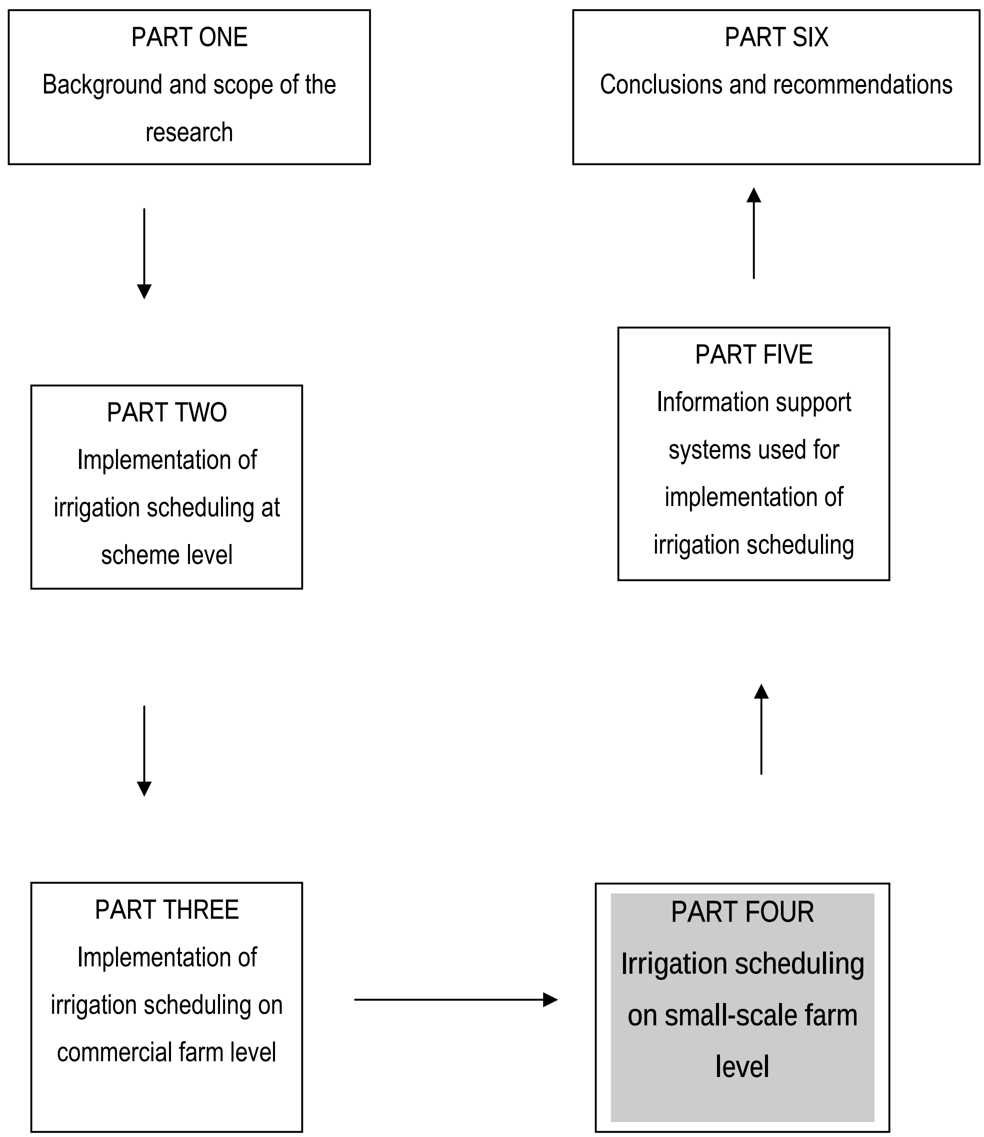
PART FOUR:

IRRIGATION SCHEDULING ON SMALL-SCALE FARM LEVEL



CHAPTER 10
BACKGROUND AND RESEARCH METHODOLOGY

10.1 INTRODUCTION AND BACKGROUND

This section deals with the current implementation status of irrigation scheduling practices by small-scale farmers in South Africa and identifies the factors and constraints that influence their adoption behaviour.

Irrigation has long been seen as an option to improve and sustain rural livelihoods by increasing crop production. Sustainable agriculture and irrigation development is defined as “agriculture, which meets today’s livelihood needs without preventing the needs of neighbours or future generation from being met” (Pretty, 1994). This definition implies a combination of ecological, economic, and social dimensions to be included in development programs and policies focused on the small-scale irrigation farmer. It also poses a challenge for professionals trained in the more conventional reductionistic scientific paradigm.

A review of the literature done by Bembridge (1996) indicates that, with a few exceptions, the economic success of small-scale irrigation schemes in South Africa falls far short of the expectations of planners, politicians, development agencies and the farmers themselves. According to a World Bank study the performance of small-scale farmer irrigation systems has generally been below expectations with low economic and financial returns (Serageldin, 1995). Small-scale irrigation in South Africa, according to Crosby *et al.* (2000), can be categorized in terms of their water supply as follows:

- Commercial and small-scale farmers on irrigation schemes
- Vegetable gardeners (served by communal water supply infrastructures)
- Independent farmers, each with “private“ water supply

It is also important to distinguish between full-time and part-time farmers in order to understand the irrigation technology requirements. Irrigated agriculture amongst the small-scale farmers is invariably aimed at the generation of a cash income or at least to supply some food for the household (food security). As far as can be ascertained from a survey done by Backeberg *et al.* (1996), there are 202 small-scale farmer irrigation schemes (SIS) in South Africa comprising approximately 46 000 to 47 500 ha under irrigation and about 50 000 ha as food garden schemes and food plots. De Lange (2004) adapted these figures as indicated in Table 10.1:

Table 10. 1: Small-scale farming in South Africa (de Lange, 2004)

	Homestead gardens	Rain fed fields	Irrigation fields	Grazing and livestock watering
No of households	2 400 000	1 700 000	56 000	1 700 000
Total area (ha)	200 000	2 000 000	100 000	12 000 000

Of the 202 small-scale irritation schemes, 79% are in the Eastern Cape, KwaZulu Natal and the Limpopo Province. As a whole, these schemes account for 4% of the irrigated areas of SA and from a rural and socio-economic point of view are of cardinal importance.

Small-scale farmer irrigation schemes in South Africa conform to one of five types (Bembridge, 2000):

- *Top-down bureaucratically managed smallholder schemes* fully administered by government or an agency of government. The management committee carries out farming operations on behalf of the irrigators. There is also no selection of farmers on the basis of “farming potential” and the majority of irrigation conforms in varying degrees to this category.

- *Jointly managed schemes* in which some of the functions are performed by the irrigation development agency, while others are the responsibility of the project participants. Such schemes are usually aimed at eventually developing farmers to produce their own food and a surplus for sale. Little selection of farmers on farming ability is evident.

- *Community schemes* which are usually small in size, operated and maintained by the water users themselves. There are relatively few of these schemes.

- *State or corporation financed schemes***,** such as those under sugarcane production, where the farmers are selected on entrepreneurial and farming ability, as well as on their financial and other resources. Government provides infrastructure to field edge and farmers pay a subsidised water charge and are responsible for their own decisions and management.

- Lastly, there are a few *large estate schemes,* which are state or private sector financed, often managed by agents at maximum use of resources through the production of high return cash crops like tea, coffee, various fruit and vegetable crops. Although there are some schemes where out growers participate on a pilot scheme basis, there is generally little farmer participation, except in the form of supervised labour.

The full range of irrigation systems is often found on the small-scale irrigation schemes, viz. flood, sprinkler, centre pivot, micro and drip irrigation (Crosby et al., 2000). Sprinkler irrigation is used on approximately 5% of irrigated land throughout the world (FAO, 2001), and in South Africa often found on relatively more modern irrigation schemes, which have recently been developed or revitalized. Flood irrigation is most widely used on the older schemes and in community gardens. A flood irrigation system that is indigenous to South Africa comprises short furrows, which are very popular because of the easiness to manage and maintain (Stimie, 2003). This system is an indigenous adaptation of the conventional long-furrow and basin systems used in commercial agriculture. A typical layout of a short furrow scheme is shown in Figure 10.1 It is highly manageable and requires comparatively little in terms of permanent infrastructure and maintenance. However, this simplicity of operation is only possible which correct system design, requiring a balance between water flow rates, furrow slope and length for the specific soil. On the community food gardens many of the farmers are making use of short furrow irrigation in vegetable crop production.

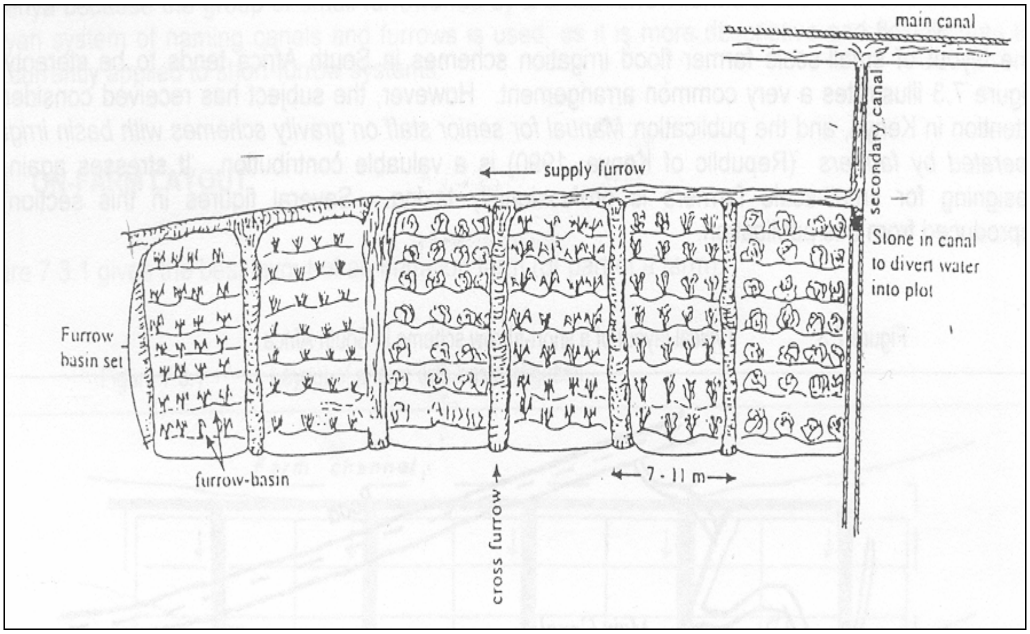


Figure 10. 1: Typical layout of a short-furrow irrigation scheme (Crosby *et al.*, 2000)

10.2 RESEARCH METHODOLOGY

The aim of this part of the study was to investigate and describe the irrigation practices and irrigation scheduling methods, which small-scale farmers are using in South Africa as well as their perceptions, and possible reasons why farmers have adopted or rejected the use of irrigation scheduling methods. This study consists of two phases. During the first phase a comprehensive literature study was done covering appraisals of the current situation of irrigation and scheduling, as well as the socio-economic and various technologies that influence small-scale irrigation farming. The interviewing of various key-informants on several of the small-scale irrigation schemes throughout the country comprised the second phase. The questions were aimed at gaining an in-depth understanding of the dynamics of irrigation management and obtaining important feedback about the farm conditions, management practices and farmers' needs. This required investigating the everyday irrigation practices of a sample of the small-scale irrigation farmers, and their interactions with other role players, and the interpreting of these relations in the relevant context.

The obvious research tradition that allows such a contextual analysis of human interaction is a case- study approach. Van Velsen (1967) refers to this as the "extended case study method" or situational analysis. In order to answer this kind of research problem, the analysis of only a single case-study is not appropriate, and therefore it was necessary to purposefully select and compare a few of the case studies (Yin, 1994). After consultation with the steering committee and several key informants, five small-scale irrigation schemes were selected for case study surveying namely:

- Zanyokwe Irrigation Scheme, Eastern Cape Province
- Tshiombo, Limpopo Province.
- Taung in the Northwest Province
- Nkomazi east (Walda, Boschfontein, Low's Creek, Figtree), Mpumalanga Province
- Bethlehem Apple Project, Free State Province

Primarily the qualitative research method (semi-structured interviewing, qualitative content analysis, analysis of narratives, history of irrigation scheme development, etc) was used to collect information to allow maximum farmer participation. The methods used range from visualization, to interviewing to evaluation of irrigation practices. Several participatory approaches have been used where farmers, extension officers and several key stakeholders participated in identifying farmer needs and possible solutions to problems faced. Knorr-Cetina (1981) refers to this method as a "sensitive method" as this approach ensures that the complex dynamics and interrelationships of a specific small-scale irrigation scheme can be understood and interpreted in their relevant context. The common theme is the promotion of interactive learning, shared knowledge and flexible, yet structured analysis.

The participants in these case studies were limited to 1) the farmers who practice farming at the specific irrigation schemes selected for the more intensive studying of irrigation practices and 2) extension officers and other key stakeholders who serve and work with these farmers at each scheme. At each site the number of participants was not predetermined, but the final sample size at each site consisted of active farmers and extension officers.

CHAPTER 11

IRRIGATION SCHEDULING IN THE EASTERN CAPE: CASE STUDY 1

11.1 EASTERN CAPE SMALL-SCALE IRRIGATION

According to Bembridge (2000) there are fifty small-scale irrigation schemes in the Eastern Cape comprising 9 527 ha with 6 349 participants. Table 11.1 indicates the information as collected by Bembridge (2000) as well as additional information collected by Eloff (2001) and Williams (2004).

Table 11. 1: Eastern Cape Irrigation Schemes (Bembridge, 2000; Eloff, 2001 and Williams, 2004)

Scheme	Area irriga-ted	Paticipants		Total	Major crops	Water source	Irrigation method	Energy source	Manage-ment agency
		CF	FPH						
Ngonyameni	17	1	0	1	Maize, Veg	River	Sprinkler	Diesel	Farmer Ass
Mzomtsha	1.5	0	9	9	Veg	River	Not implemented	Diesel	ECATU
Pakamisizwe	4	0	8	8	Veg	River	Sprinkler/ Dragline	Diesel	ECATU
Orange Grove	12.5	0	19	19	Veg	River	Not implemented	Diesel	ECATU
Phambili	3.5	0	5	5	Veg, maize	River	Not implemented		ECATU
Izikoletho	37	0	12	12	Veg, maize	River	Sprinkler/ Dragline		Private comp
Ngqubusini	3		18	18	Veg	River	Not implemented	Diesel	ECATU
Matakatye	5		6	6	Veg, maize	River	Sprinkler/ Dragline	Diesel	Num
Mjikweni	5.3		10	10	Veg	River		Diesel	-
Vukani	4		7	7	Veg	River	Sprinkler/ Dragline	Diesel	-
Lingelethu	0.8		14	14	Veg	Dam	Dragline	Diesel	ECATU
Ntsaka comm.	3		15	15	Veg	River	Dragline	Diesel	Private comp.
Xhefu	5	5	7	5	Veg	River	Sprinkler/ Dragline	Diesel	ECATU
Mngazi	32	1	0	1	Veg	River	Sprinkler	Diesel	Comm farmers
Tyefu	641	32	1646	1678	Veg, maize	River	Sprinkler/ Dragline		Comm farmers

Scheme	Area irriga-ted	Paticipants		Total	Major crops	Water source	Irrigation method	Energy source	Manage-ment agency
		CF	FPH						
Zanyokwe	471	58	146	204	Veg, maize	Dam	Sprinkler		Farmers ass
Horsehoe	56	18	0	18	Veg, maize	River	Sprinkler		Farmers ass
Keiskammahoek	744	45	102	147	Veg	Dam	Sprinkler	Diesel	Irrigation board
Mthombe	50	50	0	50	Veg, maize	River	Sprinkler		Farmers ass
Malenge	243	168	0	168	Veg, maize	River	Flood		Community
Joy comm.	1.5		36	36	Veg	Boreho le	Flood		Management comm.
Masizahke	17		143	143	Veg	River	Sprinkler/ dragline		Management comm.
Occupation post	1200					Dam	Sprinkler	Diesel	
Ncora	2490	16	256	272	Veg, maize	Dam	Sprinkler/ dragline		Farmers ass
Qamata	1959	1000	0	1000	Veg, maize	Dam	Flood. sprinkler		Farmers ass
Xonxa	780	30	0	30	Veg, maize	Dam	Centre pivot	Electricity	Farmers ass
Xonxa pilot	340		0	0		River	Sprinkler	Diesel	
Thornhill	27.5		110	110	Veg, maize	River	Sprinkler/ dragline	Diesel	Tribal auth.
Tendergate	100		400	400	Veg, maize	Dam	Flood		Community
Spring Grove 2	15		60	60	Veg, maize	Dam	Sprinkler	Diesel	Community
Spring Grove 1	43		172	172	Veg, maize	Dam	Sprinkler/ dragline	Diesel	Community
Rocklands B	70		280	280	Veg, maize	River	Sprinkler/ dragline	Diesel	Community
Rocklands A	18		72	72	Veg, maize	River	Sprinkler/ dragline	Diesel	Community
Mitford	77		308	308	Veg, maize	Dam	Sprinkler/ dragline	Diesel	Management comm.
Loudon	26		104	104	Veg, maize	Boreho le	Sprinkler/ dragline	Diesel	Tribal auth.
Hinana	40		160	160	Veg, maize	River	Sprinkler/ dragline	Diesel	Tribal auth.
Glenbrook 3	50		0	0	Veg, maize	Dam	Sprinkler	Diesel	Tribal auth. / Farmer. Ass.
Glenbrook 2	50		0	0	Veg, maize	Dam	Sprinkler	Diesel	Tribal auth. / Farmer. Ass.
Glenbrook 1	12		0	0	Veg	Dam	Flood		Tribal auth. / Farmer. Ass.
Beccles farm	22		0	0	Veg, maize	River	Sprinkler	Diesel	Tribal auth. / Farmer. Ass.
Yonda	16		64	64	Veg, maize, wheat	Dam	Sprinkler/ dragline		Tribal auth.
Shiloh	455	15	263	278	Veg, maize	Dam/ri ver		Electricity	Farmers ass

Scheme	Area irriga-ted	Paticipants		Total	Major crops	Water source	Irrigation method	Energy source	Manage-ment agency
		CF	FPH						
Prices Dale 2	29		117	117	Veg, maize, wheat	Dam/river	Sprinkler/ dragline		Farmers ass
Prices Dale 1	106.5		213	213	Veg, maize, wheat	Dam/river	Sprinkler	Diesel	Tribal auth.
Oxton Manor	60		0		Veg, maize, wheat	Dam/river	Sprinkler		Tribal auth.
Oxton	49		196	196	Veg, maize, wheat	Dam/river	Sprinkler		Community
Ngojini	18.5		74	74	Veg, maize	Dam	Sprinkler	Electricity	Farmer ass.
Mbekweni	42		84	84	Veg, maize, wheat	Dam/river	Sprinkler		Management comm.
Haytor	19		76	76	Veg, maize	Dam/river	Sprinkler/ dragline	Electricity	Farmers ass
Bushy Park	23		92	92	Veg, maize, wheat	Dam/river	Sprinkler/ dragline	Diesel	Management comm.
Katriver	1120	24	-	24	Citrus	River	Micro/ sprinkler	Electricity	Management comm.
Total	11 582	1 463	4 910	6 373					

Veg= vegetables; Farmer ass. = Farmer association; Management comm. = Management committee; Tribal auth. =Tribal authority; ECATU= Eastern Cape Appropriate Technology Unit; FPH = Food plot household; CF= Commercial farmer.

Eloff (2001) indicates that many of the schemes are either no longer in production or only partially in production. Most of these farmers, according to Bembridge (2000), are carrying a high debt load, mainly on account of poor financial management. The recent withdrawal from management from these schemes by the Department of Agriculture, the changing scenario in government financed irrigation schemes in the last couple of years and theft and vandalism of the irrigation equipment also contributed to the general poor state of in-field irrigation infrastructure. The rehabilitation of the irrigation infrastructure is currently addressed under the Comprehensive Agricultural Support Programme (CASP) and the Eastern Cape Department of Agriculture (ECDA) acknowledges the fact that the irrigation schemes need to be fully functional before it can be handed over to farmers for self-management. However to access funding from CASP, farmers have to organize themselves into legal farmer groups. In some areas farmers have successfully formed cooperatives and trusts, but in general they are lacking the necessary capacity to run and manage these institutions.

The Kat River Valley as indicated in Table 11.1 is a relative big irrigation scheme in the Eastern Cape and is well known for its citrus production. During the early 90's,some of the more productive citrus farms were taken over by a Ciskei parastatal, Ulimocor, and placed under the management of small-scale farmers. By 1994, many of the state run Ulimocor citrus farms further down the valley became unproductive, with the exception of a few farms, which were scheduled for irrigation and were licensed for water use (Eloff, 2001). In the "middle" and "lower" Kat River valley, commercial white and black farmers had continued to run commercial citrus farms, mostly for export markets that relied on irrigation water from the Kat River. These citrus farmers are members of the Kat River Cooperative, which is responsible for production inputs and helps with the marketing of the citrus. A full time extensionist is employed by the cooperative to support farmers with their day-to-day decisions on management and production. These farmers at present use no objective scheduling method, although tensiometers were used in the past. Farmers now make use of a fixed irrigation schedule as provided by the local citrus cooperative. These farmers formed the Kat River WUA during December 2001, when the Minister of Water Affairs and Forestry gazetted its constitution.

Farmers' major problems experienced on the irrigation schemes in the Eastern Cape are indicated in Table 11.2, as cited by Bembridge (2000) and confirmed by extension officers employed on some of the irrigation schemes in the Eastern Cape (Zanyokwe, Keiskammahoek and Qamata) through participation in a pair wise ranking exercise.

On many of the small-scale irrigation schemes in the Eastern Cape, farmers are experiencing problems with poorly maintained irrigation infrastructure where often hydrants, reservoirs, valves and water ways need attention. The lack of appropriate training of farmers to improve their technical and managerial capacity on the farm was also identified as stumbling blocks in the production of crops under irrigation.

Table 11. 2: Rank order of the major problems that farmers experience on the Eastern Cape irrigation schemes (Bembridge, 2000, Vusani, 2004; Dlulane, 2004, Dlovo, 2005)

Scheme problems	Rank position
Poor maintenance of infrastructure and equipment.	1
Lack of farmer training.	2
Local and political conflict.	3
High pumping and maintenance costs.	4
Lack of credit.	5
Poor market opportunities.	6

In 54 percent of the schemes listed in Table 11.1, farmers pump irrigation water using mainly diesel as source of energy. According to Bembridge (2000) and Williams (2004) many of the crop losses farmers experience are due to engine breakdowns. It seems from the rank order of problems (Table 11.2) that farmers on the relative bigger irrigation plots (>50ha) are more aware of the irrigation operational costs (Stimie, 2004).

11.2 CASE STUDY 1: ZANYOKWE IRRIGATION SCHEME

The first case study refers to a small-scale irrigation scheme namely Zanyokwe Irrigation Scheme, in the Eastern Cape. This scheme is reflecting a typical development project planned by the Ciskei Government in consultation with the community in an attempt to improve the standard of living, and to create job opportunities.

11.2.1 Background

The scheme was planned during the early 1980's and was named after Zanyokwe village, which is situated on the southern part of the scheme across the road to Keiskammahoek. Before 1984, the Ciskei government negotiated with Zanyokwe residents about the possibility of establishing an irrigation scheme for which the arable land that belonged to Zanyokwe would be used. The Development Bank of SA (DBSA) financed the project and the Ciskei government funded it. The engineering related planning and design at the scheme was done at a high standard, which can be seen from the technical reports that are available. During the establishment of the irrigation scheme, government owned and managed the entire infrastructure and this responsibility has only been transferred to the Zanyokwe Agricultural Trust recently (ATS Rural Dev. Services, 2002).

In 1984, the scheme was established with 48 members. At that time, the Ciskei government had a strong relationship with Israel. The two governments signed a five-year contract whereby the Israelis with their skills and experience would run the scheme. The main objective was for the local farmers to learn from these advanced farmers. When the Israelis left the scheme in 1989, the ECDA helped farmers with the formation of an association with surrounding communities namely Lower Ngqumeya, Zingcuka and Cwar-Kamma Furrow (ATS Rural Dev. Services, 2002).

The scheme has an irrigated (or previously irrigated) area of 471 ha. This consists of individual holdings, ranging from 0.1 to 20 ha and some communal areas and food plots. It is estimated that less than 50% of the scheme is under active production (Dlovo, 2005). The scheme is located between King Williams Town and Fort Beaufort and stretches from the Sandile dam to Middledrift in the foothills of the Amatola Mountains and receives its water from the Sandile dam. Water for irrigation is received *via* a pipeline from the Sandile dam and most of fields on the irrigation scheme are irrigated by gravity from the pipeline on an *ad hoc* basis when the plants need irrigation or when the farmer is of the opinion that he/she must irrigate. There are booster pump stations for areas where gravitational pressure is not enough, and these farmers are paying for the electricity used.

The scheme is made up of six sections as illustrated in the locality map (Figure 11.1) namely Lenye, Burnshill, Lower Ngqumeya, Zingcuka, Kamma Furrow and Zanyokwe. In Zanyokwe, little development has taken place yet al.though the Kamma Furrow section forms part of the scheme; it appears that the members of the community are slowly pulling out of the scheme. This is because of the new municipality demarcation, where Kamma Furrow falls under Nkonkobe municipality, while the rest falls under the Amahlati municipality (Nyangwa, 2004). As a result these farmers are no longer attending farmer group meetings nor participate in field days as intended for the scheme.

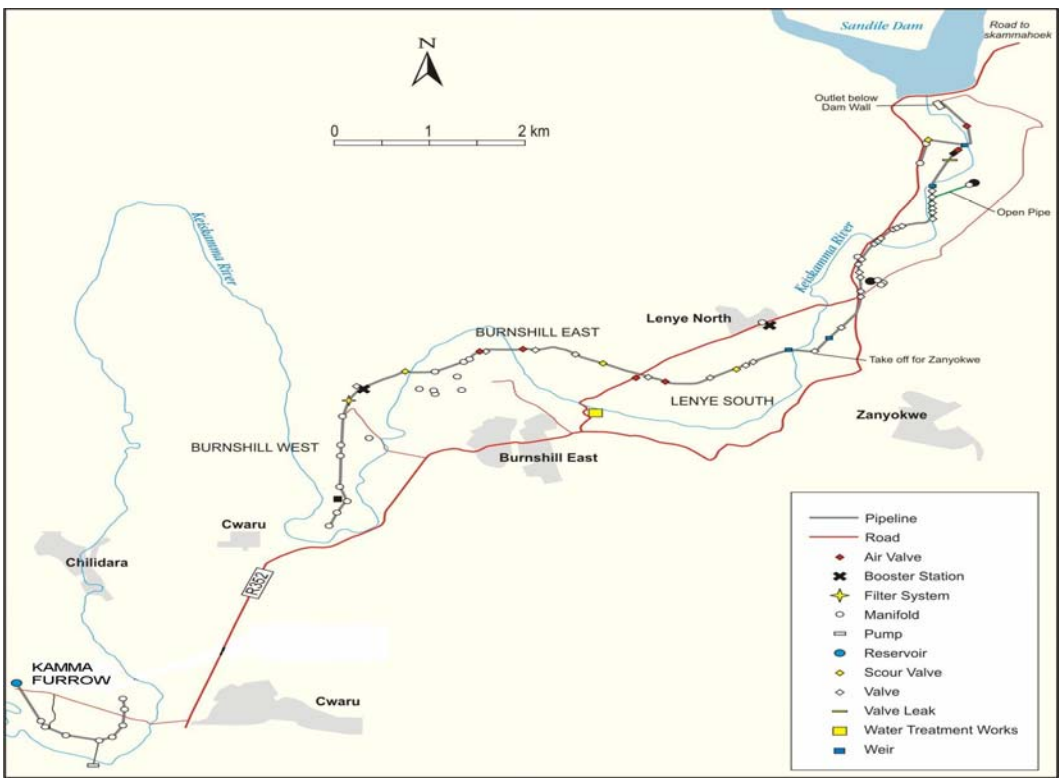


Figure 11. 1: Schematic diagram of Zanyokwe Irrigation Scheme

The scheme was supposed to be managed by a Board of Trustees, but apparently there were complications during the registration (the trust deed was not yet registered with the relevant authority), and therefore the Trust has no authority to run the scheme.

11.2.2 Irrigation methods and scheduling

Apart from Kamma Furrow the scheme receives irrigation water *via* an 800-mm pipeline from the Sandile dam. The pipeline tapers down to a smaller diameter towards the end of the scheme. Kamma Furrow is at the far end of the scheme and has a separate pump unit to pump water from the Keiskamma River into their reservoir or directly into the distribution system. Because the dam also supplies domestic water, Amatola Water Board on behalf of the Department of Water Affairs maintains the dam and pipeline. The assured yield from the dam is 12.7 million cubic meters and its capacity is 30.7 million cubic meters (Rural Urban Cons., 2001). The outlet of the dam is fitted with state-of-the-art control and measuring equipment that is in a good working order (Stimie, 2004).

There are nine main off-take points along the pipeline to distribute water to the scheme. The water supply is designed with a duty of about 0.9 litres/second per hectare. This is considered to be adequate at this level of scheme utilization (Rural Urban Cons., 2001). Each take-off was originally fitted with a flow meter, pressure gauges and filters, but currently these devices are no longer functioning any more and many pipes are leaking.

Farmers in Zanyokwe use sprinkler irrigation systems but the general maintenance of the systems is not adequate (pipes are damaged, hydrant pipes are leaking, valves are not working). Most of the irrigation fields are irrigated by gravity from the pipeline, except for Lenye North where water has to be pumped to reservoir, from where irrigation is done by gravity. About 10 farmers depend on this irrigation method. Van Averbeke *et al.* (1998) argue that the difference in height between the Sandile dam and the irrigation fields are not sufficient to provide adequate hydraulic head to operate pressurized irrigation system like sprinkler irrigation. As a result, there was a need to build storage reservoirs to be fed from the main pipeline linking Zanyokwe with Sandile dam.

With regard to water rights, farmers don't pay for the water, except for the Lenye North farmers who pay R170 per month. A management committee manages the scheme's resources and infrastructure, while the tribal authority appears to play a minor role in scheme matters. According to the farmers, the infrastructure on the irrigation scheme (buildings, irrigation infrastructure and tractors) belongs to the Zanyokwe Agricultural Trust, but it could not be verified with the Department of Agriculture. The Trust owns a tractor that is rented to farmers for the preparation of their irrigation fields (approximately R400 /ha for primary seedbed preparation).

The soils that occur on Zanyokwe are classified as having a moderate to low potential for irrigation due to the heavy texture and high percentage of sand and silt (Laker, 2002). Cultivation difficulties and slow permeability occur on some of the heavier soils. This clearly shows that irrigation management should be carefully managed to avoid soil-related problems.

According to Stewart Scott Inc. (1998), the general inefficient water management practised by many of the small-scale farmers are due to under-designed pipelines, lack of know-how of extension officers and farmers, leaks in the irrigation system, incorrect nozzle sizes and low pump efficiencies. The consequences of poor maintenance of irrigation equipment like sprinkler irrigation systems often lead to yield losses and increased pumping costs. The field evaluation as part of the case study of Zanyokwe illustrates that the irrigation systems indeed have not been well maintained.

- *Sprinkler spacing and nozzle sizes*

Great technical variation was found as apparent in different standpipe lengths, different types of sprinklers and nozzles used in a single lateral, which have an effect on the efficiency of the system. Photo 11.1 shows a single lateral with different lengths of standpipes in use at Zanyokwe.

Photo 11. 1: Sprinkler lateral with different standpipe lengths in use at Zanyokwe

The spacing of sprinklers was designed to be 12m by 12m because of prevailing strong winds in the area. For vegetables, the design operating pressure at the sprinklers is 250 kPa and the required discharge of each sprinkler is 0.97 m^3/h. The system was designed to give a net application of 5.4mm/day and a gross application of 7.2 mm/day. The stand time was designed to be 5.3 hours to give a gross irrigation of 35mm (Rural Urban Cons., 2001).

It was found that farmers are using a variation of nozzles on the same line (Photo 11.2); some were CDS (CDS nozzles are special low-pressure nozzles manufactured from nylon) some were single and some were double nozzles. This means that the distribution on that line is very uneven. CDS nozzles are prone to blockages and are easily damaged when unclogged.

Photo 11. 2: Different sprinkler nozzles (a) CDS and (b) ordinary in use by a farmer in Zanyokwe (2004)

o *Distribution and application efficiency of irrigation systems*

During the field evaluations performed on irrigation plots in the Zanyokwe Irrigation Scheme (2005), irrigation distribution tests were done by setting up catch cans in a 3 m x 3 m grid between the sprinklers and recording the amount of water collected in each can within a set period of time.

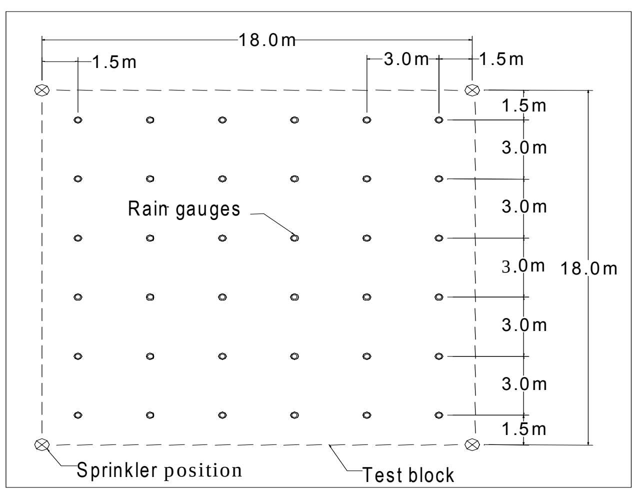


Figure 11. 2: Example of the rain gauge layout used for distribution tests at Zanyokwe irrigation plots

The collected data was used to calculate a number of water use efficiency performance indicators, including the uniformity coefficient, distribution uniformity, application efficiency and system efficiency. The results of the measurements indicated that both irrigation systems performed below average because of the following reasons:

- *Christiansen uniformity coefficient (CU)*

Since CU is a function of sprinkler type and sprinkler spacing, farmers who are not following the recommended 12 m by 12 m sprinkler spacing but rather use 12 m by 18 m spacing, experience problems with regard to sprinkler uniformity.

- *Distribution uniformity* (DU_{lq})

The amount of water collected in the catch cans varied from 3.2 to 8.9 mm, with an average application of 6.1 mm. This indicates poor distribution uniformity because of the variation both in the spacing of the sprinklers as well as the system pressure. The effect of this is a huge variation in the amount of water received by the plants in different sections of the field.

- *Application efficiency (AE)*

With regard to the evaluation of application efficiency, some farmers' system performance was well below the norm, which indicates that a considerable amount of water is lost between the sprinkler's nozzle and the soil surface. The average irrigation application (mm/h) varied between 6.05 mm/h and 2.87 mm/h, while the gross application (mm/h) varied between 10.14mm/h and 5.81 mm/h.

The field tests of the ARC (1997) indicated that evaporation losses could be expected to be as high as 40%, due to system pressure, wind speed and temperature. If irrigation is done at nighttime, the losses can be reduced to less than five percent. Trials indicate that more than half of the daily losses occur between 10h00 and 16h00 (Reinders, 2003). The majority of farmers on Zanyokwe irrigate according to a fixed irrigation schedule, three hours standing time every four days, between 6h00 and 18h00.

Farmers at Zanyokwe do not use objective scheduling methods, but make use of a combination of plant observation method and the "feel method". Although departmental extension officers are responsible for the delivery of technical support on cropping systems and help with regard to the preparation of business plans and management of irrigation, they are in general perceived to lack the necessary competency and technical skills to support farmers with regard to irrigation management.

Following a focused group discussion and presentations of problems by the irrigation farmers of Zanyokwe, the following problems were identified and ranked accordingly as presented in Table 11.3

Table 11. 3 Preferential ranking of problems that influence optimum crop production of irrigation farmers from Zanyokwe (N=20)

Problem	Problem code	Pair wise score	Preferential ranking
Weak farmer organization.	Fo	14	1
Land tenure system.	Lt	12	2
Inappropriate markets.	Ma	11	3
General poor state of irrigation infrastructure.	Irr	10	4
Poor irrigation management skills.	Im	10	4
Cropping patterns (especially during the winter).	Cp	8	5
Crop production below personal expectancy.	Prod	7	6
Lack of credit and capital.	Cr	5	7
Lack of appropriate technology.	Tech	3	8

11.2.3 Lessons learned

1. *Effective institutional arrangements and leadership conducive for the implementation of irrigation scheduling*

The findings in Table 11.3 illustrated that weak farmer organizations are perceived as farmers' biggest problem. The Zanyokwe irrigation scheme was supposed to be managed by a 12-member board of trustees elected to represent the different sections of the scheme. This has however not materialized, and currently a management committee manages the different affairs of the irrigation scheme. However due to a general lack of leadership skills, everybody is not satisfied with the management of the scheme and appropriate training of newly elected executive members of the management committee was suggested. The implementation of effective irrigation schedules and best management irrigation farming practices according to the on-farm constraints are perceived not to be possible due to inappropriate institutional arrangements. This supports partially the assumption that independent environmental variables like institutional arrangements can influence the adoption behaviour of small-scale irrigation farmers (Hypothesis 1.1).

2. *Social and cultural constraints influence on the attitude and perceptions of farmers*

The land tenure system of Zanyokwe is complex (Loxton Venn and Associates, 1984) and according to the extension officers and farmers, some irrigable land at Zanyokwe has not been farmed for many years, in spite of irrigation water being available. This happened apparently because landowners or occupiers rather preferred to rent the land to outsiders not always interested in crop production.

Clarification of land tenure arrangements of irrigation farmers could increase farmers' incentive to invest in their land and irrigation systems. Extension education is a useful tool in helping farmers to adopt appropriate irrigation management practices, but this research suggests land ownership in some areas impose strong limits on its effectiveness.

A steering committee comprised of farmers, the Department of Agriculture (DoA), Agricultural and Rural Development Research Institute of the University of Fort Hare (ARDRI), United States of America Department of International Aid (USAID), Starke Ayres and Kynoch was established to promote market linkage with Pick and Pay supermarket. However farmers in general experience problems to comply with negotiated market contracts (like for instance Pick and Pay) because of inappropriate crop planning. The support of competent extension officers in this regard is urgently needed. The Massive Food Project (MFP) is a funding programme offered by the Department of Agriculture. Several problems are experienced with the implementation of the support programme, of which the lack of proper organized farmer organizations is but one (Manona, 2005).

3. Availability of water supply to the field

Farmers ranked the general poor state of the irrigation infrastructure and lack of irrigation management skills as problem four (Table 11.3). They suggested that the Eastern Cape Department of Agriculture should assist with the repairing of infrastructure, where after the maintenance will become the farmers' responsibility. This support the assumption that unless precursor problems like infrastructure and farm layout as independent environmental factors are dealt with first, farmers will not be prepared to focus on irrigation scheduling (Hypothesis 1.1).

4. Potential benefits attached to the implementation of more accurate irrigation management should be visible

Some farmers make use of electricity to pump water to reservoirs and for higher inline water pressure where the gravitation is not adequate for irrigation. These farmers are in general more aware of the potential operational cost attached to the delivering of irrigation water to the irrigation field. It was found that they were also more prepared and willing to learn about the correct procedure of irrigation scheduling.

Many of the farmers from Burnshill East and Lower Ngqumeya cannot pay their electricity bills every month, and have requested government to help them. These farmers are also more aware of the fact that they should not all irrigate at the same time, since it tends to undermine the inline water pressure. However, farmers struggle to adjust to this since they are not properly organized into a functional farmer organization.

5. *On-farm irrigation techniques as constraints to the implementation of scheduling methods: Sprinkler irrigation*

Sprinkler irrigation is often considered as being very effective compared to surface irrigation because it enables better control of water application. However, the control is dependent on proper irrigation system design and informed selection of equipment, and also requires that farmers develop appropriate skills for managing their systems (knowledge and control of system pressure and flow that enables the system to distribute water uniformly over the field).

It is clear from the field evaluation that some farmers are struggling with the managerial challenges, because of a lack of skills and poor knowledge of system operating requirements and the regular maintenance of irrigation systems. The current situation can be improved through appropriate training and information for farmers and extension officers to improve skills in controlling and management of irrigation systems at field level (setting of equipment, operation of systems, using sensors to check and monitor distribution uniformity and application efficiency). As outlined in Part Three, irrigation scheduling is perceived to be a complex concept and therefore hard to implement even by commercial farmers.

6. Requirements for interactive communication between researchers, extensionists and farmers

The general perception of farmers about the role that extension officers could play in the day-to-day solving of problems needs to be mentioned. They do not perceive extension officers only to provide them with technical advice, but expect extension officers to play a more definite role in terms of support in the operation of farmer organizations. Farmers complained in general about the irregular visits by extension officers to the irrigation scheme. These irregular visits are according to the extension office caused due to a lack of available transport facilities.

The traditional scientific framework used by extension to help irrigation farmers often follows the linear transfer of technology approach. This approach assumes that the problem will be solved once the target audience implements the practice of irrigation scheduling. However, according to Blacket (1996), the extension and research programs offered to farmers have been based on worldviews of problem solvers rather than their clients. Therefore effective dialogue between research, extension and farmers is identified as a precursor for change in irrigation management practices at Zanyokwe. Extension should form an integrated part of every irrigation project, and the ultimate efficiency is often determined by the quality of personnel, the extension approach, organization and management. This finding provides support for the assumption that effective dialogue between extensionists, researchers and farmers is necessary in the simplifying of research information and delivering it to farmers in an effective and easily understandable manner (Hypothesis 5).

CHAPTER 12
IRRIGATION SCHEDULING IN THE LIMPOPO: CASE STUDY 2

12.1 LIMPOPO SMALL-SCALE IRRIGATION

Up-dated information on the status of the small-scale farmer irrigation schemes (SSI) in the Limpopo Province was obtained from the LPDA (Limpopo Province Department of Agriculture). There are 171 irrigation schemes identified in the Limpopo Province and these schemes comprise a total of 51 091 hectares with 7 307 participating farmers.

Hundred and fourteen schemes with a total irrigable area of 18 629 ha are included in the Revitalising Program of Small-scale Irrigation Schemes (RESIS) that the Limpopo Province Department of Agriculture (LPDA) has embarked on. The main objective with this program is the transfer of ownership of irrigation schemes and the empowerment of farmers. This program commenced in 1998, and a total of 28 irrigation schemes have since undergone the revitalization program or are in the process of implementing the program. The program entails the rehabilitation of infrastructure, the construction of conservation works and the proper management of the infrastructure and conservation works. Farmers are assisted in the establishment of appropriate institutional structures for the sustainable management of the schemes. The establishment of farmer groups and Water User Associations with their respective management committees enable the farmers to operate as a legal entity and to apply for access to the DWAF grant for additional infrastructure rehabilitation that may be necessary. However, it is expected of LPDA to take care of the follow-up support and mentorship after the formal intervention of rehabilitation is completed. Table 12.1 provides an overview of the major crop types found on the small-scale irrigation schemes in the Limpopo.

Table 12. 1: Percentage distribution of crop types found on the Small-scale Irrigation (SSI) in the Limpopo (N=171)

Crop type	Percentage irrigation schemes
Citrus	8
Subtropical fruit	12
Cash crops	72
Vegetables	4
Coffee	2
Grapes	0.5
Deciduous fruit	1
Rice	0.5
Total	**100**

Table 12.1 shows that small-scale irrigation farmers in the Limpopo are mainly engaged with the production of cash crops like cereals and cotton on the small-scale irrigation schemes. The following categories of small-scale irrigation methods are found on the 114 irrigation schemes earmarked for revitalization:

- Flood and furrow irrigation (mainly short furrow irrigation): 50%
- Centre pivot: 5%
- Sprinkler irrigation: 45%

On twelve of the irrigation schemes (30 634 ha), commercial farming is exercised under a government water scheme where farmers are directly responsible for the water tariff. The water regulation services (distribution and fee collection) on the 114 emerging small-scale irrigation schemes are largely found to be in the hands of the LPDA through the local extension agents. Farmers are in general responsible for the electricity operational costs associated with the pumping of irrigation water to the irrigation field.

12.2 CASE STUDY 2: TSHIOMBO IRRIGATION SCHEME

The second case study deals with a small-scale irrigation scheme, namely Tshiombo Irrigation Scheme located in the Limpopo Province. This scheme is reflecting a typical design that conforms to the irrigation scheme development model subscribed to by South African Government during the period 1930-1970. Physically, this model involved the establishment of a source of irrigation water, usually by means of stream diversion, and a water distribution system that consisted of concrete canals. Typically farmers were allocated 1.5-2 morgen (1.3-1.7 ha) of land (Perret, 2001).

12.2.1 Background

The Tshiombo Irrigation Scheme is situated at the northern side of Thoyandou, 40 km from Louis Trichardt in the Limpopo Province (Figure 5.4). The scheme was designed in 1990 to irrigate 1100 ha from the Mutale River with water diverted into a canal from the river by means of a weir. Approximately 930 farmers are participating in this scheme, each of them having an average plot size of 1.28 ha, subdivided into 5-6 seedbeds. Bulk water is stored in 10 storage dams that are filled on a specific night during the week. These storage dams were planned to play an important role to ensure the effective distribution of irrigation water to the four irrigation blocks of the irrigation scheme.

Hundred percent of the area is utilized and farmers use mainly short furrow irrigation to irrigate crops. Crop production is mainly for household purposes with surplus being sold to hawkers of Thoyandou and to fresh produce markets in Pretoria and Johannesburg. A wide range of crops are produced on the scheme, which include maize, cabbage, Swiss chard, chillies, beans, sweet potatoes and various other vegetables. No electricity is available, as farmers make use of gravitation irrigation from the nearby storage dams. According to the local extension officer, the majority of the farmers participating on this scheme are women (70%), while 80% of them receive a pension as an off-farm income. Farmers receive the water free of charge, while they pay R1 per month per plot rent, irrespective of the size of the plot.

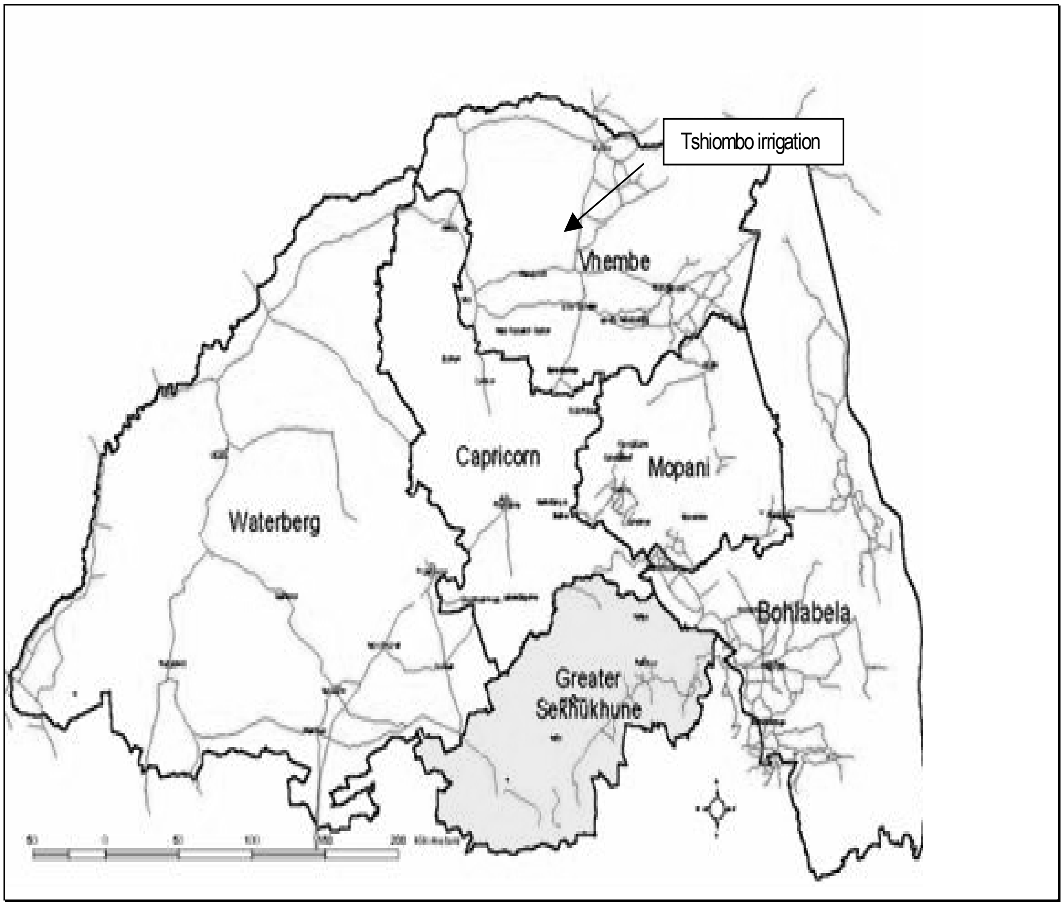


Figure 12. 1: Base map of Limpopo municipality districts indicating the location of Tshiombo Irrigation Scheme in the Vhembe district

12.2.2 Irrigation methods and scheduling

Tshiombo Irrigation Scheme consists of four irrigation blocks. Farmers are generally organized in block committees and most farmers interviewed are satisfied with the operation of the block committees. The block committees are responsible for maintaining in-house rules and conventions at a block level, and if a farmer fails to obey the rules he/she is reported to the water bailiff. If however, the water bailiff fails to solve the problem, the executive committee of the scheme will pursue the matter further.

The main canal that is used for the bulk water conveyance has 48 take-offs, which distribute water through secondary canals to farmers. A specific timetable for bulk water distribution to the four irrigation blocks is followed on the scheme according to the filling of the seven storage dams (Table 12.2).

Table 12. 2 Timetable followed for irrigation on Tshiombo Irrigation Scheme (Netangaheni, 2003)

Day of the week	Block Number
Monday	2,2A,3 & 4
Tuesday	1, 1A, 1B, 2, 2A, 3 & 4
Wednesday	1, 1A, 1B, 2, 2A, 3 & 4
Thursday	1, 1A, 1B, 2, 2A, 3 & 4
Friday	1, 1A, 1B, 2, 2A, 3 & 4
Saturday	1, 1A, 1B, 2, 2A, 3 & 4
Sunday	1, 1A, 1B, 2, 2A, 3 & 4

During a survey conducted by the ARC-IAE in 1997, it was found that the application efficiency in short furrows is generally relatively high. This means that most of the water in the short furrows actually reaches the roots of the plants being irrigated. Distribution uniformity in the short furrows can achieve 80–90%. This is a property of small-basin and short-furrow irrigation, provided the basins/furrows have a fall of less than 1:300. On a steep gradient of 1:100, the uniformity of distribution was below 40%, largely due to unequal damming in the short furrow.

Interviews with farmers from blocks 1 and 2 revealed that they do not experience problems with bulk water supply. However farmers from block 3 and 4, which are located further away from the weir, experience water shortages at critical periods of crop production, which can negatively effects their crop management and potential income. For this reason it is important that the supply canals used on the irrigation blocks are properly maintained, which is the responsibility of farmers. If a farmer maintains secondary canals on a particular day when water is scheduled for his specific block, his or her neighbour would be allowed to use water during the time. This approach works well as farmers are prepared to take up the responsibility for the maintenance of supply furrows and to organize and schedule appropriate irrigation distribution for a specific block.

Farmers from block 1 and 2 (nearest to the weir) do not irrigate on Mondays, so that a chance is provided for farmers in block 2, 3 and 4 to irrigate (Table 12.2). This time schedule for water delivery is designed especially for the farmers of blocks 3 and 4, where water is stored in a dam before irrigation can take place. Only two farmers from irrigation block 1 and 2 are allowed to irrigate simultaneously, usually during the morning (6h00 till 12h00), which is then followed by irrigation during the afternoon by the rest of the farmers. This order of irrigation can change the following day, as the schedule of irrigation is not fixed and depends on good neighbouring and the specific growth stage of a crop. During a period of water shortage, farmers from blocks 1 and 2 are expected to reduce the time of irrigation in the morning to four hours instead of the normal 6 hours, to provide some opportunity for the rest of the farmers.

Farmers in blocks 3 and 4 make use of water that is stored in storage dams to irrigate. Farmers irrigate by filling a specific furrow before moving to the next, and no objective monitoring of irrigation application is used. Apart from following the fixed timetable of bulk water delivery, farmers use regular field inspection to monitor their irrigation efficiency through observation of the plants and the soil conditions. The extensionists interviewed acknowledged the fact that his technical knowledge and skills on irrigation scheduling *per se,* and the use of scheduling methods like the “feel method” and other more sophisticated methods is inadequate to support small-scale irrigation farmers.

Extensionists were asked to list the major constraints to optimal crop production in Tshiombo that they perceive (Table 12.3).

Table 12. 3: The importance rank order of perceived problems representing constraints in crop production at Tshiombo Irrigation Scheme (Netangaheni, 2003)

Constraints	Ranking
Water shortage and vandalism (blocks 3&4).	1
Flood 2000 damage to land: gullies and dongas cause operational problems with seedbed preparation.	2
Cattle roaming on the crop fields during wintertime, due to damaged fences.	3
Transport problems experienced with regard to delivering of produce to markets (expensive) and inadequate market strategy.	4
Lack of appropriate credit facilities.	5
Cooperative not addressing the needs of farmers.	6

The major constraint perceived by the extensionists that influence crop production on Tshiombo is the availability of bulk irrigation water from April till July, especially with regard to the irrigators on blocks 3 and 4. The lack of maintenance of canals (Photo 12.1) and vandalism (Photo 12.2) cause severe problems in the distribution of irrigation water and therefore influence the production of winter crops (cabbage).

Photo 12. 1: Poor maintenance of irrigation canals and excessive vegetative growth on the canal banks at Tshiombo Irrigation Scheme (irrigation blocks 3 and 4) causing inefficient water distribution

Photo 12. 2: Vandalism of irrigation delivery structures like a canal sluice gate at Tshiombo Irrigation Scheme prevent effective water distribution on the scheme (2003)

Farmers in Tshiombo are well organized into eight commodity groups of which, the Soil and Water Conservation and Soil Fertility Management groups are important for this discussion. Farmers from these two groups meet twice per month to discuss crop production aspects like seedbed preparation, fertilization and selection of cultivars. Apparently, little time is spent on irrigation management aspects, apart from discussions regarding the operational execution of the scheduled timetable of delivery and the required maintenance activities of the canals.

Lessons learned

1. *Institutional arrangements are of critical importance for the adoption of irrigation scheduling methods*

The irrigation community at Tshiombo has operational and institutional arrangements that appear to work relatively well and which stood the test of time. Institutions like block committees, commodity farmer groups, and the newly established cooperative are important institutional "vehicles" to be in place to ensure sustainable irrigation water management. The institutions mentioned provide social rights and guidelines that govern individuals and commodity groups in a community. Crosby *et al.* (2000) found that farmers' success and acceptability of small-scale irrigation schemes are closely related to the management system of the scheme. This supports partially the assumption that independent environmental variables like institutional arrangements can influence the adoption behaviour of small-scale irrigation farmers (Hypothesis 1.1).

It was clear from the discussions held with farmers and extensionists working in Tshiombo that they had differential perceptions regarding the terminology and concepts of irrigation scheduling and therefore also the degree to which irrigation scheduling occurs. For the extension officers irrigation scheduling relate mainly to the institutional and engineering concepts of irrigation scheduling (scheme level) as practiced on the Tshiombo irrigation scheme and not the farm level where agronomic concepts of when to irrigate crops and how much to apply is important for farmer decision-making. The institutional and engineering concepts include the development and implementation of the timetable of bulk water delivery and distribution as adopted on Tshiombo irrigation scheme, namely the supplier, distributor and the user. This supports the assumption that intervening variables like the perception about irrigation scheduling influence the adoption behaviour of small-scale irrigation farmers (Hypothesis 1.2).

2. Fixed water delivery schedules affects discharge at field level

Individual irrigation farmers on this scheme have very little opportunity to apply their own adapted irrigation scheduling methods based on their and specific crop needs, as the availability of irrigation water is dictated by a fixed schedule (time-table) of bulk water deliverance. Three parameters describe the local in turn bulk water delivery schedules: a) the duration of the irrigation cycle, b) the delivery pattern and c) the method of water distribution. The irrigation cycle is the period over which water returns. Ideally, the duration of the cycle should be in line with the crop requirements. Irrigation cycles that are too long complicate the cultivation of crops with short irrigation intervals.

The second parameter, the delivery pattern, arranges the sequence in which each water user will receive his turn within the irrigation cycle. Water distribution directly affects the discharges at the field level. This is an important determinant of field efficiency as flows at field level may be too large or too small to distribute across the plot. At present farmers tend to irrigate their fields in accordance with this fixed irrigation timetable, which provides support for the assumption that an independent variable like bulk water delivery influence the implementation of irrigation scheduling (Hypothesis 1.1) However, instances of transgression of the water-sharing rules by some plot holders indicate that the current water–sharing timetable is inadequate at times, which illustrates the important role that institutions should play in actively coordinating water delivery and the capacity to revise the schedules.

Some farmers are clearly more successful than others and are more adaptable to the current irrigation cycle, delivery pattern and water delivery schedule. These farmers optimized the use of available water through the reduction of evaporation from the soil surface through the use of mulching, and increased the infiltration rates of soils by applying proper seedbed preparation (prevention of the formation of a plough layer). They also are more aware of the regular maintenance of the secondary canals in the form of weed and invader control to prevent infrastructure damage as experienced in blocks 3 and 4 of the scheme (Photo 12.1).

3. *On-farm irrigation methods (surface irrigation) as constraint to the implementation of irrigation scheduling methods*

Many farmers from Tshiombo perceived “more effective and sustainable irrigation management” as synonymous with the need to change their current furrow irrigation system to either a drip or sprinkler irrigation system. According to Stimie (2003), farmers that use short furrow irrigation can also be very effective if they understand and apply sound irrigation management principles. The following challenges must be incorporated in the management of surface irrigation:

- The variability, in time and in space of infiltration characteristics of soil types is very important. Childs *et al.* (1993) indicated that this variability could play a more important role in variability of infiltrated water than the factors governing the intake opportunity time.

- The control of field levelling is difficult (Pereira, 1996). The preparation at the beginning of the irrigation season is particularly important because it conditions the homogeneity of the water distribution over the irrigated field, as well as the soil characteristics.

- The control of field intake discharges and runoff, which is a common problem for farmers, is essential to effectively control of the depths of water to be applied.

4. Attitude of farmers to participate in institutional arrangements on the scheme

Many of the farmers (especially from blocks 3 and 4) have indicated their dissatisfaction with the water availability on the scheme during April to July of every year, when water shortages are experienced. Because the scheduling of the delivery and availability of bulk water on Tshiombo is based on the cooperation and collaboration of all the water users of the scheme, the institutional arrangements required as well as the general attitude of farmers to adhere and obey these rules and regulations of water sharing are critically important. Some farmers are guilty of transgressions of the irrigation timetable. This together with a lack of commitment to regular maintain secondary the canals is contributing to this problem.

CHAPTER 13
IRRIGATION SCHEDULING IN MPUMALANGA: CASE STUDY 3

13.1 MPUMALANGA SMALL-SCALE IRRIGATION

There are 15 small-scale irrigation schemes identified in Mpumalanga, which comprises of 8109 ha with approximately 191 participants. Table 13.1 captures the information as collected in this survey.

Irrigation development on the small-scale irrigation schemes in the Mpumalanga has been based mainly on establishing commercial farmers, most of who are involved in sugarcane, maize, tobacco, vegetable, subtropical fruit and wheat production (Table 13.1). The majority of small-scale farmers make use of sprinkler irrigation (set-move and floppy sprinklers) to irrigate the variety of crops. Drip irrigation is recently introduced to some of the "newer" irrigation schemes, where farmers use it for irrigation in sugarcane production and production of a variety of subtropical fruits. The small-scale farmers of Mpumalanga are served with extension and information by the Mpumalanga Department of Agriculture, and where farmers are involved in sugarcane production, SASRI extensionists support the extension division of MPDA with "expert" knowledge on production aspects of sugarcane.

13.2 Case study 3: Nkomazi Irrigation Project (Low's Creek, Walda, Figtree, Boschfontein)

The third case study reveals the experience of small-scale sugarcane growers in Nkomazi-east who are served by extension officers of the Mpumalanga Provincial Department of Agriculture (MPDA) and extensionists of the sugar industry (TSB and SASRI) regarding irrigation management and sugarcane production aspects. This reflects on a partnership between the sugar industry and government for the sustainable production of sugarcane.

Table 13. 1: Small-scale irrigation schemes in Mpumalanga (2003)

Irrigation scheme	Size (ha)	Number of farmers	Irrigation scheduling method	Major crops	Irrigation method	Support
Hereford	189	33	Intuition	Vegetables, tobacco	Flood	*MPDA
Elands-doorn	80	50	Intuition and fixed schedule	Vegetables, maize	Sprinkler	*MPDA
Agrisiet	69	11	Intuition & fixed schedule	Vegetables	Sprinkler/centre pivot	*MPDA
Klipspruit	120	4	Fixed schedule	Maize	Sprinkler	*MPDA
Swartkoppies	157	8	Fixed schedule	Maize	Sprinkler/ centre pivot	*MPDA
Leeufontein	4	1	Fixed schedule	Maize	Sprinkler/ centre pivot	*MPDA
Litolo	24	2	Fixed schedule	Deciduous fruit, Vegetables	Sprinkler/micro	*MPDA
Gouwsberg	340	34	Fixed schedule	Maize, vegetables	Flood	Farmer & *MPDA
Mapochs-gronde	350	11	Fixed schedule	Maize, vegetables	Centre pivot, sprinkler	Farmers
Walda	833	82	Fixed schedule, neutron probe, wetting front detector	Sugarcane, vegetables, maize	Sprinkler, drip, floppy systems	*MPDA & SASRI
Buffelspoort	229	32	Neutron probeWetting front detector, fixed schedule		Dragline	*MPDA & SASRI
Low's Creek	285	35	Neutron probe, Wetting front detector, intuition fixed schedule	Sugarcane, litchis, banana	Dragline, sprinkler, drip	MPDA & SASRI
Mfunfane	490	21	Fixed schedule	Sugarcane	Dragline, sprinkle	MPDA & SASRI
Mbunu C	154	17	Fixed schedule	Sugarcane	Dragline, sprinkler	MPDA & SASRI
Magudu Irrigation Dev.	4 785	850	Neutron probe Fixed schedule	Sugarcane, maize, banana, litchi, leather fern	Dragline, sprinkle, centre pivot, flood	MPDA & SASRI
Total	**8 109**	**1 191**				

SASRI= South African Sugar Experimental Station; MPDA= Mpumalanga Department of Agriculture

13.2.1 Background

This partnership arrangement between the South African Sugar Association (SASA) and the Provincial Departments of Agriculture of Mpumalanga and

KwaZulu Natal was signed in 1994, and since then a joint extension program is undertaken to service the smallholder sugarcane growers. Extension officers were seconded to SASA to support small-scale sugar growers with the understanding and application of on-farm technical information. SASRI extensionists serve as specialists and are responsible for the appropriate training of field extension staff. This joint venture is in the interest of both parties. The sugar industry needs sugarcane for their mills at Komatipoort and Malelane, and TSB has allocated a quota of 4 500 ha to the Nkomazi small-scale farmers. The government on the other hand lacks the necessary expertise to effectively serve the small-scale sugarcane growers.

The development activities of Nkomazi Irrigation (Figure 13.1) started in 1985 with the focus on the production of crops like cotton, maize, vegetables, sisal, leather fern and some sugarcane. Since 1990 when the Nkomazi Irrigation Expansion Programme (NIEP) was implemented, the development approach was revised with the emphasis on sugarcane production. The purpose of the NIEP was to establish 19 irrigation projects to support more than 950 small-scale farmers spread over approximately 7 000 hectares of land in the Nkomazi region.

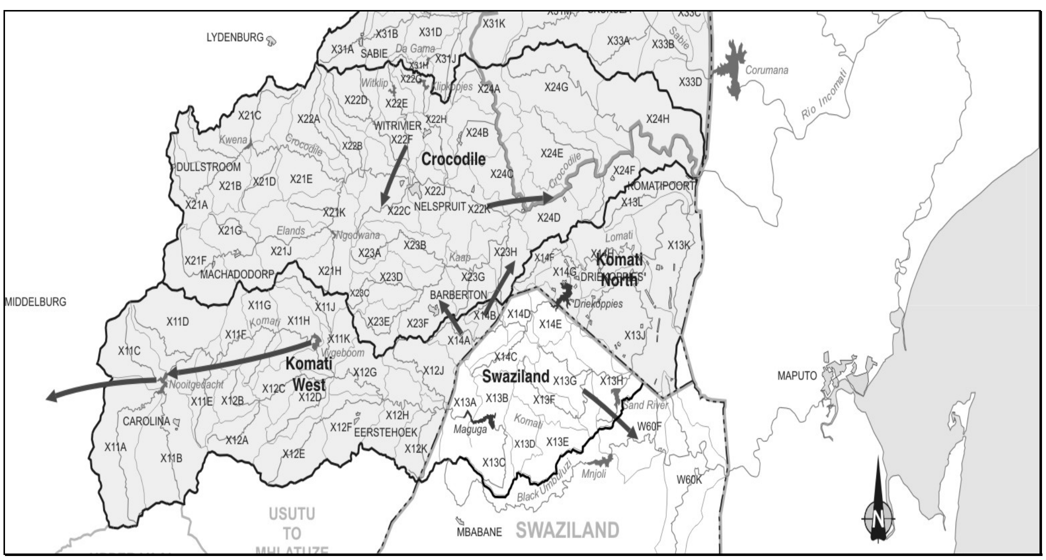


Figure 13. 1: Base map of the Nkomazi Irrigation Scheme within the Inkomati water management area (DWAF, 2004)

Since 1999, the MPDA offered an irrigation scheduling service to small-scale farmers free of charge as part of the agreement with the sugar industry. This service was rendered to some of the small-scale farmers of Walda, Buffelspoort and Low's Creek. Hundred and eight farmers were involved in this irrigation scheduling service rendered by the Division of Agriculture Engineering. Two staff members situated in the Nkomazi area was responsible for the weekly soil water measurements taken with a neutron probe. The data was regularly submitted to an agricultural engineer based in Nelspruit, who was also responsible for the interpretation of the raw data and appropriate recommendations to farmers. These recommendations on irrigation were prepared in consultation with extensionists from SASRI. In general farmers perceived this service very positively and the need was even expressed to extend the service to the rest of the growers. However, this service was discontinued by MPDA during 2002, due to a shortage of operational funds. Subsequently the majority of small-scale sugarcane growers in the Nkomazi follow a fixed irrigation schedule based on SASRI guidelines and without any objective monitoring of the soil water content.

On the irrigation schemes in Nkomazi "energy centres" or field offices have been established, where general administrative duties are taken care of like, the settlement of electricity bills, record keeping and networking where needed. It also serves as a venue for the monthly meetings of farmer groups with the executive committee of the project and it is also used for appropriate training offered by the local extensionists.

13.2.2 Walda Irrigation Scheme

The small-scale sugarcane farmers of Walda use mainly sprinkler and floppy irrigation systems to irrigate. Water availability is generally not a problem to these farmers. The average plot size per farmer is 10 ha, which is divided into 12 blocks of 0.83ha each. Farmers irrigate according to irrigation blocks and follow a three to four hour irrigation cycle every 3-4 days. The general recommendation is not to exceed a net application of 16 mm per irrigation cycle, because of the specific soil type and infiltration attributes of the soil.

Soil types in the Nkomazi area vary quite extensively, but according to Botha (2003), the majority of soil types in this area have a definite plough layer at 30 cm, which prevents the development of the root systems of sugarcane and also impedes penetration of water. The soils at Walda are also relatively high in clay content (approximately 40%), and for this reason farmers should not exceed a net application of 16 mm per irrigation cycle. Farmers usually start to irrigate at 6h00 in the morning till 18h00 when farmers leave for their homes in villages nearby. This practice often leads to relatively low irrigation efficiencies on the scheme due to the high evaporation losses experience from the irrigation between 10h00 and 16h00 as well as the general tendency of farmers to exceed the maximum recommended application rate of 16 mm per irrigation cycle.

13.2.3 Low's Creek Irrigation Scheme

This scheme (282 ha) is found in the Tikhontele village in Mpumalanga and consists of 35 farmers with the average plot size of 7 ha. A canal extracts water from the balance dam to the field. Each farmer is responsible for pumping water from the canal to his specific irrigation plot. The crops that are planted in Low's Creek Irrigation Scheme are indicated in Table 13.2.

Table 13. 2 Crops grown in the Low's Creek Irrigation Scheme

Crops	**Area (ha)**
Sugarcane	218
Litchis & bananas	62
Total	**280**

Farmers use mainly sprinkler, floppy and dragline irrigation system for sugarcane production, while a couple of farmers have changed to the use of drip irrigation. The exception is the one farmer from Low's Creek who uses flood irrigation.

These growers generally follow a fixed scheduled program of daily irrigation as provided by SASRI and with the primary purpose of improving the sucrose content (quality). They usually follow a 10-hour irrigation cycle with the overhead irrigation sprinklers and floppy irrigation system spaced at 14mx12m. For the dripper irrigation the sugarcane rows are 3m apart with one line drip tape per row. Emitters are spaced 0.75m apart and have a flow rate of 1.5l/h. Farmers usually follow a 2-hour irrigation cycle during hot summer periods and decrease it to one hour of irrigation during overcast days.

Farmers in general encountered problems to maintain the sprinklers regularly, and leaking sprinklers and worn sprinkler nozzles were observed during the field visit. All the farmers are staying in villages adjacent to the projects and are therefore not prepared to irrigate during nighttime. Most of the irrigators are old and often reluctant to accept information from the younger extension officers responsible for extension services in the area. Some farmers at the top end of the scheme i.e. furthest away from the water source experience water shortages due to lack of inline pressure because of the over pumping by farmers at the bottom end of the scheme.

13.2.4 Figtree, Boschfontein (1&2) Irrigation Scheme

Figtree and Boschfontein irrigation projects are two irrigation projects in the Magudu Irrigation Development area, situated next the Swaziland border. Farmers are responsible for their own water allocation. The Komati River Irrigation Board controls the scheduling of irrigation water during times of water shortage. The actual water tariff applicable to small-scale farmers in the Nkomazi area is R95/ha/annum.

Farmers irrigate according to irrigation blocks and usually follow a 12-hour irrigation cycle. Each farmer irrigates when it is his or her block’s turn to irrigate. They are allowed to use 11 sprinklers per field (approximately 1.8 ha), but farmers do not always adhere to this and some of the farmers were found to use more sprinklers. It was also very commonly found that sprinkler lines are extended beyond the designed length, and that irrigation cycles of 10-12 hours were found to be changed to longer nighttime irrigation cycles (14-hours) and shorter daytime irrigation cycles (6-hours). Farmers in general encountered problems to maintain the sprinklers regularly, and leaking sprinklers, worn sprinkler nozzles, different sizes of sprinkler nozzles, etc were observed during the field visit.

Farmers from Low's Creek, Figtree, Boschfontein and Walda projects were asked to identify their biggest constraint that prevent them from success with their current farming ventures? Apart from the lack of appropriate credit, relative high electricity costs per month were perceived to be their biggest constraint, which prevents them from profitable sugarcane production. Farmers on these irrigation schemes do not receive individual electricity accounts, but the scheme as the legal entity is accountable for electricity supply services. This leads to injudicious use of electricity, for instance, the unnecessary starting and stopping of pumps when shifting irrigation pipelines in between irrigation cycles.

As shown in Table 13.3, this income statement of a small-scale farmer at Walda for the 2003/2004 seasons illustrates the proportional high operational costs of electricity and irrigation water (24.8%) in comparison with other production input costs of sugarcane. This specific farmer is more progressive and therefore produces an average yield of 83 tons sugarcane per hectare, which is 8t/ha above the break-even point for sugarcane production for this specific area (Swart, 2004). According to Botha & Swart (2003), the average production yield for sugarcane by small-scale farmers in the Nkomazi area varies between 65-70t/ha. This is substantially lower than the average production of 100-110t/ha for commercial growers recorded in the same area. This case study clearly illustrates why the less successful farmers find it difficult to make a profit. These figures support the perception of many farmers on the scheme that electricity costs (and irrigation *per se*) are indeed a major input cost for sugarcane production, especially when farmers are not sensitive to the efficient use of irrigation water on the farm.

Table 13. 3: A statement of income and expenses of a small-scale sugarcane grower at Walda for the 2003/2004 season (Swart, 2004)

Farm size (ha)		4.2
Tons (t)		343
Tons/ha (t/ha)		82
RV% (%)		13.4
Tons RV (t)		45.93
RV price (R)		1 429
Gross Income (R)		65 617
Fat rate (14%)		5 189
Interest on retention		0
Gross income (R)		70 806
Costs	**Costs per ha**	
Irrigation& electricity	1 143	4 800
Hand weeding	350	470
Weed control (chemicals)	450	1 890
Fertiliser	2 300	9 660
Fertilizer application	100	420
Infield irrigation maintenance	50	210
Gapping	100	420
Consumables	100	420
Total	**4 593**	**19 290**

Other important constraints perceived by farmers within the Nkomazi area are:

- Vandalism and theft of irrigation infrastructure like irrigation pipelines, sprinklers, and other equipment during nighttime by members of the villages. According to the farmers, villagers who were not fortunate to have received land are often responsible for this. This stolen irrigation equipment is often found to be used in vegetable gardens in the villages.

- A general lack of appropriate drainage systems was found in the majority of the fields, and because of over-irrigation on many of the fields, access to the different blocks and fields of sugarcane is often perceived to be a problem.

- Farmers' inadequate knowledge of soil preparation, crop and irrigation management skills (Swart, Khosi and Mtembu, 2003).

13.2.5 Lessons learned

1. Behavioural adaptation needed

Many farmers are over-irrigating and therefore water is often observed. Although the soil types commonly found in the majority of the Nkomazi area dictate that farmers should not apply more than 16 mm net irrigation per irrigation cycle, many farmers are found to still practise a 10-12 hours irrigation cycle. This usually leads to over-irrigation and huge run-off.

Many farmers still believe in following the traditional 14-day irrigation interval with an irrigation cycle of 12 hours per position. At an application rate of 5mm/hour, and with soils that in general have a limited water holding capacity, it was found that on many farms the sugarcane crop was showing symptoms of water stress between irrigation applications. According to Swart (2003), this may be one of the reasons for the relative poor production yields that many small-scale farmers experienced.

These findings illustrate the important role that effective communication needs to play between extensionist and farmers, where extensionists and researchers need to understand the complex situation of Nkomazi farmers. This also requires that extensionists and researchers will be prepared to follow different approaches than the technology transfer approach, for instance to apply the principles of adaptive management as applied by many of the small-scale farmers. These findings support the assumption that effective dialogue between extension and Nkomazi small-scale farmers is a precursor to the implementation of irrigation scheduling (Hypothesis 5).

2. *Social constraints influence the general willingness of farmers to adopt irrigation scheduling*

Extensionists and advisors often experience that many of the farmers (owners) on these irrigation projects are part time-farmers, who work in Gauteng or elsewhere and therefore never or hardly ever attend the regular farmer meetings held at the energy centres. The labourers on the fields of these farmers, also not regularly attend monthly meetings, and therefore technology transfer and interactive communication between extensionists, researchers and farmers as decision makers are hardly possible. These social constraints create new challenges to extension and research in an effort to interact with these farmers to ensure that farmers are well informed and understand the potential benefits of irrigation scheduling practices.

3. *Credible ground level support required for implementation of irrigation scheduling*

The success of the interface between extensionists and farmers will depend on the credibility of the extensionists as illustrated through his technical competence in irrigation management. Many of the sugarcane growers in the Nkomazi complain about the technical support rendered to them by extension staff, particularly with regard to the lack of technical knowledge and skills regarding irrigation management. These findings emphasize the urgent need for appropriate training (formal and in-formal) of ground level staff in an effort to provide support to farmers through extension staff that is credible and competent. This supports the assumption that competent extension staff is needed for the implementation of irrigation scheduling (Hypothesis 4).

4. *Attitude and knowledge as important intervening variables that determine the adoption behaviour of farmers*

Apart from a limited number of farmers who were served by the MPDA in terms of weekly soil water measurements with a neutron probe, the rest of the farmers follow a fixed irrigation schedule based on general SASRI guidelines for the production of sugarcane. Much over-irrigation is evident among farmers due to the lack of appropriate knowledge and skills regarding proper irrigation management or because of the relative negative attitude of many farmers who still perceive irrigation water as a right and not a privilege. Farmers from this latter group are therefore not prepared to spend additional time, labour and capital to ensure more efficient water management on the farm, and this finding provides evidence in support of Hypothesis 1, namely that entrenched culture needs to change before they will be willing to adopt irrigation scheduling practices.

5. Inefficient use of institutional arrangements

The energy centres in Nkomazi offer excellent infrastructure and facilities for the offering of appropriate on-site training programs to farmers. However, it appears that extension officers responsible for the servicing small-scale farmers in Nkomazi do not optimally use these facilities and resources. A possible explanation for this tendency is the general lack of technical knowledge and skills of extension officers, their relative low credibility in society, but also the negative attitude and commitment found amongst some extension officers (Swart, 2004).

CHAPTER 14
IRRIGATION SCHEDULING IN NORTHERN CAPE AND FREE STATE: CASE STUDY 4

14.1 NORTHERN CAPE AND FREE STATE SMALL-SCALE IRRIGATION

In the Northern Cape and Free State, the irrigation schemes indicated in Table 14.1 are confined to the few bigger irrigation schemes. This information serves as a summary of information collected from private consultants, irrigation scheme managers, researchers and extensionists from the respective Departments of Agriculture.

Table 14.1 shows that apart from the extension and advisory services that the respective Departments of Agriculture deliver; private consultants are also involved in the training of farmers in certain production skills on table and wine grapes. However, no specific training program is in place for training of small-scale farmers regarding irrigation management. Therefore, farmers usually use fixed irrigation schedules as provided by departmental extension officers and private consultants. Both the consultants and extensionists working amongst these small-scale farmers identified the urgent need for the development of appropriate training programmes to equip them with the basic skills and knowledge in irrigation management principles.

The "mentorship program" that has been adopted by the Department of Land Affairs, was initiated at some irrigation schemes like Opperman. In this program, commercial farmers act as "mentors" to small-scale farmers to help them with the learning of appropriate production and management skills. This program has the potential of playing a very important role in the future training of farmers regarding irrigation scheduling.

Table 14. 1: Small-scale irrigation schemes in Northern Cape and Free State (2003)

Scheme	Area under irrigation (ha)	Potential area for irrigation (ha)	Number of farmers	Major crops	Irrigation method	Support
Riemvasmaak	11	600	25	Grapes, vegetables	Sprinkler, micro irrigation	*NCDA
Jacobsdal	601		17	Grapes, vegetables, wheat, maize	Sprinkler, micro irrigation	*FSDA
Kalffontein	350	350	40	Wheat, maize, cotton, groundnuts	Sprinkler	*FSDA
Bethlehem Apple project	110	110	105	Apples	Micro & drip irrigation	Afgri Trust
Eksteenskuil	620	620	117	Wine grapes	Flood & furrow	ARC Nietvoorbij & *NCDA
Iterleng community	15		8	Lucerne	Flood	*NCDA
Aganang Comm. trust	17		6	Lucerne, wheat, maize	Flood, sprinkler	*NCDA
Drie Eenheid Boerdery	60		3	Maize	Sprinkler	**NCDA
Mahau Trust	25		6	Lucerne	Flood	*NCDA
Opperman	240		48	Wheat, maize	Sprinkler	*FSDA
Zelpy	9		16	Wine grapes	Flood	*NCDA
Total	**2 058**		**391**			

** NCDA = Northern Cape Department of Agriculture; FSDA= Free State Department of Agriculture*

14.2 CASE STUDY 4: APPLE PROJECT IN BETHLEHEM

This case study illustrates how small-scale apple growers with the intensive support of an experienced "mentor" have developed adapted irrigation scheduling methods appropriate for their specific needs.

14.2.1 Background

Apples are grown on a 110 ha farm, which is situated 10 km from Bethlehem on the road (R26) towards Fouriesburg in the Free State. This agricultural development project was started in 1999 as part of a RDP initiative. A partnership agreement was made between 106 small-scale farmers who were interested in apple production, AFGRI (the local agricultural cooperative), Development Bank of South Africa (DBSA) and the municipality of Bethlehem to form a trust. The land was purchased from the municipality, and irrigation water of very good quality and at a special tariff is obtained from the municipality (Gerald dam). The availability of this irrigation water provides farmers with the necessary flexibility to apply scheduling methods that are the most appropriate for the crops grown on the farm.

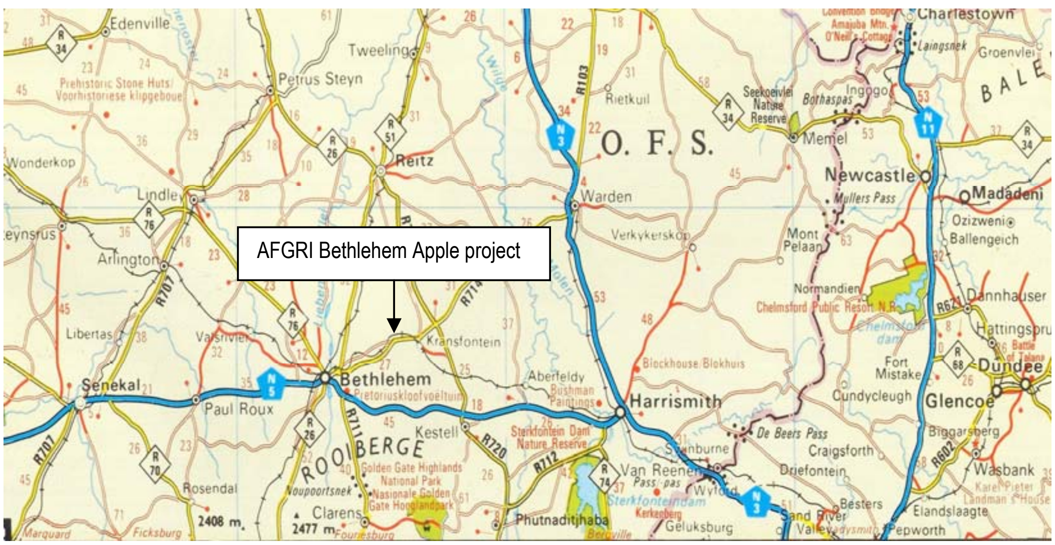


Figure 14. 1: Location map of the AFGRI Bethlehem Apple project outside Bethlehem

An experienced farmer, who had been farming for the past twenty years in the district, was appointed as a mentor to help the farmers in the propagation of apples. One hundred and six farmers were allowed to participate in this project with each participant receiving one hectare of land on which five different apple cultivars were planted. This strategic decision was taken to ensure that all the farmers have the same opportunities to gain experience in the different marketing and management requirements of the different cultivars. The 106 ha apple orchard is divided in 8 different blocks, according to different slopes, soil potential, and topography of the farm to ensure more effective management. A block manager per unit is elected, and serves on the executive committee as a representative of a specific irrigation block, which meets every week. During the weekly meetings, planning and operational management for the next week is discussed and relevant training sessions for block managers and farmers conducted. The executive committee started off under the chairmanship of the mentor, but as capacity was built, it was transferred to one of the block managers.

Each farmer is responsible for the capital investment of the establishment of one-hectare apples. Due to the fact that little or no profit was shown in the development of the project for the first couple of years, farmers were allowed to apply for "an operator's fee". This fee was calculated against the net production of his land. The mentor and farmers identified four hectares for experimental purposes where certain irrigation technology and fertilizer trials applicable on the farm are tested. This area also serves as a "demonstration unit" for training purposes of farmers.

14.2.2 Irrigation method and scheduling

With the initial establishment of the orchards, micro irrigation was installed on the first 56 hectares, but as from the second year of development, drip irrigation was installed on the remaining area. Apple rows are 1.5 m apart with 2 lines of drip tape per row. Emitters are spaced 0.75 m apart and have a low rate of 3l/h. In the micro irrigation, there is one line per row with the emitters spaced at 0.75m. Farmers, block managers and the mentor have indicated their preference for the use of drip irrigation for the production of apples from a management and maintenance point of view. Drip irrigation is perceived to lend itself to allow for the practising of fertigation, and therefore, more precise fertilizer management as needed for the five different cultivars.

Photo 14. 1: Apple orchards under drip irrigation in the AFGRI project for small-scale farmers outside Bethlehem (2003)

These farmers use a fully automatic Motorola computer system, which controls the irrigation on the 8 irrigation blocks. The SAPWAT model for irrigation planning and prediction of crop water requirements is also implemented on the farm. All the relevant climatic and weather data was collected until 2001 from an automatic weather station installed on the farm. However, due to vandalism and the destruction of the station on the farm by some farmers who were expelled from the project, the weather station at the Small-Grain Institute (Bethlehem) is subsequently being used. This weather data was initially used for the adaptation and attuning of the predictions made by SAPWAT regarding the crop water requirements.

The measurement of the soil water content is done through the use of tensiometers. Relatively early in the development of the project it was realized that figures alone do not mean anything to a farmer, until “practical value” is added. The soil auger together with the use of a tensiometer added meaning and interpretation to tensiometer readings in terms of “relative dryness and wetness”. Since the farmers and mentor on this project experienced many problems with unreliable tensiometer readings, tensiometers were replaced by the use of gypsum blocks. Gypsum blocks were found to be more appropriate and easier to use by the farmers. According to the mentor gypsum blocks also provide more accurate readings.

Farmers are convinced that the regular use of a soil auger in monitoring the soil water status helped them to develop the irrigation management strategy currently followed.

Every week, 3-4 blocks are identified for the digging of soil pits for inspection and for validation purposes of the readings as per tensiometer or gypsum pad. These opportunities are also used to train block managers and farmers of a particular block in the use of different irrigation scheduling tools (e.g. feel method) and to illustrate practical orchard management. This learning based approach provides ideal opportunities for experiential learning of farmers, where farmers' skills and understanding of irrigation management dictate where to start with the training. These training opportunities also serve as feedback to the management system. These training sessions help to make irrigation scheduling models like SAPWAT, more appropriate for the specific conditions that prevail. According to Fourie (2002), SAPWAT was initially over-predicting the crop water requirements of the apple trees on the farm, and through intensive monitoring with soil augers and regular observations by farmers it was successfully attuned.

Farmers are expected to attend regularly the training sessions arranged for a specific block. Block managers also help the participating farmers with general dissemination of information on irrigation management. Irrigation specialists from Stellenbosch assist in this project with the evaluation of the applied irrigation management on a two yearly basis. Although the exercise was recognized as perhaps an unnecessary and expensive, block managers as well as the mentor were convinced that it added much value to this project.

14.2.3 Lessons learned

1. Farmer "ownership" a prerequisite for taking responsibility

This project illustrates the importance of the development of proper institutional structures, where farmers take ownership and are trained in several aspects of irrigation management and leadership. Small-scale farmers should participate in all phases of the irrigation scheme and should be treated as "owners" rather than as "beneficiaries" of a project. As a general rule, an innovation is better adopted if the small-scale farmer themselves participate in the setting up process and operational decision-making (Fourie, 2002). External management is not conducive to farmers' taking responsibility for their farming enterprises. The farmers tend to neglect the maintenance of equipment if they do not see it as their responsibility.

2. Experiential learning as an alternative approach of training

The learning based approach used in this case study relies on the training of trainers or mentors (block managers), and recognizes the importance of the farmers' role in the dissemination of information to other farmers. This approach was found to be very successful in stimulating efficient interaction between the various stakeholders (mentor, farmers and researchers). The implementation of experiential learning by farmers and the opportunities provided for feedback on their experiences to the executive committee, proved to be successful in the building of irrigation management capacity amongst block managers and farmers. These findings provide support for the assumption that effective dialogue between the small-scale farmers, mentor and professionals involved in this project is a precursor for the adoption of irrigation scheduling (Hypothesis 5).

3. Mentorship role in the changing of adoption behaviour

This project also demonstrated a possible route to be followed in the development of appropriate scheduling methods adapted for a specific farm. The important role to be played by a mentor or an extensionist in the support of new farmers (small-scale) on a daily basis cannot be over emphasized. According to de Beer (2005) "mentoring is simply someone who helps someone else to learn something the learner would otherwise have learned less well, more slowly or not at all." Without this important support, the application of sustainable irrigation management practices by small-scale farmers is more unlikely. The importance of the selection of the right person to fulfil this job cannot be over emphasized. This person must have comprehensive expertise in order to gain the confidence of the farmers and be able to articulate terminology and concepts in a language that farmers can understand and apply. It is expected of the protégé to respect and trust the mentor to establish a caring relationship in an effort to accelerate the learning curve. The evidence collected from this case study at Bethlehem supports the assumption that competent ground level support (a mentor in this project) is conducive for the adoption of irrigation scheduling (Hypothesis 4).

4. *The need of precise irrigation scheduling techniques in the production of high value crops*

The need for embarking on the use of more precise irrigation scheduling when involved with the production of high value crops like apples were illustrated in this case study. Farmers as well as the mentor are convinced that the net benefits in spending more time, capital and resources on precise monitoring of the soil water status are positively reflected in terms of production efficiency (yield and quality of apples). This provides support for the assumption that farmers perceive an improvement in production efficiency with the implementation of precise irrigation scheduling (Hypothesis 2). The important role of quality interactive communication between research, consultants, mentor(s), block managers and farmers was illustrated in the learning that farmers undertook and the capacity that was build among the small-scale farmers.

CHAPTER 15

IRRIGATION SCHEDULING IN NORTHWEST: CASE STUDY 5

15.1 NORTHWEST SMALL-SCALE IRRIGATION

In Northwest Province, the discussion is restricted to the larger irrigation schemes that occur in the province, namely Taung and Disaneng irrigation schemes (Table 15.1). Except for the Taung and Disaneng irrigation schemes, which are commercially orientated, the majority of the 20 irrigation schemes in Northwest Province are based on vegetable growing both for food security and additional household income (Branken & de Kock, 2001). Apart from these two larger irrigation schemes, many community gardens are found in the province where farmers produce vegetables by making use of hosepipe, flood and dragline irrigation methods. The Northwest Department of Agriculture (DOA Northwest) is the main agent that supports these food plot growers. According to Swanepoel (2004), farmers are trained in relevant cultivation practices and a fixed schedule of irrigation applies for the majority of food plot growers.

Table 15. 1: Small-scale irrigation schemes in the Northwest Province (2003)

Scheme	Area under irrigation (ha)	Number of farmers	Irrigation method	Crops	Support
Taung	3580	411	Centre pivot, sprinklers	Maize, cotton, wheat, groundnuts, barley,	Northwest Dept. of Agric, Suidwes Cooperative, SA Malsters.
Disaneng	204	66	Sprinkler	Lucerne, table grapes, deciduous fruit, maize, wheat	Northwest Dept. of Agric
Total	**3 784**	**477**			

Table 15.1 shows that approximately 477 farmers are registered under these two irrigation schemes and with the exception of Taung, they use sprinkler irrigation systems to irrigate their crops. On Disaneng Irrigation Scheme, farmers produce table grapes and deciduous fruit on a very small-scale, and focus mainly on the production of lucerne and cereal crops like maize and wheat. Although this project was initiated by the Northwest Department of Agriculture, the ground level support required by farmers with regard to irrigation management is lacking because of the technical incompetence of extension officers (de Kock, 2001).

15.2 CASE STUDY 5: TAUNG IRRIGATION SCHEME, NORTHWEST

The last case study deals with a small-irrigation scheme, namely Taung Irrigation Scheme, in the Northwest Province. This scheme reflects a partnership agreement between farmers and the private industry.

15.2.1 Background

This scheme was established in the former Bophuthatswana homeland, which now forms part of the Northwest Province. It was started in 1939 with flood irrigation on two “morgen” plots and has always been known for water wastage and poor soil quality. Presently the scheme is using centre pivots irrigation systems that were introduced when Agricor developed the scheme in 1979.

The scheme is approximately 3 580 ha in size and 411 farmers are registered under the scheme. Each farmer has an average plot size of 7.5 ha. The scheme receives bulk water from the Vaal River via the Bloemhofdam. An open canal system is used from Vaalharts to Taung. The scheme has three balancing dams each with varying water-holding capacity. Water is controlled and distributed through water bailiffs. Water is ordered on a weekly basis from the main source and farmers are currently paying a yearly water tariff of R154/ha.

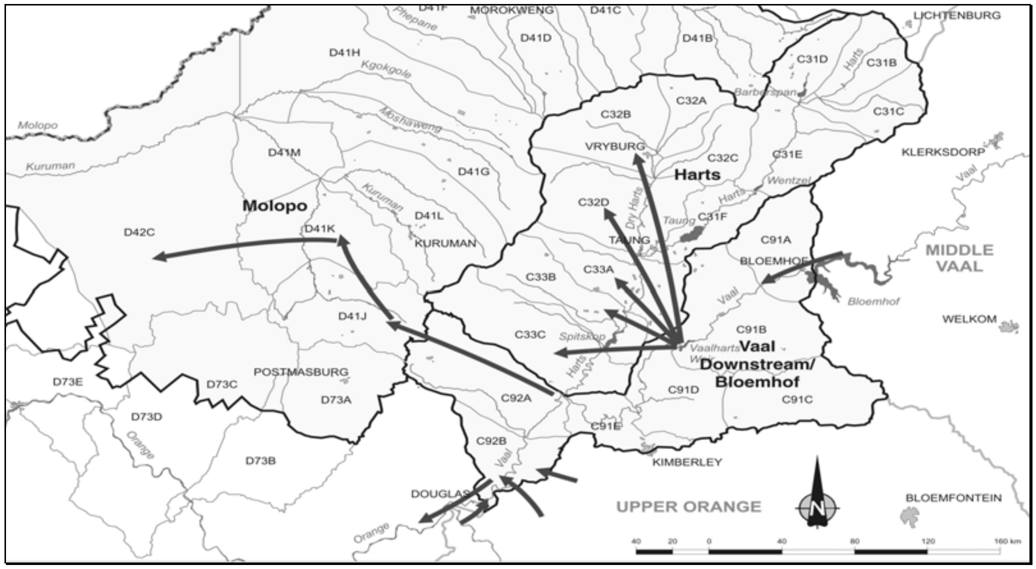


Figure 15. 1 Base map of the Taung Irrigation Scheme within the Lower Vaal water management area (DWAF, 2004)

15.2.2 Irrigation methods and scheduling

Three to four farmers usually share a centre pivot, which implies that they must plant crop types that have the same crop water requirements. There are currently 73 centre pivots in operation. A major problem found on the Taung Scheme is that the centre pivot irrigation systems were designed for 16-12 ha, but as farmers became more successful in the past, the irrigation systems were extended to the current 30 and 40 ha centre pivot irrigation systems. This however inevitably led to inefficient irrigation systems in terms of under-designed suction heads (only 3 kPa), which resulted in inefficient application and distribution of irrigation.

Since the majority of the centre pivots are 20-22 years old, the maintenance costs experienced by farmers are relatively high. Until 2000, the Department of Agriculture Northwest (DOA Northwest) was responsible for structural breakages experienced on the irrigation systems, but this has subsequently been transferred to the account of the individual farmers. Before 2000, farmers were only accountable for the maintenance of the systems in terms of sprinkler packages, pumps, motors, and maintenance of pump house. A private irrigation company is currently contracted to help farmers with the maintenance of irrigation systems, and farmers are informed to be aware of the costs in this regard (Erasmus, 2003).

Photo 15. 1: Relative old and often under-designed centre pivot irrigation systems used for crop production at Taung Irrigation Scheme (2004)

A variety of crops are planted on Taung Irrigation Scheme, with the major crops being maize, groundnuts, and cotton during the summer months and wheat and barley as winter crops. Farmers make use of the private sector to help them with the financing of their summer and winter crops. Suidwes Cooperative supported farmers with production loans for the summer crops (maize and groundnuts) during the 2002 and 2003 production seasons, while South African Malsters (SAM) provide support to 211 farmers for the production of barley. The irrigation scheduling methods that farmers follow in the production of the different crops varies as indicated in Table 15.2.

Farmers use fixed irrigation schedules for the production of summer crops like maize, groundnuts, while BEWAB and fixed irrigation schedules are used for the production of wheat. It was found that the majority of maize farmers follow a 7-day irrigation cycle.

Table 15. 2: Different irrigation scheduling methods applied on Taung Irrigation Scheme

Crop	Irrigation scheduling method
Summer crops: maize, groundnuts, lucerne	Fixed irrigation schedule
Wheat	BEWAB, fixed schedule
Barley	BEWAB, neutron probe, GWK program, SWB, irrigation calendars

In the production of barley, farmers started off with the use of the BEWAB predictions for scheduling as being practised with the production of wheat, since the industry as well the ARC in Bethlehem could not provide adapted guidelines for irrigation of barley for the Taung area. This program initially worked well until signs of over-irrigation were observed especially during the initial stages of the production season, while under-irrigation occurs during critical crop growth stages. Since 2003, the University of Pretoria has been involved in a research project to develop an irrigation scheduling program suitable for the production of barley but also adapted for the conditions of the small-scale growers in Taung. The SWB model is used to generate site-specific irrigation calendars, which can be used by the farmers for irrigation of their crops.

Apart from the on-going research, a private irrigation consultant was appointed since 2003 to measure the soil water content on a weekly basis with a neutron probe. The computer scheduling program, which the consultant is using, is similar to the one that Griekwaland Wes Cooperative uses. This scheduling service provided to the barley growers at Taung is compulsive and farmers have to pay for this service. The information provided by these weekly measurements, plus the data collected through research and the general observations made by experts from the industry helped farmers and extensionists to attune the irrigation scheduling program that is presently used.

Five Farmer Support Units (FSU) are in operation at Taung. A FSU usually comprises of 40-80 farmers, who meets regularly to discuss important aspects of crop cultivation, which also includes principles of irrigation management. Since 2001, a full time extensionist was appointed for the support of the farmers involved in barley production. This person enjoyed specialist training in the production of barley before he was appointed to support farmers involved in this project.

15.2.3 Lessons learned

1. *Competent ground level support needed for high precision irrigation technology*

It is clear from this specific case study that the use of relative high irrigation technology like centre pivots often requires the support of appropriate trained professionals to ensure efficient use of this equipment. Although this type of irrigation system is relative easy to manage, it requires farmers to understand concepts like the correct calculation and implementation of the nozzle chart of the machine, ensure that the end gun is correctly set, etc. Without intensive support and resources available to fund this type of support required, small-scale farmers usually found it difficult to complete the steep learning curve that is expected in the production of high value crops like the growing of barley under centre pivot irrigation systems. SA Malsters are offering extension support that exists in the form of a mixture of advice giving (providing a recipe on irrigation scheduling) and education or learning (proactive learning in an effort to promote independency). The experience gained with this case study at Taung supports the need for interaction or a “dance” Hayman (2001) between small-scale farmers and competent ground level support with the implementation of sound irrigation management (Hypothesis 4).

2. *On-farm irrigation system as a constraint to the implementation of irrigation scheduling methods*

Cognizance should be taken of the original capacity and design of an irrigation system before allowance be given to extend the irrigation systems to satisfy the need of additional farmers. This aspect is clearly illustrated at Taung where a decision to extend the centre pivots originally designed for 10-12 ha to 30 ha, not only affected the uniformity of irrigation water application but caused tremendous practical problems that neither the farmers nor the professionals could attend to. This inevitably leads to inefficient irrigation practices that could not be rectified by the implementation of irrigation scheduling alone.

3. *Institutional arrangements determine the efficiency of collective irrigation management*

Sharing of irrigation equipment like the 73 centre pivots at Taung is only possible with good cooperation between farmers. Farmers need to be well organized, and be able to manage and maintain their shared equipment. Five FSUs are in operation at Taung, and farmers are represented in the management committee, which is responsible for strategic decisions regarding the distribution of water and the general rules applicable in the operation of the irrigation scheme. Aspects of irrigation management are currently not discussed at FSU level, although the management committee could play an important role in changing farmers' attitude, perception and behaviour regarding the implementation of sound irrigation practices. During these monthly meeting SA Malsters capacitate farmers by offering appropriate training.

This case study also reveals that without proper institutional arrangements the changing of farmers' irrigation management behaviour will be very slow. The implementation of effective irrigation schedules and sound on-farm irrigation management is impossible if appropriate institutional arrangements do not exist. This supports partially the assumption that independent environmental variables like institutional arrangements influence the adoption behaviour of small-scale irrigation farmers (Hypothesis 1.1).

CHAPTER 16
IRRIGATION SCHEDULING IN OTHER PROVINCES

16.1 WESTERN CAPE SMALL-SCALE IRRIGATION

Small-scale farmer irrigation in the Western Cape is confined to a few schemes. The figures as presented in Table 16.1 are based on a survey completed in 58 small-scale farming communities during 2002. The Department of Agriculture, Western Cape and LANOK (Landbou Ontwikkeling Korporasie) are responsible for the rendering of extension and support to small-scale farmers in the Western Cape. LANOK is mainly responsible for the provision of production credit to farmers but also renders extension services and support where applicable to farmers regarding certain commodities.

Table 16. 1: Small-scale irrigation schemes in the Western Cape (Saaiman, 2003)

Sub region	No of schemes	Number of food plot holders	No of comm. farmers	Total number farmers	Area under irrigation (ha)	Major Crops	Irrigation method
Northwest	6	304	6	310	58	Citrus, lucerne, vegetables grapes	Sprinkler, furrow
Swartland	14	419	7	426	90	Vegetables, flowers, deciduous fruit	Sprinkler, furrow, micro
Boland	12	575	2	577	18	Vegetables, flowers, deciduous fruit	Sprinkler, furrow, micro
Klein Karoo	9	240	12	252	81	Potatoes, vegetables, deciduous fruit	Sprinkler, furrow, micro
South Coast	17	408	3	411	107	Vegetables	Sprinkler
Total	58	1 946	30	1 976	354		

According to the survey done by the Department of Agriculture (2003), 85 percent of the small-scale farmers are involved in food plot production for food security and additional household income. The relative more commercially oriented small-scale farmers earn more than R20 000/annum and are mainly involved in the production of crops like flowers, lucerne, deciduous fruit, and grapes.

According to Beukes (2002), the majority of small-scale farmers do not make use of objective irrigation scheduling methods, but rely on the use of local knowledge, experience or a fixed irrigation schedule. She is of the opinion the average small-scale fruit grower in the Western Cape lacks the basic knowledge and skills regarding proper soil preparation, cultivation of fruit and irrigation management. Only a relatively small percentage of the newly settled small-scale fruit growers are properly trained in irrigation management and have the necessary confidence to apply irrigation scheduling methods like the use of evaporation pans, feel method, etc.

Du Plessis (2002) is of the opinion that small-scale irrigation farmers' decisions regarding a specific irrigation interval and length of an irrigation cycle to follow are mainly determined by availability and reliability of irrigation water. Since irrigation water availability and reliability are often problematic in some irrigation areas, many of the small-scale fruit growers in the Western Cape are guilty of under-irrigation of their crops.

16.2 KWAZULU NATAL SMALL-SCALE IRRIGATION

In KwaZulu Natal there are 18 irrigation schemes, comprising of 6 923 ha and many community gardens that are either already established or in the process of being established (Table 16.2).

Table 16. 2: Small- scale irrigation schemes in KwaZulu Natal (2003)

Scheme	Area irriga-ted(ha)	Participants			Irrigation method	**Major Crops**	Support Agency
		CF	FPH	Total			
Bululwane	350	-	430	430	Flood	Vegetables, maize	KDA
Mzondeni	167	43		43	Sprinkler	Maize, wheat, cotton, vegetables	Illovo sugar
Ndumu B	150	11		11	Sprinkler	Sugarcane	KDA
KwaDlama	167	43		43	Sprinkler	Sugarcane	Tongaat/ Hulett
Biyela	501	277		277	Sprinkler		Tongaat/ Hulett
Ngwelezana	16	-	105	105	-	Vegetables, maize	KDA
Nzimele	338	125		125	Sprinkler	Sugarcane	Tongaat/ Hulett
Mkuphula	20	-	244	244	Flood	Vegetables, maize	KDA
Mooirivier	340	-	760	760	Flood	Vegetables, maize	KDA
Tugela Ferry	540	-	1832	1832	Flood	Vegetables, maize	Illovo
Mansomeni	186	63		63	Sprinkler	Vegetables, maize, sugarcane	Illovo
Sinamfini	272	-	176	176	Sprinkler	Vegetables, maize, sugarcane	Lima
Shinga	20	20		20	Sprinkler	Vegetables, maize	Illovo
Daka Daka	234	160		160	Sprinkler	Sugarcane	Illovo
Mthondeni	93	33		33	Flood	Sugarcane	KDA
Tukhela Estate	374	-	1275	1275	Sprinkler/ flood	Maize, wheat, vegetables	KDA
Makhatini	2 620	259		259	Sprinkler	Sugarcane, cotton, maize, vegetables, wheat	Vunesa Cotton
Impala	535	47		47	Sprinkler/semi-dragline	Sugarcane	KDA/ SASRI
Total	**6 923**			**5 903**			

KDA = KwaZulu Department of Agriculture, SASRI= South African Sugar Research Institute

FPH = Food plot household; CF= Commercial farmer.

Makhatini irrigation scheme

The Makhatini scheme is the largest in the province and has an estimated irrigation potential of 12 000 ha from the Jozini Dam. During the time of the interviews conducted with officials from ARC and Vunisa Cotton (2002), irrigation farming activities at Makhatini had been limited to 50 ha. Only five farmers were involved in the production of cotton and sugarcane under irrigation. According to Steyn (2002), the biggest constraints that irrigation farmers on Makhatini face with crop production are the fact that many of the farmers still struggle with debt accumulated from previous production seasons and access to appropriate credit facilities. Rain fed cotton production out-produced irrigated cotton production for the last couple of production seasons, and therefore many farmers switched to rain fed cotton production. The role of Vunisa Cotton is to support the cotton growers with access to credit, establishment of appropriate marketing opportunities and supply of technical support on cotton production. No objective scheduling methods are implemented by farmers who rely on a fixed schedule as provided by the industry.

Apart from the accumulated debt that farmers are struggling with, the following constraints prevent farmers from optimal crop production at Makhatini irrigation scheme as been identified by the Vunisa Cotton extensionist:

- Lack of adequate maintenance of their irrigation systems. Many nozzles and sprinkler packages were in a very poor condition, and in need of replacement.

- Cultivation practices of farmers are in general not appropriate due to lack of production knowledge and proper equipment.

- Lack of financial capacity to take care of day-to-day problems like the repairs and maintenance of machinery and irrigation equipment.

- Inadequate skills and technical knowledge of departmental extensionist regarding irrigation management.

- Vandalism and theft.

Apart from cotton and sugarcane produced on the Makhatini irrigation scheme, the other irrigation schemes mainly produce sugarcane and vegetables. SASRI, Tongaat, Illovo, and Hullet Sugar jointly deliver extension support in the production of sugarcane together with KwaZulu Natal Department of Agriculture as part of the partnership agreement, which was established in 1994. In KwaZulu Natal, two extension officers were seconded to SASA, and another two operated on a 50:50 time basis. These four extension officers supervise the extension activities of forty technicians from the Department of Agriculture. These extension officers and technicians provide technical assistance for the production of sugarcane. No official scheduling service is rendered to small-scale farmers who, in general, use fixed irrigation calendars as prepared by the sugar industry.

Tugela irrigation scheme

At Tugela Ferry Irrigation Scheme the majority of farmers (65%) are using short furrow irrigation. The supply infrastructure to the different blocks consists of parabolic concrete canal sections, reducing in size towards the end of the scheme. Water is diverted into the block with smaller lined canals and farmers receive water at a fixed time during the week. This canal-supplied short furrow system with fixed irrigation turns makes it difficult to adapt the time and quantity of water applied which are critical elements in irrigation scheduling. It is often found that most farmers apply more or less the same amount of water (mm) during the season, irrespectively of the crop water requirements.

As far as irrigation timing is concerned, a farmer has to irrigate when it is his turn. It may be that the soil still contains adequate soil water for crop production and therefore the additional irrigation application simply passes through the wetted soil profile beyond the active root zone, or it may be that the soil had already dried out beyond the allowable depletion level and that the crops have already suffered as a result. The amount of water that can be directed to the field depends on the slope and the size of the supply furrows and it is only by varying the in-flow time to each furrow that the amount of water applied to crops can be adapted.

16.3 GAUTENG SMALL-SCALE IRRIGATION

In Gauteng, apart from the many community gardens (approximately 1 200 ha) that were established or are still in the process of being established (Potgieter, 2002), Rust de Winter (Table 16.3) is the only large irrigation scheme utilized for commercial crop production. Since 1994, the problem of land tenure status of farmers has not yet been resolved, and this is still regarded by farmers as their biggest constraining factor. Short time period tenure contracts are also restricting people's investment in the property they occupy and therefore limit the level of land utilization. These socio-political issues are according to Botha *et al.*, (2000) inhibiting the normal development and functioning of the irrigation scheme.

Table 16. 3: Small-scale irrigation schemes in Gauteng (2003)

Scheme	Area under irrigation (ha)	Number of farmers	Irrigation method	Crops	Support
Rust de Winter	827	35	Centre pivot, sprinklers	Maize, cotton, wheat	Gauteng Dept. of Agric.

CHAPTER 17
SUMMARY

Certain essential factors were identified that influence the performance of small-scale irrigators namely: group cohesion, institutional support, efficiency and structure of the management committees, choice of crops and market strategy, appropriateness of technical design of irrigation systems, irrigation management capacity and the general commitment of irrigation farmers.

It is clear from the incorporated case studies that the approach to irrigation management on small-scale irrigation schemes differs between the traditional small-scale irrigation schemes and where partnership agreements with the private sector were made. These partnership agreements illustrated the necessity to take first care of precursor problems to irrigation scheduling, namely water availability, poor distribution uniformities, limitations to farm layout, identification of appropriate markets and efficient irrigation system design before farmers will be prepared to focus on irrigation scheduling.

In general it was found that the weak institutional arrangements and handling of farmers' affairs on scheme level on several small-scale irrigation schemes hampers sustainable agricultural development. Farmers in general also lack important skills such as leadership, organizational capacity, management and agribusiness skills. The challenge facing extension and rural developers in general is to build the necessary capacity of farmers and to strengthen institutional management.

The case studies illustrated that a clear set of rules and regulations for acquisition, conveyance, delivery and distribution of irrigation water to small-scale irrigation schemes apply. A framework for irrigation scheduling on a small-scale irrigation scheme (Table 17.1) distinguishes three levels of operation; the main system for irrigation water acquisition, conveyance and delivery to tertiary units, the tertiary system for water distribution among farmers and the field system for water application. Since these rules are made at different forums (main, tertiary and in-field water delivery systems) there is a need for effective communication between the various parties exist so that planned and actual water delivery as well as in-field application of irrigation water can take place in a meaningful way.

Table 17. 1: Institutional framework of water delivery necessary for irrigation scheduling

Management responsibility		Agency responsible
1.	*Main water delivery system:* acquisition, conveyance and delivery to tertiary system.	DWAF
2.	*Tertiary system:* decide on water distribution and system management on a scheme level among farmers.	Block committees, management committees, farmer support units, Water User Associations
3.	*Field level:* the irrigation system on-farm will determine the amount of water that could be applied in the field and will influence the crop selection, use of agro inputs, irrigation scheduling method.	Farmers

Sprinkler irrigation is attractive to many of the small-scale farmers – but the finding shows that it could lead to excessive water use like in the Nkomazi. Many of the small-scale farmers are of the opinion that short furrow irrigation is inappropriate and not efficient, for sustainable food production. There is however an increasing realization amongst scientists that one should rather support farmers with their current irrigation systems and try to improve the general irrigation management efficiency (prevent water logging at the bottom of the furrow for instance) through appropriate training and efficient dialogue between farmers, research and extension.

Consultants and extensionists without appropriate technical training and understanding of the situation of smallholder irrigation development should rather not participate unless they receive appropriate training beforehand. Many small-scale farmers mentioned the serious lack of competent advisors and extensionists with specialized training in irrigation. In several interviews held with extension officers it became clear that they had little to offer farmers regarding irrigation management. One of the extension officers in KwaZulu Natal even said that irrigation was not part of their job description, as his perception of “irrigation management” entailed only the engineering aspects namely water supply, distribution, and infrastructure.

Irrigation management was found to be perceived by the majority of small-scale irrigation farmers as “new technology” and it is therefore imperative that appropriate training curricula and training manuals be developed to support extensionists and advisors with the training of farmers. The innovation processes of irrigation scheduling techniques with its three main components namely, creating a technique, dissemination of the idea and the adoption of it, form a whole. The three components cannot therefore be allocated to different role players namely research who design the technique, extension services to disseminate the information and farmers to adopt the technology without effective interaction between the relevant parties. Small-scale farmers, as illustrated in the case study at Bethlehem should be included in the process of innovation and conditions should be created for them to participate.

The learning based approach used in the projects as indicated in the case studies of Bethlehem and Taung, requires extension officers and advisors to perform new roles. Illiteracy amongst many of the small-scale farmers poses specific training problems to overcome. Experiential learning can address this problem but requires people with the necessary skills and knowledge to help and support farmers. Extension officers should be equipped with the necessary skills to effectively play the facilitators’ role in starting of a dialogue with farmers and in listening sympathetically to what farmers have to say.