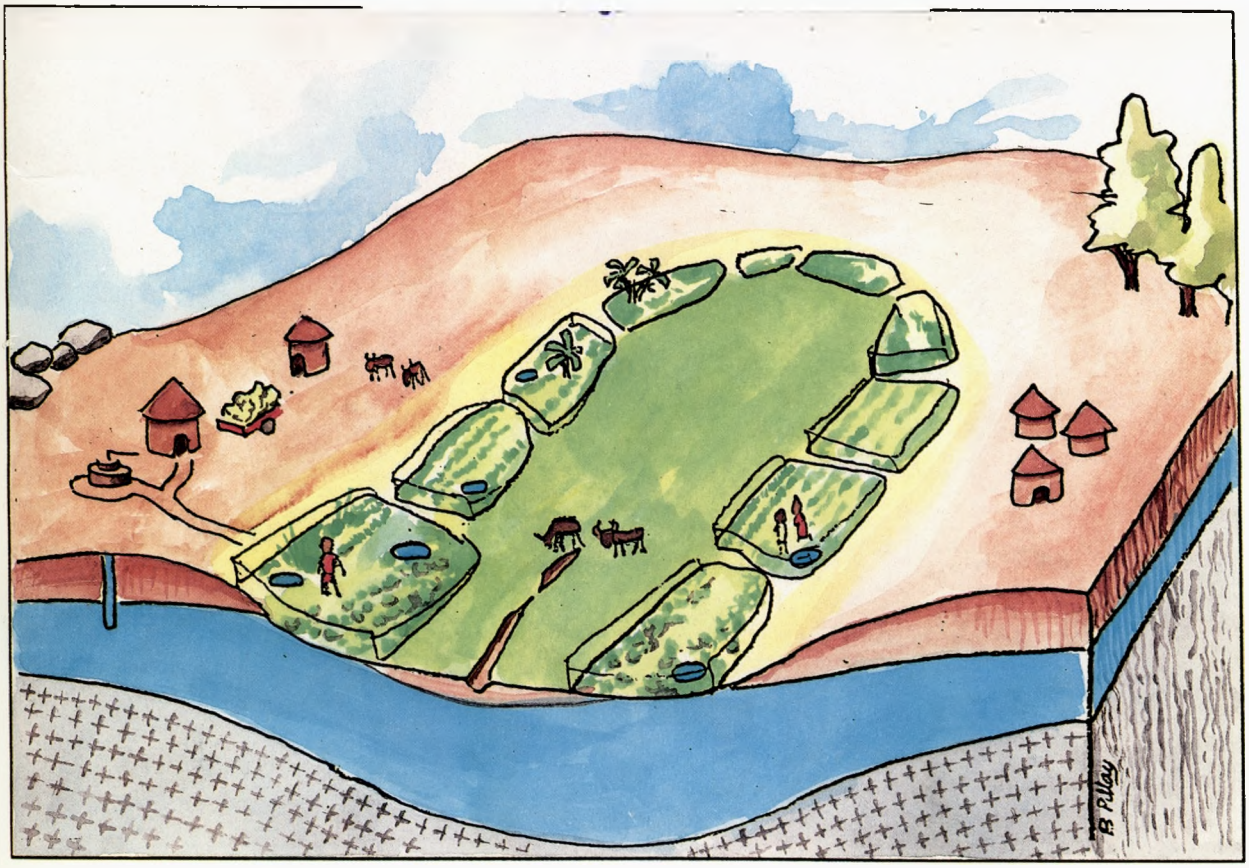
DAMBO FARMING IN ZIMBABWE:



Water Management, Cropping and Soil Potentials for Smallholder Farming in the Wetlands

Editors: Richard Owen, Katherine Verbeek, John Jackson and Tammo Steenhuis

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Conference Proceedings

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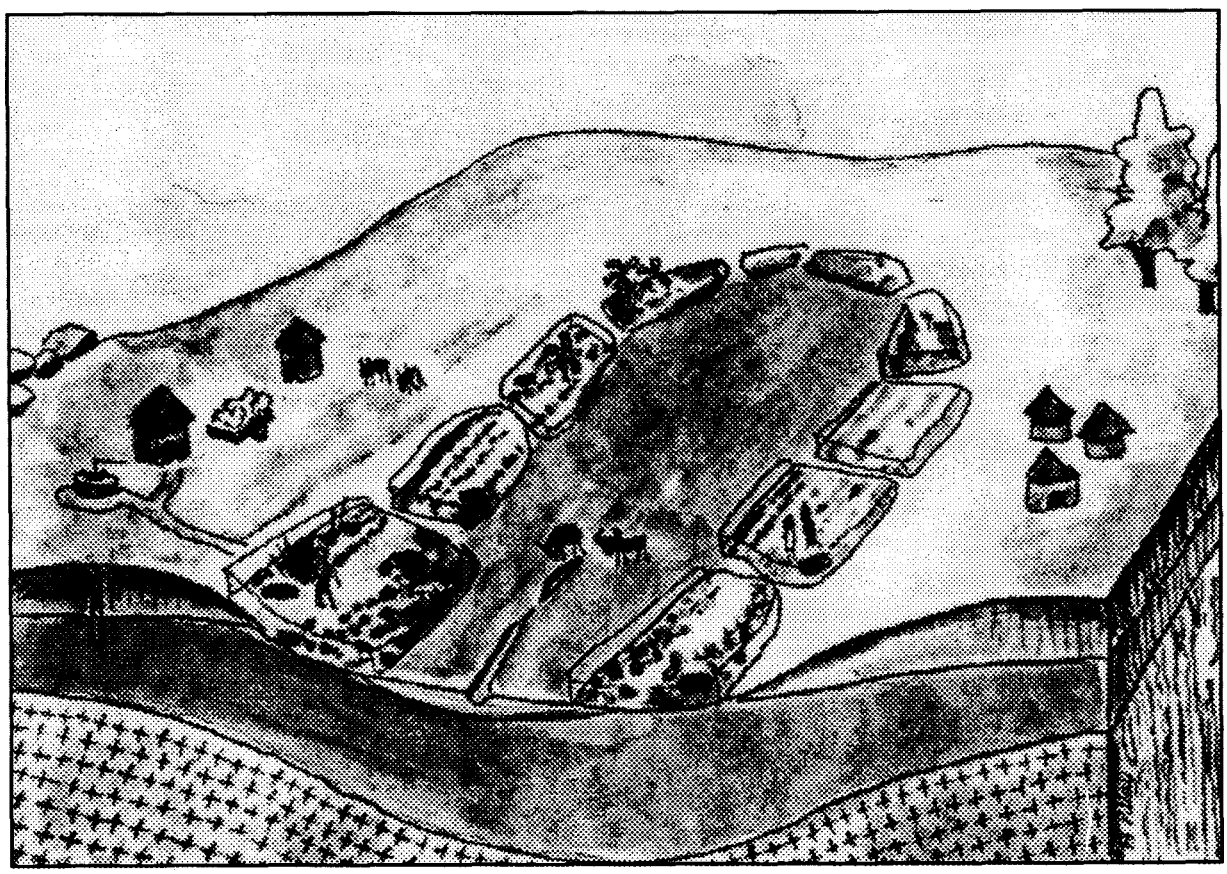
Section I

Water Management



Garden Irrigation Using Collector Wells:

Experiences from a First Scheme in Southeast Zimbabwe

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M. Murata,[2] E. Mazhangara,[2] and M. W. Brown[2]

Introduction

In semi-arid areas, low and unreliable rainfall combined with periodic years of drought has caused farmers to adopt agricultural practices that involve herding of livestock and extensive clearing of land for cultivation. Unfortunately, overgrazing and soil erosion on a massive scale and over vast areas of the semi-arid world is reducing the ability of the land to support this traditional farming system. Increasing population pressure and the possibility of climatic change make this already hazardous strategy further prone to failure. There is an urgent need to develop more sustainable farming systems for semi-arid areas that do not lead to land degradation.

The research described in this report has the potential to improve sustainability of agriculture by reducing farmer reliance on extensive farming systems. The overall aim of the project is to promote the use of small irrigated community gardens to complement rainfed cropping. In years of good rainfall, these gardens can augment rainfed crop production, reduce the need to crop marginal land and improve nutrition by providing a continuous supply of vegetables during the dry season. In years of drought, such as that now occuring in Southern Africa, there is no rainfed cropping. Irrigated gardens can provide rural communities with a vital "safety net", providing the only means of food production.

In 1988, a collaborative research project began between the Lowveld Research Stations (Department of Research and Specialist Services, Zimbabwe), the Institute of Hydrology (UK) and the British Geological Survey. The specific aims of this project are to develop efficient, low-cost methods of garden irrigation, and to study the feasibility of using shallow aquifers as a source of water for irrigated community gardens. In 1991, a first collector well and community garden was implemented in Chivi Communal Land in

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southeast Zimbabwe. This paper presents a summary of results and experiences gained during implementation and initial operation of this first scheme. For further information, the reader is also referred to the source reports by Brown (1992), Chilton and Talbot (1992), and Lovell *et al.* (1992). A summary of the activities is given in Table 1.

Principles of a Collector Well

Worldwide, 30% of the arid and semi-arid areas of developing countries is underlain by basement complex rocks. A feature of this geology is a superficial weathered layer that contains groundwater perched on hard rock beneath. Boreholes or traditional hand-dug wells tend to be ineffective at tapping this resource. Collector wells, shallow hand-dug wells of large diameter with horizontal boreholes drilled radially from the base, are designed for use in such aquifers. Extending for up to 30 m in each direction, the horizontal boreholes tap a larger area of the aquifer, can intersect discontinuities, and can greatly enhance the yield of water. Experience with collector wells constructed on basement aquifers in Zimbabwe and in other countries (Wright *et al.*, 1989) suggests that they could supply sufficient water for both domestic use and for garden irrigation.

The First Collector Well Garden, Chivi Communal Land

Site identification

During an initial survey conducted in March 1990, five potential sites for collector well gardens were identified in the communal lands of Matibi 1, Chivi, Sangwe and Nyajena. The selection criteria used during this survey are listed in Table 2. Strong interest in developing community gardens was expressed by people at all sites, but at the kraals of Tamwa, Sihambe and Dhobani in ward 22 of Chivi communal land, this interest was exceptional. The immediate enthusiasm of the people, combined with the impressive response of the local Agritex extension worker, made this site an appealing choice for the first scheme.

The collector well is providing at least a part of the drinking water requirement for over 1200 people and a continuous supply of vegetables for both home consumption and for sale for the 46 families with membership in the scheme

The three villages are located 5 km west of the Beitbridge-Masvingo road, turning off at km peg 86, 7 km north of Ngundu Halt (map reference 2030 D4, 672 037; 20° 43, S, 30° 43, E, elevation 800 m). They are situated amongst granite kopjes, in an area normally used to graze cattle and cultivate rainfed maize, cotton and sunflowers. Prior to the scheme, drinking water for all three villages was provided by a Lutheran community well sited on a nearby vlei, and by several private hand-dug wells. Small private gardens did exist next to the private wells, but there was insufficient water to allow gardening for the majority of the community. Tamwa Kraal is comprised of 36 families, Sihambe Kraal 30 families and Dhobani Kraal 37 families.

The climate is semi-arid with average annual rainfall between 450-650 mm. Most rainfall occurs as high intensity thunderstorms between November to April. The region is subject to periodic seasonal droughts and severe dry spells; less than 20% of normal rainfall fell during the 1992 'rainy' season. Maximum temperatures in excess of 30°C occur throughout the year and temperatures exceeding 40°C can occur during summer months. The soil type at the scheme is a grey medium grained sandy clay, a vertisol derived from dolerite and classified as an Udorthentic Chromustert. Water sampled at the site was found to be chemically suitable for human

Table 1. Diary of events during scheme installation

Date	Event	Comments
20/3/90	Reconnaissance survey	Shallow groundwater identified, interest expressed in collector well and garden.
5/4/90 local	Second visit	People had discussed possible scheme with Mahlekete, Agritex extension worker (AEW).
24/4/90	Letter from Mahlekete (AEW[3])	Delivered by D. Tamwa, Kraal Head, letter confirms interest in scheme.
26/4/90	First discussions	Area of land allocated for garden on lower slope.
20/5/90	Exploratory drilling	Quickly confirmed suitability of site for collector well at mid-slope position.
21/6/90	Digging of well	Vertical shaft completed to 12 m using local labour. Depth to water was 4 m.
10/7/90	MCCD participation	First meeting with Mr Mupinga, local field officer for Min.of Community and Cooperative Development (MCCD).
31/7/90	Land issue begins	Allocation of land on mid-slope near well becomes sensitive issue because land "owned" by elderly man reluctant for it to be used as a community garden. Problem put to Mr. Mhlanga (VIDCO[4] Chairman) for careful discussions with the community and elderly man.
28/11/90	Meeting to solve land issue	Project staff, Mr Mahlekete (AEW), Mr Mhlanga (VIDCO), three Kraal Heads and many members of the community, including elderly man, discuss options for land allocation. Conviction to avoid social conflict sufficient that gesture made by community to buy pipes necessary to connect well with garden sited 100m away. List of families to participate in garden prepared.
22/1/91	Materials for fence, pipe and tank delivered	46 families pay $10 to join scheme (9 male,37 female) PVC pipe linking well to garden paid for by community. Damaged contour channel resurveyed by Agritex staff. Community begin construction of water tank in garden (internal diameter 3.7 m, depth 1 m). Garden named "Chidiso changu" (which translated means "My ambition").
25/1/91	Communal garden survey	Miss Murata, LVRS Agronomist, begins collection of baseline data on current patterns of garden irrigation in Chivi communal land.

(continued)

(Table 1 continued)

4/2/91	Baseline economic survey	Mr Mazhangara, LVRS Economist, lives with community for 4 days to collect baseline socioeconomic data.
12/3/91	First cultivation	LVRS tractor used to perform ripping and first cultivation of heavy clay soil in area of 0.5 ha. Soil pit dug for soil classification. Tank completed.
15/3/91	Radial drilling of well	Laterals constructed in four directions to create collector well (see Chilton and Talbot, 1992).
28/3/91	Garden management meeting	Community discussed garden operation with staff of Agritex, MCCD and LVRS. Nomination of garden committee members. MCCD outlines role of cooperative. People to decide.
5/5/91	Construction continues	All families participate in construction and contribute bricks, sand and gravel. Fence and gates erected. Garden ploughed using 6 oxen. Trench dug from well to garden for pipe. Plots for each family marked on 0.25 ha. Nursery sown near water tank. Two 'B' type bushpumps and water level recorder installed on well. Garden committee Chairman trained in operation of recorder.
6/8/91	First season begins	46 families cultivate half garden (0.25 ha) on collective basis. Bushpumps repaired by project staff and community Garden renamed "Chadiso chamwari" ("Our ambition").
27/8/91	Official Opening Ceremony	Scheme opened by Mr. D. Ward (1st Secretary, BHC[5]) and Mr. J.Hungwe (Governor of Masvingo Province) and attended by staff of LVRS, Agritex, MEWRD, MCCD, MLGRUD and DDF.
5/9/91	Press release	Opening ceremony reported in local press.
25/11/91	Second season begins	Serious drought
3/1/92	Monitoring increased	Demand on collector well and garden rises as local wells begin to fail. Garden and domestic water use quantified.
9/3/92	To date	Serious drought continues. There is no rainfed farming in the area. 98 families (1,214 people) take drinking water from the well. 46 families grow vegetables in the garden. Surplus crops are sold to a ready market. Other gardens in the area have failed due to lack of water.

[3]AEW

[4]Village Development Committee

[5]British High Commission

consumption. It is clear and odourless, with a pH of 7.9 and electrical conductivity of 0.301 mS/cm.

Scheme Implementation

Exploratory drilling at the site quickly confirmed suitability for a collector well. Water was found at 4 m below ground level, and construction of the well began in June 1990. Full details of exploratory drilling and of well construction are given by Chilton and Talbot (1992). Briefly, the well is 2 m in diameter and 12 m deep. Hard rock was encountered at this depth. Prior to radial drilling, the safe yield of the well was estimated to be 0.4 l/s. After radial drilling, this had improved to 0.78 l/s. The well is lined with corrugated steel with a steel sanitary cover and concrete apron. Two 'B' type handpumps, manufactured by V&W Engineering in Harare, are mounted on the

Table 2. Site selection criteria used to help identify potential sites for collector well gardens, initial survey, 1990

Geographical

(a) Within a Communal Area of Natural Regions IV or V (ie. Chivi, Nyajena, Ndanga, Matsai, Sangwe, Matibi 2, Matibi 1, and possibly Maranda, Sengwe and Belingwe).

(b) In an area presently without reliable water sufficient to allow gardening, perhaps an area remote from dams, perennial rivers or alluvial aquifers.

(c) On a basement complex rock or other problem aquifer where extraction of ground-water can be improved by use of the collector-well principle (perhaps wells exist but provide insufficient water to allow gardening at present).

Hydrogeological

(d) Where groundwater is found 12 m or less below ground level, 15 m if permeable material is found immediately beneath.

(e) The groundwater found is of a quality suitable for irrigation and domestic use.

(f) Wells can be dug by hand.

Socioeconomic and agricultural

(g) The village group, found to be in need of vegetables, shows a strong interest in developing a community vegetable garden, and a willingness and ability to adopt new production techniques.

(h) The village group shows a willingness to allocate an area of land for use as a community garden and collector well site, the area henceforth to be available for the community and not overly influenced by any one single party.

(i) Perhaps a history of gardening exists in the area, but previous gardens were abandoned for legitimate reasons (eg. water at present insufficient to allow gardening).

(j) Though vegetables will be grown primarily for home consumption, access to a market should exist for surplus to be sold locally.

(k) A site chosen should ideally be one of several potential sites in an area, allowing other schemes to be developed following success of the first scheme.

(l) Many families (for example, more than 100) would benefit directly from the collector well garden if implemented.

well, complete with steel gantry to allow pump maintenance by the community.

Scheme operation

Membership of the garden was decided on a first come-first served basis; 46 families paid a Z$10 'joining' fee. On advice of staff of Agritex and MCCD, the scheme participants decided to form a committee to be responsible for decisions related to the garden. The committee was made up of four males and three females. It should be noted that, as far as possible, all decision making was left to the scheme participants. From the outset, it was stressed that the scheme belonged to the participants and that it was up to the participants to decide on crops to be grown and organisation and management within the garden.

First and second cropping seasons

Cropping commenced in August 1991. Initial performance in the garden was poor, due mainly to lack of experience, over-ambition that led to poor crop selection, poor social cohesion, and a failed attempt to operate the garden collectively. Disincentives arose for the members to contribute maximum effort to garden management. Shirking and freeloading by some members lead to discontent among others, and there was a general sense that members were not rewarded directly for their efforts. All of this contributed to inadequate weeding and erratic watering. Economic analysis showed the gross margin for the first season to be only Z$137; the garden committee decided that this money should be used to purchase seed for the next season.

In years of drought, irrigated gardens can provide rural communities with a vital "safety net," providing the only means of food production. "Gardening puts life into people and promotes self-reliance during drought" one person commented.

In complete contrast, the ongoing second season has been a resounding success. The people are quickly learning from past mistakes. At present, the collector well is providing at least a part of the drinking water requirement for over 1200 people and a continuous supply of vegetables for both home consumption and for sale. Organizationally, management within the garden has improved dramatically. Each family, represented by 33 female members and 13 male members, now has individual rather than collective responsibility for their plots. An organized system of bi-weekly irrigation has evolved that is manageable, and which allows the collector well to recover after each pumping. The scheme also benefits those people who re-sell vegetables bought at the garden and those people who bring other staple foods to the garden to sell, and it is generating cash for those scheme members who sell part of their crop. It is also providing hope for many people who would have few alternatives in time of drought.

It is clear that the women are the driving force behind the success of the scheme as they continue to carry out most of the day to day tasks. Although they are underrepresented on the garden committee, women make a significant contribution to decisions relating to the garden operation (Table 3).

Water use and abstraction rates

The partition of water taken for domestic use and for garden use was quantified by fitting two Kent 40mm PSM Class C water meters to a small header tank at the collector well. The following is a summary of results measured during a 25 day period in January (Table 4).

During the 25 day period a total of 325 cubic meters of water was abstracted from the collector well. The average daily garden use was equivalent to a daily irrigation of 4.6 mm. This was a reasonable application for the particular stage of crop growth, and would be expected to increase as the crops approached

maturity. The average daily domestic use for 1,200 people (equivalent to only 2 litres per person) was extremely low, and a census confirmed that many families did in fact supplement their domestic requirements with water from other local wells.

During the drought, monitoring of water levels and management of the collector well by the people has been very important. Since the garden places a heavy demand on the well, members have reduced cultivation in an attempt to preserve the life of the well until the next rainy season. Also, there is much interest in subsurface irrigation (demonstrations were set up on small plots within the garden), and in mulching using dry leaves. The people hope to improve water use efficiency primarily so that the maximum area of land may again be irrigated and the maximum benefits accrued.

Socio-economic analysis

Although the garden was envisaged as being primarily for subsistence, in the event, members have managed it as a commercial enterprise and are unanimous that income from vegetable sales is a prime benefit alongside drinking water and vegetables for home consumption. Vegetables are cut and offered for sale on a pre-arranged day every fortnight. A common price is set by the members who then sell their produce individually. At the end of each selling day each member pays a subscription of Z$1.25 into the common fund which is used to pay for inputs and repairs. Over the period January to May 1992 gross revenue from sales averaged Z$93.56 per member, less Z$9.75 worth of subscriptions. Respondents were unanimous that this surplus was spent on basic necessities such as sugar, salt and cooking oil and proved particularly welcome in a year of such severe drought. Indeed, an informal market has

Prior to radial drilling, the safe yield of the well was estimated to be 0.4l/s. After radial drilling, this had improved to 0.78l/s.

Table 3. Sources of decisions related to garden operation

	% of members		
	Decision maker	Source of labour	Attending and voting at meetings
Man	13	20	27
Woman	53	53	53
Joint	33	13	20
Children	-	7	-
Wage labour	-	7	-

Table 4. Water use and abstraction rates

	Metered Use (litres)	Average Daily Use (litres)
Domestic	58,267	2,353
Garden	271,576	10,655

developed on selling days with vendors coming to sell sugar and bread.

Cash flow

The value of vegetables produced by the garden up to 28 February 1992 is shown in Table 5. Given at least two more selling days in the second season, the value of produce grown in this season would increase to Z$3,922, giving a gross margin of Z$3,722 and a projected net cash flow of Z$9,836 per annum assuming three cropping seasons, labour to be unvalued, and maintenance to be at 5% of installation costs (Table 6). Initial economic analysis of the scheme using these figures indicates that the scheme yields an internal rate of return (IRR) of 33%, and a net present value (NPV) of Z$55,577 (£1=Z$8.5) at a discount rate of 12% on constant projected cash flows of Z$9,836 over a ten year period. A sensitivity analysis with a reduction in the projected returns of vegetables from the scheme of 25% would still indicate a rate of return of 21%. These figures are based on data collected in the field and, while necessary assumptions are made regarding the future trend of cash flows, it is clear that the scheme is economically viable.

These analyses are important but should not be the sole criterion for the evaluation of the scheme. The full costs and benefits of this type of small-scale irrigation schemes are very difficult, if not impossible, to appropriately quantify using conventional economics. Underhill (1990) points out that these schemes by their very nature tend to have a high social component. The costs of such schemes may be reduced by more self-help measures and the benefits are social as well as economic. It is likely, for example, that the health of the people of the community will improve due to improved nutrition. There are indications that some of the income generated by this scheme will be spent on education for the children. Fundamentally, people of this community have an improved quality of life that cannot be accurately measured in economic terms.

In a recent evaluation survey (Brown, 1992), members of the community at Tamwa, Sihambe and Dhobani kraals, and at neighbouring Puche and Matenhese kraals, revealed a high level of satisfaction with the scheme, particularly as it has so far managed to weather the drought while other water sources dry up. 73% of scheme members would probably not now have a garden if it were not for the collector well. Members (of whom 70% are women) appreciate the vegetables both as a source of nutrition for the family and cash for purchasing household necessities. Non-members benefit through access to a relatively cheap source of vegetables and also have opportunities to earn a cash income by trading in vegetables and/or an income in kind by assisting members with their gardening; "it puts life into people and promotes self-reliance during drought" was one man's comment. In the longer term, however, the true measure of success will be if the scheme is still working

Table 5. Value of produce grown

	Production (Z$)		
	Consumed	Sold	Total
Rape	388	1,369	1,757
Sweet Cabbage	568	361	929
Total	956	1,730	2,686

Table 6. Material costs (Z$) for scheme installation

	Salaries	Diesel	Compressor	Misc.	Total
Digging	2372	903	2950	428	6,653
12m Armco lining					7,514
Radial drilling	320	1540	3750	80	5,690
Test pumping	250	210	1200		1,660
Pumps, gantry and headworks (2 bushpumps, rods, rising mains, steel gantry, bricks, cement and materials for well cover and apron)					4,569
Total cost of well, pumps and gantry :					26,086
Construction of community garden (fencing for 0.5ha, gates, water meters, PVC pipe and materials for concrete/brick water tank)					3,884
Total cost of materials for scheme :					Z$ 29,970

and being maintained in several years time, and if neighbouring villages are still requesting schemes of their own as they are doing at present.

Discussion and Evaluation

1. Although site identification was time consuming, potential sites for collector well gardens were identified with greater ease than expected. Each site identified was unique in some way, reflecting the variety of landscapes and socioeconomic conditions that exist in the communal lands of the region. It will be difficult to put experiences gained at one site into context until data is gained at a number of sites.

2. Shortage of both water and vegetables is acute in this region. Strong interest in developing community gardens was expressed at all potential sites. Institutional and community participation were factors central to the eventual choice of site for the first scheme, the chosen site being notable for the strong local interest in setting up a community garden and the keenness of the local Agritex extension worker.

3. The local Agritex extension worker played a key role in encouraging and organising people of the three villages to participate and work together in community tasks. If a scheme is designed to serve more than one village, great care is vital at all stages of design, construction and operation to ensure that each village is equally represented. Lack of social cohesion, for whatever reason, can pose a serious threat

73% of scheme members would not have a garden if it were not for the collector well

to scheme success, and social conflict must be avoided at all costs[6].

4. Discussions at an early stage regarding management responsibilities and the need for a garden committee, for organisation of water user groups, and for a cash fund to start and maintain the garden, should help to prepare the people for management of their scheme and enable them to better decide if management as a full cooperative is desirable.[7] Participation during construction is important, and full responsibility should be given as soon as possible to promote the sense of ownership necessary for success.

5. Participatory monitoring and record-keeping by members of the garden has been very successful and has contributed greatly to the information gathered. Advice given on record-keeping by the local MCCD officer was very helpful.

6. Pointers to the future success of this scheme and of others are:

- The enthusiasm and hard work shown by the people
- Their ability to organise, to learn, and to respond to change
- Their full appreciation of the benefits
- The ready market for vegetables, both near and far
- Low initial targets in light of the prior situation
- The schemes once running can be independent of external inputs, with very low recurrent costs and negligible running costs to Government
- Drought (during drought there are very few alternatives)

7. Potential reasons for temporary scheme failure may be :

- Well failure due to low recharge during prolonged drought
- Well failure due to increased demand during prolonged drought
- Well failure due to over-ambitious irrigation in the garden
- Lack of good local leadership (eg. to arrange maintenance of pumps)
- Lack of social cohesion, leading to poor management
- Deterioration of groundwater quality (salinity or pollution)
- Decline in soil fertility (salinity)

8. Self reliance and independence from external inputs is very desirable. Pump maintenance will be an important component of these schemes; adequate training in pump maintenance should be given to members of the scheme at the time of pump installation to allow their confident repair as necessary.

9. Many non-members report that they did not originally enroll in the scheme due to an inability to raise the joining fee although members believe that it was because they were sceptical. There is probably some truth in both constraints which could be reduced in future schemes by an optional substitution of labour for the joining fee and citing the success of this scheme as a model for the sceptics.

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[6] During scheme implementation, a problem of land tenure arose. In theory, communal land is not owned. In practice, land tenure is a thorny issue, often important in development of small-scale irrigation (Underhill, 1990). At this scheme, conviction by some members of the community not to site their garden on land immediately next to the collector well, land "owned" by an elderly man, was sufficient that the garden was eventually sited away from the well, despite compensation offered by the VIDCO, increased cost to the community, and decreased security. Allocation of land for the community garden should be decided prior to well construction.

[7] Visits by staff of MCCD at the time of scheme implementation appeared to lead to confusion amongst the local people as to how their garden might be managed. The people had appealed to Agritex staff for advice on management, and were told of two gardens in the region that operated as cooperatives. Visits by staff of MCCD at this time gave the impression that their scheme was also to run as a cooperative.

Future Work

The British Development Division for Southern Africa (BDDSA) has agreed to provide ODA TC funds for the construction and monitoring of a six additional collector well gardens in order to identify a basis for replicating the schemes on a wider scale. Plan International has offered to fund the construction of an additional six collector well gardens as part of their long term development programme in Zimbabwe. If successful technically, socially and economically, it is hoped that these schemes can be the precursor for a much larger development project that will aim to install up to one hundred collector well gardens in the drier areas of Zimbabwe.

Research to improve water use efficiency in garden irrigation must continue. Experience from the first scheme in Chivi Communal Land highlights the heavy demand that is placed on any water source by an irrigated garden. Further work is needed to establish the practical guidelines needed. These guidelines should include simple irrigation schedules for the main vegetable crops grown, advice on crop establishment, planting arrangements, irrigation methods, manuring, and pest control. Members of the first scheme continually request advice on pest management, in particular, on low-cost safe methods of control for termites, cutworms, aphids, red-spider mites and centre-grubs. Dissemination of information to people in the Communal Lands is vital. Perhaps liason between staff of DRSS and Agritex, as a training and visit system during development of these guidelines, would be helpful.

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