3.2.7 Agricultural Support Services Strengthening Plan

3.2.7.1 Agricultural Research and Extension

(1) Research

The agricultural research system in Zimbabwe has been well established and has primarily benefited farmers, in the LSCF sector. In the planning of research component for the Project, however, some attention have to be paid to the following:

(a) In the related three districts, there is only one public research facility: the Cotton Research Institute, and facilities for other crops are not available:

(b) The system of research-extension linkages are not established and functioning, so that research results are not always available to extension staff: and

(c) The present emphasis on commercialization of research would need to be recognized in the planning of this Project.

In consideration of the above, the research facilities proposed for the Project is based on the following concept:

(a) There is no justification for the establishment of a new research facility for high-level research (e.g. breeding) under this Project. However, a facility for adaptability of technologies developed by other research stations/institutes is warranted and should be established as one of sections of the Project O&M Office to be established under the Project O&M.

(b) The objective of this section is to establish proper production technologies under irrigated conditions by carrying out field trials and adaptive research trials particularly on farmers fields.

(c) In the execution of adaptive research work, therefore, consideration should be given to the conditions of beneficiary farmers, e.g. man-power and production inputs availability, and their needs for research, which would be clarified through farmers participation in the research as well as through training in new technologies.

The major activities undertaken by the proposed Research Section would be as follows:

(a) Monitoring of research and technology developments and collection of relevant research results through coordination with other research stations/institutions including private sector.

(b) Execution of adaptive research trials based on research results provided by other research stations/institutions.

(c) Planning of demonstration plot which would be operated by FAEOs.

The proposed Applied Research Section in the O&M Office would carry out a variety of trials giving a priority to development of irrigated agriculture. However, it would

also cover dry land crops, livestock and grazing land in order to assist the prevailing agricultural production system in the Study Area.

(2) Extension

The AGRITEX's structural reform is ongoing under the Agricultural Services and Management Project (ASMP) so as to make more rational and cost effective organization for the execution of extension services. With ASMP, reorganization of AGRITEX, and reallocation of extension staff, etc., are being carried out with commercialization of some components of the extension services and by promoting private sector's involvement. On the other hand, proper extension system is needed to be developed and introduced for the successful operation of the Project, although it usually requires an additional cost of the executing agency. With sufficient support, particularly at the initial stage of the Project, expected production and income increases would be accomplished both at small holders and national levels.

As characteristics of the beneficiary farmers, the important points to be taken into account are: (i) they are not well-experienced in irrigated agriculture, (ii) their educational level is low and nearly half of the household heads are non-educated and/or did not complete primary school, (iii) women are assuming a lot of activities in crop farming, (iv) while, men's involvement is higher than women's in all communication activities, and (v) cattle is the most popular livestock in the area and playing an important role in agricultural production by providing draft power. Taking the above discussion into account, the proposed extension services for the Project are planned based on the following concept:

(a) With the objective of establishing technical guidance and extension services on irrigated agriculture to beneficiary farmers of irrigation development, technical centers called Irrigated Agriculture Extension Center (IAEC) should be established in the both sides of the Munyati River of the Project Area. The one is at the left bank side by expanding the Agricultural Extension Center (AEC) to be established under the Nyarupakwe Pilot Project. The other is in the proposed irrigated area of the Seke dam at the right bank of the river. The IAECs should be established as the bases for the extension services provided under the Project.

(b) The extension services should be cost effective with an appropriate number of capable staff and utilization of existing facilities as far as possible.

(c) The services should be given mainly for farmers within the irrigation area. However, grazing land which keep draft animals should also be covered and improved under the Project, since such animals would play an important role in the irrigated agriculture.

(d) The services should be provided densely at the initial stage of the Project for a period of about 5 years. Thereafter, each tertiary unit should be operational by the farmers themselves in terms of water management and

cropping technologies with sparse services provided by the Project.

(e) Private sector, in particular, input supply company and companies with outgrower schemes should be involved in the extension effort.

Major roles of the project extension services would be as follows:

(a) Supply of technologies to beneficiary farmers to ensure their production under irrigated conditions;

(b) Assistance of beneficiary farmers in formation of Water Users Association (WUA) at each tertiary and secondary levels. These WUAs would be responsible for O&M in the respective command areas;

(c) In collaboration with the Applied Research Section, supply of training courses to the farmers on irrigated agriculture including O&M technologies using existing training facilities, e.g. the Cotton Training Center, Hatclif Engineering Training Institute, and Domboshawa Training Center; and

(d) Maintain close cooperation with input supply companies and outgrower schemes and arrange for training by private sector in areas of irrigated agriculture.

In order to provide these services, a new organization so-called Extension and O&M Support Section would be established under the proposed O&M Office. This section would be responsible for agricultural extension services in the irrigation development area, instead of the present agencies of District AGRITEX in Kadoma, Gokwe North and Gokwe South. The extension staff would be recruited from these agencies including Provincial AGRITEXs in Mashonaland West and Midlands Provinces or even from other Provinces/Districts. Although the number of extension staff required for the Project is difficult to decide at this study stage, at least one FAEO would be needed for every three tertiary units (each tertiary unit usually have an irrigated area of 100 ha). In the assignment of extension staff, it is proposed to recruit women's extension staff more than 20% of the requirements in the light of women's importance in the crop farming in the Project Area. Since most FAEOs are luck knowledge of irrigated agriculture, they should be trained in new technologies prior to the assignment. Such training would also be provided using the existing training facilities (e.g. the Cotton Training Center, Hatclif Engineering Training Institute, and Domboshawa Training Center).

3.2.7.2 Proposals for Improving Credit Availability

The method of disbursing credit to small farmers had changed drastically in the last few years, particularly in that most credit provided by Agribank and COTCO (which two account for almost 90% of the credit in the Project Area) are now given out as group loans. This highlights the importance of group formation under the project. The group lending scheme should be 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. Formation of producer groups also has other advantages for farmers and it is therefore recommended that:

(1) Every effort is made under the Project to form farmer groups whether it is producer associations or water user associations as this is now becoming a basic condition for obtaining cultivation credit. However, formation of groups does not necessarily ensure that credit would be available to all farmers in the Project. Farmers would be eligible for group credit from COTCO for cultivation of cotton. Agribank group loans would meet some other short-term financing needs. Farmers cultivating vegetables as outgrowers from export companies and agro-processors would have access to credit for seeds, fertilizer and chemicals from the contract companies. However, growers of maize, groundnuts and wheat would need to seek other sources of credit for cultivation. In view of the increased cultivation resulting from the increase in irrigated area under the Project it is recommended that:

(2) Agribank is requested to make arrangements to provide group loans to farmers in the Project Area for cultivation of wheat, maize and groundnuts. The total cultivation cost for these three crops annually is estimated at current prices as Z$267.0 million. In addition, it is recommended that arrangements are made with Agribank for an increase in training on credit administration which is currently conducted by the bank as a pre-condition for group loan eligibility.

(3) COTCO is requested to make arrangements to provide credit for cultivation of an additional 17,500ha per year in the Project Area for which the cultivation costs is estimated at Z$153.0 million annually. It is further recommended that an adequate number of collection points be set up in the proposed irrigated areas.

3.2.7.3 Proposals for Marketing System

The reform of the marketing system for farm products brought about by the liberalization of pricing, deregulation of statutory marketing controls, and opening up of the export /import trade has led to a more competitive market environment through the emergence of many traders and agro-processors and market determined prices. The Agricultural Policy Framework 1995-2020 acknowledges that the policy and institutional changes have now been completed and that the future emphasis should be on improvements to rural infrastructure.

(1) Rationale for Market Intervention

A marketing plan for the Project Area has to be formulated within the framework of existing government policies and programs. The basic concept in this regard is that with a highly de-regulated market environment there is now a more competitive marketing system with prices for inputs and outputs being determined by the market. Within this context, it has to be recognized that due to market structure, conduct and performance, there could exist market distortions. Such market distortions or

failures should be dealt with using the right policy or market interventions to ensure that farmers in the Project Area are not disadvantaged and that they have timely access to input and product output markets just as experienced by all other sectors of the economy. In addition, for equity considerations e.g. remoteness of rural areas, lack of infrastructure facilities and lack of farm inputs at the right time, place and price and the lack of market information, there is a case for market intervention. The approach taken in this Project in formulating a marketing plan for the Project Area is to propose market interventions based on market distortion and market failures as well as for equity considerations.

(2) Farm to Market Roads

The first prerequisite for the marketing plan is for a satisfactory network of roads in the Project Area. The distance to market in the Project Area varies between 3.5 to 65.0km, with an average distance of 25km. As part of the design of the proposed irrigated area, all-weather farm roads need to be in place so that farmers have access to a road no more than 5km from their respective farms. In the proposed irrigated area, there are a sufficient number of roads with width of over 3m which are well distributed so as to ensure that farmers would not have to transport farm inputs and outputs more that 5km by cart. In a few instances these roads are in very bad condition and impassable during certain times of the year. These would need to be identified and improvements undertaken so as to ensure all weather use. It is recommended that farm to market roads in the proposed irrigated areas that require improvement be identified and work undertaken on them.

(3) Collection Points and Input Sales Points

The major commodity organizations such as GMB, COTCO, Dairibord, and CSC as well as private companies supplying inputs and purchasing outputs should be contacted and arrangements made for temporary collection points (not a project cost). In addition, in planning the Growth Point consideration should be given to office and storage facilities (on a cost recovery basis) to encourage these trading organizations to set up collection centers and selling points. GMB and COTCO now operate such points in Sanyati, Gokwe, and Nembudziya. Seedco also have an outlet in Nembudziya for sales of seeds. The maximum distance for farmer to deliver cotton or grains should be 15 km.

(4) Growth Point

As the farming population on completion of settlement would be in excess of 50,000, it would be necessary for a focal point for all economic activity to bring together government agencies, private traders, input suppliers and financial institutions etc, to serve the new settled area. A new Growth Point should therefore be set up with social and administrative facilities (such as roads, sewage, water, schools and

administrative buildings for government and local government agencies, grocery store, shops, offices, banks, post office etc.). The Growth Point should centrally located either in Marungu or Ganyungu Business Center. In addition to the Growth Point, there should also have an Open Market for selling fresh produce which the farms could dispose of from time to time. Such an open market (approximately 60x60 m) with three open sides, roof and concrete floor should provide for individual stalls (4 x 4 m) with provision for water, electricity, drainage, weighing room and weighing scales, loading bay for trucks, waste disposal facilities, toilet, telephone, an office room for a Manager/Accounts Clerk and a security/ guard room. The manager should collect stall fees and utilize funds for self-financing maintenance of the facility.

(5) Producer Association

A Producer Association should be set up for every 200 farmers with Articles of Association and registration with LMADA. The association would over time be responsible for bulk purchase of inputs, group negotiation for production credit (a condition of COTCO production loans and a pre-condition for Agribank loans), and provide easier market access to companies doing outgrower contracts due to the companies interest in bulk, uniform production methods and quality control. The association would also benefit in bulk purchase of inputs, and increased bargaining power in sale of produce. The producer association should open a savings account in a bank or building society and members should receive training in finance and management. An Association Center (similar to the Training Centers now set up by AGRITEX) should be set up a building with an office room, meeting room, a small store room for storing inputs such as seed and fertilizer and an adjoining well ventilated shed for grading and packing high value fresh produce.

(6) Market Promotion

The Market Promotion Section would be set up within the proposed organizational structure of LMADA. This section will assist farmers in the whole Project Area by facilitating the sale of farm produce and purchase of farm inputs. The section would not directly or indirectly handle inputs or outputs. The section's primary role would be to seek market opportunities by contacting exporters, processors and input suppliers and assist in organizing farmers so as to enhance bargaining power in sale and purchase of produce and inputs respectively. It is designed to reduce production and market risks through contract farming. The section would also review market developments and explore potential for high value crops either for export or processing. Recent experiences with producers after the introduction of a market based pricing system indicates a need for such a service to ensure producers receive fair price for their produce and engage in marketing activities with necessary market information.

The section will facilitate production and marketing of high value crops. In

particular, the section will: (i) review market opportunities and market potential, analyze market trends and return to farmers, the risks associated with new products and provide advise to farmers on crop alternatives; (ii) maintain frequent and regular contacts with exporter and producer organizations such as the Zimbabwe Horticultural Council and follow developments in fresh agricultural product demand and supply; (iii) monitor market for farm inputs and prices of suppliers and provide advise to farmers on farm inputs; (iv) provide advise in formation of producer associations, association management and finance, and association purchase of inputs or sale of association produce; (v) assist farmers in entering into contracts with processors/exporters on contract provisions relating to product pricing, grading, packaging and transport of produce; (vi) collect statistical information on farm production and returns as well as marketable surplus; (vii) assist farmers and producer associations in obtaining legal advise on contract provisions; and (viii) liaise with AGRITEX and research agencies and assist in dissemination of technical information on production, marketing, grading, quality control, packaging, transport, cold storage and export regulations.

3.2.7.4 Programs for Strengthening Agricultural Support Services under the Project

In accordance with the proposed approaches for the strengthening of agricultural support services in the previous sections, the proposed programs for strengthening agricultural support services under the Project are formulated as presented below.

(a) Establishment of IAECs

Establishment of two IAECs: one at the Nyarupakwe Pilot Project Area by expanding the AEC established under the Pilot Project: one at the proposed irrigated area close to the Seke dam of the Seke River. The components of the program include: construction of IAEC building with office rooms, lecture/meeting rooms, stores, water and electricity supply facility and provision of office equipment & facility and training equipment.

(b) Adaptive Trials

Adaptive trials on crop selection & production, irrigation methods, water management and range land improvement & management.

(c) Extension Programs

Field programs (small & large-scale demonstration), training programs (farming practices, water management, group dynamics & farmers organization, range management etc.), and study tour.

(d) WUG/IMC Formation Guidance

Supporting formation and establishment of WUA and IMC at each tertiary unit level. Activities under the program include mass guidance, training and

support for the formation of organization.

(e) Farmer Organizations Formation Guidance

To strengthen or support formation of farmers organizations of beneficiaries of the grazing area development pilot scheme under the Project.

The program descriptions are presented in Table 3.2.7.

3.2.8 Review of Kudu Dam Design

Under the Zimbabwean governmental policy to develop the limited water resources in the country, the construction of the Kudu Dam on the Munyati River has been planned since the 1960's. Following this, design of dam has been completed using Zimbabwean budgetary resources in 1993. General features of dam and its appurtenances designed by DWD are shown below.

General Features of Kudu Dam

Hydrological Data		Dam body	
River	Munyati	Main dam	
Major tributaries	Nyamatani, Mazde	Dam type	Zoned fill dam
	Umsweswe, Zhombe	Height of dam	72.70 m
	Sesombi, Sebakwe	Crest level	EL. 955.20 m
Catchment area	17,520 km^2	Crest length	860.00 m
Mean annual rainfall	700 mm	Crest width	8.00 m
Mean annual runoff	56.7 mm	Slope : upstream	1:2.4 – 1:2.6
	993 x 10^6 m^3	downstream	1:2.0 – 1:2.3
Yield at 10% risk	380 x 10^6 m^3	Embankment volume	6.2 x 10^6 m^6
Reservoir		Saddle dam	
Surface area at FSL	7,800 ha	Dam type	Zoned fill dam
Full supply capacity	1,551.40 x 10^6 m^3	Height of dam	30.00 m
Live storage	1,426.85 x 10^6 m^3	Crest length	875.00 m
Dead storage	60.00 x 10^6 m^3	Crest width	8.00 m
Sediment volume	64.55 x 10^6 m^3	Slope upstream	1:2.5
High flood level	EL. 953.12 m	downstream	1:2.0 – 1:2.1
Full supply level	EL. 947.00 m	Embankment volume	1.3 x 10^6 m^6
Minimum level	EL. 905.00 m		
River bed level	EL. 882.50 m		
Spillway		Outlet works	
Type	Ungated ogee type	Type	Intake tower
Crest length	300 m	Tunnel Diameter	2.5 m
Design flood discharge	12,122 m^3/s	Length	650 m
	(2000 year flood)	Outlet capacity	31.49 m^3/s
Overflow depth	6.12 m	(at level of 10% full capacity)	

To examine the validity of the dam design, the review works were carried out based on the available data and supplemental field investigation during the First Field Work in November 1998 to February 1999. The results of review works are described below.

3.2.8.1 Geo-technical Assessment

The following geological surveys were carried out by DWD in 1990/91, and a report "A Geological Assessment of the Kudu Dam Site" was prepared in 1991.

Work Quantities Geological Investigations conducted by DWD

Location	Boring (holes)	Seismic Exploration (lines)	Test Pitting	Laboratory Testing
Main Dam	16	○	○	
Saddle Dam	8	○	○	
Spillway	6	○		
Intake Facilities	6			
Borrow Area			○	○

The bedrock of damsite consists of basaltic rocks on the riverbed and the right bank, and sedimentary rocks such as argillite, arenite and conglomerate on the left bank. The bedrock is very stiff with an assumed unconfined compressive strength more than 58.9 N/mm^2 at the intact portions, and weathered and/or deteriorated on the shallow portions and along minor sheared zones. Faults on the riverbed that were described in the previous investigation report are not a serious condition. The sheared zones are closely jointed and seem to be weathered to a considerable depth, but few clayey materials have been seen in the sheared zones.

In terms of strength, suitable foundations seem to appear 1 m to 5 m below the rock surface on the left bank, 5 m to 10 m below the rock surface on the right bank. No rock excavation, except trimming, is required on the riverbed and below the terrace deposits. Although no permeability test was done, it is foreseeable that bedrock on the left bank shows high permeability and requires huge grout injection to secure water tightness. In addition, rim grouting line seems to extend for considerably long distance to make a reliable water-stop along the ridge on the left bank, because the higher portion of the bank forms relatively narrow ridge with short seepage path, and seems to consist of high permeable rocks. To avoid a large amount of rock excavation on the right bank and huge grout injection on the left bank, it is suggested to shift the dam axis upstream for 100 m to 200 m after confirmation of the rock condition and permeability of the upstream portion.

Surficial deposits consist of top soil, residual soil, talus deposits, terrace deposits, and recent river deposit. It is assumed that the talus deposits are 5m thick on the higher portion of both banks. Terrace deposits are 15m to 20m thick on the middle portion of the left bank, and 8 m to 12 m thick on the middle to lower portion of the right bank. Other surficial deposits are partial and thin. These deposits should be excavated and could be used for dam embankment depending on the respective quality.

3.2.8.2 Embankment Materials

Kudu Dam was designed as a zoned fill dam with a height of about 73 m, by DWD in

1993. Through the site investigation in 1998 by the JICA Study Team, the additional investigation was proposed to get the detail characteristics of embankment materials (especially at the depth of more than 2 m of the borrow-pit) and to study the possibility of the rock fill dam construction.

(1) Earth Material

In the original dam design, a zoned fill dam was adopted. According to the materials investigation report prepared by DWD, quantity of impervious core materials of about $6.5 \times 10^6 m^3$ which is about 2.5 times as much the required quantity, was proved at 29 borrow areas. Rolled fill materials was proved to be about $2.5 \times 10^6 m^3$, which is almost half of the required quantity. The report mentions that the average depth of each material is about 1m on each borrow area. However, it was assumed that suitable materials of more than 5 m be available on some areas. Also, it was foreseeable that materials on surfaces of the areas contain much organic matter to a depth of 50 cm to 100 cm. In general, allowable organic content in embankment materials is specified to be less than 3%, and consequently, a huge amount of waste materials will derive from clay borrow development. In addition, collection of the materials from several sources will cause confusion on quality control and cost increase on construction of haul roads. To minimize the waste materials and to avoid uneconomical and inefficient way of material collection, it is recommended to select one or two borrow areas underlined by thick available materials. Considering the above, test pitting of 5 m deep and laboratory testing were proposed as the additional survey in order to select suitable borrow areas for impervious core and semi-pervious materials for shell zone.

The impervious zone (core zone) is located at the center portion of dam cross section and shell zones are located at upstream and downstream sides of core zone. However, judging from the result of soil test of earth materials, it is difficult to collect and select those core materials and shell zone materials, because there is almost no difference of particle size distribution between them. Accordingly, the following arrangement of core and shell zones is recommended:

Core zone: main function should be put to the impervious characteristics
Shell zone: main function should be put to the shear strength

The impervious material with the permeability coefficient of less than $k = 1 \times 10^{-5}$ cm/s should be used for the core zone and the semi-pervious material with the permeability coefficient of more than $k = 1 \times 10^{-4}$ cm/s be used for the shell zone. Shear strength of those materials shows wide range values, and the material with an average shear strength of $\phi' = 25$ degree shall be used for core zone and $\phi' = 30$ degree for shell zone.

(2) Sand/Gravel

The DWD report mentions that sand and gravel for filter and concrete aggregate are

available on the riverbed at about 300 to 1,000 m upstream of the damsite, and the proved quantity is 42,400 m^3, which is only half of the required quantity for the filters. The report said some other sources of river sand deposits have to be investigated around the damsite. Through the site reconnaissance during the Phase I First Field Work, possible sources of sand and gravel were found on the riverbed at about 1 to 3 km downstream of the damsite. Pitting of 1m deep at five spots and laboratory testing were proposed as the additional investigation, and the test result showed that sand and gravel materials can be used as not only filter material but also concrete aggregate.

(3) Rock Material

The DWD material investigation report mentions that rock materials are not available and an alternative source is far away from the damsite , about 12 to 15 km northeast of the site. A possible quarry site was found approximately 4 km upstream of the damsite. The site is underlain by andesitic rocks of the Maliyami Formation, which is different in lithology from the rocks in the damsite, and thereby laboratory test was done using block samples taken from the site to clarify the quality.

The test result showed that rock materials taken from the site satisfy above conditions and all of these rock materials are available for rock zone and rip-rap material. Further investigation, such as geological mapping, drilling, seismic prospecting, and laboratory test will be required to confirm the avilable quantity of the rock materials as well as to determine an optimum quarry site.

3.2.8.3 Dam Body

(1) Dam Type and Dam Axis

(a) Dam type

In the Kudu Dam Design Report prepared by DWD(1993), the zoned fill dam type was adopted in due consideration of non-availability of rock materials around the damsite. To examine the optimum dam type, the comparative study was made for zoned fill dam and rock fill dam, because a possible quarry site was expected at about 4 – 5 km upstream of the proposed damsite through the field reconnaissance survey during the First Field Survey in 1999. Rough quantity calculation were made for both zoned fill dam and rock-fill dam based on the typical standard cross sections, and the study result showed that the zoned fill dam has economic advantage although there is a few differences of construction costs between zone fill dam and rock fill dam. Therefore, the zoned fill dam type can be adopted as same as original design in this Study. However, as the Kudu Dam is a large scale dam with the dam height of 72 m, it is recommended to examine the possibility of rock fill dam, which has more advantage of the stability for the pore pressure and deformation of the dam body, through the detailed investigation of the location of quarry site, available

quantity and quality of rock materials.

(b) Dam axis

The appropriate dam axis shall be selected in consideration of (i) examinations in terms of deformation and shear strength as the dam foundation and examination of maximum storage with minimum excavation/filling volume. The designed dam axis by DWD satisfies the above conditions, however, from the topographic map, there is a steep branch on the left bank side of the designed dam axis. Furthermore, the conglomerate strata can be observed at the left bank of more than EL.930 m. From observation of the boring core, it seems that the permeability at/near the conglomerate strata are relatively higher than other portions. Therefore, seepage flow through the abutment shall be examined carefully so as to keep safety for determination of dam axis.

There is a method of using the creep ratio to evaluate the safety to the seepage failure (piping phenomenon) of the foundation. The examination to the piping phenomenon of the dam foundation was made by Bligh's method. Figure 3.2.10 shows the comparison between two dam axis, one is the original dam axis and the other is the proposed dam axis which is shifted about 100 m to upstream direction of the original dam axis.

The creep ratio to two streamlines shown in the figure are obtained as follows:

- For the original dam axis : $C_B = 370/(947-915) = 11.5$
- For the proposed dam axis : $C_B = 470/(947-915) = 14.7$

On the other hand, assuming that the permeable strata of conglomerate consists of sand/grave to coarse sand, required creep ratio in this case is 9～12. Therefore it is recommended that the original dam axis should be shifted about 100 m to upstream direction from the original position so as to keep required creep ratio. In this case, the reservoir storage capacity will decrease but its volume is estimated only 0.26% of total storage (1,551.4 million m^3) as shown below. It is noted that geological investigations at the proposed damsite should be done to confirm the geological conditions of dam foundation. When the dam axis will be kept as the original design, special treatment should be considered for protecting seepage failure.

(2) Design Seismic Force

The seismic force is not considered for dam design in Zimbabwe, because Zimbabwe is located out of an earthquake area. In this Study, the following basic policy regarding seismic force is proposed:

(a) Seismic force is not taken as a rule but safety of dam body is checked considering the scale of dam.

(b) The maximum acceleration which will be occurred in the future is calculated by statistics analysis based on the earthquake records in and

around Zimbabwe.

(c) The safety factor (Fs) to the slope stability analysis is taken as follow :
In the case non seismic force : $Fs \geqq 1.2$
In the case the seismic force by the statistics calculation : $Fs \geqq 1.1$

Based on the statistics calculation result of earthquake records for 26 years from 1973 to 1998, the maximum acceleration of 200-year period was estimated at about 45 gal.

(3) Stability Analysis of Dam Body

Based on the data from construction material investigation, stability analysis by slip circle slice method was made for four cases of reservoir water level: design flood level, full supply level, intermediate water level, and just after completion. From the result of analysis, it is proposed to change the upstream slope of the dam body from 1 : 2.4 – 2.6 to 1 : 2.6 – 2.8 as shown in Figure3.2.11.

3.2.8.4 Foundation Treatment

Many boring tests at the proposed dam axis was conducted by DWD, but permeability analysis was not made. In the original design, only single line of curtain grouting was planned. Based on the examination from the results of observation of boring core, geological column and supplemental field investigation, two lines of sub-curtain grouting was proposed to be executed to improve permeability near the surface of the foundation. Furthermore, in addition to the curtain grouting, blanket grouting was also proposed at both sides of curtain grouting in order to make water tightness along the boundary between core zone and foundation.

3.2.8.5 Spillway

In the original design by DWD in 1993, the only part of overflow weir section of spillway was designed as the concrete structure with the design flood discharge of 2000-year return period. The flood discharge after overflow portion will be running through the natural ground and then flow into the river. From the result of the geological investigation, highly weathered basaltic rock and talus deposit seem to be distributed with the thickness of more than 5m at the downstream area of the overflow weir. Therefore, the overflow flood will erode and devastate the natural ground gradually.

On the other hand, Zimbabwe has an alternative standard regarding the design flood discharge of spillway, which indicates that emergency spillway has to be installed with the flood discharge of 2000-year return period, and 250-year flood can be taken for the service spillway in consideration of the various situations such as topographic or economic constraints.

Thus, it was proposed to install service spillway and emergency spillway. The service spillway is designed to be able to release the flood discharge of 250-year

return period, and is designed as a concrete structure so as to keep the stable flow condition of the discharge. The emergency spillway is designed to be able to release the flood discharge of a 2000-year flood. The channel is not lined with concrete except the inflow section.

3.2.8.6 Temporary Diversion Works

Generally, a fill type dam has less resistance to overflow, and overtopping from dam crest should be avoided even if during construction. In the small and medium rivers in Zimbabwe, width of the river is relatively wide and river stream disappears into underground in the dry season. From these characteristics, the construction method without diversion channel is often applied in Zimbabwe. This method is to provide a weir section cutting a part of dam body filled in the dry season and to discharge river stream through this weir section in the rainy season.

In the original design by DWD, the above construction method was applied, because DWD has many experiences in construction of fill type dams with this construction method. However, the Kudu dam is a large scale dam with about 9.5 MCM of embankment volume and construction period will be about 5 years. Also, the Munyati river is a big river and the catchment area at the proposed damsite is very wide at about 17,000 km^2. It means considerable big floods will be expected during construction period. Therefore, careful attention should be paid to the adjacent zone between previous embankment and new embankment because previous embankment may be damaged by floods in the rainy season.

From the viewpoint of safety construction, it is recommended that the originally designed intake tunnel be re-studied so as to have the function as the diversion channel such as elevation and section of tunnel, etc.

3.2.9 Environmental Management and Mitigation Plans

3.2.9.1 Construction Phase

Construction will bring employment benefits to many. There will be a large influx of skilled and semi-skilled persons living in camps near to the dam construction site and in the area of major works for irrigation scheme construction. The vast majority will be men. Housing, sanitation, medical, and recreational facilities must be planned to mitigate the indirect impacts of impermanent construction camp settlement, including waste disposal, disease transmission, and local social disruption.

In the construction period as many as 200 skilled Zimbabwean engineers (30-50 foreign personnel) could be engaged, together with some 1,000–1,500 workers during the 5–7 year dam construction period. In the downstream irrigation area as many as 1,000 men and women might be engaged in temporary construction works while the main and secondary irrigation canals are constructed. The employment policy should not discriminate against women when presenting themselves for work

on the project. It may be appropriate to consult VIDCOs and kraalheads to determine a consensually agreed recruitment policy.

Facilities for labour camps should include health services and recreational facilities. Environmental criteria need to be incorporated into siting of accommodation and office units, including sanitation and waste disposal. There must also be respect for any possible archaeological artefacts, including human remains, which might come to light in excavations. The policy will be that these must be reported immediately to the Project Manager and the Environmental Monitoring and Management Section (EMMS) within the Lower Munyati Agricultural Development Authority (LMADA) which is proposed as the new organization for implementation and operation and maintenance of the project described in the next section 3.2.10.

To ensure the integrity of watercourse systems a policy of pollution and siltation control needs to be adopted. Oil changes for mechanical equipment should be made at designated workshop sites and a policy of re-utilisation of used oil for timber preservation can be incorporated. Waste oil will be offered for use to the local communities.

Vehicle access routes should be constructed to minimise possible erosion and runoff into river courses. Around construction sites and quarries the excavation of siltation traps should be undertaken in line with normal good engineering practice. In the downstream area similar principles of good practice should apply in the construction of irrigation systems, including canals and other structures. All these aspects will be monitored by the EMMS.

Examination of project engineering plans shows that all fill materials will be sourced from within the inundated area. Therefore, there will be no important implication for landscaping of borrow areas. EMMS will advise and monitor as necessary.

3.2.9.2 Resettlement Plans

There are three Wards which will be directly affected by the dam construction and the creation of the supply reservoir. In order of potential impact they are: Mabura Ward and Sidikeni Ward in Kwekwe District and, to a lesser extent, Ward 17 (a resettlement scheme) in Kadoma District. The actual numbers to be affected will depend on three factors: a) the height of the dam and the impounded reservoir, b) the resettlement policy, and c) the extent of any possible protection or buffer zone around the dam.

Table 3.2.8 "Resettlement Scenarios" presents various different scenarios for resettlement with their implications. The two preferred resettlement options are "Resettlement Scenario 1" and "Resettlement Scenario 2".

(1) Resettlement Option 1

The first of the options is the creation of a buffer zone of 2–3 km around the

dam, with a recreation area and limited access rights to local people.

(2) Resettlement Option 2

"Resettlement Scenario 1" assumes the evacuation of three VIDCOs, necessitating only limited additional compensatory measures for those affected by loss of grazing and water access. Indirectly affected persons will benefit from access and employment.

(3) Resettlement Option 3

A third scenario, "Resettlement Scenario 2", is for evacuation of two VIDCOs (Batanai and Kubatana). This may require some additional *ad hoc* resettlement of households especially with a reservoir extending to the 950 metre contour.

(4) Resettlement Option 4

A fourth scenario, for comparative purposes, assumes minimal resettlement to cover only households submerged and those very close to the dam reservoir.

A proposal to develop an extensive buffer zone around the dam would necessitate much local dislocation (physical, social and psychological). There does appear any technical justification. There may also be considerable local resentment if a generous policy of access were not entered into. As much access should be accorded as possible so long as there is no conflict with sustainable natural resource management.

It is estimated that about 500 farm families will require resettlement. Zimbabwe and AGRITEX have mixed experience regarding resettlement. The Project must take full responsibility for managing its own resettlement requirement in liaison with the District Administrators office. The Project can then be sure that successful resettlement is achieved and no negative publicity is attached to the project at the start so that all affected persons are fairly treated. Project affected persons and their representatives will need to be involved in decision-making.

It is strongly recommended that a reliable NGO preferably with international accredition is employed to "facilitate" the resettlement process. The financial resource requirements for this will be very small and their involvement will ensure there is no bad feeling towards the government and project implementation management.

3.2.9.3 Land Re-Allocation in Irrigation Areas

(1) Policy Principles

The adopted approach for much smaller schemes so far developed has been for local leadership (DA's office, councilors and traditional leaders) to draw up lists of interested farmers from the vicinity of a project and select farmers on a more or less

consensual basis. Depending on the size of plot allocated beneficiaries have in some cases been restricted to the existing dryland farmers, on other schemes where the plot allocation has been smaller, and there is greater demand, selection is said to have been by drawing lots.

Those living closest to their fields will likely produce the best crops. To live close-by is to "be involved" - it enables greater labour time input, with reduced costs in transport and storage of inputs and harvests, and regular presence guards from intrusion and theft. Distant farmers cannot render the same care and attention. Where new houses and settlements need to be built, the traditional and local representative leadership must be consulted on matters of location and acceptability.

Women must not be excluded as potential plotholders nor must plotholders be allowed to become "vulnerable to the whims of the menfolk, whether they be husbands or male government officials" (Vijfhuizen in Mansungu and van der Zaag eds. 1996). The participation of women and their work may arguably be more critical to the implementation success of the Project than the involvement of men.

Project transparency in plot allocation is critical for this Project. It is suggested that within each ward plot allocation be determined by the members of the ward themselves and that as far as possible each ward consider its new irrigable land as a new resource to be shared within its ward. Only in special cases of insufficient interested farmers should offers of irrigated land be made across wards. It is believed that a top-down or "over-rationalised" approach is sure to fail and create a plethora of minor conflicts.

(2) Selection Criteria and Method

Naturally those women and men who are cultivating in new irrigation areas should be given an automatic right to be allocated a plot. After this, Agritex, with NGO assistance, should have lists drawn up of willing irrigators in the local kraals. In cases where there is excess local demand additional selection criteria must be brought to bear. NGO personnel will be involved in organising this process under contract to the Community Participation and Plot Allocation Section (CPPAS) of the Resettlement, Community Participation and Environmental Management Division (RCPEMD) within the LMADA.

These criteria must include reasonably close access, experience with cash crops and, if possible, evidence of commitment and capability (Master-farmer certificates are rare in the area and not necessarily appropriate as selection criteria). Government servants and their households are said to be barred from plots. Whether new settlements might need to be constructed close by isolated irrigation tracts needs to be established.

Before lots are drawn a list should be made public by the NGO organisation with opportunity for complaint against those who do not fulfil the criteria. It is proposed

by the Project that the project office in the form of the CPPAS can act as independent 'counsel' and be responsible for the drawing of lots after the local participative process of self-selection for the lists has been undertaken. AGRITEX will facilitate the planning process and draw plot maps.

It will be through local consensus who gets which plot so that those living on one side of a scheme do not have to travel unnecessarily to the other side and *vice versa*. Planning and allocation of plots must be by mutual agreement of interested farmers.

3.2.9.4 Multi-Purpose Reservoir Area Management

It has been proposed that there should be as little disruption to local people's use of resources as possible commensurate with sustainable use of these natural resources. Prioritising local employment in the facilities developed should be a guiding principle. This does not mean that there be no control or management of access to the lake. Following the initial consultations undertaken by the Department of National Parks and Wild Life Management (DNPWM) will be consulted to develop an appropriate management plan for the reservoir area, subject to agreement taken concerning resettlement policy and community access. Fisheries development and appropriate stocking need to be undertaken in a scientific manner during the course of project implementation and afterwards.

The quality of the water in the lake could change drastically over the decade after construction, supporting different commercial and non-commercial species. Investigations must be done by the Fisheries Department to see how the project can capitalise on the potential economic value of the fisheries resource. There should be a dual approach to exploitation with small local artisanal fisheries in certain zones of the lake to supply local villages and markets and a commercial operation with freezing facilities as warranted.

An outline of a possible recreational plan will be prepared during detailed design. There might be opportunities for developing a boating and lakeside resort on the south or north shore allowing possibilities of a conservation and tourist type experience. In the residual non-inundated area of Batanai and Kubatana VIDCO areas cattle should be excluded by fencing. There will then be an opportunity for vegetation to regrow and stocking with small species of buck. The potential clientele or market for a "tourist experience" is limited because the lake is far from Harare (three hours drive) and not located on a tourist circuit.

3.2.9.5 Catchment Management

There are few serious concerns about excessive siltation affecting the life of the dam. However, silt loads should be subject to monitoring by the EMMS and river and lake siltation processes observed on a periodic basis in case action becomes necessary. It is therefore not suggested that at present any check dams are necessary in the upper catchment to reinforce the sustainability of the dam reservoir capacity. Check dams

and structures are not always very successful over the long term.

The Claw Dam on the Umsweswe River and Lower Zivagwe Dam on the Sebakwe River effectively provide siltation protection from two of the three major inflowing rivers. The Claw dam (and Lake John Mack) on the Umsweswe is 50km upstream of the Kudu dam site and will trap silt from this major inflowing river. The Zivagwe Dam, on the Sebakwe River is close to the town of Kwekwe, some 80km upstream of the new dam site. There are other small dams on a large number of the smaller tributaries and a weir at the town of Munyati on the Munyati River.

Clearance of vegetation on the dam reservoir site must be attempted and firewood or timber values designated to benefit local communities. It is expected that soil erosion should be more restricted on newly irrigated land which was formerly grazed or farmed as dryland. Increased intensity of agriculture on irrigated lands will be accompanied by increased use of organic fertilisers and pesticides. There is therefore a risk from poor and wasteful practices in chemical use which could lead to downstream pollution of the Munyati and ultimately Lake Kariba into which it drains.

3.2.9.6 Health Programme

It is the responsibility of the Project to allocate resources to mitigate the impacts of waterborne disease, particularly malaria and bilharzia to the extent that the Project will otherwise be seen to be seriously aggravating and spreading existing and already important health problems affecting people in the Project Area. Boreholes are to be developed and sanitation facilities around irrigation areas can be incorporated.

A vector control and educational programme based on prevention and regular funded treatment for bilharzia (schistosomiasis) and malaria needs to be programmed and costed. Co-operative links can be established with local hospitals and medical centres. In the case of malaria, use of bednets and the spraying of buildings are also to be recommended. There is already regular government insecticide spraying activity in the Project Area by the District Department of Environmental Health.

3.2.9.7 Project Environmental Monitoring and Control

During implementation of an environmentally sound project the project management should undertake environmental monitoring of all project activities with negative implications whether impacts be temporary in duration or long term impacts. This will be the responsibility of the EMMS of the RCPEMD.

It is proposed that there should be an independent system of recourse for all persons with grievances concerning compensation for land-take, trees, crops, etc., and any environmental damage being inflicted unreasonably by the Project. Indeed there may be Zimbabwe conservation groups with particular concerns, and possibly some international issues. This will be a central area of responsibility for the CPPAS.

The head of the EMMS will be at first under the head of the RCPEMD but as

construction and implementation are completed the EMMS will take over all environmental responsibilities. From the beginning the EMMS will make a regular monthly internal report to the project manager alerting him to emerging and unresolved environmental matters. He will also produce a quarterly report for general and wide circulation which will help build awareness of environmental, social, health and project welfare issues.

There will be a formal long term environmental record keeping programme established. This will be based on decision-relevant parameters among those listed below. The EMMS/RCPEMD will keep the Project Manager informed at all times, formally and informally, of important environmental and social concerns and will be pro-active in seeking to resolve emerging problems.

3.2.9.8 Post-Implementation Monitoring

Ongoing monitoring for appropriate corrective responses would involve continuous surveillance of a range of parameters. A complete checklist of monitoring and associated evaluation areas is presented below.

(1) Water quality and ecology
   (a) Changes in water quality through measurement of salinity, pH water temperature, oxygen levels, and nutrient levels in the lake, upstream and downstream
   (b) Hydrogen sulphide and methane generation from submerged vegetation
   (c) Limnological sampling of microflora, aquatic weeds and benthic organisms
   (d) Occurrence of snails in the dam and downstream in the command area
   (e) Surveys of fish catches, species and populations
   (f) Observations of wildlife in the area around the lake

(2) Land and reservoir resource management
   (a) Strategic assessment of possible vegetation changes in the upper watershed and downstream Project Area
   (b) Handling of agro-chemicals in the irrigation areas and extension programme
   (c) Livestock changes in the Project Area
   (d) Recreational use and accommodation
   (e) Appropriateness and success of access agreements with local communities
   (f) Irrigation area and canal water quality

(3) Beneficiary health programmes and welfare status
   (a) Health status of intended beneficiary groups in the Project Area
   (b) Success of vector control programme, including malaria and bilharzia occurrence

(c) Quality and quantity of borehole drinking water supplies

(d) Women's welfare and access to land

3.2.9.9 Environmental Programme Cost Implications

The cost of buying dryland for resettlement of those to be moved from the reserved area is a function of the resettlement policy agreed. Based on current government resettlement planning estimates from the Inception Phase Framework Plan (1999-2000) of the Land Reform and Resettlement Plan-Phase 2 an appropriate cost in land acquisition and infrastructure development might be of the order of US$ 12,000 per resettler household. Cost estimates in this document vary between US$ 5,300 and US$ 21,000 based on a number of different criteria developed over recent years.

The following table applies the US$ 12,000 figure to the table in Table 3.2.8 based on actual household size from the inventory survey in affected villages of five household members.

Table of Resettlement Scenario Cost Estimates

Resettlement Options	950 metre contour	
	HHs	Cost US$
1. Full Buffer Scenario	720	8,640,000
2. Resettlement Scenario 1	640	7,680,000
3. Resettlement Scenario 2	470	5,640,000
4. Minimal Land-Take	370	4,440,000

The approximate overall costs of the necessary environmental management programme for an environmentally sound project to include full resettlement costs (a figure of 6.5 million US$ is used for resettlement – between Scenario I and II) is shown in the table below. These include a precautionary health programme to mitigate the dangers of spread of malaria and bilharzia.

Resettlement and Environmental Management Costs

Item	Cost (US$)
Environmental Staff	3,300,000
Transport/Vehicles	660,000
Resettlement Costs (submerged area)	6,500,000
Resettlement Facilitation	200,000
Land Re-Allocation Facilitation	300,000
Conservation Planning	100,000
Health Component Contingency	200,000
Total	11,260,000

3.2.10 Proposed Organizational Set-up for the Kudu Dam Irrigation Project

In formulating the organizational plan for the Project implementation and operation and maintenance, the following changes of organizational and management structure are taken into account:

(1) DWD's operational functions will be undertaken by the new organization of

Zimbabwe National Water Authority (ZINWA), which will become a commercially-oriented, self-financing entity responsible for water planning and bulk water supply, responsive to the needs of its clients. After this reformation, ZINWA will responsible for the implementation and operation and maintenance (O&M) of dams and main irrigation canal systems. Water development projects to be operated and managed by ZINWA should be economically feasible and shall have high collection rate of water charge.

(2) Another new organization of Catchment Councils will be established. The council will plan water resource management and allocation holistically, using hydrological boundaries as the basic planning and management unit, which will allow allocations and associated charges to be more equitable than in the past.

(3) AGRITEX will be responsible for the implementation and O&M of irrigation and drainage systems under main canal system. In order to provide high efficiency of services, change of organizational structure of AGRITEX is also in progress.

(4) At the farmer level, O&M of tertiary systems are being carried out by the Irrigation Management Committees (IMC) which have been established with the guidance of AGRITEX. However, many IMCs are inactive and depend upon AGRITEX for their O&M works. Particularly in "Maintenance fee (Z$ 145/ha per annum)" which farmers have been required to pay to AGRITEX is limitedly collected. AGRITEX is expected to meet the O&M costs through its declining budgetary allocations.

If these changes are adopted to the Project, ZINWA would be a responsible organization for construction and O&M of the Kudu dam and main canals with political support to be provided by the Catchment Council, while construction and O&M of secondary and tertiary systems would be undertaken by the beneficiary farmers with AGRITEX support. For the Project implementation and O&M, however, it is proposed to establish an independent authority called the Lower Munyati Agricultural Development Authority (LMADA) considering the following issues:

(1) This scale of irrigation project mainly to serve small farmers has not yet been experienced in Zimbabwe,

(2) Most of beneficiary farmers are not experienced in irrigated farming, and thus proper support services are prerequisite particularly at the initial stage of the Project operation so as to achieve the expected benefit both at farmer and national levels,

(3) On the other hand, recent structural reform of relevant agencies aims at commercialization of their services, and ZINWA and AGRITEX are requested to curtail their budgets,

(4) Present AGRITEX's structure which consists of two provinces and three

districts is considered to be difficult to provide services effectively to the one unit of proposed irrigation system, and

(5) Further, equipment and facilities for O&M and extension services such as machinery and vehicles are insufficiently available in ZINWA (or DWD) and AGRITEX.

LMADA would be a legal entity for all intents and purposes, and would have functions of ZINWA and AGRITEX for the Project implementation and O&M. Figure 3.2.12 shows the proposed organizational structure of LMADA.

3.2.10.1 Proposed Organization for Project Implementation

LMADA for Project implementation stage would consist of four divisions: (i) Engineering, (ii) Agricultural, (iii) Resettlement, Community and Environmental Management, and (iv) Administration and Finance.

(a) The Engineering Division would be responsible for planning, survey, deign, preparation of tender documents and evaluation, and construction supervision for dam, irrigation system and rural infrastructure.

(b) The Agricultural Division would mainly make preparatory works at the initial stage, such as collection of data and information on technology of agricultural production and marketing, and formulation of plan for agricultural extension program, establishment of water users group and farmers' training program. However, after construction of Kudu dam, farmers' training and adaptability research would be started in coorperation with the Agricultural Extension Center which will be established in the Nyarupakwe pilot area.

(c) The Resettlement, Community and Environmental Management Division would have responsibilities for resettlement programming, implementation of resettlement action plan, defining land re-allocation policy and modalities, and planning land re-allocation and facilitation in liaison with relevant agencies and NGOs. This division would also have a function of environmental management and monitoring during the construction period.

(d) The Administration and Finance Division would be responsible for contracting works, budget management, accounting and auditing during the construction period.

LMADA would recruit required staff for these engineering and administration activities. For dealing with important policy matters relating to the operations or financing of LMADA, it is proposed to set up a Steering Committee comprising the representatives of government agencies related to the Project as well as representatives of farmers.

3.2.10.2 Proposed Organization for Project Operation and Maintenance (O&M)

LMADA for Project O&M stage would consist of the following four divisions, same with the implementation stage basically.

(a) The Engineering Division would be responsible for the hardware O&M of the reservoir and irrigation systems including the gate operation. The Rural Infrastructure Section which be responsible for construction of rural roads and boreholes during the construction stage, would be excluded from the LMADA, because District Development Fund (DDF) will take care of their operation and maintenance.

(b) The Agricultural Division would be responsible for the adaptability research, extension and training, and market promotion, all of which would be for proper O&M and production activities to be undertaken by the beneficiary farmers. This division would be also responsible for operation and maintenance at on-farm level through water users groups.

(c) The Resettlement, Community and Environmental Management Division would have functions of environmental management at around the Kudu dam reservoir and monitoring of natural and social environment. Resettlement Section and Community Participation and Plot Allocation Section which be established during the construction period, will be excluded from the LMADA.

(d) The Administration and Finance division would be responsible for procurement, O&M budgeting including water charge and O&M fee management, monitoring/reporting, and general administration.

The Steering Committee would fulfill the responsibility for dealing with important policy matters relating to the operations or financing of LMADA.

3.3 Project Cost and Implementation Plan

3.3.1 Basic Conditions and Assumptions for Cost Estimate

The project cost was estimated based on the following conditions and assumptions:

(1) Cost estimate was referred to the prices as of the expiration time of the Phase II Field Survey, June 2000.

(2) Unit prices of labors, construction materials and engineering works, etc., were collected from DWD and AGRITEX.

(3) Price escalation was evaluated based upon "Consumer Price Index, 1990 =100", "Civil Engineering Price Index, 1990 = 100" and "Building Materials Price Index, 1990 = 100".

(4) Construction mode is on contract basis.

(5) Conversion rate among Zimbabwe Dollars (Z$), US Dollars (US$) and Japanese

Yen (¥) was assumed to be US$ 1.0 = Z$38.0 = ¥ 105.0.

3.3.2 Project Cost

The construction works of the Project comprise six (6) components of (i) Kudu dam, (ii) irrigation and drainage facilities, (iii) livestock development scheme, (iv) rural infrastructure improvement, (v) agricultural support services strengthening, and (v) pilot project as shown in Table 3.3.1.

(1) Construction Cost of Kudu Dam

Construction cost of Kudu dam was estimated through the review work for the original design and cost estimate conducted by DWD. The estimated construction cost is Z$ 3,640,574,000 (US$ 95,805,000), which includes resettlement cost.

(2) Construction Cost for Irrigation and Drainage Facilities

Construction works of the irrigation and drainage facilities consist of main and second irrigation canal system and on-farm facilities in communal/resettlement areas and small/large scale commercial farms. Main and secondary irrigation canal system includes trapezoidal concrete lining canals on both sides of Munyati river and their related structures such as a siphon for crossing Munyati river, a number of crossing structures on the tributaries and pump stations for providing irrigation water to high lands of communal/resettlement areas. Construction cost of the main and secondary irrigation system was estimated at Z$ 3,519,230,000 (US$ 92,611,000). The on-farm facilities comprise tertiary canals, related canal structures, farm drains, farm roads and also include land consolidation work for each irrigation area in communal/resettlement areas and small/large scale commercial farms. The estimated of construction cost of on-farm facilities is Z$ 2,188,450,000 (US$ 57,591,000). Therefore, the total cost of irrigation and drainage facilities becomes Z$ 5,707,680,000 (US$ 150,202,000).

(3) Cost for Livestock Development Scheme

The livestock development scheme consists of livestock water development scheme and grazing area development scheme. Construction works for these schemes will be provision of water troughs along the main and secondary irrigation canals, and establishment of fully fenced grazing blocks with water troughs. The estimated construction cost is Z$ 5,544,000 (US$ 146,000).

(4) Cost for Rural Infrastructure Improvement

Improvement of rural infrastructure is composed of rehabilitation of roads, construction and rehabilitation of wells, and improvement of communication system. The estimated cost is Z$ 286,017,000 (US$ 7,527,000).

(5) Cost for Agricultural Support Services Strengthening

For strengthening the agricultural support services, two irrigated agricultural extension centers will be established, and the extension programs will be provided. The cost for agricultural support services strengthening is Z$ 21,797,000 (US$ 574,000).

(6) Cost for Pilot Project

The pilot project is planned to be implemented in Nyarupakwe area on the left bank of Munyati river, and its components are water resources development for livestock, irrigation and domestic water, rural infrastructure improvement, institutional strengthening and agricultural support services strengthening. Cost for the pilot project was estimated at Z$ 257,653,000 (US$ 6,780,000).

Consequently, total amount of the Project cost becomes Z$ 9,919,265,000 (US$ 261,033,000) as shown in the following table, and project cost per 1ha is Z$ 396,771 (US$ 10,441). The break down of the Project cost is shown in Table 3.3.2.

Project Cost

Item	Construction Cost (Z$1,000)
Kudu Dam	3,640,574
Irrigation and Drainage Development	5,707,680
Livestock Development	5,544
Rural Infrastructure Improvement	286,017
Agricultural Support Strengthening	21,797
Pilot Project	257,653
Total Amount	9,919,265

3.3.3 Operation and Maintenance (O&M) Cost and Replacement Cost

O&M cost comprises labor costs, fuel expenses, material costs and administrative costs, etc., and is estimated as follows;

O&M Cost

Item	O&M Cost (Z$1,000/year)
Kudu Dam	25,100
Irrigation and Drainage Development	75,560
(out of which, pump operation cost for pump irrigation system)	(30,000)
Livestock Development	50
Rural Infrastructure Improvement	2,260
Pilot Project	1,945
Total Amount	104,915

The replacement cost is calculated to be 1.0% of the total project cost and counted every ten years for replacement of various equipment with shorter life than the project evaluation term.

3.3.4 Implementation Schedule

Feasibility Study will be accomplished in October 2000, and preparatory work period for project implementation is considered two years, which includes detailed design, setting up of organization, arrangement of funds, tender evaluation and contract, etc. The construction work will be started from 2003 and total construction period will be eight years from 2003 to 2010. Before project implementation, the detailed resettlement program should be prepared through discussion with residents in the submerged area, and prompt actions should be taken.

The Pilot Projects should be started earlier as soon as possible, therefore, construction work of the Nyarupakwe medium-scale dam will be started from July 2002, six months before main construction works, and should be completed in one and a half years. Other works of the Pilot Project should be completed at the end of the year of completion of the Nyarupakwe dam. Institutional strengthening program and agricultural extension services strengthening program will be started in 2003 and continued for three years up to 2005.

The Kudu dam will be constructed in 5 years from 2003 to 2007. Construction work of the main and secondary irrigation canals will be started one year after starting the Kudu dam construction work, in 2004, and will be completed in 2008. Construction work for irrigation and drainage facilities at communal and resettlement areas will be started in 2007 to be finished in 2010. As for small and large scale irrigation farms, construction of irrigation and drainage facilities and also land consolidation work will be commenced in 2008 and be completed in 2010 in step with construction works of communal and resettlement areas.

Construction of water troughs for livestock will be done in parallel with construction of these main and secondary irrigation canals because they will be provided along these canals. Grazing area development will be done in three years from 2008 to 2010. Rural infrastructure improvement works including rehabilitation of roads, improvement and construction of boreholes and improvement of information transmission measures will be conducted in 2006 to 2008.

Agricultural support services strengthening consists of construction of two Irrigated Agricultural Extension Centers (IAECs) and executing the agricultural extension services program. One IAEC proposed at the Seke area will be constructed in 2004 in expectation of completion of the Seke irrigation system upto 2003 and the other will be constructed in 2007 through expansion of the Agricultural Extension Center (AEC) to be provided at the Nyarupakwe Pilot Area. Agricultural extension services program will be executed for five years from 2007 to 2010.

Project implementation schedule is shown in Figure 3.3.1.

3.4 Project Evaluation

3.4.1 General

Project evaluation is made through assessment of the project feasibility in view of economic and financial aspects. The economic viability of the project is found by estimating economic internal rate of return (EIRR), benefit-cost ratio (B/C), and benefit minus cost (B-C). EIRR may be defined as the rate of discount at which the total present value of cost incurred during the life of the project is equal to the total present value of benefits accruing during the life of the project. Sensitivity analysis is also made in order to elucidate the economic viability of the project against the changes in benefits and costs. Financial evaluation of typical farm household economy is made to examine the capacity to pay for the water charges and O&M cost at the farm level.

3.4.2 Economic Evaluation

3.4.2.1 Basic Assumptions

Basic assumptions for project evaluation are as follows:

(1) The economic life of the project is 50 years,

(2) All prices are expressed at June 2000 constant prices. They are kept constant throughout the Project period,

(3) The exchange rate of US$ 1.00 = Z$ 38.0 = JYE 105.0 is applied,

(4) The main cause of low productivity in the Study Area is due to the lack of irrigation water. So the present agricultural conditions are regarded as without the project case,

(5) The construction period is 10 years including 2 years for the preparatory works, detailed design, and evaluation for the whole project, and

(6) Benefits from irrigation development, livestock development, industrial/domestic water supply from dam and borcholes, and road rehabilitation are taken into account.

3.4.2.2 Evaluation of Economic Factors

All the costs and benefits are identified. Economic (shadow) prices are then applied to these costs and benefits, to find their real impact on national income. A series of conversion factors have been calculated to convert financial prices to their economic values. For evaluation of economic prices and costs, the following criteria have been used.

(1) Standard Conversion Factor (SCF)

In order to evaluate project costs and benefits with respect to world market prices, a SCF of 0.93 was applied to the prices of non-traded goods and services. This figure was calculated on the basis of export and import statistics for the years 1994-1998.

(2) Construction Cost Conversion Factor (CCF)

The construction cost conversion factor was estimated at 0.80.

(3) Conversion Factors for Agricultural Inputs, Wage Rate and Transportation

Conversion factors for fertilizers, chemicals, seeds, labour and transportation were estimated as shown in the following table:

Conversion Factors for Agricultural Inputs, Transportation and Energy

Particulars	Conversion Factors	Remarks
(a) Fertilizers	0.86	See Appendix XIV
(b) Chemicals	0.76	See Appendix XIV
(c) Seeds	0.76	See Appendix XIV
(d) Shadow Wage Rate		
Skilled Labour	1.00	See Appendix XIV
Unskilled Labour	0.40	
(e) Transportation (truck)	0.68	World Bank Estimate
(f) Transportation (railroad)	0.73	World Bank Estimate
(g) Energy	0.62	World Bank Estimate

3.4.2.3 Transfer Payment

From the international economic point of view, the transfer payment such as contract tax, duty, subsidy, and interest are considered as domestic monetary movement without direct productivity. These transfer payments were excluded from the project costs and agricultural inputs in the economic evaluation.

3.4.2.4 Economic Farm-gate Prices of Agricultural Inputs and Outputs

Economic prices of farm inputs such as seeds, fertilizers and chemicals were calculated applying conversion factors as described before. Financial prices of locally traded agricultural products such as cabbage, tomato, etc. were converted to economic prices using Standard Conversion Factor (SCF) of 0.93. Economic farm-gate prices of agricultural production e.g. cotton, maize and wheat, were estimated based on the international border prices at Durban.

3.4.2.5 Economic Costs

(1) Project Cost

The financial construction costs were converted into the economic construction costs by applying construction cost conversion factor (CCF) of 0.80 as described above. The economic cost is summarized as follows :

Summary of Project Cost

(Unit: 1,000 Z$)

Financial Cost	Conversion Factor	Economic Cost
9,919,264	0.80	7,935,411

(2) Replacement Cost

Replacement Cost was estimated at Z$ 69,943,000 which is appropriated every 10 years after completion of construction works.

(3) Operation and Maintenance Cost

Operation and maintenance costs were estimated at Z$ 83,932,000/year.

3.4.2.6 Economic Benefits

(1) General

The benefit of the Project will be derived from (i) irrigation development, (ii) urban/industrial water supply, (iii) domestic water supply, (iv) maize stalk/residues supply, (v) road rehabilitation, and (vi) livestock development.

(2) Benefit from Irrigation Development

The direct benefit to be expected in the Project Area is derived from the increased crop production attributed to a stable irrigation water supply. The farmers are anticipated to add some new crops to their cropping pattern. The benefit will therefore be incremental to the existing benefit. The balance of total amount of economic net return obtained from crop production, between future with and without project conditions is the direct benefit and is summarized in the following table. The benefit is expected to increase year by year after the completion of irrigation project. The anticipated incremental net production value in the full stage is shown in Table 3.4.1.

Incremental Net Benefit from Irrigation Development

(Unit: Z$ 1,000)

Financial/Economic Value	Without Project Condition	With Project Condition	Incremental Net Benefit
Economic Value	120,643	1,507,535	1,386,892

(3) Urban/Industrial Water Benefit

Construction of Kudu dam enables to supply urban water of 60 MCM annually. Although amount of urban/industrial water supply is small comparing with irrigation water requirement, benefits from water supply are obtained applying the water pricing method of the Ministry of Rural Resources and Water Development, June 1999.

$UW = WP \times \alpha$

Where, UW : urban/industrial water benefit (Z$)
WP : willingness to pay for the urban water supplied (Z$/m^3)
α : amount of urban water supplied (m^3)

The value of water estimated by the construction of Kudu dam is Z$ 0.958/m^3 and based on this figure the urban/industrial water benefit was estimated as shown in the following table:

Benefit from Urban/Industrial Water Supply

Particulars	Amount of Water Supplied (MCM)	Unit Price of Water (Z$/m^3)	Total Amount (Z$ 1,000)
Economic Value	60	0.891	53,460

(4) Domestic Water Benefit

Rehabilitation of 90 boreholes and construction of 101 new boreholes are projected in the Study Area. The domestic water benefit was calculated based on the water pricing method of the Ministry of Rural Resources and Water Development, June 1999. The amount of water supplied from boreholes was calculated as follows:

191 units x 10m^3/day x 365 days = 697,150m^3/year

Benefit from Domestic Water Supply

Particulars	Amount of Water Supplied (m^3)	Unit Price of Water (Z$/m3)	Total Amount (Z$ 1000)
Economic Prices	697,150	14.802	10,319

(5) Benefit from Maize Stalk/Residues

Animal husbandry is a common activity in the Study Area as it is regarded as a resource of wealth and insurance against crop failure or any other problems. Livestock production depends on achieving a better balance between the livestock population and feed supply. Maize stalk is expected as a stable source of fodder. The benefit expected from maize stalk is calculated as shown in the following table:

Benefit from Maize Stalk/Residues

Particulars	Without Project Condition	With Project Condition	Increment
Cropped Area (ha)	10,500	4,500	−6,000
Per ha Stalk Production (1,000kg)	8,400	27,000	18,600
Price (Z$/kg): Economic	1.67	1.67	
Total Value : Economic (Z$1,000)	14,028	45,900	31,062

(6) Benefit from Road Rehabilitation

The proposed road rehabilitation works will be done for 279 km of farm to market link roads and 24 km of main farm road from Nyarupakwe to Gokwe. The benefit form these roads rehabilitation works was estimated at Z$ 17,833,000 as an economic basis taking account of saving cost in vehicle operation and transportation of farm products, etc.

(7) Benefits from Livestock Development

Livestock benefit is expected from savings in herding livestock, surface soil conversion and livestock water development scheme. The economic benefit from livestock development was estimated at Z$ 5,590,000.

3.4.2.7 Economic Evaluation

In order to compute EIRR, B/C and B-C, annual economic costs and benefits flows were prepared as shown in Table 3.4.2. The result of economic evaluation is summarized in the following table:

Results of Economic Evaluation

Particulars	Results	Remarks
EIRR (%)	10.5	
B/C Ratio	1.06	Discount Rate 10%
B-C (1,000 Z$)	337,753	Discount Rate 10%

3.4.2.8 Sensitivity Analysis

Sensitivity analysis for the Project was made to evaluate the soundness of the Project against unexpected adverse changes in future for the following cases:

(a) In case that the cost runs over the price and physical contingencies by 10%,
(b) In case that the expected benefit decreases by 10%, and
(c) In case of combination of (a) and (b).

The effects of these changes in EIRR were estimated and are summarized below.

Results of Sensitivity Analysis (EIIR : %)

Cost	Benefit	
	0	- 10 %
0	10.5	9.7
+ 10 %	9.7	8.9

3.4.3 Financial Evaluation

Financial viability of the Project was evaluated from the view point of the farm economy. Farm budget analysis was conducted to access whether the project will generate enough income in the farmers' economy. The payment capacity is defined as the ability of the beneficiary farmers to bear the expenses for operation and maintenance cost of the irrigation facilities as well as water charges. The average net income per farm household was estimated Z$ 53,688 after project implementation. Deducting the household expenditure the forecast capacity to pay was obtained at Z$ 38,031 as shown in the following table:

Household Budget (Unit: Z$)

Particulars	Whole Project Area	
	Without Project Condition	With Project Condition
Net Agricultural Income	8,487	45,566
Net Livestock Income	636	636
Off Farm Income	7,486	7,486
Total Net Income	16,609	53,688
Living Expenditure	13,615	15,657
Net reserve	2,994	38,031

In the above calculation, it was assumed that the standard farm household will have an irrigation area of 1ha after irrigation development. In this case water charge and O&M cost are calculated as follows;

Water charge : Z$ 310/1000 m^3 x 12,300 m^3/ha/year = Z$ 3,813/ha/year
O&M Cost : Z$ 145/ha/year

The total amount of water charge and O&M cost becomes Z$ 3,958/year, for which the beneficiary farmer will have enough capacity to pay. The water charge may increase to Z$ 561/1000m^3 within four years and the beneficiary farmer shall bear about Z$ 7,000/year of water charge and O&M cost at that time, for which the farmer will still have enough capacity to pay.

3.4.4 Socio-Economic Impacts

There are various intangible benefits expected from the implementation of the Project. Major impacts expected after the implementation of the Project are described here.

(1) Improvement of Farm Roads in the Project Area

Local transportation will be improved by the construction of the farm roads along the canals and the rehabilitation of village roads. The expanded road system will not only enhance the economic activities but also contribute inter-regional accessibility and communication.

(2) Improvement of Living Condition

The increase and diversification of crop production will generate a considerable amount of net profit to farmers. Hence the farmers will be in a position to have substantial surplus. This might give them an opportunity to renovate and rebuild their houses. They can spend more on their clothing, health care, sanitation, education, etc. This will improve social and cultural amenities of village and give an impetus to further development in the area.

(3) Improvement of Domestic Water Supply Condition

The construction of irrigation canals will improve the situation of water supply for daily use and drinking water for livestock. Availability of clean water will improve the sanitary situation of the area and will prevent sickness of farmers and livestock.

(4) Increase of Employment Opportunity

The project will generate employment opportunities during the construction period. Farmers will gain more experience, technical know-how, skills in various working fields and those skills would be applied to the future development in the region as well as O&M activities. In addition the project will create a demand of farm labour due to increased farming activities.

(5) Food Availability throughout the Year

Irrigation will intensify crop production and the food will be available throughout the year and there is a chance of a more balanced food intake on household level especially by children. Cultivation of vegetables in homestead or kitchen garden and the increment of livestock products, owing the availability of water, will elevate the nutritional standard of the farm households.

(6) Foreign Exchange Savings

The incremental production of agricultural products will contribute to food security, which has been a concern for long, both the regional level and the national level.

(7) Empowerment of Women

The project will improve agricultural production condition and bring income increase to farmers. Such income increase will enable women to have a time to participate in activities related to education, culture, leisure, etc, which will elevate their social standing.

(8) Demonstration Effects to Other Similar Projects

The successful implementation of the project including operation, maintenance and water management will bring the demonstration effect to other similar irrigation projects. Especially, technical knowledge on operation, maintenance and water management for irrigated agriculture can be transferred to other relevant staffs.