3.1.8.3 Boreholes

(1) Kadoma District

Availability of the boreholes in the related wards of K17, K20, K21, K22, K23, and K24 in the district is summarized as shown below.

Availability of Boreholes in the Related Wards in Kadoma District

Name of Ward	Population (1998/Estimated)	Numbers of Boreholes	Availability (persons/borehole)	Remarks
K17 (Muzvezve I)	8,829	59	149	
K20	10,998	-	-	Data not available.
K21	5,708	15	380	
K22	5,757	44	130	
K23	13,474	28	481	
K24	9,867	26	379	
Total/Average	54,633	172	253 (Excluding K20)	

Each community, through water point committee of the district, manages these water points. Women, for the most part as is the case with the other districts, have to carry household water, and the distance that they have to travel to fetch water can be time consuming as well as a burden. There are 10 pump minders employed by DDF in the communal areas, and 3 in the small-scale commercial farming areas, but none in the resettlement areas of the district.

(2) Gokwe North District

There are 35 boreholes and 2 deep wells in Makore I, and 14 boreholes and 1 deep well in Makore II in the district. The availability of boreholes and deep wells in these two wards is summarized as follows:

Boreholes in the Related Wards in Gokwe North District

Name of Ward	Population (1998/Estimated)	Numbers of Boreholes/Deep Wells	Availability (persons/borehole)
Makore I (GN 11)	10,721	37	289
Makore II (GN 12)	7,197	15	479
Total/Average	17,918	52	344

Source: Gokwe North District Profile, 1998.

(3) Gokwe South District

In total, there exist 386 boreholes in the district, of which, 36 boreholes exist in Chisina I, and 23 boreholes and 1 deep well in Chinina II of the district. Number of the boreholes in the two wards is summarized as shown below.

Number of Boreholes in the Related Wards in Gokwe South District

Name of Ward	Population (1998/Estimated)	Numbers of Boreholes/Deep Wells	Availability (persons/borehole)
Chisina I (GS 23)	17,251	36	479
Chisina II (GS 24)	13,303	24	554
Total/Average	30,554	60	509

Source: Gokwe South District Profile (1998).

About 35% of the households collect water from unprotected wells and boreholes, while about 25% of the same collect water from the rivers and small dams. Thus, nearly 60% of the households use water with potential health risks. Only 5% of the households in the district have access to the piped water.

Of the few with access to protected water sources, the average population per borehole per ward is very high. Furthermore, only 4% of the households in the district have water available on their premises, while the vast majority have to walk a long distance for water. Approximately, 75% of the households in the district have to walk over half a kilometer to obtain water. The following table shows the areas which are most deprived of adequate water supplies in the district.

Areas with Inadequate Water Supplies

Ward	Population (1992)	Current Water Supplies			Required Water Supplies		
		Boreholes	Deep Wells	ShallowWells	Boreholes	Deep Wells	Shallow Wells
Nemangwe V	9,596	5	0	0	23	23	4
Ndhlalambi II	10,128	9	1	0	21	22	5
Ndhalalambi I	12,159	15	3	0	22	23	6
Nemangwe IV	8,144	5	0	0	19	19	4
Chisina III	10,671	18	0	0	18	18	3
Masuka	6,550	3	0	0	17	14	4
Sai I	11,952	26	0	0	17	16	4
Chrisina I	14,376	36	0	0	17	16	5
Nemangwe I	8,678	10	0	3	17	17	4
Sai IV	5,440	2	0	0	14	13	2
Jiri I	6,865	6	0	0	15	15	3
Total	104,559	135	4	3	200	196	44

Source : Integrated Rural Water Supply and Sanitation Program (1993).
Note: Availability of water point at 1993 level: 104,559/ (135 + 4 + 3) = 736 persons per water point.

(4) Kwekwe District

There are 33 boreholes in Mabura of Ward No.6 and 20 boreholes in Sidakeni of Ward No.7 in the district. Availability of the boreholes in these two wards is summarized as follows:

Availability of Boreholes in the Related Wards in Kwekwe District

Name of Ward	Population (1998/Estimated)	Numbers of Boreholes and Deep Wells	Availability (persons/borehole)
Mabura (Ward No.6)	6,435	33	195
Sidakeni (Ward No.7)	6,419	20	320
Total/Average	12,854	53	242

Most people in the wards obtain their water from these boreholes. The average depth of these boreholes in the district is 55.0 meters with protection of galvanized iron pipes of 6 inches diameter. Figures in the above table suggest that the water supply by boreholes in Mabura meets the desired water supply level of 250 persons per borehole, while Sidakeni needs additional provision of boreholes.

3.1.8.4 Rural Electrification

Rural electrification in the Study Area is not at all in progress. Electrification in Zimbabwe is being carried out mainly by Zimbabwe Electricity Supply Authority (ZESA). However, concerning the rural electrification, ZESA is not playing its full role. Regarding the rural electrification, ZESA emphasizes to supply power lines up to the existing business centers and growth points that are expected to become the cores of development and economic growth of the target areas. ZESA , at present, is not financially capable of supplying electricity to each household in the Study Area.

In the case a farmer household or a group requesting a power line to their house, they must first contact the authority of the designated business center or growth point for wiring of power line, and pay in advance. However, at present , since the cost of wiring to each household is expensive relative to the income of the farmer household, progress in rural electrification, especially electrification of farmer households is very slow.

Under these circumstances, rural electrification in Gokwe North District, Gokwe South District and Kwekwe District is hardly progressing. Rural electrification is also promoted under the Rural Electrification Program. However, due to shortage of funds, the progress in the program is not satisfactory.

3.1.8.5 Community Centers and Communication Systems

At present, there are no community centers in the Study Area. Also, existing communication systems especially among the small farmers are not well developed. They get information through extension workers, visits to towns for shopping and selling their agricultural products as well as through reading materials and radio, etc. Under the present communication systems, public transportation still plays an important role together with the existing local road networks. Under the above-mentioned condition, however, some of the existing business centers like Sanyati and Nyimo, etc., in the Study Area are functioning as community centers where farmers can exchange information with each other.

3.1.9 Agricultural Supporting Services

3.1.9.1 Agricultural Research

(1) Current Status

The Department of Research and Specialist Services (DR&SS) within MOLA is responsible for most of the agricultural research conducted in Zimbabwe focussing on small-scale agriculture. The DR&SS's major works are agricultural technology development and specialist services including seed certification, soil testing and the development of agricultural industry health standards. DR&SS is organized into three main divisions: crops, livestock and pastures, and research services. In addition, a Farming Systems Research Unit (FSRU) is directly responsible to the Director as are the heads of the three main divisions. The department is divided into 17 institutes along disciplinary lines and operates 12 research stations throughout the country. DR&SS has been to maintain high professional standards. However, these standards are under increasing pressure of financial constraints and the loss of more senior and experience staff.

Beside DR&SS, some privately funded research is also playing an important role in the agricultural sector development particularly in commercialized crop development. The list of major research institutes and stations is shown in Table 3.1.11. As indicated in the table, most of the research facilities are located in NR II where commercial farming is dominant, and only one facility of the Cotton Research Institute is available in Region III in Kadoma.

Privately funded research includes that of the Tobacco Research Board, the Agricultural Research Trust, the Zimbabwe Sugar Association, and the Zimbabwe Seed Companies. Agricultural research is also conducted by the University of Zimbabwe. All publicly funded research is coordinated by the Agricultural Research Council (ARC) which serves as an advisory body to MOLA.

(2) Government Policy on Research

The strategies of research activities stated in the Zimbabwe's Agricultural Policy Framework (1995-2020) are as follows:

(a) Demand-driven research, linked to the needs of farmers, extensionists and researcher,
(b) Adaptive research
(c) Greater coordination between public and private research institutions,
(d) Participatory approaches in determining research priorities,
(e) Linkages with external organizations to keep abreast of regional and world developments, and
(f) Greater commercialization and cost recovery in selected research services.

In relation with item (f), the commercialization of DR&SS's services is in progress. These include contract research, royalties on crops and animal breeds developed by the department and revision of service charges on cost recovery basis. In addition, MOLA has plans for the sale of experimental produce on market prices, production activities on excess land and infrastructure at various research and experiment stations, through the provision of consultancy services and training.

(3) Cotton Research Institute

The institute was established in 1925 at the present location in Kadoma where agro-ecologically belongs to NRIII (semi-intensive farming region) and suitable for cotton production. The institute is considerably well equipped with research facilities and equipment. Under the head, the institute has five sections, namely breeding, agronomy, entomology, pathology, and farm support, the institute has been responsible for research activities solely on cotton since the establishment. Recent research priority is being given to hybrid cotton, organic farming, and colored cotton according to the institute.

3.1.9.2 Agricultural Extension

(1) Organization and Staffing

AGRITEX under MOLA plays the most important role in the public sector agricultural extension services particularly in small-scale farming areas. At the national level, AGRITEX services are organized into two major divisions, i.e. Field division and Agricultural Engineering and Technical division. The Field division is responsible for the field extension services. The Agricultural Engineering and Technical division includes the branches of Irrigation, Soil and Water Conservation, Engineering, Agricultural Management, Animal Production, Crop Production, Land Use Planning and Training (see Figure 3.1.9.).

Each of the eight provinces is led by a Chief Agricultural Extension Officer (CAEO) who is responsible for the agricultural extension in all the provincial districts. CAEO is also expected to provide the linkage between the Provincial Government and Head Office, and usually serves in a number of Provincial Government Committees concerned with agriculture and rural development. Until recently, the CAEO was supported by two Principal Agricultural Extension Officers (FAEOs), one was for leading and managing the provincial extension organization, and the other was for managing a group of Provincial Subject Matter Specialist (SMSs) as a part of the Technical division. This structure remains intact, but AGRITEX has decided to reduce the number of management positions including that of the PAEO. All these officers are now in the process of transfer and expected to be operational extension officers.

Each district (53 in total) is led by a District Agricultural Extension Officer (DAEO) who coordinates the extension services carried out at the district level by Field Agricultural Extension Officers (FAEOs), who were assigned as Agricultural Extension Officers (AEOs), Agricultural Extension Supervisors (AES) or Agricultural Extension Workers (AEWs) till recently. Like CAEO, DAEO provides the linkage between Provincial AGRITEX and the district government, and serves on a number of District Government Committees concerned with agriculture and rural development. FAEOs are stationed at ward/village level and responsible for the front line extension services.

The present assignment of extension staff in three districts related to the Study area is presented in Table 3.1.12. The number of FAEOs is 41 in Kadoma, 42 in Gokwe North and 57 in Gokwe South. On average, one FAEO serves about 670 farmers in Kadoma, 810 farmers in Gokwe North and 930 farmers in Gokwe South district. These figures are still higher than the AGRITEX's target of 400 farmers per AEW. Although AGRITEX is now in the process of AEWs' qualification upgrading program, most of them are agricultural certificate holders.

(2) Extension Methodology

FAEOs implement a variety of programs with small holders. They usually work through farmer groups with which they have contact on a regular basis. Prior to the crop season, FAEO and farmers have a meeting so-called farmer-extension worker meeting. In the meeting, annual group program is formulated. The group program varies depending on the groups' production characteristics, e.g. cropping programs for crop farmers, livestock program for livestock farmers and irrigation programs for irrigation farmers. Following the formulated group program, FAEOs disseminate specific production technologies and practices aimed at addressing the farmers needs as reflected in the farmer-extension worker annual program plan. One farmer group consists of about 100-150 farmers.

FAEOs' field activities are supervised by senior FAEOs (formerly called AESs) stationed also in wards/villages, and, as per needs, district level training for FAEOs is provided usually once or twice per month at selected venue within the FAEO's area. Further, FAEOs are trained at their respective provinces or at AGRITEX Head Office, Domboshawa Training Center, Hatclif Engineering Training Institute and other venues depending on the nature of the training or course required. The resource trainers include the SMSs from AGRITEX and others from various specialisms.

The Master Farmer (MF) training program is a special training activity for farmers. Ordinary MFs are qualified after duration of two years' undergone special training offered by the FAEOs and practices as per the ordinary MFs curriculum. For one to qualify, one will have satisfied the assessors who inspect one's MF training book and practicals. They can be advanced MFs after additional one-year training and passing the AGRITEX's national examination. The contents of training program are well organized and cover various technological aspects including crop and livestock farming, farm economy, marketing of products, housing and sanitary. In case of Gokwe South, one FAEO takes charge of the MF training for about 10-20 farmers every year. AGRITEX staff needs to devote a comparatively large proportion of their time to the MF program. As other works of FAEOs, they implement demonstrations and organize field days. Nowadays, most of demonstrations are being carried out with an assistance of private sector (e.g. seed producers) which supplies improved seeds and other inputs for crop demonstration.

(3) Government Policy on Extension

The strategies on agricultural extension works stated in the Zimbabwe's Agricultural Policy Framework (1995-2020) are as follows:

(a) The active participation of technology users will be encouraged in guiding priorities, projects and programs,

(b) Develop human resources through in-service training and short-course program aimed at improving the professional/technical capacity of staff,

(c) Professional/technical information will be developed and updated through a sound management information system,

(d) Mass communication instruments which have a higher coverage will be developed,

(e) Government will continue to support the institutions over and above funds realized through commercialization, and

(f) Agri-business and other agricultural private companies will be assisted and encouraged to provide extension services to farmers.

(4) Cotton Training Center (CTC)

The Cotton Training Center (CTC) was established in 1972 by the Commercial Cotton Growers' Association (CCGA), an organization of large-scale commercial cotton growers. The CTC is located in the northeastern part of Kadoma town nearby the Cotton Research Institute or about 5 km from the center of the town. The objectives of CTC are, (i) to facilitate the provision of training and advisory services of the highest caliber, (ii) to ensure the future development of cotton production, particularly in respect to new growers in both the large and small-scale sectors. CTC has provided training services for some 25,000 trainees after its establishment, covering cotton cultivation technique and marketing, solely for cotton.

3.1.9.3 Agricultural Credit

Financial institutions in Zimbabwe have provided credit to the agricultural sector for over 30 years, although informal credit is also widely prevalent, especially in the communal areas. The informal sector includes private moneylenders, traders, shopkeepers, relatives and friends. The formal sector includes the Agribank (formerly called Agricultural Finance Corporation/AFC), five commercial banks with branches throughout the country, the Cotton Company of Zimbabwe (COTCO), the largest provider of formal credit to farmers in the Study Area, the Cold Storage Commission (CSC), a few Cooperatives whose role in credit has diminished over the past decade, a few non-government organizations (NGO's) and companies engaged in contract farming. Over the last few years these latter companies are becoming increasingly important.

All financial institutions concentrate on the more profitable large-scale commercial agricultural sector. Small farmers as a rule have met their agricultural financing needs from their own resources. In fact, a survey of the Project Area carried out in December 1998 revealed that 65% of farmers did not or could not obtain credit in the 1997/98 cropping season. The main sources of finance for farmers who did not get credit from formal sources are cash from the sale of agricultural produce and remittances from family members working outside. Of those who sought credit some were ineligible because of a lack of collateral, could not provide a guarantor, or had defaulted on loans in the recent past.

This is the pattern in communal areas throughout the country where only some 5% received any loan credit from the formal sector. However, the December 1998 survey revealed that 35% of farmers borrowed for cultivation in the 1997/98 season. This is higher than the national average mainly because of the importance of cotton cultivation and access to COTCO credit facility.

Agribank's lending is somewhat restricted in the Project Area as a result of internal reforms and its concentration on a much-reduced clientele due to an emphasis on quality lending. The bank had low recovery rates in the early to mid nineties, partly because of the droughts but also due to poor loan appraisal and loan administration. The countrywide number of small holders receiving loans from the bank has declined from 100,000 in 1985 to 30,000 in 1998. Source of loans in the Project Area based on the survey is as follows:

Source of Loans

Source	Average Loan Size (Z$)	Percentage of Recipients (%)
Agribank	3,300	26.1
COTCO	5,553	60.9
Cargill Company	1,935	4.3
Friends/Relatives	250	4.3
Cooperatives	5,000	4.3

In the Project Area, Agribank's lending in the last two years is rather limited. Information available for two branches namely, Sanyati and Muzvezve I indicate a total of 225 short term loans in 1997/98 with the average size of loan of Z$ 8800 and 184 short term loans in 1998/99 with average size of loan of Z$ 10,360. Medium term loans are also very limited details of which appear below. Interest rates on the short-term loans are high at 34% p.a. in 1997/98 and 36.5% in 1998/99.

Agribank's Loan Disbursement in Sanyati and Muzvezve I (1997-1999)

	Loan Type	Beneficiaries (person)	Total Loans (Z$)
SANYATI			
1997/98	Short term	30	242,962
	Medium term	11	330,000
1998/99	Short term	49	453,856
	Medium term	Nil	Nil
MUZVEZVE I			
1997/98	Short term	195	1,734,588
	Medium Term	6	87,000
1998/99	Short term	135	1,452,534
	Medium term	2	97,432

Source: Agribank branches in Sanyati and Muzvezve I

Agribank also offers credit to small holders through various schemes such as the Small Farm Credit Scheme, Resettlement Credit Scheme and the Group Lending Credit Scheme. The group lending scheme has been promoted as a means of reducing credit delivery costs through consolidation of multiple loan applications from small scale farmers and improving repayment performance through incorporation of peer pressure as group loans are subject to joint and several liability. The bank provides training to groups in credit administration before a group is eligible to apply for loans and groups have to set up a savings account with a bank or building society as a condition of a loan. Group lending by the bank has increased markedly since 1993 and now accounts for around half of the value of all loans to small holders.

The five commercial banks operating in Zimbabwe concentrate on the corporate business sector. In the rural areas, the commercial banks provide short term financing mainly to large-scale commercial farmers through overdraft facilities and to small businesses and enterprises. Lending to small farmers especially in communal areas is very restricted as farmers.

The Cotton Company (COTCO) provides loans through the Input Credit Scheme to registered cotton growers in the large-scale commercial and small holder sectors. For small holders, loans are provided to groups of registered cotton growers to enable purchase of seed, fertilizer, agricultural chemicals and spraying equipment. The scheme provides credit to about 30,000 farmers countrywide on an annual basis and is currently the most important source of credit to farmers in the Project Area. The interest rate is below the market rate and the initial capital was provided through a World Bank credit facility. The recovery rate is high as the loan is repaid as a deduction from the sale of the crop on delivery to COTCO.

A recent and increasingly important source of credit for small farmers, especially in irrigated cultivation are the contract companies for outgrower farmers. These companies also operate in the Project Area and provide farmers with contracts for delivery at pre-announced prices and the companies provide seeds, fertilizers, and agricultural chemicals as part of the contract for delivery of produce to the company.

Major problems in the provision of agricultural credit is that the small farmer is largely excluded because lending policies are based on viability, proven past performance and the provision of collateral. There is also a lack of training and expertise in financial institution staff on financial management and a lack of a credit culture. The current credit structure in Zimbabwe is inappropriate to small farmer needs. Group lending has overcome some of these problems but has not yet become widespread. In an overall sense, it is clear that credit available to farmers in the Project Area is inadequate. More farmers receiving credit for working capital could ensure higher yields and farm productivity. Farm survey data indicates that only 35% of the farmers surveyed obtained cultivation loans.

3.1.9.4 Agricultural Cooperatives

There are three production cooperatives in the resettlement Ward 17 (Muzvezve 1) in Kadoma district. All these cooperatives have been established under Model B of resettlement program. Total land allocated to the cooperatives is about 7,440 ha of which only about 930 ha or 12% are presently cultivated as shown in the table below.

Production Cooperatives in the Study Area

Items	Pazvavambua Coop.	Chiwirirano Coop.	Tashinga Coop.
Year established	1993	1996	1983
Member farmers	10	78	70
Area allocated	2,401 ha	2,658 ha	2,383 ha
Present cultivation area	70 ha	358 ha	500 ha
Of which irrigated	70 ha	30 ha	0 ha
Irrigation method	pump + splinkler	pump + splinkler	-
Major crops cultivated	Maize, Cotton, Horticulture (tomato, cabbage, etc.)	Maize, Cotton, Horticulture (green maize, paplica, etc.)	Mize, Cotton
Farm machinery	1-tractor with attachments	No machinery : They hire it based on needs.	Draft power is used instead of machinery
No. of cattle	25	41	150

Sources : Each cooperatives visited during January – February, 1999 period

Support services for the cooperatives are provided mainly by the District Department of Cooperatives under the Ministry of National Affaires, Employment Creation and Cooperatives. Major supports provided are training on the cooperative management system usually at the initial stage of cooperative formation, extension services, marketing and financial assistance, however its service coverage appears to be limited

3.1.9.5 Non-governmental Organizations (NGOs)

Before 1980, the most prominent NGOs in Zimbabwe were concerned with welfare (emergency relief, health, education, home crafts) or religious activities. After independence, however, many NGOs including international NGOs emerged and started to support new local initiatives for community and/or rural development, income generation projects and agriculture as important areas of activity alongside relief and welfare. As members of National Association of Non-Governmental

Organizations (NANGO), there are 180 local and international NGOs, and most of which are concerned with the above mentioned new activity, although their degrees of involvement depend on their characteristics.

Although there are many NGOs in Zimbabwe, their activities are limited in the Study Area. According to AGRITEX, many NGOs have sifted their activities from the rural areas in the Study Area to other dry zones, e.g. southeastern part of Zimbabwe where climate is drier than the Study Area. NGOs' major supporting fields in the Study Area are health and sanitation (Catholic Mission and Red Cross Society) and water supplies (Manyura Mhanzi Trust) in a small scale. Nevertheless, NGOs are playing an important role in community and rural development in Zimbabwe. In fact, a number of NGOs are active providing financial and technical support for many programs.

3.1.10 Environmental Background

3.1.10.1 Physical and Geographical Features of Project Area

The vegetation in the project zone predominantly consists of mixed savannah woodland, dominated by brachystegia, combretum, terminalia, grewia and accacia species. Climax vegetation is a *miombo* or *mopane* mosaic.

Tsetse fly (*Glosina spp*) once infested large areas of the *Lowveld* including much of the project zone, thus restricting the presence of livestock and human settlement. Control of tsetse has allowed the in-migration into this zone over the last 30 years. There is limited woodland (when defined as <30% cleared). Remnant stands tend to be restricted to the marginal cultivable land dominated by *mopane* species.

Two ecological categories were distinguished in the 1992 Kudu Dam EIA Report: (a) the terrestrial Mopane and Acacia Woodland, and (b) the river and riparian fringe.

(a) Mopane and Acacia Woodland

The predominant tree species is the tall and short scrub mopane (*Colophospermum mopane*). The acacia woodland comprises mainly short scrub muunga (*Acacia nilotica*) in the river valley and dense impenetrable thickets of mupangara (*Dichrostachys cineria*). On the right bank taller more mature trees dominate because this was until recently unoccupied state and commercial farmlands. Bird fauna typical of mopane and acacia woodland are evident.

(b) River and Riparian Habitat

The dominant tree species are those requiring the higher moisture level and fertile silt of the river. The weeping willow (*Salix subserrata*) predominates. Other tree species associated with this aquatic ecosystem are the musuma (*Diospyros mespiliformis*), muchechete (*Ziziphus mucronata*) and mupfuti (Brachystegia boehmii). Bird fauna associated with the river fringes are apparent and dry season river pools retain fish species including Tilapia spp., Clarius spp. and kapenta (*Limnothorisa spp.*).

Very few wild animals (kudu, baboons, monkeys and squirrels) have been observed in the Project Area. As for the flora in the inundation area, the terrestrial and aquatic species are readily found elsewhere in both the Munyati Basin and in other parts of the country. There are, therefore, no biodiversity issues of concern from the construction of the dam. Indeed the new habitats created by the dam will add to the local biodiversity and at the same time increase the economic value of the environment.

3.1.10.2 Human Environment

(1) Farming Systems, Land Use and Mining

Subsistence farming is dominated by maize, sorghum and millet: cotton is the most important cash crop. Livestock husbandry is an important element in the livelihood system of communal land areas, where there is persistent low offtake. Most smallholders also keep goats and hens. The reasons for land degradation are an inherent tendency to overstocking, sometimes poor soils and limited technology, aggravated by occasional drought.

Gold, nickel, coal, asbestos, copper, chrome ore, iron ore, silver, and tin are exploited near to the Project Area by commercial companies. Drought and loss of formal employment opportunities has intensified artisanal mining, including illegal river bed activities which have been rendered politically difficult to control.

(2) Population and Social Characteristics of Project Area

The population of Zimbabwe is increasing at 2.9% (1992 census), creating environmental pressures both in the rural communally owned areas (through over-grazing) as well as in the major towns (in terms of sanitation and housing). Access to safe drinking water records, as calculated from 1992 census figures for Districts (and Provinces), shows: Gokwe 40.8%, Kwekwe Rural 73.9% (Midlands Province Rural Areas 56.2%): Kadoma Rural 82.5% (Mashonaland West Rural Areas 59.8%). The national rural average is 64.3%. In the Project Area Gokwe appears particularly low and Kadoma Rural District high in provision.

There is a considerable gender imbalance in Zimbabwe in the rural areas with 85.9 males to 100 females. Men have sought wage labour elsewhere and are increasingly less able - and sometimes less willing - to remit funds to family members in rural areas. Farmers are predominantly female as elsewhere in Sub-Saharan Africa and almost all cultivation activities are undertaken by women. This is equally the case for irrigation projects visited. It is essential that extension efforts in agriculture and water management recognise this.

In terms of health status, diseases in the Project Area are dominated by malaria, particularly during the wet season and especially in the months of February to April. Figures from clinics at Sanyati in the centre of the Project Area are particularly high. Bilharzia is a consistent problem throughout rivers and irrigation schemes visited.

AIDS is a scourge for the country with incidence of HIV positive individuals at 30%. The potential economic impact on the agricultural sector is already serious with women too often infected by their marriage partners. Family subsistence production, cash revenues and savings are necessarily diverted to supporting and caring for incurably sick and dependent family members, seriously affecting labour availability and resources for farm re-investment.

(3) Findings of Social Surveys in Project Zone

(a) Villager Intention (Attitude) Survey" in Potentially Submerged Area

Most of the people living in the two affected wards of Mabura and Sidakeni to the south of the Munyati River came from Chirimanzu, Shurugwi, Mberengwa and Masvingo during the 1960s. Between 36-40% of households are female headed associated with AIDS, the migrant labour phenomenon in Zimbabwe, also polygamy/divorce. Nearly half the population is under 17 (45%) and about 40%, age 17-40. In Muzvezve 1 Resettlement Area 80% have been resettled only in the last 10 years.

Approximately 80% of population get water from boreholes and report that the quality is good throughout the year, in both summer and winter. About 40% of households achieve a surplus to subsistence of their cereal requirements which they can sell with cotton for cash. Protein is provided by occasional consumption of chickens and other small livestock, but also from groundnuts, beans and round peas. Cattle are kept as a source of draught power, security and cash in emergency, apart from ingrained cultural reasons. One-third of households have had no extension advice from AGRITEX in the last five years.

Most households would like to be moved as a group and females particularly from different households value sharing tasks together. Social relations are important in exchange of unpaid labour and access to draught power. Many said they would like to be relocated on an irrigation scheme close to where they are currently living.

(b) Village Inventory Survey

The submerged area village inventory identified physical infrastructures such as shops and boreholes (10 in Batanai and Kubatana). In Sumambwa there was also two schools (primary and secondary), a clinic, eight small churches and three grinding mills. Few in number, these buildings are mostly dilapidated. Indeed there has been a small planning blight in the area because people have been aware of the dam proposal and have avoided any property investment for fear of not being properly compensated.

As an indicator of the insignificance of the economic loss which would be set against the economic benefits of the dam. A calculation based on the survey inventory of the housing stock value in Batanai shows a value of only Z$ 2,702,000 or about US$ 71,105 (Z$38.0=US$1.0). The housing stock of Kubatana, the second most affected village is valued at Z$ 2,187,000 (US$ 57,552). The value of Koronika housing stock is reckoned at Z$ 2,854,000 (US$ 75,105). The cost of proper resettlement will of course be very much greater than these potential losses.

The survey identified certain graves of elders and former chiefs as well as special sites of spiritual value. The graves it was said can be moved after performing a small ceremony and five minor sacred sites were identified. Four of these were pools on the Munyati River or its tributaries, used for traditional ceremonies and for Christian baptism and exorcisms. The other site identified was Kasawe spring. They are not considered to be of great consequence, but spiritual and psychic losses are real, especially for old people. Though impossible to value they should not be ignored.

Non-physical social infrastructure include church communities, loyalty of certain shop clientele and market systems/knowledge. The value of these is difficult to estimate but is considered to be close to zero and at most negligible.

3.2 Formulation of Development Plan of Kudu Dam Irrigation Project Area

3.2.1 Basic Development Concept

3.2.1.1 Development Objective

In Zimbabwe's agricultural sector before independence in 1980, the large scale commercial farms played a predominant role, and the government gave them support through development of water resources, agricultural support services, etc. However, since independence, the government has changed its basic agricultural policy emphasis to recognition that domestic food security as well as the sustainability of the country's agriculture would be threatened without development of self-support by smallholder farmers in the communal and the resettlement areas and the small scale commercial farms who hold the majority of individual farmers in the country. In the Zimbabwe Agricultural Policy Framework (1995 – 2020) issued in 1996, the short to medium term goals are to double grain yields on smallholder farming; move smallholder to high value commodities; improve women's participation; reform public sector agricultural institutions; increase smallholder irrigation by 40,000 ha; improve efficiency of water use; and improve access of fertilizer to smallholders.

Under such circumstances, the major objectives of the Lower Munyati River Basin Agricultural Development Project are to increase the incomes and food security of smallholder irrigation households in the Project Area, and to develop the regional economy through improvement of living standard of inhabitants and rural society.

3.2.1.2 Development Needs

A larger part of the Project Area is classified as the Natural Region III in which annual rainfall is about 700 mm. Most farming is single cropping and rainfed. Rainfall is highly variable from year to year and production risks are extremely high. Farmers are therefore reluctant to introduce improved cultivation techniques or more purchased inputs such as fertilizers and improved seeds. This results in low technology, low output, low productivity cropping system. In addition, farming in communal and resettlement areas have been adversely affected by frequent droughts.

The low productivity farming system makes it difficult for farmers in communal and resettlement areas to secure adequate financial resources to purchase required farm inputs leading to a vicious circle. Cattle that is an asset, is also resources for farming and the household is sold to repay outstanding debt or to purchase needed inputs for the next season. This results in shortage of draught power for land preparation, food for the household and organic fertilizer for the crops. It also leads to less crop production, due to failure in implementing timely cultivation practices. This leads to lower farm output.

Irrigated water is a critical factor in the farming system and could vastly reduce the production risks associated with rainfed farming. But water is lacking even for household use, for drinking purpose, and for livestock. In addition, the water demand for industries and for urban use around the Project Area increases annually and a serious water shortage is projected by 2020. It is therefore imperative to ensure stable water resources for the Project Area by launching this Project.

3.2.1.3 Development Potential

(1) Human Resources

In ten (10) wards concerned to the communal and resettlement areas in the Project Area among three(3) districts such as Kadoma, Gokwe North and Gokwe South, the population and the household in 1998 is about 103,000 and 17,800, respectively. The number of agricultural extension workers in charge of these three districts is 114 who presently serve about 113,200 farm households in total of three districts, that is, one extension worker for every 1,000 farm households. The Cotton Research Institute and the Cotton Training Center serving the Project Area are located in Kadoma.

(2) Land Resources

The irrigable area is estimated at about 23,000 ha based on the soil survey. These areas are scattered consisting of small blocks and located between El. 850 m and El.

950 m.

(3) Water Resources

The surface water of Munyati river and its tributaries has potential as the water resources in the Project Area. The groundwater has been used for drinking water and domestic water of farmers by use of wells, but it is not useful for irrigation. The Munyati river is a large river. The catchment area at the proposed Kudu Dam site designed by DWD is 17,520 km^2 and the average annual discharge in past 30 years is about 900 MCM. Therefore, a large scale water development can be expected on this river. As to its tributaries, these do not have enough catchment area or geographically suitable dam site for large reservoir, so they have only a little potential for water resources development.

3.2.1.4 Development Constraints

Through the field survey during the first field work, the following constraints are identified as the agricultural development in the Study Area:

(1) Physical Constraints

(a) Annual rainfall is limited to about 700mm and in winter season there is almost no rain because about 95% of annual rainfall is concentrated in the summer season from October to March.

(b) Crop productivity is low and unstable due to unreliable rainfall distribution and wide range fluctuation of annual rainfall year by year.

(c) In the communal and resettlement areas, a plot of the existing cultivated land is generally small and scattered depending on undulating topography and soil condition.

(2) Technological Constraints

(a) There is no comprehensive irrigation system except small scale schemes where irrigation water are taken from small reservoir and boreholes, and therefore farmers in the Study Area have almost no experience in irrigation cultivation.

(b) Farming activities such as ploughing, land grading and carting, etc. depend on manpower and domestic animals, especially cattle, and farmers in the Study Area have low level of inputs such as fertilizers, chemicals and high yield seeds, resulting in low agricultural productivity in the area.

(c) The road network in the Study Area is not well developed, which hampers the transportation of farm input materials and agricultural outputs. Although asphalt paved roads link the central locations in the district and some roads connecting business centers of villages are paved with gravel, most of roads within Study Area are not paved, which cause traffic difficulty during the rainy season.

(3) Socio-economic and Institutional Constraints

(a) Short-term and medium-term loan schemes are available to small holder farmers, however, smallholders are often ineligible due to high interest rates and insufficient assets.

(b) In the Study Area, community action is rather weak and there exist none of a wide range farmers' organization. The agricultural cooperative filled a important role in agricultural credit and guarantee for loan in communal and resettlement areas, but presently only a few cooperatives are in existence.

(c) The Study Area belongs to the Mashonaland West Province on the right bank side of Munyati river and to the Midlands Province on the left bank side. There exist differences in level of institutions as well as level of recognition on the proposed project among local offices of concerned ministry and provincial offices as well.

3.2.1.5 Development Scenarios in the Master Plan Study

The development scenarios drawn up in the Master Plan Study conducted from 1994 to 1995 include two cases with and without Kudu Dam. The latter is further divided into two cases, one is with consideration of small/medium scale dams in tributaries and the other is no consideration of any water source development as summarized below.

Outline of Development Scenario in Master Plan Study

Case Code	A	B-1	B-2
Kudu Dam	With	Without	Without
Other Water Sources	-	With	Without
Development Purpose	Agricultural & Rural Development through Wide Area Irrigated Agriculture	Agricultural & Rural Development through Spot Irrigated Agriculture	Agricultural & Rural Development without Irrigation
Development Component	1. Irrigation Facilities Construction according to Available Water Source in Kudu Dam 2. Agricultural Extension, Marketing, Agricultural Credit 3. Rural Infrastructure	1. Water Source Development in Tributaries and Irrigation Facilities Construction 2. Agricultural Extension, Marketing, Agricultural Credit 3. Rural Infrastructure	1. Agricultural Extension, Marketing, Agricultural Credit 2. Rural Infrastructure

In the Master Plan Study, the development plan was worked out for each scenario, and the project evaluation for each plan was comprehensively made from the economical, financial, engineering, organizational, social, and environmental aspects. As a result of the evaluation, the Case A was selected as the first priority, which plans to raise the living standard of smallholder farmers in the communal and resettlement areas of the Project Area through irrigation development including the water resource development of the Munyati river, i.e., the Kudu Dam.

3.2.1.6 Basic Development Concept

The Lower Munyati River Basin Agricultural Development Project aims to implement the large-scale irrigation project mainly for smallholder farmers through the construction of the Kudu Dam as a water source on the Munyati River. This Project is expected to play a pioneering role in the future direction of small-scale agricultural development in the country. However, the small-scale agricultural sector has had little experience in irrigation cultivation, and farmers in communal and resettlement areas are generally said to have little experience of participatory development as mentioned in the previous section. Therefore, when implementing the irrigation project, comprehensive agricultural development including establishment of farmers' organizations and improvement of agricultural support services is indispensable. The environmental problems should also be examined and measured to provide a coordinated and environmentally sustainable agricultural development plan with adequate mitigation measures to combat negative environmental impacts.

The basic development concept of the Project is shown below.

(1) Creation of Kudu Dam Reservoir on the Munyati river at optimum scale to provide water for irrigation mainly in communal and resettlement areas and for urban use in surrounding towns of the Study Area,

(2) Provision of an irrigation system with open canals to introduce irrigation farming in areas downstream of Kudu Dam,

(3) Effective land allocation to increase farm income per household,

(4) Crop diversification for attaining self-sufficiency of staple food, import substitution and export earnings,

(5) Efficient use of land and water in all irrigated lands,

(6) Introduction of farming practices focused on environmental conservation including environmentally friendly farming practices,

(7) Improvement of agricultural support services,

(8) Reinforcement of social services especially infrastructure such as rural roads and water supply system,

(9) Establishment of a new project office under inter-agency committee for smooth implementation and proper O&M of the project,

(10) Provision of an environmental conservation plan in respect of natural and social environments, and development of an environmental monitoring plan, and

(11) Establishment of a pilot project to assist in project formulation which will serve as a place of technical training and trial-and error learning for farmers

so as to promote smooth transition to irrigation farming.

3.2.2 Water Resources Development Plan

3.2.2.1 General

In order to secure water not only for irrigation but also for industry and urban demand in and around the Study Area, the large-scale Kudu Dam is proposed to be constructed on the Munyati river as mentioned in the previous section. Based on the review of the previous study and the latest data of river discharges, water rights, water demands for irrigation and urban requirements collected during field survey period, the study on water resources development was conducted through the water balance study to optimize dam capacity and the size of irrigation command area.

3.2.2.2 Water Resources of Munyati River Basin

(1) Hydrological Zone

Zimbabwe is classified into six hydrological zones namely Zone A to Zone F. The Study Area is located in Zone C in this classification. In Zone C, the river systems drain in the northerly direction and there is unexploited potential in the zone. Zone C consists of 23 subzones as shown below.

Sub-Hydrological Zones in Hydrological Zone C

Name of Sub-Zone	Number of Sub-Zone	Area (km^2)	Major River in the Sub-Zone
CA1-CA2	2	9,479	Angwa
CH1-CH5	5	14,339	Munyati
CS	1	9,657	Sanyati
CUF1-CUF4	4	11,866	Umfuli
CUG1-CUG2	2	6,925	Musengesi
CUN1-CUN6	6	21,771	Munyati
CUS	1	3,215	Umsweswe
CZ1-CZ2	2	13,271	-
Total	23	90,523	

The proposed Kudu Dam is located in CUN1 in the classification, and the dam can receive natural flow from its catchment area, CUN2-CUN6 and CUS. Sub-hydrological zones in the Kudu Dam catchment area are summarized below and shown in Figure 3.2.1.

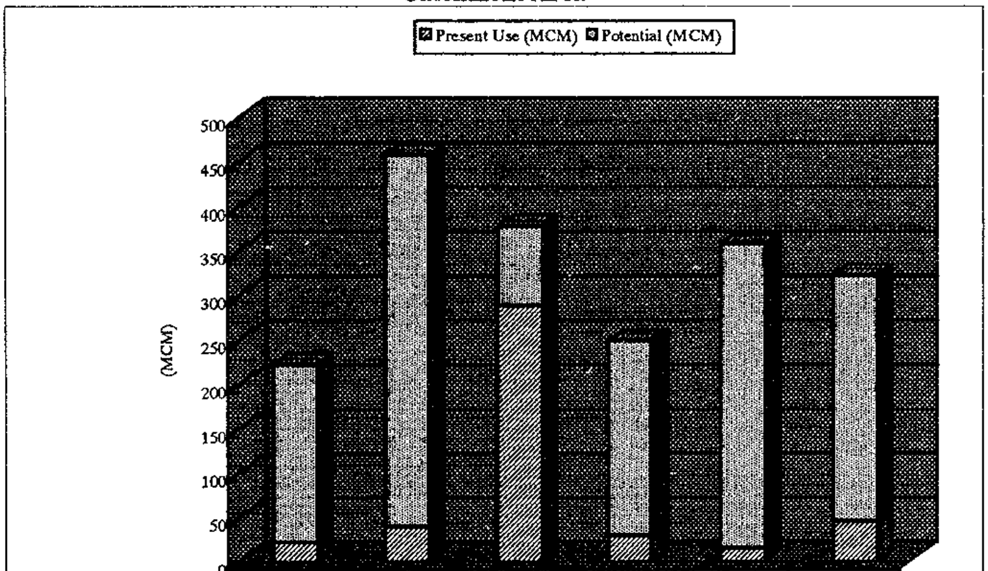
Sub-Hydrological Zones in the Kudu Dam Catchment Area

Name of Sub-Zone	Name of Catchment	Area (km^2)	Mean Annual Runoff (mm)	Major River
CUN2	Munyati	3,179	35	Munyati
CUN3	Lower Sebakwe	4,161	55	Sebakwe
CUN4	Upper Sebakwe	2,705	70	Sebakwe
CUN5	Ngesi	1,775	70	Ngesi
CUN6	Upper Munyati	2,748	65	Munyati
CUS	Umsweswe	3,215	50	Umsweswe
Total		17,783		

(2) Potential Water Resources

Present water utilization and water resources development potential of the catchment subzones are estimated by Zimbabwean Government as shown in the following figure. Among the catchment subzones, water utilization of CUN4 is higher than other subzones. The catchment area has about 1,545MCM of water resource development potential in total, which can be fully developed by Kudu Dam construction.

Present Water Utilization and Water Resource Development Potential of Kudu Dam Catchment Area



	CUN2	CUN3	CUN4	CUN5	CUN6	CUS
Potential (MCM)	200.080	418.472	89.533	218.851	342.331	276.247
Present Use (MCM)	21.92	39.528	288.467	29.149	15.669	45.753

3.2.2.3 Water Balance Study

(1) Dam Yield at 10% Risk

Dam yield at 10% risk means available water amount from the dam in 90% dependability. According to the Detailed Design Report of Kudu Dam prepared by DWD in 1992, yield at 10% risk for Kudu Dam was estimated at 380MCM/year.

Since the yield shows general information for water development potential without any consideration for water use, the detailed water balance study is necessary to confirm the available water for irrigation command area. In water balance study, some important parameters which are not considered in dam yield estimation such as fluctuation of water demand (peak demand for irrigation), seepage loss, river maintenance flow, etc. should be taken into account.

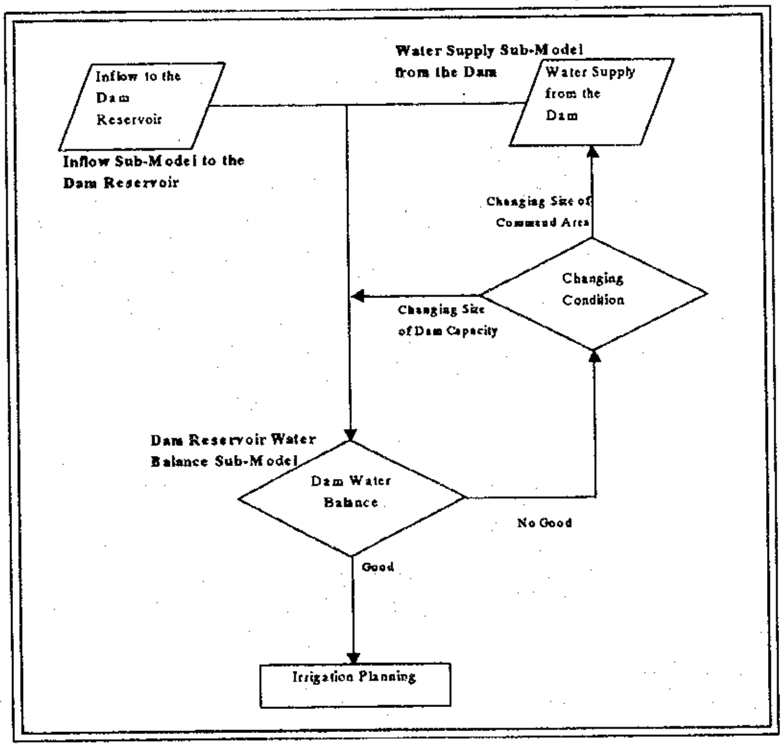
(2) Water Balance Study Model

Water balance study model consists of three submodels:

(a) Inflow submodel to the dam reservoir (upstream of the dam)
(b) Water supply submodel from the reservoir (downstream of the dam)
(c) Dam reservoir water balance submodel

Relationship between above three models and procedure of the water balance study is summarized in the following flow chart and total water balance model is shown in Figure3.2.2.

Flow Chart of Water Balance Study



(a) Inflow Sub-Model to the Dam Reservoir

Inflow submodel was established to estimate the volume of inflow to Kudu dam reservoir. Inflow submodel consists of three parts:

(i) Measured river runoff at river runoff gauging station

Daily measured river runoff data in Munyati river basin were collected from DWD hydrological section. Among them, data of Station C8 at Munyati river, C9 at KweKwe river, C36 at Sebakwe river and C48 at Umsweswe river are used for the study. Insufficient data were supplemented by using specific river runoff of the most highly correlative river runoff gauging station.

(ii) Water rights in downstream of river runoff gauging station

In the inflow submodel, water rights in the river basin must be considered because it may take certain amount of water from the natural river runoff. As water rights at the upstream of river runoff gauging stations are already abstracted in the measured river runoffs at the gauging stations, only downstream water rights of gauging stations are considered in the submodel. The list of water rights in the river basin was collected at the DWD water rights section.

(iii) Inflow from the tributaries

Inflow from the tributaries were estimated by using specific runoff of the most nearest upstream runoff in the submodel. Catchment area of the river basin used for the study is shown in Figure 3.2.3.

The result of Inflow Sub-Model calculation is shown in Figure 3.2.4.

(b) Water Supply Sub-Model from the Dam Reservoir

Water supply submodel has three components:

(i) Irrigation water requirement for the command area

Irrigation water requirement of the command area was estimated based on the proposed cropping pattern in the Study Area shown in the next section 3.2.3.

(ii) Urban water demand for the surrounding town area

Urban water demand in year 2025 for the surrounding towns was estimated based on the collected water demand data of Gokwe, Kadoma, KweKwe Gweru, Sanyati and Nembudziya. Data of present water use and future demand were obtained from respective provincial offices of DWD, Local Authorities of the respective Urban Centres and Rural District Councils. The result of estimation shows that net urban water demand of Kudu dam will be about 60 MCM/year in year 2025.

(iii) River maintenance flow to the downstream of the dam

River maintenance flow will be released from the dam for several purpose, such as water rights in the downstream, environment conservation, fishery and so on. In case of Munyati river, there is little natural flow in the dry season and water demand after confluence point of Munyati river and Mupfure river is very small since there are no major irrigation schemes. Accordingly, for the water supply submodel, only water rights from downstream of Kudu dam up to the confluence point of Munyati river and Mupfure river was taken into consideration as the river maintenance flow.

(c) Dam Reservoir Water Balance Sub-Model

The procedure of dam reservoir water balance calculation is shown in Figure 3.2.5. The following formula was used for the dam reservoir water balance submodel.

$$Q_{(i+1)} = Q_{(i)} + Fin + DR - Wi - Wu - Wm - EL - SL$$

where, $Q_{(i+1)}$: Storage at time (i+1)
$Q_{(i)}$: Storage at time (i)
Fin : Inflow to dam reservoir
DR : Direct rainfall to dam reservoir
Wi : Irrigation water supply
Wu : Urban water supply
Wm : River maintenance flow
EL : Evaporation loss
SL : Seepage loss

(3) Result of Water Balance Study

H - A (Water surface elevation - Water surface area) and H - Q (Water surface elevation - Storage capacity) curves of the Kudu Dam reservoir were obtained from the detail design report of Kudu Dam prepared by DWD as shown in Figure 3.2.6. In the submodel, water balance calculation was made on the ten-days basis and started from March (end of the rainy season) to February.

In the water balance study, water deficit risks for urban water and irrigation water are defined as follows:

(a) Urban Water

$$WDR_{(U)} (\%) = NWD_{(U)} / (36 \times 30) \times 100$$

where, $WDR_{(U)}$: Water deficit risk for urban water (%), less than 4%
$NWD_{(U)}$: Number of water deficit period of ten-days in 30 years

(b) Irrigation Water

$$WDR_{(I)} (\%) = NWD_{(I)} / 30 \times 100$$

where, $WDR_{(I)}$: Water deficit risk for irrigation water (%) , less than 20%

$NWD_{(I)}$: Number of water deficit year in 30 years

Since water shortage risks for urban water and irrigation water are different as shown above, certain amount of water should be stored in the reservoir, so that urban water shortage risk can be less than 4%. In other words, when the storage is less than required storage for urban water, irrigation supply shall be cut off to maintain urban water shortage risk of less than 4%. In the dam reservoir water balance submodel, the minimum storage for urban water to clear its water shortage risk was calculated.

Water balance calculation was done to optimize dam scale and irrigation area, using the above mentioned model for several cases of different dam heights as shown in the following table:

Alternative Model of Kudu Dam

Dam Height (Full supply Level)	Storage Capacity (MCM)	Irrigable Area (ha)	Storage for Urban Water (MCM)
72.70m (EL.947.00m)	1,551.4	25,000	60.0
67.70m (EL.942.00m)	1,266.6	20,000	60.0
62.70m (EL.937.00m)	972.6	16,000	60.0
57.70m (EL.932.00m)	732.6	11,000	60.0
52.70m (EL.927.00m)	542.6	7,500	60.0
47.70m (EL.922.00m)	393.6	3,700	60.0

Figure 3.2.7 shows the results of water balance study in the case of the maximum dam height of 72.7 m. In this figure, required storage for urban water is shown by water surface level with light line, and it means when the water surface level is below this level, irrigation supply should be cut off to keep urban water with less than 4% of water deficit risk.

3.2.2.4 Optimum Scale of Kudu Dam

For determining the optimum scale of Kudu Dam, environmental impact and project economy should be considered. The construction of Kudu Dam will force a maximum 3,100 persons (about 500 households) to leave their own lands and houses. Judging from the result of villagers' intention survey in the proposed submerged area and public consultation meetings held two times during the First Field Survey, the local inhabitants do not oppose the dam construction. However, as about 9% inhabitants are positively against the resettlement due to dam construction and about 36% inhabitants agree with conditions, the Government of Zimbabwe should have discussions with the inhabitants about this matter including their compensation hereafter. In case of resettlement, the local inhabitants wish to move on a village or a ward level than on a personal level. The result of inventory survey in and around the submerged area shows that there are neither animals/plants to be conserved strictly nor cultural or historical heritages, and therefore it can be judged that both natural environment and social environment would not be affected greatly by the dam scale.

Regarding economic aspect of the Project, water demand should be taken into account. In the Study Area, extensive farmlands spread out over the communal and resettlement areas, small and large scale commercial farms. About 23,000 ha of irrigable areas are identified in the communal and resettlement areas, however, these irrigable areas are scattered with small blocks and are located in the lands with elevation of EL 850 m to EL 950 m. The areas are divided into two categories depending on whether gravity irrigation is practicable or not. This classification is judged from the relation between water level of the main canal and elevation of the farmland. Therefore, economical evaluation of irrigation water distribution to gravity irrigation area and pumping irrigation area in the communal and resettlement areas, small and large scale commercial farms shall be made in relation to the Kudu dam scale.

Considering the above, following case study was made for examining the project economy. It is noted that the urban water requirement of 60 MCM per annum is assured in every cases.

Case Study for Optimization of Kudu Dam Scale

Description	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
(1) Dam Height (m)	72.7	72.7	62.7	62.7	59.7	53.7
(2) Storage Capacity (MCM)	1,551.4	1,551.4	972.6	972.6	828.6	580.6
(3) Dam Embankment Volume(m^3)	9,557,000	9,557,000	6,068,000	6,068,000	5,237,000	3,842,000
(4) Irrigation Area(ha)	25,000	25,000	16,000	16,000	13,230	8,992
(a) Communal & Resettlement Area	14,500	18,207	9,280	16,000	13,230	8,992
(i) Gravity Irrigation Area	8,992	8,992	8,992	8,992	8,992	8,992
(ii) Pump Irrigation Area	5,508	9,215	288	7,008	4,238	0
(b) Large Scale Commercial Farm	4,500	6,793	2,880	0	0	0
(c) Small Scale Commercial Farm	6,000	0	3,840	0	0	0
(5) Main Irrigation Canal(km)	177.9	172.9	177.9	172.9	172.9	172.9
(a) Right Bank Canal	74.1	74.1	74.1	74.1	74.1	74.1
(b) Left Bank Canal	103.8	98.8	103.8	98.8	98.8	98.8

For the above six cases, the economic evaluation was made based on the costs and benefits which were estimated using unit prices in June 2000. The result of economic evaluation in six cases is shown in Table 3.2.1 and summarized as follows:

Result of Comparative Study

Case	Economic Cost (1,000Z$)	Economic Benefit (1,000Z$)	EIRR (%)
1	7,478,603	1,393,711	10.1
2	7,550,910	1,393,711	10.0
3	5,489,150	891,975	9.0
4	5,290,612	891,975	9.3
5	4,845,261	737,552	8.5
6	3,970,703	501,290	7.2

As shown in this table, it can be said that Case-1 and Case-2 have advantage of the project economy providing the largest irrigation area of 25,000 ha with the maximum dam scale. Case-1 is followed by the allocation rate adopted in the Master Plan Study, where the irrigation water will be distributed to the small and large scale commercial farms besides the communal and resettlement areas. At the meeting with the Government of Zimbabwe on Progress Report (1) of Phase-I First Field Survey, both of the Government of Zimbabwe and the JICA Study Team agreed, "The irrigation development plan will be made following the water allocation as in the Master Plan Study. Re-allocation of irrigation water shall be considered when the economic analysis is made available." Taking into account this agreement, Case-1 is adopted as the optimum water resources development plan, in which the Kudu dam is designed as the maximum scale (dam height: 72.7 m, reservoir capacity: 1,551.4 MCM) supplying irrigation water to 14,500 ha in the communal and resettlement areas, 6,000 ha in the small scale commercial farms, and 4,500 ha in large scale commercial farms, moreover, urban/industrial water to the urban areas around the Study Area.

3.2.3 Irrigation and Drainage Development Plan

3.2.3.1 Proposed Irrigation Areas and Irrigation System

(1) Probability and level of certainty

It is proposed to adopt 20% risk level for irrigation development plan. This Project, though including a little urban/industrial water supply, is a single purpose irrigation project and in such projects the management of water in short supply years is easy by establishing appropriate operation plans. More difficult problems arise in multipurpose projects, which cater for the needs of power, flood control or navigation, in addition to irrigation. The multiple objectives of power or flood control restrict the releases of water as per their functional requirements. For example, power needs may be small but sufficient water is required to be reserved in the reservoir for their regular releases round the year: flood control measures may warrant extra releases of water even when it is not required for irrigation in hope of subsequent excess inflows to moderate floods. These pre-requisites of multipurpose projects warrant lower risk factors. No such problems are encountered here in this single purpose project.

In the irrigation project, on the other hand, adoption of 20% risk has the advantage to that of 10% risk, because it would cover more large irrigation area. As for moisture stress conditions in high risk cases, net effect is very little. Though the manner in which water deficit affects the crop growth depends the crop species and crop growth requirements at a particular point, slight modifications in the cropping pattern and staggering of sowing dates of various crops-seed varieties, having different maturity duration time are sufficient to obviate this stress conditions.

The rainfall in the Project Area tapers off in March and project management will be able to evaluate with reasonable level of certainty, the supplies likely to be available. Operational rules will help in deciding allocations for winter crops, and carry over allocations for summer crops. The deficit year planning is much easier in case of single purpose projects, leaving only a little constraint with adoption of 20% risk level.

(2) Irrigation Area and Irrigation Method

As discussed in the previous section 3.2.2, the project economy is at best when the height of the Kudu Dam is proposed as 72.70 m, enabling the available water resources to serve an irrigation area of 25,000 ha. Based on the allocation rate of available water in the reservoir adopted in the Master Plan Study, irrigation water will be supplied to 14,500 ha of communal and resettlement areas, 6,000 ha in the small scale commercial farms and 4,500 ha in large commercial farms.

The small scale commercial farms are located downstream from the tail end of the left main irrigation canal and the large scale commercial farms are located on the high lands at the right bank of the Kudu damsite. The irrigation areas in these commercial farms are not definitely identified, however, all the areas related to communal and resettlement have been identified based on soil surveys and other specific considerations. Soil surveys carried out for the project communal and resettlement area identified 23,000 ha of area (gross) fit for irrigation. This area is scattered and wide spread. Accordingly to service the designated area, two main canals, one on the left side and other on right side, have been planned using 1:15,000 orthophoto maps prepared in the Phase I study.

From the planned canal route and the available working head it is broadly observed that: (i) 2,770 ha of irrigable area, out of 23,000 ha as that identified for communal and resettle area, is not found suitable because of their too far away and scattered locations. This leaves a balance area of 20,230 ha, and (ii) 9,991 ha (gross area) can only be served through gravity irrigation and the remaining 10,239ha through pump irrigation.

From the available area, net irrigation area of 14,500 ha has been selected for communal and resettlement area as detailed below (See Figure 3.2.8).

Irrigation Area (Unit : ha)

Item	Irrigable Area		Net Irrigation Area Selected
	Gross Area	Net Area	
Gravity Irrigation Area	9,991	8,992	8,992
Pumping Irrigation Area	10,239	9,215	5,508
Pump Head			
< 5m	2,603	2,343	2,343
5m – 10m	2,106	1,895	1,895
10m – 15m	1,516	1,364	1,270
> 15m	4,014	3,613	-
Total	20,230	18,207	14,500

Note: Net Area is estimated as 90% of Gross Area, considering lands for roads and irrigation facilities, etc.

Selection of method for gravity irrigation mainly depends upon land slopes, type of soils, type of crops, depth of irrigation and water stream size. The soils of the irrigation area are mostly loamy and land slope is slight. The cropping pattern indicates maize, cotton, groundnut and vegetables in rainy season for which furrow method of irrigation is considered most suitable. In the dry season wheat crop has been proposed for which border method of irrigation is considered suitable. Under these conditions long/medium furrows and medium borders area generally preferred.

In pump canal irrigation areas, water is proposed to be pumped in bulk from the main canal and conveyed to the respective high areas, in stage if so required to serve the higher areas. Irrigation area at each stage of pumping is proposed to be served by gravity methods of irrigation.

3.2.3.2 Irrigation Water Requirements

(1) Crop Water Requirements

The procedure adopted for the calculations of crop water requirements is mainly based on the methodologies presented in FAO Irrigation and Drainage Paper No. 46, "Cropwat: A Computer Program for Irrigation Planning and Management", Paper No. 24 "Crop Water Requirements" and Paper No. 33, "Yield Response to Water." Agronomic data has been extracted from "Irrigation Manual, Second Edition 1994" published by UNDP / FAO / AGRITEX Project ZIM/91/005.

(2) Meteorological and Agronomical Data

The meteorological data were collected from the meteorological stations of Kadoma and Gokwe. Data on agronomical aspects of crops covering lengths of stages, crop coefficients, rooting depths, depletion level, and yield response factors for all the crops were taken from "Irrigation Manual, Second Edition, 1994" published by UNDP / FAO / AGRITEX Project ZIM/91/005.

(3) Net Irrigation Requirements

Crop water requirement was calculated by CROPWAT computer program presented by FAO, and the program was worked out for the case in which effective rainfall is not considered. The meteorological data obtained from the Gokwe Station only can meet the requirements for this calculation. The effective rainfall for 30 years were separately worked out from ten-day rainfall data as converted from the corresponding daily rainfall data. Net irrigation water requirements were worked out by reducing effective rainfall from crop water requirements.

(4) Diversion Irrigation Requirements at Canal Head

Diversion irrigation requirements was worked out by applying 50% of irrigation efficiency, which consists of conveyance efficiency, field canal efficiency and field application efficiency to net irrigation water requirements. Average monthly diversion irrigation water requirements under proposed cropping pattern are shown below.

Monthly Diversion Irrigation Requirements

(Unit : MCM)

Category	Irrigation Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
For C.A. and R.A.	14,500 ha	8.0	13.2	21.8	15.1	4.5	18.6	30.9	32.7	17.6	5.5	5.7	5.4	179.0
For S.S.C.F.	6,000 ha	3.3	5.5	9.0	6.2	1.8	7.7	12.8	13.5	7.3	2.3	2.4	2.2	74.0
For L.S.C.F.	4,500 ha	2.5	4.1	6.8	4.7	1.4	5.8	9.6	10.1	5.5	1.7	1.8	1.7	55.7
Total	25,000 ha	13.9	22.8	37.7	26.0	7.7	32.0	53.3	56.3	30.3	9.5	9.9	9.3	308.7

C.A. : Communal Area, R.A. : Resettlement Area, L.S.C.F : Large Scale Commercial Farm,
S.S.C.F : Small Scale Commercial Farm

(6) Unit Design Water Discharge

Unit design water discharge was worked out on 10-day basis from diversion irrigation requirements, by applying planned cropping pattern and the meteorological data having been observed at Gokwe Station from 1968 to1997. The following table shows the top ten years of peak diversion requirements by decade in the 30 years of water requirements analysis. The sixth biggest year of peak diversion requirements was selected as basic year out of 30 years, because 5-year return period was applied in determination of the unit design water discharge.

Peak Diversion Requirement

Order	Peak Diversion Requirement ($m^3/s/ha$)	Peak Decade
91	1.25	Feb-3 rd, 1991
83	1.25	Feb-3 rd, 1983
68	1.21	Feb-3 rd, 1968
90	1.15	Feb-3 rd, 1990
70	1.14	Feb-3 rd, 1970
71	1.12	Feb-3 rd, 1971
92	1.05	Feb-3 rd, 1992
94	1.05	Feb-3 rd, 1994
96	1.03	Feb-3 rd, 1996
85	1.03	Feb-3 rd, 1985

According to this table, the basic year should be 1971 (peak decade : third decade in February) and peak diversion requirement at the time is 1.12 l/s/ha. The farmers are new to cultivation and their needs/aspiration may vary as per future time resulting in some change of cropping pattern at any subsequent stage. As such it is proposed to keep around 5% additional allowance. It is therefore proposed to adopt unit design water discharge as 1.2 l/s/ha. The details are given in Appendix – VI.

3.2.3.3 Basic Plan of Irrigation Facilities

(1) Concept of Water Management

As mentioned earlier, only small projects are being constructed and operated in Zimbabwe. The maximum size of the project in the communal and settlement areas has been found to be around 500 ha. These projects have mainly suffered from inequity in water distribution and sub-optimal/inefficient water utilization. These projects being small, some laxity developed in the implementation of basic requirements and principles concerning operation of the system and water management. One of the issues, which have attracted attention, is the absence of night irrigation and provision of night storage reservoir. In the small schemes, the flows in the main canal during the nighttime are being contained in night reservoirs. During the daytime this stored water is utilized in irrigating a separate block of almost half the area. That means, in a way, one more reservoir has been constructed, of half the capacity at the head of the system. Normally, the farmers do not take water during the night-time. A few projects have, however, been identified where, during the scarcity period all the farmers took water in rotation round the clock in both day and night. For success of any irrigation project, it is necessary that awareness of water as a scarce resource be fostered. There is need to create artificial scarcity conditions to inculcate the habit of optimal and economic utilization of this resource.

This night storage reservoir concept cannot be adopted on bigger projects, because of higher discharge in the system requiring huge reservoirs and specific operational requirements and methodologies. The potential dangers of avoidable reservoirs in respect of loss of water through seepage and health need not be emphasized.

All the above issues and maladies as detailed earlier have been considered to develop a viable concept of water management. The concept would ensure:

- Well defined water allocation and distribution principles
- Efficient system design
- Equitable distribution of water
- Fixation of turn schedules at the secondary and tertiary levels
- Optimum utilization of water at the farm level
- Introduction of volumetric concept
- Control and monitoring mechanism
- Water accounting
- Simple and efficient procedures for operations and maintenance

- Training and adaptive research
- Preparation of manuals and guidelines, etc.

(2) Water Allocation and Distribution Principles

Water allocation and distribution principles form the basis on which an irrigation project is planned, constructed and operated. The main theme revolves round the water availability, the corresponding demands, adjustments/compromise between availability and demand and its distribution amongst the farmers. The social obligations of benefiting as many farmers as possible, is also an important consideration. The existing systems suffer from inequity in water distribution, the tail-enders don't get their allocated share, over irrigation is generally observed. Water allocation and distribution in the Project Area is being proposed with due regard to equity. Disparities in the distribution of water between head reach and tail farms would be obviated by adoption of rotational water distribution system. Supply of water is proposed on need based and with volumetric concept.

(3) Approach

The project is being planned for a risk period of 20%. Under this 20 out of 100 years may have deficient water availability conditions. The method of water distribution will be divided into two cases: (a) when water resources are adequate, and (b) when water resources are deficient.

(a) Adequate Water Availability Condition

The approach to water management with adequate supplies is based on filling the soil root-zone reservoir to field capacity, allowing the crop to deplete the moisture to the defined value of wilting point, and then irrigating the soil to make up this deficit in the root-zone-plans. In short, the crops would be irrigated when the available soil moisture has reached a specified level. The concepts of field capacity and wilting point have proved satisfactory criteria for fixing the turn schedules of canal systems.

This approach is also based on co-relation of yield response to soil moisture deficits for crops after taking into account plant characteristics, growth stages and evapotranspiration losses. Here the turn schedules of water distribution will be fixed in such a manner that all the farmers get the required water allotted to them turn by turn during a rotational cycle of one week. In this case irrigation requirements as worked out by modified Penman Method would be matched with the water availability condition to ensure that the demands are fully met.

(b) Deficient Water Availability Condition

During the water deficient periods, when the supplies are not sufficient to meet full crop requirements over the entire Project Area, two options are available:

(i) reduce the irrigated area so that full crop water requirements are met on the newly planned limited area.

(ii) meet the crop water requirements only partially on the Project Area in the most suited scientific method.

It is proposed to follow the alternative (ii). The policy of spreading water thinly over extensive area recognizes the fact that the crops will slightly suffer water deficit during the growth period.

In fact when at a particular stage, the supply of water is deficient and crop water requirements are not fully met, moisture stress conditions develop, in which case the water loss due to evapotranspiration exceeds the rate of water supply to plant. These conditions affect the crop growth adversely. The manner in which water deficit affects the crop growth depends upon the crop species and crop growth requirements at a particular point. Generally crops are more sensitive to water deficiency during emergence, flowering and early yield formations than they are during early vegetative and late growth periods. As such in these cases schedule would be fixed as per water requirements of crops during their sensitive/critical stages of growth. Slight modifications in the cropping pattern and staggering of sowing dates of various crops-seed varieties, having different maturity duration time are sufficient to obviate stress conditions.

(4) System Design

A good network planning and operational criteria are essential to achieve equity and assured timely water supplies to all farmers. For every farmer to know well in advance his seasonal entitlement and when he will receive it, distribution system must have the following attributes:

- well designed network with an adequate number of control points, measurement and regulating structures to divide the available supply so that every channel receives and delivers its design flow:
- single operational plan based on realistic system efficiencies that ensures farmers receiving their allocations in time: and
- trained management force whose duty and functions are to accomplish these tasks.

(a) Structured System

The guiding principal in the structured system design is that a minimum amount of intervention will be needed for day to day operations and the structured layout fulfills this criterion. The structured system would be a sort of fully self-regulated/automated system at the primary and secondary level when sufficient water is available to meet the crop water requirements. The system would require a bit of regulation during short supplies. The distribution of water at tertiary level would be attended by the farmers.

Accordingly, the networks have been planned in two stages. Firstly the main canal system has been designed to supply water to the whole of the command area, and then distribution net works are laid out within this area (through distributary or minor canals off-taking from the main canal) to deliver water to the respective distributary/minor blocks. Within distributary/minor blocks water is distributed through tertiary canals. In this system each distributary or minor taking-off from main canal, functions as an independent unit to deliver the required quantum of water to each sub unit. The system either flows with full design discharge or kept fully closed.

As such the command area is proposed to be irrigated through a network of distributaries/minors. Outlets would be provided in the distributaries/minors to feed the respective sub units.

(b) Components of the Structured System

Each component of the structured system has hydraulic and networks flow considerations, which will be taken care through integrated planning methodology.

(i) Main canal/Branch canal – Primary system

Water from the outlet of the reservoir is led into the Main Canal, which would further bifurcate in the Left Main Canal and Right Main Canal. The discharge in these canals would vary as per the requirements and as such these primary canals may or may not run full. Preferably, no direct irrigation is carried out from the main canals.

(ii) Distributary/Minor canals - Secondary canals

A channel taking-off from the main canal is called a distributary or a minor depending upon their discharge. A minor may also take-off from a distributary. Outlets are fixed on the distributary/minor, which provide water to the watercourses (tertiary canals). To facilitate the outlets to draw their authorized discharge, the distributaries/minors would always be run to their full capacities or alternatively kept closed. Similar will be the case for the running of distributaries and minors where in the FSL of the main canal at the off-take point of distributary/minor would be maintained at the designed level.

(iii) Tertiary canals

Tertiary canals called as watercourses carry water from the outlets provided in the distributaries/minor canals to the fields.

In the main canal, principal concerns relate to sizing, spacing of control structures, locating escape structures, determining response time for gate operation to ensure safe filling and emptying periods, water losses, and establishing method of communicating information from downstream network to main canal operations. The secondary canal system concerns involve mainly maintaining designed Full Supply Levels (FSLs), estimating response time, and ensuring that control and regulating structures deliver the required flows with a high level of precision to the designated areas. The concerns in the tertiary area mainly relate to the alignment of tertiary canals taking into account the micro-topography of the sub areas and farmers fields. With this in view, the entire system has been planned, to be operated as an integrated network.

(5) Design of Main Irrigation Canal

Considering the above mentioned design policy and economic aspect, main canal routes, irrigation diagram, canal type, typical canal cross-section and crossing structures are proposed as follows:

(a) Main Canal Routes and Irrigation Diagram

Irrigation water being impounded in Kudu Dam is conveyed to Left Main Canal through intake structure of the dam, and diverted to Right Main Canal at 6.4km from the beginning point. After diversion, Right Main Canal is designed to cross Munyati River by siphon. The length of Left Main Canal and Right Main Canal is 103.8 km and 74.1 km, respectively, and total length becomes 177.9 km.

Main canal routes were selected by use of orthophoto map with a sacle of 1:15,000 and detailed topographic map with a scale of 1:5,000, which were prepared during the Phase I and II First Field Surveys. The canal routes were decided to keep gravity irrigation areas as much as possible, considering the design headwater at the intake structure of the dam and hydraulic losses. The canal route and irrigation diagram are shown in Figure3.2.8 and 3.2.9, respectively.

(b) Canal Type

In this Study, two types of canal lining were compared: (i) trapezoidal concrete lining type and (ii) rectangular reinforced concrete type. Since efficiency of irrigation water use, labor requirements and O&M cost and construction works are not so different between two canal types, the canal type was examined through financial aspect. The comparative study showed that the trapezoidal concrete lining type became more profitable. Moreover, trapezoidal concrete lining type canals have been constructed in Zimbabwe since former Rhodesian period, e.g., Mutiriawe Canal (Constructed in 1960s, length: 56.0 km) and Tokwane Canal (Constructed in 1992, Length: 14.0 km, Design Discharge: 14.5 m^3/s). Therefore, the trapezoidal concrete lining type was selected as the main irrigation canal of this Project.

(c) Typical Cross-section

The cross-section of main irrigation canal was designed based on the design discharge by using Manning formula. The design discharge was derived from multiplication of irrigation area and unit design water discharge, and roughness coefficient (n=0.015) was adopted for Manning formula. The design discharge of the left main canal was estimated at 24.6–7.2 m^3/s and that of the right main canal was 8.5–0.8 m^3/s. Gravel-paved O&M road with 5.0 m width was planned to be constructed along the main canal. In relation with the ground surface elevation along the canal, two type canals of excavated canal and embanked canal were considered. Typical cross-sections for the both types are shown in the Drawings.

(d) River Crossing Structures

There exist many tributaries on the both banks of Munyati river. In case the main canal crosses a tributary, if topographical conditions are allowed, aqueduct is proposed considering decrease of the hydraulic loss and continuity of O&M road along the canal. When the topographic condition is not suitable for construction of aqueduct, siphon structure is proposed. Major river crossing structures on the main canals are shown below. Further, if the canal crosses depression such as small river and stream other than the above tributaries, cross drain is proposed to be constructed to convey the water easily. If the canal crosses existing major road, box culvert is recommended. The typical figures of these structures are shown in the Drawings.

River Crossing Structures on Main Irrigation Canals

Right Main Canal				Left Main Canal			
Crossing River	Crossing Distance (m)	Canal Design Discharge (m^3/s)	Crossing Structure	Crossing River	Crossing Distance (m)	Canal Design Discharge (m^3/s)	Crossing Structure
Munyati River	406	8.493	Siphon	Ngondoma River	261	24.600	Aqueduct
Ncherechere River	82	8.493	Aqueduct	Unknown	182	16.107	Aqueduct
Grisnake River	183	8.493	Aqueduct	Unknown	72	16.107	Aqueduct
Unknown	100	8.306	Aqueduct	Unknown	188	16.017	Aqueduct
Chemveri River	150	7.774	Aqueduct	Gwenya River	1,252	16.018	Siphon
Unknown	133	7.626	Aqueduct	Gwanika River	112	15.908	Aqueduct
Unknown	120	7.626	Aqueduct	Mtanke Tributary	80	15.908	Aqueduct
Renji River	981	2.838	Siphon	Mtanke River	352	15.908	Aqueduct
Unknown	500	0.828	Aqueduct	Mtanke Tributary	82	15.908	Aqueduct
Unknown	350	0.828	Aqueduct	Unknown	110	14.634	Aqueduct
				Msorowa Parukwe River	291	14.373	Aqueduct
				Unknown	127	14.373	Aqueduct
				Nyamachene River	175	14.373	Aqueduct
				Nyarpakwe Tributary-1	411	14.373	Aqueduct
				Nyarpakwe River	137	13.739	Aqueduct
				Muzongwe River	405	10.650	Aqueduct
				Karaya River	336	10.650	Aqueduct
				Umuchini River	448	10.650	Aqueduct
				Mabiribiri River	383	10.650	Aqueduct

3.2.3.4 Water Users Associations (WUAs)

(1) Necessity of Farmers Participation

Water Users Associations is a step towards Participatory Irrigation Management (PIM) under which the management responsibilities (including decision-making) are taken over by the WUAs in an upwardly tapering manner, proceeding from outlets through minors, distributaries, and to higher levels The basic essence of PIM is the transfer of authority and responsibility for irrigation management below an agreed point. This is initially proposed to be promoted below an outlet and develop upwards to cover higher levels.

The main objective of organizing WUAs is to improve irrigation utilization and ensure all the farmers under the system to share available water equitably. Participation of farmers in operation, management and maintenance of the irrigation system aims at the following:

(a) Participation of farmers in decision making, policy formulation in water distribution, implementation of water deliveries at minor and distributaries.

(b) Creating awareness among the farmers about their rights to water, right of information on irrigation related subjects such as water availability, its distribution, crop planning, agricultural inputs, including credit.

(c) Maintaining the irrigation infrastructure so as to improve efficiency, attain equitable distribution and achieving most efficient use of available water from canal.

(d) Strengthening of O&M program management capabilities and process.

(e) Priority funding of special maintenance program, when required.

(2) Enactment for Water Resources Development and Distribution

Water resources development and distribution in Zimbabwe has been regulated through enactment of two new acts viz. (a) Zimbabwe National Water Authority (ZINWA) Act (Chapter 20:25) No.11/98 and (b) Water Act (Chapter 20:24) No.31/98.

(a) Zimbabwe National Water Authority (ZINWA) Act

ZINWA Act, inter-alia, provides for its establishment and its functions, appointment and functions of a board of the Authority, raising of charges for the provision of water and other services by the Authority, funds of the Authority, imposition and collection of a water levy, etc. ZINWA has been established as a body corporate capable of suing and being sued in its own name and, subject to this Act, for performing all acts that bodies corporate may by law perform. As per the Schedule, ZINWA has the power of authority, with the approval of the Minister, to construct, establish, acquire, maintain and operate dams, reservoirs, canals, distribution works, and hydro-electric power stations in any area on such terms and conditions as may be approved by the Ministers. For such purposes ZINWA may raise loans or borrow money.

(b) Water Act

The new Water Act provides for the development and utilization of water resources of Zimbabwe: establishment, powers and procedures of catchment councils and sub-catchment councils: grant of permits for the use of water: control of the use of water when water is in short supply: acquisition of servitude in respect of water: protection of environment and the prevention and control of water pollution: etc. The Water Act emphasis on the development through catchment councils. A catchment describes the drainage area of a particular river system, which often encompasses parts of different administrative areas such as Rural District Councils and may be even parts of different nations.

As is known, the Rural Districts Councils cover comparatively small area, and river water plans made on district basis may remain fragmented or overlap in some cases, thus obviating the overall utilization of resources on optimal and sustainable basis. It has, thus been decided to plan the water resources on catchment basis through River Catchment Councils.

(3) Water Management in Council Boundaries

The Lower Munyati Sub-Catchment Council has already been planned and its water management aspects would be guided by the Water Act (Ch. 20:24) No.31/98. As for water allocation/distribution, the Act entrusts the Minister, as one of his functions, to ensure the equitable and efficient allocation of available water resources in the national interest for the development of the rural, urban, industrial, mining and agricultural sectors. In the performance of this function, participation by consumers in all sectors and catchment councils will be encouraged.

(4) Organisational Work at Command Level

Though sub-catchment council for Lower Munyati is already planned, there will be need to start mobilising farmers participation in terms of organising WUAs at the outlet command level and proceed to higher levels. As per the basic concept organising work would start from the initial hydraulic unit i.e. outlet and extend to distributaries.

For a WUA to be established as a legal entity there has to be a law authorising its establishment. The legal framework for establishing them and facilitating them to operate may be derived through:

- The enabling act
- Co-operative Societies Act, Societies/Associations Registration Act or any other Act as available facilitating their registration as a Society or Association
- The transfer agreement between the sub-catchment council and the WUA

(a) Structure of WUAs

The structure of WUAs will depend upon the available legal framework, however, from the general management point of view, a WUA should not be too large to be non-cohesive and personal contacts lessened, nor too small to endanger its viability. The organization activities will be focused initially on each minor or each part distributary through outlet commands. Initially the operation and maintenance of distributaries will be the responsibility of Agritex. Subsequently, after the WUAs on minors/part distributaries have gained experience and have become sustainable, the activity would be extended to the distributary level. Depending upon the available legal framework, a three-tiered organisation is envisaged: (i) Out let Committee, (ii) WUA, and (iii) Federation.

(b) Implementation Process

It is proposed to start the activity of organising WUA even before the starting of construction of main canal, which include training and orientation of staff, participatory rapid appraisals, organising WUA and turn over.

3.2.3.5 Drainage Plan

(1) Drainage System

Surface Drainage is removal of water from the surface of land. The water may be from excess precipitation, water applied in irrigation, or losses from conveyance channel, etc. For maintenance of sustained production from irrigated agriculture, drainage of land is essential. The prime objective of drainage in the cropped lands is to develop and maintain soil zone in such a condition that moisture, air and soluble salts are in favorable balance for the plant growth. In irrigated agriculture, drainage is necessary to achieve and maintain such a balance. Proper drainage results in better and increased production compared to that in a poorly drained area.

Surface drainage broadly comprises the following categories:

(a) On-farm field drainage system - It consists of graded channels that collect excess water from fields.

(b) Link drains - These are intermediate collector drains that link various field drains and sub main drains or main drains.

(c) Main drains - Main/sub drains are principally excavated or natural drains, collecting water from link drains or directly from field drains.

The Project Area is new to irrigated agriculture and most natural soil surfaces including many cultivated fields are some what irregular consisting of randomly distributed elevated areas and depressions. It results in pondage of water in depressions and inefficient irrigation. Farmers, by themselves will be able to take care of these situations by reforming the land surface so as to provide continuous gentle slope to result in regulated water flow and adequate drainage.

(2) Drainage Needs of the Project Area

Drainage requirements are determined on the basis of various factors such as physiography of the area, soils, rainfall, sub-soil water conditions of the area, and the types of crops grown. The elevation of the Study Area extends from 800 to 1000 m. The right bank of the Munyati river has a gentle slope towards the Munyati river, and its tributaries which flow from the east to west are almost except for the Sakungwe river. On the other hand, the left bank is characterized by the Mafungabusi Plateau and Chinwavaenzu Hills. In the left bank, there are many tributaries and form riverbank terraces.

The command area has uniform slopes and is interspersed with small streams. These streams are expected as drainage for the proposed command area. A network of natural drainage out falling into major streams is available. As such no surface drainage problem is expected. However, the command area on development of irrigation would require some link drains leading to natural streams.

(3) Determination of Runoff From Rainfall

One of the best and complete methods for determination of direct runoff from the rainfall is Soil Conservation Service Method. This method is developed by the United States Soil Conservation Services. It takes in to consideration the antecedent soil moisture conditions, soil characteristics, like infiltration and permeability, land use and cropping pattern etc.

Normally, drainage system is designed for runoff occurring from rainfall frequencies that occur on the average of once in every five years (20% chance). However when increased drainage protection is required, 10% chance is adopted. It is proposed to adopt a chance of 10%. The depth of rainfall for the storm for which runoff is to be estimated is determined from the selected design frequency. Rainfall depths for 24 hours have been used for drainage design as per normal practice. The probable rainfall for the adopted chance of 10% has been found using Plotting Method of determining frequency curve for annual series record of 24 hours rainfall intensities. Daily rainfall data for Gokwe station is available for the period from 1964 to 1998 and this data has been used to compile the year wise maximum 24-hour rainfall. Maximum 24-hour rainfall was found to be 98.8mm on 10 February 1996. This data has been used in the frequency curve analysis.

Initial abstraction essentially consists of losses from interception, surface storage, and water which infiltrates prior to runoff. It is related to and is a part of the maximum retention. The relationship has been determined from the runoff potential of the soil with due regard to Antecedent Moisture Conditions (AMC). Knowing the values of depth of rainfall in the catchment, initial abstraction in equivalent depth, and the potential maximum retention, the depth of actual runoff over the catchment has been worked out using the given formulae. The value of the unit runoff works out to 1.76 l/s/ha.

3.2.4 Agricultural Development Plan

3.2.4.1 Land Use and Land Allocation

Land use in the Project Area was designed to promote irrigated agriculture. The land suitable for irrigated agriculture was selected from the viewpoint of land suitability as well as the proposed canal layout. The bush area of 1,451ha will be changed to the irrigated cultivated area. The rainfed arable area of 13,049ha will be irrigated by the Project. In total an area of 14,500ha will be used for irrigated agriculture. The detail of the land use is as follows:

Future Land Use Plan (ha)

Present Land Use		Future Land Use	
1. Bush	38,300	1. Bush	36,849
		2. Irrigated area	1,451
2. Cultivated area	39,800	3. Rainfed cultivated area	26,751
		4. Irrigated area	13,049
3. Residential area	3,900	5. Residential area	3,900
4. Rivers	800	6. River	800
Total	82,800		82,800

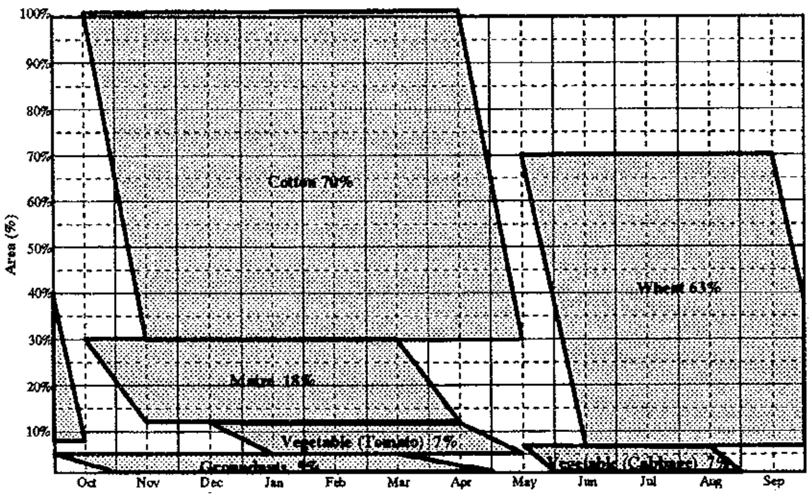
In accordance with current regulations relating to communal and resettled land, farmers would have to surrender their land to the government when their land becomes irrigable and such land would be re-allocated.

3.2.4.2 Proposed Cropping System

The proposed cropping system shown in the figure below was prepared taking into account the following factors:

(1) Subsistence requirements of maize and groundnuts,
(2) Available family labor for farming,
(3) Relative profitability of a crop,
(4) Marketability of a crop, especially for export, and
(5) Irrigation water balance.

Proposed Cropping Pattern for the Project Area



Twelve crops were studied as follows: maize, groundnuts, cotton, tomatoes, cabbage, paprika, baby corn, paddy, tobacco, wheat, dry beans and sugar cane. Among them, sugar cane was omitted because it is climatically unsuitable to the area. Temperature in the Study Area is too low to grow sugar cane economically. Tobacco was also excluded due to its poor long term market prospects globally. Paddy rice was also excluded because it is a new crop and farmers in the Project Area are too conservative to accept it, and the technical support system for rice development is not available. The subsistence requirements of food crops were projected based on the per-capita consumption derived from the farm household survey. Per capita requirements of maize and groundnuts were estimated respectively at 136 kg and 16.8 kg per year. The minimum planted areas for maize and groundnuts were estimated, respectively, at 0.16 ha and 0.05 ha per household as shown in the next table.

Subsistence Requirements of Crops

Crop	Per Capita Consumption (kg/Year)	Family Size (persons)	Annual Consumption (kg/year)	Yields (ton/ha)	Land Required (ha)
Maize	136	7.1	966	6.0	0.16
Groundnuts	16.8	7.1	119	2.5	0.05

The available family labor was estimated by month for an average farm family of 7.1 members. Rainy days were excluded from workable days. Three household members were assumed to be school children. The remaining members, 4.1 persons, would be available for farming. The labor requirements of each farming practice in 9 crops were estimated monthly, and the results were presented in Table 3.2.2.

The future crop yields with project were estimated taking account the crop records in the existing irrigation areas as shown in the following table;

Crop Yields in the Existing Irrigation Areas

Crops	Yields (ton/ha)
Maize	5.8
Wheat	5.2
Cotton	2.4
Groundnuts	2.7

Source : The Agricultural Sector of Zimbabwe Statiscal Bulletin – 2000

The target yields of crops were set as follows:

Target Yields of Crops

Crops	Yields (ton/ha)
Maize	6.0
Cotton	2.5
Groundnuts	2.5
Wheat	4.2
Tomatoes	75.0
Cabbage	50.0
Dry beans	2.0
Paprika	3.0
Baby corn	1.0

The crop yields at present was obtained from the available data in Gokwe district, for the last 8 years. Gokwe appears to have similar climatic and soil conditions as the Project Area and has no large commercial farms.

Projected Crop Yields

Crops	Yields (ton/ha)
Maize	0.8
Cotton	0.6
Groundnuts	0.5

The profitability of a crop was estimated making a typical crop budget, which included costs and return with breakdowns of farm inputs such as labor, fertilizers and chemicals. Crop budgets were made for farms after project completion and for the present. The details of the crop budgets are presented in Tables 3.2.3 and 3.2.4. Cropping calendars follows basically the existing ones.

The cropping pattern proposed for the areas irrigated by the Kudu Dam takes account of domestic market trends and export market prospects. The proposed crops for the irrigated areas in the Kudu Dam Project at full development (after 2010) and expected production is as follows:

Proposed Crops and Expected Production

Commodity	Crop Season	Crop Area (ha)	Expected Production (ton)
Maize	Summer	4,500 (18%)	27,000
Cotton	Summer	17,500 (70%)	43,750
Groundnuts	Summer	1,250 (5%)	3,125
Wheat	Winter	15,750 (63%)	66,150
Vegetable (Tomatoes)	Summer	1,750 (7%)	131,250
Vegetables (Cabbage, etc.)	Winter	1,750 (7%)	87,500

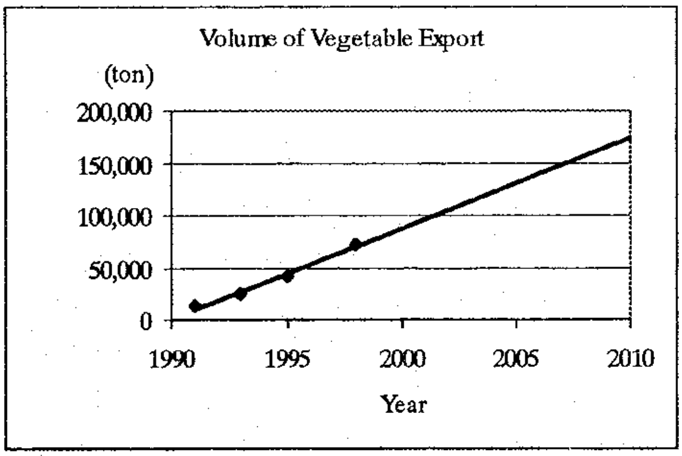
In Zimbabwe, maize production on average is grown on about 1.3 to 1.5 million ha each season and production, though highly variable, averaged between 1.5 to 2.5 million tons. This is to be expected as with rising incomes, the consumption of starchy cereals reaches near saturation point and then declines. The expected increased production from the Kudu Dam project is 27,000tons a year, that is approximately 1.3% of present annual production. At present, even at the current per capita consumption rate, an additional 36,000tons of maize would be required each year to feed the increase in population. By the year 2010, in view of estimated population increase of 2.1% per annum over the next decade, an additional 47,000tons would be required each year. In addition, to domestic requirements, maize has been exported, if production has been in excess of domestic requirements. On average, exports over the four years ending 1997-98 has been 308,000tons. The additional production from the Kudu Dam from year 2010 onwards of 27,000tons could therefore meet the increasing domestic requirements and possibly exports.

Cotton production has been averaging around 280,000tons a year but production has been highly variable. Most of the increase in the past decade has been from the communal sector. The planned production increase from the Kudu Dam irrigated area from year 2011 onwards would account for an increase on current levels of 16%. This is a big expansion. However, domestic demand for cotton lint by the textile industry has increased sharply in recent years. Domestic lint utilization by the textile industry increased from an average of 36,000tons lint to an average of 177,000tons lint in the three years ending 1997. Lint utilization is estimated to increase sharply in future years as textile firms have made significant new investments in recent years. The textile industry turnover is also forecast to continue in its upward trend. On the export market, cotton exports are expected to continue to increase. Export of lint in recent years have accounted for about 75% of total production and has registered dramatic increases. Exports of lint rose from an average of 24,000tons in the three years ending 1994 to an average of 438,000tons in the three years ending 1997. Export market prospects continue to be good due to world demand for natural fibres. The additional output from Kudu Dam from 2010 onwards of 43,750tons annually should assist in meeting the domestic and export market requirements.

Groundnuts annual production is around 100,000tons from about 200,000ha. Most of groundnuts are grown in the communal sector where yields are much lower and groundnut is retained by farmers for household consumption. There are no imports but groundnuts were consistently exported until the 1993-94 season after which due to increase in domestic requirements and decrease in production exports ceased. Additional annual requirements of groundnuts due to population increase and increase in per capita consumption is estimated at 3,000tons a year from year 2010 onwards. It is estimated that production from the Kudu Dam in year 2010 onwards would be 3,125tons. In addition to domestic consumption, due to increasing demand for oil, there would be increased demand for groundnut from the oil expeller industry. The increased production from Kudu Dam could cater to this increased domestic demand, demand from oil expellers and provide for exports.

The cropping pattern also indicates an emphasis on wheat cultivation. Wheat is grown on large commercial farms under irrigation. Production of wheat, on average is about 225 – 250,000tons a year and imports average about 325,000tons a year. The domestic demand for wheat has grown rapidly since 1985 except for a brief three years when subsidies were withdrawn. At present imports account for about one half of domestic requirements. Domestic demand is expected to rise sharply in the next decade and per capita consumption could also rise steadily. It is proposed to cultivate wheat on 15,750ha under the Kudu Dam and it is projected to provide about 66,000tons of wheat annually. This is only a small proportion of projected domestic requirements. It is estimated that by year 2010, domestic requirements could be around 740,000tons assuming population growth of 2.1% and per capita consumption of 45kg. There is scope for import substitution if domestic production is competitive with imports. Furthermore, the prospects for export to the neighboring countries is also good as the South African region is a deficit area and consumes about 850,000tons a year.

Fresh vegetable export volume has seen very rapid growth in recent years. Volume of exports from 1991 to 1998 is as follows:



A linear trend of the exports of fresh vegetables from 1991 to 1998 projected to the year 2010, the first year of production of the Kudu Dam Project, gives an export volume of 175,000tons and export value is projected at Z$ 2,000 million. The cropping system proposed for the Kudu Dam estimates that vegetable production from 3,500ha. About one half of this would be for tomatoes for canning to feed the tomato processing plant at Chegutu and other processors who can tomatoes as juice and paste for export. These processors depend on out grower contracts for tomatoes. It is proposed to grow 1,750ha of tomatoes estimated to produce 131,250tons. Production of vegetables from the 1,750ha is estimated to be 87,500tons. After accounting for culling and wastage, the quantity available for export would be 78,850tons. This compares with the estimated 175,000tons of exports in year 2010.

The Zimbabwe Horticultural Council has indicated that following the devaluation of the dollar, Zimbabwe has a advantage over its competitors from Africa in European destinations. Though final data is not available, exports have risen sharply in 1999 and so far in 2000. Exports of 175,000tons in 2010 appears feasible. Zimbabwe has made heavy investments in infrastructure such as packaging and transport to support this export activity. It is also well equipped with air freight facility to European destinations and a further expansion is planned.

It should be noted for further consideration to the proposed copping pattern that in the light of a recent growing tendency of dry beans in small holders' irrigation schemes, there is a potential to introduce dry beans also to the proposed cropping pattern, giving a certain part of the cropping area allotted for wheat.

3.2.5 Livestock Development Plan

3.2.5.1 Development Approach

Livestock rearing is the second most important economic activity next to crop production in the Study Area and the livestock subsector has substantial potential for further development. However, for the realisation of such potential, there are a number of constraints to be tackled in areas of animal health, nutrition, breeding, water availability & drought, poor management of grazing land, marketing and others as discussed in Section 3.1.5. Accordingly, the development options of the subsector will have to be directed toward improvement in the above areas.

In the present Project, however, the improvement of water availability and management of grazing land are envisaged as most important for the development of the subsector and the development approach takes the following into consideration:

- to avail of water resources developed through irrigation development for livestock subsector,
- to be demonstrative of what can be done in general terms,
- to make significant contributions of beneficial communities to ensure "ownership" of development as community development and involvement as a key to the success of livestock development,

- to contribute to irrigated agricultural development plan under the Project, and
- to introduce irrigated fodder production is not recommended because it is economically less attractive to crop production.

The livestock development plan proposed accordingly in the present Project consists of the livestock water development scheme and grazing area development pilot scheme as discussed in the following section.

3.2.5.2 Livestock Development Plan

(1) Livestock Water Development Scheme

The limited availability of water sources for livestock in grazing areas is one of the most serious constraints restricting the efficient utilisation of range resources in the Study Area. The scheme aims to construct water troughs for livestock along the main and secondary canals. The provision of water for livestock in range lands along the canals will enable efficient use of grazing resources and also allow animals to extend the length of their grazing in an area. Especially in the dry season, this will have great advantage of enabling farmers to continue to use grazing areas otherwise inaccessible due to shortage of drinking water. The scope and components of the scheme are as follows:

Scope and Components of Livestock Water Development Scheme

Scope	Construction of water troughs along main & secondary canals	
Components	Size of a trough	$3\ m^3$ (length 6m, width 0.7m, depth 0.7m) 1m)
	Specification	Brick made with cement lining
	Volume of works along main canals	36 units (approx. 5km interval)
	Volume of works along 2^{nd} canals	36 units
	Total volume of works	72 units

(2) Grazing Area Development Pilot Scheme

The low grazing capacity of range lands and the over grazing is the other major constraint in the livestock subsector in the Study Area, which cause the degradation of range resources and erosion. The scheme aims to establish the fully fenced pilot grazing areas in the project related 10 wards and to introduce controlled grazing management in pilot scale in the Area.

The anticipated benefits of the grazing area development scheme are:

- It will greatly reduce the amount of time farmers have to spend in herding their animals,
- By the introduction of controlled grazing management, loses of surface soils from erosion will be reduced, and erosion deposits in the areas and in the irrigation canals. This is because much of the grazing areas in the Study Area are above the currently proposed irrigation area contour,

- The scheme could be used to improve the current grazing capacity of the range lands from its rather low level up to its potential capacity. It will help ensure that the range land is at less risk to overgrazing. Thus, there could be an overall improvement in carrying capacity from current 1 LU: 8-12ha to 1 LU: 5-9 ha,
- It would be possible in a few years to establish grazing in equilibrium with range environment and avoid a loss in productivity of livestock, and
- Animals can be put in grazing areas for longer periods than at present, which will result in improved productivity.

The scope and components of the scheme are shown in the following table:

Scope and Components of Grazing Area Development Pilot Scheme

Scope	Establishment of fully fenced grazing blocks with water troughs	
Components	Size of a block	600 ha/block
	Length of fencing/block	Boundary-6km; internal-11km; total-17km
	No. of blocks	10 blocks (1 each for project related wards)
	No. of troughs	10 troughs (1 each for a block)
	Total volume of works	10 blocks

3.2.6 Rural Infrastructure Improvement Plan

3.2.6.1 Basic Concept

As described in the previous section 3.1.8, infrastructures to be improved in future are wells, roads, schools, hospitals, clinics, rural electrification, and marketing facilities, etc. However, the project, through introduction of irrigated agriculture, intends to achieve stable as well as productive agriculture and, through which to contribute to raise the income as well as the living standard of the farmer households in the Study Area. Accordingly, the rural infrastructure improvement plan under the project must be basically formulated so as to support the above target. The rural infrastructure improvement plan must also cope with the change of agriculture and diversification of agricultural crops due to implementation of the project. In addition to improvement of roads and marketing facilities, etc., attention to such social infrastructures as drinking water facilities, schools, hospitals, clinics must be paid to raise the standard of social welfare in the rural area to achieve the target given in the project.

However, since the project is an agriculture-oriented project, improvement of schools, hospitals, clinics etc., should be taken care of by the other sectors or through continuous implementation of the existing projects and programs. With this understanding, rural infrastructure improvement plan under the project will take care of only rural roads, rural water supply facilities (boreholes), including recommendation for improvement of communication system.

3.2.6.2 Roads

Rural roads improvement plan under the project intends to improve the access to the existing social infrastructure as well as access to the markets in due consideration of improved transportation of agricultural crops to the markets. To achieve the above, existing rural roads (tracks or unpaved roads connecting the villages with local trunk roads, which fall under the category of Local Authorities Roads) of 279 km in total are proposed to be upgraded with gravel pavement of 20cm thick and 3.0 m width as shown in Table 3.2.5.

3.2.6.3 Boreholes

As one of the development strategy, it may be possible to put a strong emphasis on increasing the number of boreholes to meet the desirable number of boreholes of 250 persons per borehole according to the water supply standard recommended by NRWSSP (National Rural Water Supply and Sanitation Program). Improvement and strengthening of rural water supply under the Project will be made by rehabilitation of 90 existing boreholes and construction of 101 boreholes as shown in Table 3.2.6. With this improvement plan, it is expected that the drinking water supply condition in Sanyati communal area, Chisina-I area and Chisina-II area, where extreme shortage of drinking water from the wells is observed, will be improved.

3.2.6.4 Community Center and Communication System

As for the community improvement plan under the Project, no additional infrastructure will be constructed under the Project. As it is proposed to construct a community development center at Nyarupakwe Business Center as one of the pilot project components, which can accommodate approximately 300 people, it may be proposed that several community centers be constructed in future at different points of the related districts in the Study Area, only when the proposed community development center at Nyarupakwe is found useful and effective for dissemination of information. Under the said rural infrastructure development plan, improvement of the existing communication systems will be made by provision of several sets of audiovisuals and cars etc. The audio visuals will provide the farmers with agriculture-related technology and information applicable to their daily farming activities. These equipment will be managed by 3 working groups, each of which consists of 3 agricultural extension officers under the Lower Munyati Agricultural Development Authority (LMADA), a new organization proposed for the Project as mentioned in the next section 3.2.10. They will be utilized as the movable tools for dissemination of information by visiting from village to village of the related districts of the Study Area. It is proposed that each working group should have one audiovisual set and one car.