JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF AGRICULTURE
REPUBLIC OF ZIMBABWE

THE MASTER PLAN STUDY ON THE LOWER MUNYATI BASIN AGRICULTURAL DEVELOPMENT

FINAL REPORT

APPENDIX

OCTOBER 1995

SANYU CONSULTANTS INC.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF AGRICULTURE
REPUBLIC OF ZIMBABWE

THE MASTER PLAN STUDY
ON
THE LOWER MUNYATI BASIN
AGRICULTURAL DEVELOPMENT

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APPENDIX

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SANYU CONSULTANTS INC.

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APPENDIX A. GENERAL AFFAIRS

SCOPE OF WORK

FOR

THE MASTER PLAN STUDY ON

THE LOWER MUNYATI BASIN AGRICULTURAL DEVELOPMENT

IN

REPUBLIC OF ZIMBABWE

AGREED UPON BETWEEN

THE MINISTRY OF LANDS, AGRICULTURE AND WATER DEVELOPMENT

OF

REPUBLIC OF ZIMBABWE

AND

THE JAPAN INTERNATIONAL COOPERATION AGENCY

HARARE, 20 APRIL 1994

B. N. Ndimande
Permanent Secretary
The Ministry of Lands,
Agriculture and Water Development

Ikuo Fujimori
Leader
Preparatory Study Team
The Japan International
Cooperation Agency

I. INTRODUCTION

In response to the request of the Government of Republic of Zimbabwe (hereinafter referred to as Zimbabwe), the Government of Japan decided to conduct the Master Plan Study on the Lower Munyati Basin Agricultural Development (hereinafter referred to as the Study) in accordance with the relevant laws and regulations in force in Japan. Accordingly, the Japan International Cooperation Agency (hereinafter referred to as JICA), the official agency responsible for the implementation of the technical cooperation programmes of the Government of Japan, will undertake the Study in close cooperation with the authorities concerned of the Government of Zimbabwe.

The present document sets forth the scope of work with regard to the Study.

II. OBJECTIVES OF THE STUDY

The objectives of the Study are:

1. to prepare a master plan for the agricultural development in the lower Munyati basin and

2. to carry out on-the-job training of the Zimbabwean counterpart personnel in the course of the Study.

III. OUTLINE OF THE STUDY

1. Study Area

The Study shall cover the Munyati basin within Kadoma District, Gokwe North District, Gokwe South District and the northern part of Kwekwe District.

2. Scope of the Study

a. Diagnostic analysis of the Study Area.

(1) collection and review of the relevant existing data and information with regard to:
- development policies, strategies and plans;
- existing studies;
- natural conditions;
- socio-economic conditions;
- agricultural activities/conditions;
- agricultural/rural infrastructure and facilities; and
- environmental conditions

(2) collection of additional data and information through field surveys.

(3) evaluation of the Study Area situation in terms of:
- natural conditions, focusing on land and water resources;
- socio-economic conditions;
- agricultural activities/conditions;
- agricultural/rural infrastructure and facilities;
- rural institution and administration; and
- environmental consideration, including public health.

(4) identification and assessment of development needs, potentials and constraints.

b. Formulation of the Master Plan

(1) identification and evaluation of possible development scenarios.

(2) formulation of the Master Plan consisting of the following components:
- agricultural development plan,
- water resources development plan,
- irrigation and drainage development plan,
- agricultural/rural institutional development plan,
- agricultural support service plan,
- marketing development plan,
- environmental conservation plan,
- identification and evaluation of priority projects,
- implementation plan,
- operation and maintenance plan, and
- approximate estimation of the costs.

(3) evaluation and recommendation.

IV. Study Schedule

The tentative schedule of the Study is as attached (see Annex).

V. REPORTS

JICA shall submit the following reports in English to the Government of Zimbabwe.

1. Inception Report
Twenty (20) copies two weeks before the commencement of the work in Zimbabwe.

2. Progress Report
Twenty (20) copies around the middle of the work in Zimbabwe.

3. Interim Report

Twenty (20) copies at the end of the work in Zimbabwe.

4. Draft Final Report

Twenty (20) copies at the end of the work in Japan. The Government of Zimbabwe shall submit the comments on the Draft Final Report to JICA within one (1) month after the receipt of the Draft Final Report.

5. Final Report

Fifty (50) copies within two months after the receipt of the comments from the Government of Zimbabwe on the Draft Final Report.

VI. UNDERTAKING OF JICA

For the implementation of the Study, JICA shall take the following measures:

1. to dispatch, at its own expense, a Study Team to Zimbabwe and

2. to pursue technical training of the Zimbabwean counterpart personnel in the course of the Study.

VII. UNDERTAKING OF THE GOVERNMENT OF ZIMBABWE

1. To facilitate smooth conduct of the Study, the Government of Zimbabwe shall take necessary measures:

   (1) to secure the safety of the study team;

   (2) to permit the members of the study team to enter, leave and stay in Zimbabwe for the duration of their assignment therein and exempt them from foreign registration requirements and consular fees;

   (3) to exempt the members of the study team from taxes, duties and other charges on equipment, machinery and other materials brought into Zimbabwe for the conduct of the Study;

   (4) to exempt the members of the study team from income tax and charges of any kind imposed on or in connection with any emoluments or allowance paid to the members of the study team for their services in connection with the implementation of the Study;

   (5) to provide necessary facilities to the study team for the remittance as well as the utilization of funds introduced into Zimbabwe from Japan in connection with the implementation of the Study;

   (6) to secure permission for the study team to enter private properties or restricted areas for the implementation of the Study;

(7) to secure permission for the study team to take all data and documents (including maps and aerial photographs) related to the Study out of Zimbabwe to Japan; and

(8) to provide the study team with medical services as needed, the expenses of which shall be chargeable on the members of the study team.

2. The Government of Zimbabwe shall bear claims, if any arises, against the members of the study team resulting from, occurring in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willful misconduct on the part of the members of the study team.

3. The Department of Agricultural, Technical and Extension Services (hereinafter referred to as AGRITEX) of the Ministry of Lands, Agriculture and Water Development shall act as a counterpart agency to the study team and also as a coordinating body in relation with other relevant organizations for the smooth implementation of the Study.

4. AGRITEX shall, at its own expense, provide the study team with the following in cooperation with other organizations concerned:

(a) available data and information,

(b) additional survey related to the Study, if necessary,

(c) counterpart personnel,

(d) suitable office space with necessary equipment in Harare and the Study Area, and

(e) credentials or identification cards.

VIII. CONSULTATION

JICA and AGRITEX shall consult with each other in respect of any matter that may arise from or in connection with the Study.

ANNEX

TENTATIVE SCHEDULE

MONTH	1	2	3	4	5	6	7	8	9	10	11	12
WORK IN ZIMBABWE	■	■	■	■	■			■				
WORK IN JAPAN						■	■			■		
SUBMISSION OF REPORT	* Ic/R		* P/R		* It/R				* DF/R			* F/R

(Note) Ic/R: Inception Report
P/R : Progress Report
It/R: Interim Report
DF/R: Draft Final Report
F/R : Final Report

THE MINUTES OF MEETINGS

ON

THE SCOPE OF WORK

FOR

THE MASTER PLAN STUDY ON

THE LOWER MUNYATI BASIN AGRICULTURAL DEVELOPMENT

IN

REPUBLIC OF ZIMBABWE

HARARE, 20 APRIL 1994

B. N. Ndimande
Permanent Secretary
The Ministry of Lands,
Agriculture and Water Development

Ikuo Fujimori
Leader
Preparatory Study Team
The Japan International
Cooperation Agency

The Japan International Cooperation Agency (JICA) dispatched the Preparatory Study Team (the Team) for the Master Plan Study on the Lower Munyati Basin Agricultural Development (the Study) to Republic of Zimbabwe from 12 to 21 April 1994 in response to a request by the Government of Zimbabwe.

During their staying in Zimbabwe, the Team had a series of meetings on the outline of the Study and administrative and logistic arrangements for the implementation of the Study with the representatives of the Ministry of Lands, Agriculture, and Water Development (MLAWD), the Department of Agricultural, Technical and Extension Services (AGRITEX), the Department of Water Development (DWD), the Department of Research and Specialist Services (DR&SS) and the Department of Natural Resources (DNR) in the Ministry of Environment and Tourism. The Team also made a field visit, accompanied by the staff of AGRITEX, to the proposed study area.

Consequently, the Team and MLAWD mutually agreed on the Scope of Work for the Study. The following minutes were prepared to supplement the Scope of Work as well as to confirm the main issues discussed and matters agreed upon.

1. Inter-Ministerial Committee

For the smooth and effective implementation of the Study, it was mutually agreed to establish an Inter-Ministerial Committee which should be comprised of various organizations concerned with the Study. The chairman of the Committee shall be MLAWD, and the members will be from AGRITEX, DWD, DR&SS, DNR, National Economic Planning Commission (NEPC), the Ministry of Finance and the Ministry of Local Government, Rural and Urban Development.

2. Objectives of the Study

The original request by the Government of Zimbabwe to JICA was for them to conduct a feasibility study for the Kudu Dam Irrigation Scheme. However, JICA proposed to conduct a master plan study for agricultural development in the lower Munyati Basin. It was mutually agreed that a master plan study, which would look into various issues in a comprehensive manner, should be necessary for sustainable agricultural development in the lower Munyati Basin.

3. Study Area

It was agreed in the meetings that though the area covered by the Study was as defined in the Scope of Work, the Study Team should be flexible enough to look into other potential development areas further down the lower Munyati Basin.

For the assessment of water resources, it was mutually agreed that the whole catchment area of the Munyati River should be studied. This assessment will be primarily based on the review of the existing data and information.

4. Study Schedule

It was agreed in the meetings that the Study Schedule should take into account the fact that, if the Study commenced during the rainy season, there might be need to extend the study period by one month. JICA shall inform the Government of Zimbabwe of the Study Schedule once it is fixed.

5. Review of the Proposed Kudu Dam Irrigtion Scheme

It was agreed that the proposed Kudu Dam Irrigation Scheme would be reviewed in the course of the Master Plan Study.

6. Environmental Considerations

It was mutually agreed that environmental impacts of the Master Plan on both up-stream and down-stream areas of the Munyati River should be assessed in the course of the Study.

7. Report

It was agreed during the meetings that JICA would submit the Inception Report well in advance so that there would be enough time for the Government of Zimbabwe to consider and approve it.

8. Undertakings of AGRITEX

AGRITEX agreed to provide offices for the JICA Study Team both in Harare and the Study Area. Office necessity, such as desks, chairs, electricity and local telephones, shall be provided by AGRITEX. On the other hand, to facilitate smooth conduct of the Study, AGRITEX requested JICA to procure vehicles and other necessary study equipment.

AGRITEX agreed to carry out the following tests in cooperation with DWD and DR&SS:

- soil test, and
- water quality test.

9. Counterpart Personnel

The Government of Zimbabwe will assign counterpart personnel to the JICA Study Team, and these will include the following:

- agronomist
- irrigation engineer/planner
- hydrologist
- soil specialist
- sociologist
- agricultural economist
- agriculture marketing specialist
- environmental specialist

10. Training of Counterpart Personnel

It was agreed that counterpart personnel assigned by the Government would be given technical on-the-job training by the JICA Study Team. This will also include training in report writing and preparation.

LIST OF THE PARTICIPANTS IN THE MEETINGS

Representatives of the Government of Zimbabwe

Dr. B. N. Ndimande, Permanent Secretary, MLAWD
Mr. T. Takavarasha, Deputy Secretary, MLAWD
Dr. S. S. Mlambo, Deputy Secretary, MLAWD
Mr. D. Mfote, Senior Agricultural Economist, MLAWD
Mr. C. Kapuyanyika, Acting Chief, Project & Research Division, MLAWD
Mr. D. Mungate, Chief Agricultural Extension Officer, MLAWD
Mrs. J. Ndoro, Senior Agricultural Economist, MLAWD

Mr. J. Chitsiko, Deputy Director (Engineering), AGRITEX
Mr. E. Chidenga, Acting Head of Irrigation, AGRITEX
Mr. F. F. Paradza, Senior Irrigation Specialist, AGRITEX
Mr. A. Dube, Senior Irrigation Specialist, AGRITEX

Mr. D. S. Durham, Deputy Director, Planning and Hydrology, DWD
Mr. D. Kammer, Planning Engineer, DWD

Mr. S. Mashiri, Principal Research Officer, DR&SS

Mr. S. Chaibva, Principal Environmentalist, DNR
Mr. I. D. Kunene, Chief Ecologist, DNR
Mr. R. Mkwanda, Senior Ecologist, DNR

The JICA Preparatory Study Team

Mr. I. Fujimori, Leader
Ms. Y. Katsumata, Coordinator
Mr. A. Araki, Irrigation and Drainage
Mr. T. Fujimori, Agriculture
Mr. H. Sasaki, Environmental Consideration

Embassy of Japan in the Republic of Zimbabwe

Mr. T. Ohashi

MINUTES OF THE MEETING

ON

THE INCEPTION REPORT FOR THE MASTER PLAN STUDY

ON

THE LOWER MUNYATI BASIN AGRICULTURAL DEVELOPMENT

IN

THE REPUBLIC OF ZIMBABWE

HARARE, DECEMBER 6, 1994

Mr M P KAVIYA
Deputy Secretary
Administration and Finance
MINISTRY OF LANDS, AGRICULTURE
AND WATER DEVELOPMENT

Mr Yoshitomo MIYANISHI
Leader
Master Plan Study Team
JAPAN INTERNATIONAL
COOPERATION AGENCY

Mr R J CHITSIKO
Deputy Director
Dept. of Agricultural Technical
and Extension Services
MLAWD

Dr Shoichiro NAKAGAWA
Chairman
Advisory Committee for
the Master Plan Study
JICA

A joint meeting between the representatives from the Ministry of Lands, Agriculture and Water Development (hereinafter referred to as "MLAWD"),
Ministry of Finance, Ministry of Local Government, Rural and Urban Development,
National Economic Planning Commission and the JICA Study Team (hereinafter referred to as "the Team") was held on 6th December, 1994 at the conference room of MLAWD, to discuss the contents of the Inception Report. The Team submitted twenty (20) copies of the Inception Report through AGRITEX on 2nd December, 1994.

After discussion, the contents of the Inception Report were agreed by and between both parties with confirmation of the following items:

1. **MLAWD** has nominated Mr David Mfote, Acting Principal Agricultural Economist as Zimbabwean Coordinator, and names and positions of the counterpart staff will be discussed and finalised at the meeting to be held on 12th December, 1994 at AGRITEX.

2. **AGRITEX** understands the Minutes of Meeting on the Scope of Work for the Study signed on 20th April, 1994, however, due to financial constraints, Department of Research and Specialist Services (DR&SS) strongly requested the Team to supply necessary chemicals for soil analytical tests, and this will be discussed and finalised in the said meeting.

3. Delineation of the Study Area should be, in principle, based on the boundary fixed by the Team, and be adjusted in the course of the Study if deemed necessary.

4. MLAWD requested the involvement of Zimbabwean counterpart personnel in the preparation of the Draft Final Report, in order for them to learn the process of project formulation. And, the Team promised to convey the MLAWD's request to JICA Head Quarters.

5. MLAWD pointed out that the scenario with Kudu Dam should include an option to develop other water sources for the agricultural development, and the Team replied such concept will be considered as one of alternative scenario in the Study.

6. Both parties agreed to make maximum cooperation and effort among each other to obtain the best and fruitful outcome in the Master Plan Study.

Attached Sheet No. 1

LIST OF ATTENDANCE

Representatives of the Government of Zimbabwe

1.	Mr M P Kaviya	Deputy Secretary, MLAWD
2.	Mr R Mariga	Act. Chief Agricultural Economist, MLAWD
3.	Mr D Mfote	Act. Principal Agricultural Economist, MLAWD
4.	Mr R J Chitsiko	Deputy Director (Engineering), AGRITEX
5.	Mr E Chidenga	Acting Chief of Irrigation Branch, AGRITEX
6.	Mr F F Paradza	Senior Irrigation Specialist, AGRITEX
7.	Mr A Dube	Senior Irrigation Specialist, AGRITEX
8.	Mr S Mushiri	Principal Research Officer. DR&SS
9.	Mr A C Mpamanga	Deputy Secretary, MLGRUD
10.	Mrs L R Kahari	Desk Officer, MOF
11.	Mr R Dhlodhlo	Senior Planner, NEPC

JICA

1.	Dr Shoichiro Nakagawa	Chairman, Advisory Committee
2.	Mr Shiro Nabeya	Coordinator

Study Team

1.	Mr Yoshitomo Miyanishi	Team Leader
2.	Mr Michio Goto	Water Utilization/Source Planner
3.	Dr Philip Chigaru	Farm Management Planner
4.	Mr Akio Koto	Soil/Land Use Expert
5.	Mr Tetsuo Oda	Coordinator

MINUTES OF THE MEETING

ON

THE PROGRESS REPORT FOR THE MASTER PLAN STUDY

ON

THE LOWER MUNYATI BASIN AGRICULTURAL DEVELOPMENT

IN

THE REPUBLIC OF ZIMBABWE

HARARE, FEBRUARY 9, 1995

Mr C. Kapuyanyika
Principal Agricultural Economist
Project and Research Section
MINISTRY OF LANDS, AGRICULTURE
AND WATER DEVELOPMENT

Mr. Yoshitomo MIYANISHI
Leader
Master Plan Study Team
JAPAN INTERNATIONAL
COOPERATION AGENCY

Witnessed by

Mr. R. J. Chitsiko
Deputy Director
Dept. of Agricultural, Technical
and Extension Services
MLAWD

Mr. Michio GOTO
Co-Team Leader
Master Plan Study Team

A joint meeting between the representatives from the Ministry of Lands, Agriculture and Water Development (hereinafter referred to as "MLAWD"), Department of Natural Resources, Department of Physical Planning, National Economic Planning Commission and the JICA Study Team (hereinafter referred to as "the Team") was held on 8th February, 1995 in the conference room of MLAWD, to discuss the contents of the Progress Report. The Team submitted twenty (20) copies of the Progress Report through MLAWD on 6th February, 1995. Attendance to the meeting is listed in the attached sheet No.1.

After discussion, the contents of the Progress Report were agreed by and between both parties with confirmation of the following items:

1. Both sides agreed the boundary of the Study Area set forth in the progress report with total area of 5,052 sq.km extending two provinces of Mashonaland West and Midlands.

2. Both sides agreed the primary objective of the Master Plan Study is to formulate an agricultural development plan for the Lower Munyati River Basin, which includes examination of possibility to implement a feasibility study of the Kudu Dam project.

3. Government guiding policy for full time or part-time irrigation: for household plot size of 1.0 ha or more, full-time irritation is recommended on the basis of labour availability for irrigated crop production. Part-time irrigation is recommended for irrigation plot size of less than 1.0 ha.

4. In compliance with the request made by Inter-Ministerial Committee in the joint meeting on the Inception Report regarding the involvement of Zimbabwean counterpart personnel in the preparation of Draft Final Report, the Study Team reported that JICA Head Quarters will accept one trainee for about a month.

5. Inter-Ministerial Committee requested successive use of the equipment brought by the Study Team as listed in the attached sheet No. 2 for the purpose of fulfillment of data required for further studies. The Team promised to convey this request to JICA Head Office.

6. Additional or further comment on the Progress Report shall be forwarded to the Study Team through the chairman of the Inter-Ministerial Committee.

(Attached Sheet No. 1)

LIST OF ATTENDANCE

Representatives of the Government of Zimbabwe

1.	Mr. C. Kapuyanyika	Act. Chief Agricultural Economist, MLAWD
2.	Mr. D. Mfote	Senior Agricultural Economist, MLAWD
3.	Mr. R. J. Chitsiko	Deputy Director, AGRITEX
4.	Mr F. F. Paradza	Senior Irrigation Specialist, AGRITEX
5.	Mr S. Madyiwa	Senior Irrigation Specialist, AGRITEX
6.	Mr. D. S. Durham	Deputy Director (Planning), DWD
7.	Mrs. E. Mlalazi	Chief Planning Officer, Dept. of Physical Planning
8.	Mr. R. Dhlodhlo	Senior Economist, NPEC
9.	Mr. E. J. Mhaka	Senior Nat. Res. Officer, DNR

Study Team

1.	Mr Yoshitomo Miyanishi	Team Leader
2.	Mr Michio Goto	Water Utilization/Source Planner
3.	Dr. Philip Chigaru	Farm Management Planner
4.	Mr. Takehiko Ogawa	Agricultural Economist/Project Evaluation
5.	Mr. Jiro Yabe	Irrigation & Drainage/O & M. Expert
6.	Prof. Lovemore Zinyama	Environmental Management Planner

(Attached Sheet No. 2)

LIST OF EQUIPMENT BROUGHT STUDY TEAM

Item		Unit	Quantity	Specification
1.	Photocopying Machine	set	1	Minolta EP 3170
2.	GPS (Global Positioning System	set	1	IPS-760 (JE)
3.	Planimeter	set	2	Tamaya
4.	Water Quality Tester	set	1	WQC-20A
5.	Standard Soil Colour Book	vol.	1	
6.	Spot Imagery	set	1	1/100,000 (2 sheets)

MINUTES OF THE MEETING

ON

THE INTERIM REPORT FOR THE MASTER PLAN STUDY

ON

THE LOWER MUNYATI BASIN AGRICULTURAL DEVELOPMENT

IN

THE REPUBLIC OF ZIMBABWE

HARARE, MAY 26, 1995

Mr. V. Vudzijena
Chief Agricultural Economist
Economic Division
MINISTRY OF AGRICULTURE

Mr. Yoshitomo MIYANISHI
Leader
Master Plan Study Team
JAPAN INTERNATIONAL
COOPERATION AGENCY

Witnessed by

Mr. E. Chidenga
Chief, Irrigation Section
Dept. of Agricultural, Technical
and Extension Services
MOA

Mr. Akira KAITSUMARU
Team Leader
JICA Advisory Team

A joint meeting between the representatives from Ministry of Agriculture (hereinafter referred to as "MOA"), Ministry of Lands and Water Resources, Ministry of Finance, Ministry of Local Government, Rural and Urban Development, JICA Advisory Team and JICA Study Team (hereinafter referred to as "the Team") was held on 23rd May, 1995 at the conference room of MOA, to discuss the contents of the Interim Report. The Team submitted twenty (20) copies of the Interim Report through AGRITEX on 16th May, 1995. Attendance to the meeting is as per attached.

After discussion, the contents of the Interim Report were agreed by both parties with confirmation of the following items:

1. Both sides confirmed the following conditions applied in the formulation of the basic agricultural development concept (Development Scenarios):

   - Target year in each development scenario.

   - Projected population and households in year 2010.

   - For allocation of farmland in communal/resetllement areas, 1 hectare under irrigated condition and minimum of 4 hectares under rainfed.

2. Both sides confirmed the following points for preparation of a basic agricultural development plan (Master Plan):

   - Proposed three development scenarios are to be independently examined towards their prioritization.

   - For allocation of any water resources to be developed for the agricultural purpose under the Master Plan, AGRITEX suggested the guidelines that due priority is given firstly to the communal and resettlement areas, secondly to the small scale commercial areas, and thirdly to the large scale commercial areas.

3. The Zimbabwean side requested the Team to work out measures for solving the development constraints in each scenario with required cost estimation.

4. The Team made remarks on further issues as mentioned in the attached paper No.1, which should be taken into account to prioritize the proposed scenarios.

5. Although both sides confirmed that the proposed scenarios include many significant constraints and issues to be cleared, especially in Scenario A, the Zimbabwean side strongly expressed their preference to promote regional development by Scenario A.

6. In spite of separation of the former Ministry of Lands, Agriculture and Water Development into two ministries, namely, Ministry of Agriculture, and Ministry of Lands and Water Resources, the former will remain as a coordinating body of the Inter-Ministerial Committee for the Master Plan Study.

7. The Team informed the Committee that JICA will dispatch a mission to Zimbabwe for explanation and discussion on the Draft Final Report in early August, 1995.

Further Issues to be Considered/Cleared in Each Scenario

Further Issues	Development Scenario		
	A	B-1	B-2
1. Realization of dam component from viewpoint of management, operation & maintenance	***	*	-
2. Establishment of new set-up for overall project planning/implementation/management	***	**	*
3. Financial examination on allocated farm size under irrigated condition	***	**	-
4. Financial examination on guideline for allocating farm land under rainfed condition	*	**	***
5. Reviewing role & activities of existing research institution for irrigated agriculture	***	**	-
6. Reviewing role & activities of existing research institution for rainfed agriculture	*	***	***
7. Farmers training and set-up of farmers' organization	***	**	*
8. Due attention on people to be relocated from reservoir area	***	*	-
9. Measures to create farm economic surplus especially under rainfed condition	*	***	***
10. Due attention on both economic and social approach for promotion of proposed project	***	**	*
11. Introduction of staged development approach	***	**	-
12. Preparation of countermeasures for water-born diseases including malaria	***	**	-
13. Preparation of detailed topo-map and hydrological data	***	**	-
14. Implementaion of feasibility study	***	**	*
15. Procurement of development fund	***	**	*

Note: *** Strongly considered, ** Fairly considered, * Slightly considered, - Not necessary

LIST OF ATTENDANCE

Representatives of the Government of Zimbabwe

1.	Mr. V. Vudzijena	Chief Agricultural Economist, MOA
2.	Mr. D. Mfote	Act. Principal Agricultural Economist, MOA
3.	Mr. E. Chidenga	Chief, Irrigation Sect., AGRITEX
4.	Mr. F. F. Paradza	Senior Irrigation Specialist, AGRITEX
5.	Mrs. Chari	Chief Planning Officer, AGRITEX
6.	Mr. U. K. R. Spurway	Senior Research Officer, DR&SS
7.	Mr. M. N. Mutede	Planning Engineer, DWD
8.	Mr. A. Mpamhanga	Deputy Secretary, MLGRUD
9.	Mrs. E. Malazi	Chief Planning Officer, MLGRUD
10.	Mr. L. T. Kuwanda	Senior Administrative Officer, MLGRUD
11.	Mrs. L. R. Kahari	Administration Officer, Ministry of Finance

JICA Advisory Team

1.	Mr. Akira Kaitsumaru	Team Leader
2.	Mr. Hideo Osawa	Coordinator

JICA Study Team

1.	Mr. Yoshitomo Miyanishi	Team Leader
2.	Mr. Michio Goto	Water Use/Water Source Planner

MINUTES OF THE MEETING

ON

THE DRAFT FINAL REPORT FOR THE MASTER PLAN STUDY

ON

THE LOWER MUNYATI BASIN AGRICULTURAL DEVELOPMENT

IN

THE REPUBLIC OF ZIMBABWE

HARARE, AUGUST 10, 1995

Mr. V. Vudzijena
Chief Agricultural Economist
Economic Division
MINISTRY OF AGRICULTURE

Mr. Yoshitomo MIYANISHI
Leader
Master Plan Study Team
JAPAN INTERNATIONAL
COOPERATION AGENCY

Witnessed by

Mr. E. Chidenga
Principal Irrigation Specialist
Dept. of Agricultural, Technical
and Extension Services
MOA

Mr. Yoshihiko OGAWA
Leader
JICA Advisory Team

A joint meeting between the representatives from Ministry of Agriculture (hereinafter referred to as "MOA"), Ministry of Lands and Water Resources, Ministry of Local Government, Rural and Urban Development, JICA Advisory Team, and JICA Study Team (hereinafter referred to as "the Team") was held on 10th August, 1995 at the conference room of MOA, to discuss the contents of the Draft Final Report. The Team submitted twenty (20) copies of the Draft Final Report through AGRITEX on 2nd August, 1995. Attendance to the meeting is as per attached.

After discussion, the contents of the Draft Final Report were agreed by both parties with confirmation of the following items:

1. The Zimbabwean side expressed its appreciation that the Study concluded to adopt the Scenario A for the further step of the agricultural development in the Lower Munyati Basin;

2. The Study team pointed out that the financial and the social analysis on the project evaluation should be backed up in more details, which will be incorporated in the final report;

3. The Zimbabwean side asked the possibility whether the Japanese government would extend its assistance for the proposed feasibility study with the Scenario A. In this connection, the Japanese side responded that the inquiry will be forwarded to JICA's Head Quarter for further consideration, and suggested that the Zimbabwean side should take prompt action to prepare its official request through the required channel for the Japanese technical assistance; and

4. Both sides confirmed that the Zimbabwean side compiles any outstanding comments on the draft final report, and submits them to the Embassy of Japan by the end of August, 1995, based on which the Study Team will prepare the Final Report.

LIST OF ATTENDANCE

Representatives of the Government of Zimbabwe

1. Mr. V. Vudzijena	Chief Agricultural Economist, MOA
2. Mr. D. Mfote	Act. Principal Agricultural Economist, MOA
3. Mr. E. Chidenga	Principal Irrigation Specialist, AGRITEX
4. Mr. S. Mushiri	Principal Research Officer, DR&SS
5. Mr. B. R. S. Ranatunga	Planning Engineer, DWD
6. Mr. L. T. Kuwanda	Senior Administrative Officer, MLGRUD

JICA Advisory Team

1. Mr. Yoshihiko Ogawa	Leader
2. Mr. Shiro Nabeya	Coordinator

JICA Study Team

1. Mr. Yoshitomo Miyanishi	Leader
2. Mr. Michio Goto	Water Use/Water Source Planner
3. Mr. P. Chigaru	Farm Management Planner
4. Mr. L. Zinyama	Environmental Specialist

A.7 PERSONNEL RELATED TO THE STUDY

(1) Zimbabwean Side

Ministry of Agriculture (MOA)

1. Dr. B. N. Ndimande	Permanent Secretary
2. Mr. M. P. Kaviya	Deputy Secretary
3. Mr. V. Vudzijena	Chief Agricultural Economist
4. Mr. D. Mfote	Act. Principal Agricultural Economist
5. Mr. C. Kapuyanika	Chief Agricultural Economist (Former)
6. Mr. R. Mariga	Act. Chief Agricultural Economist (Former)

Dept. of Agricultural, Technical and Extension Services (AGRITEX)

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2. Mr. R. J. Chitsiko	Deputy Director (Engineering)
3. Mr. A. H. McGregor	Chief Agricultural Specialist
4. Mr. Z. Chidenga	Act. Chief of Irrigation Branch
5. Mr. F. F. Paradza	Senior Irrigation Specialist
6. Mr. A Dube	Senior Irrigation Specialist
7. Mr. S. Madyiwa	Senior Irrigation Specialist
8. Mrs. Chasi	Chief Planning Officer
9. Mr. Mukwereza	Agricultural Farm Management Specialist
10. Mr. F. Dzvurumi	Irrigation Agronomist
11. Mrs. M. Chimbira	Liaison Officer
12. Mr. D. Tawonezvi	Irrigation Economist
13. Mr. Zata	Kadoma District A & E Officer
14. Mrs. Ndoro	Kadoma District A & E Officer
15. Mr. E. P. Goto	Gokwe South District A & E Officer
16. Mr. Pilime	Gokwe South District A & E Officer
17. Mr. J. Zishiri	Chief A & E Officer, Midland Province

Department of Research & Specialist Services (DR&SS)

1. Mr. S. Mushiri	Principal Research Officer
2. Mr. U. K. R. Spurway	Senior Research Officer
3. Mr. J. N. Mushonga	Staff

Department of Water Development (DWD)

1. Mr. D. S. Durham	Deputy Director (Planning)
2. Mr. H. B. Williams	Chief Engineer (Planning)
3. Mr. M. N. Mutede	Planning Engineer
4. Mr. Chedono	Midland Provincial Water Engineer
5. Mr. Chatora	Mashonaland West Provincial Water Engineer
6. Mr. Musariri	Hydrologist

Ministry of Local Government, Rural and Urban Development (MLGRUD)

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2. Mr. J. Mutamiri	Deputy Director, Development, Planning and Co-ordination
3. Mrs. E. Malazi	Chief Planning Officer
4. Mr. L. T. Kuwanda	Senior Administrative Officer

Ministry of Finance

1. Mrs. L. R. Kahari	Administration Officer

Department of Natural Resources

1. Mr. E. J. Mhaka	Senior National Resources Officer

(2) Japanese Side

Japan International Cooperation Agency (JICA)

1. Mr. H. Ono	Managing Director, Agriculture, Forestry and Fisheries Development Study Department (AFFDSD)
2. Mr. T. Tsuchiya	Deputy Managing Director, AFFDSD
3. Mr. T. Sato	Director, Agricultural Development Study Division (ADSD), AFFDSD
4. Mr. S. Nabeya	Deputy Director, ADSD, AFFDSD
5. Mr. H. Osawa	Deputy Director, ADSD, AFFDSD
6. Mr. M. Takahashi	Staff, ADSD, AFFDSD
7. Mr. S. Ogasawara	Managing Director, AFFDSD (Former)
8. Mr. Y. Sasaki	Deputy Managing Director, AFFDSD (Former)
9. Mr. M. Inaba	Deputy Director, ADSD, AFFDSD (Former)

Advisory Committee

1. Dr. S. Nakagawa	Chairman
2. Mr. A. Kaitsumaru	Irrigation and Drainage
3. Mr. Y. Ogawa	Agricultural Economy
4. Mr. H. Fukuoka	Farm Management Planning
5. Mr. H. Misaki	Project Evaluation

Ministry of Agriculture, Forestry and Fisheries

1. Mr. I. Ohba	International Cooperation Division, Economic Affairs Bureau
2. Mr. J. Yamauchi	Design Division, Agricultural Structural Improvement Bureau

Ministry of Foreign Affairs

1. Mr. S. Takagi	Development Cooperation Division, Economic Cooperation Bureau

Embassy of Japan

1. Mr. M. Konishi	Ambassador Extraordinary & Plenipotentiary
2. Mr. H. Okamoto	Minister
3. Mr. T. Ohashi	Counsellor
4. Mr. Y. Shoji	First Secretary

Study Team

1. Mr. Y. Miyanishi	Team Leader
2. Mr. M. Goto	Water Utilization & Water Source Planning
3. Dr. P. Chigaru	Farm Management Planning
4. Mr. T. Ogawa	Agricultural Economy & Project Evaluation
5. Mr. M. Kakizaki	Rural Sociology & Agricultural Extension
6. Mr. J. Yabe	Irrigation & Drainage and O & M Planning
7. Mr. A. Koto	Soil and Land Use Planning
8. Prof. L. Zinyama	Environmental Management Planning
9. Mr. T. Oda	Coordinator

APPENDIX B NATIONAL/ REGIONAL ECONOMY

B. NATIONAL/REGIONAL ECONOMY

Table B-1 CONSUMER PRICE INDEX

Period	Food	Drink and tobacco	Clothing and footwear	Rent, Rates, Fuel & Power	Furniture and House-hold stores	Medical care	Trans-port & commu-nication	Recrea-tion & entertain-ment	Educa-tion	Misc-goods & services	All items
WEIGHTS	29.2	9.9	9.8	18.7	7.2	2.8	8.4	2.0	7.6	4.4	100
1990	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1991	112.6	123.9	122.7	117.9	122.0	116.3	141.4	123.9	127.6	116.3	123.3
1992	192.7	188.2	161.5	150.2	163.0	144.4	193.8	169.1	191.6	155.2	175.2
1993	267.4	239.6	185.6	204.4	195.1	169.3	224.3	196.9	211.4	175.9	223.6
1991 March	116.5	115.8	112.5	113.2	114.1	112.8	139.0	115.5	125.3	114.7	118.1
June	125.6	117.9	116.9	114.8	120.1	114.3	137.0	127.1	132.6	114.1	122.3
September	125.6	134.5	130.3	129.0	127.0	120.5	141.1	130.7	137.2	118.5	129.5
December	133.3	146.7	141.7	132.0	138.4	124.8	165.3	133.0	137.2	124.0	139.7
1992 March	159.7	164.0	150.6	143.5	150.9	136.9	168.7	150.7	202.8	135.7	157.7
June	187.2	190.0	161.2	148.1	163.3	141.8	201.6	178.6	203.3	145.6	175.0
September	218.4	210.9	170.3	152.9	172.5	159.3	206.9	190.0	203.3	156.3	190.3
December	240.5	216.7	175.8	186.3	178.1	160.6	209.0	188.2	196.3	161.3	204.4
1993 March	248.6	226.6	180.4	198.0	184.5	161.9	211.3	190.3	213.4	170.4	212.8
June	264.0	234.5	184.7	199.7	194.5	164.2	219.8	191.7	214.5	173.5	220.6
September	282.7	257.4	189.2	219.4	201.9	181.2	236.4	208.0	214.8	181.5	235.5
December	293.1	261.3	194.7	226.3	208.2	181.9	246.3	215.5	215.6	186.9	242.5
1994 March	315.5	271.8	202.1	234.2	217.3	452.4	256.4	216.9	230.7	195.0	262.9
June	330.0	290.3	204.4	234.9	234.4	457.7	271.0	217.7	231.7	210.5	272.7
September	362.2	304.0	212.5	244.1	244.7	468.6	270.5	221.7	232.2	229.0	288.0
December											
Rates of increase from June 1994 to Sept 1994	9.8	4.7	4.0	3.9	4.4	2.4	-0.2	1.8	0.2	8.8	5.6
Rates of increase from Sept 1992 to Sept 1994	28.1	18.1	12.3	11.2	21.2	158.6	14.4	6.6	8.1	26.2	22.3

NOTE:

a). The annual figures are the averages of twelve monthly figures.

b). The indices are inclusive of sales tax and excise duty.

Table B - 2 Total Population, Area and Population Density

(a) Mashonaland West Province

District	Total Population	Percent	Area[1] (sq.km.)	Density
Chegutu Rural[2]	160 783	14.45	5 429.39	35.17
Hurungwe[3]	248 627	22.34	19 678.34	13.38
Kadoma Rural[4]	151 112	13.58	9 327.41	23.46
Kariba Rural[5]	27 579	2.48	8 142.81	6.09
Makonde[6]	116 956	10.51	8 663.91	18.47
Zvimba	230 161	20.68	6 199.74	37.12
Chegutu Urban	30 191	2.71	-	-
Chinhoyi	43 054	3.87	-	-
Chirundu	1 243	0.11	-	-
Kadoma Urban	67 750	6.09	-	-
Kariba Urban	20 736	1.86	-	-
Karoi	14 763	1.33	-	-
Total	**1 112 955**	**100.00**	**57 441.60**	**19.38**

1) Source: Surveyor General's Office
2) Area and Density includes Chegutu Urban
3) Area and Density includes Karoi
4) Area and Density includes Kadoma Urban
5) Area and Density includes Kariba and Chirundu
6) Area and Density includes Chinhoyi

(b) Midlands Province

District	Total Population	Percent	Area[1] (sq.km.)	Density
Chirumhanzu	70 361	5.38	4 591.14	15.33
Gokwe	403 653	30.87	18 384.57	21.96
Gweru Rural[2]	85 198	6.51	6 095.88	34.98
Kwekwe Rural[3]	147 721	11.30	8 866.49	28.55
Mberengwa	182 214	13.93	4 943.40	36.86
Shurugwi Rural[4]	80 450	6.15	3 645.14	23.72
Zvishavane Rural[5]	82 914	6.34	2 639.70	37.41
Gweru Urban	128 037	9.79	-	-
Kwekwe Urban	75 425	5.77	-	-
Redcliff	29 959	2.29	-	-
Shurugwi Urban	6 013	0.46	-	-
Zvishavane Urban	15 824	1.21	-	-
Total	**1 307 769**	**100.00**	**49 166.32**	**26.60**

1) Source: Surveyor General's Office
2) Area and Density includes Gweru Urban
3) Area and Density includes Kwekwe Urban and Redcliff
4) Area and Density includes Shurugwi Urban
5) Area and Density includes Zvishavane Urban

Source: Zimbabwe 1992 Population Census

Table B - 3 Population, Household and Average Household Size

(a) Mashonaland West Province

District	Population	Households		Average Household Size
		Number	Percent	
Chegutu Rural	160 461	34 802	15.04	4.61
Hurungwe	248 343	49 242	21.29	5.04
Kadoma Rural	148 614	28 704	12.41	5.18
Kariba Rural	27 540	5 954	2.57	4.63
Makonde	116 753	23 688	10.24	4.93
Zvimba	228 340	47 983	20.74	4.76
Chegutu Urban	30 024	7 123	3.08	4.22
Chinhoyi	41 532	9 412	4.07	4.41
Chirundu	1 213	327	0.14	3.71
Kadoma Urban	67 170	15 691	6.78	4.28
Kariba Urban	20 034	4 976	2.15	4.03
Karoi	14 044	3 438	1.49	4.08
Total	**1 104 068**	**231 340**	**100.00**	**4.77**

(b) Midlands Province

District	Population	Households		Average Household Size
		Number	Percent	
Chirumhanzu	69 587	14 403	5.81	4.83
Gokwe	401 299	67 937	27.42	5.91
Gweru Rural	82 753	15 417	6.22	5.37
Kwe Kwe Rural	147 431	26 906	10.86	5.48
Mberengwa	180 332	32 267	13.03	5.59
Shurugwi Rural	80 161	15 295	6.17	5.24
Zvishavane Rural	82 104	16 000	6.46	5.13
Gweru Urban	126 003	29 198	11.79	4.32
Kwe Kwe Urban	74 788	17 607	7.11	4.25
Redcliff	29 894	6 890	2.78	4.34
Shurugwi Urban	5 818	1 587	0.64	3.67
Zvishavane Urban	15 729	4 216	1.70	3.73
Total	**1 295 899**	**247 723**	**100.00**	**5.23**

Source: Zimbabwe 1992 Population Census

Table B - 4 Distribution of Population by Rural and Urban Areas

(a) Mashonaland West Province

District	Urban Areas	Rural Areas	Total	Percent Urban
Chegutu Rural	20 405	140 378	160 783	12.69
Hurungwe	-	248 627	248 627	-
Kadoma Rural	25 060	126 052	151 112	16.58
Kariba Rural	-	27 579	27 579	-
Makonde	19 353	97 603	116 956	16.55
Zvimba	26 795	203 366	230 161	11.64
Chegutu Urban	30 191	-	30 191	100.00
Chinhoyi	43 054	-	43 054	100.00
Chirundu	1 243	-	1 243	100.00
Kadoma Urban	67 750	-	67 750	100.00
Kariba Urban	20 736	-	20 736	100.00
Karoi	14 763	-	14 763	100.00
Total	**269 350**	**843 605**	**1 112 955**	**24.20**

(b) Midlands Province

District	Urban Areas	Rural Areas	Total	Percent Urban
Chirumhanzu	9 654	60 707	70 361	13.72
Gokwe	7 418	396 235	403 653	1.84
Gweru Rural	-	85 198	85 198	-
Kwekwe Rural	-	147 721	147 721	-
Mberengwa	3 000	179 214	182 214	1.65
Shurugwi Rural	10 125	70 325	80 450	12.59
Zvishavane Rural	17 160	65 754	82 914	20.70
Gweru Urban	128 037	-	128 037	100.00
Kwekwe Urban	75 425	-	75 425	100.00
Redcliff	29 959	-	29 959	100.00
Shurugwi Urban	6 013	-	6 013	100.00
Zvishavane Urban	15 824	-	15 824	100.00
Total	**302 615**	**1 005 154**	**1 307 769**	**23.14**

Source: Zimbabwe 1992 Population Census

Table B - 5 Percent Distribution of Population by Sex

(a) Mashonaland West Province

District	Males	Females	Percent	Total Number	Percent	Sex Ratio
Chegutu Rural	49.64	50.36	100.00	160 783	14.45	98.58
Hurungwe	49.37	50.63	100.00	248 627	22.34	97.50
Kadoma Rural	50.15	49.85	100.00	151 112	13.58	100.59
Kariba Rural	49.13	50.87	100.00	27 579	2.48	96.59
Makonde	50.88	49.12	100.00	116 956	10.51	103.60
Zvimba	50.93	49.07	100.00	230 161	20.68	103.80
Chegutu Urban	50.49	49.51	100.00	30 191	2.71	101.96
Chinhoyi	50.53	49.47	100.00	43 054	3.87	102.15
Chirundu	61.54	38.46	100.00	1 243	0.11	160.04
Kadoma Urban	50.01	49.99	100.00	67 750	6.09	100.04
Kariba Urban	54.10	45.90	100.00	20 736	1.86	117.88
Karoi	50.65	49.35	100.00	14 763	1.33	102.65
Mashonaland West	**50.22**	**49.78**	**100.00**	**1 112 955**	**100.00**	**100.90**

(b) Midlands Province

District	Males	Females	Percent	Total Number	Percent	Sex Ratio
Chirumhanzu	47.56	52.44	100.00	70 361	5.38	90.70
Gokwe	48.19	51.81	100.00	403 653	30.87	93.03
Gweru Rural	49.54	50.46	100.00	85 198	6.51	98.18
Kwekwe Rural	48.71	51.29	100.00	147 721	11.30	94.98
Mberengwa	46.98	53.02	100.00	182 214	13.93	88.63
Shurugwi Rural	48.90	51.10	100.00	80 450	6.15	95.70
Zvishavane Rural	49.08	50.92	100.00	82 914	6.34	96.38
Gweru Urban	50.35	49.65	100.00	128 037	9.79	101.43
Kwekwe Urban	49.58	50.42	100.00	75 425	5.77	98.33
Redcliff	51.96	48.04	100.00	29 959	2.29	108.16
Shurugwi Urban	47.38	52.62	100.00	6 013	0.46	90.04
Zvishavane Urban	47.31	52.69	100.00	15 824	1.21	89.78
Midlands	**48.60**	**51.40**	**100.00**	**1 307 769**	**100.00**	**94.55**

Source: Zimbabwe 1992 Population Census

Table B - 6 Percent Distribution of Population for Rural & Urban Areas

(a) Mashonaland West Province

District	Urban	Rural	Total	Total Number
Chegutu Rural	12.69	87.31	100.00	160 783
Hurungwe	-	100.00	100.00	248 627
Kadoma Rural	16.58	83.42	100.00	151 112
Kariba Rural	-	100.00	100.00	27 579
Makonde	16.55	83.45	100.00	116 956
Zvimba	11.64	88.36	100.00	230 161
Chegutu Urban	100.00	-	100.00	30 191
Chinhoyi	100.00	-	100.00	43 054
Chirundu	100.00	-	100.00	1 243
Kadoma Urban	100.00	-	100.00	67 750
Kariba Urban	100.00	-	100.00	20 736
Karoi	100.00	-	100.00	14 763
Mashonaland West	**24.20**	**75.80**	**100.00**	**1 112 955**

(b) Midlands Province

District	Urban	Rural	Total	Total Number
Chirumhanzu	13.72	86.27	100.00	70 361
Gokwe	1.84	98.16	100.00	403 653
Gweru Rural	-	100.00	100.00	85 198
Kwekwe Rural	-	100.00	100.00	147 721
Mberengwa	1.65	98.35	100.00	182 214
Shurugwi Rural	12.59	87.41	100.00	80 450
Zvishavane Rural	20.70	79.30	100.00	82 914
Gweru Urban	100.00	-	100.00	128 037
Kwekwe Urban	100.00	-	100.00	75 425
Redcliff	100.00	-	100.00	29 959
Shurugwi Urban	100.00	-	100.00	6 013
Zvishavane Urban	100.00	-	100.00	15 824
Midlands Province	**23.14**	**76.86**	**100.00**	**1 307 769**

Source: Zimbabwe 1992 Population Census

Table B - 7 Crude Birth and Death Rate and Natural Increase Rate

(a) Mashonaland West Province

District	Crude Birth Rate (per 1000)	Crude Death Rate (per 1000)	Rate of Natural Increase (percent)
Chegutu Rural	32.66	10.28	2.24
Hurungwe	34.43	11.92	2.25
Kadoma Rural	33.17	9.20	2.40
Kariba Rural	41.44	10.44	3.10
Makonde	36.11	9.43	2.67
Zvimba	33.65	9.02	2.46
Chegutu Urban	36.83	8.55	2.83
Chinhoyi	35.30	8.36	2.70
Chirundu	28.16	1.61	2.66
Kadoma Urban	34.73	7.90	2.68
Kariba Urban	35.93	7.96	2.80
Karoi	34.68	9.01	2.57
Mashonaland West	34.33	9.82	2.45

(b) Midlands Province

District	Crude Birth Rate (per 1000)	Crude Death Rate (per 1000)	Rate of Natural Increase (percent)
Chirumhanzu	31.49	10.23	2.13
Gokwe	38.59	10.26	2.83
Gweru Rural	32.54	9.51	2.30
Kwekwe Rural	35.74	10.53	2.52
Mberengwa	34.76	11.07	2.37
Shurugwi Rural	30.59	10.54	2.01
Zvishavane Rural	29.46	10.75	1.88
Gweru Urban	33.71	6.12	2.76
Kwekwe Urban	35.84	9.71	2.61
Redcliff	32.71	7.01	2.57
Shurugwi Urban	38.75	10.14	2.87
Zvishavane Urban	38.93	9.80	2.91
Midlands	35.12	9.88	2.52

Source: Zimbabwe 1992 Population Census

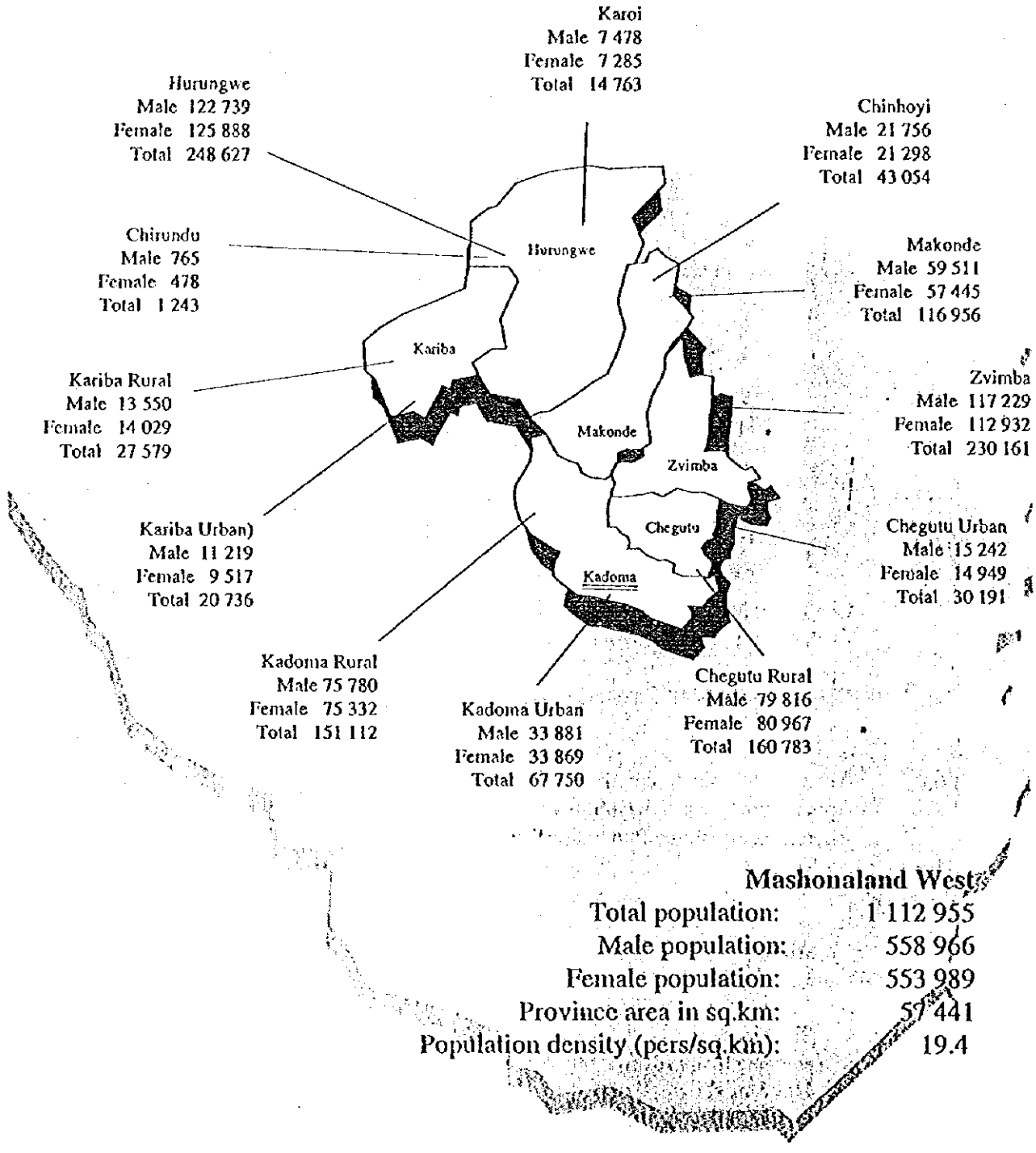


Figure B - 1 Population Distribution by District
Mashonaland West Province

Total population:	1 307 769
Male population:	635 583
Female population:	672 186
Province area in sq.km:	49 166
Population density (pers/sq.km):	26.6

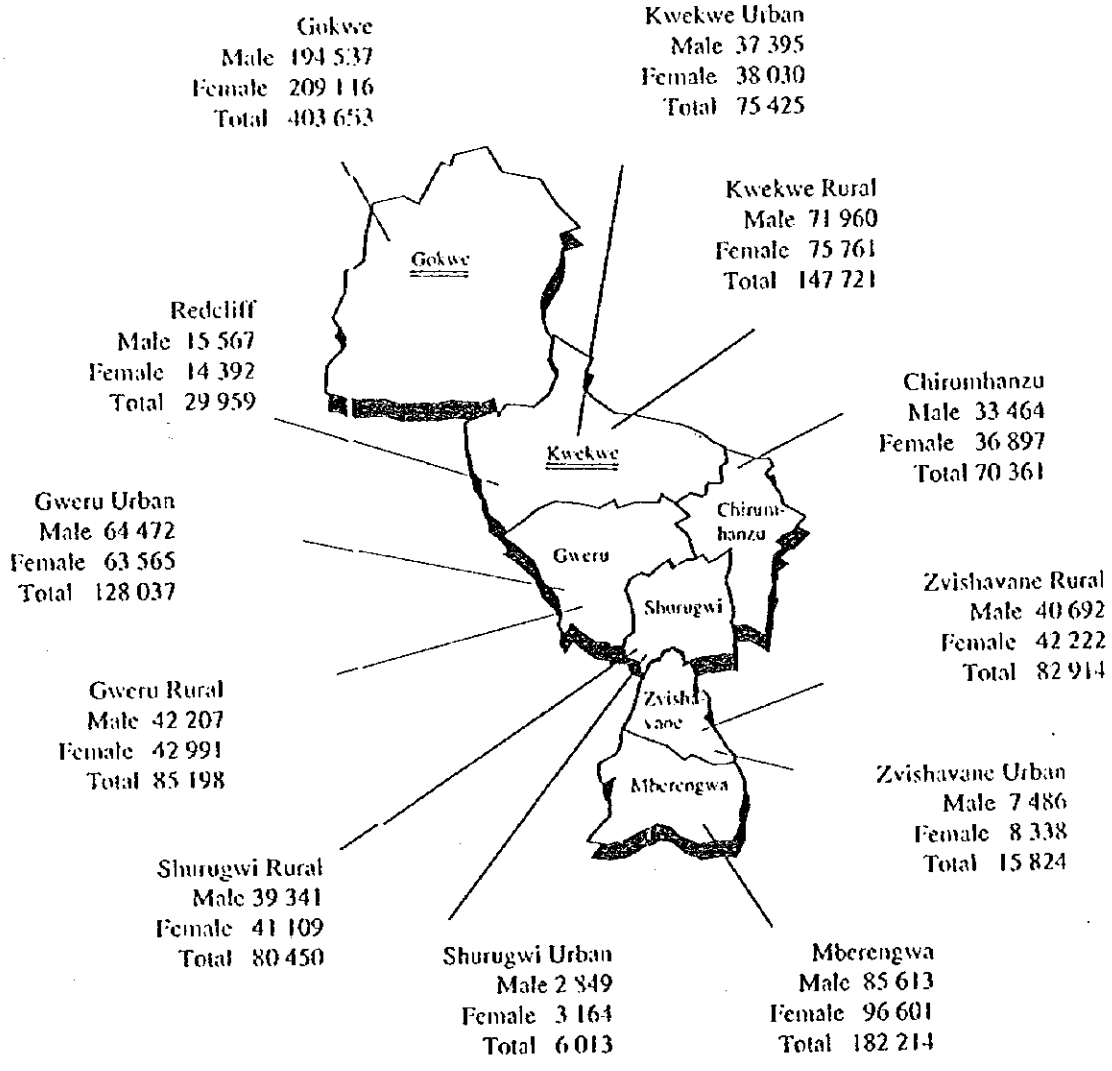


Figure B-2 Population Distribution by District
Midlands Province

APPENDIX C SOIL AND LAND USE

APPENDIX C. SOIL AND LAND USE

C.1 The Soils

C.1.1 Soil Survey

The soil survey was conducted to explore and evaluate the land and soil resources of the Study Area aiming at the following points;

i) To review the existing data and check the validity of the existing soil map,
ii) To make the supplementary soil survey to identify the major kinds of soils occurring in the area, and
iii) To evaluate the soils in terms of land suitability for agricultural use.

In consideration with above points, the following works were carried out by the Study team.

a) Review and evaluation of existing data
b) Preparation of provisional soil map
c) Supplementary field survey

Prior to the field survey, the existing soil survey reports were studied in detail. On this basis, provisional soil map on the scale of 1:250,000 was prepared and used as field map. Satellite photographs (SPOT; 1:100,000) were also taken into consideration when necessary. The soils were studied along the selected traverses with distance between observation points depending upon the complexity of the soil. The intensity of observation was one per 100 Km^2 approximately. The field work was started on 28th December 1994 and was completed on 13th January 1995.

C.1.2 Soil Analysis

Soil test pits upto 1m depth were excavated in the selected locations representing the soil mapping units for general morphological description and sampling of different horizon or layers. At each observation site, information recorded including soil texture, dry and moist Munsell color, depth and thickness of horizons or layers, structure and soil hardness. The location of soil pits were recorded by a GPS receiver (Sony IPS-760).

Seventy-four soil samples of the representative horizons were taken from the test pits for physical and chemical characterizations in laboratory. These samples were sent to the DRSS (Department of research & Specialist Service) laboratory in Harare for the analysis. The items to be analyzed are soil texture, pH, electrical conductivity (EC), cation exchange capacity (CEC), exchangeable cations, organic carbon and available phosphorous.

The methods of analysis employed are outlined below:

a) Mechanical analysis

Mechanical analysis was carried out by Bouyoucos hydrometer after dispersion with sodium hexametaphosphate reagent; sedimentation times of 5 minutes for silt + clay reading, and 5 hours for clay reading; coarse and medium sand fractions separated by sieving, fine sand calculated by difference. Particle sizes are:

Coarse sand (cS)	2.0-0.5 mm.
Medium sand (mS)	0.5-0.2 mm.
Fine sand (fS)	0.2-0.02 mm.
Silt	0.02-0.002 mm.
Clay	less than 0.002 mm.

b) Determination of pH ($CaCl_2$)

The pH was measured in a 1:5 suspension of soil in 0.01 M $CaCl_2$.

c) Cation exchange capacity

Cation exchange capacity (CEC) in milligram equivalents per cent, was determined by leaching the soil with either M ammonium acetate at pH 7 for soils of pH greater than 6.5 or with 0.2 M ammonium chloride at approximately field pH for soils of pH less than 6.5. If free carbonates were present the soils were pretreated with 0.5 M acetic acid prior to leaching with M ammonium acetate. Ammonium ions were displaced by the direct distillation method after washing with 96 per cent ethyl alcohol. The E/C value denotes cation exchange capacity per 100 g of clay.

d) Exchangeable cations

The exchangeable cations were determined in the ammonium leachates and expressed as milligram equivalents per 100 g of soil (me %). Calcium, magnesium and sodium were determined by atomic absorption spectrophotometry and potassium by emission spectrophotometry; total exchangeable bases (TEB) were taken as the sum of exchangeable cations. Exchangeable sodium percentage

(ESP) is the exchangeable sodium (after correction for sodium in the saturation extract) as a percentage of TEB. The percentage base saturation (BS %) is the TEB as a percentage of CEC. The S/C value denotes TEB per 100 g of clay.

e) Organic carbon

Organic carbon was determined by Walkely Black method.

f) Carbonates

Carbonates was determined by acid treatment (HCl method).

g) Available phosphate

Available phosphate was determined by anion exchange resin extraction.

C.1.3 The Characteristics of the Soils

The soil order

The soils of the Study Area are accommodated in three soil orders comprising amorphic, calcimorphic and kaolinitic soils. All soils of the amorphic order show little or no horizon development. The soil groups fall within this order are the skeletal soils or lithosols. The calcimorphic order includes all soils that are relatively unleached and unweathered. Base saturation of the soils is high and in most soils some part of bases takes place in the lower part of the solum or at relatively shallow depth in the underlying non-soil horizons. At the group level, the calcimorphic soils are subdivided into vertisols and siallitic soils. All soils of the kaolinitic order are markedly leached and weathered. The exchange complex is therefore less base saturated than in the calcimorphic soils. The kaolinitic soils are subdivided into fersiallitic soils, paraferrallictic soils and orthoferrallitic soils at the group level.

The soil group

At the group level, the lithosol group was created to accommodate shallow soils (less than 25cm deep). All the other soil groups found in the Study Area are separated out on their exchange properties. The basis of the separation is the activity of the clay fraction as measured from the total exchangeable bases (TEB) and the cation exchange capacity (CEC) per 100 grams of clay. The term S/C value and E/C value are used to refer TEB and CEC per 100g of clay, respectively.

a) The lithosol group

This soil group includes all soils having a depth less than 25cm, overlying hard rock that may be partially weathered. They vary widely in soil reaction, clay content and morphology according to the parent material from which they are derived. Those derived from mafic materials generally have more clay while those from sialiceous materials are sandy. Lithosols are simply soils that have not had adequate time to develop beyond their present depth either because of climatic conditions or other environmental factors. As an example of the lattice aspect, most of the lithosols occur on broken land with substantial slopes. This makes the soils susceptible to erosion thus reducing the possibility of solum thickening. An examination of their distribution in relation to climatic factors shows that the most extensive occurrences are within tile areas of lowest rainfall. This implies that the climatic factor is perhaps part of the explanation for their skeletal nature due to minimal weathering as a result of limited moisture.

Because of their shallowness, these soils are not arable. Although, in places where the underlying weathering rock is highly weathered, it may increase the effective depth sufficiently to make it possible for some cultivation to take place. In fact, numerous examples of cultivation on lilthosols have been cited. Lithosols are also generally cultivated where they occur as minor inclusions within larger bodies. Their most common use though is as game reserves and national parks of one type or another. This appears to be the most ecologically sound land use for them.

b) The vertisol group

Vertisols are soils with a high proportion of montmorillonitic clay. In the dry state wide cracks develop into which some soil material falls. Rewetting of the soil and the consequent expansion results in enormous pressures being set up in the subsoil and this in turn brings about internal soil movement. In the soil profile this movement, which results in varying degrees of self-churning, is readily detected by the presence of slickensides which in most instances are intersecting. These slickensides, which are the essential diagnostic feature, are shiny, polished surfaces almost invariably inclined at about a 45° angle to the soil surface, and usually showing striations. Most vertisols are very dark in color but in Zimbabwe some that are dark reddish brown and even reddish brown have been found. As is to be expected, vertisols are formed only on mafic or ultramafic rocks, and other materials that produce a high clay content. Both S/C and E/C values are generally greater than 60, and base saturations are almost invariably greater than 95%.

These are the soils which in the old American and European literature where called the Black Cotton Soils a name referring directly to the land use to which they were commonly put. In Zimbabwe they form some of the best irrigable land in the semi-arid parts of the country where they are most extensive. The main crops are winter wheat and rainfed cotton in the summer. A major fear with the production of tree crops on Vertisols is the danger of root pruning which can result in stunted growth of trees. This has not been evident under irrigation, because extreme drying conditions do not ever exist thus reducing the shearing potential of the swell-shrink characteristic of the soils. Susceptibility to root pruning may also be a function of the type of root network.

Although these soils are inherently fertile being particularly rich in bases, they require moderate applications of nitrogen fertilizer to ensure economic yields. It is also reported the need of micro nutrient fertilization especially the need for Zn. The high content of active clay in these soils results in poor trafficability when they are wet and their swell-shrink property creates problems with the laying of foundations for building and engineering works.

c) The siallitic group

The soils of this group are relatively unleached and are high of base status. The clay fraction of the siallitic soils generally differs from that of the vertisols, not only in the presence, usually, of some 1:1 lattice minerals and generally lower clay content but also in the nature of the 2:1 lattice minerals present. These tend to be of the less active clay mica and mixed-layer minerals rather than the more expansive montmorillonite. E/C and S/C values are therefore usually lower than those of the vertisols. The lower limit of S/C values is set at 31 which corresponds to an E/C value of about 35 since base saturation is generally greater than 85%. Most siallitic soils have a large reserve of weatherable minerals.

Siallitic soils in Zimbabwe have very high agricultural potential, the main limitation being the aridity of the environments in which they occur. Thus, in a number of cases, where water is available for irrigation, some very high levels of productivity have been achieved. In their natural state, the semi-arid environments support extensive woodlands of *Colophospermum mopane* whose leaves have high protein content and are considered to be of high nutritive value for wildlife and cattle. Therefore, ranching of both cattle and wildlife is an important activity in those areas where irrigation water is not

readily available. The grasses which thrive in these areas are also generally highly palatable.

d) The fersiallitic group

This group consists of the moderately leached soils amongst the three groups within the kaolinitic order. S/C values range from 6 to 30, and E/C values from 12 to 35. Base saturation is usually greater than 80% in soils of appreciable clay content, but is lower in sandy soils. The wide range of values accepted as diagnostic for this group is something of a weakness in the classification. That weakness is in some ways taken care of by the numerous series already defined. Another important diagnostic feature is that a small amount of 2:1 lattice clays should always be present for soils to fit into this group. In most fersiallitic soils there is some reserve of weatherable minerals. Since the fersiallitic soils have rather broad criteria, the soils further divided into several different sub-groups; such as the red clays, the relatively silty clays, the highly micaceous soils, the sandy soils derived from granite, the sandy soils derived from sandstones, and the fersiallitic soils subject to hydromorphy.

In general, their considerable broad extent, wide range of properties and moderate fertility makes the Fersiallitic soils the most important single soil group with regard to crop production. Therefore, a very wide range of crops are grown. The main physical factors determining what type of crop is grown being such considerations as altitude in relation to length of growing season and reliability of rainfall or availability of alliterative sources of water rather than any major soil constraints. The fact that Fersiallitic soils span an area which encompasses Natural Regions II to IV provides conditions for almost unlimited land use possibilities.

The soil family

At this level a further subdivision is made into units within which the soils are broadly similar in profile morphology and soil texture. Such characteristics are in most instances largely attributed to broad similarity of the parent material. The soil family constitutes an essential intermediate link between the soil series and the soil group. Soil families are designated by a numerical and alphabetical symbol, the former indicating the soil group and the latter (except in the sodic group) the broad nature of the parent material. Thus at the family level a great deal of information about the soil can be inferred. This includes not only the nature of the clay fraction but also an indication of the clay content and general profile morphology.

The letter symbols used to denote the various, broadly similar parent materials are as follows:

A—Siliceous sediments, volcanics, metasediments and metavolcanics that give rise to light to medium textured soils, but in which silt content is significantly high.

B—Basalt. This parent rock is differentiated from other mafic rocks in that in Zimbabwe it invariably gives rise to dark clayey soils even in areas of relatively high rainfall

C—Colluvium.

E—Igneous and metamorphic mafic rocks other than basalt that give rise to soils of high clay content.

F—Parent materials that give rise to highly micaceous, light to medium textured soils.

G—Granites and gneissic granites that give rise to soils in which the sand fraction is coarse; grained. Clay content varies according to degree of weathering and catenal position.

I—Ferruginous metasediments that give rise to medium to heavy textured soils in which the silt content is not significantly high.

K—Unconsolidated fine to medium trained sands without weather able minerals. Most of these are Kalahari sands.

M—Sandstones and quartzites that give rise to light to medium textured soils in which silt content is not significantly high.

P—Siliceous gneisses that give rise' to light textured soils in which the sand fraction is fine to medium grained.

S—Combines argillaceous sediments and metasediments which volcanics and metavolcanics that all give rise to heavy textured soils in which silt content is significantly high.

U—Alluvium.

C.1.4 Profile Description of the Major Soils

Vertisols (Black Cotton Soils; 3B)

Profile No.		4
Location		Copper Queen North, Small Scale Commercial Farm #165. 17°39'32" S, 29°05'42"E.
Site		Flat.
Vegetation / Land use		Ploughed field, previous crop is maize.
Erosion		Not evident.
Classification		3B
Ap	0 - 12 cm	Brownish black (10YR 3/1), dry, silty clay, very hard, many roots, coarse angular blocky structure, soil hardness 28.
B	12 - 90 cm	Brownish black (10YR 3/1), dry, silty clay, very hard, few roots, coarse angular blocky structure, soil hardness 30.

Profile No.		8
Location		Copper Queen South, Small Scale Commercial Farm #26. 17°44'40" S, 29°12'35"E.
Site		Flat.
Vegetation / Land use		Grazing area.
Erosion		Not evident.
Classification		3B
A	0 - 12 cm	Dull orange (7.5YR 6/4), dry, silty clay, very hard, some roots, coarse angular blocky structure, soil hardness 25.
B	12 - 32 cm	Brownish gray (7.5YR 6/1), dry, silty clay, very hard, a few roots, coarse angular blocky structure, soil hardness 25.
C	32 - 100 cm	Grayish brown (7.5YR 5/2), dry, silty clay, very hard, no roots, coarse angular blocky structure, soil hardness 26.

Siallitic group (4E, 4M, and 4S)

Profile No.		3
Location		Copper Queen North, Small Scale Commercial Farm #165. 17°39'40" S, 29°05'55"E.
Site		Flat.
Vegetation / Land use		Ploughed field, previous crop is maize.
Erosion		Not evident.
Classification		4E
Ap	0 - 15 cm	Reddish brown (5YR 5/6), dry, silty clay, massive, few roots, soil hardness 12.
B	15 - 90 cm	Reddish brown (2.5YR 4/6), dry, clay, massive, very hard, no roots, soil hardness 32.

Profile No.		13
Location		Chenjiri, Small Scale Commercial Farm #61. 17°50'05" S, 29°25'05"E.
Site		Flat.
Vegetation / Land use		Ploughed field, maize.
Erosion		Not evident.
Classification		4E
Ap	0 - 15 cm	Brown (7.5YR 4/4), dry, silty loam, a few roots, moderately coarse angular blocky structure, soil hardness 22.
B	15- 30 cm	Brown (7.5YR 4/4), dry, silty loam, a few roots, moderately coarse angular blocky structure, soil hardness 22.
C1	30 - 55 cm	Brown (7.5YR 4/4), moist, silty clay, mottles, some gravels, no roots, soil hardness 27.
C2	55 - 100 cm	Brown (7.5YR 4/4), moist, silty clay, brownish yellow mottles, no roots, soil hardness 30.

Profile No.		5
Location		Copper Queen North, Small Scale Commercial Farm #26. 17°51'51" S, 29°08'05"E.
Site		Flat.
Vegetation / Land use		Ploughed field, previous crop is maize.
Erosion		Not evident.
Classification		4M
Ap	0 - 15 cm	Brownish black (5YR 3/1), moist, sandy loam, friable moist, some roots, moderately well drained, soil hardness 18.
B	15 - 35 cm	Reddish brown (5YR 5/4), moist, sandy loam, friable moist, a few roots, moderately well drained, soil hardness 18.
C1	35 - 63 cm	Bright brown (7.5YR 6/6), dry, silty loam, very hard, no roots, brownish yellow mottles, soil hardness 30.
C2	63 - 100 cm	Bright brown (7.5YR 6/6), dry, silty loam, very hard, no roots, brownish yellow mottles, soil hardness 32.

Profile No.		10
Location		Butete village, Sanyati Communal Land. 17°59'38"S, 29°23'04"E.
Site		Flat.
Vegetation / Land use		Ploughed field, maize and cotton.
Erosion		Not evident.
Classification		4S
Ap	0 - 15 cm	Bright brown (7.5YR 5/6), dry, silty loam, some roots, coarse angular blocky structure, soil hardness 12.
B	15 - 25 cm	Reddish brown (2.5YR 4/6), dry, clay loam, some roots, some gravels, medium angular blocky structure, soil hardness 25.
C	25 - 100 cm	Reddish brown (2.5YR 4/6), dry, clay loam, roots, many gravels, medium angular blocky structure, soil hardness 28.

Fersiallitic group (5E, 5M, 5G and 5S)

Profile No.		1
Location		Copper Queen North, Small Scale Commercial Farm #165. 17°39'55" S, 29°14'54"E.
Site		Flat.
Vegetation / Land use		Ploughed field, previous crop is maize.
Erosion		Not evident.
Classification		5E
Ap	0 - 12 cm	Brownish black (5YR 2/1), dry to slightly moist, silty loam, soil hardness 12.
B1	12 - 40 cm	Reddish brown (5YR 5/6), dry to slightly moist, clay loam, massive, few fine yellowish red mottles, soil hardness 18.
B2	40 - 72 cm	Reddish brown (5YR 5/6), dry to slightly moist, clay loam, massive, few fine yellowish red mottles, soil hardness 22.
C	72 - 100 cm	Reddish brown (5YR 4/6), dry, clay loam, massive, soil hardness 22.

Profile No.		23
Location		Near Mutanke river, Chisina II, Gokwe South Communal Land. 18°16'51"S, 29°15'47"E.
Site		Flat.
Vegetation / Land use		Ploughed field, cotton.
Erosion		Not evident.
Classification		5E
A	0 - 15 cm	Reddish brown (5YR 4/6), dry, silty clay, moderately coarse angular blocky structure, a few roots, soil hardness 22.
B1	15- 35 cm	Reddish brown (2.5YR 4/6), dry, silty clay, moderately coarse angular blocky structure, a few roots, soil hardness 27.
B2	35- 100 cm	Reddish brown (2.5YR 4/6), dry, silty clay, moderately coarse angular blocky structure, a few roots to no roots, soil hardness 28.

Profile No.		21
Location		Chisina II, Gokwe South Communal Land. 18°06'20"S, 29°10'37"E.
Site		Flat.
Vegetation / Land use		Ploughed field, cotton.
Erosion		Not evident.
Classification		5G
Ap	0 - 20 cm	Grayish yellow brown (10YR 5/2), moist, loamy sand, friable, a few roots, well drained, soil hardness 12.
B	20- 50 cm	Dull yellow orange (10YR 6/3), dry, sand to loamy sand, friable, no roots, moderately well drained, soil hardness 18.
C	50- 100 cm	Dull yellow orange (10YR 7/2), dry, sand to loamy sand, friable, no roots, moderately well drained, soil hardness 22.

Profile No.		22
Location		Murandu school, Chisina II, Gokwe South Communal Land. 18°10'18"S, 29°13'41"E.
Site		Flat.
Vegetation / Land use		Ploughed field, maize.
Erosion		Not evident.
Classification		5G
A1	0 - 18 cm	Brownish black (7.5YR 3/2), moist, loamy sand, some roots, well drained, soil hardness 6.
A2	18 - 28 cm	Dark brown (7.5YR 3/3), moist, sandy loam, some roots, moderately well drained, soil hardness 11.
B	28- 48 cm	Brown (7.5YR 4/4), moist, loamy sand, some roots, moderately well drained, soil hardness 10.
C	48- 100 cm	Gravels.

Profile No.		7
Location		Copper Queen South, Small Scale Commercial Farm #139. 17°44'46" S, 29°12'53"E.
Site		Flat.
Vegetation / Land use		Grazing area.
Erosion		Not evident.
Classification		5M
A	0 - 10 cm	Brownish gray (5YR 4/1), wet, loamy sand, friable moist, some roots, moderately well drained, soil hardness 18.
B	10 - 26 cm	Orange (5YR 6/6), wet, loamy sand, friable moist, some roots, moderately well drained, soil hardness 21.
C	26 - 100 cm	Orange (5YR 7/6), dry, loamy sand, very hard, no roots, soil hardness 30.

Profile No.		16
Location		Makore I, Gokwe North Communal Land. 17°51'01" S, 28°58'56"E.
Site		Flat.
Vegetation / Land use		Ploughed field, maize.
Erosion		Not evident.
Classification		5M
Ap	0 - 15 cm	Dark reddish brown (5YR 3/2), moist, loamy sand, some roots, moderately well drained, soil hardness 15.
B	15- 33 cm	Reddish brown (5YR 4/4), moist, loamy sand, some roots, moderately well drained, soil hardness 16.
C1	33 - 53 cm	Reddish brown (5YR 4/6), dry, sandy loam, no roots, soil hardness 25.
C2	53 - 100 cm	Reddish brown (5YR 4/6), dry, sandy loam, no roots, soil hardness 21.

Profile No.	12
Location	Chenjiri, Small Scale Commercial Farm #31. 17°52'10" S, 29°27'29"E.
Site	Flat.
Vegetation / Land use	Ploughed field, maize.
Erosion	Not evident.
Classification	5S

Ap	0 - 10 cm	Dull brown (7.5YR 5/4), dry, silty loam, some roots, soil hardness 25.
B1	10 - 25 cm	Dull reddish brown (5YR 4/4), moist, silty loam, some roots, soil hardness 25.
B2	25 - 53 cm	Dull reddish brown (5YR 4/4), moist, silty loam, mottles, no roots, soil hardness 26.
C	53 - 100 cm	Dull reddish brown (5YR 4/4), moist, clay loam, mottles, no roots, soil hardness 22.

TABLE C-1 RESULTS OF THE SOIL ANALYSIS (1)

No.	Depth (cm)	LAB No	DM (%)	Texture	Clay (%)	Silt (%)	F.Sand (%)	M.Sand (%)	C.Sand (%)	Gravel (%)	pH (CaCl2)	Org. C (%)	Carbonates (%)	Available P (ppm)
1-1	0 - 12	E 409	98.8	mSaL	17	15	28	36	4		4.6	0.69		1
1-2	12 - 40	E 410	96.8	mSaCL	32	12	25	28	4		3.9	0.32		3
1-3	40 - 72	E 411	96.4	mSaC	37	14	23	23	4		3.8	0.24		2
1-4	72 - 100	E 412	95.4	mSaC	38	16	21	21	4		4.0	0.21		2
2-1	0 - 20	E 413	96.8	fSaCL	20	11	57	10	2		7.0	0.62	2.6	2
2-2	20 - 50	E 414	95.3	fSaCL	28	8	53	8	2		5.8	0.47		15
2-3	50 - 75	E 415	95.3	fSaCL	31	9	51	7	2		4.8	0.29		4
3-1	0 - 15	E 416	96.5	fSaCL	32	21	33	10	5		6.4	0.57		2
3-2	15 - 40	E 417	95.2	C	40	23	27	6	4		7.4	0.58	0.5	6
3-3	40 - 90	E 418	96.0	CL	34	29	31	4	2		7.7	0.24	0.4	4
4-1	0 - 12	E 419	93.5	C	55	21	19	4	2		6.5	0.57	0.2	3
4-2	12 - 30	E 420	92.4	C	53	22	21	2	2		7.7	0.44	0.4	4
5-1	0 - 15	E 422	98.7	mSaL	12	9	40	34	6		4.7			2
5-2	15 - 35	E 423	98.2	mSaL	18	8	36	32	6		4.4	0.46		4
5-3	35 - 63	E 424	97.5	mSaCL	20	7	38	29	6		4.2	0.30		1
5-4	63 - 100	E 425	96.0	mSaCL	23	8	35	28	6		4.2	0.19		2

TABLE C-1 RESULTS OF THE SOIL ANALYSIS (2)

No.	Depth (cm)	LAB No	Ex-Ca (meq)	E-Mg (meq)	Ex-Na (meq)	Ex-K (meq)	TEB (meq)	CEC (meq)	Base Sat. (%)	E/C	S/C	ESP	EKP
1-1	0 - 12	E 409	3.1	2.7	0.03	0.23	5.8	5.8	100	34.6	34.6	0.4	3.9
1-2	12 - 40	E 410	3.6	3.8	0.05	0.15	7.5	10.7	71	33.8	23.9	0.5	1.4
1-3	40 - 72	E 411	4.5	4.4	0.06	0.14	9.0	12.5	72	34.2	24.6	0.4	1.1
1-4	72 - 100	E 412	7.0	5.5	0.05	0.11	12.6	13.9	91	36.1	32.9	0.4	0.8
2-1	0 - 20	E 413	35.5	6.0	0.08	0.68	14.1	14.1	100	71.6	71.6	0.5	4.8
2-2	20 - 50	E 414	7.9	4.9	0.06	0.06	12.8	15.6	83	54.9	45.3	0.4	0.4
2-3	50 - 75	E 415	9.2	5.1	0.08	0.03	14.4	16.1	89	51.1	45.7	0.5	0.2
3-1	0 - 15	E 416	8.2	5.4	0.10	0.61	14.4	16.2	89	51.2	45.5	0.6	3.8
3-2	15 - 40	E 417	24.9	10.0	0.86	0.12	22.1	22.1	100	54.6	54.6	3.9	0.6
3-3	40 - 90	E 418	23.0	9.3	2.05	0.16	21.0	21.0	100	61.6	61.6	9.8	0.8
4-1	0 - 12	E 419	33.3	14.6	0.27	0.48	47.1	47.1	100	86.0	86.0	0.6	1.0
4-2	12 - 30	E 420	35.5	16.2	2.05	0.27	47.3	47.3	100	88.7	88.7	4.3	0.6
5-1	0 - 15	E 422	2.4	1.2	0.02	0.14	3.7	4.6	82	38.3	31.5	0.5	3.0
5-2	15 - 35	E 423	2.4	1.6	0.02	0.06	4.1	4.7	87	25.9	22.5	0.5	1.4
5-3	35 - 63	E 424	1.9	1.4	0.03	0.00	3.3	4.6	71	23.3	16.5	0.6	0.0
5-4	63 - 100	E 425	2.2	1.6	0.02	0.02	3.9	4.9	79	21.6	17.2	0.4	0.4

TABLE C-1 RESULTS OF THE SOIL ANALYSIS (3)

No.	Depth (cm)	LAB No	DM (%)	Texture	Clay (%)	Silt (%)	F.Sand (%)	M.Sand (%)	C.Sand (%)	Gravel (%)	pH (CaCl2)	Org. C (%)	Carbonates (%)	Available P (ppm)
6-1	0 - 19	E 426	99.2	mSaL	10	7	36	39	9		5.1	0.83		4
6-2	19 - 48	E 427	98.8	mSaL	15	6	36	35	8		4.4	0.33		3
6-3	48 - 100	E 428	97.7	mSaCL	20	6	33	32	9		4.0	0.21		2
7-1	0 - 10	E 429	99.3	mSaL	9	11	25	39	16		5.5	0.99		2
7-2	10 - 26	E 430	99.2	mSaL	13	10	27	35	16		5.1	0.33		15
7-3	26 - 52	E 431	99.0	mSaL	15	10	23	34	18		5.2	0.16		2
8-1	0 - 12	E 433	97.0	fSaCL	26	23	34	11	6		6.4			3
8-2	12 - 32	E 434	94.3	C	46	22	22	7	4		7.0	0.57	0.1	18
8-3	32 - 100	E 435	94.0	C	47	23	21	5	3		7.8	0.37	0.2	7
9-1	0 - 15	E 731	89.4	C	53	24	14	7	2		5.5	0.92		11
9-2	18 - 35	E 732	95.4	C	50	19	21	8	2		5.0	0.63		3
9-3	35 - 100	E 733	95.0	C	53	21	17	7	2		5.5	0.43		1
10-1	0 - 15	E 734	100.0	fSaL	9	10	53	22	6	6	6.0	0.38		20
10-2	15 - 25	E 735	97.5	fSaCL	21	14	40	18	7	19	6.4	0.49		7
10-3	25 - 100	E 736	96.9	cSaCL	31	10	24	13	23	72	7.0	0.43	0.0	5

TABLE C-1 RESULTS OF THE SOIL ANALYSIS (4)

No.	Depth (cm)	LAB No	Ex-Ca (meq)	E-Mg (meq)	Ex-Na (meq)	Ex-K (meq)	TEB (meq)	CEC (meq)	Base Sat. (%)	E/C	S/C	ESP	EKP
6-1	0 - 19	E 426	28.4	0.7	0.03	0.13	3.9	3.9	100	39.6	39.6	0.7	3.4
6-2	19 - 48	E 427	1.4	1.4	0.03	0.05	2.8	3.4	83	22.4	18.5	0.8	1.5
6-3	48 - 100	E 428	1.2	1.3	0.03	0.03	2.6	4.0	66	19.8	13.2	0.7	0.7
7-1	0 - 10	E 429	2.2	1.0	0.02	0.15	3.4	3.9	86	44.3	38.2	0.5	3.7
7-2	10 - 26	E 430	2.8	0.6	0.04	0.04	1.9	1.9	100	14.7	14.7	2.2	2.2
7-3	26 - 52	E 431	1.0	1.1	0.02	0.06	2.2	2.6	84	17.2	14.6	0.8	2.4
8-1	0 - 12	E 433	7.0	4.1	0.05	0.96	12.1	13.5	90	51.6	46.4	0.4	7.1
8-2	12 - 32	E 434	14.4	10.1	1.26	1.32	25.7	25.7	100	56.3	56.3	4.9	5.1
8-3	32 - 100	E 435	17.9	12.1	1.92	0.85	26.3	26.3	100	55.7	55.7	7.3	3.2
9-1	0 - 15	E 731	17.3	10.2	0.09	0.12	27.7	30.4	91	57.5	52.4	0.3	0.4
9-2	18 - 35	E 732	14.7	9.1	0.19	0.25	24.3	25.4	95	51.2	48.8	0.7	1.0
9-3	35 - 100	E 733	16.5	9.8	0.26	0.15	26.7	28.8	92	54.8	50.7	0.9	0.5
10-1	0 - 15	E 734	3.5	1.3	0.04	0.34	5.2	5.7	91	67.5	61.5	0.7	5.9
10-2	15 - 25	E 735	8.0	2.2	0.07	0.35	10.5	10.5	100	49.9	49.9	0.7	3.4
10-3	25 - 100	E 736	7.0	5.1	0.11	0.99	13.1	15.3	86	48.7	41.9	0.7	6.5

TABLE C-1 RESULTS OF THE SOIL ANALYSIS (5)

No.	Depth (cm)	LAB No	DM (%)	Texture	Clay (%)	Silt (%)	F.Sand (%)	M.Sand (%)	C.Sand (%)	Gravel (%)	pH (CaCl2)	Org. C (%)	Carbonates (%)	Available P (ppm)
11-1	0 - 22	E 737	100.0	mS	3	4	30	46	17		4.2	0.47		52
11-2	22 - 45	E 738	100.0	mLS	7	4	30	45	15		3.7	0.38		5
11-3	45 - 68	E 739	100.0	mSaL	13	3	26	41	18		3.6	0.43		2
11-4	68 - 100	E 740	100.0	mSaL	12	4	29	41	15		3.6	0.36		3
12-1	0 - 10	E 741	98.8	fSaCL	20	10	52	16	2		4.5	0.92		8
12-2	10 - 25	E 742	96.8	fSaCL	30	9	45	14	2		4.5	0.52		3
12-3	25 - 53	E 743	98.1	fSaC	41	5	41	11	1		4.8	0.37		2
12-4	53 - 100	E 744	95.7	fSaC	42	7	37	12	2		4.8	0.25		3
13-1	0 - 15	E 745	94.3	C	55	19	18	5	3		5.8	0.82		16
13-2	15 - 35	E 746	95.7	C	62	16	16	4	3		5.7	0.68		7
13-3	35 - 55	E 747	92.5	C	72	11	11	2	3		5.0	0.37		2
13-4	55 - 100	E 748	92.7	C	69	15	12	2	2		5.6	0.31		5
14-1	0 - 12	E 749	97.2	fSaC	38	13	40	7	2		6.0	0.64		23
14-2	12 - 28	E 750	96.8	fSaC	39	15	37	7	3		6.0	0.70		5
14-3	28 - 100	E 751	96.0	C	50	16	27	5	3		5.8	0.47		3
15-1	0 - 12	E 752	97.1	CL	36	24	29	8	3		6.6	1.06	0.0	12
15-2	12 - 32	E 753	95.2	C	45	23	22	6	4		6.0	0.54		4
15-3	32 - 100	E 754	95.7	C	47	23	21	5	3		6.4	0.41		3

TABLE C-1 RESULTS OF THE SOIL ANALYSIS (6)

No.	Depth (cm)	LAB No	Ex-Ca (meq)	E-Mg (meq)	Ex-Na (meq)	Ex-K (meq)	TEB (meq)	CEC (meq)	Base Sat. (%)	E/C	S/C	ESP	EKP
11-1	0 - 22	E 737	0.1	0.2	0.02	0.10	0.5	0.9	52	29.8	15.5	2.1	10.4
11-2	22 - 45	E 738	0.0	0.1	0.02	0.04	0.2	0.8	26	11.6	3.0	2.6	5.2
11-3	45 - 68	E 739	0.0	0.2	0.02	0.06	0.3	1.0	25	7.9	2.0	1.9	5.8
11-4	68 - 100	E 740	0.0	0.2	0.04	0.06	0.3	1.0	26	8.7	2.2	3.9	5.9
12-1	0 - 10	E 741	4.4	2.2	0.03	0.36	6.9	8.4	83	41.6	34.6	0.4	4.3
12-2	10 - 25	E 742	4.9	2.4	0.05	0.12	7.5	9.1	83	29.9	24.8	0.5	1.3
12-3	25 - 53	E 743	5.8	3.0	0.12	0.17	9.1	10.6	86	25.9	22.3	1.2	1.6
12-4	53 - 100	E 744	6.2	2.8	0.08	0.30	9.4	10.9	86	25.8	22.2	0.7	2.7
13-1	0 - 15	E 745	10.4	8.0	0.05	0.96	19.4	21.8	89	40.0	35.6	0.3	4.4
13-2	15 - 35	E 746	10.0	8.1	0.04	0.85	19.0	20.4	93	33.2	30.9	0.2	4.2
13-3	35 - 55	E 747	11.7	10.0	0.06	0.27	22.1	24.0	92	33.5	30.8	0.3	1.1
13-4	55 - 100	E 748	13.8	10.6	0.09	0.24	24.7	26.3	94	38.0	35.8	0.3	0.9
14-1	0 - 12	E 749	8.6	3.6	0.11	0.77	13.1	14.2	92	37.8	35.0	0.8	5.4
14-2	12 - 28	E 750	10.4	4.0	0.09	0.19	14.7	17.2	85	44.2	37.8	0.5	1.1
14-3	28 - 100	E 751	11.1	3.4	0.08	0.21	14.8	16.4	90	32.9	29.6	0.5	1.3
15-1	0 - 12	E 752	12.6	4.8	0.05	0.79	18.3	18.9	97	52.3	50.6	0.3	4.2
15-2	12 - 32	E 753	12.2	6.6	0.16	0.30	19.3	19.8	97	43.9	42.7	0.8	1.5
15-3	32 - 100	E 754	13.1	7.0	0.40	0.11	20.6	22.7	91	48.4	43.9	1.8	0.5

TABLE C-1 RESULTS OF THE SOIL ANALYSIS (7)

No.	Depth (cm)	LAB No	DM (%)	Texture	Clay (%)	Silt (%)	F.Sand (%)	M.Sand (%)	C.Sand (%)	Gravel (%)	pH (CaCl2)	Org. C (%)	Carbonates (%)	Available P (ppm)
16-1	0 - 15	E 755	99.2	mLS	8	3	52	32	5		4.4	0.60		6
16-2	15 - 33	E 756	99.2	mSaL	12	4	50	30	4		4.0	0.42		5
16-3	33 - 53	E 757	99.3	mSaL	13	4	49	29	5		3.7	0.32		4
16-4	53 - 100	E 758	98.2	mSaL	17	5	40	30	8		3.6	0.32		4
17-1	0 - 20	E 759	98.9	fLS	7	5	55	25	7		4.7	0.43		6
17-2	20 - 40	E 760	98.9	mSaL	11	6	40	35	8		4.1	0.32		4
17-3	40 - 100	E 761	96.7	mSaCL	21	7	34	24	14		5.8	0.32		2
18-1	0 - 18	E 762	95.9	mLS	6	4	46	40	4		4.9	0.47		9
18-2	18 - 50	E 763	98.7	fSaL	12	3	53	30	2		4.9	0.61		3
18-3	50 - 100	E 764	98.6	mSaL	11	8	48	30	3		4.1	0.57		2
19-1	0 - 18	E 765	99.1	mLS	7	3	41	44	5		4.4	0.44		6
19-2	18 - 33	E 766	98.1	mSaL	17	5	30	44	5		3.9	0.34		3
19-3	33 - 53	E 767	98.2	mSaL	16	4	35	39	5		4.0	0.29		4
19-4	53 - 100	E 768	96.9	mSaCL	20	4	35	37	5		4.3	0.18		4
20-1	0 - 22	E 769	98.3	mSaL	11	8	39	32	10		5.4	0.39		9
20-2	22 - 68	E 770	95.0	mSaC	37	8	27	18	10		4.4	0.27		3

TABLE C-1 RESULTS OF THE SOIL ANALYSIS (8)

No.	Depth (cm)	LAB No	Ex-Ca (meq)	E-Mg (meq)	Ex-Na (meq)	Ex-K (meq)	TEB (meq)	CEC (meq)	Base Sat. (%)	E/C	S/C	ESP	EKP
16-1	0 - 15	E 755	1.8	0.9	0.04	0.26	3.0	3.6	83	43.6	36.0	1.1	7.2
16-2	15 - 33	E 756	1.3	1.2	0.05	0.14	2.7	3.7	72	32.4	23.2	1.4	3.6
16-3	33 - 53	E 757	0.6	1.3	0.05	0.11	2.0	4.3	47	32.6	15.2	1.2	2.5
16-4	53 - 100	E 758	0.4	1.2	0.05	0.10	1.8	5.1	34	29.2	10.1	1.0	1.9
17-1	0 - 20	E 759	2.9	1.3	0.07	0.14	4.4	5.1	86	72.9	62.3	1.4	2.8
17-2	20 - 40	E 760	2.9	1.5	0.26	0.05	4.7	5.6	84	52.4	43.9	4.6	0.9
17-3	40 - 100	E 761	7.7	3.0	0.50	0.07	11.2	13.5	83	65.6	54.5	3.7	0.5
18-1	0 - 18	E 762	1.4	0.6	0.10	0.12	2.2	2.6	86	41.3	35.5	3.7	4.7
18-2	18 - 50	E 763	1.2	1.3	0.04	0.11	2.7	3.2	84	26.6	22.3	1.3	3.3
18-3	50 - 100	E 764	0.8	1.3	0.03	0.13	2.3	3.2	71	29.3	20.9	0.8	4.0
19-1	0 - 18	E 765	1.7	0.7	0.02	0.22	2.7	3.5	78	51.9	40.4	0.6	6.4
19-2	18 - 33	E 766	1.6	1.5	0.02	0.07	3.2	4.5	70	27.0	19.0	0.5	1.6
19-3	33 - 53	E 767	1.8	1.6	0.02	0.06	3.5	4.7	73	28.8	21.2	0.4	1.3
19-4	53 - 100	E 768	2.0	1.9	0.07	0.03	4.0	4.9	81	24.6	19.9	1.4	0.7
20-1	0 - 22	E 769	3.3	2.2	0.05	0.51	6.0	7.0	86	63.0	54.2	0.7	7.3
20-2	22 - 68	E 770	5.5	5.0	0.22	0.58	11.3	16.2	70	43.3	30.2	1.4	3.6

TABLE C-1 RESULTS OF THE SOIL ANALYSIS (9)

No.	Depth (cm)	LAB No	DM (%)	Texture	Clay (%)	Silt (%)	F.Sand (%)	M.Sand (%)	C.Sand (%)	Gravel (%)	pH (CaCl2)	Org. C (%)	Carbonates (%)	Available P (ppm)
21-1	0 - 20	E 771	100.0	mS	3	7	34	45	11		5.8	0.41		37
21-2	20 - 50	E 772	100.0	mS	3	8	30	45	13		6.3	0.10		20
21-3	50 - 100	E 773	100.0	mS	3	7	30	46	14		6.0	0.04		6
22-1	0 - 18	E 774	100.0	cS	2	4	28	36	29		4.5	0.36		11
22-2	18 - 28	E 775	100.0	cS	3	6	26	31	35		4.0	0.41		6
22-3	28 - 48	E 776	100.0	cLS	8	5	26	33	28		3.9	0.27		4
23-1	0 - 15	E 777	98.4	mSaL	12	7	45	31	4		4.2	0.23		8
23-2	15 - 35	E 778	97.1	mSaCL	20	6	43	27	4		4.7	0.16		3
23-3	35 - 100	E 779	94.8	mSaCL	24	7	40	26	4		4.6	0.07		5

TABLE C-1 RESULTS OF THE SOIL ANALYSIS (10)

No.	Depth (cm)	LAB No	Ex-Ca (meq)	E-Mg (meq)	Ex-Na (meq)	Ex-K (meq)	TEB (meq)	CEC (meq)	Base Sat. (%)	E/C	S/C	ESP	EKP
21-1	0 - 20	E 771	1.6	0.9	0.05	0.32	2.7	2.7	100	84.4	84.4	1.7	11.8
21-2	20 - 50	E 772	3.0	2.8	0.12	0.32	1.3	1.3	100	40.0	40.0	9.3	24.9
21-3	50 - 100	E 773	0.5	0.4	0.07	0.18	1.1	1.1	100	37.5	37.5	6.4	16.9
22-1	0 - 18	E 774	0.5	0.4	0.05	0.27	1.2	1.5	84	59.8	49.9	3.7	18.6
22-2	18 - 28	E 775	0.5	0.3	0.02	0.07	0.9	1.6	58	54.1	31.3	1.4	4.2
22-3	28 - 48	E 776	0.2	0.3	0.05	0.05	0.6	1.4	42	17.4	7.3	3.7	3.7
23-1	0 - 15	E 777	1.5	1.5	0.03	0.19	3.2	4.5	72	36.9	26.6	0.6	4.2
23-2	15 - 35	E 778	2.2	3.7	0.03	0.09	6.0	7.1	85	35.0	29.6	0.4	1.3
23-3	35 - 100	E 779	2.0	5.2	0.03	0.10	7.3	8.4	87	35.6	30.9	0.4	1.2

C. 2 Analysis of the Satellite Data

C.2.1 General

Each SPOT scene represents a ground area of 60 km x 60 km. In the multispectral mode of SPOT, observations are made in three spectral bands (channels) with a pixel size of 20 meters.

- Channel 1 : a green band from 500nm to 590nm
- Channel 2 : a red band from 610nm to 680nm
- Channel 3 : a near infra red band from 790nm to 890nm

In the absence of clouds, the SPOT sensors will sense vegetation, bare ground, or open water. Consequently, useful ecological information can be obtained about land surface. The channels 1, 2 and 3 of the SPOT sensors are mainly utilized for measuring reflection of green vegetation, absorption of chlorophyll, and biomass, respectively.

C.2.2 Land Use Survey

Land use survey was carried out through the review of existing reports, satellite photograph interpretation and additional field trips. The satellite photographs for the area taken in 1986 brought comprehensive and detailed information to the study. The false color imagery (Figure C-1) was produced in hard copy form at a scale of 1:100,000 to facilitate visual interpretation of the land use classes. The interpretation was performed by placing transparent overlays on the imagery and demarcating boundaries between land use classes. The resulting land use map at a scale of 1:100,000 was photographically reduced to a scale of 1:250,000 for presentation and publication.

Land use category was also classified by maximum likelihood method through computer analysis. Two sample areas were selected for the analysis; namely Copper Queen Central & South and Chisina I, Gokwe South. The result is shown in Figure C-2. Five different land use categories were found in the area through the analysis. The ratio of each category is as follows;

Land use category	Copper Queen	Chisina I
Cultivated land	5.6%	12.3%
Fallow land	11.5%	15.0%
Grazing land	22.2%	46.2%
Forest land	22.6%	14.7%
Dense forest land	4.1%	3.5%

According to the result, cropping ratio can be estimated from the extent of the cultivated and fallow lands. The ratio as of May 1986 was 32.7% and 45.1% in Copper Queen and Chisina I, respectively. More satellite data taken over different years or seasons will be necessary for the further analysis.

C.2.3 NDVI (Normalized Difference Vegetation Index) Map

NDVI map shows difference in plant vigor of the area. NDVI is calculated by the following equation;

NDVI = (channel 3 - channel 2) / (channel 3 + channel 2)

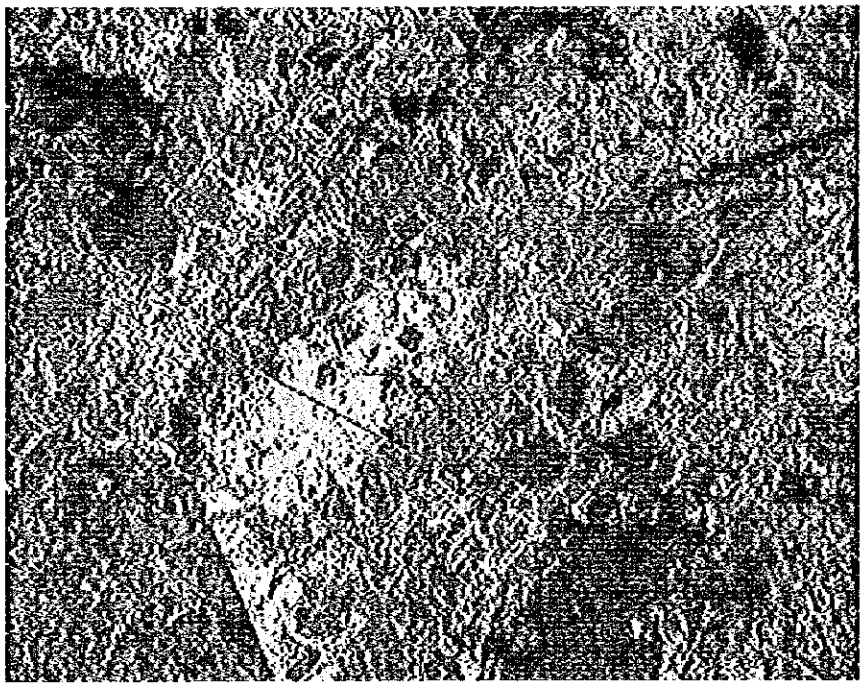
NDVI data is usually utilized for processing vegetation and land cover mapping. There is some correlation between NDVI data and biomass parameters. NDVI map of the project area is shown in Figure C-3. Vegetation and land use type can be estimated from the map; for example, red area shows dense woodland and blue area shows cultivated land.

C.2.4 Classification of Vegetation Type

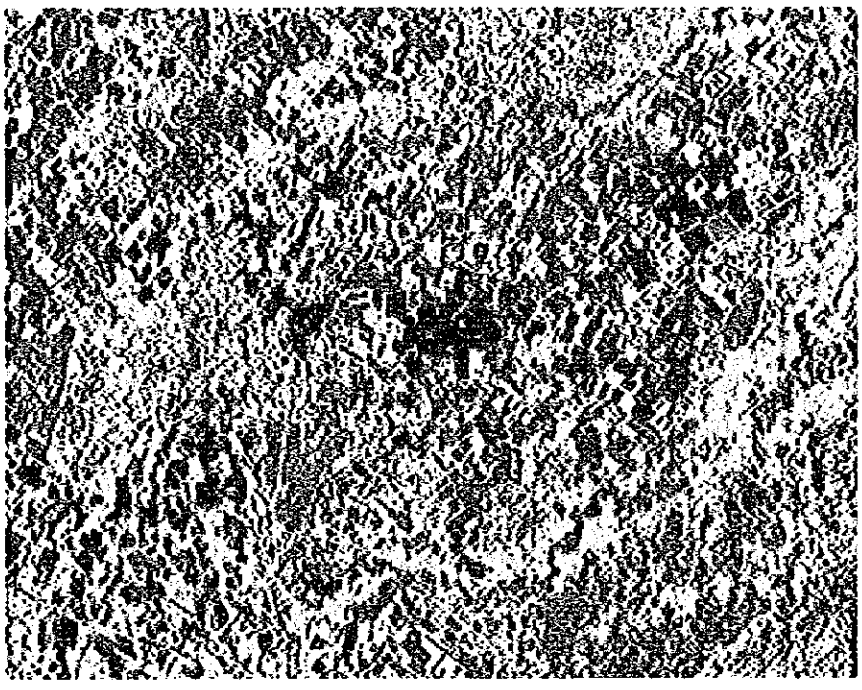
Based on the satellite data and vegetation map of the area, vegetation type was classified provisionally. Another two sample areas were selected for the vegetation analysis; namely Muzvezve I & Chisina II area and Sanyati area. The result is shown in Figure C-4. According to the figure, Miombo-Mopane woodland is dominant in both two sample areas. More detailed ground truth survey will be necessary to get further information.

Figure C-1 THE FALSE COLOR IMAGERY OF THE STUDY AREA

Figure C-1 THE FALSE COLOR IMAGERY OF THE STUDY AREA



(a) Copper Queen Central & South

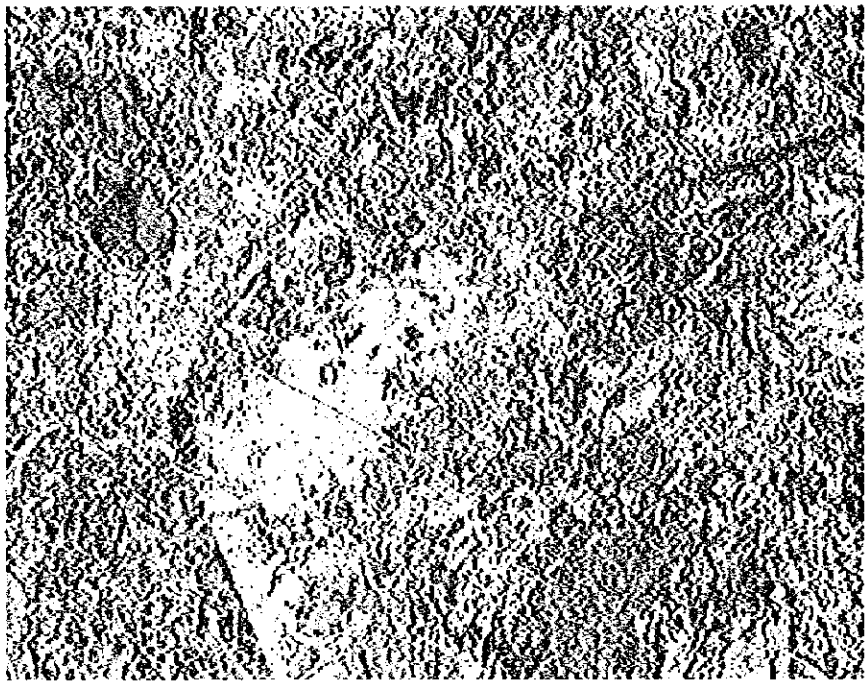


(b) Chisina I, Gokwe South

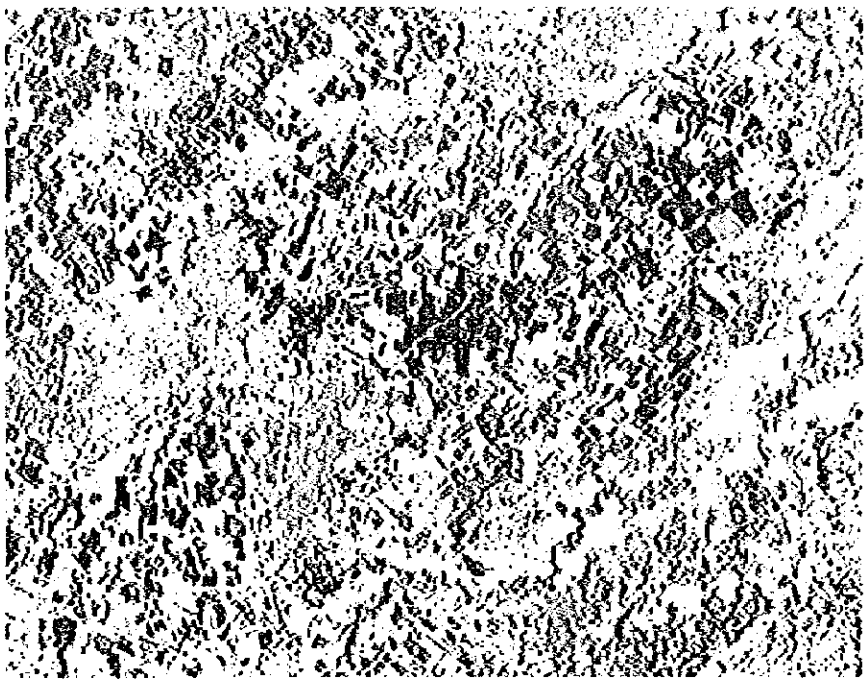
Cultivated area | Fallow area(1) | Fallow area(2)

Grazing area | Forest area | Dense forest area

Figure C-2 LAND USE CLASSIFICATION FOR TWO SAMPLE AREAS



(a) Copper Queen Central & South



(b) Chisina I, Gokwe South

Cultivated area | Fallow area(1) | Fallow area(2)

Grazing area | Forest area | Dense forest area

Figure C - 2 LAND USE CLASSIFICATION FOR TWO SAMPLE AREAS

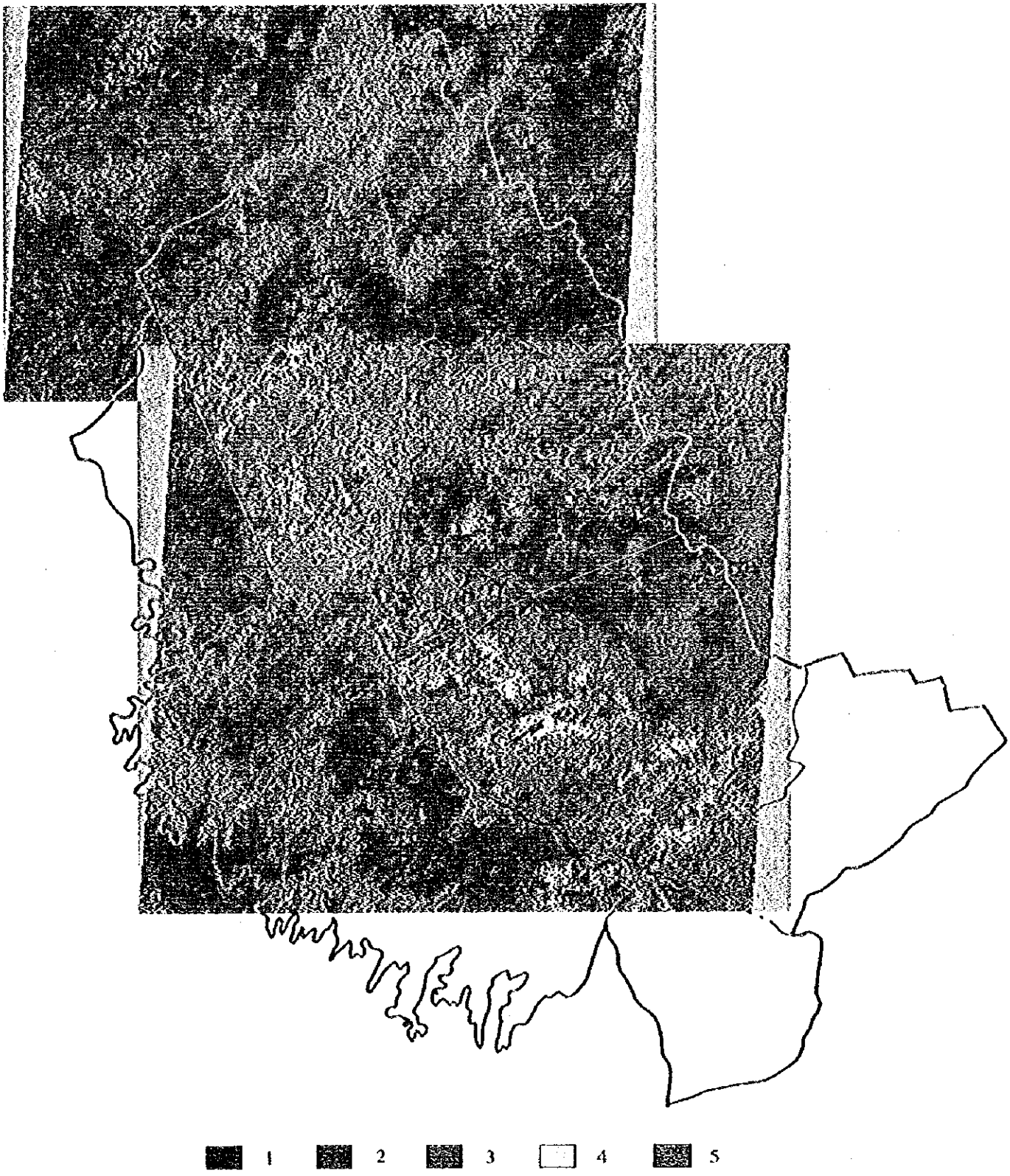
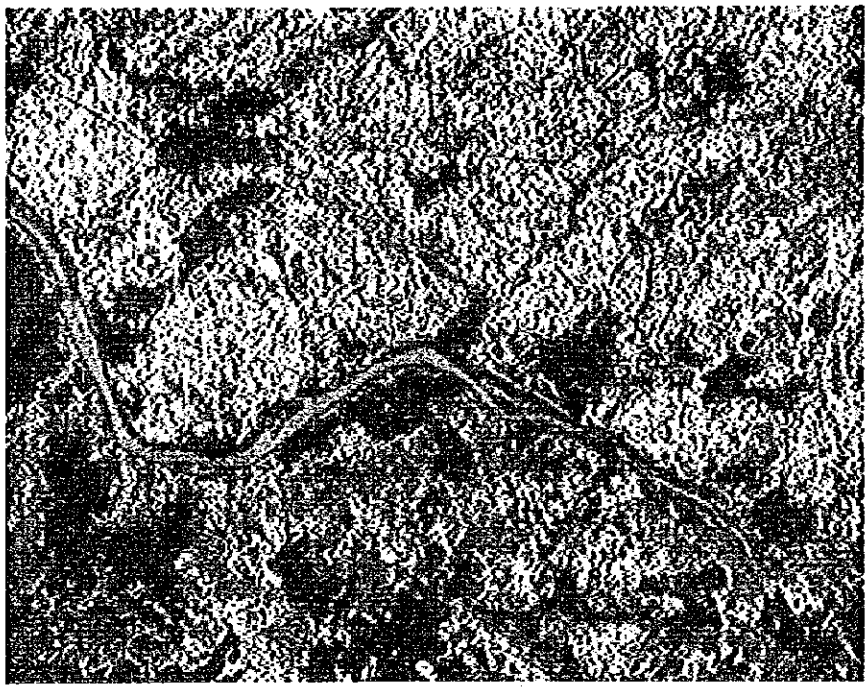


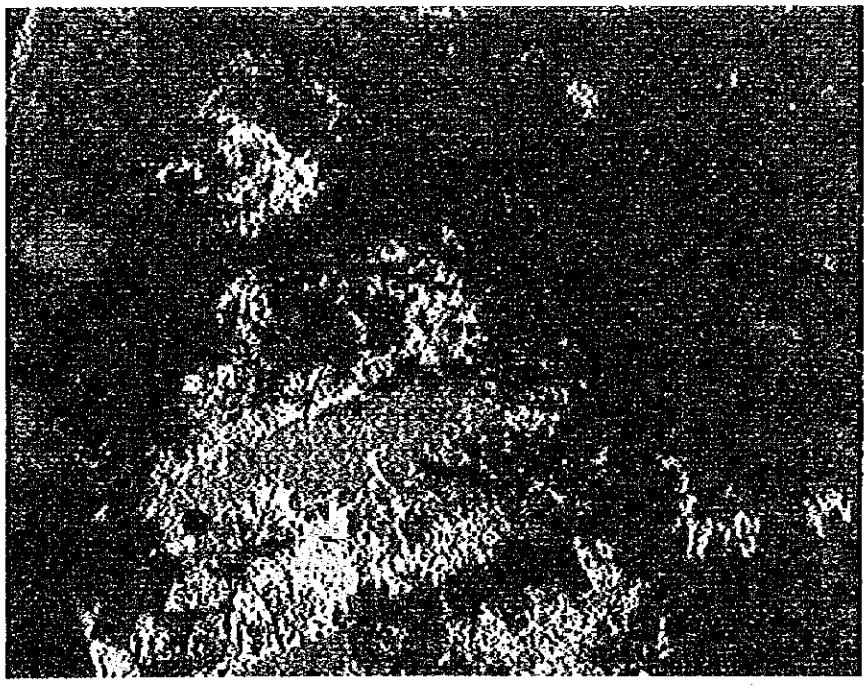
Figure C-3 NDVI (NORMALIZED DIFFERENCE VEGETATION INDEX) MAP OF THE STUDY AREA

Figure C-3 NDVI (NORMALIZED DIFFERENCE VEGETATION INDEX) MAP OF THE STUDY AREA



Miombo-Mopane woodland Acacia open woodland Munyati river

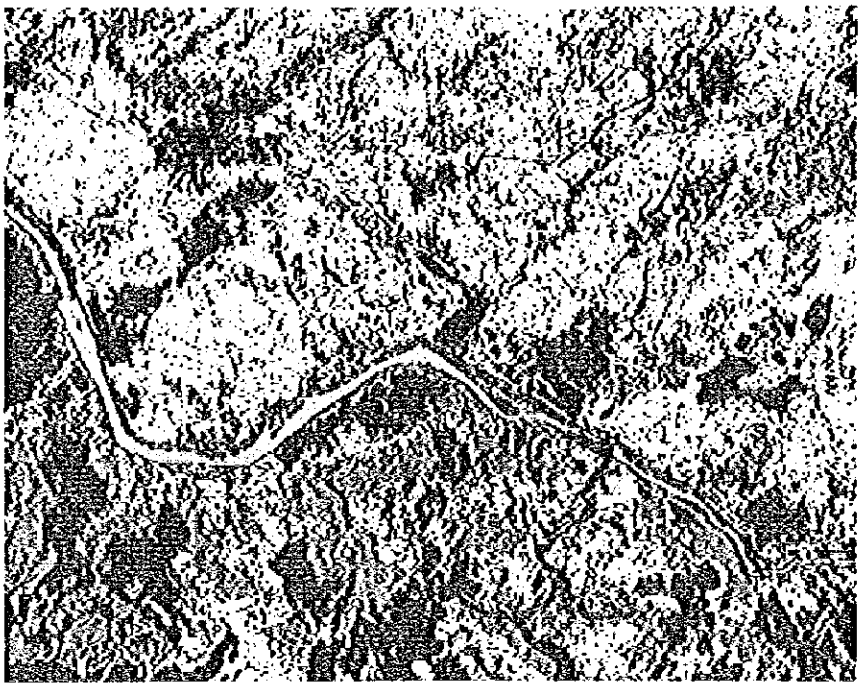
(a) Muzvezve I and Chisina II



Miombo-Mopane woodland Dry forest & Thickets Cultivated land

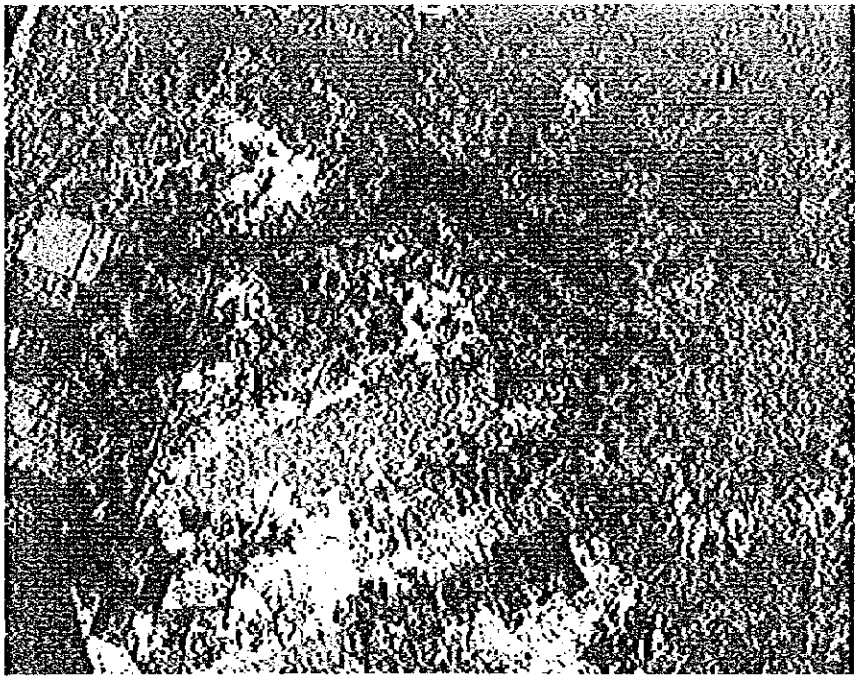
(b) Sanyati

Figure C-4 VEGETATION MAP FOR TWO SAMPLE AREAS



Miombo-Mopane woodland Acacia open woodland Munyati river

(a) Muzvezve I and Chisina II



Miombo-Mopane woodland Dry forest & Thickets Cultivated land

(b) Sanyati

Figure C-4 VEGETATION MAP FOR TWO SAMPLE AREAS

C.3 Land Use Planning

C.3.1 Soil Conservation

(1) Problems of soil erosion

Soil erosion, both in the form of gully erosion from grazing lands and sheet erosion from arable fields, is one of the major concern in agricultural management in Zimbabwe. It has been estimated that about 15% of agricultural land in the country is very severely eroded, 13% is severely eroded, 19% moderately eroded, and 53% is in relatively good condition. Most of eroded land is in communal areas, and most of the land in commercial areas is in good condition. In a soil erosion study, Elwell (1983) estimated soil loss from communal farms to average 50 tonnes a hectare a year. It was reported that; when sandveld on 4% slopes is denuded of vegetation by overgrazing, annual soil loss increases by 21 times and runoff by 8 times, than from veld with 80% total vegetation cover.

Large areas of communal lands are naturally more prone to soil erosion than other areas. The presence of granitic rocky outcrops is the most significant physical factor influencing rates of erosion. The mean eroded area in communal croplands where rocky outcrops were present, was measured to be between 8.4 and 10.4%, compared with an eroded area of 4.2% in communal farming areas as a whole.

(2) Control of soil erosion

Contour bunds

Most soil erosion control activities in communal areas are concentrated on the construction of contour bunds, which is encouraged by AGRITEX. Cultivation along contours, with terracing or mounding, has long been recommended as it inhibits overland water flow. While rill and gully erosion are serious problems mainly in grazing areas, sheet erosion contributes the most to soil and nutrient loss in farming lands. Rates of sheet erosion are directly related to rainfall runoff, and if rates of runoff could be reduced and rates of infiltration increased, sheet erosion could be brought under control. Contour bunds do provide some protection against rill and gully erosion, however for conservation measures to be more effective, contour bunds must be used in conjunction with improved tillage practices such as tied-ridging.

Tied-ridging

Tied-ridging involves shaping the soil into continuous rows of small basins. They are intended to last four or five years before they are plowed under, and re-ridged. Tied-ridging tends to reduce runoff and allows water to infiltrate. Labor and draft power requirements are high in the first year, but lower in subsequent years. To farmers, the short-term benefits are principally in the form of higher yields because of water conservation. Longer term benefits are those associated with sustained nutrient levels through reduced soil erosion.

Combination with other water harvesting techniques

Generally, soil conservation is closely related to water conservation, and water harvesting techniques are very important for soil and water conservation in arid and semi-arid areas. Water harvesting can be used with many other agroforestry practices in order to enhance the survival of trees and shrubs.

The role of trees

The presence of trees is widely believed to help conserve soil. Generally, the coarse and deep network of tree roots is less effective in binding the soil than the near-surface root mats of grass and herbs. Soil binding is only one aspect of the problem, and one of more importance is the exposure of the soil surface to rainfall energy. The most immediate effect of trees on soil erosion is modifying the impact of rainfall by intercepting and reducing the energy of rain with their canopy.

Other effects of trees on erosion are related to leaf litter. Compaction of the bare soil by animal hoofs, or on pathways and roads, concentrates overland flow and leads to gullying and sheet wash erosion. Leaf litter from trees mitigates this process by providing a cushion to absorb rainfall energy and by disrupting and diffusing overland flow. Therefore, the reduction of leaf litter in open woodlands as a result of grazing and the transfer of leaf litter from woodlands to farmlands can significantly increase erosion rates.

Trees also help to stabilize field contours, thereby reducing labor requirements for repairing damage. The relationship between soil conservation contours and vegetation on these contours is important. In some respects, contour ridges act as micro catchments, harvesting water runoff and changing soil-water relationships, helping trees to get established more easily than on fields without ridges.

C.3.2 Drought Resistant Fodder Shrub Crops

(1) Introduction

The most important single factor limiting plant production in the Study Area is the lack of moisture. The important factors to increase the plant production in the area are thus either increasing the amount of moisture or making better use of it. Irrigation water is limited in the area and practical methods of increasing the rainfall are not available, resulting that the establishment of drought resistant fodder crops, which make better use of the available moisture, remains the most important possibility.

The planting of drought resistant fodder crops not only assures the building up of fodder reserves, but they can also be grazed annually or in times of drought, and can play an important part in the conservation and improvement of the natural vegetation. The control of soil erosion, efficient grazing control and fodder conservation contribute considerably to the strengthening of the farmer's position in times of drought, but the establishment of drought resistant fodder crops is a very important factor that is often disregarded. The establishment of drought resistant fodder crops should form an important part of the farming enterprise in the area. There are various plants which can be used as drought resistant fodder crops. Due to the low relative water requirements, spineless cactus *(Opuntia* spp*)*, oldman saltbush *(Atriplex nummularia)* and American aloe *(Agave americana),* as shown in the following table, are the important drought resistant fodder crops.

Crop	Mass of water (kg) required to produce kg of dry material
American aloe	93
Spineless cactus	267
Oldman saltbush	304
Fodder sorghum	369
Maize	369
Wheat	507
Lucerne (Alfalfa)	750

(2) Requirements of a drought resistant fodder crop

Drought resistant shrubs do well in areas where the rainfall is low and variable, where the cultivation of fodder crops such as lucerne and annual

crops is uncertain. Due to their well developed root system, low transpiration and physiological adaptation (such as high mineral content) these plants can make efficient use of water. The major requirements of these crops are as follows;

a) As the name implies the crop must be relatively drought resistant. It must not only be able to survive long droughts, but must also be able to produce large quantities of fodder during preceding times of plenty or periods of favorable rainfall, which can be utilized during periods of drought.
b) Drought resistant fodder crops must have a high carrying capacity.
c) It must be able to supply succulent fodder to animals during droughts.
d) It must not have an adverse effect on the health of the animals utilizing it.
e) The plants must have a high recovery ability after severe utilization.
f) The establishment must have as few problems as possible.
g) The establishment and maintenance of the plantations must be economical. It must thus have a low initial cost.
h) The plants must be adapted to a wide ranges of soil and climatic conditions.

(3) Important drought resistant shrubs

Spineless Cactus *(Opuntia* spp)

Spineless cacti have been referred to as "camels of the plant world", "nature's fodder bank" and "living fodder banks". They possess the exceptional characteristics of begin able to store large quantities of water in their succulent leaves in a relatively short period. A shower of rain measuring a few millimeters which would normally be of no value to the ordinary fodder crop, can be efficiently utilized by spineless cacti. This is made possible by their relatively shallow spreading root system and their ability to absorb water from the soil at a stage when other crops can no longer do so.

Oldman saltbush *(Atriplex nummularia)*

Oldman saltbush is a perennial shrub, indigenous to Australia, and also found in southern Africa. It can grow to a height of 3m and can form bushes with a diameter of 3m. It possesses a well-developed taproot system together with horizontal basal root development. The seed consists of two leathery or papery scale leaves which have grown together around the small round reddish-brown seed. These scale leaves contain a high sodium chloride concentration which serves as a germination inhibitor. The sodium chloride

first has to be leached out before the seed will germinate. This is a mechanism which prevents seed from germinating after a light rain and only allows germination when there is sufficient moisture for the plant to become established.

Oldman saltbush is a halophyte, or salt-loving plant. Due to the high concentration of salt in the roots and leaves the plant maintains a high osmotic value in the cellsap which is a physiological adaptation of the plant to moisture stress, thus making it drought resistant. The plant also possess a C4 carbon metabolism which means that photosynthesis is very effective especially at high temperatures and high light intensity.

American Aloe *(Agave americana)*

American aloe is one of the hardiest plants which can be established for the production of fodder in the arid and semi-arid regions. It can be of value in the control of erosion when established on the periphery or on eroded patches. This crop uses exceptionally little water for the production of dry material.

C.3.3 Utilization of Woody Plant in Livestock Production

(1) Major vegetation types and dominant woody species in the area

The classification of the indigenous woodlands of Zimbabwe is determined by ecological factors such as climate, geology, altitude and soil. Five major types of woodland are defined in Zimbabwe such as Miombo woodlands, Mopane woodlands, Teak woodlands, *Acacia* woodlands, and *Terminalia-Combretum* association. The dominant vegetation types in the Study Area are miombo, mopane and *Acacia* woodlands,

(a) Miombo woodlands are dominated by *Brachystegia spiciformis* in association with *Julbernadia globiflora.* Minor variations are found; *Brachystegia spiciformis* may be replaced by *B. utilis* in the wetter area, and *B. bochmii* may be dominant on thin soils on rocky slopes. This latter type is also known as escarpment woodland and generally has a more open canopy. The relative balance of these different Brachystegias is also determined by soil factors, particularly depth and texture. A number of subsidiary species may also be present, such as *Faurea saligna, F. speciosa, Combretum molle, Uapaa kirkiana, Pteroarpus angolensis, Albizia antunesiana, Strychnos* spp and *Monotes glaber.* Where miombo woodland is relatively undisturbed, it is characterized by a single stratum

between 6m and 12m in height, which gives a canopy cover of up to 80%. Although not constituting a genuine understorey, scattered shrubs may be found beneath the canopy.

(b) Mopane woodlands are dominated by *Colophospermum mopane* and occur at lower altitudes than miombo, below 900m. This woodland type develops best on deep, well-drained soils. A closed canopy is common on favorable sites, and in such cases there is little understorey. In more open situations, a number of shrub species may form a scattered layer beneath the tree canopy. *Grewia* spp are characteristic of this sparse understorey. A number of subtypes can be observed. Like the escarpment miombo, in areas of poor soils or where soil moisture is less, dry mopane savannas have more open canopy than mopane woodlands. In general, species diversity is much lower than in miombo, with mono specific stands of *Colophospermum mopane* being quite common. Where this woodland type has more mixed species assemblage, typical subsidiaries are from the followings; *Acacia, Sclerocarya, Combretum, Kirkia,* and in transitional zones, *Brachystegia. Adansonia digitata* may be characteristically associated with this woodland type. Unlike miombo, which is frequently associated with sandy soils, mopane can develop on more clay-rich substrates, although where exchangeable sodium levels are high, stunting of the trees is likely to occur.

(c) Acacia woodlands and savannas occupy extensive, but specific, areas of the country. They favor eutrophic soils developed from a number of base-rich geological formations. Several subtypes are recognized, corresponding to these geological determinants. The species complex varies like *Acacia nilotica* on black clays, *A. gerrardii* on basement schists, and *A. tortilis* on the colluvial sands. Tree density varies across these associations, while canopy height may reach 9m. Lower rainfall areas support more open savannas. Although other tree species occur, *Acacia* woodlands are less diverse than miombo.

(2) Utilization and palatability of woody vegetation

There are marked differences in the palatability of woody species. Most of the woody plant have palatable leaves and twigs since these provide by far the bulk of the food. Some species, however, are particularly important because of their fruits or seeds. These notable examples are *Acacia erioloba, A. albida* (large pods) and many other *Acacia* species, such as *A. nilotica,* which have very palatable, smaller pods. The large fleshy fruits of *Sclerocarya caffra, Uapaca kirkiana* and *Ficus* species contribute a substantial amount but for only a very short period. The

smaller fruits of species such as *Ziziphus mucronata* and the *Grewia* species dry out and remain on the branches, providing a smaller but prolonged food source.

The degree of utilization of woody species is a function of their relative palatability, their growth form and the structures of the herbivore community. Palatability is a complex characteristic and there is no single factor which can be used to assess it. Characteristics which seem to be positively related to it are crude protein content, high percentage of minerals (especially Na) and moisture content. Negative characteristics include high fiber content and the presence of tannins and aromatic substances.

Growth form can influence the degree of browsing by allowing some maximum amount of use beyond which the remaining browse is unobtainable, either through height or a physical barrier. The thorns of *Acacias* are an obvious example, but species such as *Gardenia spatulifolia, Balanites* spp and *Carissa bispinosa,* all of which have thick woody spines, are much more effective in limiting browsing.

(3) The role of browse in livestock production

In the wetter savannas the best form of land use is either arable cropping or clearing the woody vegetation and grazing the area with cattle. Where the rainfall is above about 750mm, and where capital and management expertise are available, then it is desirable to remove the woody vegetation and introduce legumes into the grassland, or to replace the natural grassland with improved, fertilized pastures. However, when economics dictate the use of natural vegetation then, even in these wetter savannas, browse can play an important role.

In the semi-arid and arid savannas it is uneconomical to clear the woody vegetation, and without irrigation fertilized pastures are not possible. The carrying capacity of the vegetation is such that the increased returns from the extra grass which results from clearing may not even cover the cost of clearing. A major problem has been the increase in woody scrub vegetation which has resulted from the replacement of a mixed herbivore community, which made considerable use of the woody vegetation and controlled its density by cattle. In addition, overgrazing has weakened the competitive effect of the grasses, and further enhanced the growth of woody plants. Control of woody plants is therefore a prime objective over vast areas of these rangelands. Complete removal of the shrubs, however, is

not only uneconomical, but undesirable, as woody plants have a number of advantages in this region. Four in particular are follows;

(a) The time of the new leaf flush. The woody vegetation breaks dormancy and begins to produce the new season's flush of leaves from August to October (depending on species and region), well before the rains begin. Grass growth only begins with the rains in November. For 2-3 months, therefore, at the time when grass biomass and quality are minimal, the woody vegetation produces a high quality food source.

(b) Food quality. The crude protein content of most browse is generally considerably higher than that for the grasses at all times other than the early growing season. The grass layer supplies a surfeit of energy but is usually limiting in protein supply.

(c) Vegetation stability. Both woody and grass vegetation are adversely affected by drought, and in bad years some plants will always die. Generally, however, the existing structure of the woody biomass remains essentially the same, so the woody component provides protection to the soil from erosions.
The value of the woody vegetation especially lies in the bad years when the grass cover fails.

(d) The influence of tree canopies on grass species composition. Although removal of woody plants leads to higher grass production, this is often accompanied by a change to less palatable grasses. There are many cases that total grass (fodder and non-fodder species) biomass is much higher in open areas without trees, however, the biomass of the fodder grasses is about the same or sometimes less.

From all the existing evidence it is apparent that there is some optimum ratio of woody : grass vegetation, and that complete clearing is undesirable. The optimum ratio depends on the types of plant species, and also on the herbivores.

APPENDIX D METEOROLOGY AND HYDROLOGY

APPENDIX D. METEOROLOGY AND HYDROLOGY PAGE

Table D-1 MONTHLY AND ANNUAL RAINFALL AT SANYATI REST CAMP

(Unit: mm/Month)

YEAR	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
1964/65	0.0	0.0	0.0	53.8	125.5	125.7	96.0	50.3	5.8	5.3	0.2	0.0	462.6
1965/66	0.0	0.0	0.0	10.2	83.1	152.1	133.9	229.1	50.5	22.6	7.6	2.0	691.1
1966/67	0.0	3.6	0.0	0.0	21.8	218.4	177.8	231.1	143.0	33.5	12.4	0.0	841.6
1967/68	0.0	0.0	0.0	41.9	24.6	100.6	97.5	64.8	15.5	34.8	20.8	0.0	400.5
1968/69	0.0	0.0	0.0	5.1	96.0	137.4	106.4	82.0	367.5	18.0	0.0	0.0	812.4
1969/70	0.0	0.0	0.0	44.7	91.4	285.5	68.3	89.9	0.0	57.9	0.0	0.0	637.7
1970/71	0.0	0.0	6.4	10.7	120.7	206.2	213.1	124.5	27.4	7.4	0.0	0.0	716.4
1971/72	0.0	0.0	0.8	10.2	160.5	83.2	259.1	67.9	154.2	46.0	0.0	0.0	781.9
1972/73	2.5	0.0	1.5	15.9	21.6	34.0	104.7	94.0	24.0	9.3	0.0	0.0	307.5
1973/74	0.0	0.0	3.9	33.5	52.9	284.2	198.3	307.3	94.1	27.5	5.0	0.0	1006.7
1974/75	0.0	11.5	1.0	9.5	148.0	133.5	109.0	231.0	0.0	29.5	0.0	0.0	673.0
1975/76	0.0	0.0	0.0	12.0	34.0	235.5	190.5	111.0	421.5	49.0	2.5	0.0	1056.0
1976/77	0.0	0.0	0.0	35.2	55.5	91.5	127.5	322.0	163.5	15.5	0.0	0.0	810.7
1977/78	0.0	4.5	10.9	0.0	60.1	286.0	363.7	189.4	171.0	28.0	20.5	0.0	1134.1
1978/79	3.0	0.0	0.0	45.2	75.8	193.6	163.2	110.0	41.4	0.0	0.0	0.0	632.2
1979/80	9.0	0.0	0.0	55.1	117.3	378.8	13.0	160.1	128.7	0.0	0.0	0.0	862.0
1980/81	0.0	0.0	16.3	24.5	154.2	55.3	213.9	332.5	149.0	25.4	0.0	0.0	971.1
1981/82	0.0	0.0	0.0	0.0	131.0	60.5	****	56.0	0.0	11.6	0.0	0.0	268.1
1982/83	0.0	0.0	0.0	106.5	69.0	18.0	183.5	34.0	53.0	28.0	0.0	0.0	492.0
1983/84	0.0	0.0	0.0	0.0	48.0	114.0	63.0	217.0	120.5	65.0	7.0	0.0	634.5
1984/85	0.0	0.0	0.0	35.5	60.0	171.5	246.0	294.5	48.0	7.0	0.0	0.0	862.5
1985/86	0.0	0.0	0.0	0.0	23.0	241.0	206.0	179.0	96.0	167.0	0.0	0.0	912.0
1986/87	0.0	0.0	0.0	103.0	21.0	300.0	111.0	70.0	28.0	0.0	0.0	0.0	633.0
1987/88	0.0	0.0	0.0	14.0	40.0	337.0	199.0	240.0	320.0	15.0	0.0	15.0	1160.0
1988/89	0.0	0.0	0.0	15.0	50.0	14.0	159.5	248.0	58.0	200.0	0.0	0.0	744.5
1989/90	0.0	0.0	0.0	15.0	32.0	4.6	188.0	149.5	44.8	74.7	0.0	0.0	508.6
1990/91	0.0	0.0	0.4	0.0	16.0	55.8	186.5	93.0	92.5	0.0	0.0	0.0	444.2
1991/92	0.0	0.0	0.0	4.0	87.0	51.0	11.5	23.0	179.5	4.0	0.0	0.0	360.0
1992/93	0.0	0.0	0.0	5.4	31.9	183.5	72.0	124.5	0.0	40.5	0.0	0.0	457.8
1993/94	0.0	0.0	0.0	2.0	171.0	105.5	355.5	59.5	20.0	0.0	0.0	0.0	713.5
Mean	0.5	0.7	1.4	23.6	74.1	154.9	153.9	152.8	100.6	34.1	2.5	0.6	699.6
1st decade	0.3	0.4	1.3	22.6	79.8	162.7	145.5	134.1	88.2	26.2	4.6	0.2	686.9
2nd decade	1.2	1.6	2.8	28.8	89.3	157.6	142.7	176.3	124.9	25.2	3.0	0.0	772.3
3rd decade	0.0	0.0	0.0	19.4	53.2	144.4	173.5	148.1	88.7	50.8	0.0	1.5	679.6

Table D-2 MONTHLY AND ANNUAL RAINFALL AT GOKWE

(Unit: mm/Month)

YEAR	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
1964/65	0.0	0.0	0.0	6.4	77.5	168.9	224.3	65.8	6.9	1.3	2.3	0.0	553.4
1965/66	0.0	0.0	11.2	4.1	53.8	73.7	144.5	219.8	26.9	32.3	1.8	2.5	570.6
1966/67	0.0	7.6	0.0	0.0	34.5	224.0	184.4	146.1	53.8	90.4	53.1	0.5	794.4
1967/68	0.0	0.0	0.0	33.3	67.1	74.7	110.2	140.5	38.1	26.9	20.6	0.0	511.4
1968/69	0.0	0.0	0.0	1.3	119.1	187.2	198.1	155.7	184.9	23.1	0.3	0.0	869.7
1969/70	0.0	0.0	1.3	78.2	52.1	394.5	16.5	57.9	0.0	124.0	0.0	0.0	724.5
1970/71	0.0	0.0	0.0	3.8	194.1	134.4	263.7	81.5	17.8	23.1	0.0	0.0	718.4
1971/72	0.0	0.0	0.0	14.9	181.8	62.4	286.0	143.9	53.9	39.7	0.0	0.0	782.6
1972/73	0.0	0.0	1.2	1.6	23.9	70.1	121.1	136.5	14.8	2.1	0.0	0.0	371.3
1973/74	0.0	0.0	7.5	12.0	155.8	324.7	245.4	230.9	133.0	16.0	10.5	0.0	1135.8
1974/75	2.9	11.6	2.4	18.0	127.5	354.9	240.1	202.3	34.1	31.5	0.0	0.5	1025.8
1975/76	0.0	0.0	0.0	20.8	52.1	150.5	261.3	122.4	251.7	50.2	1.8	0.0	910.8
1976/77	0.0	0.0	2.8	30.9	26.5	109.6	131.7	302.6	186.6	2.3	0.0	0.0	793.0
1977/78	0.0	0.0	22.5	0.0	165.0	333.5	214.7	232.9	105.8	74.8	27.1	0.4	1176.7
1978/79	1.6	0.0	0.0	44.3	113.9	230.9	141.0	81.7	90.6	1.6	0.0	0.0	705.6
1979/80	0.0	0.0	0.0	77.3	100.4	341.3	47.0	106.8	94.7	10.7	0.0	0.0	778.2
1980/81	0.0	1.0	3.1	35.6	118.1	228.0	278.7	405.5	70.2	0.4	0.0	0.0	1140.6
1981/82	0.0	0.0	0.0	10.5	114.9	48.6	156.6	75.1	0.8	44.2	0.0	0.0	430.7
1982/83	0.1	0.0	1.1	74.2	61.8	81.3	183.2	159.7	32.3	35.9	7.7	0.0	637.3
1983/84	0.0	0.0	0.0	29.8	58.0	126.1	115.4	156.9	98.8	55.8	1.4	0.0	642.2
1984/85	0.0	0.0	0.0	19.2	80.8	205.2	249.7	224.9	62.6	30.0	7.0	0.0	879.4
1985/86	0.0	0.0	0.0	7.0	24.6	193.2	138.7	100.7	78.1	170.5	0.0	0.0	712.8
1986/87	0.0	0.0	2.9	26.9	31.1	185.8	156.4	88.6	48.8	0.0	0.0	0.0	590.5
1987/88	0.0	0.0	10.4	17.8	113.0	172.7	143.8	205.4	169.5	32.9	0.8	32.1	898.4
1988/89	0.6	0.0	0.0	71.9	46.7	42.0	266.6	231.0	59.5	12.6	3.4	0.0	674.3
1989/90	0.0	2.9	0.0	26.6	57.9	79.5	282.6	179.8	69.9	61.9	4.6	0.0	765.7
1990/91	0.0	0.0	0.7	10.5	40.3	81.3	165.8	74.2	114.6	0.0	1.6	0.0	489.0
1991/92	0.0	0.0	0.3	55.4	49.1	157.0	106.0	14.3	138.0	6.6	0.0	0.0	526.7
1992/93	0.0	0.0	0.0	7.0	41.0	184.5	81.3	156.1	103.0	67.0	0.0	0.0	639.9
1993/94	2.4	0.5	11.6	0.0	167.5	118.2	187.4	146.4	1.5	0.0	1.5	0.0	637.0
Mean	0.3	0.8	2.6	26.3	85.0	170.6	176.1	154.9	78.0	35.6	4.9	1.2	736.2
1st decade	0.0	0.8	2.1	15.6	96.0	171.5	179.4	137.9	53.0	37.9	8.9	0.3	647.9
2nd decade	0.5	1.3	3.9	35.3	109.4	230.9	201.5	207.7	109.9	32.3	4.9	0.1	899.5
3rd decade	0.3	0.3	2.6	29.2	65.2	141.9	171.8	142.1	84.6	38.2	1.9	3.2	681.4

Table D-3 MONTHLY AND ANNUAL RAINFALL AT KADOMA

(Unit: mm/Month)

YEAR	July	Aug.	Set.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
1964/65	0.0	10.2	0.0	22.1	95.5	188.5	145.8	68.3	22.4	0.2	0.2	0.0	553.2
1965/66	0.0	0.0	27.4	5.8	101.1	14.7	167.1	257.8	36.8	31.0	3.8	0.0	645.5
1966/67	0.0	0.8	1.5	0.0	38.1	58.2	181.9	272.8	27.9	21.1	11.2	0.0	613.5
1967/68	0.0	9.7	7.1	54.4	61.2	43.2	56.4	106.4	8.4	36.3	8.4	0.0	391.5
1968/69	0.0	0.0	0.0	8.9	72.1	214.1	254.5	56.6	282.4	84.3	0.0	0.0	972.9
1969/70	0.0	0.0	0.3	51.6	64.3	252.2	40.9	30.2	0.5	45.0	0.0	0.0	485.0
1970/71	0.0	0.0	0.8	24.6	195.8	54.4	126.0	95.3	47.0	17.5	2.8	0.0	564.2
1971/72	0.0	0.0	4.6	21.5	197.0	109.5	390.6	277.9	101.2	41.6	2.5	0.0	1146.4
1972/73	0.0	0.0	6.5	19.4	25.1	69.3	142.7	85.3	39.4	0.0	1.0	0.0	388.7
1973/74	0.0	0.0	1.8	67.5	141.6	267.6	309.4	190.7	122.7	3.5	13.8	0.0	1118.6
1974/75	5.9	0.0	1.5	8.5	153.9	319.2	109.6	121.7	60.5	73.8	1.4	0.0	856.0
1975/76	0.0	0.0	1.0	9.6	29.7	207.0	265.5	180.2	141.6	47.2	34.2	18.5	934.5
1976/77	0.0	0.0	2.9	83.1	78.0	152.9	97.6	211.7	208.5	0.0	0.0	0.0	834.7
1977/78	0.0	0.3	21.8	0.0	63.3	313.1	299.2	178.2	137.5	82.2	57.0	2.7	1155.3
1978/79	0.1	0.0	58.5	48.1	203.0	129.7	120.9	44.9	1.9	0.0	0.0	0.0	607.1
1979/80	0.0	12.9	0.0	68.7	90.6	351.1	77.0	107.7	68.9	21.5	0.0	0.0	798.4
1980/81	0.0	0.0	11.6	76.9	154.3	218.4	147.2	326.2	72.3	48.4	0.0	0.0	1055.3
1981/82	0.0	0.1	1.0	20.8	113.7	57.6	108.7	114.6	5.6	26.0	0.0	0.0	448.1
1982/83	2.0	0.0	5.9	71.8	79.0	78.4	133.4	49.6	26.4	8.7	12.6	0.0	467.8
1983/84	3.0	0.0	0.0	40.7	25.7	194.7	49.9	80.6	186.7	9.0	8.5	0.0	598.8
1984/85	0.0	0.0	1.5	36.4	62.7	231.3	357.9	177.3	74.5	3.5	8.5	0.0	951.6
1985/86	0.0	0.0	1.0	9.5	51.8	327.9	231.0	110.6	51.5	96.3	0.0	0.0	879.6
1986/87	0.0	0.0	3.3	31.4	75.7	213.6	85.7	61.4	53.6	0.0	0.0	0.0	525.7
1987/88	0.0	0.0	1.0	34.4	37.0	132.7	205.5	247.5	204.0	35.1	0.0	26.7	923.9
1988/89	0.1	0.0	48.9	67.3	106.9	181.4	209.6	40.0	11.7	4.5	0.0	0.0	670.4
1989/90	0.0	5.6	0.0	56.7	93.5	52.7	387.4	195.0	39.2	68.4	0.0	0.9	899.4
1990/91	0.0	0.0	0.0	9.5	63.1	107.6	202.8	103.5	178.6	2.9	0.0	0.0	668.0
1991/92	0.0	0.0	0.0	78.8	55.2	211.3	100.7	3.5	125.9	16.5	0.0	0.0	591.9
1992/93	0.0	0.0	0.0	3.2	69.9	125.9	128.4	215.6	56.3	33.3	1.8	0.0	634.4
1993/94	0.1	0.0	2.1	5.4	115.1	87.8	159.8	52.8	9.7	1.0	1.5	0.0	435.3
Mean	0.4	1.3	7.1	34.6	90.5	165.5	176.4	135.5	80.1	28.6	5.6	1.6	727.2
1st decade	0.0	2.1	5.0	27.6	99.2	127.2	181.5	144.1	68.9	28.1	4.4	0.0	718.2
2nd decade	1.1	1.3	10.4	42.8	99.1	202.2	140.9	141.5	91.0	31.7	11.4	2.1	785.2
3rd decade	0.0	0.6	5.8	33.3	73.2	167.2	206.9	120.7	80.5	26.0	1.2	2.8	718.0

Table D-4 MONTHLY AND ANNUAL RAINFALL AT MAROWA

(Unit: mm/Month)

YEAR	July	Aug.	Set.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
1964/65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965/66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1966/67	0.0	0.0	0.0	0.0	0.0	0.0	169.4	195.3	104.4	31.0	32.3	0.0	532.4
1967/68	0.0	0.0	0.0	46.2	40.9	98.6	75.9	118.6	90.4	21.6	36.1	0.0	528.3
1968/69	0.0	0.0	0.0	0.0	111.8	204.0	226.1	68.6	276.1	7.4	0.0	0.0	894.0
1969/70	0.0	0.0	0.0	43.9	36.1	365.5	65.5	57.7	11.2	37.6	0.0	0.0	617.5
1970/71	0.0	0.0	9.9	42.9	154.2	157.2	221.5	133.6	1.5	5.3	0.0	0.0	726.1
1971/72	0.0	0.0	3.8	29.8	89.2	89.2	286.8	102.3	133.5	37.2	0.0	0.0	771.8
1972/73	0.4	0.0	0.3	38.0	42.0	40.7	105.8	113.0	58.0	12.0	0.0	0.0	410.2
1973/74	0.0	0.0	3.0	19.3	68.7	271.5	288.2	274.0	185.3	50.8	6.0	0.0	1166.8
1974/75	7.5	15.5	0.0	11.5	239.2	258.2	96.1	233.8	6.8	32.0	0.0	0.0	900.6
1975/76	0.0	0.0	0.0	16.0	74.0	221.5	188.5	80.6	247.6	46.0	4.0	0.0	878.2
1976/77	0.0	0.0	0.6	33.3	122.1	149.7	82.2	241.1	189.6	5.0	0.0	0.0	823.6
1977/78	0.0	0.0	26.5	0.0	79.6	169.0	256.1	278.7	208.4	27.2	1.4	1.3	1048.2
1978/79	7.0	0.0	55.1	23.5	215.0	147.5	157.0	87.5	0.0	0.0	0.0	0.0	742.6
1979/80	9.0	0.0	0.0	55.1	117.3	378.8	13.0	160.1	128.7	0.0	0.0	0.0	862.0
1980/81	0.0	0.0	10.5	17.8	119.2	149.0	140.6	375.8	108.3	0.0	0.0	0.0	921.2
1981/82	0.0	0.0	0.0	6.0	88.0	23.0	195.3	97.5	5.2	26.6	14.5	0.0	456.1
1982/83	***	***	***	29.0	13.3	15.0	44.8	69.5	47.0	4.3	1.5	0.0	224.4
1983/84	0.0	0.0	0.0	2.4	3.6	171.0	154.0	204.0	147.3	15.0	0.0	0.0	697.3
1984/85	0.0	0.0	0.0	22.0	107.0	135.5	306.0	191.4	73.5	0.0	0.0	0.0	745.4
1985/86	0.0	0.0	0.0	0.0	33.8	297.0	77.5	201.0	92.2	121.0	0.0	0.0	822.5
1986/87	0.0	0.0	0.0	67.8	9.0	112.0	112.0	53.5	102.0	0.0	0.0	0.0	456.3
1987/88	0.0	0.0	0.0	26.7	25.1	161.0	120.0	129.0	105.0	0.0	0.0	32.0	598.8
1988/89	0.0	0.0	0.0	31.5	12.4	47.3	257.0	289.5	59.0	27.5	0.0	0.0	724.2
1989/90	0.0	0.0	0.0	1.1	30.4	96.5	187.5	201.5	30.0	34.0	0.0	0.0	581.0
1990/91	0.0	0.0	0.0	20.0	31.5	142.0	115.5	116.0	137.5	0.0	0.0	0.0	562.5
1991/92	0.0	0.0	0.0	58.0	56.5	108.0	65.0	78.5	178.5	3.5	0.0	0.0	548.0
1992/93	0.0	0.0	0.0	0.0	37.0	144.5	118.5	302.5	141.5	51.5	0.0	0.0	795.5
1993/94	0.0	0.0	10.0	5.0	104.5	91.5	197.0	99.0	4.0	0.0	0.0	0.0	511.0
Mean	0.8	0.5	4.0	23.2	68.7	149.5	144.1	148.8	95.8	19.9	3.2	1.1	651.6
1st decade	0.1	0.0	2.1	27.5	67.9	153.3	179.9	132.9	107.6	25.4	9.3	0.0	818.5
2nd decade	2.4	1.6	9.3	24.5	107.1	168.3	132.8	182.9	108.9	15.6	2.1	0.1	739.9
3rd decade	0.0	0.0	1.0	23.2	44.7	133.5	155.6	157.2	92.3	23.8	0.0	3.2	634.5

Table D-5 MONTHLY RAINFALL SUMMARY AT NGWENYA

(Unit: mm/Month)

YEAR	July	Aug.	Set.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
1964/65	***	***	***	6.4	27.9	201.2	191.3	44.7	10.4	0.0	0.0	0.0	481.9
1965/66	0.0	0.0	0.0	3.0	16.3	39.4	111.8	243.1	235.7	20.8	25.9	8.1	674.1
1966/67	0.0	0.0	0.0	0.0	20.8	121.4	293.1	247.9	135.9	17.8	31.8	0.0	838.7
1967/68	0.0	23.4	0.0	23.4	29.7	50.8	124.7	125.2	11.2	27.9	32.5	0.0	448.8
1968/69	0.0	0.0	0.0	0.0	91.7	309.9	111.8	48.5	376.4	13.7	0.0	0.0	952.0
1969/70	0.0	0.0	0.0	85.1	75.2	223.3	17.8	76.5	5.1	88.4	0.0	0.0	571.4
1970/71	0.0	0.0	1.3	18.5	151.6	129.8	163.1	41.9	23.1	20.3	0.0	0.0	549.6
1971/72	0.0	0.0	0.0	9.2	170.1	39.4	322.7	27.2	91.2	78.0	0.0	0.0	737.8
1972/73	0.0	0.0	0.0	0.0	66.0	35.5	125.4	65.7	30.3	0.7	0.0	0.0	323.6
1973/74	0.0	0.0	0.0	33.3	74.9	369.3	342.2	358.9	115.6	32.5	13.7	0.0	1340.4
1974/75	8.0	0.0	0.0	7.6	106.6	273.0	154.1	189.8	35.8	0.0	0.0	0.0	774.9
1975/76	0.0	0.0	0.0	9.1	32.0	147.7	210.6	235.5	263.1	81.2	2.7	0.0	981.9
1976/77	0.0	0.0	15.2	14.5	34.8	99.9	213.4	376.1	139.6	0.0	0.0	0.0	893.5
1977/78	0.0	0.0	7.5	7.5	67.9	241.0	213.9	193.1	163.5	29.1	1.0	0.0	924.5
1978/79	0.0	0.0	0.0	43.8	34.2	109.7	63.9	106.9	***	0.0	0.0	0.0	358.5
1979/80	0.0	0.0	***	42.0	35.5	34.0	48.0	175.3	87.2	3.6	0.0	0.0	425.6
1980/81	0.0	0.0	0.0	19.1	83.7	94.7	159.9	364.7	103.0	0.0	0.0	0.0	825.1
1981/82	0.0	0.0	0.0	0.0	59.4	25.5	163.8	79.7	25.5	14.0	15.0	0.0	382.9
1982/83	0.0	0.0	17.0	62.5	51.0	48.0	145.8	50.5	23.0	28.0	0.0	0.0	425.8
1983/84	0.0	0.0	0.0	9.0	22.9	198.0	185.0	192.5	58.6	8.8	0.0	0.0	674.8
1984/85	0.0	0.0	0.0	14.7	8.5	103.6	321.7	73.7	29.0	0.0	3.3	0.0	554.5
1985/86	0.0	0.0	0.0	0.0	8.5	246.1	133.0	114.4	44.0	124.5	0.0	0.0	670.5
1986/87	0.0	0.0	0.0	22.4	13.0	295.0	48.3	81.4	0.0	0.0	0.0	0.0	460.1
1987/88	0.0	0.0	0.0	15.8	***	157.3	129.3	274.6	206.0	22.0	0.0	28.2	833.2
1988/89	1.1	0.0	0.0	0.0	25.8	40.5	236.7	336.2	109.9	3.8	0.0	0.0	754.0
1989/90	0.0	0.0	0.0	0.0	66.9	78.5	266.5	151.3	6.5	26.6	0.0	0.0	596.3
1990/91	0.0	0.0	0.0	0.0	22.0	174.3	180.3	47.4	146.5	0.0	0.0	0.0	570.5
1991/92	0.0	0.0	2.2	51.4	78.6	137.8	102.4	4.5	69.5	1.5	0.0	0.0	447.9
1992/93	0.0	0.0	0.0	4.1	29.4	104.9	113.4	209.5	15.0	25.5	0.0	0.0	501.8
1993/94	0.0	0.0	9.9	0.0	260.8	116.6	111.4	35.1	31.8	0.0	0.0	0.0	565.6
Mean	0.3	0.8	1.8	16.7	58.9	141.5	166.8	150.4	86.4	22.3	4.2	1.2	651.3
1st decade	0.0	2.3	0.1	17.9	72.4	152.0	180.4	122.0	103.5	30.0	10.4	0.8	721.1
2nd decade	0.8	0.0	4.0	21.5	52.8	127.2	155.8	196.4	89.9	16.5	1.9	0.0	644.7
3rd decade	0.1	0.0	1.2	10.8	51.4	145.5	164.3	132.8	65.8	20.4	0.3	2.8	595.4

Table D-6 MONTHLY AND ANNUAL RIVER FLOW AT C 8

RECORDER STATION - UMNIATI POWER STATION WEIR

ZONE REF. NO - C8 CATCHMENT AREA 5890.00 SQ.KM.

(unit : cu.m/sec)

MONTH/ YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
1964/65	0.000	0.218	22.700	41.600	3.090	1.930	0.142	0.000	0.000	0.084	0.091	0.005	5.822
1965/66	0.000	0.202	0.536	0.328	61.800	23.700	1.300	0.284	0.213	0.000	0.000	0.000	7.364
1966/67	***	***	***	***	***	***	***	***	***	***	***	***	***
1967/68	***	***	***	***	***	***	***	***	***	***	***	***	***
1968/69	0.000	0.299	8.870	32.100	9.730	105.000	***	***	***	***	***	***	***
1969/70	0.334	2.410	52.800	11.200	1.590	0.165	0.082	0.154	0.006	0.000	0.000	0.000	5.728
1970/71	0.000	2.780	6.250	17.400	0.924	0.181	0.274	0.065	0.000	0.000	0.000	0.000	2.323
1971/72	0.000	0.531	0.193	37.700	158.000	10.900	12.700	0.392	0.017	0.000	0.000	0.000	18.369
1972/73	0.000	0.000	0.000	0.669	0.629	1.070	0.000	0.000	0.000	0.000	0.000	0.000	0.197
1973/74	***	***	***	***	***	***	***	***	***	***	***	***	***
1974/75	0.143	1.050	69.100	34.700	41.400	7.280	1.130	0.173	0.010	0.000	0.000	0.000	12.916
1975/76	0.000	0.000	1.480	2.190	12.700	62.200	19.800	2.170	0.529	0.114	0.012	0.000	8.433
1976/77	0.007	0.103	2.160	1.200	80.900	177.000	6.830	1.060	0.327	0.078	0.043	0.004	22.476
1977/78	***	***	***	***	***	***	***	***	***	***	***	***	***
1978/79	***	***	***	***	***	***	***	***	***	***	***	***	***
1979/80	0.026	1.280	40.000	4.370	20.400	10.900	0.559	0.013	0.017	0.011	0.008	0.002	6.466
1980/81	0.059	1.720	12.400	77.800	328.000	68.100	10.200	3.190	0.853	0.408	0.113	0.020	41.905
1981/82	0.095	3.200	3.340	9.720	2.820	0.280	0.019	0.007	0.011	0.011	0.011	0.006	1.627
1982/83	0.014	0.019	0.028	0.330	1.010	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.117
1983/84	0.000	0.087	5.330	0.430	1.970	0.229	0.070	0.000	0.000	0.000	0.000	0.000	0.676
1984/85	***	***	***	***	***	***	***	***	***	***	***	***	***
1985/86	***	***	***	***	***	***	***	***	***	***	***	***	***
1986/87	***	***	***	***	***	***	***	***	***	***	***	***	***
1987/88	54.800	62.900	70.800	121.000	0.000	34.400	3.550	0.362	0.020	0.009	0.001	0.000	28.987
1988/89	0.030	0.077	2.000	3.650	46.600	5.900	0.359	0.003	0.853	0.135	0.011	0.052	4.973
1989/90	0.002	3.170	0.262	51.100	79.300	1.590	2.070	0.866	0.159	0.016	0.036	0.019	11.549
1990/91	0.011	0.321	0.033	2.350	13.700	12.200	0.153	0.000	0.000	0.003	0.004	0.002	2.398
1991/92	0.000	0.000	0.008	1.750	0.567	0.135	0.031	0.000	0.000	0.000	0.000	0.000	0.208
1992/93	0.000	1.550	16.800	19.500	26.200	3.070	1.180	0.061	0.373	0.155	0.103	0.004	5.750
1993/94	0.000	0.000	1.150	7.240	2.740	0.028	0.004	0.000	0.000	0.009	0.006	0.000	0.931
MEAN	2.524	3.724	14.375	21.742	40.640	23.921	2.879	0.419	0.161	0.049	0.021	0.005	9.205
1964-73	0.048	0.920	13.050	20.142	33.680	20.421	2.416	0.149	0.039	0.014	0.015	0.001	7.575
1974 83	0.043	0.932	16.730	16.343	61.150	40.749	4.826	0.827	0.218	0.078	0.023	0.004	11.827
1984/93	7.835	9.717	13.008	29.513	24.158	8.189	1.050	0.185	0.201	0.047	0.023	0.011	7.828

Table D-7 MONTHLY AND ANNUAL RIVER FLOW AT C 9

RECORDER STATION - KWEKWE CACTUS PORT DAM D/S

ZONE REF. NO - C9 CATCHMENT AREA 1250.00 SQ.KM. (unit : cu m/sec)

MONTH/ YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
1964/65	***	***	***	***	***	***	***	***	***	***	***	***	***
1965/66	***	***	***	***	***	***	***	***	***	***	***	***	***
1966/67	***	***	***	***	***	***	***	***	***	***	***	***	***
1967/68	***	***	***	***	***	***	***	***	***	***	***	***	***
1968/69	0.000	0.000	0.000	0.391	0.098	2.510	1.920	0.151	0.007	0.000	0.012	0.025	0.426
1969/70	***	***	***	***	***	***	***	***	***	***	***	***	***
1970/71	0.000	0.000	0.006	1.540	0.027	0.039	0.062	0.000	0.000	0.000	0.000	0.000	0.140
1971/72	***	***	***	***	***	***	***	***	***	***	***	***	***
1972/73	***	***	***	***	***	***	***	***	***	***	***	***	***
1973/74	0.000	0.000	18.800	31.400	30.900	7.620	0.000	0.000	0.000	0.000	0.000	0.000	7.393
1974/75	***	***	***	***	***	***	***	***	***	***	***	***	***
1975/76	***	***	***	***	***	***	***	***	***	***	***	***	***
1976/77	***	***	***	***	***	***	***	***	***	***	***	***	***
1977/78	***	***	***	***	***	***	***	***	***	***	***	***	***
1978/79	***	***	***	***	***	***	***	***	***	***	***	***	***
1979/80	0.000	0.000	9.200	6.100	9.910	4.900	0.229	0.095	0.073	0.054	0.081	0.061	2.559
1980/81	0.025	0.036	0.891	14.000	33.700	8.510	1.040	0.394	0.076	0.076	0.062	0.002	4.901
1981/82	0.000	1.230	0.563	0.052	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.154
1982/83	***	***	***	***	***	***	***	***	***	***	***	***	***
1983/84	0.000	0.000	0.000	0.001	0.442	0.002	0.006	0.000	0.000	0.000	0.000	0.000	0.038
1984/85	0.000	0.000	0.033	7.390	31.400	0.507	0.000	0.000	0.000	0.000	0.000	0.000	3.278
1985/86	0.000	0.000	0.013	1.440	0.151	0.009	0.165	0.005	0.000	0.000	0.000	0.000	0.149
1986/87	0.000	0.000	0.000	6.440	14.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.728
1987/88	0.000	0.000	0.105	0.451	8.950	6.080	1.130	0.038	0.000	0.000	0.103	0.886	1.479
1988/89	0.000	0.000	0.000	0.000	0.416	1.430	0.179	0.002	0.000	0.000	0.000	0.000	0.169
1989/90	0.000	0.000	0.000	1.750	4.550	0.421	0.704	0.105	0.000	0.000	0.000	0.000	0.628
1990/91	***	***	***	***	***	***	***	***	***	***	***	***	***
1991/92	***	***	***	***	***	***	***	***	***	***	***	***	***
1992/93	***	***	***	***	***	***	***	***	***	***	***	***	***
1993/94	***	***	***	***	***	***	***	***	***	***	***	***	***
MEAN	0.002	0.000	2.115	5.068	9.632	2.288	0.388	0.056	0.011	0.009	0.018	0.070	1.646
1964-73	0.000	0.000	6.269	11.110	10.342	3.390	0.661	0.050	0.002	0.000	0.004	0.008	2.653
1974-83	0.006	0.317	2.664	5.038	11.013	3.353	0.319	0.122	0.037	0.033	0.036	0.016	1.913
1984/93	0.000	0.000	0.022	2.496	8.538	1.207	0.311	0.021	0.000	0.000	0.015	0.127	1.061

Table D-8 MONTHLY AND ANNUAL RIVER FLOW AT C 18

RECORDER STATION - MUNYATI DYKE G/W

ZONE REF. NO - C18 CATCHMENT AREA 2631.00 SQ.KM. (unit : cu.m/sec)

MONTH/ YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
1964/65	0.022	0.022	9.900	18.200	1.580	0.338	0.058	0.026	0.026	0.026	0.019	0.019	2.520
1965/66	0.010	0.136	0.710	0.098	97.600	12.700	1.150	0.469	0.188	0.071	0.021	0.013	9.431
1966/67	0.012	0.017	1.500	25.800	7.490	3.730	0.434	0.102	0.032	0.023	0.019	0.019	3.265
1967/68	0.017	0.018	0.231	0.103	0.790	0.056	0.013	0.005	0.009	0.017	0.017	0.011	0.107
1968/69	0.006	0.020	8.720	16.400	6.280	58.500	10.300	1.400	0.565	0.273	0.137	0.041	8.554
1969/70	0.272	0.912	73.800	5.080	0.650	0.151	0.063	0.032	0.026	0.026	0.026	0.024	6.755
1970/71	0.026	1.680	3.900	10.100	1.010	0.113	0.030	0.022	0.026	0.017	0.017	0.010	1.413
1971/72	0.005	0.055	0.340	***	11.200	9.800	7.780	2.850	0.502	0.266	0.106	0.029	2.744
1972/73	0.021	0.017	0.014	0.451	0.192	0.279	0.011	0.007	0.006	0.006	0.008	0.005	0.085
1973/74	0.007	16.200	98.600	40.000	59.100	25.400	3.730	1.630	0.474	0.490	0.185	0.062	20.490
1974/75	0.115	3.450	49.900	19.200	24.900	3.590	2.050	0.565	0.290	0.204	0.102	0.053	8.702
1975/76	0.022	0.015	1.010	1.700	7.570	25.700	8.300	1.670	0.734	0.418	0.180	0.065	3.949
1976/77	0.059	0.846	5.650	2.080	60.900	109.000	5.170	1.700	0.859	0.620	0.423	0.191	15.625
1977/78	0.131	0.036	44.800	102.000	60.400	62.400	20.900	3.610	2.130	1.290	0.676	0.392	24.897
1978/79	1.470	4.600	34.700	24.100	2.650	4.560	0.734	0.190	0.145	0.114	0.086	0.032	6.115
1979/80	0.010	2.680	26.800	4.880	6.370	7.680	1.050	0.172	0.069	0.071	0.051	0.044	4.156
1980/81	0.122	0.856	11.400	62.700	235.000	43.900	5.170	2.090	1.100	0.745	0.520	0.313	30.326
1981/82	0.667	3.520	1.020	4.500	0.690	0.309	0.018	0.009	0.007	0.013	0.009	0.006	0.847
1982/83	0.245	0.033	0.009	0.004	0.089	0.004	0.002	0.002	0.009	0.009	0.009	0.009	0.035
1983/84	0.004	1.010	6.710	0.276	1.940	0.765	0.226	0.005	0.003	0.003	0.003	0.000	0.912
1984/85	0.000	0.000	3.360	37.600	68.700	3.620	0.430	0.093	0.028	0.017	0.010	0.002	9.488
1985/86	0.030	0.005	7.210	35.900	12.200	10.500	7.470	0.892	0.363	0.211	0.078	0.020	6.240
1986/87	0.014	0.029	10.400	1.800	1.460	0.041	0.019	0.012	0.009	0.009	0.009	0.009	1.151
1987/88	0.023	0.007	2.610	3.350	19.100	22.000	0.775	0.348	0.072	0.081	0.023	0.005	4.033
1988/89	***	***	0.212	0.031	11.900	6.800	1.180	0.062	0.017	0.026	0.018	0.003	1.687
1989/90	0.000	0.078	0.479	29.100	51.600	2.860	1.310	0.643	0.172	0.060	0.023	0.019	7.195
1990/91	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991/92	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992/93	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993/94	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MEAN	0.090	1.208	13.466	14.848	25.045	13.827	2.612	0.620	0.262	0.170	0.093	0.047	6.024
1964-73	0.049	1.908	19.772	11.623	18.589	11.107	2.357	0.654	0.185	0.122	0.056	0.023	5.536
1974-83	0.225	1.705	18.200	22.144	40.051	25.791	4.362	1.001	0.535	0.349	0.206	0.111	9.556
1984/93	0.007	0.012	2.427	10.778	16.496	4.582	1.118	0.205	0.066	0.040	0.016	0.006	2.979

Table D-9 MONTHLY AND ANNUAL RIVER FLOW AT C 20

RECORDER STATION - NGESI RHODESDALE

ZONE REF. NO - C20 CATCHMENT AREA 1820.00 SQ.KM. (unit : cu.m/sec)

MONTH/ YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
1964/65	***	***	***	***	***	***	***	***	***	***	***	***	***
1965/66	***	***	***	***	***	***	***	***	***	***	***	***	***
1966/67	***	***	***	***	***	***	***	***	***	***	***	***	***
1967/68	***	***	***	***	***	***	***	***	***	***	***	***	***
1968/69	***	***	***	***	***	***	***	***	***	***	***	***	***
1969/70	***	***	***	***	***	***	***	***	***	***	***	***	***
1970/71	0.342	0.045	0.000	0.000	0.000	0.000	0.000	0.049	0.432	0.411	0.411	0.533	0.185
1971/72	0.499	0.344	0.372	***	***	***	***	***	0.233	0.141	0.112	1.020	0.227
1972/73	0.508	0.378	0.141	0.000	0.000	0.000	0.000	0.036	0.662	0.664	0.619	0.606	0.301
1973/74	0.695	0.899	2.120	18.700	***	***	***	***	***	***	***	***	***
1974/75	1.830	0.643	2.760	2.650	2.160	2.450	2.570	1.290	0.265	0.163	0.322	0.645	1.479
1975/76	***	***	***	***	***	***	***	***	***	***	***	***	***
1976/77	***	***	***	***	***	***	***	***	***	***	***	***	***
1977/78	0.126	0.917	10.600	45.600	38.900	22.400	15.200	2.990	1.860	1.200	0.750	0.385	11.744
1978/79	1.850	1.530	20.800	5.940	0.778	0.687	0.215	0.104	0.113	0.101	0.557	0.594	2.772
1979/80	0.625	0.809	***	2.540	4.990	3.720	0.447	0.242	0.740	0.507	0.427	0.441	1.291
1980/81	0.418	0.535	1.400	1.750	6.370	9.270	2.480	2.240	1.070	0.916	0.627	0.516	2.299
1981/82	1.100	0.933	0.846	1.510	0.971	0.662	0.548	0.573	0.573	0.543	0.519	0.467	0.770
1982/83	0.555	0.523	0.565	0.651	1.140	0.120	0.090	0.452	0.463	0.292	0.279	0.242	0.448
1983/84	0.039	0.036	0.115	0.033	0.087	0.105	0.034	0.006	0.004	0.006	0.004	0.000	0.039
1984/85	0.000	0.000	0.235	10.300	27.500	1.170	0.244	0.115	1.450	0.750	0.704	0.697	3.597
1985/86	0.632	0.618	3.070	13.800	5.940	2.480	1.490	0.482	0.238	0.126	0.223	0.568	2.472
1986/87	0.266	0.220	0.404	0.252	0.266	0.444	0.098	0.850	0.818	0.818	0.627	0.516	0.465
1987/88	0.844	0.747	0.755	0.305	3.540	6.920	0.557	0.247	0.432	***	***	0.565	1.243
1988/89	0.550	0.583	0.829	0.623	14.000	0.268	0.075	0.138	0.595	0.684	0.577	0.530	1.621
1989/90	0.564	0.501	0.555	1.590	14.400	0.689	0.973	0.829	0.841	0.806	0.783	0.727	1.938
1990/91	0.667	0.625	0.559	0.701	1.090	1.110	0.109	0.266	0.399	0.447	0.719	0.145	0.570
1991/92	***	***	***	***	***	***	***	***	***	***	***	***	***
1992/93	***	***	***	***	***	***	***	***	***	***	***	***	***
1993/94	***	***	***	***	***	***	***	***	***	***	***	***	***
MEAN	0.404	0.363	1.538	3.565	4.071	1.750	0.838	0.364	0.373	0.286	0.275	0.307	1.115
1964-73	0.204	0.167	0.263	1.870	0.000	0.000	0.000	0.009	0.133	0.122	0.114	0.216	0.071
1974-83	0.654	0.593	3.709	6.067	5.540	3.941	2.158	0.790	0.509	0.373	0.349	0.329	2.084
1984/93	0.352	0.329	0.641	2.757	6.674	1.308	0.355	0.293	0.477	0.363	0.363	0.375	1.191

Table D-10 MONTHLY AND ANNUAL RIVER FLOW AT C 29

RECORDER STATION - DUTCHMAN'S POOL DAM

ZONE REF. NO - C29 CATCHMENT AREA 4170.00 SQ.KM. (unit : cu.m/sec)

MONTH/ YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
1964/65	***	***	***	***	***	***	***	***	***	***	***	***	***
1965/66	***	***	***	***	***	***	***	***	***	***	***	***	***
1966/67	***	***	***	***	***	***	***	***	***	***	***	***	***
1967/68	***	***	***	***	***	***	***	***	***	***	***	***	***
1968/69	***	***	***	***	***	***	***	***	***	***	***	***	***
1969/70	***	***	***	***	***	***	***	***	***	***	***	***	***
1970/71	***	***	***	***	***	***	***	***	***	***	***	***	***
1971/72	***	***	***	***	***	***	***	***	***	***	***	***	***
1972/73	***	***	***	***	***	***	***	***	***	***	***	***	***
1973/74	***	***	***	***	***	***	***	***	***	***	***	***	***
1974/75	***	***	***	***	***	***	***	***	***	***	***	***	***
1975/76	***	***	***	***	***	***	***	***	***	***	***	***	***
1976/77	***	***	***	***	***	***	***	***	***	***	***	***	***
1977/78	0.417	0.000	46.700	202.000	97.800	142.000	49.300	11.300	7.140	3.730	1.510	0.011	46.826
1978/79	1.100	6.790	78.200	26.600	4.700	8.760	***	***	***	***	***	***	10.513
1979/80	0.000	0.000	0.000	0.000	0.896	1.530	1.170	2.380	1.500	1.830	0.345	0.004	0.805
1980/81	0.458	2.700	5.470	52.400	210.000	52.100	8.750	5.520	2.250	0.060	0.000	0.000	28.309
1981/82	0.000	1.450	1.080	0.512	0.772	1.410	0.668	0.000	0.000	0.000	0.000	0.000	0.491
1982/83	0.805	0.000	0.000	0.037	3.820	0.347	0.078	0.000	0.000	0.000	0.000	0.000	0.424
1983/84	0.000	0.000	2.590	0.135	9.180	0.519	0.019	0.000	0.000	0.000	0.000	0.000	1.037
1984/85	0.000	0.000	4.250	33.700	84.300	15.800	5.470	0.029	0.000	0.000	0.000	0.000	11.962
1985/86	0.000	0.000	18.700	67.600	8.560	1.950	7.900	1.010	0.732	0.403	0.250	0.890	9.000
1986/87	0.178	0.000	4.370	1.690	0.000	0.000	0.394	0.578	0.700	0.000	0.000	0.000	0.659
1987/88	2.460	0.810	3.530	17.800	12.700	7.960	0.624	0.000	0.494	1.560	0.000	0.000	3.995
1988/89	0.000	0.000	1.350	0.063	12.500	2.150	0.000	0.000	0.000	0.000	0.000	0.000	1.339
1989/90	0.000	0.886	2.230	1.980	26.000	0.165	0.000	0.000	0.000	0.000	0.000	0.000	2.605
1990/91	***	***	***	***	***	***	***	***	***	***	***	***	***
1991/92	***	***	***	***	***	***	***	***	***	***	***	***	***
1992/93	***	***	***	***	***	***	***	***	***	***	***	***	***
1993/94	***	***	***	***	***	***	***	***	***	***	***	***	***
MEAN	0.417	0.972	12.959	31.117	36.248	18.053	5.721	1.601	0.986	0.583	0.162	0.070	9.074
1964-73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1974-83	0.397	1.563	19.149	40.241	46.738	29.524	8.569	2.743	1.556	0.803	0.265	0.002	12.629
1984/93	0.440	0.283	5.738	20.472	24.010	4.671	2.398	0.270	0.321	0.327	0.042	0.148	4.927

Table D-11 MONTHLY AND ANNUAL RIVER FLOW AT C 30

RECORDER STATION - UMNIATI RHODESDALE

ZONE REF. NO - C30 CATCHMENT AREA 2780.00 SQ.KM.

(unit : cu.m/sec)

MONTH/ YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
1964/65	***	***	***	***	***	***	***	***	***	***	***	***	***
1965/66	***	***	***	***	***	***	***	***	***	***	***	***	***
1966/67	***	***	***	***	***	***	***	***	***	***	***	***	***
1967/68	***	***	***	***	***	***	***	***	***	***	***	***	***
1968/69	***	***	***	***	***	***	***	***	***	***	***	***	***
1969/70	***	***	***	***	***	***	***	***	***	***	***	***	***
1970/71	***	***	***	***	***	***	***	***	***	***	***	***	***
1971/72	***	***	***	***	***	***	***	***	***	***	***	***	***
1972/73	***	***	***	***	***	***	***	***	***	***	***	***	***
1973/74	***	***	***	***	***	***	***	***	***	***	***	***	***
1974/75	***	***	***	***	***	***	***	***	***	***	***	***	***
1975/76	***	***	***	***	***	***	***	***	***	***	***	***	***
1976/77	***	***	***	***	***	***	***	***	***	***	***	***	***
1977/78	0.218	0.059	20.400	43.300	46.000	27.800	15.800	6.740	4.090	2.410	1.230	0.659	14.059
1978/79	2.650	2.860	3.770	9.330	4.420	3.170	1.330	0.322	0.239	0.205	0.142	0.060	2.375
1979/80	0.043	0.723	***	4.920	5.410	5.300	1.550	0.381	0.140	0.128	0.101	0.062	1.563
1980/81	0.113	1.290	9.840	32.900	68.500	29.900	7.960	4.920	2.160	1.380	0.898	0.562	13.369
1981/82	0.188	3.330	2.160	4.870	3.050	0.613	0.069	0.039	0.032	0.036	0.027	0.009	1.202
1982/83	0.470	0.155	0.031	0.019	0.427	0.037	0.000	0.000	0.000	0.000	0.000	0.000	0.095
1983/84	0.000	1.330	7.190	3.210	2.910	0.733	0.425	0.003	0.000	0.000	0.000	0.000	1.317
1984/85	0.000	0.023	5.040	21.300	42.000	6.360	1.090	0.214	0.077	0.052	0.036	0.010	6.350
1985/86	0.000	0.000	2.930	23.100	12.900	9.110	7.560	2.610	0.848	0.382	0.149	0.036	4.969
1986/87	0.000	0.000	0.000	***	***	***	***	***	***	***	***	***	***
1987/88	5.180	1.210	1.100	1.930	11.600	14.900	1.900	0.809	0.133	0.133	0.024	0.003	3.244
1988/89	0.136	0.161	0.869	0.154	14.500	4.930	0.999	0.133	0.122	0.009	0.014	0.007	1.836
1989/90	0.000	0.338	1.060	15.800	25.700	4.390	3.870	0.903	0.250	0.070	0.023	0.005	4.367
1990/91	0.000	0.000	0.024	0.904	10.200	4.450	0.743	0.046	0.001	0.000	0.000	0.000	1.364
1991/92	0.000	0.000	0.000	1.900	0.387	0.410	0.454	0.005	0.000	0.000	0.000	0.000	0.263
1992/93	0.000	0.000	8.940	12.700	17.800	4.470	1.330	0.217	0.007	0.000	0.000	0.000	3.789
1993/94	***	***	7.610	10.200	***	***	0.004	0.000	0.000	0.000	0.000	0.000	1.485
MEAN	0.300	0.383	2.365	6.218	8.860	3.886	1.503	0.578	0.270	0.160	0.088	0.047	2.055
1964-73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1974-83	0.368	0.975	4.339	9.855	13.072	6.755	2.713	1.241	0.666	0.416	0.240	0.135	3.398
1984/93	0.532	0.173	2.757	8.799	13.509	4.902	1.795	0.494	0.144	0.065	0.025	0.006	2.767

Table D-12 MONTHLY AND ANNUAL RIVER FLOW AT C 36

RECORDER STATION - LOWER ZIVAGWE D/S

ZONE REF. NO - C36 CATCHMENT AREA 4170.00 SQ.KM.

(unit : cu.m/sec)

MONTH/ YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	TOTAL
1964/65	0.072	0.039	4.980	16.100	1.340	0.034	0.077	0.721	0.000	0.000	0.000	0.197	1.963
1965/66	0.000	0.678	0.030	0.002	27.000	8.960	0.242	0.110	0.055	0.055	0.055	0.055	3.104
1966/67	0.230	0.056	3.500	11.100	17.200	3.850	0.015	0.000	0.000	0.000	0.000	1.450	3.117
1967/68	0.980	0.389	0.148	0.032	2.800	0.012	0.078	0.055	0.179	0.890	0.828	0.645	0.586
1968/69	0.859	1.230	0.270	10.700	2.610	65.000	16.800	1.110	0.128	0.043	0.020	0.003	8.231
1969/70	0.000	0.063	41.600	12.700	1.040	0.030	0.014	0.060	0.055	0.675	0.586	0.583	4.784
1970/71	0.611	2.030	2.950	7.140	0.147	0.060	0.072	0.432	0.566	0.751	0.841	1.970	1.464
1971/72	1.070	1.510	0.632	19.900	62.700	13.400	13.400	1.210	1.000	1.140	0.912	1.090	9.830
1972/73	1.060	0.981	0.861	0.956	1.030	0.704	0.604	0.470	0.588	0.692	0.614	0.538	0.758
1973/74	0.405	5.670	86.400	135.000	83.200	92.900	11.600	3.050	0.709	0.794	0.626	0.607	35.080
1974/75	0.417	2.350	68.700	85.800	74.300	21.300	9.010	1.810	0.678	0.711	0.691	0.607	22.198
1975/76	0.353	0.893	0.600	1.160	2.380	46.800	16.400	2.880	0.501	0.489	0.195	0.378	6.086
1976/77	0.439	0.451	2.470	0.861	32.800	105.000	7.710	1.500	0.360	0.368	0.320	0.299	12.715
1977/78	0.299	0.167	43.600	231.000	87.000	134.000	44.900	9.330	4.780	1.890	0.661	0.236	46.489
1978/79	0.543	5.350	56.100	24.900	2.570	4.410	0.330	1.880	0.790	0.703	0.503	0.359	8.203
1979/80	0.975	1.320	11.100	14.200	29.800	15.100	0.920	0.190	0.285	0.305	0.274	0.358	6.236
1980/81	0.145	2.160	5.920	54.600	189.000	63.100	6.300	3.470	0.820	0.483	0.333	0.259	27.216
1981/82	0.220	1.580	2.530	1.660	0.580	0.415	0.104	0.070	0.171	0.209	0.163	0.119	0.652
1982/83	0.246	0.105	0.497	0.540	2.130	0.497	0.098	0.133	0.082	0.137	0.091	0.072	0.378
1983/84	0.153	0.156	1.390	0.464	1.250	0.057	0.074	0.052	0.079	0.086	0.057	0.234	0.338
1984/85	0.444	1.850	0.016	0.000	0.000	3.800	3.460	0.340	0.223	0.129	0.059	0.042	0.864
1985/86	0.026	0.142	8.340	11.200	1.570	1.150	2.070	0.665	0.634	0.174	0.069	0.066	2.176
1986/87	0.071	0.069	2.840	2.290	0.482	0.385	0.002	0.053	0.121	0.647	1.120	1.330	0.784
1987/88	1.510	2.710	3.580	9.200	10.900	12.900	0.585	0.788	0.970	1.070	1.100	1.080	3.866
1988/89	0.977	1.250	1.750	1.090	3.960	1.730	0.782	0.854	0.943	1.070	1.230	1.090	1.394
1989/90	0.995	1.260	2.020	6.920	22.700	1.140	1.010	0.894	1.110	1.140	1.090	1.270	3.462
1990/91	0.821	0.866	0.850	0.190	1.680	6.590	0.960	0.596	0.975	0.929	0.930	1.020	1.367
1991/92	0.735	0.663	0.598	0.206	0.120	0.120	0.116	0.012	0.000	0.000	0.000	0.000	0.214
1992/93	0.014	0.144	4.260	5.520	16.000	0.476	1.210	0.505	1.160	1.250	1.250	0.866	2.721
1993/94	0.937	6.990	1.340	2.940	0.950	0.670	0.265	1.050	1.190	1.250	0.000	0.000	1.465
MEAN	0.520	1.437	11.996	22.279	22.641	20.150	4.640	1.143	0.638	0.603	0.487	0.561	7.258
1964-73	0.529	1.265	14.137	21.363	19.907	18.495	4.290	0.722	0.328	0.504	0.448	0.714	6.892
1974-83	0.379	1.453	19.291	41.519	42.181	39.059	8.585	2.132	0.855	0.538	0.329	0.292	13.051
1984/93	0.653	1.594	2.559	3.956	5.836	2.896	1.046	0.576	0.733	0.766	0.685	0.676	1.831