenance may be done during irrigation season. Along this, the guideline or procedures for maintenance and repair works is necessary in bringing out better irrigation services to farmer clienteles. If the importance of maintenance and repair works is brought to the concern of the beneficiaries, the problem on the preserving longer the useful life of the irrigation system's facilities could be minimized.

(1) Inventories and Drawings for System Facilities

To prepare the inventories of system facilities is very important for the operation and maintenance in the irrigation system. At the same time, the lay out map of service area about 1/50,000 indicated stations, type and size of

structures or gates are very useful on the execution of maintenance works. The following inventories and drawings for system facilities shall be arranged:

- Inventories of system facilities by each kind of structure in every canal system
- Canal system diagram for planning and designing of canal and related structures.
- Canal layout basic map with a scale of 1 to 50,000
- Road layout map with a scale of 1 to 50,000

(2) Routine Inspection of System Facilities

The system facilities shall be periodically inspected. The result of inspection is arranged and tabulated by the following items, then it will be used for basic data of maintenance plan.

- Water source fasility
- Canal system
- Gate

(3) Maintenance of System Facilities

System maintenance may be classified according to the nature of the work, namely:

(a) Maintenance of water source facility
(b) Maintenance of canal
(c) Maintenance of structures and mechanical facilities
(d) Maintenance of service/access road
(e) Maintenance of system drain
(f) Maintenance of pump
(g) Maintenance of farm level facility

Personnel of the O & M, such as the Ditchtender, Gate Keeper, and WM are directly involved in these activities. It shall be their responsibility that irrigation facilities such as farm ditches, irrigation canals, drainage

ditches/canals, appurtenant structures, measuring devices, gates, access/service roads, etc., in their respective coverage are properly maintained. On the other hand, pump facilities and its appurtenances shall be in order for effective operation. Farm level facilities, as well, shall be maintained by farmer-users with the motivation of the WM concerned.

Prior to irrigation water releases, all these facilities much be in good shape. Once irrigation commences, farmer-users shall not be allowed to draw water from the canal unless farm ditches are properly cleaned and ready to receive irrigation water. This procedure will oblige the end-users to do their part in the maintenance of the irrigation system.

(4) Repair and Improvement Work

Repairs usually undertaken consists of earthworks, replacement of R.C Pipes, lubricating gate lifting devices, painting, rip-rapping, desalting and others. the repairing and improvement work will be carried out the following procedures:

- Inspection of defective facilities and reporting to zonal officer/district manager by WM
- Preparation of the inspection report and repair and improvement plan by zonal officer/district manager and submittance them to the OM offices
- Preparation of budgetary plan and implementation of repair and improvement work by the OM offices on force account basis

APPENDIX 5-4 REFERENCES

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