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SMALL SCALE IRRIGATION
USING COLLECTOR WELLS
PILOT PROJECT - ZIMBABWE

SECOND PROGRESS REPORT

April 1993 - October 1993

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ZIMBABWE

MINISTRY OF LANDS
AGRICULTURE AND
WATER DEVELOPMENT

SUMMARY

The pilot project "Small scale irrigation using collector wells-Zimbabwe" started on the 1st October 1992. This report outlines progress made on all aspects by project staff during the second six months of work.

A review at the time of the first progress report revealed that each site identified, though representing a variety of social structures and administrative boundaries, lay on a single geology type. To provide reliable hydrogeological evaluation for future development, site selection for the pilot project has since concentrated on geologies unrepresented at that time. Good progress has been made. At the time of writing, two sites have been completed, two are nearing completion, a fifth has been proposed, these sites representing a wide range of physical, social, economic and institutional settings:

#1 Muzondidya	5 kraals	124 members	rural	vlei landform	undifferentiated gneiss
#2 Cokota	6 kraals	130 members	public	vlei landform	undifferentiated gneiss
#3 Dekeza School	5 kraals	56 members	public	valley side	undifferentiated gneiss
#4 Nemauka B/C	6 kraals	74 members	public	amphitheatre	younger intrusive granite
#5 Zvidozvevanhu	VIDCO	proposed	rural	flat land	older gneiss complex

Methodology designed during the first six months of work has now been implemented to collect baseline socio-economic data at the first four sites. The formal surveys of thirty households randomly selected reveal a number of aspects likely to influence the success or failure of the project: (i) demand for membership of the community garden will almost certainly exceed supply in terms of water; it will be necessary to compare circumstances of those chosen to be members with those who are not; (ii) the important role of women may have positive or negative net effects depending on balance between extra work created, distribution of benefits, and costs in terms of other activities which may be compromised; (iii) the importance and influence of different institutions and local leaders identified must be understood particularly if the scheme encounters problems which technical solutions do not alleviate; and (iv) priorities for extension include pest/disease control and pump repair/maintenance.

Case studies of four households selected to represent different income groups have also been completed at each of these sites, to record more detailed information on income and expenditure, vegetable consumption, gender divisions, attitudes, institutional issues etc. Analysis of data is ongoing.

In order to test technical and economic viability of collector wells as a method of abstracting water for garden irrigation, a borehole, traditional well, large diameter improved well, and collector well are being constructed at each pilot project site. First comparisons of well design by pump test analysis have now been completed at sites one and two:

#1 Muzondidya:	Traditional Well	0.5 m ³ /day	#2 Cokota:	Traditional Well	6.7 m ³ /day
	Borehole	38.0 m ³ /day		Borehole	23.0 m ³ /day
	Improved Well	7.5 m ³ /day		Improved Well	14.7 m ³ /day
	Collector Well	30.0 m ³ /day		Collector Well	16.5 m ³ /day

While it is premature to make recommendations at this stage, it is clear that further valuable information will be obtained during the next twelve months regarding social and institutional aspects of implementing groundwater based community gardens, the technical and economic viability of alternative well designs, and the value of exploratory drilling in this region to site high yielding wells including perhaps even conventional boreholes. Continued success during both drought and rains at the first collector well garden established in 1991 also bodes well for the future of this approach in the short-term. However, long-term viability of groundwater based garden irrigation must remain uncertain as long as development of this type of project continues in isolation. Long-term viability is inextricably linked to sustainable management of land and water resources at the catchment scale. The magnitude and complexities of the problems to be addressed require a coordinated, holistic programme of work, a multi-disciplinary approach to catchment management. First ideas of how this might be achieved are included in this report.

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1. INTRODUCTION

The pilot project "Small scale irrigation using collector wells - Zimbabwe" contains the following main elements:

- i) selection of suitable sites and the installation of six small irrigation schemes using water from collector wells in south-east Zimbabwe;
- ii) the assembly and collection of adequate baseline data and design of a monitoring system to facilitate the assessment required at iv below;
- iii) the regular collection of data through the monitoring system;
- iv) production of a final integrated report on the scheme's technical, economic, financial, institutional, social and environmental viability, with recommendations for future development.

The main objectives of the project are:

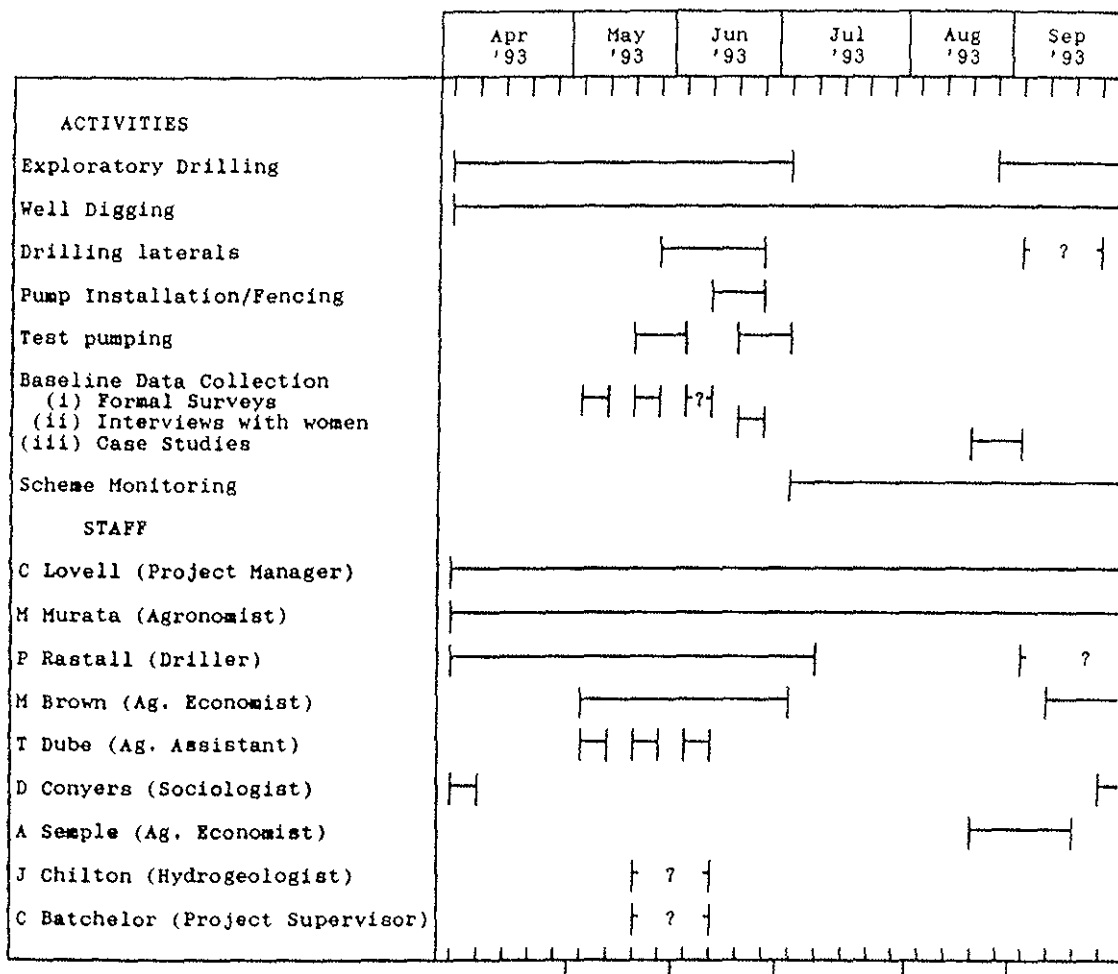
- i) to field test the validity of small scale irrigation and collector well research results obtained at the Lowveld Research Stations (LVRS);
- ii) to identify ways of improving the operation of the schemes, for example by identifying and overcoming constraints;
- iii) to identify a basis for replicating the schemes on a wider scale.

(Ref. Project Data Sheet, BDDSA March 1992)

The project started on the 1st October 1992. This report outlines progress made during the second six months of work, subsequent to that described in the first progress report published in March 1993.

2. WORK COMPLETED DURING SECOND SIX MONTHS

A provisional programme of work for the second six months proposed at the time of the first progress report was:



In the event, good progress has been made on site selection, exploratory drilling, well construction, collection of socio-economic baseline data at four sites, initiation of gardens and the comparison of well performance at two of these.

2.1 Site Selection

At the time of the first progress report, more than fifty potential sites nominated by staff of Agritex and DDF had been visited by project staff. Eight considered to show most promise for the pilot project had been shortlisted (Chindondodza; Cheshato; Muzondidya; Dimbiti; Tadzikunda; Gokota; Makwevera; Muvuyo) and at four, non-suitability (Chindondodza; Cheshato) or suitability (Muzondidya; Gokota) had been determined by exploratory drilling.

2.1.1 Site Selection by Geology

A review at this time revealed that both Muzondidya and Gokota (henceforth referred to as sites #1 and #2 respectively), a third site (Makwevera) at which exploratory drilling was ongoing and subsequently successful nearby, the sites listed above still to be drilled, and even the pilot collector well garden site at Tamwa/Sihambe/Dhobani Kraals in Chivi Communal Area, all lay on a single geology: younger mobile belt gneiss (see Figure 1).

Although an important rock type (and corresponding terrain type) in several communal lands of this area, other formations also exist that would assume equal or greater importance in any future development programme in the region as a whole. In order to provide reliable hydrogeological evaluation, it was therefore decided that further site selection for the pilot project should concentrate on those geologies as yet unrepresented ie. older gneiss complexes, younger intrusive granites, Beitbridge paragneisses and Karoo basalts.

Practical constraints of distance and drilling equipment available to construct and monitor six schemes in a limited time meant that this objective could best be achieved by selecting further sites on a line parallel to the main Buffalo Range - Zaka road, a road near to which sites #1 and #2 were already located and which, further north or south, crosses the first three of the required geologies listed above.

Visits to appropriate areas based on geology were arranged with respective Agritex Extension Workers for the local wards. Three sites were identified for exploratory drilling in this way, and full details are given in Appendix 1. They were:

Chikodza, Ward 7, Zaka District (older gneiss complex)
Nemauka Business Centre, Ward 7, Zaka District (younger intrusive granite)
Zvidozvevanhu Vidco, Ward 19, Zaka District (older gneiss complex)

Visits to the small area of paragneiss within communal land on the southern edge of Zaka District failed to locate a sixth site suitable for the pilot project. The majority of paragneiss in this particular area lies further to the south within commercial ranching land. However, this geology is also found to the east (re. the saline water site at Chindondodza described in the first progress report), to the west (Nyajena Communal Area), as well as in the communal lands of Diti, Chipice, Mtetengwe, Matibi No.1, Sangwe, Maranda and Siyoka, considering the region as a whole. A visit to the relevant part of Nyajena Communal Area (Chikuza School) again revealed saline water to be a very serious problem on this geology, all three boreholes in this area being sour.

At present it is not known if the sixth site for the pilot project should be pursued on paragneiss, or if the abstraction of fresh water from above saline water perhaps possible using the horizontal laterals of a collector well should form the basis of a small, independent R&D-funded project. A concept note outlining this possibility is given in Appendix 2.

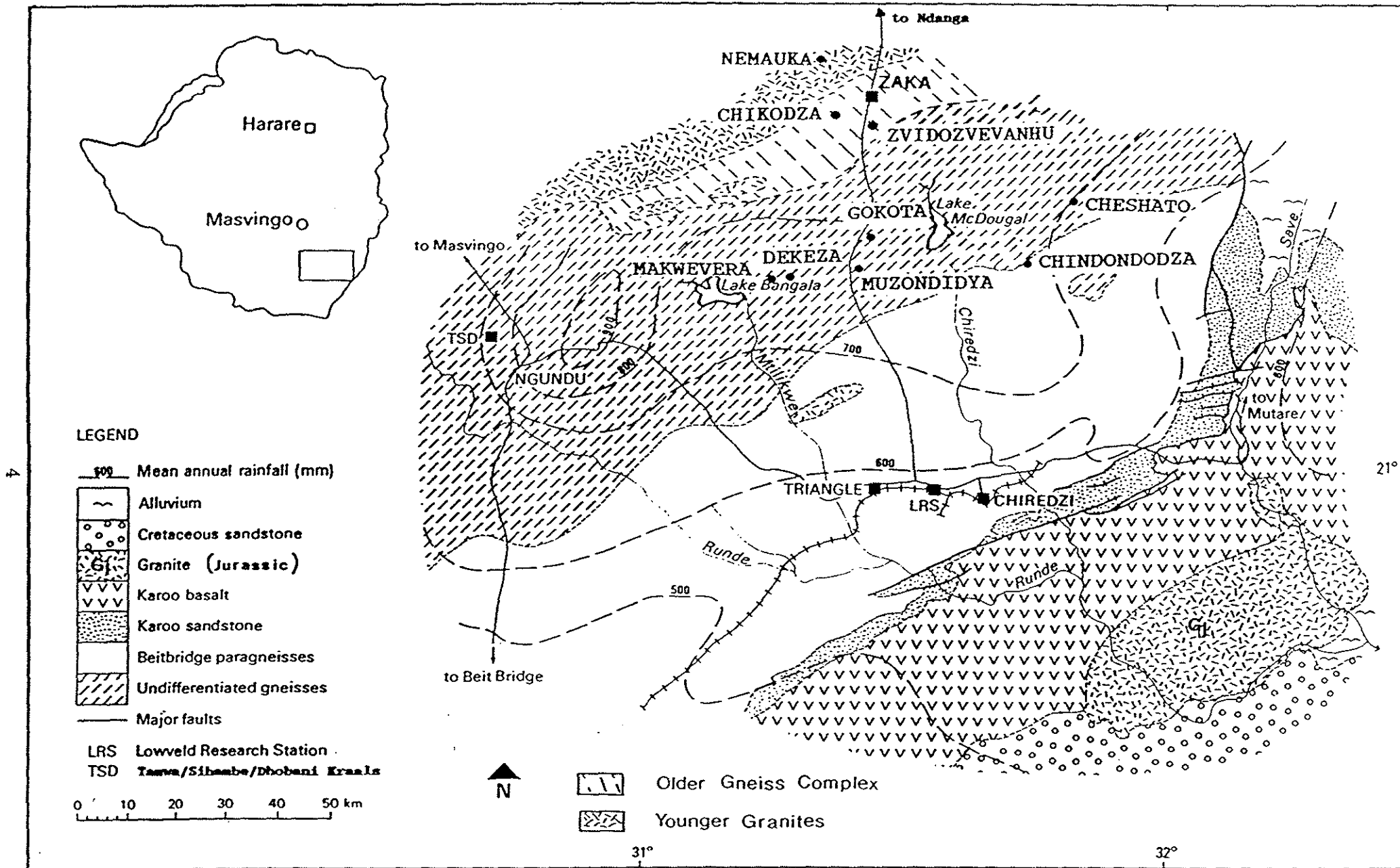


Figure 1 Regional Geology and Location of Sites Investigated (1:100,000)

The final geology to be represented in order to provide reliable hydrogeological evaluation at a regional scale is that of Karoo basalt. In the immediate project area, this is found in the communal lands of Sangwe and Matibi No.2, and in Chizvirizvi Resettlement Area. Plan International, an NGO involved in long-term development programmes in these particular areas, have offered to fund additional schemes on basalt to complement those of the pilot project. It is worrying therefore, that to date, colleagues in the UK have failed to complete the small input required of them to a draft contract delivered in March of this year. If the contract is completed, and Plan International are still able and willing to fund this work, the additional schemes on basalt will be funded in this way. If not, the alternative would be to site the sixth scheme of the pilot project on basalt rather than paragneiss.

2.2 Exploratory Drilling

During the second six months of work, exploratory drilling has been completed at five locations.

2.2.1 Exploratory Drilling at Gokota

At the time of writing the first progress report, exploratory drilling had just proved to be successful at Gokota in ward 33 of Zaka District. A full description of this site was given in Appendix 4 of that report. Briefly, the particular area of interest was identified via existing DDF wells and corresponding hydrogeological records. However, in the event, the successful exploratory hole was not found near to the existing well but in a neighbouring valley to the north, confirming the importance of exploratory drilling to locate high yielding wells where conditions are most favourable. Five holes to 15m were drilled in the vicinity of the existing DDF well, each producing little water and or poor depth of weathering. Four holes were drilled in the valley to the north, each producing a reasonable amount of water and the best (hole 6: RWL 1.0m; EC of 0.34 mS/cm on 7/4/93) was chosen as the site for collector well garden #2.

2.2.2 Exploratory Drilling at Makwevera

A full description of a potential site identified at Makwevera was given in Appendix 5 of the first progress report. Drilling commenced on 10 May. Eight holes were drilled in a relatively large area (4km²) defined by the particular VIDCO. The first seven holes yielded very little water despite promising surface features. A good inflow of water was recorded at 14m in hole 8, but this occurred within extremely hard, fractured rock ideally suited to a borehole. Furthermore, the location also lay close (0.3km) to an existing borehole and community garden. For these reasons, it was decided that the site was unsuitable for the pilot project. To allay the inevitable community disappointment at this decision, it was agreed that the 6" borehole could be completed and equipped at this site at a later date convenient to the project.

2.2.3 Exploratory Drilling at Dekeza School

Information collected during site selection and exploratory drilling at Makwevera confirmed that a second potential site also existed at nearby Dekeza School. Full details of this site are given in Appendix 3. This centre of population and activity on the main dirt road from Chivamba to Zinwana is served by only a single borehole and handpump, which although good is placed under extreme pressure by the demands of approximately 400 families and two existing school gardens. Upon failure to locate a suitable site at Makwevera, the drilling rig was moved to Dekeza School. Only three holes to 15m were needed at this site. The best (hole 2: RWL 7.6m; EC of 0.26 mS/cm on 26/5/93) was found to be very good and chosen as the site for collector well garden #3.

2.2.4 Exploratory Drilling at Chikodza (older gneiss complex)

Drilling commenced on 2 June. Six holes to 15m were drilled but only one was successful, that drilled very close to the longstanding well and community garden of Tanwadzana (see Appendix 1). Conditions at this point were in fact technically ideal for a collector well (weathered rock to 15m, RWL 1m) but unfortunately, as holes were drilled further away, conditions quickly deteriorated. Given the apparent limited extent of the aquifer, and the danger of upsetting the existing well and garden by introducing a larger community project nearby, this area was deemed unsuitable for the pilot project.

2.2.5 Exploratory Drilling at Nemauka Business Centre (younger intrusive granite)

Drilling commenced on 5 June. Only four holes to 15m were needed, the fourth being successful (weathered rock to 15m; RWL 5m; EC of 0.33 mS/cm on 12/6/93) and was chosen as the site for collector well garden #4.

2.3 Well Construction

In order to test whether a collector well is the most viable well design to supply water for garden irrigation, a methodology was developed during the first six months of work to allow direct comparison of the technical and economic viability of collector well, traditional dug well, improved dug well and borehole each constructed at each site of the pilot project. Full details of this methodology are given in the first progress report. During the second six months of work, this methodology has been applied at sites #1 and #2, and is ongoing at sites #3 and #4.

2.3.1 Well Construction at Muzondidya

Digging commenced in late March. Water was struck at 3m and following the programme of comparative testing mentioned above, a hole of 1.2m diameter and 1.5m deep was dug in the centre of the 2m diameter shaft to simulate a traditional dug well at this site. The hole was pumped dry and recovery measured in order to

obtain an estimate of inflow and hence approximate yield of the traditional well, which in this case was about 500 litres per day (see Section 2.4.1 below). Digging was continued to 16.1m in moderately weathered gneiss, and completed on 6 June. The improved dug well of 2m diameter was then pump tested in similar fashion prior to the drilling of radials. Briefly, five radials were completed, four to 30m and one to 15m. Further details are given by Chilton (1993). Upon completion, the collector well was pump tested. Drilling and testing of a conventional 6" borehole drilled to 40m depth at a distance of 10m from the collector well completed well construction at this site.

2.3.2 Well Construction at Gokota

A similar sequence of well construction and testing was followed at the second site Gokota. Digging commenced on 17 April, water was encountered at 1m depth, a traditional well was constructed and tested, and the 2m diameter shaft completed to 16.5m by 2 July. Four radials to 30m were drilled to complete the collector well, and a 6" borehole to 30m depth was again drilled 10m away from the collector well.

2.3.3 Well Construction at Dekeza School

Digging commenced on 10 July. Water was encountered at 7.6m, a traditional well was constructed and tested, and the 2m diameter shaft completed to hard rock at 14.9m by 3 September. At the time of writing, headworks are being completed prior to pump testing the improved dug well and drilling radials to complete the collector well. The borehole to 40m is also still to be drilled at this site.

2.3.4 Well Construction at Nemauka B/C

Digging commenced on 27 July. Water was encountered at 5m, and a traditional well constructed and tested. At the time of writing, digging of the 2m diameter shaft is ongoing at 11m.

2.4 *First Comparisons of Well Design by Pump Test Analysis.*

2.4.1 *Methodology*

Pump tests were designed to calculate the current yield of :-

- Traditional well (1.2m dia, 1.5m bwl)
- Collector well (2m dia, 15m bgl, with 30m laterals)
- Deep well (2m dia, 15m bgl)
- Borehole (0.15m dia, 40m bgl)

A detailed test methodology is given by Chilton (1993). Briefly the test results were obtained as follows:

The *traditional well* was rapidly de-watered and the water level recovery timed to achieve the inflow in cubic meters per day. The *collector well* was pumped at a constant rate (per day) for seven days, drawdown was recorded and the maximum yield was calculated from the available drawdown in the well. Further analysis of this test may provide a tentative prediction of sustainable yield throughout the year. The effect of the laterals was assessed by drawing the water level in the well down to 11m and timing the recovery from ten to eight meters before and after the laterals had been drilled. The yield of the *deep well* was calculated from the yield of the collector well minus the effect of the laterals. The *borehole* was subject to a high discharge test, yield being calculated as:

$$\text{test rate} \times \frac{\text{available drawdown}}{\text{test drawdown (1yr)}}$$

2.4.2 Pump Test Results at Sites One and Two

Muzondidya (site 1)	Well Type	Yield (cubic meters /day)
	Traditional well	0.5
	Borehole	38.0
	Deep well	7.5
	Collector well	30.0
Gokota (site 2)	Well Type	Yield (cubic meters /day)
	Traditional well	6.7
	Borehole	23.0
	Deep well	14.7
	Collector well	16.5

2.4.3 Comment on First Results

These tests provide a first estimate of the current, maximum daily yield for each well design. The excellent performance of borehole compared to collector well at each of the first two sites was unexpected, and results from the further schemes are awaited with interest. It should be noted that the cost of achieving maximum abstraction each day would in practice be different for each well design, and indeed the cost of locating the preferred site for each well design, related to success rate of siting, would be different aswell. Due to low storage, the *borehole* would require a high discharge electric or diesel pump operating most of the day and discharging into a storage tank. Alternatively, the single hand pump that is possible on a borehole, operating for twelve hours a day, would limit the abstraction to approximately 15 cubic meters per day. The small storage in a *traditional well* would allow approximately 60% of the maximum yield to be abstracted using a good windlass and bucket in twelve hours. The large storage associated with the *deep well* and *collector well* would allow approximately 85% of maximum yield to be abstracted with two hand pumps in twelve hours. Further work during the course of the project will attempt to assess the technical and economic viabilities of such options, and to assess how performance and viability of each well design varies between different seasons and different years.

Government Analyst's Laboratory

Location	pH	FE _{total}	F	Na	K	Ca	Mg	HCO ₃	SO ₄	Cl	NO ₃ N
WHO guideline	6.5-8.5	0.3	1.5	200	-	250	150	-	400	250	10
Muzondidya	8.5	1.2	0.2	26.0	1.6	27.0	17.0	217.2	2.3	16.1	0.4
Gokota	8.3	0.9	0.1	23.0	1.3	26.9	11.0	115.1	0.3	10.9	0.3
Dekeza School	7.3	0.4	0.1	17.0	0.2	24.7	15.5	178.0	2.0	16.1	0.5
Nemauka B/C	8.3	0.7	0.8	48.0	3.9	36.7	11.5	297.8	2.3	13.3	4.0

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British Geological Survey

Location	pH	FE _{total}	F	Na	K	Ca	Mg	HCO ₃	SO ₄	Cl	NO ₃ N	P _{total}	B	Si
Muzondidya	8.14	.06	0.27	21.2	1.4	44.7	20.7	273	0.9	10.8	<0.4	<.5	<0.3	26.8
Gokota	7.09	.02	0.09	22.6	1.3	14.3	11.4	152	1.7	11.7	<0.4	<.5	<0.3	37.2
Dekeza School	7.41	.37	0.62	14.7	<0.5	22.2	17.8	175	0.9	13.4	<0.4	<.5	<0.3	38.2
Nemauka B/C	8.06	.10	0.87	53.9	2.3	36.6	12.5	301	0.8	15.7	0.9	<.5	<0.3	30.4

Table 1. Water Quality Analyses Performed by Government Analyst's Laboratory and British Geological Survey

2.5 Analysis of Water Quality

Water samples from sites one to four were sent to the Zimbabwe Government Analysts Laboratory for chemical analysis to determine suitability for human consumption. The results in detail are provided in Appendix 4, but as shown in Table 1 above, high iron concentrations were measured at each of the four sites, exceeding the maximum permissible limits according to the WHO guideline for drinking water quality. In contrast, similar analysis conducted as a matter of course by British Geological Survey confirm this high iron concentration only at one of the four sites, that of Dekeza School. This discrepancy, and the possible need for water treatment at one or all sites, will be investigated.

2.6 Establishment of Community Gardens

At the time of writing, steel fencing for 0.5ha community gardens has been erected at sites one and two only, but at all four sites identified to date, community membership of the proposed gardens has been decided.

2.6.1 Muzondidya Community Garden

Membership of Muzondodya Community Garden was determined by the community, families qualifying for membership by simply being able and willing to pay a donation of Z\$1.00 towards initial ploughing of the garden and Z\$0.20 for seeds. These monies were collected by a Garden Committee elected a long time previously when discussions of a community garden were first in progress. The garden area was divided into 132 beds, each 23.5m long by 1m wide. 124 families have paid the required sum and qualified for membership, each family having one bed, 8 beds remaining vacant.

2.6.2 Gokota Community Garden

Membership of Gokota Community Garden was again determined entirely by the community. Each family of the community is reported to be represented in the 130 families that paid Z\$2 for seed and who worked to spread a large anthill within the garden.

2.6.3 Dekeza School Community Garden

No monies were paid to qualify for membership of Dekeza School Community Garden. Membership was determined by random selection in proportion to the size of kraal considered, but selections were subsequently vetted by a self-elected committee comprising of Agritex Extension Worker, Councillor, Headman and four Village Health Workers who could apparently reject the selected family on a basis of "enthusiasm and gardening experience". 56 families representing the five kraals were eventually selected.

2.6.4 Nemauka Business Centre Community Garden

On advice of project staff regarding the need for funds to establish a community garden, an interim steering committee

comprising of seven women determined that a fee of Z\$6.00 was appropriate, to be paid within a two week deadline. 74 families from the six kraals represented became members of this community garden in this way.

2.7 Collection of Baseline Socio-economic Data

Following methodology developed during the first six months of work and reported in the first progress report, baseline socio-economic data at each scheme is to be collected in three parts:

- i) formal surveys of thirty households randomly selected;
- ii) case studies of four households selected to represent different income groups to record more detailed information on income and expenditure, vegetable consumption, gender divisions, attitudes, institutional issues etc.; and
- iii) informal meetings with groups of women only to discuss gender issues, general household budgets etc.

During the second six months, progress has been made on parts (i) and (ii) at each of the four sites identified to date.

2.7.1 Formal Household Surveys

Formal household surveys have been completed at Muzondidya, Gokota, Dekeza School and Nemauka Business Centre. Reports written by MW Brown and T Dube that present results of each of these surveys are given in Appendix 5.

The surveys have provided data on social and economic aspects of life in the project area which can be used later in assessing the impact that the collector wells and community gardens have on the peoples' lives. Their expectations from the project are revealed and should act as a guide in the implementation and evaluation of the scheme. The survey revealed a number of aspects which are likely to be important influences on the success or failure of the project and so will need to be monitored. These are summarised as follows:

a) Demand for membership of the community garden will almost certainly exceed supply in terms of the water which is likely to be available. Therefore it will be necessary to compare the social and economic circumstances of those who are chosen to be members with those who are not in terms of their access to land, labour, capital, local leaders, and agricultural extension, in order to determine whether particular groups are being favoured or excluded.

b) The benefits of the scheme will need to be assessed. According to the survey people expect to use water for vegetable production (both for home consumption and sale), tree planting, brickmaking and as a standby domestic source. Brickmaking should be monitored for possible adverse environmental effects which may necessitate corrective measures.

c) Women are likely to have an important role to play judging by their greater numbers and involvement in existing gardens. However the net effects may be positive or negative depending on the balance between the extra work which the scheme will demand of women, the distribution of the benefits and any opportunity costs in terms of other activities which may need to be compromised such as work on rainfed crops where labour can be in short supply.

d) The influences of different institutions and local leaders which the survey has identified need to be monitored and the importance of each understood particularly if the scheme encounters problems which technical solutions do not appear to alleviate.

e) Priorities for agricultural extension are likely to include pest and disease control, pump repair and maintenance (involving outside institutions such as the DDF), and the need to raise money to purchase inputs. To date there appears to have been little advice given to farmers on the subjects of vegetables and irrigation.

2.7.2 Case Studies

Case studies have been completed of four households at each of the four sites. Initially meetings were arranged to inform each community of the objectives and logistics of the proposed case studies. Given that the objective in selecting households for interview was to reflect the range of socio-economic characteristics present in that community, random selection was not considered appropriate. The selection methodology utilised data collected during the formal household surveys (Appendix 5) and also made use of suggestions from each community.

The socio-economic variables considered during selection were wealth, age, number of children, number of people employed away from the homestead, and status concerning community institutions both modern and traditional and membership of the collector well garden. Data on these variables was tabulated and households shortlisted on the basis of their level of income. Project staff then discussed the individual merits of each shortlisted household to make a final selection.

Data collection was achieved by means of single visit interviews conducted at each selected household by M Murata, A Semple and T Dube. The questionnaire used as a guide for the interviews is given in Appendix 6. Analysis of data is ongoing, however initial results suggest that the selection procedure has worked well with selected households showing a wide range of socio-economic characteristics. Despite being a fairly long interview, responses are felt to have been truthful and accurate.

Baseline case studies will be completed in the same way at the final two collector well garden sites once identified and following formal household surveys.

3. PERFORMANCE OF THE FIRST COLLECTOR WELL GARDEN AT TAMWA, SIHAMBE & DHOBANI KRAALS

In June 1991, a first collector well garden was established in Chivi District to serve the three villages of Tamwa, Sihambe and Dhobani as part of an initial research and development project to assess the potential of using this type of well to provide sufficient water for both domestic and community garden use. It was largely a result of the encouraging success of this first scheme, as it weathered the severe drought of 1991-92 when other crops, water sources and gardens failed, that the present TC-funded pilot project was implemented. The first scheme at Tamwa, Sihambe and Dhobani Kraals continues to flourish (Brown, 1992), and continues to provide valuable information as garden members gain in experience and as seasons and weather patterns change.

3.1 Collector Well Abstraction and Water Levels

Figure 2 presents weekly water levels, abstraction and rainfall recorded for the T/S/D collector well during the severe drought of 1991/92 and subsequent good rains. During the drought, daily abstraction was typically about 13m³, four-fifths being applied as irrigation. However, demand for domestic water steadily increased as local wells dried and eventually with water level in the collector well being drawn down to 10m and reaching pump suction during operation, cultivation within the garden had to be reduced from seven beds per family to three beds per family (Section 3.3 below). With good rainfall received during December 1992 and February 1993, recharge to the aquifer did occur to some extent, water level recovery being further assisted by the corresponding decrease in demand for both irrigation and domestic water as other dug wells came back into use. However, by the end of the rains in March 1993, the water level in the well had not returned to the level at time of construction. Monitoring during the coming rainy season will continue.

3.2 Economic Comparison of Collector Well and Local Dug Wells

In January 1993, a survey was conducted of 22 traditional wells in Tamwa, Sihambe and Dhobani Kraals to obtain data on their performances and costs so as to be able to make economic comparisons with the Collector Well. The full results are reported in Brown (1993).

The report suggests that, at this particular site, the Collector Well compares favourably with traditional dug wells on the basis of average capital cost per unit of water, provided that each well type is constructed to the same standards. For example, if both wells were constructed using traditional stone lining, the average capital cost per cubic metre of water is \$20.48 for the Collector Well compared with \$20.52 for an average traditional well. If however both wells are constructed using the safer (but more expensive) steel lining used for the Collector Well, then the cost for the traditional well soars to

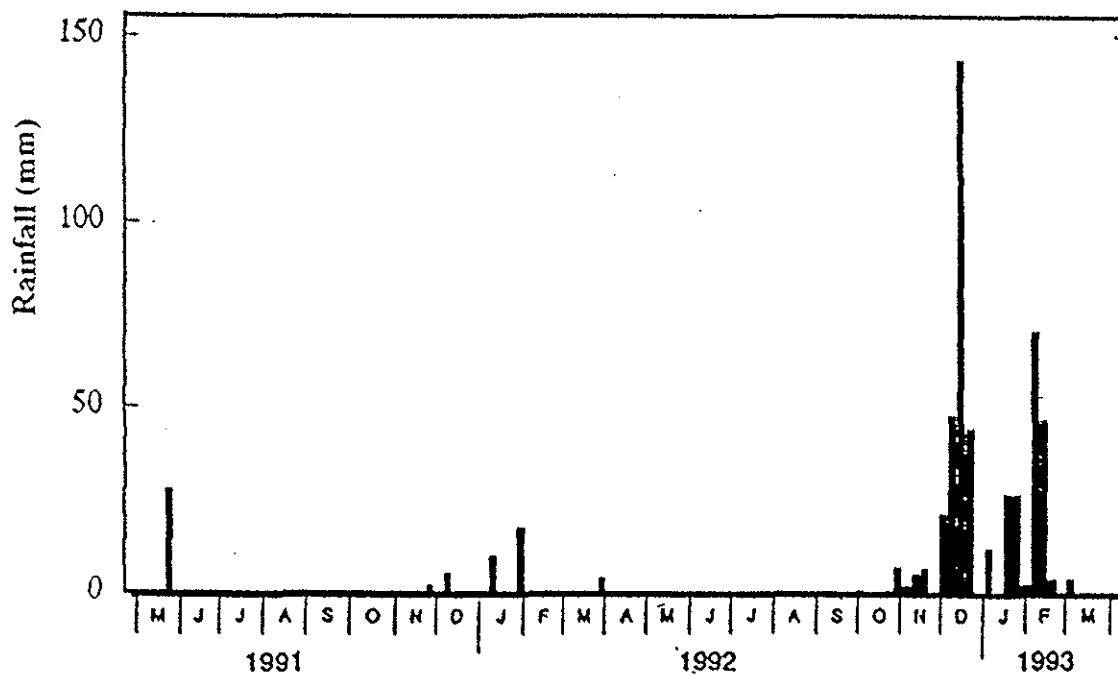
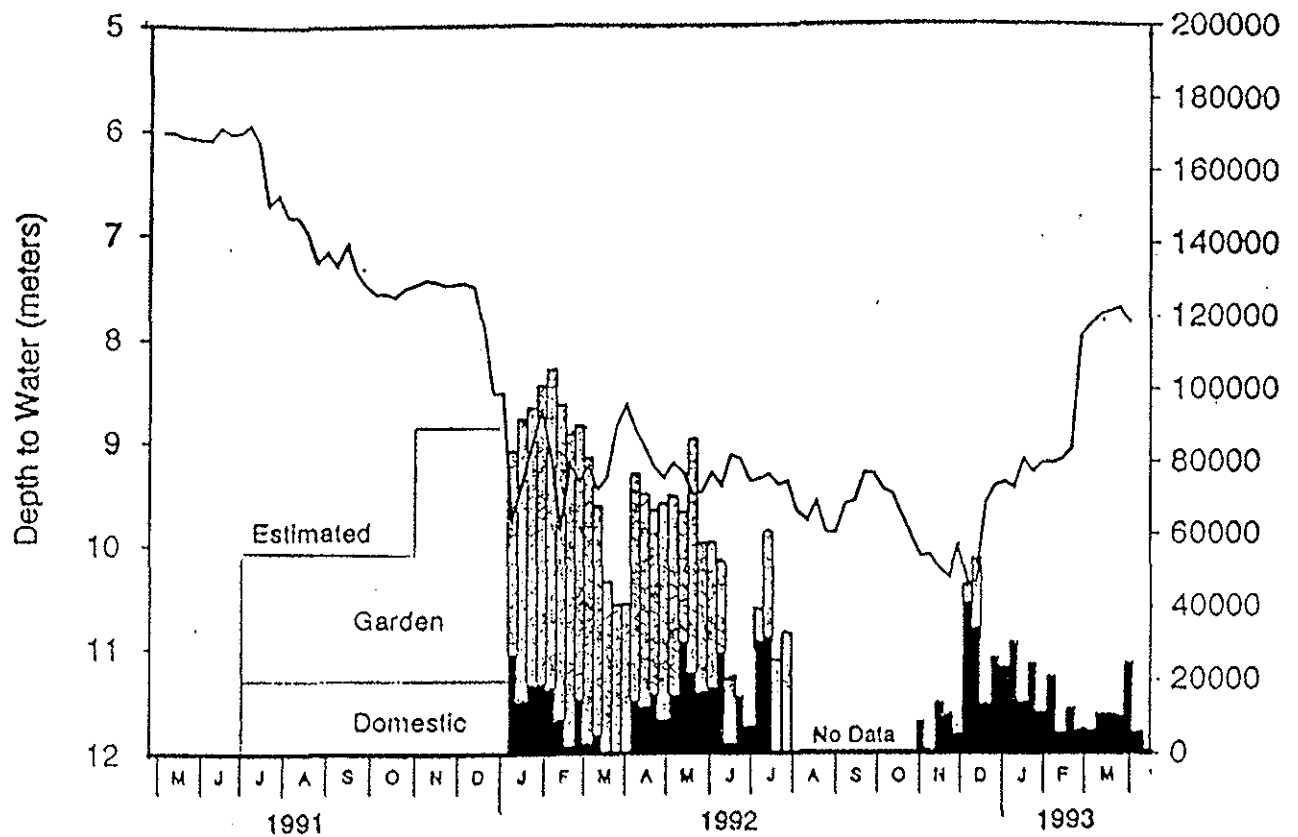


Figure 2. Tamwa, Sihambe & Dhobani Kraals Collector Well Garden: Weekly water levels, abstraction and rainfall during severe drought (1991/92) and subsequent good rains.

\$3.04 per cubic metre of water compared to \$20.84 for the collector well. This is because the increase in costs is spread over a much higher water yield for the collector well compared to the lower yielding traditional wells.

However, further work needs to be done to evaluate the most economic water source for a given location since, at this particular site, a third option, namely the wide (two metres) diameter well optimally sited by exploratory drilling, seems to be the best option because the additional lateral drilling to create the Collector Well only increased yields by 10 per cent (Chilton and Talbot 1992). This contrasts with other sites in Zimbabwe where yield increases of up to 250 per cent have been reported for a collector well in comparison with the wide diameter well. The TC-funded pilot project should go some way towards answering this question.

3.3 Garden Performance

3.3.1 During the Drought, October 1991 - October 1992

The period October 1991 to October 1992 saw an exceptionally good start made to the garden, despite severe drought that was the main feature of this period. The continuous supply of water provided by the Collector Well enabled members to take advantage of new opportunities which the drought created; in particular by bringing forward the start of their gardening season to December rather than the usual April/May. There were a number of reasons why they could do this: Firstly their rainfed crops had failed thus leaving them with surplus labour to devote to gardening at a time of year which is normally very busy. Secondly the unusually dry weather reduced the incidence of pests which are normally a severe constraint to gardening at this time of year. Thirdly, the drought had caused a general shortage of food, there was thus an incentive to use whatever means were available to produce vegetables both for home consumption and to sell in order to purchase basic necessities. Fourthly there was a good market for vegetables since neighbouring gardens which were dependent on small dams or conventional wells were unable to operate since these sources had dried up.

The members of the Collector Well garden took full advantage of this situation and were able to produce vegetables throughout the period January to September 1992. Exceptionally high yields were obtained; over 70 tonnes per hectare for single crops of rape and cabbage leaves. Input costs (particularly agro-chemicals for plant protection) were kept to a minimum and as a result high Gross Margins were achieved; averaging \$52 000 per hectare or \$220 per member.

3.3.2 During the Rains, Summer Season October 1992 - March 1993

In contrast to the previous year, this summer season was marked by relatively good rains which can be a mixed blessing as far as

gardening is concerned. On the plus side (and most importantly) it enabled the Collector Well to recharge, due both to deep percolation of rainfall to the aquifer and to a reduction in demand for irrigation water taken from the well; this reduction in irrigation also saved labour. However on the negative side the good rains promoted heavy infestations of pests, diseases and weed growth, waterlogging and a labour shortage as members worked on their rainfed crops, made even more laborious by the absence of draught animals that had died during the previous year's drought. Nevertheless, 0.3 hectares of garden was cropped with rape, tomatoes and maize and positive returns were earned.

Cropping operations

All 46 members sowed three and a half beds each of maize in October by dibbling with no land preparation necessary. Around the same time one nursery bed of tomato was sown; this was transplanted in early December and was sufficient to provide one bed for each of the 41 members who wanted them. At the same time, four nursery beds of rape were sown and transplanted at the beginning of January, also at one bed per member though by this time membership had swelled to 48 members. Basal dressings of manure were applied at varying rates to rape and tomatoes only.

The maize was irrigated once per week from the Collector Well during November at the rate of four buckets per bed (10mm). By the time the rape and tomatoes had been transplanted, sufficient rain had fallen to enable the nearby stream to flow which was used to supplement the rainfall when necessary. The maize received a top dressing of Ammonium Nitrate which members had received free as part of the drought relief effort.

Spraying of tomatoes and rape against aphids was done at fortnightly intervals over the period 16 December to 10 February. However there was some dissatisfaction amongst members that this should have been done more frequently but for the pre-occupation of the chairman (who supplied the sprayer and labour) with other activities, notably construction of a community dam. Instead, the assistant secretary took over the spraying which he did free of charge but he was also constrained by other commitments. A consequence of this was that members purchased their own second hand sprayer at the end of the season.

Due to the demands of rainfed cropping and the wet weather, members only worked for half a day per week on the garden. The time was spent weeding, harvesting and irrigating from the stream when necessary.

Production

The maize was harvested green over the period late January to late March. The rape began bearing on 9 February and the tomatoes on 24 February but both were brought to a premature end when heavy rains in late February/early March caused severe waterlogging. Estimated total production and average yields are summarised in the following Table.

Total production and average yields

Crop	Production (Kg):			Area (Ha)	Average yield Kg/Ha
	Sold	Consumed	Total		
Rape	325	238	563	0.0576	9 774
Tomatoes	233	328	561	0.0492	11 402
Maize (grain)	327	468	795	0.1932	4 115

Gross Margin analysis

Output	Z\$	Z\$
Rape	394	
Tomatoes	748	
Green maize	1 309	
Total Revenue		2 451

Variable costs		
Seed	20	
Chemicals	43	
Total Variable Cost		63

Total Gross Margin	2 388
Gross Margin per hectare	7 965
Gross Margin per member	50

Family labour	Hours	Hours
Land preparation/transplanting	300	
Irrigating/weeding/picking	1 900	
Total		2 200

Average Gross Margin return to family labour = \$8.68/day (8 hrs)

Comment

Considering the shortness of the season and the problems referred to above, the Gross Margin figures are quite acceptable. Purchased inputs were kept to a minimum and all labour was supplied "free" by members and their families. Fixed costs were also minimal, being limited to \$70 for purchase of a second hand sprayer or \$1.46 per member. Since the well itself was not paid for by the members, so they are likely to regard the Gross Margin as the reward to the members for the labour and management which they put into the garden. This worked out an an average of \$8.68 per day which compares favourably with wage labour (if available). In such a season as this, when the rains are good, it is probably lower than the returns from rainfed cropping (the "opportunity cost") which explains why members decided to allocate more of their labour to their rainfed crops rather than the garden at this time. However rainfed cropping is a more risky undertaking as evidenced by last year's crop failure due to drought. Members therefore do not abandon the garden completely

but keep it going during the rainy season at a lower level of intensity, partly as an insurance policy against such disasters.

A further factor to consider is that all output in the above analysis is valued at the prices charged by members for produce sold at the "garden gate". For rape and tomatoes these were two to three times lower than retail prices at the nearest market centre of Ngundu at that time. If the members did not have the Collector Well garden than they might have had to purchase their own vegetable requirements at these market prices. If the value of the home consumed vegetables from the Collector Well garden are valued at the ruling market prices then Total Gross Margin increases to \$3 154 (\$66 per member) and \$11.47 per day. This may further explain why members found it worthwhile to continue gardening during this time.

3.3.3 Some Observations on the Winter Season March 1993 to date

In contrast to the previous year a slow start was made to the winter season as members were pre-occupied with headloading their bumper harvests of rainfed crops until well into May. An attempt was made to start a nursery for rape and cabbage in February however many seedlings died due, it was said, to members of one kraal not pulling their weight. More rape was sown in the nursery in March but again there was high mortality this time due to pests. It was not until mid-May that substantial nursery beds of onions, rape and cabbage were sown and successfully transplanted in June/July. In late May, quantities of tomato seedlings were obtained free from members' private gardens and transplanted into the Collector Well garden.

Water for irrigation continued to be drawn from the stream until mid-April when it dried up. Hopefully this rest should have helped the Collector Well to further recharge.

Pests continue to be a problem necessitating spraying at one to two weekly intervals throughout the season. Again this can probably be attributed to the good rains supplemented by wet weather in July. However the regularity of pest control has been improved with the acquisition of the sprayer and the employment of a man who is paid \$5.28 per spraying (11 cents per member).

At the time of writing (September) the garden is fully cropped with three beds of rape, two beds of tomatoes and one bed each of onions and cabbage per member. However only the rape and cabbage have commenced bearing. Problems have been encountered in marketing the leaf vegetables due to competition from other gardens, many of which are making use of water stored this year in small dams as a result of the good rains. Consequently members of the collector well garden are retaining more vegetables for home consumption and/or drying. However hopes are high that the market will pick up once the tomatoes and onions start bearing since these crops are less commonly available in the area at this time.

4. COMPLEMENTARY ODA R&D-FUNDED PROJECTS IN SOUTH-EAST ZIMBABWE

Good as the pilot project is, it is not complete. The concept of collector well gardens can go only a limited way towards helping people and improving land management in this region if developed in isolation. In fact, sustainability and long-term viability of even this improved management practice will be threatened if other land use practices within the catchment continue to cause damage to the environment. In particular, the process of groundwater recharge, upon which the sustainability and long-term viability of collector well gardens must depend, is not constant and is sensitive to land use change, surface management, and associated change to catchment hydrology:

"The basement aquifers of this region are distinctive in that their occurrence and characteristics are largely a consequence of the interaction of weathering processes related to recharge and groundwater throughflow. A close relationship exists therefore between groundwater occurrence and relief, surface water hydrology, soil and vegetation cover. Recharge is sensitive to certain land use changes, notably those associated with desertification. Improvements in the understanding of these relationships will be fundamental to the planning and management of groundwater resources in crystalline basement terrain." (Wright, 1992)

Two ODA R&D-funded projects that complement the TC-funded pilot project and which are designed to address the issues of groundwater recharge and sustainable yield as affected by land management are now underway. A note that outlines in more detail the rationale and objectives of this complementary approach at a single small catchment scale is given in Appendix 7.

4.1 *"The Effects of Land Management on Groundwater Recharge"*

A detailed project description is given in Appendix 8. Briefly, this surface oriented project brings together scientists primarily from MLAWD (DR&SS, DWD, Agritex) and Institute of Hydrology. The small catchment to be studied initially is that of Tamwa, Sihambe and Dhobani kraals in Chivi District. Counterparts Francis Mugabe (DR&SS) and John Butterworth (IH) will begin collection of field data during the coming rainy season. In particular, a first objective will be to install, with help from DWD, flow measuring devices so that baseline data can start to be collected on catchment water balance under present land management.

4.2 *"Sustainability of Wells & Boreholes in Hard Rock Aquifers"*

A detailed project description is given in Appendix 9. Briefly, this subsurface oriented project brings together scientists primarily from MLAWD (DWD, DR&SS) and British Geological Survey. The small catchment initially under study is again that of Tamwa, Sihambe and Dhobani kraals, and close collaboration with the above project is fundamental (re. Appendix 7). Monitoring of groundwater levels in this catchment via a network of existing dug wells began prior to the severe drought. Fascinating results indicating variable recharge around the catchment are already

coming to light and additional observation holes are currently being installed and monitored by project counterparts Duncan Thompson (APO/BGS) and Mr Mafunga (DWD) prior to the next rains.

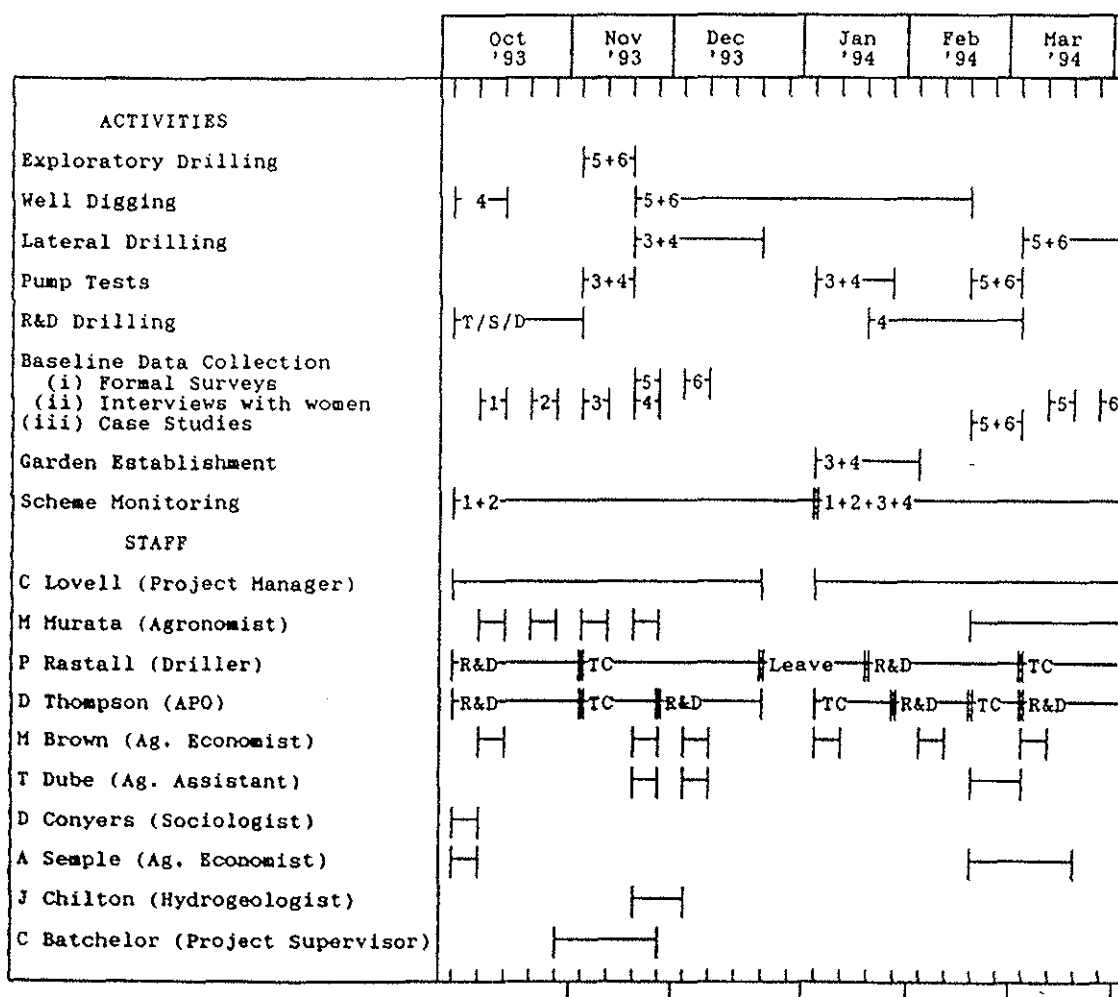
4.3 "Optimal Use of Water in Garden Irrigation"

A third ODA R&D-funded project ongoing in south-east Zimbabwe is that based at the Lowveld Research Stations and designed to develop appropriate, low-cost methods of garden irrigation efficient in water use. Results of this project are reported in separate progress reports, but it is worth mentioning here that highly promising methods of garden irrigation have been developed under research conditions, and it is hoped that extension of this research may now occur, at least to a limited extent, within the community gardens of the TC-funded pilot project. R&D funding for this particular project will cease shortly.

5. FORWARD WORK PROGRAMMES

5.1 Programme Of Work For The Next Six Months

The following is a provisional programme of work proposed for the next six months:



5.1.1 Assumptions

a) Contract Driller becomes available for TC-funded activities as indicated and is able to complete tasks as indicated prior to leave. It should be noted that the above programme is a compromise to allow progress to be made on both TC and R&D-funded activities. If TC-funded activities were considered alone, this programme would be different. Exploratory drilling at sites 5 and 6 would commence immediately. Similarly, radial drilling at site 3 now and at site 4 in only a few weeks time. Availability of contract driller and rig is again the constraint. This is disappointing given that this situation was envisaged and first discussed with staff of BGS in May of this year. Continuous full time input of one driller or of two drillers able to overlap was suggested at that time. Unfortunately, no action has been taken.

b) Luck concerning minimal loss of drilling time due to weather, breakdowns etc. During the second six months of work, one day was lost due to weather, seven days due to ill health, and fifteen days due to breakdowns.

c) A decision is made regarding geology for site 6. To aid this decision, the draft contract for Plan International should be completed as a matter of some urgency, and funding by Plan International for the complementary schemes on basalt secured.

5.2 Programme of Work in the Longer-Term

Valuable information regarding technical, economic, social and institutional viability of groundwater based garden irrigation is already coming to light in the pilot project and from the original collector well garden. For example, during the first year of the pilot project, the importance of exploratory drilling to locate preferred sites for high yielding wells has been demonstrated, and if the excellent performance of the first two boreholes sited in this way is repeated, it is clear that a comparison of the viability of siting boreholes in this unconventional manner with that of conventional geophysics will become a priority. Irrespective of well design, success at the original garden during both drought and subsequent rains bodes well for the future of this component of the project. Strategies to aid marketing would help in certain years, but it is fair to say that a continuous rolling programme of garden construction could already help many people in this region.

However, concern over long-term viability of groundwater based garden irrigation must remain as long as development of this type of project continues in isolation. Long-term viability is sustainable land use and surface management in the surrounding catchment. A first step towards recognising this has been taken by development of the complementary R&D projects described above, but the magnitude and complexities of the problem to be addressed require a coordinated programme of work that is holistic, a multi-disciplinary approach to catchment management. First ideas towards achieving this are given in Appendices 10 and 11.

5.3 Action List

a) BDDCA to consider appropriateness of ODA TC funding to support one or more components of a coordinated programme of work towards watershed resource management in this region. At this stage, these components might include :

- i) Identification of a representative network of small catchments (5-10 km² each) in Natural Regions III, IV and V chosen on the basis of their environmental, physical and socio-economic characteristics. Catchments will also be chosen such that they lie within a larger river system eg. Save/Lunde Basin, to permit regional extrapolation of results. Installation of flow measuring devices in these catchments so that baseline data can start to be collected.
 - ii) Preliminary catchment modelling as a decision support strategy. Landsat images for this region for 23/7/92, 24/6/93 and or 27/8/93 could be purchased and analysed to produce first "what if" scenarios for the above catchments based on data from before, during and after the recent drought
 - iii) Improved dissemination of information on improved gardening and rainfed farming techniques, a need identified during pilot project baseline surveys (Section 2.7.1), and fundamental to watershed management if education and change at the village level is to be promoted.
- b) BGS to review: (i) availability of driller and drilling rig when full time work is the requirement; (ii) approach to training of DWD staff in order to improve local capacity to take over more drilling and scheme construction tasks, thereby improving continuity of drilling activities in pilot project, reduce cost of new projects (eg. Plan International), and increase the likelihood of groundwater based irrigation becoming a standard approach; and (iii) counterpart situation for R&D project on sustainability of wells.
- c) Project Manager to confer with Plan International re. sites on basalt.

6. ACKNOWLEDGEMENTS

Many staff of MLAWD have given their advice and support to this project during the second six months of work. Particular thanks must also go to the Project Contract Driller, Mr Peter Rastall, for his hard work during this period, and to Social Development Adviser, Dr Diana Conyers for her assistance.

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APPENDIX 1: SITES SELECTED BY GEOLOGY

District	Zaka
Ward	7, Nemauka
Extension Worker	Mr Chamunorwa, Nemauka B/C
Placename	Chikodza
Kraal(s)	Chikodza(22);Rangrira(10);Peri(40);Mutamba(12)
VIDCO (Chairman)	Mahuridzana (Mr Chatimba) (Cncl Bhindu)
Grid Reference	Map 2031 A4; 337 478 31°25'E 20°22'S
Initial Site ID by:	Project staff, based on geology
Site Location	Beside main dirt road Jerera-Devure B/C. 1.5km to Mutamba School, Jerera 6km
Landform / Catchment	Flat plain feeding into sloping funnel, water held back by outcrops of rock down slope
Geology	Older gneiss complex
Community Structure	4 sub-kraals in 1 VIDCO 1.5km radius
Present Water:Domestic Gardening	5 dug wells provide 3 kraals under normal conditions. Many more families came during drought, from up to 3km. 3 small community gardens, for 15,6 and 2 families; 4 beds 50x1, 3 beds 3x1 and 8 beds 5x1m respectively.
Previous Gardens	As above, plus Chiredzi river now illegal
Present Vegetables	Shortage
Community Enthusiasm	Positive, community recognises value of gardens and wish to develop more
To serve: Domestic Gardening	As necessary Priority
Land Allocation	Would need time for discussion
Market Opportunities	Appear good; at Mission School & Jerera 6km
Other factors	Perhaps people in immediate area not as needy, being fortunate in having water, but this is generally a difficult area and resource could perhaps benefit more people.Cncl Bhindu active
Overall Impression	Small aquifer held back by barrier and fed by large plain above. Difficult area generally. Cncl above VIDCO or kraal heads at this site.
Recommendation	Shortlist for exploratory drilling

District	Zaka
Ward	7, Nemauka
Extension Worker	Mr Chamunorwa, Nemauka B/C
Placename	Nemauka B/C
Kraal(s)	Mukambwe(27); Mwerane(30); Tinarwo(15); Chapfidza(12); Nezvikonde(30); Mashanyare(16)
VIDCO (Chairman)	Chimbamba(Mr Mangezich);Runinga(Mr Mashanyare)
Grid Reference	Map 2031 A4; 300 542 31°22'E 20°18'S
Initial Site ID by:	Project staff, based on geology
Site Location	Small rural business centre, public, directly behind shops next to main dirt road. Schools 1km south, clinic 4km north, Chiredzi river 2km
Landform / Catchment	Ampitheatre of granite upslope, small catchment sandy loam soil, flat area good for garden
Geology	Younger intrusive granite
Community Structure	6 sub-kraals in 2 VIDCO's
Present Water: Domestic	Community well nr eucalypts, private well at shops (Mrs Chipato), 5 other private wells. In drought only that of Mrs Chipato.
Gardening	4 individual gardens at B/C, others at river now illegal, community garden (27) Nezvikonde
Previous Gardens	Many gardens at Chiredzi river
Present Vegetables	Shortage
Community Enthusiasm	Positive, but discussion of kraals eligible. Meetings well attended: Cncl Bindu, Mrs Muvavi (VCW), kraal heads Muvavi, Tinarwo, Makwindi, 5 females 3 males on VIDCO, 30 women, 24 men
To serve: Domestic Gardening	As necessary Priority
Land Allocation	Land previously reserved for B/C growth can be used for development without affecting people.
Market Opportunities	Appear good; 2 schools & clinic, Jerera 20km
Other factors	Garden committee of 7 women chosen almost immediately following initial meeting without suggestion. Talk of cooperative general store & grinding mill, and community piggery.
Overall Impression	Small contained catchment on granite typical of local area, tributary of Chiredzi river
Recommendation	Shortlist for exploratory drilling

District	Zaka
Ward	19, Chidzurira
Extension Worker	Mr Imbayago, Jerera Growth Point
Placename	Zvidozvevanhu VIDCO
Kraal(s)	Chivasa(50);Sieyawareva(100);Tumbudzuku(50)
VIDCO (Chairwoman)	Zvidozvevanhu (Mrs Chikwenhere)
Grid Reference	Map 2031 A4; 400 430 (approx) 31°28'E 20°24'S
Initial Site ID by:	Project staff, based on geology
Site Location	Populated area, Jerera Growth Point and main tar road 2km, but not public.
Landform / Catchment	Shallow undulating land typical of area, sandy loam soils, tributary of Chiredzi river 2.5km.
Geology	Older gneiss complex
Community Structure	3 sub kraals in VIDCO, 2km radius
Present Water: Domestic Gardening	B/hole at Chipezese School 2.5km used by 400 families, and 5 shallow dug wells on shallow system of drainage lines. 4 small individual gardens at dug wells
Previous Gardens	As above, and Chiredzi river 2.5km now illegal
Present Vegetables	Shortage
Community Enthusiasm	Positive, Mrs Chikwenhere VIDCO Chairwomen already actively linking 3 sub-kraals
To serve: Domestic Gardening	As necessary Priority
Land Allocation	Mrs Chikwenhere has confirmed land availability with kraal heads
Market Opportunities	Appear good; Jerera Growth Point only 2km
Other factors	Highly active local leader Mrs Chikwenhere, VIDCO Chairwomen, friend of local MP, famous for promoting community activities. Highly active and very enthusiastic AEW.
Overall Impression	Flatter, undulating land typical of local, older gneiss area, tributary of Chiredzi river, reasonably large area to explore
Recommendation	Shortlist for exploratory drilling

*APPENDIX 2: CONCEPT NOTE FOR R&D PROJECT: SMALL SCALE IRRIGATION
USING COLLECTOR WELLS IN AREAS OF SALINE GROUNDWATER*

Location : SOUTH-EAST ZIMBABWE
Organisations: DEPARTMENT OF RESEARCH & SPECIALIST SERVICES,
DEPARTMENT OF WATER DEVELOPMENT, AGRITEX,
INSTITUTE OF HYDROLOGY, BRITISH GEOLOGICAL SURVEY

BACKGROUND

Recent ODA-funded research conducted by the above organisations indicates that irrigation of community gardens using groundwater abstracted from collector wells has the potential to improve sustainability of agriculture in many semi-arid parts of Africa. As witnessed during the recent drought, collector well gardens are capable of providing a continuous supply of fresh vegetables even during such difficult times, provide a source of income and improved nutritional standard, reduce dependence on extensive cultivation of often marginal lands, and are capable of being self-financing and self-managing by rural communities themselves (Brown, 1992; Lovell et al, 1992).

An ODA TC-funded pilot project is now underway to identify a basis for replicating such groundwater based schemes on a wider scale. Technical, economic, financial, institutional, social and environmental viability is being assessed at a number of schemes and recommendations made for future development.

One environmental factor that has become evident as particularly important and possibly limiting the potential value of this approach is that of water quality. Saline groundwater is known to be prevalent in certain areas, and water of electrical conductivity up to 10 mS/cm has been located during siting of schemes for the pilot project. In south-east Zimbabwe, areas underlain by basalt and by a transition from paragneiss to younger undifferentiated gneiss appear particularly prone to this problem. Unfortunately, these areas include some parts of communal lands and resettlement areas most in need of improved water supply and small scale irrigation (Diti; Chipice; Mtetengwe; Zaka; Nyajena; Matibi No.1; Sangwe; Maranda; Siyoka).

Salinity generally increases with depth below ground. In order to minimise the risk of intercepting highly saline water, the Zimbabwe Department of Water Development, when operating in these danger areas, tends at present to reduce the depth to which boreholes are completed. Despite this measure, the occurrence of saline boreholes remains high and indeed, within south-east Zimbabwe as a whole, more than 50% of all boreholes drilled are saline to some degree (DWD, pers.comm.). With the advent of machine drilling of horizontal boreholes at the base of shallow collector wells, considerable interest has now been expressed in the possibility of abstracting more efficiently the reserve of fresher water that often lies above more saline water at depth.

** A collector well is a shallow, large diameter well whose yield has been enhanced by drilling of horizontal boreholes radially at the base of the well.*

If moderately saline water could reliably be abstracted in this way, irrigation of vegetables in these difficult but needy areas could be possible. Yields would be reduced but local crops of rape, cabbage and tomatoes could be cultivated by traditional flood irrigation using water having electrical conductivities as high as 5 mS/cm (FAO, 1977). The reduction in yield incurred could be minimised by use of localised irrigation methods, to as little as only 10% using water of 5 mS/cm if the pattern of salt distribution in the soil was known and well managed (FAO, 1980). Finally, irrigation using such saline water could be sustained in the long term provided that good management was given. This relies on the ability to periodically leach or flush accumulated salts from the soil profile, thereby preventing a net increase in salt content with time, and may be achieved naturally using surface management practices designed to concentrate rainfall and or artificially by application of additional water as an annual leaching requirement.

The use of localised irrigation methods such as subsurface clay pipes, and surface management practices such as ridge and furrow, to provide and ensure sustainable production of crops irrigated using saline water forms the basis of ongoing ODA R&D-funded research at the Loveweld Research Stations; practical research recommendations are now becoming available (Lovell et al, 1992).

OBJECTIVES

Considering the above, the project proposed here has the following main objectives:

- i) To construct a single collector well on a saline aquifer in order to evaluate technical feasibility of reliably skimming fresh (probably brackish) water from above more saline water at depth using the horizontal boreholes of the collector well;
- ii) If successful in (i) above, to implement a community based garden irrigated using this brackish water in order to test and validate research recommendations at village level and to provide a platform for adaptive research in which long term monitoring of results will allow appropriateness of the technologies to be evaluated and the value of these technologies to be demonstrated directly in the field.

METHODOLOGY

- i) Site location for the proposed project has largely been accomplished during site location for the above mentioned pilot project. Perhaps the most suitable of several sites found to date is that at Chindondodza in Ward 36 of Zaka District, where eight villages comprising over two hundred families face a critical shortage of fresh water for both drinking and gardening, people walking 5km to the nearest fresh borehole, but where indications are that the proposed approach might succeed. Exploratory drilling has identified a large inflow of water of conductivity 4.68 mS/cm at one location. At other locations, dug wells of various depths have water varying in conductivity from 1.12 up to 7.70 mS/cm. Alternatively, the proposed project could be located under similar conditions but at Chikuza School in Ward 29 of Nyajena Communal Land, or at a community garden in

Chiredzi Township where at present fresh water from the town supply is payed for but where a borehole having water of 3 mS/cm conductivity has been drilled.

ii) Construction of collector well and garden would largely make use of equipment made available via the pilot project. It is proposed that at the site selected, identified by exploratory drilling, a 6" borehole would first be drilled in stages to allow a detailed salinity profile to be established. This information would then be used to aid construction of the collector well, determining the optimum depth of well and position of horizontal boreholes in order to provide sufficient yield of moderately saline water without intercepting more saline water at depth.

iii) Long term results monitoring will be the only way to monitor the appropriateness of the proposed technologies. Technical, economic and social viability will be assessed using methods previously developed in the above mentioned pilot project (Lovell, 1993). Environmental viability will be assessed by monitoring both water and soil salinity levels through time. Institutional viability will form an important component, given the fundamental importance of good management to success of this and any irrigation scheme where water quality is a consideration, and the corresponding fundamental role of Agritex extension staff in providing this good management and environmentally sound management practices. Demonstration of and training in appropriate management practices will form a major component of the proposed project, and is also timely given the present interest in a larger irrigation scheme newly opened in Sangwe Communal Area where water quality is less than ideal.

COSTS

Detailed costs for the project will be prepared once comments have been received on this concept note. However, it is estimated that £30K per year over a three year period would be required to meet equipment and staff costs.

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APPENDIX 3: SITE #3 AT DEKEZA SCHOOL

District (Communal land)	Zaka (Ndanga)
Ward	32, Dekeza
Extension Worker	Mr Maireva, Dekeza School
Placename	Dekeza School
Kraal(s)	Munjanja(38); Mamutse(53); Mushava(50); Tovana(40); Chakavata(12)
VIDCO (Chairman)	Manyanga(Mr Zimuto); Chiszimbi(Mr Mdambakuwa) Mujurwi(Mr Gomo)
Grid Reference	Map 2031 C2; 277 159 31°21'E 20°39'S
Initial Site ID by:	AEW, following work at Makwevera nearby
Site Location	Centre of population and activity on main dirt road Chivamba-Zinwana.
Landform / Catchment	Sloping valley side, Mashavutwana catchment extending 2km upstream.
Geology	Younger mobile belt gneiss
Community Structure	5 sub-kraals in 3 VIDCO's radius 5km plus primary and secondary schools
Present Water: Domestic Gardening	Single B/hole at school, second at dip tank 3km, good yield but heavy pressure. 2 school gardens, 1 community garden (12) at Dekeza B/hole, 1 community garden at dip tank
Previous Gardens	As above, but much reduced during drought due to extremely heavy demands placed on B/holes.
Present Vegetables	School gardens provide some
Community Enthusiasm	Excellent, meetings well attended: Chief Bota, Sub-Chief Dekeza, 4 kraal heads, 2 VCW's, Headmasters, businessman, 50 men and 25 women.
To serve: Domestic Gardening	To avoid queue at B/holes Priority, estimate 100 families plus schools
Land Allocation	Sub Chief Dekeza confirmed with local leaders
Market Opportunities	Good; businessman Mr Maweri to Jerera daily.
Other factors	Gardening education in Prim. School compulsory for 996 pupils, in Sec School 363 study at O'level. Catchment is scene of particularly severe deforestation on upper slopes.
Overall Impression	Small, contained catchment, poor management; opportunity to compare collector well where B/hole yield high but limited by single pump; opportunity to assess scheme that serves both families of several kraals and two schools.
Recommendation	Shortlist for exploratory drilling as site #3

APPENDIX 4: WATER QUALITY ANALYSIS PERFORMED BY GOVERNMENT
ANALYST'S LABORATORY

To : O.J. Lovell

Sample : Muzondidya

Odour : odourless

Colour : yellowish tinge

General Appearance : opalescent

Suspended Matter : small amounts

Sediment : small amounts

Note : N.D. = not detected

Parameter	Unit	Guideline value WHO. (1984)	Actual Results	Comment
pH		6.5 - 8.5	8.5	
Colour	T.C.U.	15	10.0	
Turbidity	N.T.U.	5	1.0	
Specific Conductivity	mSm ⁻¹		34.2	
App. T.D.S.	mg/l*	1 000	200.1	
Lime Hardness	mg/lCaCO ₃		67.5	
Total Hardness	mg/lCaCO ₃	500	149.6	
Alkalinity	mg/lCaCO ₃		178.0	
Chloride	mg/lCl	250	16.1	
Sulphate	mg/lSO ₄ ²⁻	400	2.3	
Nitrate- Nitrogen	mg/lNO ₃ - N	10	0.4	
Bicarbonate	mg/lHCO ₃ ⁻		217.2	
Fluoride	mg/lF	1.5	0.2	
Sodium	Na mg/l	200	26.0	
Potassium	mg/l K ⁺		1.6	
Magnesium	mg/l Mg ²⁺	150	17.0	
Calcium	mg/l Ca ²⁺	250	27.0	
Iron	mg/l Fe ³⁺	0.3	1.2 *	
Manganese	mg/l Mn ⁴⁺	0.1	0.1	

District :-

Grid Reference :-

WATER QUALITY ANALYSIS PERFORMED BY GOVERNMENT ANALYSTS LABORATORY

To : C.J. Lovell

Sample : Gokota

Odour : odourless

Colour : colourless

General Appearance : clear

Suspended Matter : none

Sediment : none

Note : N.D. = not detected

Parameter	Unit	Guideline value WHO (1984)	Actual Results	Comment
pH		6.5 - 8.5	8.3	
Colour	T.C.U.	15	0.0	
Turbidity	N.T.U.	5	0.9	
Specific Conductivity	mSm ⁻¹		27.1	
App. T.D.S.	mg/l*	1 000	158.5	
Lime Hardness	mg/lCaCO ₃		90.3	
Total Hardness	mg/lCaCO ₃	500	99.0	
Alkalinity	mg/lCaCO ₃		127.1	
Chloride	mg/lCl	250	10.9	
Sulphate	mg/lSO ₄ ²⁻	400	0.5	
Nitrate- Nitrogen	mg/lNO ₃ - N	10	0.5	
Bicarbonate	mg/lHCO ₃ ⁻		155.1	
Fluoride	mg/lF	1.5	0.1	
Sodium	Na mg/l	200	23.0	
Potassium	mg/l K ⁺		1.3	
Magnesium	mg/l Mg ²⁺	150	11.0	
Calcium	mg/l Ca ²⁺	250	26.9	
Iron	mg/l Fe ³⁺	0.3	0.9 *	
Manganese	mg/l Mn ⁴⁺	0.1	ND	

District :-

Grid Reference :-

WATER QUALITY ANALYSIS PERFORMED BY GOVERNMENT ANALYSTS LABORATORY

To: C.J. Lovell

Sample: Dekeza School

Odour: odourless

Colour: yellowish tinge

General Appearance: slightly opalescent

Suspended Matter: none

Sediment: none

Note: N.D. = not detected

Parameter	Unit	Guideline value WHO (1984)	Actual Results	Comment
pH		6.5 - 8.5	7.3	
Colour	T.C.U.	15	2.5	
Turbidity	N.T.U.	5	2.6	
Specific Conductivity	mS m^{-1}	4	27.2	
App. T.D.S.	mg/l^*	1 000	159.1	
Lime Hardness	mg/l CaCO_3		62.5	
Total Hardness	mg/l CaCO_3	500	129.4	
Alkalinity	mg/l CaCO_3		147.5	
Chloride	mg/l Cl	250	16.1	
Sulphate	mg/l SO_4^{2-}	400	2.0	
Nitrate- Nitrogen	$\text{mg/l NO}_3 - \text{N}$	10	0.5	
Bicarbonate	mg/l HCO_3^-		178.0	
Fluoride	mg/l F	1.5	0.1	
Sodium	Na mg/l	200	17.0	
Potassium	mg/l K^+		0.2	
Magnesium	mg/l Mg^{2+}	150	15.5	
Calcium	mg/l Ca^{2+}	250	24.7	
Iron	mg/l Fe^{3+}	0.3	0.4 *	
Manganese	mg/l Mn^{4+}	0.1	N.D.	

District :-

Grid Reference :-

WATER QUALITY ANALYSIS PERFORMED BY GOVERNMENT ANALYSTS LABORATORY

To : C.J. Lovell

Sample : Nemauka B/C

Odour : odourless

Colour : ~~white~~ milky

General Appearance : opalescent

Suspended Matter : large amounts

Sediment : large amounts

Note : N.D. = not detected

Parameter	Unit	Guideline value WHO (1984)	Actual Results	Comment
pH		6.5 - 8.5	8.3	
Colour	T.C.U.	15	20.0 *	
Turbidity	N.T.U.	5	114.0 *	
Specific Conductivity	mSm ⁻¹		42.8	
App. T.D.S.	mg/l*	1 000	250.4	
Lime Hardness	mg/lCaCO ₃		96.4	
Total Hardness	mg/lCaCO ₃	500	137.5	
Alkalinity	mg/lCaCO ₃		244.1	
Chloride	mg/lCl	250	13.3	
Sulphate	mg/lSO ₄ ²⁻	400	2.3	
Nitrate- Nitrogen	mg/lNO ₃ - N	10	4.0	
Bicarbonate	mg/lHCO ₃ ⁻		297.8	
Fluoride	mg/lF	1.5	0.8	
Sodium	Na mg/l	200	48.0	
Potassium	mg/l K ⁺		3.9	
Magnesium	mg/l Mg ²⁺	150	11.5	
Calcium	mg/l Ca ²⁺	250	36.7	
Iron	mg/l Fe ³⁺	0.3	0.7 *	
Manganese	mg/l Mn ⁴⁺	0.1	ND	

District :-

Grid Reference :-

APPENDIX 5. BASELINE HOUSEHOLD SURVEYS

Farms and households in Semende, Maranele, Manyetu, Gachiti and Muzondidya Kraals, prior to the installation of a Collector Well in 1993.

M.W. Brown and T. Dube June 1993

1. Introduction

As part of the pilot project entitled "Small scale irrigation using Collector Wells" it is planned to establish six wells each with a community garden at selected sites in the communal farming areas of Masvingo Province, Zimbabwe. A Collector Well is a large diameter hand dug well whose yield is enhanced by radial drilling. The project is being implemented jointly by Agritex*, the Lowveld Research Stations**, the Institute of Hydrology (U.K.) the British Geological Survey and supported by the Overseas Development Administration of the U.K.

This is the report of the baseline study for the first of the six Collector Well gardens. It is intended to describe social, economic and agricultural aspects of life at the five villages which are to be served by this first Collector Well. They are intended as a source of baseline data against which future monitoring and evaluation of the project can be carried out. They are also designed to elicit people's feelings on how the project should be implemented.

The five villages are situated in Zaka Communal Lands in the semi-arid south east of Zimbabwe (Natural Region IV) at an altitude of approximately 600 metres. The construction of this Collector Well commenced in April 1993.

2. Methodology

It was decided to gather information by means of a single visit household survey. Each village in the proposed project area supplied a list of households from which a random selection of 30 was made with the number of sample households per village being in proportion to the total for the village. In order to be seen to be fair and to give local leaders a prominent role, selection was done by Kraalheads drawing names out of a hat in front of assembled villagers. At the same meeting, the purpose and logistics of the survey was explained and discussed. The survey was conducted over one week by an experienced enumerator*** from the Lowveld Research Stations, assisted by a guide supplied by the community and the Agricultural Extension Worker. The questionnaire used is given in Appendix 6 of the first progress report.

The persons interviewed depended on who was available from each household on the day of the interview. This resulted in a mixture of male and/or female respondents as shown in the following Table 1.

* Department of Agricultural, Extension and Technical Services and

** Department of Research and Specialist Services. Both Ministry of Lands, Agriculture and Water Development, Zimbabwe

*** Terence Dube, Agricultural Assistant, Chisumbanje Experiment Station

Table 1. Identities of survey respondents

Respondents	Per cent of households
Men only	27
Women only	40
Men and women	33

From the above it can be seen that a reasonable balance between male and female points of view in answering the questionnaire was achieved. In 84 per cent of cases the interview was with the household head and/or the spouse. In the remaining 16 per cent they were represented by one or other members of the family (son, daughter, father or uncle).

Overall, this methodology worked well. The random selection procedure resulted in a range of households which differed on the bases of size, wealth, and local standing amongst other things. All selected households proved willing to be interviewed and the answers given were generally felt to be plausible with a few exceptions which are discussed below. A number of respondents proved exceptionally helpful and these have been taken note of for possible inclusion in later case studies and/or as key informants during project monitoring.

3. Social aspects

3.1 Family size and labour force

The following Table 2 depicts the average composition of sample households.

Table 2. Household composition

	Average number per household:	
	Total	Available full-time for work on family home and farm
Men	2.5	1.6
Women	2.5	2.1
Children (5-15)	3.2	0.2
Infants	1.0	0
Totals	9.2	3.9

It was found that 35 per cent of men are away working of whom 19 per cent are in the lowveld at either the Triangle sugar estates or Chiredzi. Most of the remainder are in one or other of the main urban centres of Zimbabwe. Just seven per cent of women were said to be away working (all in the lowveld) with a further eight per cent attending school. Overall, 53% of households have at least one member earning a full-time income away from the family farm. Of the children, 94 per cent are attending school and so are only available to help out on a part-time basis.

The numbers of people available to help out full-time on the household, farming and gardening tasks are therefore correspondingly reduced with women becoming

relatively more important. Furthermore, the averages conceal the fact that in 23 per cent of households there is no man permanently present. In 10 per cent of households the head is a woman.

On the basis of appearances, 83 per cent of respondents were estimated to be in the middle age range of between 30 and 60 years with ten per cent over 60 and 7 per cent under 30.

3.2 Indicators of wealth

Eighty per cent of families occupy traditional style compounds of pole and dagga huts while 20 per cent live in predominantly modern style homesteads constructed with bricks and asbestos roofs.

The main items of capital owned by farmers are livestock and implements. Livestock ownership was said to have been dramatically affected by the drought of 1991-92 as the following Table 3 shows.

Table 3. Livestock ownership

	Cattle:		Donkeys:		Sheep:		Goats:	
	Pre- 1992	Now	Pre- 1992	Now	Pre- 1992	Now	Pre- 1992	Now
Per cent farmers owning	63	7	7	3	23	10	77	57
Total head (sample families)	347	2	14	3	45	4	219	54

Prior to the latest drought, cattle were the main source of draught power and store of wealth with 63 per cent of households owning some. The total figure however is distorted by one farmer (a Kraalhead) who was said to have owned around 200 head. Goats appeared to have survived better and 20 per cent of respondents commented that the numbers were reduced through the need to sell them so as to buy food rather than through starvation.

The main implement (after the hand hoe) is the animal drawn plough which is owned by 60 per cent of households though the average number per household has fallen slightly from 1.5 before the drought to 1.3 today. Ten per cent of households each own an animal drawn "Scotch" cart.

Based on these indicators of wealth, 30 per cent of households were judged to be relatively "well off" in comparison to the remaining 70 per cent.

3.3 Health

There was general agreement that the two main problems are malaria which is associated with the rains and mosquitoes, and stomach aches which are said to be common at harvest time and are attributed to the over-eating of green maize. One respondent commented on the importance of vegetables for promoting good health.

3.4 Vegetable consumption

The majority of households (73 per cent) consume fresh vegetables mainly during the rainy season, usually from October to May. This is a reflection of the fact that the most common source of fresh vegetables (quoted by 87 per cent of

households) are the rainfed arable fields where farmers inter crop with a range of cucurbits, particularly pumpkins, water melons and cucumbers. Gathering of wild vegetables is also said to be an important source at this time for 30 per cent of households.

The potential benefits of a new community garden can be gauged from the fact that 66 per cent of households said that purchased vegetables constitute an important source of supply while just 23 per cent said that their own gardens are an important source. Furthermore only 13 per cent of households consume fresh vegetables throughout the year (and not every day), while 13 per cent say that they rarely if ever consume fresh vegetables.

For all households, the main period of scarcity is said to be the dry season; from June until the rains begin which is normally from September to November. It is hoped that the Collector Well can help fill this gap by enabling winter production of vegetables from the community garden. At present during this time households consume some dried vegetables if they had a surplus or could afford to buy. Cowpea leaves are favoured for this purpose but the quantities available this season have been less due to a shortage of seed.

3.5 Community problems

Respondents were unanimous that shortage of water was the main problem besetting the community. Fifty per cent of households said that they did not normally have sufficient for domestic use while 13 per cent remarked that the nearest borehole is far from their homesteads. The average daily water requirement for domestic use was found to be 130 litres per household.

However just one household (three per cent) said that if more water became available the first priority would be for domestic use, the remaining 97 per cent said that any extra water would be used for gardening including two respondents (seven per cent) who said that water would also be used for trees. The other main use would be for the moulding of bricks (60 per cent of households) both for sale and for the construction of houses since there was said to be a shortage of building poles. However possible adverse environmental effects need to be monitored since brick kilns make demands on forests for firewood. Brewing of beer was the only other potential use, mentioned by one respondent.

4. Economic activity

4.1 Rainfed farming

All households engage in rainfed cropping which is the principal form of economic activity in the area. The areas cropped and yields said to be obtained by farmers during a "normal" year are presented in the following Table 4 together with the estimated Gross values of production based on 1992-93 GMB prices.

Table 4. Cropping patterns

Crop	Per cent farmers sowing	Per cent total crop area	Average crop area hectares per farm	Average yield Kg ha ⁻¹	Average Gross Income \$ per farm
Maize	97	58	0.98	1 337	1 179
Finger millet	77	16	0.28	1 126	164
Sorghum	70	15	0.26	1 028	139
Sunflower	20	6	0.06	703	62
Pearl millet	10	2	0.04	948	20
Cotton	7	5	0.08	1 083	261
Totals			1.70		1 825

The major crop is maize, the staple food with sorghum and finger millet of more importance for beer but with sorghum coming into its own during drought years together with pearl millet. The cash crops, cotton and sunflower are of relatively little significance as is groundnut which is cultivated by seven per cent of farmers on a negligible area. The computed figures for average yields are realistic for rainfed crops in Natural Region IV. They suggest that in an average year, each farm household produces 1.9 tonnes of grain which is sufficient to meet the average annual requirement of 1 tonne per family and leave some in reserve towards meeting the shortfall in a drought year or be sold for cash.

Farm sizes are small at an average of 1.7 hectares per household and are only approximate since they are based on estimates made by farmers as it was not practical to measure the fields. There is some variability in cropped areas per household as the following Table 5 shows.

Table 5. Distribution of average cropped areas

Range hectares	Per cent of households
0.1-1	40
1.1-2	20
2.1-3	23
3.1-4	13
Over 4	3

The distribution is somewhat uneven in that the smallest 40 per cent of farms occupy 12 per cent of the total cropped area while the largest ten per cent take up 25 per cent. However, the differences are not that great since even the largest farm is only 5.7 hectares followed by the second largest at 3.7 hectares.

The figures for gross incomes are likely to be close to net incomes since the only significant input costs are for hybrid maize seed and seed and agro-chemicals for cotton which few farmers cultivate. The resulting gross farm

income per year can therefore be interpreted as the reward to the farm family for its inputs of labour which it expended in growing the crops. The figure of \$1 825 is similar to one year's wages from unskilled employment though such job opportunities are extremely limited in the local area. However this average hides a relatively wide variation in crop incomes as the following Table 7 shows

Table 7. Distribution of average incomes from rainfed cropping

Range \$	Per cent of households
1-1 000	40
1 001-2 000	27
2 001-3 000	20
3 001-4 000	3
Over 4 000	10

The distribution is skewed with the poorest 40 per cent of households accounting for 11 per cent of the total incomes earned from rainfed cropping and averaging less than \$1 000 each. The richest 10 per cent, who average over \$4 000 each, account for 34 per cent of the total income.

There is a heavy dependence on labour as a source of farm power particularly since the losses of draught animals during recent drought years. Ploughing and sowing was said to be the main labour peak for 63 per cent of households. Depending on the rains, this can be carried out from October to February. The remaining 37 per cent named harvest as the busiest time plus a further 20 per cent who named it as second only to ploughing and sowing. It normally commences in January and finishes by the end of May.

The extent to which labour is a constraint can be gauged by the fact that 53 per cent of households reported that at times they make use of non family labour; either on a casual basis (37 per cent), or full-time (three per cent) or on an exchange basis (13 per cent). The latter is the traditional "nhimbe" labour when people work in groups for each other (particularly weeding and harvesting) with beer and food supplied in turn by the host family. Outside labour was said to be used for weeding (37 per cent), harvest (30 per cent) and ploughing and sowing (7 per cent). Some of this is in the form of exchange labour with one woman commenting that it had been useful for ploughing and sowing due to a shortage of draught animal power following the drought.

4.2 Gardening

The popularity of vegetable gardening is evident from the fact that 77 per cent of respondents practise gardening. A further 10 per cent are believed to have gardens though they did not admit to it, possibly in the belief that this would have lessened their chances of joining the Collector Well garden. The remaining four households (13 per cent) have never had gardens, three because they are new to the area and one due to ill health.

Table 8. Main vegetables cultivated

Vegetable	Per cent of households
Rape	73
Tomatoes	67
Cabbage	30
Covo	13

The range of vegetables grown is limited and suggests the potential for research and extension to widen peoples' choice in the Collector Well garden. Most of the garden produce is or was destined for home consumption as the following Table 9 shows.

Table 9. Main uses of garden vegetables

	Per cent of households
all or mainly home consumed	47
part consumed/part sold	30
all or mainly sold	0
no garden or no response	23

As the following Table 10 shows, gardening is primarily a female occupation.

Table 10. Garden management and labour

Persons responsible	Per cent of households:	
	Decision maker	Labour
wife/daughter	60	57
male household head	10	3
husband and wife	3	7
Co-operative	3	-
all family	-	7
wife and children		3

The main water sources for the 77 per cent who admitted to experience of gardening are as in the following Table 11.

Table 11. Water sources for gardens

Source	Per cent of households
well	33
river bed/pool	30
river bed & well	10
borehole	4

Most gardening (57 per cent) is practised during the winter months; beginning in May, once the harvest of rainfed crops is complete and ending with the commencement of land preparation for the next rainfed cropping season in August/September. Just 17 per cent maintained their gardens all year. The reason given by respondents for the restriction on the season was a shortage of labour during the summer months due to the demands of rainfed cropping. Also, as was pointed out earlier, at this time vegetables are available from rainfed fields and the wild. It is also the case that pests and diseases are more prevalent during the wet summer months while the availability of water in wells and the river bed is at its greatest in the months following the end of the rainy season.

The importance of pests and diseases is supported by the fact that these were said to be the main gardening problems for 73 per cent of respondents. Perhaps surprisingly, theft was the second most important problem (47 per cent) ahead of water at 40 per cent with shortage of seed; three per cent.

These observations need to be taken into consideration when planning the setting up and running of the proposed community gardens.

4.3 Household incomes and expenditure

The main sources of income ranked by households are as shown in the following Table 12.

Table 12. Main sources of household income

Source	Numbers of farmers ranking:			Total points*
	First	Second	Third	
Farm produce	15	1	0	47
Beer brewing	8	4	2	34
Vegetables	3	2	2	15
Remittances	1	3	2	11
Off-farm employment	2	2	0	10
Miscellaneous	0	4	0	8
No response	1	14	24	

* Based on three points for first, two points for second and one point for third.

The importance of rainfed cropping can be seen by the top ranking of sales of farm produce which is said to be the most important source of income for 50 per cent of households and by the brewing of beer using local sorghum and millet as a clear second. The potential importance of gardening as a source of income can be seen by the numbers who rank selling of vegetables as important. Sources of off farm employment consisted of labouring for other farmers, and traditional healing while miscellaneous comprised knitting, selling tobacco, poultry and basketry.

There was less variation in what people judged to be their main items of expenditure as the following Table 13 shows.

Table 13. Main items of expenditure

Item	Numbers of farmers ranking:			Total points
	First	Second	Third	
Food	27	3	0	87
Clothing	0	15	12	42
School fees	3	11	9	40
casual labour	0	0	2	2
No response	0	1	7	

* Based on three points for first, two for second and one for third

The basic necessities of food and clothing are the dominant items reflecting the fact that this is a traditional rural community situated in a semi-arid environment where crop failures due to drought are frequent. School fees are the only significant non-traditional item of expenditure. Since vegetables are an important component of the traditional diet so the Collector Well garden might be expected to make a significant contribution towards improving the family budget. If there is a surplus of vegetables then their income earning potential might be expected to contribute towards the purchase of clothing and school fees and, in the event of a drought year, staple foodstuffs.

5. Institutional considerations

5.1 Importance of local institutions

In order for any development scheme to succeed it is necessary to know the identities of local leaders and to have their support. The relative importance of different institutions can vary from place to place often depending on the personalities of the characters involved. The following Table 14 shows the institutions which are regarded by respondents as the most important in this collection of villages.

Table 14. Recognition of importance of local institutions

Institution	Per cent of households
Village Councillor	43
VIDCO Chairman	40
Kraalheads	23
Agritex	20
Headmaster	3

5.2 Positions of leadership held by sample households

The following Table 15 shows the numbers of households who have a member of the family or relative who holds a local position of responsibility.

Table 15 Local leadership positions held

Position	Per cent of households
Kraalhead	30
Feeding scheme leader	23
Garden committee member	7
VIDCO chairman	3

It will be interesting to observe whether there is any correlation between a family being well connected and its probability of becoming a member of the Collector Well Garden. Overall 50 per cent of households have at least one member or relative in a position of leadership.

5.3 Exposure to agricultural extension

Twenty three per cent of households have one or other of their members attending Master Farmer training classes and a further ten per cent are already qualified as Master Farmers. In addition, three households (ten per cent) have relatives who have received agricultural training through working as an Agricultural Extension Worker, as a General Hand at Chiredzi Research Station and for the Veterinary Services Department respectively. The main extension messages which respondents have found useful are listed in the following Table 16.

Table 16 Recall of Extension advice

Message	Per cent of households finding of use
Contour channels/bunds for erosion control	77
Fertilizer application	40
Various cultivation practices	30
Terracing of steep slopes	3
Nothing	7

Construction of bunds and channels on the hillsides has been a long established extension message in the country. By aligning them at a slight angle to the contours they are intended to direct run-off water away from fields and into established drainage systems with the aim of preventing soil erosion. The interest in fertilizer application has probably been enhanced by free Government issues made during the 1992-93 season. Amongst the cultivation practices, plant spacing for maize was most commonly cited with the importance of crop rotation and sowing time also mentioned. Only seven per cent claimed not to have received any benefit. Of relevance to the Collector Well scheme is the fact that no mention was made of any extension advice relating to vegetables, gardening or irrigation practices.

5.4 Experiences of other community development schemes

The only two schemes which respondents were aware of are both connected with efforts to mitigate the effects of the 1992-93 drought. These are the feeding scheme for children and the Food for Work programme. There was general

agreement that these schemes had encouraged people to appreciate the virtues of working together, punctuality and cleanliness when handling food; all of which should stand them in good stead in the Collector Well scheme. One respondent noted that the feeding of beans and groundnuts to children improved their health.

6. Attitudes and expectations towards the Collector Well scheme

All respondents were aware of the scheme and are eagerly awaiting its inception with high expectations. Ninety three per cent of respondents expressed a willingness to join a community garden with only old age and ill health preventing the remainder. The majority of respondents believe that membership of the garden should be decided by established community leaders:

Table 17. Determination of garden membership

Decision maker on who should become members	Per cent of households*
Kraalheads	37
"The community"	27
VIDCO chairman	27
Garden committee/chairman	24
Agritex	3
The Councillor	3

* Some households named more than one decision maker

There is however a significant majority (27 per cent) who advocate that "the community" themselves should decide on membership though the mechanism by which this would be carried out and criteria to be used were not discussed. These issues are worthy of further exploration to find out what roles if any are played by such considerations as wealth, need, chance and democracy.

People were unanimous in the belief that the scheme should be managed by "the people" but with opinion more divided on who should assume the role of leadership. A garden committee has already been chosen "by the people" though the exact mechanisms of this process are not known) and 40 per cent think that responsibility for management should rest with this body. Thirty three per cent suggested Agritex and 21 per cent, a combination of the two. The Councillor and Kraalheads were named by three per cent each. However in practice it seems that the influence of the Kraalheads will be greater than this since they have combined to form their own committee to monitor the activities of the garden committee. It was encouraging to learn that 80 per cent of respondents expressed a willingness to become involved in the management themselves.

The following Table 18 shows the main benefits which people anticipate.

Table 18. Main expected benefits

Benefit	Per cent of households
Opportunity to grow vegetables to eat	83
Opportunity to grow vegetables to sell	80
Cleaner source of domestic water	76
More reliable source of domestic water	70
Closer source of drinking water	40
Water for livestock	40

From the above it can be seen that gardening is expected to be the main benefit from the well though cleaner and more reliable domestic water is also rated highly. The lower priority given to proximity of supply suggests a potential disadvantage of opting for a single high yielding water source as opposed to several lower yielding but more widely distributed traditional wells. Watering of livestock is also seen as a relatively less important benefit possibly due to the fact that numbers are still low after the drought.

Potential difficulties which might be encountered in the implementation of the scheme are shown in the following Table 19.

Table 19. Potential problems

Problem	Per cent of respondents
Breakdowns	30
Pests and diseases	17
Shortage of cash to buy inputs	13
Labour shortage	10
Disagreements	3
No problems	57

Breakdowns are seen as the main potential problem and will need to be taken into account in the project design as for example has been done at the first scheme in Chivi where a gantry was built for removal of the pumps, and members have been given training in their repair and maintenance and encouraged to purchase the necessary tools. The importance of plant protection has already been highlighted in the context of existing gardens and will need to be a priority for Extension. The importance of raising funds both to pay for inputs and repairs and maintenance will also need to be emphasised. A promising sign is that respondents are prepared to contribute an average of \$1.42 per household per month towards the upkeep of the scheme. Early indications are that membership of the garden could be as many as 100 families, in which case a total of \$ 1 704 per year could be raised to meet these needs.

All respondents commented that the proposed garden area is small in relation to the numbers of families who want to join the scheme.

Farms and households in Gokota area, prior to the installation of a Collector Well in 1993.

M.W. Brown and T. Dube June 1993

1. Introduction

The site for this Collector Well is named after a local hill and covers the kraals of Gwindingwe, Chipato, Njaya, Chikoho, Maroyi and Guvanye Kraals. Together they have a population of 263 households.

2. Methodology

The survey was conducted in May 1993 amongst 30 randomly selected households.

Table 1. Identities of survey respondents

Respondents	Per cent of households
Men only	17
Women only	63
Men and women	20

From the above it can be seen that there was a bias towards women and wives in particular who accounted for 47 per cent of respondents. In 87 per cent of cases the interview was with the household head and/or the spouse. In the remaining 16 per cent they were represented by one or other members of the family (mother, sister or brother).

3. Social aspects

3.1 Family size and labour force

The following Table 2 depicts the average composition of sample households.

Table 2. Household composition

	Average number per household:	
	Total	Available full-time for work on family home and farm
Men	2.1	1.0
Women	2.2	1.9
Children (5-15)	2.2	0
Infants	1.7	0
Totals	8.2	2.9

Fifty seven per cent of men are unavailable for full time farm work either because they are away working at a variety of locations (28 per cent) or are attending school (29 per cent). Fifteen per cent of women are away but only three per cent are working, the remainder attend school. Overall, 47% of

households have at least one member earning a full-time income away from the family farm. All the children are attending school. Again women make up a majority of the labour force with 23 per cent of households being without a man full-time, though just one household (three per cent) is headed by a woman.

On the basis of appearances, 73 per cent of respondents were estimated to be in the middle age range of between 30 and 60 years with 17 per cent over 60 and ten per cent under 30.

3.2 Indicators of wealth

Fifty three per cent of families occupy traditional style compounds of pole and dagga huts, 27 per cent live in predominantly modern style homesteads constructed with bricks and asbestos roofs and the remaining 20 per cent occupy compounds containing a mixture of the two styles.

The main items of capital owned by farmers are livestock and implements. Livestock ownership was said to have been dramatically affected by the drought of 1992-93 as the following Table 3 shows.

Table 3. Livestock ownership

	Cattle:		Donkeys:		Sheep:		Goats:	
	Pre-1992	Now	Pre-1992	Now	Pre-1992	Now	Pre-1992	Now
Per cent farmers owning	77	20	7	7	7	7	77	53
Total head	227	10	9	9	8	7	217	74

Distribution of cattle is more equal than at the first site with 38 being the highest number of head per household though this may be explained by the fact that no Kraalhead is included in this sample

The main implement (after the hand hoe) is the animal drawn plough which is owned by 73 per cent of households with an average of 1.2 each. Animal drawn "Scotch" carts are owned by 23 per cent of households (one each). Based on these indicators of wealth, 76 per cent of households were judged to be "average" with seven per cent relatively affluent and 17 per less well off.

3.3 Health

Malaria is again the universal malady with stomach aches at harvest noted as a problem by 27 per cent of respondents.

3.4 Vegetable consumption

Table 4. Frequency of vegetable consumption

Frequency	Per cent of households
Mainly during the summer	97
All year	3

Almost all households are only able to consume vegetables on a frequent basis during the summer months when they practise inter-cropping of cucurbits with their rainfed crops. This is reflected in the following Table 5 which shows the main sources of supply

Table 5. Main sources of vegetables

Source	Per cent of households
Rainfed fields	100
Buy from others	90
Wild	55
Own garden	20

The importance of rainfed vegetables is clear from the above Table 5 supplemented by gathering of wild vegetables which also grow during the summer. The potential benefits of the Collector Well garden can be seen from the high percentage of families who need to buy vegetables and the small number who can depend on their existing gardens as significant sources of supply. As might be expected from the above observations, the main period of scarcity is said to be the winter months of May to September. Vegetables are commonly dried for consumption during this time.

3.5 Community problems

Shortage of water was again said to be the main problem afflicting the community though it is more of a constraint for vegetable gardening than for domestic use with only 13 per cent of respondents saying that they did not normally have sufficient for this purpose. Average daily water requirement was found to be 120 litres per household. However 13 per cent of respondents commented that the existing borehole is unreliable as the pump is prone to breakdowns and a similar percentage pointed out that it is distant (two kilometres was mentioned) from their homes. One respondent noted that existing private wells are prone to collapse. As a result, 100 per cent of households said that any extra water would be used for vegetable gardening and 94 per cent for brickmaking. Shortage of firewood and cattle were mentioned as problems by one household each.

4. Economic activity

4.1 Rainfed farming

All households engage in rainfed cropping which is the principal form of economic activity in the area. The areas cropped and yields said to be obtained by farmers during a "normal" year are presented in the following Table 6 together with the estimated Gross values of production based on 1992-93 GMB prices.

Table 6. Cropping patterns

Crop	Per cent farmers sowing	Per cent total crop area	Average crop area hectares per farm	Average yield Kg ha ⁻¹	Average Gross Income \$ per farm
Maize	93	46	0.70	1 738	1 077
Finger millet	93	31	0.46	1 567	379
Sorghum	63	7	0.12	1 600	104
Pearl millet	37	6	0.08	1 644	37
Sunflower	33	4	0.06	1 137	107
Groundnut	13	2	0.03	1 033*	36
Cotton	10	4	0.06	659	120
Totals			1.51		1 860

* Unshelled

Maize is the main crop reflecting its position as the preferred staple while finger millet is favoured for brewing of beer. Sorghum is also popular for beer and for its drought tolerance as is pearl millet to a lesser extent. A number of farmers are cultivating sunflower as a cash crop though judging by the small areas it is still at an experimental stage. Cotton and groundnuts are minor cash crops.

The computed figures for average yields appear high, possibly due to the influences of the previous season which was relatively good and/or the underestimation of crop areas which appear to be on the low side. Total average annual grain production at 2.26 tonnes per household is sufficient for two years consumption. There is some variability in cropped areas per household as the following Table 7 shows.

Table 7. Distribution of average cropped areas

Range hectares	Per cent of households
0.1-1	27
1.1-2	47
2.1-3	23
3.1-4	3

The distribution is more equal than at the first site in that the smallest 40 per cent of farms occupy 18 per cent of the total cropped area while the largest ten per cent take up 20 per cent. The largest farm is only 3.2 hectares.

The average gross crop income at \$1 860 is similar to that computed for other sites and is again close to net income since the only significant purchased input is hybrid maize seed. The following Table 8 suggests that the distribution is skewed.

Table 8. Distribution of average incomes from rainfed cropping

Range \$	Per cent of households
1-1 000	27
1 001-2 000	37
2 001-3 000	10
3 001-4 000	16
Over 4 000	10

The poorest 40 per cent of households earn 15 per cent of the total gross income from rainfed cropping and average \$ 690 per family. This compares to the richest ten per cent who account for 24 per cent of total incomes and average \$4 544 per family.

Labour is in greatest demand during the time of ploughing and sowing for 60 per cent of households followed by harvest (33 per cent) and weeding (17 per cent). Non-family labour is called upon at times by 53 per cent of households including ten per cent which is repaid on an exchange basis ("Nhimbe" labour). Also included in this figure are two households (seven per cent) who employ one permanent male worker and two maids respectively. As the following Table 9 shows, it is weeding for which non-family labour is most commonly used.

Table 9. Uses of non-family labour

Use	Per cent of households	
	Hired	Exchange
Weeding	33	10
Harvest	30	-
Ploughing/sowing	17	-

4.2 Gardening

Ninety seven per cent of households have gardens though many respondents pointed out that they are small due to limited water. Only one respondent is prevented from having one now by old age.

Table 10. Main vegetables cultivated

Vegetable	Per cent of households
Rape	97
Tomatoes	87
Cabbage	70
Onion	13
Covo	3
Sugar cane	3

The range of vegetables grown is limited and suggests the potential for research and extension to widen peoples' choice in the Collector Well garden.

Most of the garden produce is destined for home consumption as the following Table 11 shows.

Table 11. Main uses of garden vegetables

	Per cent of households
all or mainly home consumed	53
part consumed/part sold	43
all or mainly sold	0
no garden	3

As the following Table 12 shows, gardening is primarily a female occupation.

Table 12. Garden management and labour

Persons responsible	Per cent of households:	
	Decision maker	Labour
wife/other family women	87	90
male household head	7	-
husband and wife	3	3
all family	-	3

The main water sources for gardening are as in the following Table 13.

Table 13. Water sources for gardens

Source	Per cent of households
well	33
borehole	33
river bed & well	10
well/borehole	10
river bed/pool	7
small dam	3

The majority of gardens are dependent for water on private wells or the community borehole. Garden water from the latter is said to be rationed to between two and four 20 litre containers per day (though whether this is normal or related to the recent drought needs confirmation). Consequently most respondents pointed out that their gardens are small. Only one respondent mentioned the small dam which supports a community garden at Njaya Kraal though it is believed that others may have been reluctant to disclose their participation in this for fear of prejudicing their chances of joining the Collector Well garden. Similarly there is known to be a second community garden which is supported by the borehole at Rudanda school.

Cultivation of gardens is confined to the winter months for 80 per cent of

respondents due to a shortage of labour during the rainfed cropping season. However 17 per cent are able to garden all year round. Pests and diseases were said to be the main gardening problems for 93 per cent of respondents followed closely by shortage of water on 90 per cent. As well as water rationing, the borehole is said to suffer from frequent breakdowns. Theft is also a problem here for 33 per cent of respondents.

These observations need to be taken into consideration when planning the setting up and running of the proposed community gardens.

4.3 Household incomes and expenditure

The main sources of income ranked by households are shown in the following Table 14.

Table 14. Main sources of household income

Source	Numbers of farmers ranking:			Total points*
	First	Second	Third	
Remittances	13	4	0	47
Farm produce	11	2	1	38
Beer brewing	1	4	0	11
Brick making	1	0	0	3
Vegetables	0	1	0	2
Casual farm labour	0	1	0	2
Knitting	0	0	1	1
No response	4	18	28	

* Based on three points for first, two points for second and one point for third.

The large numbers of family members who are away from home working is reflected in the importance of remittances as the main source of household income. Rainfed cropping however is still important with sales of produce a clear second followed by brewing of beer. Other activities are of relatively minor significance. There was again little variation in what people judged to be their main items of expenditure as the following Table 15 shows.

Table 15. Main items of expenditure

Item	Numbers of farmers ranking:			Total points
	First	Second	Third	
Staple food	26	3	0	84
School fees	3	10	7.5	36.5
Clothing	0	9	15	33
vegetables	0	6	0	12
casual labour	1	1	1.5	6.5
No response	0	1	6	

* Based on three points for first, two for second and one for third

The basic necessities of staple foodstuffs and clothing are the dominant items reflecting the fact that this is still a traditional rural community with school fees being the only significant non-traditional item of expenditure. The importance of vegetables as an item of expenditure suggests a potential benefit for the community garden.

5. Institutional considerations

5.1 Importance of local institutions

In order for any development scheme to succeed it is necessary to know the identities of local leaders and to have their support. The relative importance of different institutions can vary from place to place often depending on the personalities of the characters involved. The following Table 16 shows the institutions which are regarded by respondents as the most important in this collection of villages.

Table 16. Recognition of importance of local institutions

Institution	Per cent of households
VIDCO Chairman	60
Kraalheads	37
Village Councillor	3
Agritex	3
No response	3

The main contrast with the first site is the lack of prominence given to the village councillor and Agritex. The VIDCO chairman is clearly the most important person followed by the Kraalheads.

5.2 Positions of leadership held by sample households

The following Table 17 shows the numbers of households who have a member of the family or relative who holds a local position of responsibility.

Table 17. Local leadership positions held

Position	Per cent of households
Feeding scheme leader	47
Policeman to the Kraalhead	7
Garden committee member	3
Community Health Worker	3
None	47

With the exception of the feeding scheme, there are relatively few households who have family connections with local leaders.

5.3 Exposure to agricultural extension

Thirty per cent of households have one or other of their members attending Master Farmer training classes and a further 17 per cent are already qualified as Master Farmers. In addition, one household is related to the Officer-in-

Charge of Chisumbanje Experiment Station. The main extension messages which respondents have found useful are listed in the following Table 18.

Table 18. Extension advice

Message	Per cent of households finding of use
Contour ridges for erosion control	97
Fertilizer application	23
Various cultivation practices	23
Attractive homestead	20
Growing of cotton and sunflowers	10
Correct animal husbandry	3
Conservation of stover	3
Keeping of poultry	3
Acquisition of correct implements	3

Contour ridging is the message which is most remembered followed by fertilizer application. The main cultivation practice is row planting followed by contour ploughing and correct plant spacing. The importance of maintaining an attractive homestead refers to such aspects as zinc roofing and whitewashing of walls. No mention was made of any extension advice relating to vegetables, gardening or irrigation practices despite the fact that gardening is commonly practised.

5.4 Experiences of other community development schemes

The only two schemes which respondents were aware of are both connected with efforts to mitigate the effects of the 1992-93 drought. These are the feeding scheme for children and the Food for Work programme. There was general agreement that these schemes had encouraged people to appreciate the virtues of working together, punctuality and cleanliness when handling food; all of which should stand them in good stead in the Collector Well scheme. One respondent noted that the feeding of beans and groundnuts to children improved their health.

6. Attitudes and expectations towards the Collector Well scheme

All respondents were aware of the scheme and are eagerly awaiting its inception with high expectations. Ninety per cent of respondents expressed a willingness to join a community garden with only old age, a disability and distance preventing the remainder. The majority of respondents believe that membership of the garden should be decided by established community leaders as the following Table 19 shows.

Table 19. Determination of garden membership

Decision maker	Per cent of households*
Kraalheads	73
VIDCO chairman	33
"The community"	7
Garden chairman	7
Priority to people not already in a co-operative	3

* Some households named more than one decision maker

A clear majority believe that membership should be decided by the Kraalheads despite the finding earlier that the VIDCO chairman is more highly regarded in the community as a whole. The garden chairman would appear to have little say in the matter, nor "the community", though it might be argued that the Kraalhead is expected to reflect the will of the community. One respondent made the interesting suggestion that those people who are not already members of existing co-operative schemes (presumably referring to the existing community garden) should be given the first option to join the Collector Well garden.

There seemed to be a general feeling that the scheme should be managed by the people themselves through the committee but with Agritex also taking a prominent role as the following Table 20 shows.

Table 20. Preferred forms of garden management

Management	per cent of households
Garden committee assisted by Agritex	37
Garden committee led by Agritex	37
Garden committee alone	16
Agritex alone	10

Interest in management was again high with 83 per cent of respondents expressing a desire to be involved.

The following Table 21 shows the main benefits which people anticipate.

Table 21. Main expected benefits

Benefit	Per cent of households
Opportunity to grow vegetables to eat	87
Opportunity to grow vegetables to sell	73
More reliable source of domestic water	63
Cleaner source of domestic water	50
Closer source of drinking water	47
Water for livestock	33

Vegetable gardening comes top of the list with the first priority being for home consumption. The importance attached to a more reliable domestic supply probably reflects earlier comments made about the prevalence of breakdowns to the borehole. Again, proximity of supply and livestock receive relatively low priorities.

On the subject of potential problems, not one respondent was prepared to foresee a single one. This seems a little unlikely and may have been prompted by the belief that any such suggestions may jeopardise the chances of the scheme going ahead.

The extent to which people are prepared to commit money to the scheme is similar to the first site with respondents offering to contribute an average of \$1.61 per month towards repairs and maintenance. The range was between 50 cents and five dollars.

Farms and households in the vicinity of Dekeza school, prior to the installation of a Collector Well in 1993.

M.W. Brown and T. Dube August 1993

1. Introduction

The Kraals of Mamutse, Mushava, Munjanja, Tsvana and Chakavata are to be served by this Collector Well which is being sited at Dekeza school. Total population was enumerated as 244 households.

2. Methodology

The survey was conducted during July 1993 amongst 30 randomly selected households.

Table 1. Identities of survey respondents

Respondents	Per cent of households
Men only	43
Women only	40
Men and women	17

There was almost an equal balance in the proportions of men and women interviewed with 77 per cent of households being represented by the household head and/or spouse.

3. Social aspects

3.1 Family size and labour force

The following Table 2 depicts the average composition of sample households.

Table 2. Household composition

	Average number per household:	
	Total	Available full-time for work on family home and farm
Men	2.5	1.3
Women	2.3	1.9
Children (5-15)	1.3	0
Infants	1.3	0
Totals	7.4	3.2

Forty nine per cent of men are unavailable for full time farm work either because they are away working (31 per cent) or are attending school (18 per cent). The lowveld is the most popular place of work accounting, for 18 per cent of men most of whom are employed on the Triangle sugar estates. Seventeen per cent of women are away but only seven per cent are working; the remainder

attend school. Overall, 60 per cent of households have at least one member earning a full-time income away from the family farm. All the children are attending school. Again women make up a majority of the labour force with 23 per cent of households being without a man full-time, while three household (ten per cent) are headed by women.

On the basis of appearances, 87 per cent of respondents were estimated to be in the middle age range of between 30 and 60 years with the remaining 13 per cent estimated to be under 30.

3.2 Indicators of wealth

Seventy three per cent of families occupy traditional style compounds of pole and dagga huts, and only seven per cent live in predominantly modern style homesteads constructed with bricks and asbestos roofs. The remaining 20 per cent occupy compounds containing a mixture of the two styles.

The main items of capital owned by farmers are livestock and implements. Livestock ownership was said to have been dramatically affected by the drought of 1992-93 as the following Table 3 shows.

Table 3. Livestock ownership

	Cattle:		Donkeys:		Sheep:		Goats:	
	Pre- 1992	Now	Pre- 1992	Now	Pre- 1992	Now	Pre- 1992	Now
Per cent farmers owning	90	27	3	3	3	3	73	37
Total head	219	17	4	2	12	2	212	86

Prior to the drought, ownership of cattle was widespread and relatively evenly distributed with 38 being the most number of head owned by a single household.

The main implement (after the hand hoe) is the animal drawn plough which is owned by 87 per cent of households with an average of 1.2 each. Perhaps surprisingly not one animal drawn scotch cart is owned by any household.

Based on these indicators of wealth, 33 per cent of households were judged to be "average" and 67 per less well off with no household falling onto the "relatively affluent " category.

3.3 Health

Malaria was the only prevalent illness, noted to be a problem by 97 per cent of respondents during the rainy season. The only other health problem was stomach aches associated with over indulgence at harvest time but it was only mentioned by two respondents (seven per cent).

3.4 Vegetable consumption

Table 4. Frequency of vegetable consumption

Frequency	Per cent of households
Mainly during the summer	70
Mainly during the summer and winter	10
All or most days throughout the year	17
Throughout the year but not every day	3

Again a majority of households are only able to consume fresh vegetables on a regular basis at certain times of the year. This is mainly during the summer when inter-cropping of rainfed crops with vegetables is common and, to a lesser extent, gathering of wild vegetables. The 30 per cent of households who are able to consume fresh vegetables at other times of the year can do so either because they have their own irrigated gardens or by purchasing from others. Twenty per cent of these are able to consume throughout the year while 10 per cent face a shortage during the spring months of April and May when the rainfed vegetables are finished and before production from the winter irrigated gardens has begun. The main sources of vegetables for households are shown in the following Table 5.

Table 5. Main sources of vegetables.

Source	Per cent of households
Rainfed fields	100
Own gardens	57
Wild	40
Purchased	37

Again the winter months from June to September are said to be the times of greatest scarcity for vegetables even for those who cultivate their own gardens at this time. Drying of vegetables for consumption during this interval is said to be practised by 83 per cent of households.

3.5 Community problems

A wide range of problems affecting the community were mentioned by respondents.

Table 6. Community problems

Problem (all shortages of:)	Per cent of respondents
Water	100
Transport	63
Draught power	47
Land for rainfed farming	13
Health care	10
Gardening opportunities	3

Shortage of water was again said to be the main problem afflicting the community and is more of a constraint for vegetable gardening than for domestic use with only seven per cent of respondents saying that they did not normally have sufficient for this purpose. However 20 per cent of respondents noted that the single borehole is at distances of two, three or more kilometres from their homesteads while one respondent noted that it is unreliable. Average daily water requirement was found to be 120 litres per household. Again gardening and brickmaking were popular choices for the use of any extra water; for 97 and 94 per cent of respondents respectively. One respondent (three per cent) mentioned tree planting as a use for extra water.

The transport problem referred both to the lack of a frequent bus service between Dekeza and the tar road and nearest Business Centre at Chivamba which is situated approximately 15 kilometres away and also in transporting produce to the GMB and CMB at Jerera. The shortage of draught power has been referred to above while 13 per cent of households also said that they had insufficient land for rainfed farming, which might explain the relatively small land holdings quoted. Concern was expressed over the absence of a clinic in Dekeza necessitating a journey to Chivamba for the nearest health care facilities.

4. Economic activity

4.1 Rainfed farming

All households engage in rainfed cropping which is the principal form of economic activity in the area. The areas cropped and yields said to be obtained by farmers during a "normal" year are presented in the following Table 7 together with the estimated Gross values of production based on 1992-93 GMB prices.

Table 7. Cropping patterns

Crop	Per cent farmers sowing	Per cent total crop area	Average crop area hectares per farm	Average yield Kg ha ⁻¹	Average Gross Income \$ per farm
Maize	90	35	0.51	1 633	757
Finger millet	80	24	0.36	1 367	253
Sorghum	70	15	0.22	1 157	132
Pearl millet	57	11	0.16	990	81
Sunflower	37	6	0.09	846	117
Groundnut	23	6	0.10	611*	71
Cotton	7	3	0.04	1 306	150
Totals			1.43		1 561

* Unshelled

Maize is the major crop and staple food with finger millet being important for beer brewing. Sorghum and pearl millet are sown for their greater drought resistance. The main cash crops are sunflower and groundnuts though the areas sown are relatively small. The resulting estimates of average yields are realistic although crop areas appear low. Nevertheless farmers were still able to harvest on average 1.67 tonnes of grain per year; sufficient to supply a family for one and a half years.

There is some variability in cropped areas per household as the following Table 8 shows.

Table 8. Distribution of average cropped areas

Range hectares	Per cent of households
0	7
0.1-1	33
1.1-2	44
2.1-3	13
3.1-4	3

Two households have yet to cultivate any rainfed crops in Dakeza. One of these has newly arrived in the area and has not yet been allocated any land; it has been excluded for the purposes of calculating the averages in the above Table 8. The second of these households consists of a newly married couple where the husband is away working and the wife lives with her parents-in-law, who, coincidentally are also included in the survey. The wife works on their fields and is included in the averages in Table 8.

The distribution is more equal than at the first site in that the smallest 40 per cent of farms occupy 16 per cent of the total cropped area while the largest ten per cent take up 21 per cent. The largest farm is 3.2 hectares.

The average annual gross crop income per household at \$1 561 is lower than those for the other sites. Distribution is skewed as the following Table 9 shows.

Table 9. Distribution of average incomes from rainfed cropping

Range \$	Per cent of households
0	7
1-1 000	37
1 001-2 000	33
2 001-3 000	10
3 001-4 000	3
Over 4 000	10

The poorest 40 per cent of households earn 18 per cent of the total gross incomes from rainfed cropping; averaging \$ 693 per family. Meanwhile, the richest 10 per cent account for 30 per cent of total crop incomes and average \$4 518 per family.

Ploughing and sowing was said to be the main labour peak for 90 per cent of households followed by harvesting at 10 per cent and weeding three per cent. Forty per cent of households said that they never make use of non-family labour. Exchange labour ("Nhimbe") was said to be used by two households (seven per cent); both for weeding. Hired labour is used on occasions by 53 per cent of households with harvesting being the main use as Table 10 shows.

Table 10. Use of hired labour

Use	Per cent of households
Harvesting	23
Weeding	20
Ploughing	10
Cotton picking	7
Carting manure	3
Watering garden	3

4.2 Gardening

Gardening has been practised by 93 per cent of households with two households (seven per cent) not having done so since they are new to the area. Nowadays, 73 per cent of households still have gardens. Of the 20 per cent who have had to give up, ten per cent were confronted with a shortage of water, seven per cent were prohibited due to their proximities to riversides and in the case of one household (three per cent) the reason was unclear. Twenty seven per cent of households are members of an existing community garden.

Table 11. Main vegetables cultivated

Vegetable	Per cent of households
Rape	77
Cabbage	77
Tomatoes	50
Onion	10
Covo	10
Choumollier (leaf vegetable)	10

The range of vegetables grown is limited and suggests the potential for research and extension to widen peoples' choice in the Collector Well garden. Although most of the garden produce is or was destined for home consumption as the following Table 12 shows sales of produce appear to be relatively more important than at the preceeding sites.

Table 12. Main uses of garden vegetables

	Per cent of households
part consumed/part sold	60
all or mainly home consumed	33
all or mainly sold	0
no garden	7

The following Table 13 suggests that decision making in the garden is more evenly shared between men and women than at other sites but that working in the garden remains primarily a female role. It is interesting to note that of the 27 per cent of respondents who are members of the existing community garden,

20 per cent regard the Agricultural Extension Worker as the decision maker rather than the members themselves. The remaining seven per cent believe that this role is fulfilled by the garden chairman.

Table 13. Garden management and labour

Persons responsible	Per cent of households:	
	Decision maker	Labour
wife/other family women	27	64
male household head/brother	20	7
husband and wife	20	23
Agricultural Extension Worker	20	-
Community Garden Chairman	7	-

The main water sources for gardening are as in the following Table 14.

Table 14. Water sources for gardens

Source	Per cent of households
Well in riverbed	40
borehole	40
river bed & borehole	10
Well	3
No garden	7

The majority of private gardens are dependent for water on riverbeds into which shallow wells are dug. Most users of the borehole are members of the existing community garden.

Gardening is again highly seasonal with 90 per cent of respondents cultivating only during the winter months of May/June to August/September due to a shortage of labour during the summer season when priority is given to rainfed cropping. Just one household (three per cent) practises gardening throughout the year.

Pests and diseases were said to be the main gardening problems for 90 per cent of respondents with shortage of water less of a problem but still significant at 57 per cent. Theft is also prevalent and was mentioned by 43 per cent of respondents. Minor problems related to difficulties in obtaining seed (seven per cent), shortage of manure (three per cent) and inadequate fencing (three per cent).

4.3 Household incomes and expenditure

The main sources of income ranked by households are as shown in the following Table 15.

Table 15. Main sources of household income

Source	Numbers of farmers ranking:			Total points*
	First	Second	Third	
Farm produce	13.5	4	-	49.5
Remittances	12	2	1	41
Beer brewing	1	9	2	23
Handicrafts	1	1	1	6
Selling vegetables	0.5	1	-	4.5
No response	2	13	26	

* Based on three points for first, two points for second and one point for third.

The large numbers of family members who are away from home working is reflected in the importance of remittances as the main source of household income. Rainfed cropping however is still important with sales of produce a clear second followed by brewing of beer. Other activities are of relatively minor significance. The handicrafts consisted of carpentry, basketware and crocheting.

There was again little variation in what people judged to be their main items of expenditure as the following Table 16 shows.

Table 16. Main items of expenditure

Item	Numbers of farmers ranking:			Total points
	First	Second	Third	
Clothing	20	10	-	49.5
School fees	9	3	-	33
Casual labour	1	-	-	3
Cotton chemicals	-	1	-	2
No response	-	16	30	

* Based on three points for first, two for second and one for third

The only two items of significance are clothing and school fees. No mention was made of the need to purchase staple foodstuffs which suggests that a better harvest of rainfed crops was reaped during the previous season compared with the first two sites at both of which it was the main item of expenditure.

5. Institutional considerations

5.1 Importance of local institutions

In order for any development scheme to succeed it is necessary to know the identities of local leaders and to have their support. The relative importance of different institutions can vary from place to place often depending on the personalities of the characters involved. The following Table 17 shows the institutions which are regarded by respondents as the most important in this collection of villages.

Table 17. Recognition of importance of local institutions

Institution	Per cent of households
Agricultural Extension Worker	80
Village Councillor	27
Headman	13
No response	3

The Agricultural Extension Worker wins the vote by a large majority followed by the Village Councillor. Traditional leaders such as the Headman and, particularly, the Kraalheads appear to be regarded as having less importance in this area.

5.2 Positions of leadership held by sample households

The following Table 18 shows the numbers of households who have a member of the family or relative who holds a local position of responsibility.

Table 18. Local leadership positions held

Position	Per cent of households
Feeding scheme leader	7
Farmers' Club Chairman	7
Community Garden Chairman	7
Kraalhead	3
None	76

Relatively few households have family connections with local leaders at this site.

5.3 Exposure to agricultural extension

Seventeen per cent of households have members who have qualified as Master Farmers. Experience of other agricultural training was limited to one respondent who used to be an Agricultural Extension Worker and is the brother of a second respondent. However, as the following Table 19 shows, an impressively long list of extension messages was recalled by respondents.

Table 19. Extension advice

Message	Per cent of households finding of use
Contour ridges for erosion control	93
Fertilizer and manure application	57
Planting in rows	37
Winter ploughing	10
Contour ploughing	10
Pest identification and control	7

Cotton scouting and spraying	3
Terracing	3
De-stumping	3
Sowing dates	3
Sowing in tied furrows	3
Growing sunflowers	3
Ploughing depth	3
Vegetable cultivation	3
Nothing	7

Contour ridging and fertilizer application are again the most commonly remembered messages followed by row planting with all the other recommendations being recalled by one, two or three farmers each. Again, little or no advice appears to have been given on vegetables and irrigation.

5.4 Experiences of other community development schemes

Respondents were again aware of the two schemes which are both connected with efforts to mitigate the effects of the 1992-93 drought: The feeding scheme for children and the Food for Work programme. As noted above, some households are also members of an existing community garden. There was general agreement that these schemes had encouraged people to appreciate the virtues of working together, punctuality and cleanliness when handling food; all of which should stand them in good stead in the Collector Well scheme.

6. Attitudes and expectations towards the Collector Well scheme

All respondents were aware of the scheme and are eagerly awaiting its inception with high expectations. Ninety seven per cent of respondents expressed a willingness to join a community garden with only old age preventing one respondent. The following Table 20 shows how respondents believe that garden membership should be decided upon.

Table 20. Determination of garden membership

Decision maker on membership	Per cent of households*
Agricultural Extension Worker	63
Kraalheads	40
"The community"	7
Headman	3
Village Councillor	3
Local womens' leader	3

* Some households named more than one decision maker

The importance accorded to the Agricultural Extension Worker is reflected in the majority of respondents who believe that he should be responsible for selecting members. However the Kraalheads are also deemed to have an important say in the matter despite the fact they were not mentioned earlier. Little reference was made to the role of the community in selecting members.

The belief in the importance of Agritex is continued through into the management of the garden as the following Table 21 shows.

Table 21. Preferred forms of garden management

Management	per cent of households
Garden committee led by Agritex	83
Garden committee alone	10
Agritex alone	7

Interest in management was again high with 90 per cent of respondents expressing a desire to be involved.

The following Table 22 shows the main benefits which people anticipate.

Table 22. Main expected benefits

Benefit	Per cent of households
Opportunity to grow vegetables to eat	90
Opportunity to grow vegetables to sell	90
Cleaner source of domestic water	60
More reliable source of domestic water	37
Closer source of drinking water	30
Water for livestock	27

Vegetable gardening again comes top of the list with equal priority being given to production for home consumption and sales. The importance attached to a cleaner source of domestic supply probably reflects the fact that people often take water from shallow wells in the river bed. Again, proximity of supply and livestock receive relatively low priorities due to the fact that not all homesteads are within easy reach of the Collector Well and livestock are few. Reliability of supply also seems to be less of a concern presumably because the existing borehole is reasonably dependable.

People were again reluctant to foresee any problems with the new scheme. Just one respondent (three per cent) thought there might be a shortage of water while a second suggested shortage of land for the garden as a possible difficulty.

People appear to be willing to contribute somewhat more towards repairs and maintenance at this scheme than at the other sites studied; an average of \$6.08 per household per month. One respondent suggested as much as \$20 and nine (30 per cent) thought that \$10 per month would be reasonable.

Farms and households in the vicinity of Nemauka Business Centre, prior to the installation of a Collector Well in 1993.

M.W. Brown and T. Dube September 1993

1. Introduction

This Collector Well is to be sited at Nemauka Business Centre and will serve the six kraals of Nezvikonde, Mukambwe, Mashanyare, Merana, Tinarwo and Chapfidza. The total number of households is 154.

2. Methodology

The survey was conducted during July 1993 amongst a randomly selected sample of 30 households.

Table 1. Identities of survey respondents

Respondents	Per cent of households
Men only	33
Women only	47
Men and women	20

For this survey there was a bias towards women respondents. Ninety per cent of households were represented by the household head and/or spouse.

3. Social aspects

3.1 Family size and labour force

The following Table 2 depicts the average composition of sample households.

Table 2. Household composition

	Average number per household:	
	Total	Available full-time for work on family home and farm
Men	2.0	1.2
Women	2.0	1.9
Children (5-15)	2.6	0
Infants	1.1	0
Totals	7.7	3.1

Forty three per cent of men are unavailable for full time farm work either because they are away working (32 per cent) or are attending school (11 per cent). Harare is the most popular place of work accounting for 15 per cent of men. Ten per cent of women are away; only three per cent are working, the remainder attend school. Overall, 47 per cent of households have at least one member earning a full-time income away from the family farm. All the children

are attending school. Again women make up a majority of the labour force with 27 per cent of households being without a man full-time, while twenty per cent of households are headed by women.

On the basis of appearances, 80 per cent of respondents were estimated to be in the middle age range of between 30 and 60 years with 13 per cent estimated to be under 30 and seven per cent over 60.

3.2 Indicators of wealth

Fifty seven per cent of families occupy traditional style compounds of pole and dagga huts while 13 per cent live in predominantly modern style homesteads constructed with bricks and asbestos roofs. The remaining 30 per cent occupy compounds containing a mixture of the two styles.

The main items of capital owned by farmers are livestock and implements. Livestock ownership was said to have been dramatically affected by the drought of 1992-93 as the following Table 3 shows.

Table 3. Livestock ownership

	Cattle:		Donkeys:		Sheep:		Goats:	
	Pre- 1992	Now	Pre- 1992	Now	Pre- 1992	Now	Pre- 1992	Now
Per cent farmers owning	83	20	7	0	7	3	77	60
Total head	210	20	6	0	14	2	203	90

Prior to the drought, ownership of cattle was widespread and relatively evenly distributed with 32 being the most number of head owned by a single household. The main implement (after the hand hoe) is the animal drawn plough which is owned by 77 per cent of households with an average of one each. Twenty per cent of households each own an animal drawn "scotch cart". Based on these indicators of wealth, 33 per cent of households were judged to be "average" and 67 per cent less well off with no household falling onto the "relatively affluent" category.

3.3 Health

Malaria was the only prevalent illness, noted to be a problem by 90 per cent of respondents during the rainy season. The only other health problem was stomach aches associated with over indulgence at harvest time but it was only mentioned by one respondent (three per cent).

3.4 Vegetable consumption

Table 4. Frequency of vegetable consumption

Frequency	Per cent of households
Mainly during the summer	80
Mainly during the summer and winter	7
All or most days throughout the year	13

The majority of households are only able to consume fresh vegetables on a regular basis at certain times of the year. This is mainly during the summer when inter-cropping of rainfed crops with vegetables (mainly cucurbits) is common. The 20 per cent of households who are able to consume fresh vegetables at other times of the year can do so either because they have their own irrigated gardens or by purchasing from others. Thirteen per cent of these are able to consume throughout the year while seven per cent face a shortage during the spring months of April and May when the rainfed vegetables are finished and before production from the winter irrigated gardens has begun. The main sources of vegetables for households are summarised in the following Table 5.

Table 5. Main sources of vegetables.

Source	Per cent of households
Rainfed fields	93
Purchased	37
Own gardens	33
Wild	0

The importance of rainfed vegetables is clear from the above Table 5 though surprisingly nobody rated gathering of wild vegetables as significant. The potential demand for further gardening opportunities can be gauged from the findings that only one third of respondents rate their own existing gardens as important sources of supply while 37 per cent purchase appreciable amounts of vegetables.

Again the winter months from June to September are said to be the times of greatest scarcity for vegetables even for those who cultivate their own gardens at this time. Drying of vegetables for consumption during this period is said to be practised by 90 per cent of households.

3.5 Community problems

As the following Table 6 shows a wide range of problems affecting the community were mentioned by respondents.

Table 6. Community problems

Problem (all shortages of:)	Per cent of respondents
Draught power	93
Water	90
Transport	43
Gardening opportunities	3
A Market place in the village	3
Pesticides	3

Shortages of draught power (arising from the 1991-92 drought) and water were said to be the main problems besetting the community. More water is needed primarily for gardening since only 13 per cent of households said that they

have insufficient for domestic use. However, a further 13 per cent said that they are far from the borehole (1.5 to four kilometres) of whom seven per cent say that as a result they often take water from the river or river bed which is not always clean. Average daily water requirement was found to be 137 litres per household. Again gardening and brickmaking were popular choices for the use of any extra water; for 100 and 83 per cent of respondents respectively. One respondent (three per cent) mentioned that extra water would be used for livestock.

The transport problem referred to the difficulty in getting both people and produce to the nearest Business Centre at Jerera.

4. Economic activity

4.1 Rainfed farming

All households engage in rainfed cropping which is the principal form of economic activity in the area. The areas cropped and yields said to be obtained by farmers during a "normal" year are presented in the following Table 7 together with the estimated Gross values of production based on 1992-93 GMB prices.

Table 7. Cropping patterns

Crop	Per cent farmers sowing	Per cent total crop area	Average crop area hectares per farm	Average yield Kg ha ⁻¹	Average Gross Income \$ per farm
Maize	97	61	1.37	1 286	1 583
Finger millet	87	30	0.67	846	297
Groundnut	20	5	0.11	284*	36
Sunflower	20	4	0.09	330	46
Pearl millet	3	-	-	-	-
Cotton	3	-	-	-	-
Sorghum	0	-	-	-	-
Totals			2.24		1 962
* Unshelled					

The cropping pattern is relatively simple compared with those at the other sites studied with 91 per cent of the crop area being accounted for by just two crops; maize, the staple food and finger millet for its beer brewing qualities. The preference for these crops plus the absence of the more drought tolerant crops of sorghum and pearl millet suggests that this area expects better rainfall on average than the previous three areas studied. Total average annual grain production per household at 2.3 tonnes also suggests a more hospitable environment for rainfed farming. The cash crops of cotton, sunflowers and groundnuts are of only minor importance in the area. The average yields calculated are relatively low compared to the other sites, particularly for groundnuts and sunflowers, however this may be due to the higher estimates of the crop areas for this site.

The average farm size at 2.24 hectares is the largest of the sites studied to date but still relatively small, hence the large numbers of family members working away. There is a limited variability in the distribution of holding sizes as the following Table 8 shows.

Table 8. Distribution of average cropped areas

Range hectares	Per cent of households
0	3
0.1-1	7
1.1-2	27
2.1-3	43
3.1-4	17
Over 4	3

Just one household does not engage in rainfed cropping, this is headed by an elderly lady who is supported by her working son. A further two households share the same piece of land and crops which are assumed to be divided equally between them for the purposes of Tables 8 and 9: One of these households is headed by the senior wife of the household head of the other.

The distribution is comparatively equal in that the smallest 40 per cent of farms occupy 23 per cent of the total cropped area while the largest ten per cent take up 18 per cent. The largest farm is 4.5 hectares.

The figures for average gross crop incomes are close to net incomes since the only input costs are likely to be hybrid maize seed. The average annual total crop income of \$1 962 compares favourably with other sites and with wage labour. The following Table 9 shows the distribution of rainfed cropping incomes.

Table 9. Distribution of average gross incomes from rainfed cropping

Range \$	Per cent of households
0	0
1-1 000	20
1 001-2 000	27
2 001-3 000	37
3 001-4 000	3
Over 4 000	10

The distribution is again skewed with the poorest 40 per cent of households accounting for 19 per cent of total incomes earned from rainfed cropping; averaging \$924 per household. This compares with the richest ten per cent who average \$ 4 486 each and account for 23 per cent of the total.

Ploughing and sowing was said to be the busiest time of the year for 70 per cent of households followed by weeding at 27 per cent and harvesting 13 per cent. Fifty per cent of households said that they never make use of non-family

labour. Exchange labour ("Nhimbe") was said to be used by three households (ten per cent); all for weeding. Hired labour is used on occasions by 40 per cent of households with weeding being the main use as the following Table 10 shows.

Table 10. Use of non-family labour

Use	Per cent of households	
	Hired	Exchange
Weeding	30	10
Ploughing	17	-
Harvesting	7	-
Miscellaneous (maintaining fruit trees and contour ridges)	3	-

4.2 Gardening

Gardening has been practised by 100 per cent of households of whom 70 per cent still have gardens today. Of the 30 per cent who have had to give up, 20 per cent were prohibited due to their proximities to riversides. The remaining ten per cent (three households) were prevented by old age, the loss of the wife and the drying up of the well, respectively. Ten per cent of households belong to an existing community garden.

Table 11. Main vegetables cultivated

Vegetable	Per cent of households
Rape	97
Cabbage	90
Tomatoes	73
Covo	17
Onion	13
Choumollier (leaf vegetable)	10
Okra	3
Fruit trees	3

The range of vegetables grown is limited and suggests the potential for research and extension to widen peoples' choice in the Collector Well garden. Although most of the garden produce is or was destined for home consumption as the following Table 12 shows sales of produce appear to be relatively more important than at the preceeding sites.

Table 12 Main uses of garden vegetables

	Per cent of households
part consumed/part sold	83
all or mainly home consumed	17
all or mainly sold	0

The following Table 13 shows that traditional garden management and, to an even greater extent, work, is essentially a female occupation. However in the case of the community garden, the chairman makes the decisions in conjunction with the Agricultural Extension Worker.

Table 13. Garden management and labour

Persons responsible	Per cent of households:	
	Decision maker	Labour
wife/other family women	50	73
male household head	17	3
husband and wife	23	20
Community Garden Chairman	10	-
All family	-	3

The main water sources for gardening are as in the following Table 14.

Table 14. Water sources for gardens

Source	Per cent of households
Well in river bed	73
Well	23
river bed & borehole	3

The majority of private gardens are dependent for water on rivers, either by drawing water directly from them or by digging shallow wells in the river beds.

Gardening is again highly seasonal with 83 per cent of respondents cultivating only during the winter months of May/June to August/September due to a shortage of labour during the summer season when priority is given to rainfed cropping. Of the 17 per cent who are able to garden all year round, 14 per cent have access to a conventional well as opposed to one in the river bed.

Pests and diseases were said to be the main gardening problems for 90 per cent of respondents. Shortage of water is less of a problem but still significant at 63 per cent; the problem mainly refers to the drying up of the rivers in August/September according to 30 per cent of respondents. Two other respondents explained the water problem in terms of the ban on riverside gardening and the distance which they had to walk to the river respectively. Theft is also common and was mentioned by 30 per cent of respondents. Minor problems related to shortages of manure and fertilizers (ten per cent) and encroachment by animals (ten per cent).

4.3 Household incomes and expenditure

The main sources of income ranked by households are as shown in the following Table 15.

Table 15. Main sources of household income

Source	Numbers of farmers ranking:			Total points*
	First	Second	Third	
Farm produce	10	2	1	35
Remittances	9	2	-	31
Beer brewing	2	6	1	19
Building	2	-	-	6
Handicrafts	1	1	1	6
Selling vegetables	1	1	-	5
Brickmaking	-	2	-	4
Agricultural labour	-	2	-	4
Well digging	1	-	-	3
Poultry	1	-	-	3
No response	3	14	27	

* Based on three points for first, two points for second and one point for third.

Selling of rainfed farm produce and remittances are the main sources of family income with beer brewing as an important supplementary enterprise. A wide variety of other activities was encountered though each was limited to one or two households. Handicrafts consisted of knitting and pestle and mortar manufacture.

There was again little variation in what people judged to be their main items of expenditure as the following Table 16 shows.

Table 16. Main items of expenditure

Item	Numbers of farmers ranking:			Total points
	First	Second	Third	
Clothing	10	14	-	58
School fees	16	3	-	54
Casual labour	1	1	-	5
No response	3	12	30	

* Based on three points for first, two for second and one for third

The only two items of significance are clothing and school fees. No mention was made of the need to purchase staple foodstuffs which suggests that a better harvest of rainfed crops was reaped during the previous season compared with the first two sites at both of which it was the main item of expenditure.

5. Institutional considerations

5.1 Importance of local institutions

In order for any development scheme to succeed it is necessary to know the identities of local leaders and to have their support. The relative importance of different institutions can vary from place to place often depending on the

personalities of the characters involved. The following Table 17 shows the institutions which are regarded by respondents as the most important in this collection of villages.

Table 17. Recognition of importance of local institutions

Institution	Per cent of households
Agricultural Extension Worker	77
Village Councillor	20
VIDCO Chairman	13
Kraalhead	10

The Agritex Extension Worker wins the vote by a large majority followed by the Village Councillor. Traditional leaders such as the Kraalheads appear to be regarded as having less importance in this area.

5.2 Positions of leadership held by sample households

The following Table 18 shows the numbers of households who have a member of the family or relative who holds a local position of responsibility.

Table 18. Local leadership positions held

Position	Per cent of households
Kraalhead	27
Feeding scheme leader	7
Kraalhead's policeman	7
Food For Work Chairman	7
Community Garden Chairman	3
VIDCO Chairman	3
District Health Coordinator	3
None	43

At this site over 50 per cent of households have a family connection with somebody who is regarded as a local leader.

5.3 Exposure to agricultural extension

Seventeen per cent of households have members who have qualified as Master Farmers and a further 10 per cent are currently receiving the necessary training. Experience of other agricultural training was limited to one respondent who used to be an Agricultural Extension Worker. However, as the following Table 19 shows, large numbers of Extension messages were recalled by respondents.

Table 19. Recall of Extension advice

Message	Per cent of households finding of use
Contour ridges for erosion control	90
Fertilizer and manure application	40
Planting in rows	30
Winter ploughing	17
Correct plant spacing	10
Sowing dates and timely purchase of seed	10
Vegetable cultivation	7
Cotton scouting and spraying	3
Contour ploughing	3
Correct ploughing depth	3
Crop diversification	3
Avoid stream bank cultivation	3
Cotton grading	3
Poultry management	3

Contour ridging and fertilizer application are again the most commonly remembered messages followed by row planting and winter ploughing. All the other recommendations being recalled by one, two or three farmers each. Again, little or no advice appears to have been given on vegetables and irrigation.

5.4 Experiences of other community development schemes

Respondents were again aware of the two schemes which are both connected with efforts to mitigate the effects of the 1992-93 drought: The feeding scheme for children and the Food for Work programme. As noted above, some households are also members of an existing community garden. There was general agreement that these schemes had encouraged people to appreciate the virtues of working together, punctuality and cleanliness when handling food; all of which should stand them in good stead in the Collector Well scheme.

6. Attitudes and expectations towards the Collector Well scheme

All respondents were aware of the scheme and are eagerly awaiting its inception with high expectations. Ninety seven per cent of respondents expressed a willingness to join a community garden with only old age preventing one respondent. The following Table 20 shows how respondents believe that garden membership should be decided upon.

Table 20. Determination of garden membership

Decision maker on membership	Per cent of households*
Agricultural Extension Worker	53
VIDCO Chairman	33
Kraalheads	23
"The community"	10
Village Councillor	10

* Some households named more than one decision maker

The importance accorded to the Agricultural Extension Worker is reflected in the majority of respondents who believe that he should be responsible for selecting members. However the Kraalheads and Village Councillor appear to be accorded a proportionately greater importance in selecting garden members than they were earlier given in the community generally.

The belief in the importance of Agritex is continued through into the management of the garden as the following Table 21 shows.

Table 21. Preferred forms of garden management

Management	per cent of households
Garden committee led by Agritex	80
Garden committee alone	10
Agritex alone	3
Agritex and "Research"	3
Garden committee led by the chairman	3

Interest in management was again high with 87 per cent of respondents expressing a wish to be involved.

The following Table 22 shows the main benefits which people anticipate from the Collector Well.

Table 22. Main expected benefits

Benefit	Per cent of households
Opportunity to grow vegetables to eat	97
Opportunity to grow vegetables to sell	97
Cleaner source of domestic water	60
Water for livestock	57
More reliable source of domestic water	53
Closer source of drinking water	47

All the expected benefits are rated highly with respondents being almost unanimous that vegetable gardening both for home consumption and sales is the top priority. The importance attached to a cleaner source of domestic supply probably reflects the fact that people often take water from shallow wells in the river bed. Watering of livestock receives a notably higher ranking than at other sites. Again not all families are going to be within easy reach of the Collector Well for drawing of domestic water hence the relatively low importance attached to this consideration.

People were again reluctant to foresee any problems with the new scheme. Just one respondent (three per cent) thought that disagreements between members might be an issue. Respondents offered to contribute an average of \$3.37 per month towards repairs and maintenance. The modal values were \$3 and \$5 per month both of which were suggested by 30 per cent of respondents.

APPENDIX 6: CASE STUDY QUESTIONNAIRE

Section 1

Basic Information

Case Study number.....
Village.....
Date.....
Head Household.....
Respondent(s).....

1. Family

- a. How long have you lived here ?.
b. How many people are there in your family household ?. Who is 'head of the household' ?.

Person	Resident in House	Age	Relation (to head)	Primary occupation

- c. Do any members of your family belong to community institutions or have they in the past ?. What is their position ?.

Family member	Institution (community status / VIDCO, WADCO etc)	For how long

2. House and land

- a. What type of house do you live in ?. How big is your house, how is it divided, how old, how constructed, what sort of roof. ?.
b. How much land do you farm ?. Do you consider this 'good' land ?, why ?.(general description).
c. Description of capital items available/visible at household.(ploughs, carts, radio, furniture, for example)

Section 2

Sources of income

1. Rain-fed Agriculture

- a. In an average year approximately what area of land would you expect to cultivate, how would you describe it ("your" land, inherited etc.) ?.

Crop	Area
Sorghum	
Maize	
Sunflower	
Mhunga	
Rapoko	
Groundnuts	
Cotton	
Other	

- b. Is there a typical production pattern, rotation etc. Why?.

- c. What makes you decide which crops to grow ?.

Crop	Home consumption	Cash	Tradition	Other

- d. What inputs do you normally use ?.

Crop	Seed	Hire draft	Fertil.	Manure	Pestic. Herbic.	Hire labour

- e. Approximately what is your normal production, and how much is sold (Z\$/ha) ?.

Crop	Output per area	Consumed	Sold	Value

- f. Did you want to grow more, if so what were the reasons you did not or could not ?.

- g. In your rain fed agricultural production do you make any special arrangements for example share buying of inputs/labour/marketing ?.

2. Vegetable production

- a. Do you produce any vegetables during the year ?.
b. Typically what is grown, when and how much and why ?.

Vegetable	Period grown	Area grown	Irrigate ?	Why ? (cash or home consumption)
Rape				
Covo				
Tomato				
Cabbage				
Okra				
Onion				
Other				

- c. Of the crops you irrigate, what is your source, how far away is it, how is water carried, delivered, how long does it take ?. Is this source private or shared ?. Is it secure or perennial ?. Can you detail your schedule.

Vegetable	Method	Mulch etc.	Schedule details

- d. What inputs do you use?.

Veg.	Seed	Hire draft	Fertil.	Manure	Pestic. Herbic.	Hire labour

- e. How much do you produce ?.
From this how much do you sell ?. Where do you sell it, with what arrangements, trade for other goods ?.

Vegetable	Output	Consumed	Sold	Value

- g. Did/do you want to produce more vegetables at any time, if so what stopped you from doing so ?.
h. In your vegetable production do you make any special arrangements for example to share buying of inputs/labour/marketing ?.
i. For your vegetable and your rainfed cropping what tools do you have available ?. Which do you use for both ?.

Tool	Main use	Age/replaced	Hire/own

3. Livestock

a. How many of the following do you have at present ?.

Livestock	Numbers		Cause of change	Main reason for keeping
	now	pre '92		
Cattle				
Goats				
Donkeys				
Sheep				
Other				

b. Are you presently intending to sell any ?.

4. Other Sources of Income
(eg.brewing, crafts, firewood)

Activity	Unit produced	Qty/year	Value

5. Remittances

- Do any members of your family work away ?.
- Who are they, what do they do and where (permanently) ?.
- Do they send you any money, regularly or not ?.
- How much does your household receive per month ?
- Are remittances spent on particular items if so which ?.

Applications of income

a. In a normal week/month/year how much do you spend on the following ?.

Item	Amount	Details
Food items		
Clothes -adult -children (school?)		
Transport -work -visits		

Agricultural Inputs -seed -fertiliser -pesticide -labour -draft		
Livestock -new -inputs		
Tools -bought -hired		
Household Items -consumables -utensils		
Education -fees -support		
Fuel -wood -oil/parafin etc.		
Medicine/health -day to day -clinical		
Other		

b. Could you be more specific regarding expenditure on food items ?.

Food Item	Quantity (unit)/month(week)	Price/unit	Value

c. Approximately how much water does your household consume per day

Member	Quantity

What is the source for domestic water, how far is it ?, is it private or shared ?, does it last year round ?

- d. If you become ill where would you go ?.
- e. Do you also go there for check ups ?.
- f. About how often do you go ?. Have you received any medication recently ?. What was it ?.

Savings and credit

- a. Do you spend all the money that you earn or do you save some, and at specific times of the year ?.
- b. If some is saved how much do you save per month ?.
- c. Where do you save it ?.
- d. Are there times when you have borrowed money to buy something ?. Have you a debt at the present moment ?.
- e. If so what did you buy ?.
- f. What were the arrangements for credit ?.

Labour Analysis

- a. Who works on the following and decides how they should be done ?. Approximately how long does each take ?.

Task	Responsible	Decision maker	Aprox. Time taken/period
Rainfed farming: -land preparation -sowing -weeding -spraying etc. -harvesting -selling			
Vegetable garden: -land preparation -sowing -weeding -irrigation -spraying -harvesting -selling			
Water -domestic(collect) -livestock(lead)			
Shopping generally			
Cooking			
Clothes			
Collecting fuel			
Other, crafts etc.			

Section 3

Vegetable consumption

- a. What vegetables do you generally consume through the year, is this seasonal, if so when.

Vegetable	When consumed	Bought or grown

- b. If they are bought/traded when, where, how often ?.
- c. Are they a relish or a staple, how is the meal combined ?.
What complements are necessary for the preparation, oil, salt, sugar etc.?
- d. Which is a priority to buy/grow, staples or vegetables ?.
- e. How do you prepare the vegetables that you eat ? (detailed kitchen data). Quantities recipes etc. Combination with staples.
- f. Who generally consumes the vegetables, all the family, mainly children, ?.
- g. Do you carry out any preservation procedures, drying etc ?.
- h. Do you like vegetables, why ?, do you perceive them as good for you ?.
- i. Would you be more healthy if you ate more, why ?.

Section 4

Perceptions

1. Collector well project

- a. Have you had experience of or know of a community development project like this before ? (Give details and an indication of the extent of community involvement in its management/running/decision making). What did you see as its objectives, were these met in your opinion ?.
- b. How did you first hear about the collector well project, what do you understand it to involve, will you be interested in joining, what about other people in the community that you know ?. What do you think about the idea
- c. Should everyone in the community who wants to, be allowed to join ?. If not how should it be decided who joins ?. Why
- d. How best do you think that this particular project should be managed/run, for example committee management, individual control ?. Why ?. What do you see as the responsibilities of the chosen organisation ?.
- e. How much money do you think it will be necessary to contribute for maintenance. How much will you be willing to pay if you join (per month) ?.
- f. What do you see as the main benefits of the collector well project ? (How) Do you rank these in order of importance
- g. Which elements do you think may present the most serious problems for the success of such a scheme ?. Which do you think may be the most important ?.

2. Extension

- a. Who is your extension worker, how often do you see him/talk to him ?. Who generally talks to him ?.
- b. Have you received any special training from the extension service ?. (Master farmer etc.) Was this valuable ?.
- c. Can you recall any advice that he/she has given to you recently, what was it ?.
- d. Do you try the ideas that Agritex gives you ?. Why, are they generally good ideas that you permanently adopt ?.
- e. Do you receive any advice from elsewhere ?. Can you give details. (media, radio, neighbours). How do you think extension could be improved ?.
- (f. Where applicable ask about the interviewees experience of Rhodesian extension, CONEX, 'stick approach').

3. Environment

- a. Are there any changes to the area in which you live from years ago. What are they, why do you think they happened ?.
(-deforestation ?, soil erosion/fertility ?, water ?, population. Determine differences between cropping land, slopes, grazing(communal) land).
- b. Have these changes lead to problems ?.What ?. Can you see any solutions ?.
(eg. new improved agricultural techniques eg measures to conserve water (ridging), increased productivity measures, planting wood land).
- c. Do you carry out some solutions ?. If not what constrains you from undertaking them ?.
(knowledge, cash, land, training, education motivation, (dis)incentive eg. resettlement, riskiness)
- d. Do you see some farmers doing better than others ?. Can you describe why?
- e. Do you think that your life and circumstances here will change soon ?. Why ?.
- f. Do you think that you will be here in 5/10 years time ?.Why

APPENDIX 7: PROGRAMME OF WORK IN SOUTH-EAST ZIMBABWE

DISCUSSION DOCUMENT

by C.J. Lovell (25/3/93)

I hope that the following notes will be helpful in discussion of:

- i) the need for a coordinated programme of work in south-east Zimbabwe to address the problem of land degradation and, in particular, to work towards the restoration of degraded catchments;
- ii) how proposed studies of 'sustainable yield' (BGS/MLAWD) and 'recharge' (IH/MLAWD) might fit into such a programme, given the findings of past studies, ongoing work, and the present situation here in south-east Zimbabwe;
- iii) how the proposed studies can be complementary, both to each other and to ongoing work;
- iv) how the proposed studies might develop in the near future.

A Coordinated Programme of Work

The following is a very brief outline of why a coordinated programme of work directed in the long term towards restoration of degraded catchments is needed in south-east Zimbabwe :

- * Drought is endemic, rainfall low, highly variable, often of high intensity
- * Increasing population pressure continues to lead to further deforestation clearance of marginal lands for agriculture, and overgrazing by livestock;
- * Poor surface management practices have caused decreased surface cover, surface retention and infiltration, increased surface runoff and associated soil erosion, faster movement of water through zones of transmission via efficient drainage networks of rills and gullies now developed, and an apparent decline in rates of groundwater recharge in the dessicated catchments that we now observe;
- * Many catchments in the region are in this degraded condition. Drought and increased abstraction of groundwater exacerbate the situation;
- * Catchment hydrology has been changed, further deterioration will occur, the present system of land use is not sustainable.

Although a considerable challenge, sustainable land use is possible. Management at present is poor, but improved practices and alternative systems of land use appropriate to the region are known, and in a few cases have been introduced (in isolation) into the field.

The magnitude and complexities of the problem to be addressed requires that the coordinated programme of work be holistic, a multi-disciplinary approach to catchment management. In order to provide sound recommendations for effective control and sustainable management of the hydrology of catchments in this

region by the people who live in these catchments, complementary studies of social, economic, institutional and various technical aspects will be required at least. It is not the intention of these notes to describe in detail a possible content for this overall programme of work, rather to suggest how present and proposed studies could work together now to make a start in this direction.

Present Studies

As an insurance against unreliable rainfall and low crop yields, farmers in this region traditionally cultivate large areas and herd cattle and goats. As mentioned above, with increasing population pressure this practice is becoming increasingly difficult and hazardous. Soil erosion and overgrazing on a massive scale are reducing the ability of the land to support agricultural production. There is an urgent need to develop sustainable farming systems that reduce dependence on extensive cultivation and large stock holdings.

Irrigation of small gardens offers one hope. If irrigated gardens can reliably be included in the farming system, they can provide a continuous supply of vegetables even during dry periods and years of drought, and go some way to improving sustainability of crop production by reducing the need for extensive cultivation of ever more marginal lands.

Water is the limiting factor to this approach, but recent research shows promise. Currently, use of groundwater in Masvingo Province is approximately 4% of the annual average recharge (see Appendix A1); thus, increased abstraction to allow irrigation of gardens could be accommodated if the available aquifers could be appropriately developed and managed. In this region of crystalline basement rock, indications are that the weathered material of the regolith aquifer stores and transmits most groundwater compared to the bedrock aquifer beneath. The regolith aquifer thus may provide a key to future resource development in this region. A methodology for increased economic abstraction of water from this low permeability aquifer has been developed. The horizontal boreholes of a *collector well* can pass through discontinuities and overcome the low-permeability constraint to enable sufficient abstraction for garden irrigation. The technical and economic viability of collector wells used to abstract sufficient water for garden irrigation, and the technical, economic, institutional and social viability of garden irrigation as a component of the overall farming system, is currently being assessed in the present study: '*Small Scale Irrigation using Collector Wells - Pilot Project*'.
Groundwater Recharge / Sustainable Abstraction

Good as the present study is, it is not complete. Developed in isolation, the concept of collector well gardens can only go a limited way towards improving land management in this region. In fact, sustainability of even this 'improved' land use system is threatened if other land use practices within the catchment continue to damage the environment. For example, the process of

groundwater recharge, on which the long-term viability of collector well gardens must depend, is not a constant and is sensitive to land use change, surface management practices, and associated changes to catchment hydrology:

"The basement aquifers of this region are distinctive in that their occurrence and characteristics are largely a consequence of the interaction of weathering processes related to recharge and groundwater throughflow. A close relationship exists therefore between groundwater occurrence and relief, surface water hydrology, soil and vegetation cover. Recharge is sensitive to certain land use changes, notably those associated with desertification. Improvements in the understanding of these relationships will be fundamental to the planning and management of groundwater resources in crystalline basement terrain." (Wright, 1992)

Studies of the relationships between groundwater recharge, abstraction and land use are needed. An important question to be addressed with regard to the present study is: "What level of water well abstraction can be sustained in a given catchment under present land management practices?" Important questions to be addressed in the longer term, hopefully as part of a coordinated programme of work, will include: "How is the sustainable level of water well abstraction modified by introduction of improved land management practices designed to conserve water and soil, improve crop yields, and replace lost trees?" and "What is the optimum combination of improved land management practices, including abstraction of groundwater for irrigation, that best allows for restoration of the degraded catchment and sustainable catchment management in the future?"

Catchment Studies

Studies of recharge in the region have been made by Houston (1982;1988), Howard and Karundu (1992) and Wright (1992), using analysis of baseflow, chloride balance of rainfall and groundwater, and soil moisture balance using Penman evaporation equations.

This work, conducted on relatively large catchments with areas of hundreds or thousands of km², begins to highlight the important effects that changes to land use and catchment hydrology can have on recharge, but also serves to highlight the need for more detailed studies. The work suggests that loss of deep rooted trees and of wetlands (both features characteristic of the present situation in south-east Zimbabwe) might both be expected to produce a net increase in water available for recharge. Instead, local observations suggest a general decline in recharge (Price, 1993), and dessication of wetlands or vleis now efficiently drained by erosion gullies appears to be an additional consequence of increased runoff and interflow caused by the land use change.

A better understanding of the effects of present land use on catchment hydrology, and the consequence of different land use practices on available water resources now and in the future, will only be made possible by more detailed studies of the

separate components of the present catchment water balance, that is, the contributions by rainfall to baseflow, surface runoff, evaporation from soil and vegetation, recharge, and water well abstraction.

A catchment approach is requisite. The size of catchment to be studied is vital. The catchments should be small enough to allow direct measurement of the components of the water balance outlined above and to minimise meteorological and geological variability, but should be large enough to integrate spatial variability of recharge and reflect the discontinuous nature typical of basement aquifers.

The main groundwater flow systems of the basement aquifer are relatively localised between recharge on watersheds to discharge by runoff and evaporation in valley bottomlands. In this region, this scale of catchment is typically of the order 10-20 km². It is consistent with that in which collector well gardens are currently being implemented. Furthermore, the collector well gardens are being sited in small catchments chosen to represent the range of local terrain features found in the region. In agreement with Farquharson and Bullock (1992), it is recommended that future studies of catchment hydrology be conducted in catchments of this scale; to begin work in this direction, and to coordinate our efforts from the beginning, it is suggested that the proposed studies of 'Sustainable Yield' (BGS/MLAWD) and 'Recharge' (IH/MLAWD) be conducted in those catchments selected for the present 'Collector Well Garden' pilot project.

Proposed Studies

Methods to estimate recharge and sustainable yield are subject to considerable uncertainty which will generally be increased for basement aquifers because of their heterogeneity and the complexity of the flow systems. Both groundwater and surface hydrology studies are required to better understand effects of present land management on catchment hydrology and the consequence of different management practices on available water resources now and in the future. Only by studying both elements will we be able to separate components of the water balance important to recharge and sustainable yield, and better understand how these components vary during time and with changes to land management. The regolith aquifer may provide a key to future resource development and in itself permit improvement of land management in the region. Water levels of wells completed in the regolith respond in phreatic fashion to recharge; they depend upon the near surface system associated with infiltration and land use. Groundwater studies directed at this stage towards sustainable management of the regolith aquifer at a catchment scale, and surface hydrology studies directed towards understanding mechanisms important to recharge to this aquifer, will be important for future land management in this region.

A comparative approach similar to that reported by Howard and Karundu (1992) appears to be appropriate, but study of catchments several orders of magnitude smaller than that studied in Uganda

can allow quantification rather than estimation of many components of the water balance. The smaller catchments of the proposed studies can allow catchment recharge to be quantified as a whole, but can also allow attention to be paid to the importance of localised recharge mechanisms. Areas of high or localised recharge identified within catchments can be studied in more detail to provide better understanding of particular terrain features and processes important and how changes to land use will affect this recharge.

When considering a small catchment as a unit, negligible groundwater inflow can be assumed if the headwaters of the catchment to be studied are included. However, more thought is needed concerning surface hydrology and groundwater studies required within the catchments and at the chosen catchment outlets in order to separate and quantify direct and indirect recharge, baseflow when and if it occurs, aquifer outflow in regolith and bedrock, and possible abstraction of groundwater by deep rooted trees. Some ideas are given in Appendix A2.

Measurement of groundwater levels at TSD using the existing network of existing hand dug wells began at an opportune time, following the worst drought on record and before a wet season of above average rainfall. It is suggested that BGS/IH/MLAWD take up and improve upon this work, in this catchment and subsequently in other catchments identified in the ongoing pilot project.

In the longer term, it is hoped that methods developed and experience gained during these studies will be valuable in work towards restoration of degraded catchments. In particular, it is hoped that the present studies will help to identify management practices that increase available water resources, and be used in future work to quantify the impact that these management practices have when introduced into a catchment.

The longer term programme of work might take one of two paths. It is possible that present studies conducted over a number of years in a number of small catchments could form baseline data collection for these catchments. Improved management practices would then be introduced to these catchments and changes to catchment hydrology and available water resources quantified to some degree. Alternatively, using the methods and materials developed in the present work, a longer term study of several paired catchments could begin, baseline data and data on the effects of improved land management practices being collected simultaneously over a number of years. Thinking towards this longer term programme of work is at an early stage, but work conducted at catchment scale now will help to point the way.

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Appendix A1: Estimation of current use of groundwater in Masvingo Province as a percentage of annual average recharge.

At present, there are 2,161 boreholes and 1,225 wells recorded within Masvingo Province (DDF, pers. comm.). These have been constructed over a number of years by NGO's, DDF and MLAWD, and each has been or will be fitted with a single handpump. [NB. 756 of these boreholes and 610 of these wells are known to go dry during drought; the 610 wells are the subject of a present well deepening exercise.]

Assuming that all boreholes and wells yield water, the total number of waterpoints is 3,386. The average demand of a handpump is 6,500 m³/annum assuming a pumping rate of 0.5 l/s over a 10 hour day, 360 day year. This gives a total groundwater abstraction for the province of 22 x 10⁶ m³/annum.

A conservative estimate of recharge for the drier parts of Masvingo Province is 2% of rainfall (Houston, 1988). Assuming an average annual rainfall of 500 mm, recharge of at least 10 mm/annum over the province might be expected. The area of the province is approximately 57,000 km², giving an annual average recharge for the province of 570 x 10⁶ m³/annum.

The current use of groundwater in Masvingo Province is therefore of the order 4% of annual average recharge.

Appendix A2: A possible combination of groundwater and surface hydrology studies designed to quantify recharge at catchment scale and to better understand mechanisms important to this recharge within the catchment.

To quantify recharge by observing changes to the water table within a small catchment of total area 10-20 km² that includes the catchment headwaters, the following basic parameters must be measured:

Rainfall

Catchment groundwater levels

Aquifer outflow in the regolith and in the bedrock

Abstraction by water wells and by deep rooted vegetation

Observation of groundwater levels in some detail will also help to identify areas of high or localised recharge within the catchment. This recharge may be either direct or indirect. Direct recharge refers to water that infiltrates to the aquifer directly as a result of rainfall. Indirect recharge refers to water that enters the aquifer via permeable sections of streams where surface runoff and or interflow has collected. It can become important when a combination of high ground slopes, poor surface cover, and high intensity rainfall generates considerable overland flow, and may occur in some of the small catchments to be studied. Finally, if the watertable is high and intercepts the stream, baseflow from aquifer to stream may occur. Thus, at different times and for different periods of time, one of three possible flow regimes may exist:

i) Direct and indirect recharge: when surface water has concentrated in an influent (losing) stream or vlei. To separate recharge by each mechanism, separate studies of either the direct or indirect recharge will be needed, total recharge at catchment scale being given by:

$$\begin{array}{l} \text{Total recharge} \\ \text{(direct + indirect)} \end{array} = dS + A_r + A_v + O_r + O_b$$

where dS is change in groundwater storage for the period, A_r and A_v are abstraction from water wells and by vegetation respectively, and O_r and O_b are aquifer outflows from regolith and bedrock respectively.

ii) Direct recharge only, no baseflow: when the stream is neither influent or effluent, for example when the stream is dry and the water table does not intercept. Separate studies of direct recharge in this case can be comparative, since direct recharge at catchment scale will also be given by:

$$\begin{array}{lcl} \text{Total recharge} & = & dS + A_v + A_r + O_r + O_b \\ \text{(direct only)} & & \end{array}$$

iii) Direct recharge only, baseflow occurring: when the stream is effluent, baseflow B_f occurring from aquifer to stream. Separate studies of direct recharge can again be comparative since direct recharge in this case is given by:

$$\begin{array}{lcl} \text{Total recharge} & = & dS + A_v + A_r + O_r + O_b + B_f \\ \text{(direct only)} & & \end{array}$$

where $B_f = TR_0 - SR_0 - I_f$,

the latter three terms being total runoff from the catchment, surface runoff and interflow respectively. Baseflow can be determined by analysis of the runoff hydrograph and or by separate studies of surface runoff and interflow.

Separate study of direct recharge required in the above analyses can be based upon determination of the soil water balance for different soils within the catchment and or by direct measurement of soil moisture content, potential and hydraulic conductivity near the soil/regolith interface. The former approach could be achieved using Penman evaporation equations and or direct measurement of separate components of the soil water balance, the latter approach might be possible using neutron probe and tensiometers depending upon depth to regolith. Direct measurement of separate components of the soil water balance would have the advantage that surface runoff and interflow needed in analysis of flow regime (iii) would also be provided, but measurement techniques able to consider large areas should be chosen to reduce problems of spatial variability.

Sufficient piezometers within the catchment and in two transects across the chosen catchment outlet will be required in order to identify areas of localised or high recharge and to measure hydraulic gradients, transmissivity and aquifer cross section where aquifer outflow occurs. Piezometers across and along a streamline if it exists will also be needed to observe when and if baseflow or indirect recharge occurs. A weir will also be required at the catchment outlet to measure surface outflow.

Finally, abstraction of groundwater by deep rooted vegetation might perhaps be quantified by direct measurement techniques, by use of satellite data, by estimates of the soil moisture budget in an approach similar to that taken by Howard and Karundu (1992), or during periods of no recharge by quantifying the water balance in areas with and without trees and calculating the difference. This component of the work (at least) requires further consideration.

PROJECT TITLE: THE EFFECT OF LAND MANAGEMENT AND
GROUNDWATER RECHARGE

LOCATION: NATURAL REGIONS IV AND V, ZIMBABWE

COLLABORATORS: DEPARTMENT OF RESEARCH AND SPECIALIST
SERVICES AND THE INSTITUTE OF HYDROLOGY

FUNDING: ODA ENGINEERING DIVISION

BACKGROUND

Basement complex gneiss and granite underlie much of semi-arid Africa. This formation provides a limited but widespread water supply for domestic use and small scale irrigation. During periods of drought, when surface water sources are scarce or non-existent, this groundwater resource plays a life saving role for millions of people. The development of the collector well by BGS has greatly enhanced the ability to abstract groundwater from these generally low yielding basement aquifers. However, the sustainability of the yield of these wells and all existing wells is almost entirely dependent on the amount of recharge, and its year to year variability. This is unknown at present.

Typically basement aquifers are not uniformly productive, but only yield adequate and sustainable supplies, (a) where conditions allow adequate recharge, and (b) where weathering and/or fracturing has developed a significant permeability and storage over a sufficient area. Recharge has been estimated from baseflow analysis to be in the range of 0.5 - 4.0%, but this will be locally very variable. Recharge is influenced by many factors, including surface management (land use and agricultural practices), quantity, intensity and distribution of rainfall, topography, soil type (infiltration rate), and vegetation type. An understanding of the processes controlling recharge and the management effects of land use on these processes is needed.

The project is specifically designed to address the hydrological processes which affect the partitioning of rainfall at the land surface. As such, it forms a complementary and important addition to the existing IH and BGS studies in Zimbabwe. The process studies will be set within a catchment based study involving input from DRSS, IH and BGS. The catchment containing Tamwa, Sihambe and Dhobani (TSD) kraals (where there is a collector well) has been selected. This catchment is well defined and initial surveys have already been carried out. Water levels are being monitored in dugwells throughout the catchment, and in boreholes around the collector well.

AIMS

This study is aimed initially at identifying the main sources (loci) and processes of recharge. Once identified, the aim is to assess the influence of land use and agricultural practice on the recharge process and attempt to quantify the amount of recharge occurring. With this information we will be in a position to identify appropriate management practices that will ensure and perhaps even enhance present recharge rates. To achieve these aims, the process studies will be carried out within the catchment. This will provide baseline information on

catchment response that will be instrumented. It is hoped that this catchment will then continue as a long term monitoring and experimental site after the current project has ended.

OBJECTIVES

- i) To obtain a baseline catchment water balance (by quantifying the separate components) and by difference to estimate the amount of recharge occurring under present land use and management.
- ii) In liaison with BGS to identify the main loci and processes of groundwater recharge in the catchment.
- iii) To study and understand the processes of groundwater recharge identified in (ii) and in this way advise on potential benefits to recharge and catchment hydrology of improved surface management practices or different land use.

OUTPUT

The project will produce:

- 1. Fundamental data on the processes controlling recharge within the catchment under present land use and management.
- 2. An assessment of which processes are vulnerable to or can be improved by change of land use/agricultural practice and prediction of the effects of these changes. (ie. working toward better management and enhanced recharge from an already poor starting condition)
- 3. (In collaboration with the BGS/IH collector well project) An objective technique or series of techniques for defining areas favourable for the location of shallow wells and boreholes to provide a plentiful and sustainable yield for both domestic use and irrigation.

APPLICATIONS

The impact of land use and surface management practices on the sub-surface hydrology of the region can be quantified and appropriate surface management practices to enhance recharge can be identified. This will aid long term planning of development in these areas (Natural Regions IV and V), and can be used by agricultural extension offices to develop sound agricultural practices to minimise the effects of different land uses on recharge.

Development (in association with the collector well project) of successful siting techniques, and the delineation of areas of high groundwater potential will be of vital importance for the future selection of collector well, hand-dug well and borehole sites.

RECHARGE PROCESSES - OVERVIEW

The collector well, and virtually all of the dugwells are within the central cultivated part of the TSD catchment. Here, the soils are generally fairly deep and overlie saprolite of varying depth. Recharge may occur directly when there is sufficient rainfall to wet up the entire profile or may occur indirectly where water is concentrated through surface run-off from either:

- a) field areas, collecting behind contour bunds
- b) sloping areas of bare rock (inselbergs and smaller but extensive rock outcrops along the edges of the cultivated areas
- c) the beds of ephemeral streams fed by surface runoff from cultivated areas, or
- d) the beds of ephemeral streams in which most of the flow originates from the steeply sloping, very rocky, wooded areas of the catchment

In addition, recharge to the cultivated valley floor area may occur as upward movement of artesian water through inter-connecting fracture and joint systems, the head resulting from recharge in the surrounding hills, a process sometimes referred to as "by-pass flow".

All of the above processes may occur although it is likely that one or two will dominate. It is possible that their relative importance will vary as the wet season progresses and from season to season, depending on the rainfall regime.

LINKS TO THE BGS GROUNDWATER SUSTAINABILITY PROJECT

The British Geological Survey (BGS) are concurrently conducting a complementary groundwater study at the same catchment. The objective of the BGS investigation is to investigate the factors important to the sustainability of yield from wells and boreholes in hard rock aquifers. To this end they will: attempt to establish the extent of the weathered and fractured basement aquifers; estimate the storage of the aquifer, and use this data along with values for recharge and discharge to and from the aquifer to quantify the sustainable resource available to abstraction points. The link between the two studies involving complementary acquisition of data and sharing of results will further the joint aim of improving understanding of the sustainable resource.

The BGS work at T/S/D is part of a wider study that is being carried out in collaboration with Hydrogeology Unit of MLAWD. This study approaches the problem of groundwater recharge from the hydrogeological perspective. One method that will be used will be a numerical model to simulate the response of measured groundwater levels to rainfall events. The modelling approach supplies an integrated regional recharge value for the catchment as a whole. The study described here uses a process based approach. Recharge is calculated by measuring the deep infiltration taking place under various soil and land use types and in areas where run-off is concentrated. The work involves quantifying and defining the distribution and variety of recharge processes that operate within the catchment. This will enable the development of guidelines for appropriate surface management practices to improve the surface and sub-surface hydrology and in this way eventually enhance recharge. The results will also enable the regional recharge figures, derived from the BGS model to be distributed

within the catchment and to be linked to the various processes observed.

PROJECT MANAGEMENT

The project will be managed jointly by the DRSS and IH. Work schedules and visits will be agreed with Mr. Mharapara (Ag. Ass. Director DRSS), Dr. C. Batchelor (IH Programme Coordinator) and Dr. C. Lovell (IH Programme Manager) prior to implementation. Regular meetings will be held at the Lowveld Research Station to discuss project progress. Minutes of these meetings will be circulated to ODA and within IH, BGS and DRSS.

WORK PROGRAMME

1. The project start date is 1st April 1993 and will continue until 31st March 1996. The work will involve field measurements carried out over two rainy seasons, (1993/4 and 1994/5) and requires the presence of two personnel on site throughout each season. The Institute of Hydrology will place John Butterworth in the field to undertake part of the research programme; DRSS will provide a second field person to carry out the other part. As yet, the DRSS person has not been named.
2. The research topics: The research will be carried out at the Tamwa/Sihambe/Dhobani (TSD) catchment, where a collector well has already been in operation for two years.

John Butterworth will work toward obtaining a catchment water balance, with particular emphasis being placed on the distribution and quantification of groundwater recharge processes. This work will be closely linked to the BGS groundwater study being carried out at the same site. Results will provide baseline data to improve understanding of recharge mechanisms with a view to implementing surface management techniques to enhance the process.

The research programme of the Zimbabwe Counterpart is to be finalised. However, we suggest the work might concentrate on either; investigating the way in which different soils, land use types and agricultural practices affect infiltration characteristics or; it can be a study of the hydrological role of deep rooted natural vegetation in this type of catchment. For example do deeply rooted trees extract water directly from the water table? Such research will show how changing the land use and introducing different agricultural practices modifies the hydrology of catchments in this part of Zimbabwe and many basement complex areas of semi arid Africa in general.

3. **Timetable of activities:**
A summary timetable of activities is given on the accompanying bar chart.

a) Field visits. It is planned for John Butterworth to arrive in Zimbabwe at the beginning of October 1993. This will allow for some preparation time in the UK (eg ordering equipment). The Zimbabwe counterpart should ideally begin at the same time, though it will be preferable to select the person by the end of July at the latest. This will allow time for an application to be made to the British Council for help with funding toward the costs of either an MSc or PhD at the department of soil science

at Reading University.

b) Purchase and shipping of equipment. This will be done between July and the middle of October 1993. The list of equipment to be supplied, purchased and/or constructed is as follows:

- 3 Weir structures
- 3 Stilling wells
- 10 Water level transducers (3 for weirs, 7 for dipwells)
- 3 Munro Chart Recorders (backup for weirs)
- 3 Single channel loggers
- 1 Automatic Weather Station with Campbell logger (spare channels to be used to monitor water levels)
- 2 Recording raingauges with single channel loggers
- 3 Manual storage check gauges
- 2 20 m well dippers
- 40 lengths 6 m access tube
- 40 lengths 6 m pvc tube (40 mm dia.)
- 30 Ground protection platforms (for np obs)
- 1 Neutron probe and ratescaler (hire?) Access tube/dipwell installation equipment (borrow/hire)
- 1 Hand drill for the installation of shallow dip tubes and deep access tubes
- 1 Rainfall simulator

c) Installation of weir: This is a top priority exercise which needs to be completed before the beginning of the rainy season. It will be necessary to select a site at the TSD catchment, obtain permission from local farmers and find out the costs and time taken to construct a weir before the end of September. We hope this can be arranged through Chris Lovell. Construction should ideally take place in October at the latest. The location will be at the catchment outlet as shown on the accompanying map. If sufficient resources become available at a later date, weirs and recorders could also be installed on the two tributary streams, where they enter the cultivated area from the surrounding hills. A water balance for these forested subcatchments may be able to provide some information on whether "leakage" from these areas recharges the aquifers in the main valley through by-pass flow.

d) Collection and appraisal of existing hydrogeological, geomorphological, land use and soils data in the region will be carried out in September and October. Initial correlations of well yield with geomorphology, geology and soils will be carried out at this stage in liaison with BGS. The data will be used within a GIS system to produce preliminary maps of hydrological domains.

e) Installation programme: The installation of equipment will begin in October and will proceed for as long as necessary to complete. A target date for completion is the end of January 1994.

- * Automatic Weather Station (AWS), complete with raingauge and manual check gauge centrally in the catchment (probably close to the collector well garden)

- * 2 further recording raingauges (each with a storage check gauge), one at the head of the catchment, the other in the forested hills along the southern edge.
- * Transects of water level monitoring and deep access tubes extending:
 - i) Downslope from a bare rock slope shedding water into the cultivated area
 - ii) Across the main stream bed
 - iii) Across the tributary stream channel
 - iv) Down a slope with contour bunds but with no significant runoff contribution from a rock slope above. Other transect locations may yet be identified, for example on different soil types.

Potential sites are shown on the map. Access tubes will be installed where possible to the water table, but in any event will be installed to at least 5 m depth (below rooting depth of crops). Installation will be made using a Leopard air drill fitted with either a 48 mm or 51 mm star bit. The object of the transects are to gain an idea of the relative importance of these zones in contributing to recharge. Most will be monitored manually, at least daily following rainfall events. Some key locations will be fitted with recorders for continuous monitoring. The water level tubes will be of narrow diameter and installed by hand wherever possible; where this is not possible a hand held motor driven drill will be used. BGS are planning to drill further observation holes for pumping test monitoring and IH will liaise on the location of these holes so that wherever practicable, they form part of the proposed transects.

Water content data measured by Neutron Probe would allow:

- i) the determination of the depth of wetting and the increase in soil water storage, and its variation with soil type, position on slope and in relation to bunds. Recharge is only likely to occur where the depth of wetting is sufficient to reach beyond the zone from which root abstraction occurs.

If the access tubes are deep enough:

- ii) the monitoring of water table level changes and an indication (from (a)) of whether an increase in water table level was the result of local vertical infiltration or lateral movement following recharge elsewhere.
- iii) the measurement of saturated storage, ie a very good direct measurement of the specific yield of the material. It is important to note that a large rise in water level does not necessarily imply a large amount of recharge. A small amount of recharge into a material with a low specific yield will cause a large water level rise. Water content data will clarify this.

If it appears that direct recharge through the soil is an important process, more detailed measurements of soil hydraulic properties and soil moisture changes will be necessary at selected sites covering a range of soil and land use types. A possible distribution of three potential sites is shown on the map. Similarly, if it appears that indirect recharge from sources of concentrated flow is an important process, more detailed work in these areas will be needed.

f) Soil hydraulic properties: Detailed measurements of soil hydraulic properties will be made using disc infiltrometers, rainfall simulators and the internal drainage method. Infiltration can also be studied using runoff plots (see map).

Measurement of soil hydraulic properties can best be undertaken when water is available at the end of the rainy season during April and May 1994. Further work could be carried out during the 1994/5 field season in necessary. Work on rainfall run-off plots will need to be completed during the latter half of the 1993/4 rainy season and during the 1994/5 season.

This part of the study, investigating the effects of soil type and agricultural practice on infiltration and runoff generation, will involve significant input from the counterpart if our research suggestions are taken up.

g) Transpiration rates from trees: Preliminary work can be carried out in the dry season to establish whether large trees/shrubs are actively transpiring at rates higher than can be sustained by soil moisture storage. If rates are higher, the implication is that groundwater is being directly accessed by roots. In this case the abstraction needs to be incorporated within any water balance. The best time for this work is at the end of the dry season (August/September). Techniques will involve the use of porometers and/or deuterium tracing.

h) Supervisory visits: It is anticipated that Dr. Lester Simmonds will be the higher degree supervisor for both John Butterworth and the counterpart and will make one short (3 week) visit per field season. A second supervisor may also be appointed depending on the exact nature of the work undertaken. From the Institute of Hydrology it is also planned for J. Bromley and M. Hodnett to pay one short supervisory visit per field season. J. Bromley will visit in his capacity as sub-project leader and ground water hydrologist; M. Hodnett will advise and direct on soil physics aspects of the research.

4. Transport

IH is able to provide one vehicle for sole use on the project, plus running costs. Since most of the work is being carried out at one site and it is expected that both staff will stay at or near the field site, this is expected to be adequate for most of the time. However, it may be necessary for DRSS to provide a pool vehicle for transport where circumstances demand (eg. breakdown of project vehicle)

5. Housing

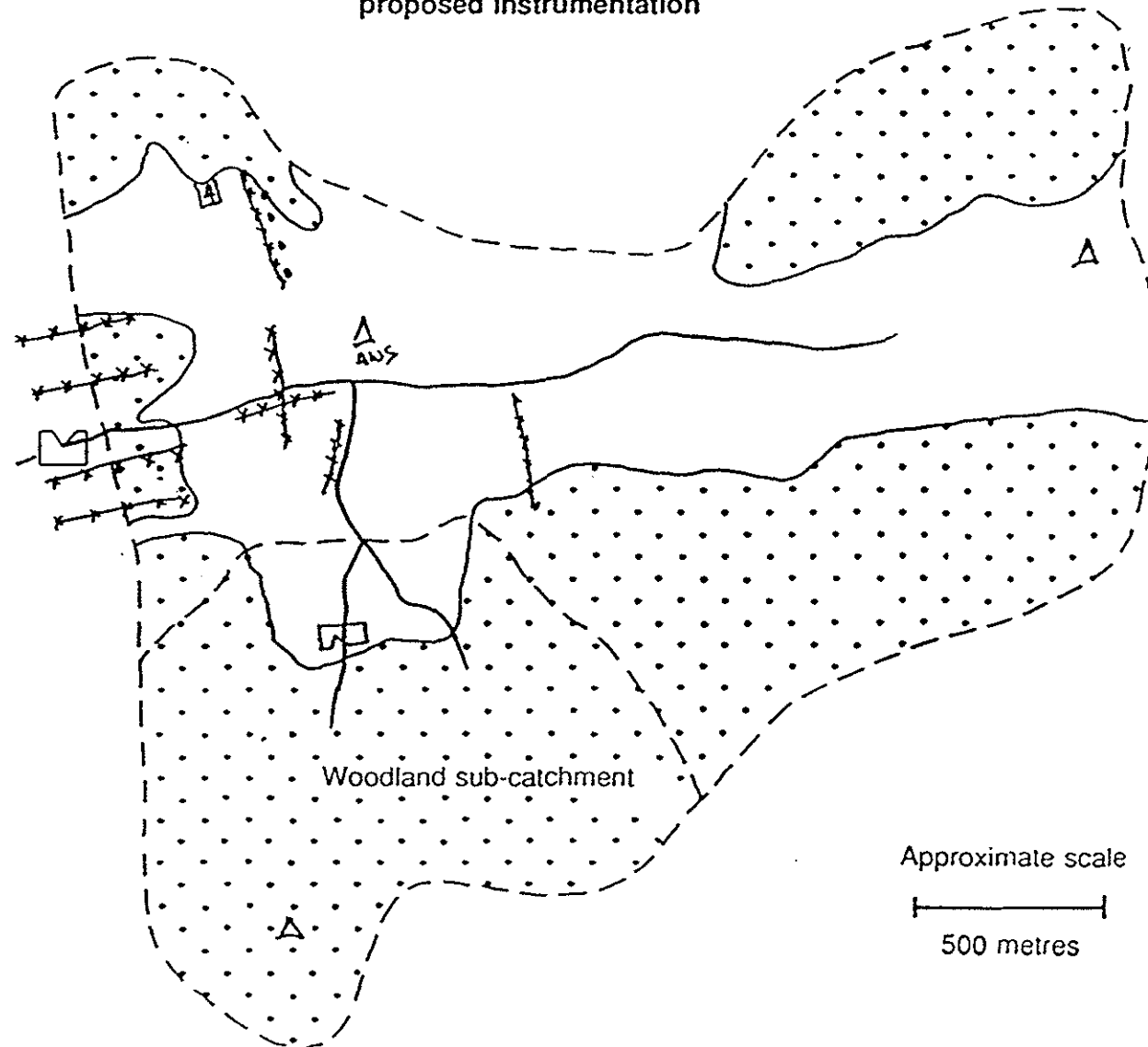
The project will provide funds for accommodation near to the field site and subsistence for both the IH and DRSS representatives.

6. Publications

Interim reports will be prepared by project staff each year and jointly published by IH, BGS, DRSS and DWD. Generally, technical papers using results from the project will be published under joint authorship with the senior author being the person responsible for the bulk of the writing and preparation. In the case of single authorship, the permission of the other organisations should be sought and their contribution to the study fully acknowledged.

Tamwa/Sihambe/Dhobani Kraal Catchment proposed instrumentation

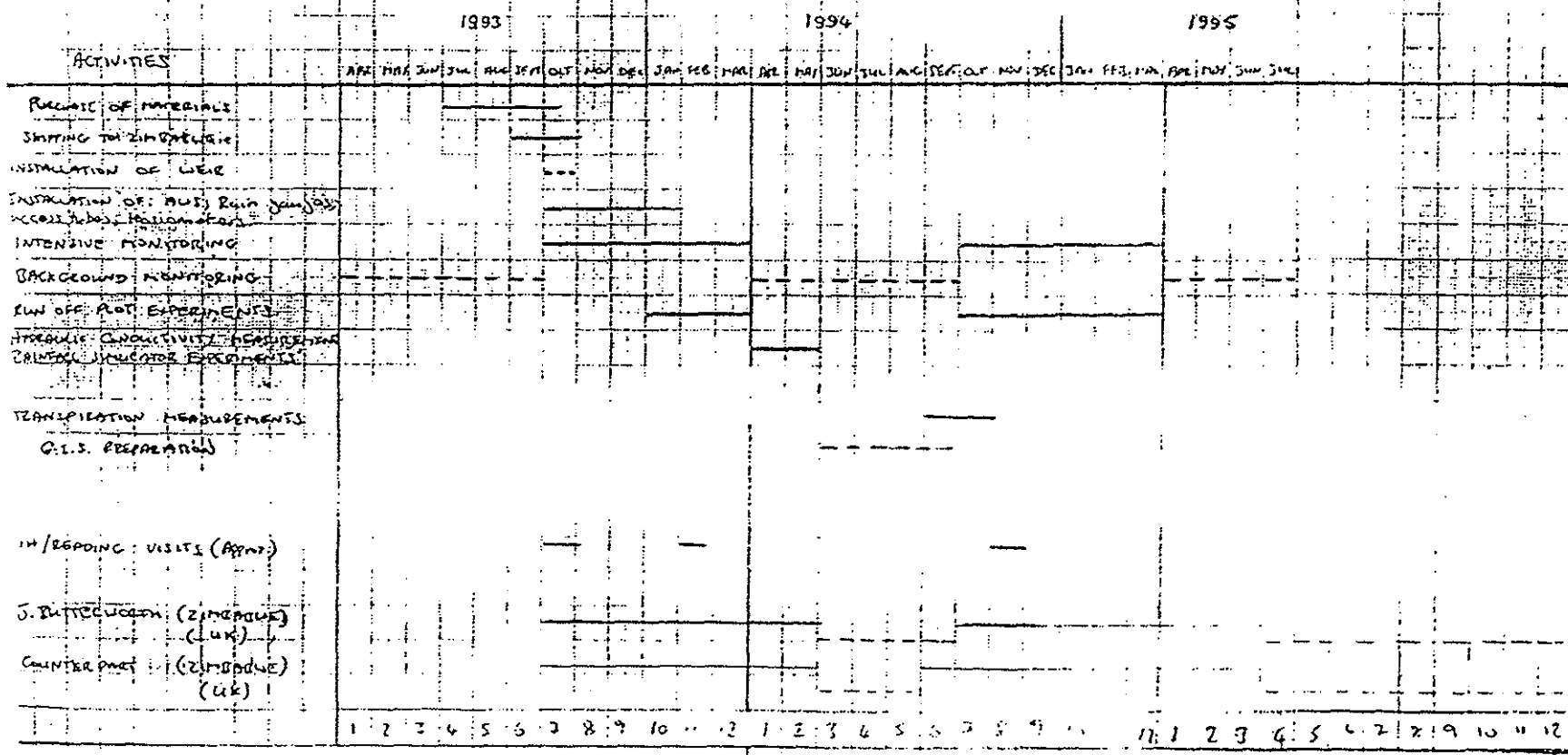
- Key**
-  Agricultural land
 -  Woodland (much exposed rock)
 -  Stream channel
 -  Catchment boundary
- Instrumentation**
-  V-notch weir
 -  Automatic weather station
 -  Raingauge
 -  Observation borehole transect
 -  Soil moisture monitoring transect
 - A* Run-off plots



Approximate scale
500 metres

← Rains →

← Rains →



YEAR 1

YEAR 2

YEAR 3

YEAR 1

YEAR 2

YEAR 3

SUSTAINABILITY OF WELLS IN BASEMENT AQUIFERS (ZIMBABWE)

A substantial amount of research has been carried out by BGS over the last decade into the yield of wells in basement aquifers and on exploratory techniques for siting productive wells. This project will use that work as a platform to investigate specifically the sustainability of yield from wells using detailed study of individual sites. By monitoring groundwater levels in a catchment long-term over dry and wet seasons and by quantifying recharge, storage, transmissivity, flowthrough and abstraction from wells a better understanding of the groundwater systems will result and will give greater insight into factors important to sustainability.

Aims

1. To better understand the aquifer and groundwater flow systems within basement aquifers
 - spatial variability of storage and transmissivity
 - areal variability of regolith thickness
 - recharge processes
 - groundwater flow in the aquifer
 - groundwater flow to wells
2. Identify factors important to sustainability and relate those to exploration techniques

Objectives

1. Identify a number of well sites and carry out a detailed program of field work to investigate all relevant processes taking place within the aquifer
2. Produce a conceptual/digital model of the aquifer system and well hydraulics as a tool for identifying factors important to sustainability
3. Analyse further/update/add to the database of wells set-up during the Basement Study Project 1983-89

Criteria for selecting investigation sites

There are many variables that could be important to the sustainability of the yield from wells in basement aquifers. It was envisaged that approximately four sites would be selected. The small number of sites means that it will be necessary to keep some of the criteria 1-6 (listed below) constant.

1. Geology
2. Geomorphology
3. Average Regolith thickness
4. Vicinity to lineaments
5. Relief
6. Well type (borehole, dugwell, collector well)
7. Locality
8. Sites with relevant data already collected
9. Sites identified by the Institute of Hydrology

Work necessary at sites

This will be undertaken by resident and visiting BGS staff, by staff of collaborating organisations and by local people where necessary.

1. Produce a plan including
 - all abstraction well sites
 - observation wells (when drilled)
 - topography
 - soil types
 - geology
 - surface water features
2. Monitor groundwater levels
 - design monitoring network
 - drill observation wells
 - level-in observation wells
 - set-up monitoring program
3. Quantify abstraction rates
 - either approximately or by attaching flow meters
4. Investigate recharge processes (collaboration with IHI)
 - monitor rainfall
 - sample for chloride balance
5. Monitor river flow (where appropriate)
6. Identify aquifer dimensions and properties
 - geophysical surveying of the depth of weathering zones
 - pump tests on existing and newly drilled wells
 - falling head tests during drilling of new wells
 - recovery testing of existing dugwells over time with falling water levels
 - log core
 - core analysis (Wallingford)
 - packer testing for transmissivities with depth



Institute of
Hydrology

Watershed Resource Management for Semi-Arid Regions

A discussion document for reducing
land degradation and improving
resource management at the watershed
level in Natural Regions III, IV and V
in Zimbabwe

C.J.Lovell, I Mharapara,
C.H.Batchelor & P.G.Whitehead

May 1993

WATERSHED RESOURCE MANAGEMENT FOR SEMI-ARID REGIONS

A Programme for Natural Regions III, IV and V of Zimbabwe

1. BACKGROUND

Watersheds in the semi-arid areas of Zimbabwe are degrading at an alarming rate. It is clear that action is needed immediately to halt this degradation.

The physical causes of degradation are well known. Loss of trees, overgrazing, and poor surface management of marginal lands cleared for agriculture give rise to decreased infiltration, increased surface runoff and associated soil erosion, faster loss of water via efficient drainage networks of rills and gullies, and apparent decline in groundwater recharge. Throughout semi-arid regions including southern Zimbabwe watersheds exhibiting this degraded and dessicated condition can be seen. Increasing population pressure and drought exacerbate the situation. Watershed hydrology has been changed for the worse in recent decades and further deterioration will occur in the future. The present system of land use and resource management is not sustainable.

Although a considerable challenge, sustainable watershed management in semi-arid regions is possible. Management at present is poor, but improved practices and alternative systems of land use appropriate to the region and to its people are known, and in a few cases have been introduced in isolation at field scale.

The magnitude and complexities of the problem require an holistic programme of land and water resource management at the watershed scale. The programme would bring together both well proven and recent research recommendations, technical and social, to implement a full range of improved resource management practices. An interdisciplinary approach (physical, social, economic and environmental) would be undertaken to quantify interactions and assess benefits. The programme will provide a new link between agricultural research and extension and a new platform for community education.

Village leaders in southern Zimbabwe are acutely aware of the effects of land and water resource degradation. They have seen it occur and remember better times. The programme would build on this awareness by providing alternative management practices, making full use of participatory methods and experience gained in recent work that shows the potential of this approach.

The Rio Earth Summit emphasised the importance of achieving sustainable systems and this principle is central to the Agenda 21 document signed by all countries. Chapter 18 of Agenda 21 is entitled 'Protection of the Quality and Supply of Freshwater Resources: Application of Integrated approaches to the Development, Management and Use of Water Resources'. The proposed programme is directed precisely at meeting the Agenda 21 goal of establishing sustainable systems for Semi-Arid Regions.

2. OBJECTIVES

2.1 Wider Objectives

- i) To develop and evaluate resource management strategies that halt the degradation of watersheds in semi-arid areas and lead to improvements in the environment and in the quality of life of rural communities;
- ii) To develop and evaluate methods of encouraging and promoting sustainable resource management by rural communities;
- iii) To enable extension services and rural communities to better understand the physical, social, economic and political causes of land degradation at the watershed level in semi-arid areas;
- iv) To provide guidelines for governments, aid agencies and extension services for arresting the degradation of watersheds in semi-arid areas.

2.2 Specific Objectives

- i) To identify representative watersheds in southern Zimbabwe covering a range of physical and social conditions;
- ii) To carry out baseline surveys to quantify the current socio-economic and physical conditions;
- iii) To evaluate different strategies of introducing improved resource management practices;
- iv) To evaluate the short and long term social and physical effects of resource management practices at the watershed level;
- v) To use watersheds as demonstration areas for policy-decision makers and for training and educating extension workers and rural communities;
- vi) To understand the processes controlling watershed behaviour and to develop generalised models for application to other regions.

3. PROJECT DESCRIPTION

3.1 Broad Strategy

A multidisciplinary study of watershed management will be initiated to investigate interactions between the physical, social, economic and environmental factors that cause and influence land degradation. Several small representative watersheds will be selected in the semi-arid areas of southern Zimbabwe. These watersheds will cover a range of physical and socio-economic types and exhibit different degrees of land and water resource degradation. Baseline data on physical and social factors will be collected in the first phase of the project to quantify the current situation. In the second phase of the

project improved management practices will be introduced using different strategies and the impact of these changes on land and water resources, the environment, and the quality of the life of rural communities will be monitored. The project will aim to arrest and eventually reverse degradation at the watershed scale in the project watersheds and thereby to demonstrate that sustainable resource management in semi-arid areas is feasible.

3.2 Component Studies

Figure 1 shows that the project can be split into a number of component studies that will be tackled concurrently. The components are as follows:-

a) Physical Aspects

Figure 2 shows the main components of the physical aspects of the project. These fall into baseline studies which establish information on watershed hydrology and sediment transport under current land use and resource management practices and monitoring studies that assess the impact of changes to land use and resource management. Changes that would be encouraged would include the adoption of improved soil and water conservation practices, conservation and replanting of forestry in marginal areas, increased use of gardening where feasible, and improved management of livestock.

In addition to monitoring and data collection, mathematical models will be employed to integrate information and process studies developed to improve understanding of the key mechanisms operating. Models will be generalised so that application of results and recommendations to other sites and regions is possible.

b) Social and Economic Components

Figure 3 shows the main components of the social and economic aspects of the project. As in the case of the physical aspects of the project baseline monitoring will be undertaken to establish the current quality of life of rural communities in the watersheds. This will include assessing income levels, nutritional status of, in particular, women and children, education levels, gender issues and health levels. The project will evaluate different strategies of promoting and encouraging improved resource management as well as monitoring change and the effects of change on a range of social and economic indicators.

c) Environmental Components

The environmental component of the project will include assessing the impact of change on wildlife in the study areas and on pollution levels within and outside the study areas. Environmental cost benefit studies will be carried out to assess the effects of change in resource management on the environment.

3.3 Timetable

It is envisaged that work on a number of components of the project could start immediately, in some cases, by changing the emphasis of existing DR&SS and AGRITEX collaborative projects. For example the objectives of current collaboration between DR&SS and IH on groundwater recharge could be changed to include monitoring of the water balance at the watershed scale. Work on the overall project will depend partly on obtaining sufficient funding and partly on the formation of a multi-disciplinary team capable of tackling the project. Figure 4 is a barchart that gives an indication of a possible timetable during the first six years of the project.

4. PROGRAMME ORGANISATION AND FUNDING

A multidisciplinary team (or unit) will be required to fulfill the programme objectives. This core team should include a programme manager, a hydrologist, a hydrogeologist, a soil and water conservationist, an economist, and an agricultural extension / education officer. Additional expertise will be used as necessary to undertake well defined project tasks. The core team should be located at the Lowveld Research Station near Chiredzi and fall under the jurisdiction of the DR&SS.

Funding would be sought from a number of agencies such as CEC, ODA, Care International, World Bank GEF and IUCN. The cost of the programme will be high but certain aspects of the programme will appeal to different funding agencies. A consortium agreement could be reached in which each funding agency support a specific part of the programme. Given the high profile of the Rio Earth Summit and the demand for action towards sustainable systems, the submission of such proposals to the above agencies is very timely.

5. PROGRAMME OUTPUT

5.1 Guaged Watersheds

A major output from the programme will be instrumented watersheds that can be used not only to achieve programme objectives but also for additional socio-economic or physical studies such as the impact of climate change on semi-arid areas. If the programme is successful, communities within the demonstration watersheds will benefit directly in the form of improved local economies, improved water supplies and improved food supplies.

5.2 Publications

The main method of disseminating results and recommendations from the programme will be in the form of training materials, handouts, reports, conference papers and journal publications. These will serve to inform at the local, national and international levels.

5.3 Education and Training

The programme watersheds will be used for demonstration of sustainable resource management to policy makers, extension staff and rural communities. Extension staff could be seconded to the programme for periods during which they would receive "hands-on" training from programme staff. Educational aids such as videos and posters will be produced for local and international use.

5.4 Development Plans and Guidelines

Recommendations emanating from the programme will enable development plans to be drawn up by government authorities and by donor agencies that will counter the large-scale degradation occurring in semi-arid regions. The Rio Earth Summit produced Agenda 21 which is a plan for the 21st Century. This specifically states that countries should look to new methodologies for the development of sustainable systems. Output from the proposed programme, if successful, will enable Zimbabwe and other countries with large semi-arid areas to meet the commitments falling under Agenda 21 protocol.

6. RECOMMENDATIONS

i) Use this document at the national ministry and planning level to initiate discussion on all aspects of the proposed programme.

ii) Prepare project proposals for funding for components or modules of the overall programme. Funding agencies that have an interest in funding studies of this nature include ODA, CEC, IUCN, AKRDP, UNEP, Care International, Ford Foundation and, possibly, the World Bank GEF.

iii) Set up a WATERSHED RESOURCE MANAGEMENT UNIT within MLAWD based in the south-east of Zimbabwe. In addition to assembling the necessary skills needed for the programme, this unit would act as a focal point for funding.

iv) Change the emphasis of current DR&SS and IH collaborative research on soil physical processes to include evaluation of water balance at the watershed level.

• Department of Research and Specialist Services
Institute of Hydrology

31 May 1993

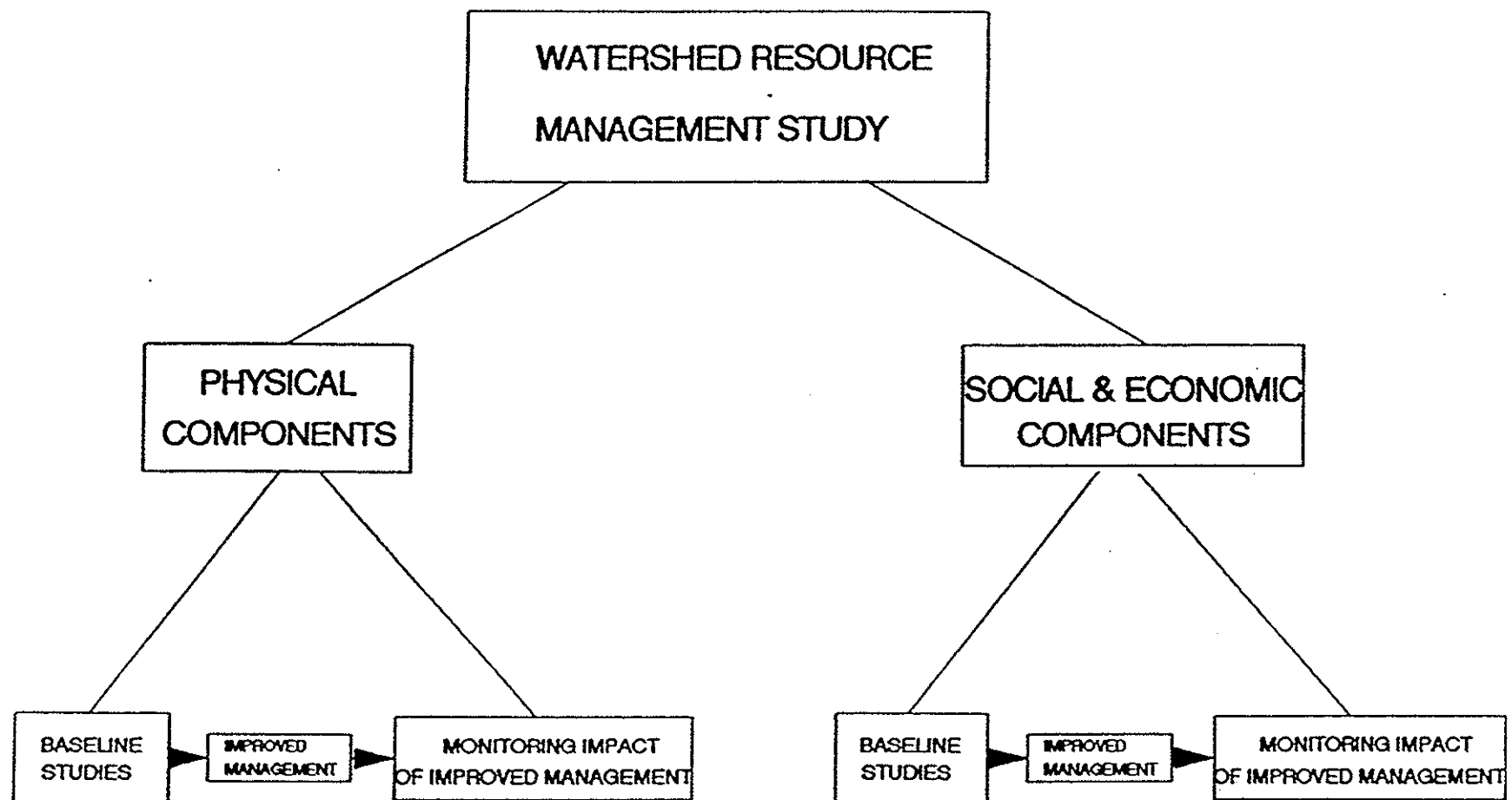


Figure 1. Major Components of the Programme

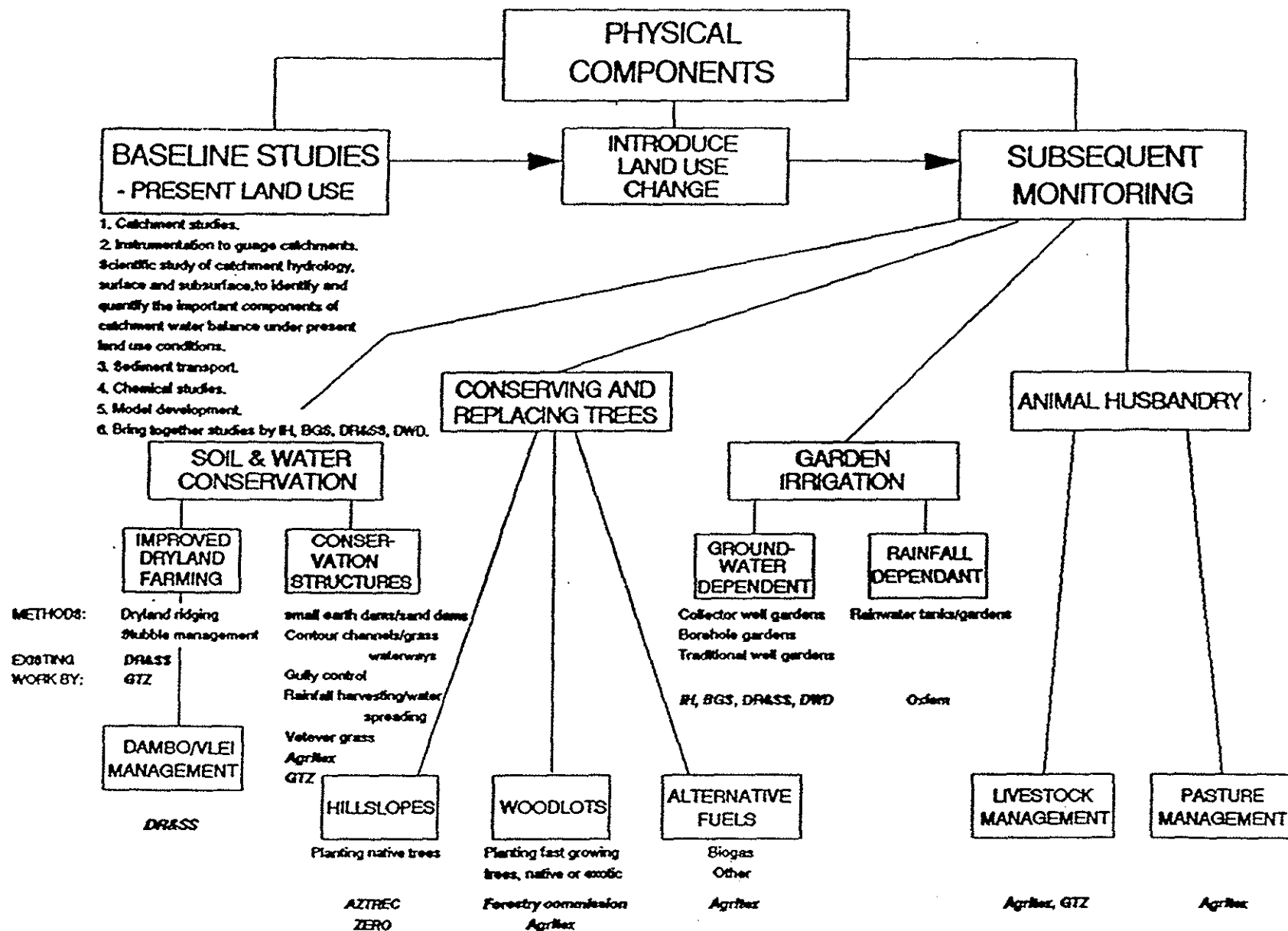


Figure 2. Specific Physical Components of the Programme

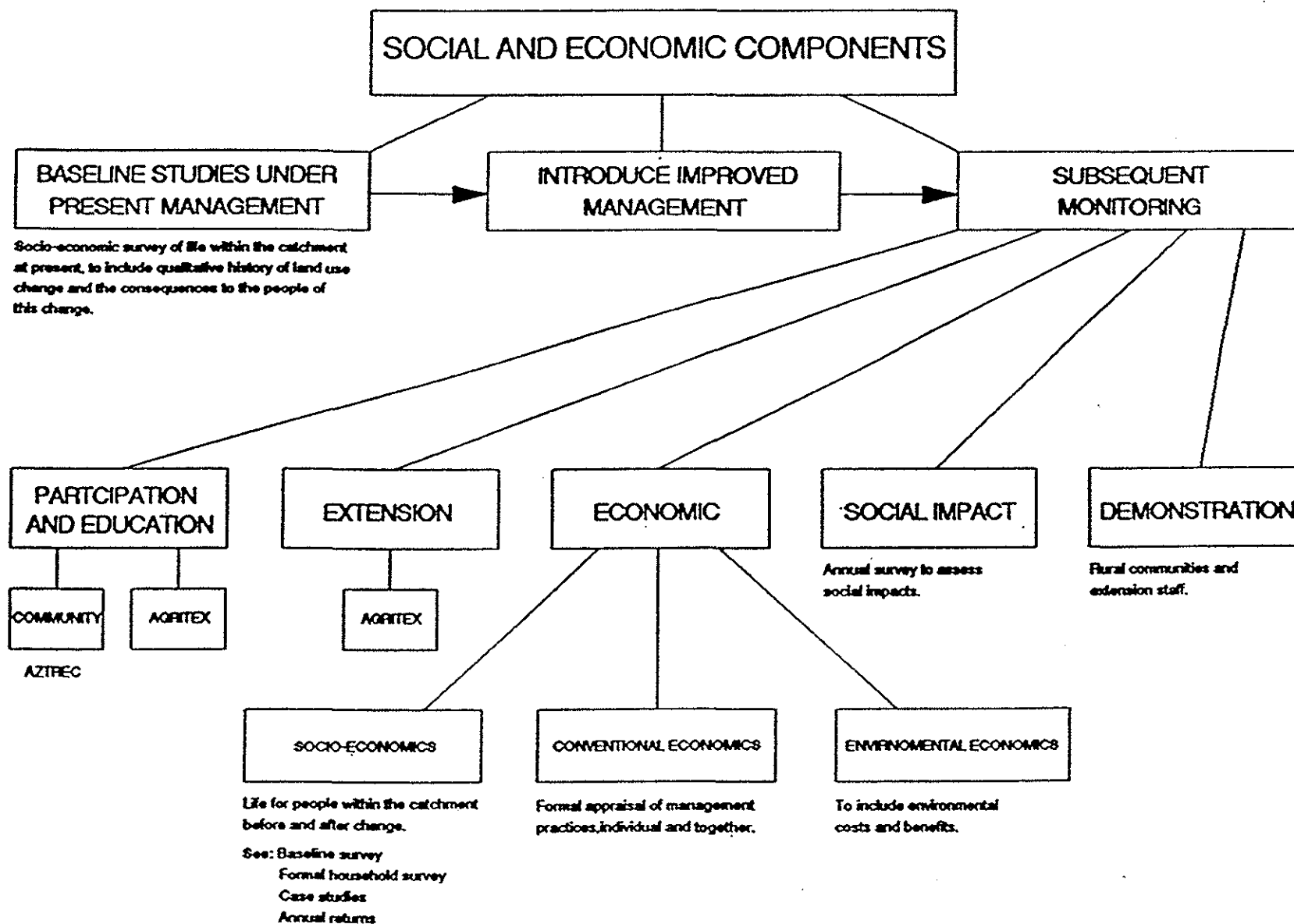


Figure 3. Specific Social and Economic Components of the Programme

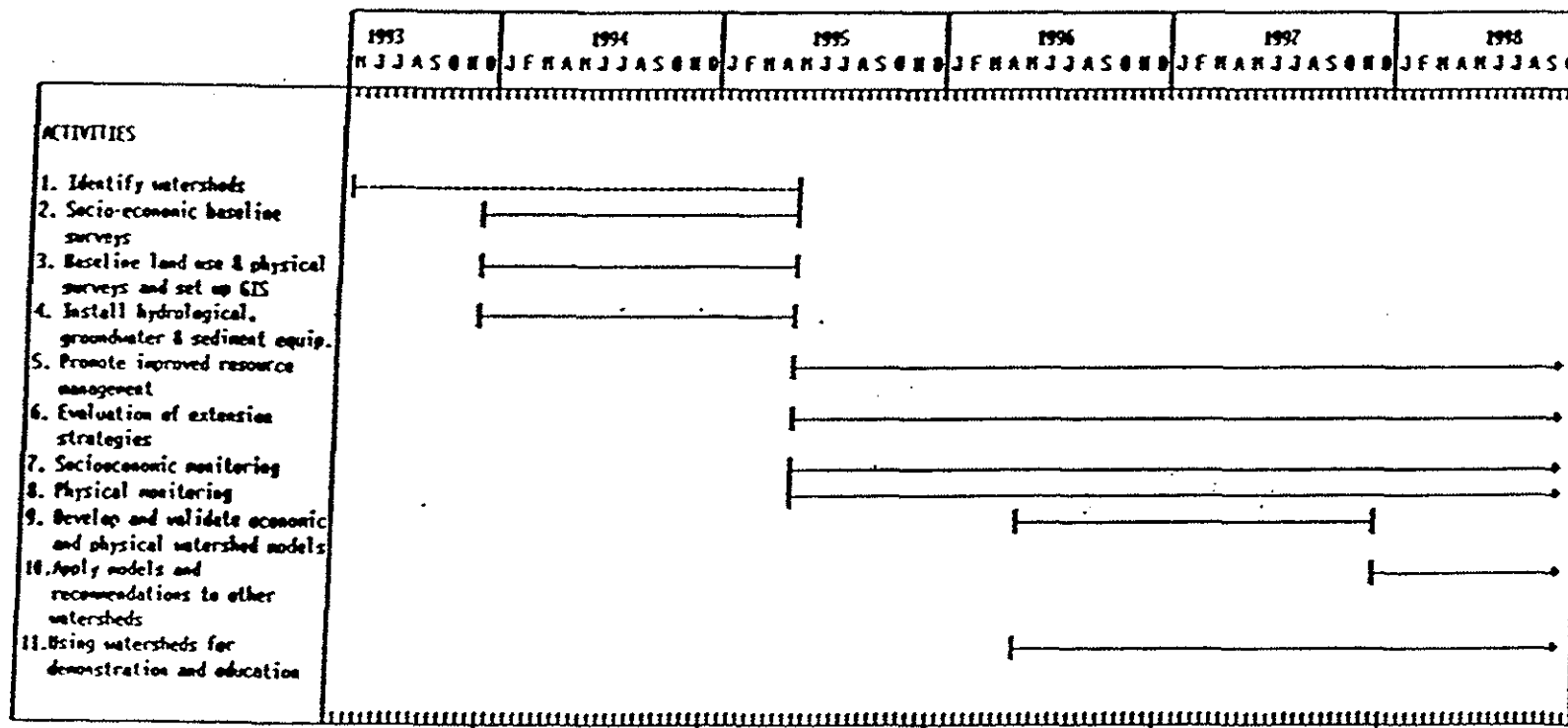


Figure 4. Possible Timetable for the First Five Years of the Programme.

APPENDIX 11

CONCEPT NOTE:

Project : CATCHMENT MODELLING AS A DECISION SUPPORT STRATEGY
FOR GOVERNMENT

Location : SOUTH-EAST ZIMBABWE

Organisations: DEPARTMENT OF RESEARCH & SPECIALIST SERVICES,
DEPARTMENT OF AGRICULTURAL EXTENSION &
DEPARTMENT OF WATER DEVELOPMENT, ZIMBABWE.
INSTITUTE OF HYDROLOGY, UK.

BACKGROUND

"The main processes of land degradation in Zimbabwe are deforestation, overgrazing and soil erosion. These result from mismanagement of land resources in a country characterised by a high rate of population growth, large livestock numbers, a lack of financial and manpower resources for sustainable land management, and a land tenure system which promotes overgrazing. Soil erosion and siltation in river systems are widespread, and an energy crisis resulting from rapid denudation of woodland reserves is acute in communal areas and some resettlement areas" (ODA, 1992).

In Zimbabwe, as well as other countries in semi-arid Africa, the inevitable consequences of not improving present land and water resource management need conveying in a more forceful way. The alternative in the long run is further descent into poverty and hunger. Already, poor crop yields and eroded lands highlight the tragic consequences of neglect; further degradation will continue to drive more and more farm households into poverty from which it will become harder and harder to re-emerge.

The very complex, interdisciplinary issues of land and water resource management call for their integration into sustainable development strategies. There is presently no well developed 'package' of recommendations for sustainable land management in either the communal or resettlement areas of Zimbabwe. It seems reasonable to question whether policymakers have either a realistic perception of the risks of remaining static, or of the potential benefits of alternative management strategies.

For more than thirty years, agricultural science has been central to the development of alternative management strategies, but to date has provided little assistance to those seriously considering the policy options. Information is urgently required

of the potential costs and benefits at local and regional scale of implementing various simple, improved management practices appropriate for the highly populated, presently degraded, communal lands of natural regions III, IV and V; of the risks of remaining static; and of the merits or risks of resettlement in less populated parts of these drier zones.

One way forward appears to be scenario building, sobering predictions based on the 'what if' approach to land and water resource management using as input historical weather, hydrologic and demographic records available and data from agricultural science relating to the performance and potential of simple, alternative management practices. The natural unit for land and water resource management is the river basin or catchment. In order to put forward potential management options in a credible and visual way, a predictive tool is needed. Simulation models that consider the catchment scale and which now offer a powerful management tool for this purpose are available eg. ANSWERS (Beasley et al, 1980); Institute of Hydrology Distributed Model (Eeles & Blackie, 1993).

METHODOLOGY

The project proposed would be conducted in several stages:

i) A review of available catchment hydrology simulation models placing particular emphasis on simulation of the effects of land use change and surface management, in order to identify a current model most suited for use in this region and for this purpose, given present weather, demographic and agricultural data available in Zimbabwe;

ii) Identification of a representative network of small catchments (5-10 km² each) in Natural Regions III, IV and V chosen on the basis of their environmental, physical and socio-economic characteristics. Catchments will also be chosen such that they lie within a larger river system eg. Save/ Lunde basin to permit regional extrapolation of project results.

iii) A case study approach, to assess in more detail the history of environmental, physical, and socio-economic change that has occurred in each project catchment since the time of settlement. This interdisciplinary study will include:

a) remote sensing to identify catchment boundaries, quantify present land use, and provide an historical record of land use change;

b) household surveys to collect data on environmental, social and economic change that has occurred within the catchment for people living there. Particular emphasis will be placed on peoples perceptions of the reasons for these changes and their perceptions relating to different aspects of the environment including adoption of alternative management practices, constraints to this adoption, hopes for the future etc;

c) specific scientific studies to quantify certain physical parameters required for model simulation in (iv) below.

iv) Use of the catchment hydrology/land use model, in conjunction with demographic, meteorological, and agricultural science data on performance of alternative surface management practices, to simulate various management scenarios for the catchments and more broadly for the communal and resettlement areas of the region. These scenarios might include:

- * Remaining static ie. present land use, continuing increase in population.
- * Introduction of various improved management strategies, continuing increase in population.
- * Introduction of alternative land use, continuing increase in population.
- * Present land use, temporary reduction in population ie. resettlement of some families.
- * Present land use on new lands allocated for resettlement
- * Introduction of various improved management strategies on new lands at the time of resettlement.

Key issues to be addressed will include assessment of viable family land holdings under present and potential farming practices, and the social, economic and technical constraints that limit change at present.

v) A social cost benefit analysis of each scenario, to include an economic appraisal of their related environmental impacts.

The project will make full use of data currently being collected in other ongoing studies (eg. those funded by ODA, GTZ, NORAD, ACIAR, IBSRAM).

Several of the various improved management strategies for cropping lands that may be represented in scenario building have been used to some degree in communal areas previously eg. structural soil conservation measures. Others (eg. crop residue retention, fertiliser augmented soil enrichment, conservation tillage, dryland ridge and furrow) have been successfully applied on a more limited scale in agricultural on-farm trials. Several alternative land use patterns as components of the farming system (eg. controlled livestock grazing, groundwater based garden irrigation, vlei management, agro-forestry, cultivation of woodlots) have shown promise in discrete R&D projects. All are appropriate to some degree under present communal farming conditions.

The proposed project will provide the opportunity to bring together these various management options in an integrated manner and at an appropriate scale. It will go some way to identifying preferred options for sustainable land and water resource management in the region and, by assessing the potential costs and benefits both in human and environmental terms of implementing or not implementing change, will be of particular value to those considering policy options.

COSTS

Given the complexity of modelling land and water resource management at catchment scale, the project should remain simple in its early stages and include many simplifying assumptions. However, the complexity of scenarios to be simulated may be developed as the potential of this approach is recognised and further data becomes available. Detailed costs for the project can be prepared once comments have been received on this concept note, however it is estimated that £65K per year over a three year period would be required.

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