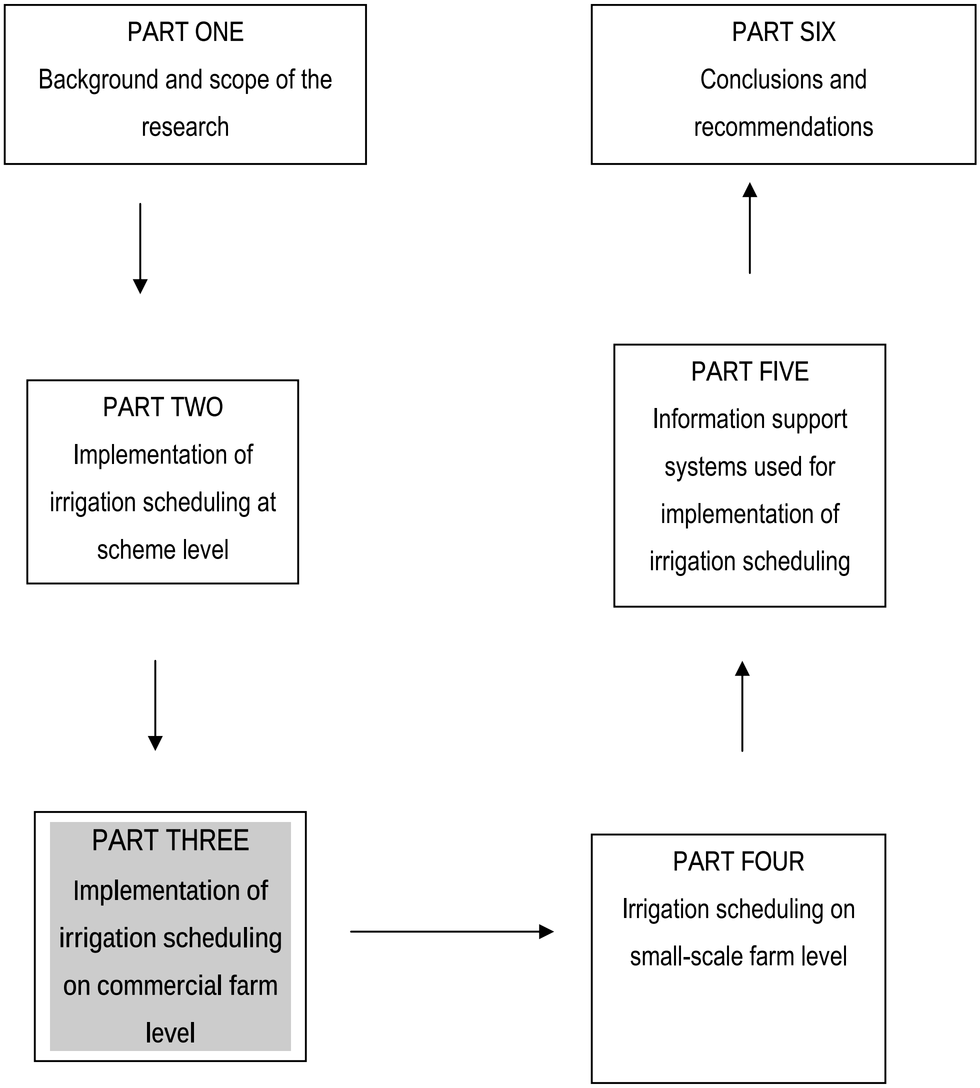
PART THREE

IMPLEMENTATION OF IRRIGATION SCHEDULING ON COMMERCIAL FARM LEVEL



CHAPTER 7
INTRODUCTION AND RESEARCH METHODOLOGY

7.1 INTRODUCTION

Irrigation farming encompasses a group of interrelated activities occurring in an economic, cultural and social context and hence farming activities are influenced by values and social norms as well as by economic, financial and technical imperatives. Adoption of new irrigation scheduling practices is a dynamic process that is potentially determined by various factors, including farmers' perceptions of the relative advantages and disadvantages of new technologies vis-à-vis that of existing technologies and the efforts made by extension and change agents to disseminate these technologies. Other factors, which influence adoption, are resource endowments, socio-economic status, demographic characteristics, and access to institutional services (extension, input supply, markets, etc).

Commercial farmers showed reasonable awareness of irrigation technologies that could help them irrigate more accurately, but were less sure how these technologies would translate into profitability on their farms (Feather & Amacher 1994). From a farmer's perspective, the implementation of an innovation involves (1) some form of immediate investment with long term expected returns, (2) trade offs between current yield and future yields, (3) trade offs between yield and its production costs, (4) trade offs between yield and its related risk. All decisions to adopt or reject an innovation and the subsequent behaviour or practice change, rest with the individual or the farmer. Continuous learning and complex responses to stimuli that rarely produce observable constancy, characterize human behaviour.

In general, review of the literature indicates that the research tradition in the area of behavioural sciences is largely dominated by an investigation of the relationships between socio-economic and personal (independent) variables and behaviour. Rogers (1983) generalizations based on the findings of more than 200 adoption studies, indicated that factors responsible for behaviour change of farmers are mainly confined to the role of these independent variables, without taking account of the direct influence of intervening variables (need, perception and knowledge), which according to Tolman (1951) and Düvel (1975) are immediate precursors of behaviour.

Since Part Three deals with the human factors and constraints that impact on adoption of irrigation scheduling practices, the objective of this part of the study was to identify the socio-economic and personal characteristics of respondent farmers such as age, education and farming experience, which are assumed to differentiate irrigation farmers into those that implement objective irrigation scheduling methods and those that are implementing subjective scheduling methods. It is however also intended to evaluate the influence of the intervening variables perceptions and knowledge of farmers on the selection and use of irrigation scheduling tools and to gain insight into the practice adoption behaviour of commercial farmers in the study areas of the following provinces: Northwest, Free State, Northern Cape, Eastern Cape, KwaZulu Natal, Western Cape, Limpopo and Mpumalanga.

7.2 RESEARCH METHODOLOGY

The following outlines the methodology used to investigate and describe the reasons from a cross section of commercial farmers for using the different irrigation scheduling methods and models and to investigate and describe why irrigators discontinue the implementation of irrigation scheduling.

7.2.1 Research area

Instead of selecting only one specific research area for the detailed micro level on-farm survey, preference was given to the inclusion of various irrigation areas from the eight provinces as indicated in the outcome of the national survey. This was done to ensure the inclusion of sufficient variation regarding irrigation scheduling methods as well as the perceptions of respondents in different stages of the innovation-decision process. Irrigation systems form an integral part of the different farming systems and therefore effective irrigation scheduling is, in addition to the technical capacity of the system and agricultural requirements of the crop, determined by a set of cultural, social and institutional conditions. To try and accommodate these differences in institutional and social cultures, irrigation schemes from eight different water management areas and provinces were included. Respondents were selected on the basis of:

- ❑ Availability: respondents who resided in the area or who could be reached for interviews.

- ❑ Experience in irrigation farming: new irrigation farmers as well as farmers with many years of experience were included to capture the differences in perceptions that prevail.

- ❑ Irrigation scheduling: farmers were included that were either still involved in irrigation scheduling or have discontinued scheduling practices.

- ❑ Ownership: interviews were conducted with farm owners or irrigation managers who are responsible for decision-making concerning irrigation management.

The following areas within the water management areas of South Africa were identified and selected after discussions with Steering Committee members and opinion leaders in irrigation:

- o ***Sundays River and the Gamtoos Valley irrigation schemes***

These irrigation schemes form part of the Fish to Tsitsikama water management area, which is situated in the south-eastern part of South Africa, within the Eastern Cape Province (Figure 7.1). This area is characterized by poor quality of natural water, which drains from the inland areas. The Fish and Sunday Rivers are of natural high salinity, and large quantities of good quality water are transferred from the Orange River (Upper Orange water management area) to blend with local resources (DWAF, 2004).

Figure 7. 1: Base map of the Fish to Tsitsikama water management area (DWAF, 2004)

The Sundays River and Gamtoos Valley are well known for their choice of citrus, and vegetables. After consultation with the chief executive officer from the local citrus cooperative, twenty-three farmers in the Kirkwood, Hankey, Patensie and Boskop area were randomly selected from a list of cooperative members as respondents for this survey and face-to-face interviewed *(Appendix 3).*

- ***Northern Cape: Rietriver / vd Kloof /Rust /Lower Orange River Irrigation Schemes (Boegoeberg, Keimoes, Malanshoek).***

These irrigation schemes belong to the Upper and Lower Orange water management areas. The Upper Orange water management area lies to the centre of South Africa and extends over the southern Free State and parts of the Eastern and Northern Cape provinces while the Lower Orange water management area largely corresponds with that of the Northern Cape Province. The latter is situated in the western extremity of South Africa and borders on Botswana, Namibia and the Atlantic Ocean (Figure 7.2).

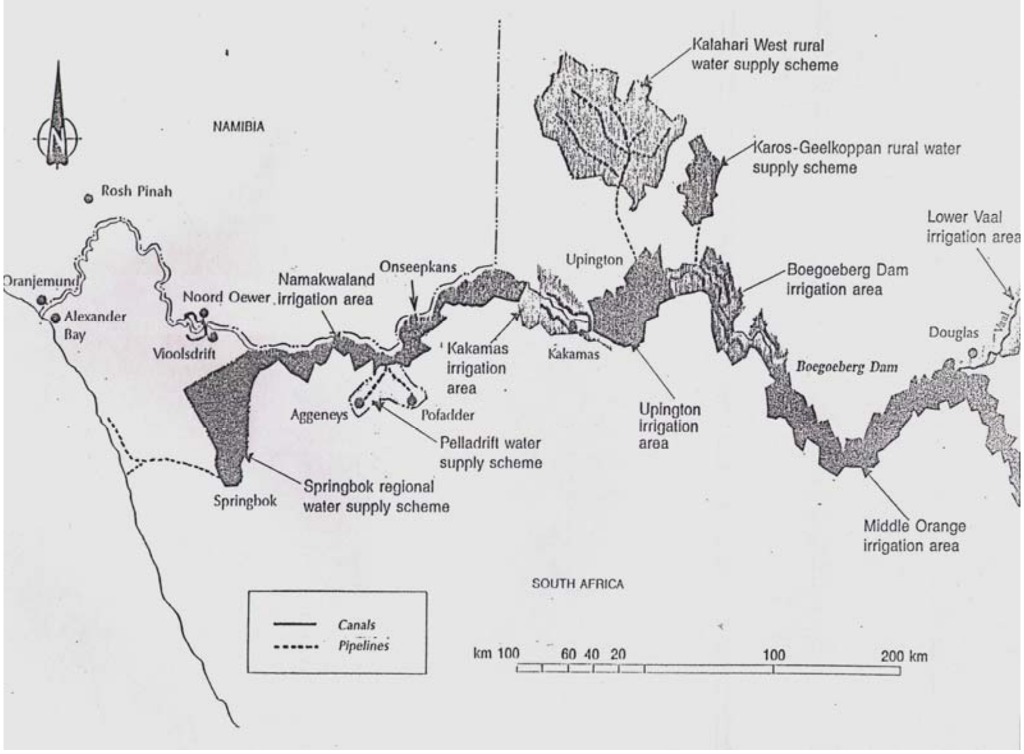


Figure 7. 2 Location map of the Upper Orange water management area (DWAF, 2004)

The Riet River Irrigation Scheme (Figure 7.3) was selected after discussions with members of Griekwaland Wes Agricultural Cooperative and various opinion leaders in the Free State and Northern Cape. General consensus exists that this area represents one of the largest areas of land under irrigation scheduling. It was also an excellent opportunity to monitor the changes that took place since the previous survey done by Botha, Steyn & Stevens (1999/2000) in this area where factors that influence the acceptance of irrigation scheduling models were researched. Thirty-seven farmers from Riet River, Van der Kloof and Lower Orange River irrigation schemes were selected for participation in the survey.

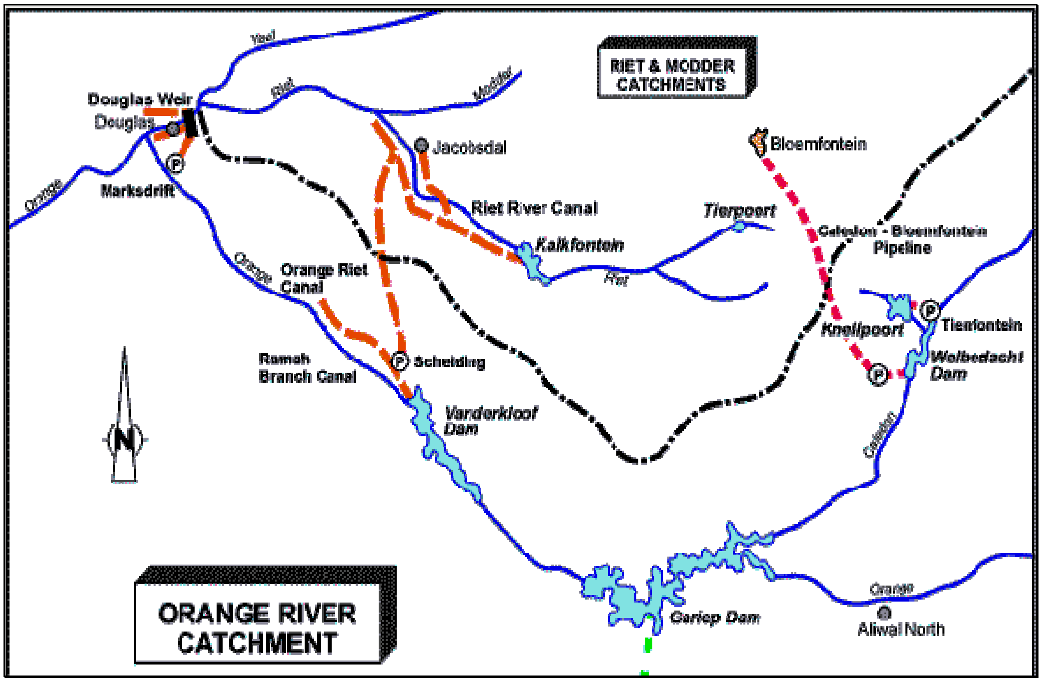


Figure 7. 3 Location map of the Orange Riet River catchment area (DWAF, 2003)

After consultation with the CEO at Orange Riet Water User Association (ORWUA) a random sample of 17 respondents of this irrigation area was selected in terms of availability, experience, and application of irrigation scheduling and relevancy of the typical irrigation farming systems at the irrigation scheme. In the van der Kloof irrigation scheme, after the consultation of a private irrigation consultant, 10 farmers were randomly selected from a list provided. In the Lower Orange River irrigation area, 10 farmers were randomly selected with the help of the local extension officer and officials from the Department of Water Affairs at Upington.

- ***Mpumalanga: Nelspruit/Malelane and Onderberg***

The study area is situated in the Inkomati water management area (Figure 7.4), which borders on Mozambique and Swaziland and all rivers flow through Mozambique to the Indian Ocean. The Komati, Lomati and Crocodile rivers service this water management area. In this area most important economic activities centres on irrigation with related industries and commerce.

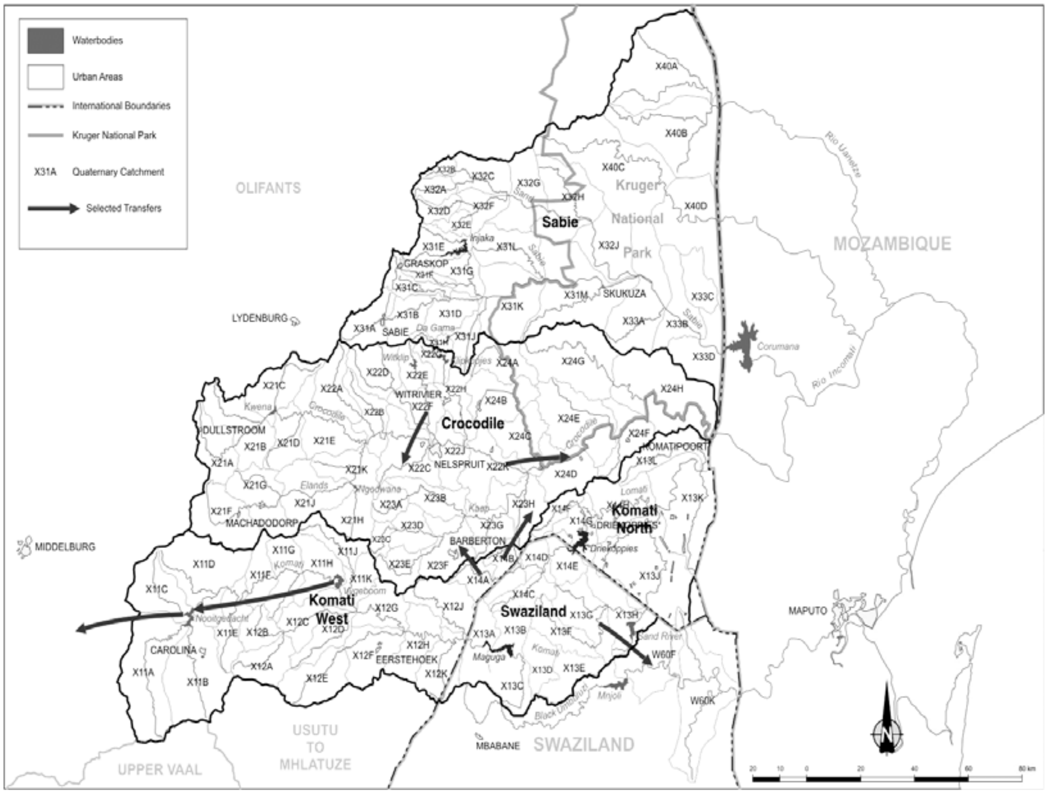


Figure 7. 4 Base map of the Inkomati water management area (DWAF, 2004)

Onderberg area is well known for the production of citrus, subtropical fruit and sugar cane. This forms an integral part of the Komati/Lomati River and Crocodile River catchments areas. Seventeen farmers of this area were interviewed during December 2002 and January 2003. Farming operations in this area are generally operated on a relatively high skill-level and irrigation scheduling support services are mainly rendered by the sugar industry, and citrus, mango, avocado and banana producer societies and private irrigation consultants. Active study groups in the banana, mango, avocado and citrus industry play a very important role in informing farmers of the important aspects of irrigation scheduling in the production of quality fruit. In general farmers are very much aware of objective irrigation scheduling devices and possible models that are available. The consultants in this area do enjoy a high credibility for the kind of service that they render. The seventeen respondents included from this area were randomly selected with the help of officials from SASRI, citrus cooperatives, Mpumalanga Department of Agriculture and Department of Water Affairs and Forestry.

- ***Mzimvubu to Keiskamma water management area (Kokstad/Underberg)***

The Mzimvubu to Keiskamma water management area lies predominantly within the Eastern Cape Province, and borders on Lesotho to the north. The Mzimvubu River, which also reflects in the name of this water management area, is the largest undeveloped river in South Africa (DWAF, 2004). The Mvoti to Umzimkulu water management area borders on the Mzimvubu to Keiskamma water management area in the south and lies predominantly within the KwaZulu Natal, with a small portion in the southern part which falls in the Eastern Cape. The main rivers found in this water management area being the Mvoti, Mgeni, Mkomazi, Umzimkulu and Mtamvuna Rivers, with several small coastal rivers in between. The general location of these two water management areas is illustrated in Figure 7.5.

Seventeen respondents from these two water management areas (Underberg and Kokstad), mainly involved in crop and pasture production, were interviewed by an experienced member of the research team. The random selection of the respondents was done with the help of officials from the local cooperative of Underberg.

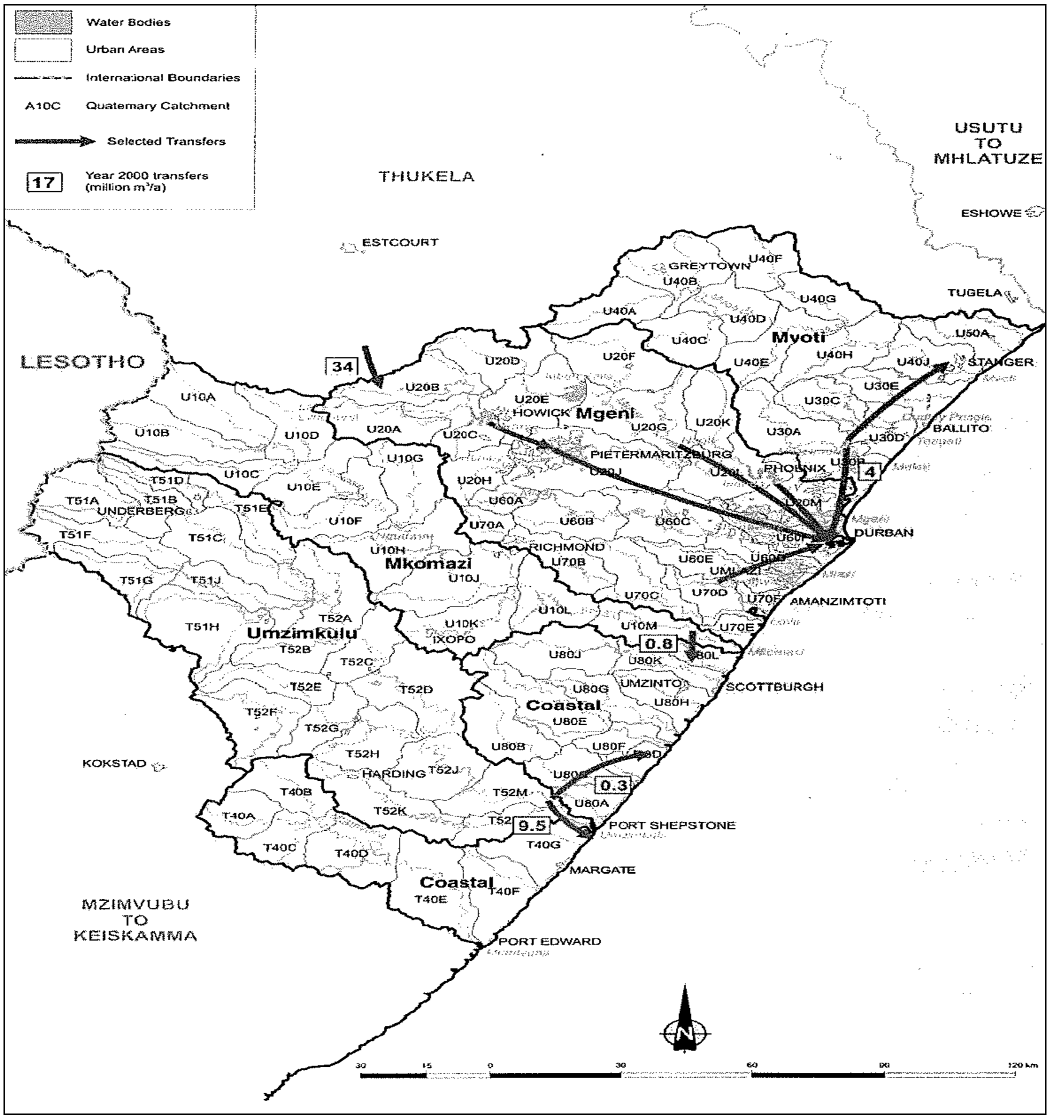


Figure 7. 5 **Base map of the Mzimvubu/Keiskamma and Mvoti/Umzimkulu water management areas (DWAF, 2004)**

o ***Crocodile west water management area (Brits/Rustenburg area)***

The Crocodile west and Marico water management areas border on Botswana to the northwest (Figure 7.6). The main rivers, the Crocodile and Marico, give rise to the Limpopo at their confluence. Extensive irrigation development occurs along the Crocodile River and in the Brits /Rustenburg area farmers produce mainly citrus, table grapes and deciduous fruit as permanent crops. Cash crops like wheat and vegetables are produced during the winter and soybeans, vegetables and maize during summer months. The local citrus and grain cooperatives as well as the Northwest Department of Agriculture in Brits play a major role regarding the irrigation management support services rendered to farmers. The project team interviewed fourteen farmers from this area after consultation with officials from the local citrus cooperative and from the Northwest Department of Agriculture.

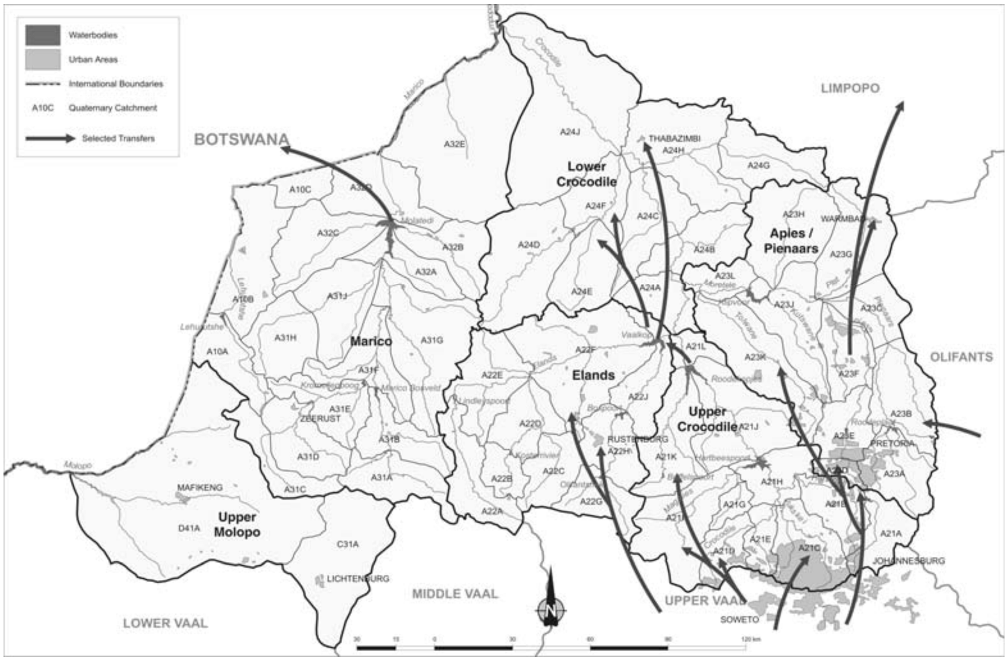


Figure 7. 6: Base map of the Crocodile and Marico water management area (DWAF, 2004)

o ***Middle Vaal water management area: Sand-Vet sub area***

The Middle Vaal water management area is situated in the Free State and Northwest Provinces in the central part of South Africa. It covers the middle reaches of the Vaal River, between the Upper Vaal and the Lower Vaal water management areas (Figure 7.7). The Sand-Vet Irrigation scheme is one of the three sub-areas of the Middle Vaal water management area. It consists of several different areas, served by a network of different channels. Seven farmers, mainly involved with the growing of cereal crops i.e. maize, wheat, soybeans, dry beans, on the Sand and Vet canals, was interviewed. These seven farmers were randomly selected after consultation with the scheme manager at Sand-Vet Irrigation scheme from a list of farmers involved in irrigation scheduling as well as those who were not using irrigation scheduling.

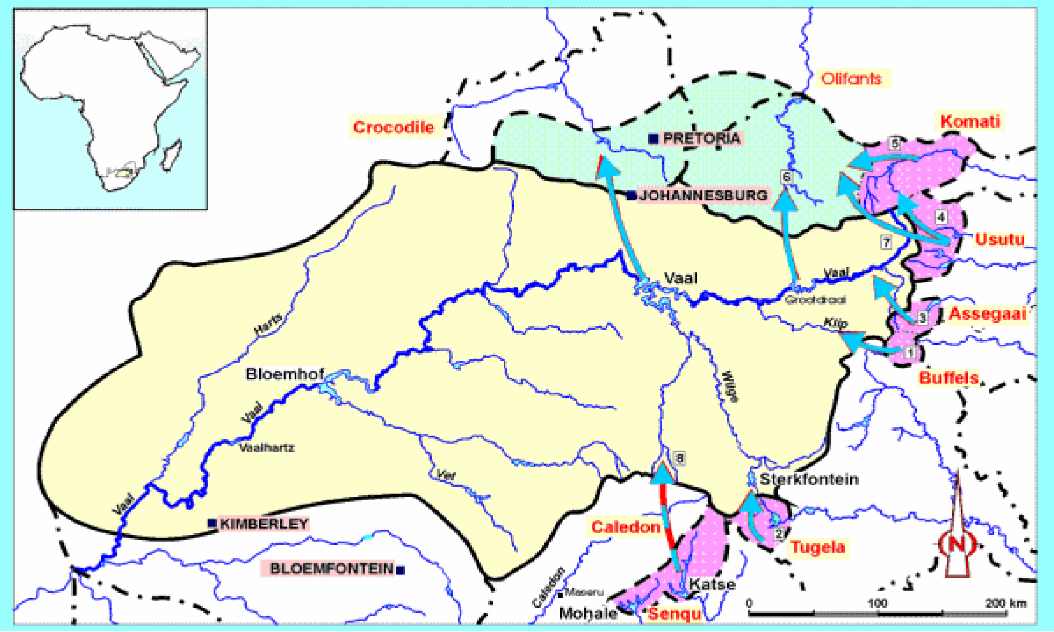


Figure 7. 7: Location map of the Middle Vaal water management area (DWAF, 2004)

- ***Breede water management area***

The Breede water management area is the southern most water management area in South Africa, and lies entirely in the Western Cape Province. The Breede River and its main tributary, the Riviersonderend River drains most of the water management area as indicated in Figure 7.8. The economy of the region is mainly agricultural based, and vineyards and fruit orchards are grown under irrigation.

Ten randomly selected respondents from the Worcester, Monatgu, and Riebeeck Wes area were interviewed. These ten respondents were selected after discussions with the scheme manager of the Breëriver Irrigation Board.

These irrigation farmers were involved with the production of table grapes, wine grapes and deciduous fruit for export or canning.

Figure 7. 8 Base map of the Breede water management area (DWAF, 2004)

o ***Levuvhu/Letaba water management area***

The Levuvhu/Letaba water management area lies in the Limpopo Province. The Letaba River flows into the Olifants River, which is a tributary to the Limpopo River (Figure 7.9).

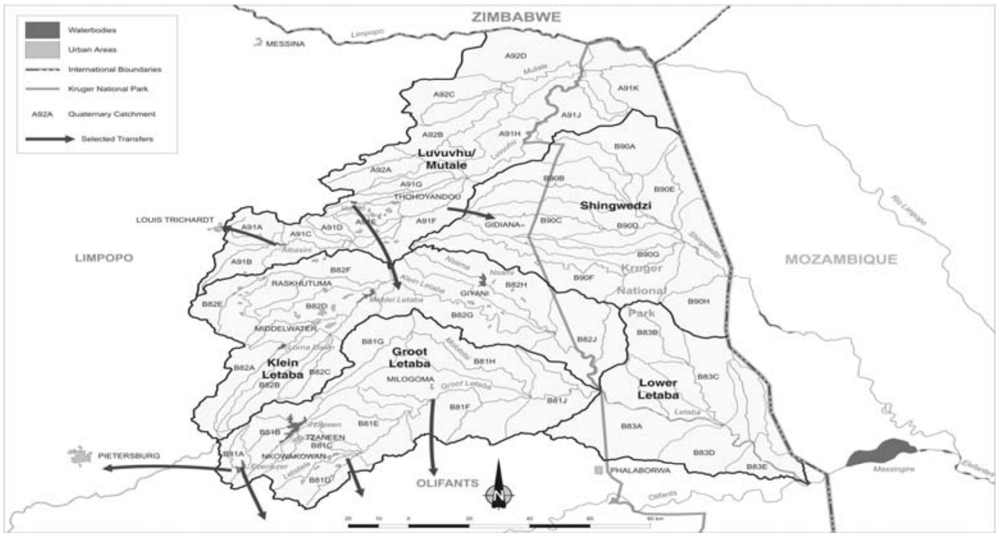


Figure 7. 9: Base map of the Luvuvhu/Letaba water management area (DWAF, 2004)

Nine respondents were randomly selected, seven from the Letaba irrigation area and two from the Settlers area. The two respondents from the Settlers area irrigate mainly from boreholes (private irrigation) and do not belong to a traditional irrigation board scheme or government irrigation scheme. The Levuvhu/Letaba water management area lies in the Limpopo Province.

7.2.2 Data collection and analysis

The field survey for this part of the study was conducted by means of structured and semi-structured interview schedule where respondents were asked questions orally and responses recorded by the researcher. This was done in a face-to-face encounter, but in some cases respondents were also telephonically interviewed. Before the investigation commenced semi-structured interviews were conducted with respective government officials, irrigation scheme managers, members of the local farmers' association, private consultants and commodity institutions active in the different areas. The information gathered from the semi-structured interviews helped with the identification of possible factors that may influence the adoption of irrigation scheduling. Once the variables assumed to influence the adoption behaviour of irrigation farmers were identified, scales were developed for the purpose of quantification and for providing a basis for analysing relationships. The draft questionnaire was tested with several irrigation and extension specialists after it was adapted as required.

The main objectives of the questionnaire for irrigation farmers were:

- To assess the demographics of the respondents and present an overview of irrigation practices.

- To assess the perception of the irrigation farmers regarding the practice of irrigation scheduling in general and the comparison between old and new irrigation scheduling technology.

- Identify the specific irrigation scheduling methods used on farms as well the reasons, perceptions and attitudes of farmers.

- Determine the human and environmental factors, which influence the adoption or discontinuation of irrigation scheduling methods and models.

- Identify the learning and information sources that irrigation farmers normally use.

Table 7.1 provides an overview of the distribution of respondents according to location that were involved in the survey for this part of the study.

Table 7. 1: Distribution of respondents according to province and irrigation area (N=134)

Province	Irrigation area	Number of respondents selected
Free State	Sand/Vet Irrigation Scheme	7
KwaZulu Natal /Eastern Cape	Underberg& Kokstad area	17
Mpumalanga	Onderberg /Komati & Lomatiriver Irrigation Schemes	17
Northern Cape	Orange Riet River WUA/ vd Kloof Irrigation Scheme/ Rust Irrigation Scheme/Lower Orange Irrigation Scheme	37
Eastern Cape	Gamtoos & Sundaysriver Irrigation schemes	23
Western Cape	Worcester, Hexriver & Riebeeck Kasteel Irrigation Schemes	10
Limpopo	Letaba & Settlers irrigation area	9
Northwest	Brits & Rustenburg-area	14
Total		**134**

Many of the questions are open-ended so as to minimize external influences and to allow the respondents to motivate their responses. The data analysis involved the use of Statistical Package for Social Science (SPSS version 10). Before analysis, the data was captured on a computer, which involved coding, data cleansing and editing, and finally modifications and collapse of data into variables.

CHAPTER 8

SOCIO-ECONOMIC FACTORS ASSOCIATED WITH THE ADOPTION OF IRRIGATION SCHEDULING

The following socio-economic factors as independent variables (personal and environmental factors) were assumed to influence the farmers' adoption decision, albeit indirectly through intervening variables like the irrigation farmer's subjective perceptions; attitudes and beliefs.

8.1 AGE

The relative age of decision-makers is a key factor in determining the life cycle "disposition" (VanClay, 2003). Several studies (Bembridge & Williams, 1999; Alene *et al.*, 2000; Mahabile *et al.*, 2002) indicated that age is negatively related with the adoption behaviour and production efficiency of farmers. This led to the hypothesis that younger farmers tend to be more inclined to adopt objective irrigation scheduling to increase the overall water use efficiency on the farm and that there is a negative relationship between age and the adoption behaviour (Hypothesis 1).

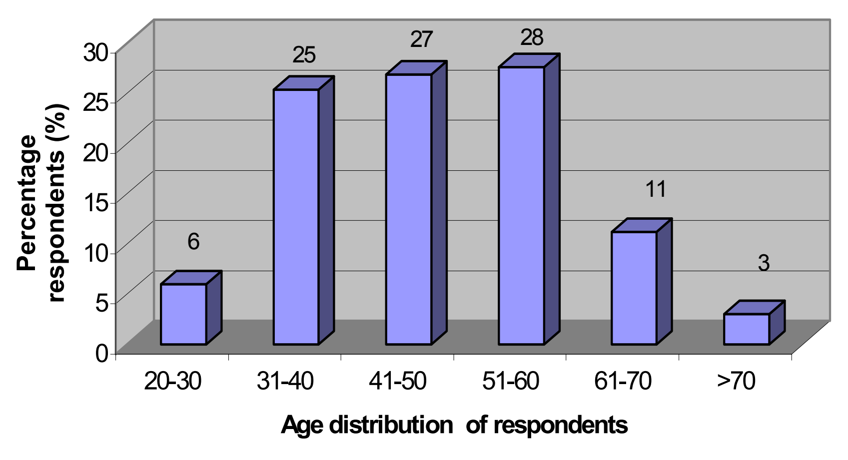


Figure 8. 1 Percentage distribution of respondents according to age (N=134)

Figure 8.1 indicates that 42% of the respondents are older than 50 years, which also reflects a significant pool of first-hand irrigation management experience and knowledge amongst the respondents. Thirty one percent of the respondents are younger than 40 years.

The relationship between age and the selected irrigation scheduling method by farmers was tested by using the independent samples t-test and to compare the willingness of farmers to implement the objective irrigation scheduling methods below 30 years and older than 60 year farmers. There is a significant difference in the scores for young farmers (M=3.3, SD=0.51) and elder farmers (M=1.87, SD=0.35; t (21) =2.7, p=0.013).

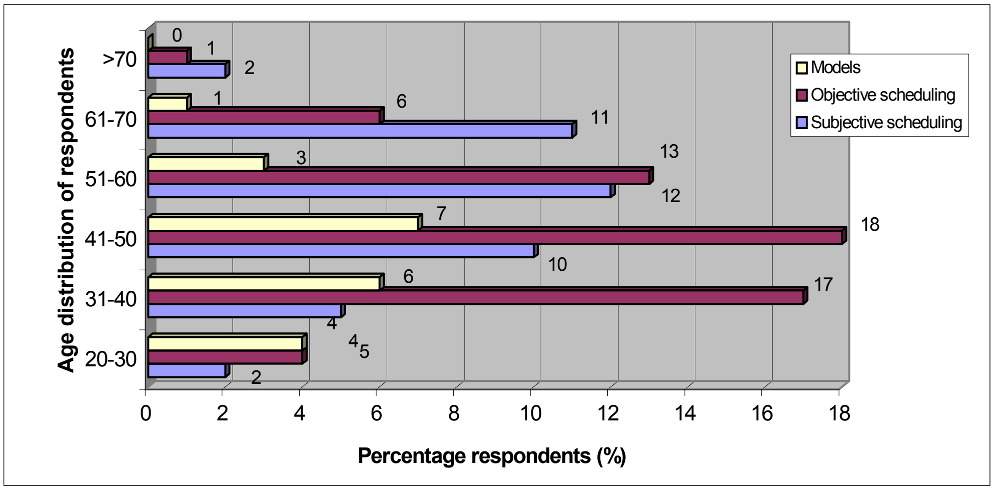


Figure 8. 2: Distribution of respondents according to age and the implementation of irrigation scheduling (N=134)

The results suggest a reduction in the willingness to invest in practices like objective irrigation scheduling (risk aversion) and an increase in the use of intuition and a fixed /semi-fixed rotational scheduling program as a method of scheduling (Figure 8.2). A significant negative relationship (Cramer's V=0.521, p=0.000) exists between age and the use of soil water content measurement, which provides evidence in support of Hypothesis 1.1 namely that an increase in age is negatively correlated with the use of objective irrigation scheduling practices.

A similar tendency is found in the case of the adoption of computer models, where a negative relationship (r=–0.253; p=0.004) provides evidence in support of Hypothesis 1, namely that the age of the farmer influences the preparedness of farmers to engage in the use of computer models for more precise irrigation scheduling on the farm. Younger farmers are more willing to use irrigation scheduling models, probably because of their computer literacy levels, and their willingness to use computer programs for farm management plans and budgets in which irrigation management is often reflected.

8.2 EDUCATION AND TRAINING

Mixed evidence regarding the relationship between farmers' education levels and the adoption of agricultural practices exists. Studies by Rossouw (1989), Bembridge & Williams (1990), Alene *et al.*, (2000) and Alene & Hassan, (2003) found that education is positively related to adoption behaviour of farmers. The findings of these empirical studies led to the hypothesis that education is positively associated to the adoption behaviour of irrigation farmers (Hypothesis 1.1).

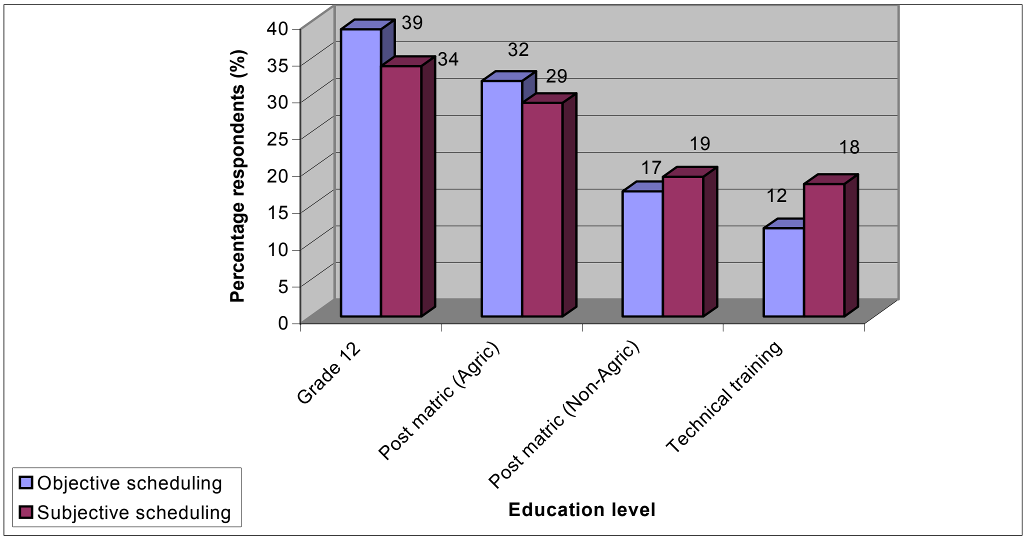


Figure 8. 3: Percentage distribution of the adoption of irrigation scheduling methods according to the education levels of respondents (N=134)

According to Figure 8.3, which presents the formal education profile of irrigation farmers, it appears that no significant difference in formal education exists between respondents using objective and subjective scheduling methods. Higher educational levels are correlated positively with adult training as been reflected through the preparedness of farmers to attend training courses in irrigation management (F=5.9; p=0.008).

There is tendency that higher education is associated with more positive attitude towards the implementation of irrigation scheduling models as supported by the significant Cramer's V value (Cramer's V=0.297, p=0.041).

Table 8. 1: Percentage distribution of respondents according to the attendance of training courses in irrigation management and irrigation scheduling implementation (N=134)

Training	Objective scheduling		Subjective scheduling		Total	
	(n)	%	(n)	%	(N)	%
Short course in irrigation management	57	71	19	35	76	57
No short course in irrigation management	23	29	36	65	58	43
Total	80	100	54	100	134	100

Training is clearly an important contributor to an individual's perception and capacity to change irrigation management practices (X^2=3.4, df=1, p=0.048). Involvement in irrigation management training courses is significantly associated with farmers' willingness to implement on-farm objective irrigation scheduling practices, as 71% of the irrigation farmers who used objective on-farm irrigation scheduling methods also attended short courses in irrigation management. It seems that farmers that had not attended any training courses in irrigation management are more likely to adopt subjective scheduling methods (Table 8.1).

These findings supply evidence in support of Hypothesis 1, namely that the attendance of more training courses in irrigation management is associated with the adoption of precise irrigation scheduling practices. This confirms the study results of Mues, Chapman & van Hilst (1998), where training was positively associated with practice adoption. Training may alleviate technical concerns that farmers have about irrigation scheduling practices.

8.3 PROPERTY SIZE AND IRRIGATION SCHEDULING

Rogers (1983) has generalized that early adopters have a larger farm-size unit than late adopters. Various authors like Cary (1992), Curtis *et al.*, (2000); Mahabile *et al.*, (2002) and Alene *et al.*, (2003) supported this.

In the case of irrigation farming, the same tendency can be expected. In fact, many irrigation farmers and consultants are of the opinion that the scale of irrigation operation is an important factor, which can influence the choice of on-farm irrigation scheduling practices. The findings regarding the relationship between farm size and implementation of irrigation scheduling models are shown in Figure 8.4.

There are significant differences in the implementation of objective scheduling methods with regard to the different categories of areas under irrigation (F=5.91; p=0.016). Fifty-five percent of the farmers that use scheduling models for irrigation scheduling are farming on a relatively big irrigation plot of bigger than 101 hectares. A positive correlation exists between the size of irrigation and the use of the use of computer models (r=0.291; p=0.035).

However, the relationship between the practicing of subjective irrigation methods and the size of irrigation area is not significant (r=0.137; p=0.181). This suggests that there are other factors involved in influencing the subjective irrigation scheduling behaviour of farmers, which need more careful analysis of the adoption behaviour of these farmers.

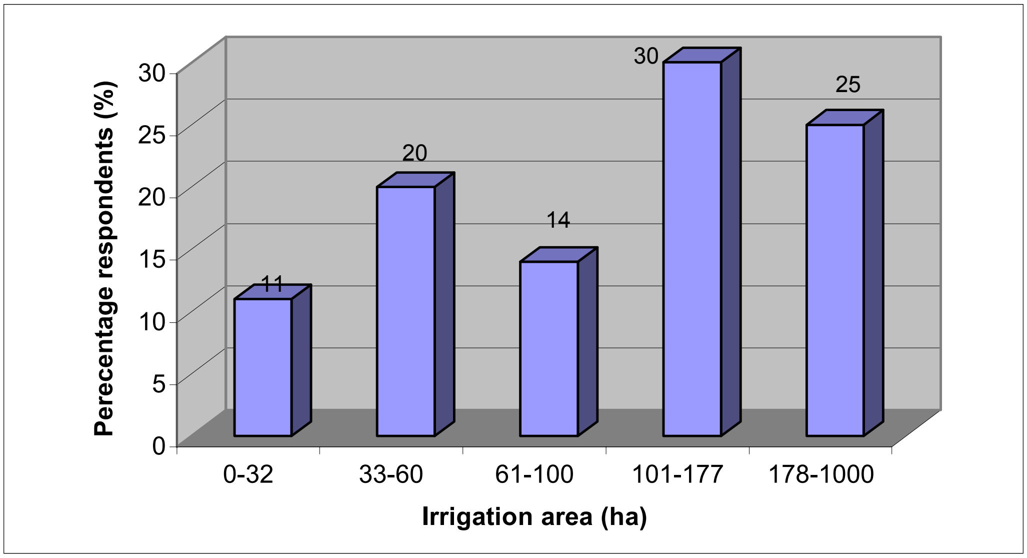


Figure 8. 4: Interrelationship between irrigation area and implementation of irrigation scheduling models (N=134)

8.4 FARMING EXPERIENCE

A general assumption is that a positive association exists between farming experience and the adoption behaviour of irrigation farmers. Experience is considered to be an accumulation of human capital, because with the accumulation of experience farmers are building confidence and knowledge over time, which in addition to the experience gained from other farmers, can become a powerful factor in addressing the best irrigation management practice.

Figure 8.5 illustrates that farmers with relative more farming experience are inclined to make use of subjective scheduling methods. Fifty-two percent of the respondents with more than 20 years farming experience use subjective scheduling methods, while 49 percent of the farmers with less than 10 years farming experience implement objective scheduling methods (F=6.27, p=0.018). The negative relationship between farming experience and the adoption of objective irrigation scheduling practices is supported by the significant negative correlations between an increase in farming experience and the use of on-farm soil water measurement techniques (r=-0.549;

p=0.049) as well as the use of computer models (r=-0.209; p=0.018). These findings are not in accordance with expectations (Hypothesis 1.1), and illustrate that farmers with relatively more irrigation farming experience are more prepared to rely on their local experience, observation and intuition instead of making use of objective irrigation scheduling methods

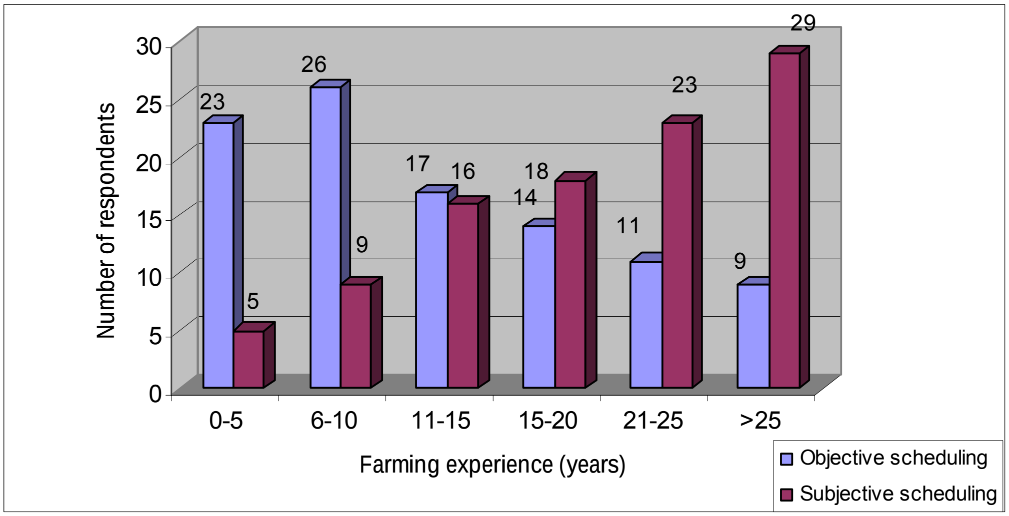


Figure 8. 5: Percentage distribution of irrigation farmers according to their farming experience and implementation of irrigation scheduling practices (N=134)

8.5 NON-FARMING EXPERIENCE

It is noteworthy that 62% of the respondents' experience is limited to that of farming, while the rest of the respondents exist over a wide range of experiences, which includes education, commerce, industry, business and the technical field. Interviews with irrigation consultants and advisors, as reflected upon in Part 5, revealed that there is a tendency that farmers with experience in other careers apart from farming are more open to agricultural innovation and more likely to seek objective advice as part of their decision-making process.

Table 8. 2: **Percentage distribution of respondents according to their non-farming experience and the association with irrigation scheduling implementation (N=50)**

Non-farming experience	Objective scheduling (n=30)		Subjective scheduling (n=58)	
	(n)	(%)	(n)	(%)
Technical field	5	17	5	25
Professional career	10	33	5	25
Commerce & business	7	23	5	25
Education	5	17	0	0
Administration	3	10	5	25
Total	30	100	20	100

Table 8.2 illustrates that 60% of the farmers with experience in other careers are prepared to implement objective scheduling methods on the farm. Fifty-five percent of these farmers are either professional people or businessmen that have started with irrigation farming. Although a relatively high percentage respondents with experience in other careers show interest for the implementation of objective scheduling methods, no significant relationship exists between the implementation of objective scheduling methods and farmers with experience in other careers (X^2=9.46, p=0.149; r=0.018, p=0.083).

8.6 SUMMARY

The study reveals that the following independent variables or socio-economic factors influence the implementation of on-farm irrigation scheduling:

- The increase in age and experience of irrigation farmers suggest a shift in reduction of their general willingness to invest and practise objective irrigation scheduling methods, although no statistical correlation exists. It is clear, however, that a tendency exists that younger farmers are more willing to use computer models because of their higher computer literacy levels and attitude towards the use of computers.

- A positive relationship exists between the educational level of farmers and their general attitude towards the attendance of short courses in irrigation management and the implementation of objective scheduling methods like irrigation scheduling models.
- The relationship between the size of irrigated area and the adoption of objective irrigation scheduling reveals positive relationships with a tendency for the implementation of irrigation scheduling models to increase with an increase in the size of the irrigated area.

CHAPTER 9

INFLUENCE OF INTERVENING VARIABLES ON THE ACCEPTABILITY OF IRRIGATION SCHEDULING

9.1 INTRODUCTION

In view of Hypothesis 1, which states that the influence of intervening variables on the adoption behaviour is higher than the independent variables, the influence of the intervening variables will now be assessed in this chapter. Their influence will be evaluated by using the normative classical five-stage adoption process (NSRC, 1955) as a conceptual framework for the identification of the role of perception, knowledge and needs to solve particular problems in irrigation management.

According to the classical five-stage model (NSRC, 1961) the adoption process is a rational decision-making process that extends over a period of time and implies a sequence of phases. Farmers, however, are not always strictly adhering to rational decision-making procedures (Simon, 1976), but rather regard decision-making as learning process with variation in deliberation and consciousness (Giddens, 1984). Therefore, Leeuwis (2004) refers to the different stages of the adoption process as aspects of learning, since the order in which awareness, interest and experiential learning through trialling occur may vary between different farmers.

The acceptability of a specific irrigation scheduling practice or the change from one irrigation scheduling practice to another, usually involves the following aspects of learning:

1. Awareness: Where the individual becomes aware of an innovation or the problematic situation.

2. Interest: The individual becomes more interested in the new idea and seeks additional information. This is where irrigation farmers select various information and learning sources.

3. Evaluation: The individual mentally applies innovation to his present and anticipated future situation, and then decides whether to try it or not.

4. Trialling: Where the individual becomes actively involved in experiential learning and makes full use of the innovation within his or her current situation.

5. Adoption or Rejection: The individual seeks reinforcement for making decisions - leading to the continuation or discontinuance of an innovation.

9.2 AWARENESS OF THE NEED FOR IRRIGATION SCHEDULING

In this context, “awareness” means not just awareness of the existence of an innovation, but also an awareness of its potential or practical value to the farmer. According to Ghadim & Pannell (1999), when a farmer reaches the stage where the potential value of the innovation is recognised, it serves as a trigger, which prompts the farmer to be willing to “open his ears and eyes”. The farmer will commence by noting and collecting information about the specific innovation in order to decide whether or not to proceed to the next step of adoption, namely trialling of the specific innovation.

All but one of the farmers indicated that they had heard about irrigation scheduling before the survey. The information sources used by farmers in the study areas include the local agricultural cooperatives, private consultants and advisors from wine cellars and commodity institutions like the sugar, citrus, subtropical fruit and deciduous industries, fellow farmers and family members, universities and tertiary institutions, field days by ARC extensionists from Department of Agriculture, and representatives of seed, fertilizer and agrochemical companies. The frequencies, with which these sources are used, are summarized in Table 9.1.

Table 9. 1: Information sources through which farmers become aware of irrigation scheduling (N=134)

Sources of awareness	**Objective scheduling**		**Subjective scheduling**		**Total number of respondents**	
	(n)	**(%)**	**(n)**	**(%)**	**(N)**	**(%)**
Cooperatives	25	33	12	21	37	28
Private consultants/advisors	22	29	6	10	28	21
Fellow farmers	11	15	16	28	27	20
Universities	7	9	11	19	18	13
Departmental extensionists	5	7	6	10	11	8
ARC Institutes	5	6	3	5	8	6
Representatives (seed, fertilizer and agrochemical companies)	1	1	3	5	4	3
Missing			1	2	1	
Total	**76**	**100**	**58**	**100**	**134**	**100**

Based on the frequencies, it is clear that local agriculture cooperatives (grain, citrus and cellars), private consultants from the various industries and fellow farmers are important information sources that create awareness about on-farm implementation of irrigation scheduling.

Private irrigation consultants and advisors (29%) from wine cellars and commodity institutions like the sugar, citrus, subtropical fruit and deciduous fruit industries as well as cooperatives (33%) play a significant role in raising awareness among farmers to start with the implementation of on-farm objective irrigation scheduling techniques. Fellow farmers (28%) play an important role to raise awareness of the use of subjective irrigation scheduling methods. Although a tendency exists that different information sources are responsible for raising awareness of irrigation scheduling, no statistical significant relationship (F=1.43, p=0.233; r=0.108, p=0.177) exists between the source of information used and the on-farm irrigation scheduling method implemented.

9.2.1 Perception of the concept "irrigation scheduling"

Respondents were assessed regarding the "technical correctness" of their perception with respect to the principles that apply to the concept "irrigation scheduling" as commonly used by scientists. These perceptions of irrigation farmers reflect their attitude and beliefs towards irrigation science. According to Table 9.2, only 22 percent of the respondents fully understand the definition of irrigation scheduling; which implies that farmers could referred to the relationship between soil, plant and atmospheric. Seventy-two percent could only partially refer to the major principles included in the definition.

Table 9. 2: Percentage distribution of respondents according to their perceived understanding of the definition irrigation scheduling (N= 134

Perception regarding the definition "irrigation scheduling"	Objective scheduling (n=76)		Subjective scheduling (n=58)		Total (N=134)	
	n	(%)	n	(%)	N	(%)
Fully understand the definition	21	28	9	16	30	22
Partially understand the definition	53	69	43	74	96	72
No understanding of the definition	2	3	4	7	6	4
Did not answer the question			2	3	2	2
Total	**76**	**100**	**58**	**100**	**134**	**100**

Table 9.2 shows significant differences between the categories of understanding of the concept "irrigation scheduling" (X^2=3.65, df=2, p=0.016). Irrigation farmers using objective scheduling methods show more insight into the understanding of the concept than irrigation farmers using subjective scheduling methods. A significant positive Spearman correlation (r=0.179, p=0.041) confirms this association between perception about irrigation

scheduling and the implementation of objective irrigation scheduling methods. This finding emphasizes the important role that competent extensionists and irrigation institutions have to play in training and informing irrigators in this regard.

9.2.2 Perceived need for on-farm implementation of irrigation scheduling

The incentive or need related motive of a problem lies primarily in the perceived discrepancy between the current and desired or potential situation. Düvel (1991) referred to this as the need tension or need potential, and the influence of this factor is well documented in various research findings (Koch, 1985; Düvel & Scholtz, 1986; Koch, 1987; Louw & Düvel, 1993; Botha, 1997; Düvel & Botha, 1999). The need potential as illustrated through the perceived importance of implementing irrigation scheduling is illustrated in Figure 9.1.

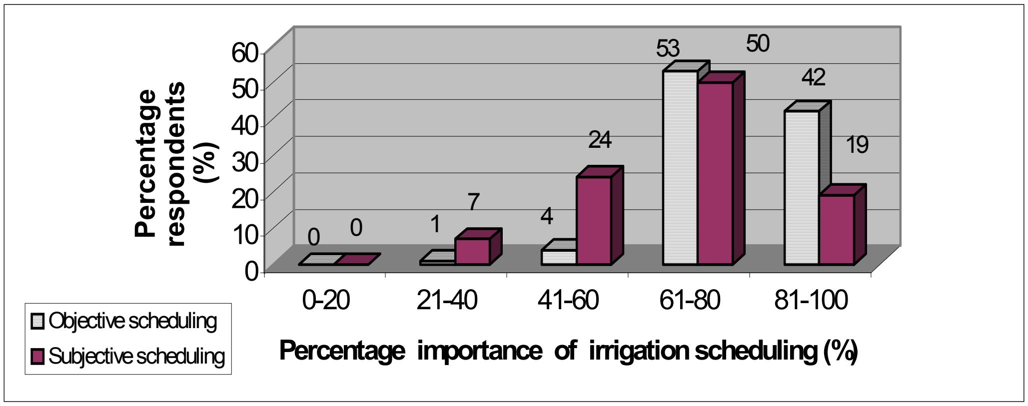


Figure 9. 1 Percentage distribution of respondents according to their perception regarding the importance of irrigation scheduling and their application of different irrigation scheduling methods (N=134)

The majority of respondents (85%) rated irrigation scheduling as an important practice on the farm for sound irrigation management, with a clear tendency of farmers implementing objective scheduling methods to be more convinced about the importance of irrigation scheduling than those farmers using subjective scheduling (Figure 9.1). This association between perception of the importance of the implementation of on-farm irrigation scheduling and the implementation of objective irrigation scheduling is supported by significant differences (χ^2=21.45, df=7, p=0.003).

Farmers involved with the practicing of objective irrigation scheduling rated the importance of implementation of on-farm irrigation scheduling higher than farmers involve in subjective irrigation scheduling. Forty-two percent of the farmers involved with the implementation of objective scheduling methods perceived irrigation scheduling to be highly important (>80%), while only 19% of farmers applying subjective scheduling methods shared the same perception. A significant correlation (r=0.424, p=0.000) exists between the perceived importance of on-farm irrigation scheduling and adoption of objective scheduling methods. This finding provides supporting evidence for Hypothesis 1.2, namely that the adoption of irrigation scheduling is directly correlated with the perceived importance of on farm irrigation scheduling.

9.2.3 Perceived need for the implementation of irrigation scheduling by fellow farmers

Sometimes the simultaneous learning of interdependent stakeholders is necessary, to arrive at coherent innovations and practices, which authors like Röling (2002) and Woodhill (2002) have labelled as “social learning”. Röling (2002) defines social learning where collective or distributed cognition is taking place, and where the different stakeholders may work together and engage in complementary practices while significant differences in perception remain. Farmers were asked to rate the importance of the practising of irrigation scheduling by their fellow irrigation farmers in an irrigation area.

Approximately 84% of the respondents regarded the implementation of irrigation scheduling by fellow farmers to be important for sound irrigation management (Table 9.3). There is an indication of a slightly higher expectation among irrigation farmers who implement objective irrigation scheduling (χ^2=16.04, df=8, p=0.042; r=0.216, p=0.013). Irrigation water is generally perceived as a common property, which necessitates stakeholders to focus on more than one system level. Therefore, it is not enough for farmers that sustainable water management principles are applied at the farm-level only, but it necessitates that stakeholders at an irrigation scheme level need to work collectively to ensure effective water management.

Table 9. 3 Percentage distribution of respondents according to their perceived importance of the implementation of irrigation scheduling by fellow farmers and their on-farm irrigation scheduling (N= 134)

Importance of irrigation scheduling by fellow farmers	**Objective scheduling (n-76)**		**Subjective scheduling (n=58)**		**Total number of respondents**	
	(n)	**%**	**(n)**	**%**	**(N)**	**%**
0-20	0	0	10	17	10	8
21-40	0	0	4	7	4	3
41-60	5	6	3	6	8	6
61-80	46	61	24	41	70	52
81-100	25	33	17	29	42	31
Total	**76**	**100**	**58**	**100**	**134**	**100**

9.2.4 Perceived reasons for implementation of irrigation scheduling

Showing interest in an innovation is an aspect of learning where the farmer collects information to decide about the possible opportunities, threats and personal consequences attached to the innovation. The motivation of farmers to learn about irrigation scheduling will depend on the priority or urgency of solving the identified problem and the magnitude of the tension between the desired and current state of affairs (Leeuwis, 2004).

The reasons provided by farmers for their initial interest shown in the implementation of irrigation scheduling (Table 9.4) reveal significant variation in the need potential of irrigation farmers (F=6.46, p=0.013). The majority of respondents (64%) maintain that the main purpose for the implementation of objective irrigation scheduling was to ensure efficient use of water on the farm and in the field according to the crop water requirements.

Table 9. 4 Percentage distribution of respondents according to the perceived reasons for the implementation of irrigation scheduling practices (N= 134)

Most important reasons for the application of irrigation scheduling	Objective scheduling (n=76)		Subjective scheduling (n=58)		Total (N=134)	
	n	%	n	%	N	%
Optimum water use on the farm ("Can't farm without it")	49	65	38	66	87	64
Control of nutrient leaching	36	47	21	36	57	43
Improved quality of crops	36	47	19	33	55	41
Electrical costs too high	16	21	11	19	27	20
Profit maximization	8	10	5	9	13	10
Application of water according to crop water requirements and maintain a full profile	8	10	4	7	12	9
Follow in the footsteps of father	2	3	8	14	10	7
To meet export standards (Eurepgap, ISO standards)	7	9	0	0	7	5
Popular and socially acceptable	2	3	0	0	2	1

Forty-seven percent farmers involved with the production of high value/high input crops, perceived the implementation of objective irrigation scheduling as a means of ensuring improved quality of crop and the prevention of nutrient leaching. The need potential of the subjective irrigation scheduling group on the other hand was less, in that only 36 percent of farmers perceived controlling of nutrient leaching and 33 percent perceived improved quality of crops as important reasons for the implementation of on-farm irrigation scheduling. Nine percent of irrigators from the objective irrigation scheduling group perceived precise irrigation scheduling practices as important to qualify in terms of Eurepgap and ISO standards that prevail as the minimum standards for good agricultural practices of export horticultural products like fruit and certain commodities like tobacco and citrus.

From the findings presented in Table 9.4, it is interesting that 14 percent of the respondents using subjective scheduling methods indicated that they are following in their fathers' footsteps in this regard. This illustrates the important role that indigenous knowledge systems play in irrigation management. It is imperative for irrigation extensionists and advisors to recognize this knowledge system as it has often evolved from years of experience and trial-and-error problem solving by irrigators. These expressed reasons provided for the implementation of irrigation scheduling differ significantly (X^2=8.63, df=2, p=0.013) between the objective and subjective scheduling groups. This finding supports Hypothesis 1.2, which implies that there is a significant relationship between perceived need for on-farm irrigation scheduling and the implementation of irrigation scheduling.

9.3 INFLUENCE OF PERCEIVED IRRIGATION SCHEDULING EFFICIENCY ON ADOPTION BEHAVIOUR

Irrigation efficiency and the adoption behaviour of irrigation farmers are hypothesized to be a function of personal and environmental factors, which are in turn divided into independent and intervening variables. One of the intervening variables identified by Düvel (1975) as a behaviour determinant is the perceived current efficiency of irrigation scheduling adoption. The more accurately a farmer perceives his or her problem, the more likely he or she is to appreciate the improvement potential, and the more willing is he to change his behaviour.

9.3.1 Perception regarding the efficiency of on-farm irrigation scheduling

The perception of irrigation farmers regarding their level of irrigation accuracy is reflected in Table 9.5. Farmers were asked to rate the accuracy of their current irrigation scheduling on the farm, using a ten-point semantic scale.

The majority respondents (66%) rated the accuracy of their on-farm irrigation scheduling practises relatively high (between 70-80%). There is a tendency for respondents implementing objective irrigation scheduling to be more convinced of the accuracy level of their method than is the case with those using subjective scheduling, although the differences are not statistical significant (F=2.517, p=0.116). Ninety percent of the farmers implementing objective irrigation scheduling methods rated their current accuracy of on farm irrigation scheduling between 70-90%, while 71 percent of respondents from the subjective scheduling group provided the same assessment.

Table 9. 5: Percentage distribution of respondents perception of the accuracy level of on-farm implementation of irrigation scheduling (N=134)

% Accuracy irrigation scheduling	Objective Scheduling (n=76)		Subjective scheduling (n=58)		Total (N=134)	
	n	**%**	**n**	**%**	**n**	**%**
20	0	0	2	3	2	1
50	1	1	3	5	4	3
60	7	9	11	19	18	13
70	28	37	19	33	47	35
80	26	34	15	26	41	31
90	14	19	7	12	21	16
100	0	0	1	2	1	1
Total	**76**	**100**	**58**	**100**	**134**	**100**

As far as the perception of accuracy of on-farm irrigation scheduling is concerned, a significant relationship (Cramer’s V=0.410, p=0.000) exists between the use of soil water measurement techniques and the accuracy of on-farm irrigation scheduling. However, the relationship between the perception of accuracy of on-farm irrigation scheduling and the use of computer irrigation scheduling models is not significant (Cramer’s V=0.228, p=0.569).

9.3.2 Perceived satisfaction with current level of on-farm irrigation scheduling

It is only because of an existing need that a person can have a goal or a goal appears to be attractive (Düvel, 1990). The level of satisfaction with the current method of irrigation scheduling will determine the perceived improvement potential, which can influence the willingness of the farmer to change his behaviour and thereby improve the efficiency of irrigation scheduling. This assumption (Düvel, 1991) has led to the hypothesis that the need tension is positively associated with adoption behaviour.

In response to a question as to how satisfied respondents are with the current accuracy of implementation of irrigation scheduling, it appears as if the farmer group using subjective scheduling methods is relatively more satisfied than farmers using objective irrigation scheduling methods (Figure 9.2).

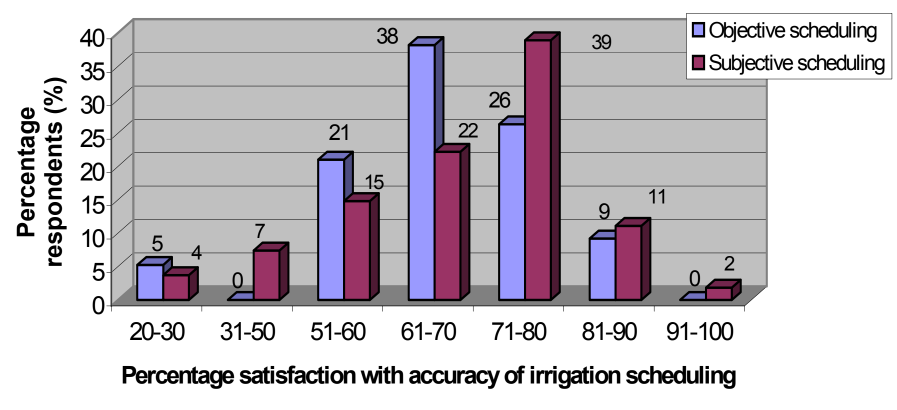


Figure 9. 2: Percentage distribution of respondents according to their perceived satisfaction with on-farm irrigation scheduling and the implementation of different irrigation scheduling methods (N=134)

Thirty five percent of the respondents that use objective irrigation scheduling methods rate their satisfaction with the accuracy of the on-farm irrigation scheduling at more than 70%. This percentage satisfaction is 52 percent in the group of respondents using subjective methods.

There is a clear indication of a higher need tension among the objective scheduling group (r= -0.234, p=0.048), which is in accordance with what has been hypothesized (Hypothesis 1.2). The explanation for this is the fact that farmers that belong to the subjective scheduling group had overrated their current level of efficiency, while farmers from the objective scheduling group are more realistic and even underrated their level of irrigation efficiency. This is an important finding for the extensionists and irrigation consultants to take cognizance of, as it illustrates the difference of the need potential as perceived between the objective and subjective scheduling groups. The more accurately a farmer perceives his efficiency of on-farm irrigation scheduling, the more likely he is to appreciate the improvement potential, and the more likely he is to alter his behaviour and thereby improve the on-farm irrigation management.

9.4 PERCEPTION REGARDING IRRIGATION OPERATIONAL COSTS

Irrigation water application costs are related to the actual cost of water, interest on capital equipment, energy (electricity or diesel), labour and also opportunity costs, especially if water is limited. In an effort to determine the need related motive for the adoption of irrigation scheduling, farmers were asked to indicate the operational cost of irrigation in relation to the other production cost items applicable to various crops and whether they experience the tariffs of irrigation water to be expensive. Seventy percent of the respondents perceived the actual tariff of irrigation water to be expensive.

Table 9.6 provides an overview of the distribution of the operational cost of irrigation water as perceived by the respondents involved in the production of cash crops (like maize, wheat, cotton, sugar cane, etc.) and intensive, high value crops (like deciduous fruit, table grapes, wine grapes, citrus, subtropical fruit, vegetable seed, etc.) respectively.

Table 9. 6: Percentage distribution of perceived irrigation operational irrigation costs with regard to the production of cash and high value/high input crops. (N=134)

Cash crops			Intensive or high value crops		
Percentage of total production cost/ha	**n**	**%**	**Percentage of total production cost/ha**	**n**	**%**
0-5%	3	3	0-5%	22	28
6-10%	29	31	6-10%	31	40
11-20%	32	34	11-20%	19	24
21-30%	29	31	21-30%	6	8
Total	**93**	**100**	**Total**	**78**	**100**

Table 9.6 illustrates highly significant differences with regard to the perceived operational irrigation costs (X^2=9.109, df=3, p=0.028) between cash and high value crop producers. Irrigation water as an operational cost proportionate to the total production costs per hectare of cash crops and high value/ high input crops like deciduous fruit, table grapes, wine grapes, and sub tropical fruit are found to be relatively small. Sixty eight percent of the respondents involved in the growing of high input crops reflected the operational cost of irrigation to be between 0-10% of the total production costs per hectare. Whereas, the relationship between the perceptions of irrigation operational costs proportionate to the total production costs of high value/intensive crops per hectare and the adoption of objective irrigation scheduling is significant (r=0.302, p=0.007).

However, although 65% of the cash crop farmers indicated the operational cost of irrigation to be between 11-30% of the total production cost per hectare, no significant relationship exists with the adoption of objective irrigation scheduling (r=0.208, p=0.265). These findings illustrate that the major advantages by the implementation of objective irrigation scheduling is not perceive to be demonstrated in terms of the possible saving on irrigation water and irrigation operational costs by cash crop farmers alone. This finding illustrates that cash crop farmers are probably underrating the effect of the operational irrigation costs on their production efficiency, and thereby supporting Hypothesis 3, which states that the specific farm business characteristics influence the irrigation farmers' willingness to adopt more precise irrigation scheduling methods.

Farmers were asked to identify the most important production inputs and rank them in order of importance with regard to their respective contribution to the total crop enterprise budget. Although farmers are generally aware of the importance of water as a primary constraint to production, they do not perceive irrigation operational costs as the most important contributor to the total production input costs for cash and intensive crop production (Table 9.7).

Table 9. 7 The perceived importance rank order of operational irrigation costs relative to the other production cost factors in terms of cash and high value crop production as expressed by weighted average score * (N=134)

Production input	**Cash crops (n=92)**		**High value/high input crops (n=76)**	
	Weighted average score	**Rank order position**	**Weighted average score**	**Rank order position**
Fertilizers	2.49	1	1.20	2
Seed	0.64	3		
Labour	0.79	2	1.52	1
Pest and weed control	0.23	4	0.65	4
Mechanization	0.17	6	0.09	7
Marketing	0.19	5	0.93	3
Packaging			0.60	5
Irrigation	0.14	7	0.13	6

** Weighted average score is the sum of the rank order frequencies multiplied respectively by 7 for the first position, 6 for the second position, 5 for the third position, 4 for the fourth position 3 for the fifth position, 2 for sixth position, 1 for seventh position and divided by the number of farmers expressed as percentage.*

Cash crop irrigation farmers ranked the production input costs of fertilizers, seed and labour as overwhelmingly important, with the production costs of irrigation ranked relatively low (position seven as weighted score). Also high value crop farmers ranked irrigation operational costs relatively low (position six as weighted score), which illustrates that other inputs like fertilizers, labour, marketing and timeous controlling of pest and diseases are more expensive than irrigation water.

These findings provide a possible explanation why farmers illustrate a higher need tension to spend time, money and skills to monitor production inputs like fertilisers, seed, labour, etc. more accurately than they do with regard to the adoption of more precise on-farm irrigation scheduling methods.

9.4.1 Relationship between source of irrigation and irrigation operational costs

The operational cost of irrigation could vary considerably depending on whether a farmer receives water from a canal distribution system within an irrigation scheme, or whether the farmer is pumping water directly from a river. Seventy-six percent of the respondents indicated that they receive water from a canal delivery system, while 15 % respondents pump water directly from a river. Nine percent of the respondents use boreholes as their water source.

Farmers, who pump water directly from a river or borehole, can expect to experience relatively higher electricity operational costs than farmers receiving irrigation water from a canal delivering system. Table 9.8 reveals the analysis of the differential irrigation operational costs that farmers' experience where different water sources and irrigation systems are used for the production of wheat in the Northwest province. The unit operational cost of irrigation as calculated in Table 9.8 reflects only the actual water cost, electricity and an average labour costs of R275/ha as assumed for this exercise.

Table 9. 8 Irrigation operational costs for the production of wheat with a target yield of 6t/ha and a crop water requirement of 540 mm/ha, using different water sources and irrigation systems in the Northwest Province (2003)

Source of irrigation water	Irrigation system	Tariff of irrigation water (R/ha/ annum)	Elec-tricity cost (R/ha)	Cost /unit irrigation water (R/mm)	Total irrigation cost/ season /ha (R/ha)
River	Centre pivot (Low pressure)	64.28	287.95	2.08	1123
River	Centre pivot (High pressure)	64.28	374.33	2.53	1366
Canal	Centre pivot (Low pressure)	700	287.95	2.20	1188

Table 9.8 shows a substantial difference (R243/ha) that exists regarding the total irrigation cost/season/ha between the uses of low *versus* high-pressure centre pivots, mainly because of the differential electricity consumption between these two irrigation systems. Variation is illustrated regarding the total operational costs for irrigation per hectare per season where irrigation water is directly pumped from a river compared to irrigation water received from a canal within an irrigation scheme. A significant relationship (r=0.319, p=0.004) exists between the source of irrigation used by irrigation farmers and the irrigation operational irrigation costs experienced. These findings emphasize the importance of the correct design and selection of irrigation systems that are appropriate for specific farm situations (soil, climate, management capacity etc.).

9.4.2 Perception regarding implementation of volumetric irrigation water tariffs

The Water Demand Management (WDM) as incorporated into the National Water Resources Strategy (NWRS), is an innovative strategy implemented to help manage water resources efficiently in southern Africa (de Lange *et al.*, 2002). The Water Management Plans of WUAs must therefore illustrate the current and expected water demand as well as proposed water conservation measures. Water measurement is considered to be of fundamental importance for the implementation of these plans, and except for the legislative reasons for the measuring of irrigation water, many other benefits related to practical water management are perceived from the upgrading of water measurement programs and systems (United States Bureau of Reclamation, 1997).

One way to achieve an efficient allocation of water is to price its consumption correctly. A variety of methods for pricing water have been developed, depending on natural and economic conditions. These include volumetric pricing, non-volumetric pricing and market-based methods. Volumetric pricing mechanisms charge for irrigation water based on consumption of actual quantities of water. This requires information on the volume of water used by each user or some other way to infer a measurement of water consumption. Implementation costs associated with volumetric pricing are relatively high and require a water user association (WUA) to set the price, monitor use and collect fees (Knoetze, 2003).

As illustrated in Part Two, on the majority of schemes non-volumetric pricing is exploited where the individual abstraction of irrigation water is not measured, and irrigators generally pay water tariffs that are based on irrigated area. Bos & Walters (1990) in their global survey of farmers on 12 million ha, found that in more than 60% of the cases water is charged on a per unit area basis. Under this pricing mechanism users are charged for water used per irrigated area, often depending on crop choice, extent of crop irrigated, irrigation method and season. Rates are typically greater for pumped water from a storage facility than for gravity flow from stream diversion. Consequently there are little financial and social incentives for the implementation of non-volumetric pricing.

Market-based methods have recently arisen as a need to address water-pricing inefficiencies inherent in existing irrigation institutions. Markets are far better than bureaucrats at capturing this opportunity cost, so government should encourage the establishment of markets in order to determine the most economically beneficial use of water sources (De Lange & Maritz, 1998). Formal water markets can only work if there are “buyable” and “sellable” water rights, and willing irrigation farmers to make use of this opportunity during critical crop growth stages. Water markets are, however, localized in nature because it is expensive to transport and therefore the number of suppliers and users are limited. The general perception of farmers regarding the volumetric measurement of water at farm off-takes was tested.

It was generally found that farmers have a positive attitude towards the implementation of volumetric water tariffs and water measurement at individual abstractions (Figure 9.3). Many farmers, however, indicated that they lack the necessary financial incentives for the implementation of irrigation scheduling and efficient use of water on the farm with the current water allocation and non-volumetric tariff system in use by water organisations.

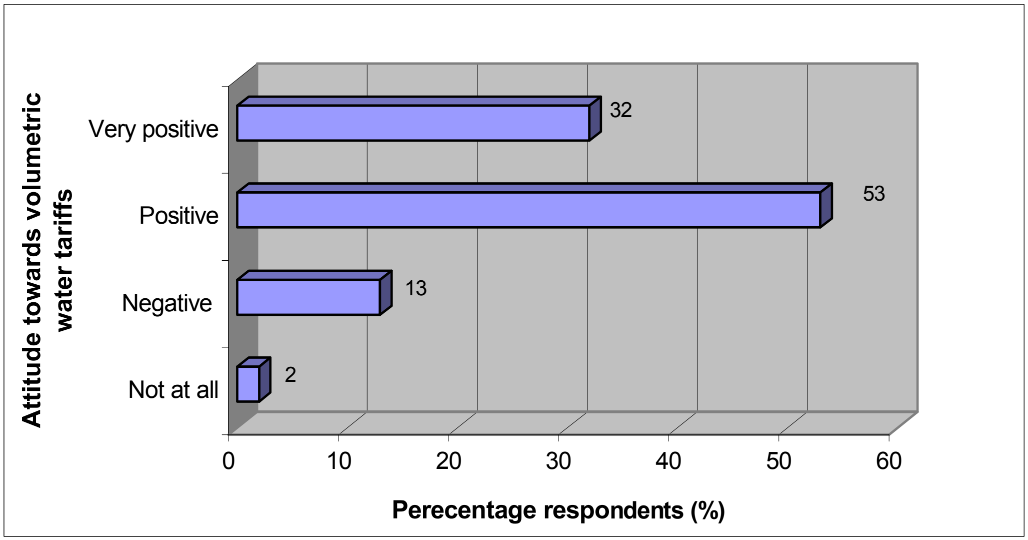


Figure 9. 3: Percentage distribution of respondents according to their attitudes towards the application of volumetric water tariffs (N=134)

Although 85 percent of farmers showed relative positive attitudes towards the application of volumetric water tariffs with the placement of water meters at each individual abstraction point, no significant relationship exists with the adoption of on-farm objective irrigation scheduling (r=0.136, p=0.162). Thirteen percent of the farmers indicated concern about the accuracy and the practical application of this technology. Common causes of meter defects perceived by farmers are defective flow meters (resulting in providing incorrect information), ageing technology and meter tempering. Often physical impurities include water grass, sticks, frogs, silt and any other object or substance conveyed by water, which can affect the meter accuracy. Therefore, the limited number of water measurement devices currently installed in the field is not perceived to be successful by farmers, and several questions regarding the practical implementation of the concept were raised.

A commercially available mechanical meter could be bought and installed for less than R8000 on most irrigation pipes smaller than 300mm in diameter (vd Stoep, 2004). However, farmers are often using more than one pump on the farm to abstract water, and therefore will need more than one device to be installed. Thirty seven percent of the respondents, who indicated a positive attitude towards the implementation of volumetric measurement, were concerned with regard to the initial cost of the device or meter and the installation of it. Although the cost of the device is relatively small in comparison with many items of the crop budgets applicable for summer and winter crops, the necessary financial incentives through the potential increasing of water use efficiency on the farm was not perceived enough for the justification of the additional costs. Respondents had raised concern about the financial responsibility for installing and buying of measurement or equipment (farmers or the responsible water organization or Department of Water Affairs?).

9.5 INFLUENCE OF PERCEIVED INNOVATION CHARACTERISTICS ON IRRIGATION SCHEDULING ADOPTION

For irrigation farmers to adopt certain irrigation scheduling practices requires an understanding of their current situation, the improvements possible, and the degree of complexity of improvements to meet the identified need potential. This implies that the adoption of irrigation scheduling technology as a practice must be regarded as a multi-stage decision process involving information acquisition and learning-by-doing. The degree to which an innovation may be experimented with on a limited scale prior to full implementation is critical in the adoption or learning process as it helps to organize and provide feedback to the farmer (Rogers, 1983, Bembridge, 1991, Leeuwis, 2004). Therefore, small-scale trials and evaluation of a new on-farm irrigation scheduling practice can provide valuable information to the farmers. This can reduce uncertainty and help with the judging or assessment of specific technology. Even financially and socially secure farmers are unlikely to plunge blindly into a new practice, but prefer to limit their risk as much as possible by gathering information and extending knowledge in a cautious way. If possible, they prefer a phased implementation of new irrigation scheduling practices, adjusting the scale either upwards towards full adoption, or downwards towards rejection as they gain knowledge, experience and confidence in their perceptions about the performance (Stirzaker *et al.*, 2004.)

9.5.1 Perception regarding irrigation technology attributes

According to Düvel (1975), all potential forces of behaviour change can be directly traced back to the perception of the psychological field. Several research studies (Louw & Düvel, 1973; Düvel, 1975; Koch, 1985; Botha, 1986; Koch, 1986; Botha, 1999) present evidence of this and led to the hypothesis (Hypothesis 1.2) that the implementation of irrigation scheduling is positively associated with the perception of irrigation scheduling technology attributes.

Linder (1987) highlighted the importance of the characteristics of a specific technology in the adoption of agricultural practices. Important attributes found to influence the rate of adoption of objective irrigation scheduling technology by farmers are the relative advantage, complexity, compatibility, trialability and the observability (Rogers, 1983). Leeuwis (2004) refers to these as characteristics of learning areas that help to understand why some learning occurs easily, or not.

Irrigation farmers usually evaluate the new irrigation scheduling devices and recommended practices in terms of the relative complexity to use or apply them, the relative risk involved and the investment characteristics relative to traditional technology. Table 9.9 provides information of the difference in perception of irrigation farmers who implement objective and subjective irrigation scheduling with regard to perceived characteristics of the ideal irrigation scheduling technology are reflected in terms of:

- Risk characteristics: some technologies have risk reducing effects in a high-risk environment, where others have no effect on risk or even increase it.

- Relative management complexity: relative management complexity refers to the flexibility characteristics of the irrigation scheduling technology or the ability to function under a variety of irrigation farming systems,

- Initial capital costs: the initial capital costs to be spent before the device can be implemented will determine adoption decisions, especially in the case of resource poor farmers.

- Relative profitability of technologies: farmers will be more willing to adopt irrigation technology that gives high returns on investment.

Table 9. 9: Percentage distribution of respondents according to their perception regarding the technological characteristics of irrigation scheduling devices and their style of irrigation scheduling implementation (N=134)

Technology characteristics	Objective scheduling (n=76)	Subjective scheduling (n=58)	Number of respondents (N)	% Respondents
1. Risk characteristics of technology				
Accuracy and reliability of data	65	32	97	72
Timeliness and speed of use of data	32	12	44	33
2. Relative management complexity				
Easiness of implementation within farming system	54	28	82	61
Robustness of device	7	2	9	7
Simple technology	27	22	49	37
3. Initial costs				
Affordable (initial cost)	38	28	66	49
4. Profitability of technology				
Cost effectiveness	15	5	20	15

It is apparent from these findings in Table 9.9 that farmers' decisions to adopt or reject the use of a specific irrigation scheduling technology are likely to be determined by the perceived usefulness of the technology as characterized by the accuracy and reliability of information produced for decision-making (72%) and timeliness of data (33%). The possible explanation for this finding is that irrigation farmers are generally "risk averse" and therefore perceive accurate and trustworthy information resulting from the implementation of irrigation scheduling technology as the most important prerequisite for the adoption of irrigation scheduling.

Respondents rated characteristics regarding the adaptiveness or easiness of technology to interact and implement with other technology in the relevant farming system relatively high (61%). To benefit from the irrigation scheduling technology, these technologies have to be adapted to the local conditions before finally adopted by farmers. In general farmers found it difficult to implement irrigation scheduling models and some of the sophisticated soil water measurement techniques like the use of neutron probes and capacitance sensors without the support from extensionists and/or irrigation consultants.

The initial capital investment in a new irrigation technology was also perceived to influence the adoption of a technology, especially in the case of resource poor smallholders. Forty nine percent of the respondents perceive the initial fixed costs for the implementation of irrigation scheduling as an important characteristic of irrigation scheduling technology. This initial capital cost for the implementation of irrigation scheduling generates an “option“ for some farmers to delay the implementation of such an investment as in the case of some of the more sophisticated scheduling methods. Farmers therefore have to decide whether the long-term investment will pay off and if the necessary incentives are inevitable to adopt such a technology.

The decision to adopt or reject an innovation is largely determined by a farmer’s self-interest. Profitability of a practice is an important element of self-interest, but self-interest also includes the farmer’s attitude to risk and conservation of the environment, as well as his general perception of success and failure. A practice like the implementation of objective irrigation scheduling was found to vary in terms of its relative profitability and appropriateness depending on the particular farming system (locality, different technical, soil, and climatic endowments and cropping system. Although the profitability of irrigation scheduling technologies were perhaps not rated as high as expected by the farmers (15%), it is known from the literature (Pannell & Glenn, 2000) on adoption studies, that this characteristic is usually a critical factor in farmers’ decision making. The value of on-farm trials and experimentation to obtain information for the reduction in uncertainty about the profitability of irrigation scheduling technology is important.

The perception regarding the technology characteristics of irrigation scheduling technology vary significantly between farmers who apply objective and subjective scheduling methods (χ^2=13.44, df=5, p=0.020; r=0.178, p=0.043). This finding supports Hypothesis 1.2, which states that the perceptions of irrigation farmers with regard to the irrigation scheduling technology attributes influence irrigation farmers' adoption behaviour.

9.5.2 Perception regarding the potential benefits with the implementation of irrigation scheduling

Innovations can either be adopted or rejected, and most often like in the case of the adoption of objective irrigation scheduling techniques, the implementation of this decision requires considerable additional learning before it can be effectively implemented. In this instance we are not dealing with the adoption of one innovation only, but rather a package of innovations offered to the farmer, which includes both technical and socio-organisational elements. The adoption of on-farm irrigation scheduling can only be effective in conjunction with effective management of the irrigation system and proper cultivation practices to name a few.

As farmers interact with technology, so their knowledge increases through experimentation and trialling on the farm. This is likely to affect the overall perceptions of the attractiveness of the innovation and also reduces the uncertainty about its potential benefits. The relative advantages of alternative on-farm irrigation scheduling practices should be observable, to enhance adoption of a new practice. Relative advantage of an innovation means the degree to which a new technology or practice is perceived as better than the one it supersedes (Rogers, 1983).

Farmers rated the perceived relative advantages of using irrigation scheduling methods on a ten-point semantic scale regarding the following production aspects:

- Conservation of water on the farm
- Possible increase of production yields
- Improvement of the quality of the crops (fruit and grain)
- Saving of operational costs of electricity or alternative energy sources

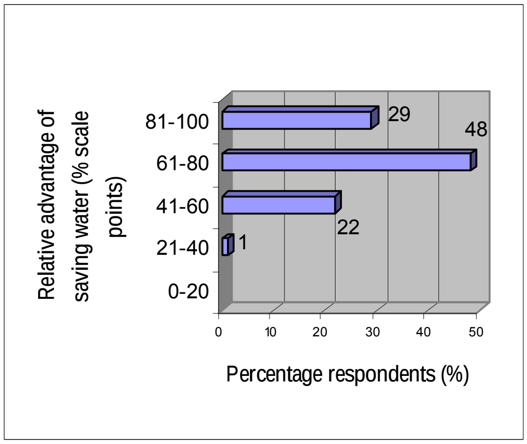
- Optimization of nitrogen use and the prevention of nitrogen leaching
- Maximization of profit on the farm.

In Figure 9.4, the perceived potential benefits with regard to the implementation of on-farm irrigation scheduling are summarized, which indicate significant differences (X^2=15.84,df=7,p=0.027). Although the conservation of on-farm water is perceived as an important production factor to farmers, only 77 percent perceived the relative advantages of the implementation of irrigation scheduling as the saving of water *per se* compared to the 97, 91, 87, 86 and 83 percent perceived improvement of profitability, optimum use of nitrogen, improvement in production yields of crops, saving on electricity costs and improvement of crop quality. This implies that irrigation farmers perceive the investment with regard to more precise on-farm irrigation scheduling primarily in terms of potential improvement of profitability of the farming concern through the improvement of crop yields, improvement of crop quality, optimizing of nitrogen use and the potential saving on electricity operational costs.

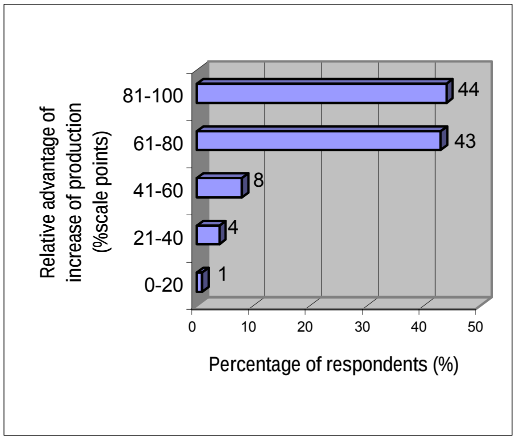
For most of the irrigators in South Africa irrigation water is the major production constraint, and the potential saving of water through on-farm irrigation scheduling entail additional irrigation area that could be irrigated with the potential increase in total net income. Also the practices of double cropping common amongst irrigation crop farmers were perceived as an observable advantage due to the implementation of irrigation scheduling.

The implementation of irrigation scheduling often necessitates small-scale farmers to irrigate bigger volumes of water, more regularly. This practice also implies the use of more resources in terms of labour and time. Therefore the implementation of more precise irrigation scheduling methods are not always perceived to be advantageous to all small-scale farmers, since many of them are often guilty of under-watering their crops.

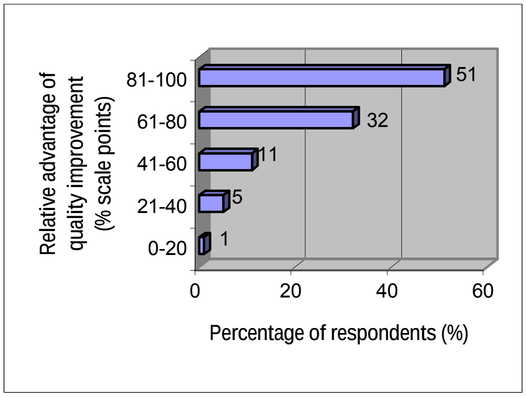
(a) Saving of water on the farm



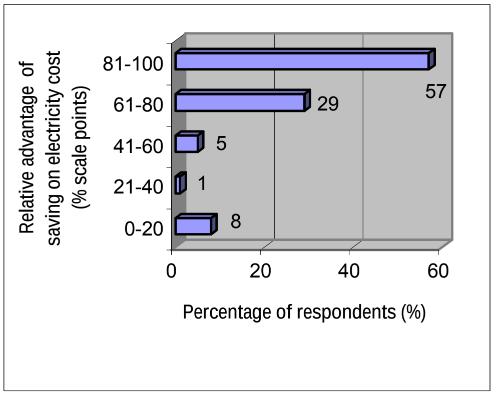
(b) Increasing of production yields



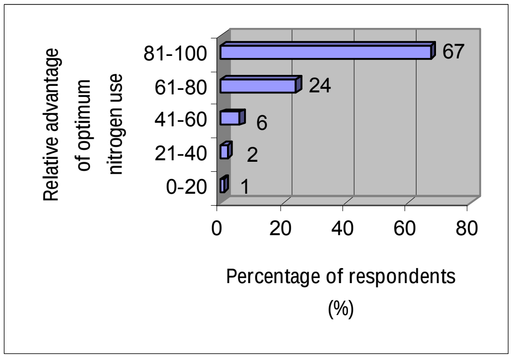
(c) Improving of crop quality



(d) Saving on electricity operational costs



(e) Efficient use of nitrogen



(f) Increase of profitability

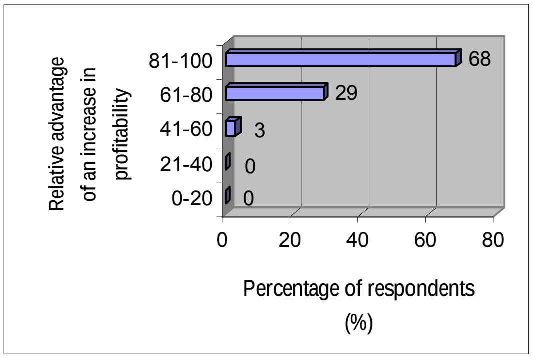


Figure 9. 4: **Percentage distribution of respondents according to their perceived relative advantages with regard to on-farm irrigation scheduling based on a 10-point semantic scale (N=134)**

Eight percent of the respondents indicated the saving of electricity as not important, due to the fact that they either use surface irrigation methods or the fact that they are situated beneath the canal system for the delivering of irrigation water, and are therefore using gravitational irrigation, i.e. van der Kloof irrigation scheme. A significant Spearman relationship (r=0.355; p=0.038) exists between the implementation of on-farm irrigation scheduling and the potential saving of electricity costs, which provides evidence in support of Hypothesis 2, namely that precise irrigation scheduling is perceived to improve production efficiency.

Electricity is usually charged at prices that vary for peak, standard and low demand (Ruraflex) periods. The Ruraflex rates apply during the off-peak hours of the night and over the weekend so that some degree of automated control is usually desirable. In general farmers involved in the growing of crops like wheat, maize, etc are more aware of Ruraflex since electricity operational costs form a significant percentage of the total production costs of these crops.

Irrigation usually removes the primary constraint to productivity, namely water, but nutrition, and specifically nitrogen availability is quickly revealed as the next constraint of fast growing, shallow rooted crops (Stirzaker, 2004). The optimum use of nitrogen, as indicated in Figure 9.4, is a prime motivator for the implementation of objective irrigation scheduling especially among farmers involved in “Open Hydroponic Systems” (OHS) and farmers involved in the growing of high value crops as been indicated by the significant Spearman correlation (r=0. 298, p=0.046).

The questionnaire used in the survey also allowed respondents the opportunity to list and rate additional advantages they perceived with the implementation of on-farm irrigation scheduling. Fourteen percent of the respondents indicated “peace of mind” since they are sure that the correct amount of irrigation water at the right time of the crop growth stage is applied with the practicing of irrigation scheduling.

a) Visibility of the wetting front

In many instances the awareness of a problem can be restricted because the process involved cannot be observed. The wetting front (line which separates wet and dry soil) is usually not observable for many of the irrigation farmers, unless they make use of a soil auger or spade to monitor their irrigation practices. Therefore, many irrigation farmers base their decisions on the observation of certain plant stress indicators or on the measurement of soil water content.

Respondents were asked to rate the importance of the visibility of a wetting front for water management decisions on a ten-point semantic scale. The majority of respondents (98%) perceived the visibility of the wetting front important for irrigation management decisions, and a significant Spearman correlation (r=0.376; p=0.000) supports the relationship between visibility of the wetting front and objective monitoring of soil water content.

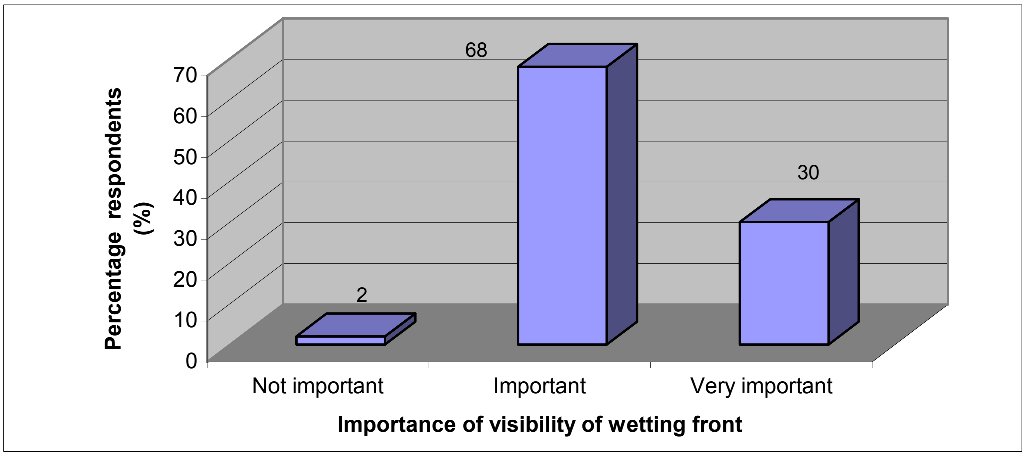


Figure 9. 5: Percentage distributions of respondents regarding their perceived importance of the visibility of the wetting front after irrigation. (N=134)

Farmers traditionally make use of a spade or soil auger to monitor the depth of the wetting front since the last application of irrigation. The finding in Figure 9.5 explains why 11 % of the farmers indicated their return from the implementation of sophisticated scheduling methods to the use of this simple and valuable irrigation scheduling method. The development of an irrigation scheduling device like the wetting front detector by CSIRO, Australia will help farmers to overcome this problem.

b) Perceived improvement regarding production efficiency

A specific innovation like irrigation scheduling is not compatible with the individuals' need, if it is not perceived as need related or a means towards achieving it (Düvel, 1991). Need compatibility is therefore positively associated with adoption behaviour and the corresponding improvement in production efficiency (Hypothesis 1.2). Düvel & Botha (1999) provided evidence of this relationship, namely that non-adoption by farmers is usually related to incompatibility of an innovation.

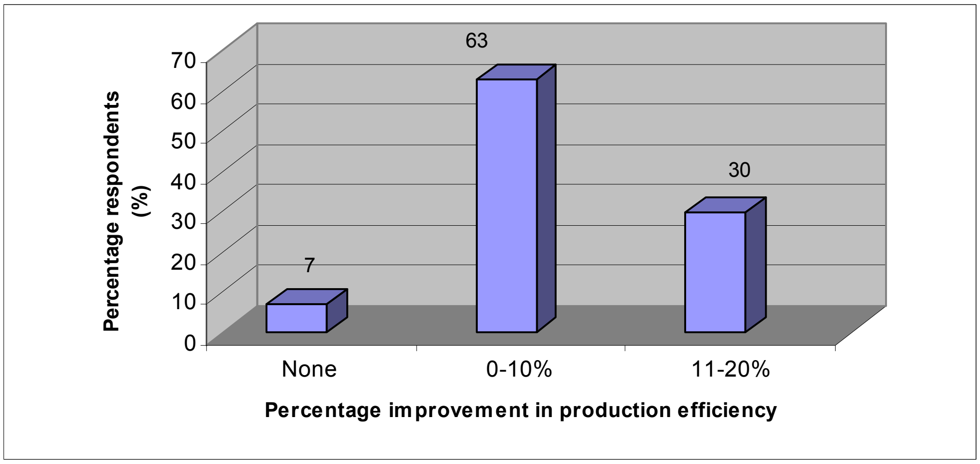


Figure 9. 6: Percentage distribution of respondents according to the perceived improvement in production efficiency since adoption of on-farm irrigation scheduling (N=84)

As far as perceived improvement with regard to production efficiency is concerned, a significant variation exists among the respondents (X^2=8.62; df=2; p=0.013). Sixty three percent of respondents indicated an improvement of production efficiency between 0-10 percent, while 30 percent perceived 11-

20% improvement in efficiency subsequent to the adoption of on-farm irrigation scheduling (Figure 9.6). Respondents, who did not respond to the question, were either too shortly involved with objective irrigation scheduling to have observed any changes or perceived the changes in production efficiency to the introduction of improved irrigation systems (changing from flood irrigation to sprinkler or centre pivot irrigation).

Seven percent of respondents, perceived no change in production efficiency subsequent to their adoption of the objective irrigation scheduling on-farm. These respondents were either newly introduced to objective irrigation scheduling or were farmers involved in the growing of pastures. Farmers involved in the growing of pastures generally make use of a fixed or semi-fixed program, and only a few of them indicated the regular monitoring of soil water to help them with decision-making.

An assessment of the perceived contribution of on-farm irrigation scheduling to production efficiency on the farm was made by requesting respondents to judge the contribution of different aspects of irrigation scheduling, using a ten point semantic scale. The main aspects of production improvement perceived in the production of cash crops (cereals, cotton, sugar cane, etc.) with the implementation of irrigation scheduling are in order of importance as indicated in Table 9.10: an increase in production yield, saving on nitrogen input costs and saving on the electricity operational cost of irrigation.

One of the farmers referred to an average improvement of 1ton/ha in the production of wheat between irrigation fields scheduled *versus* those that were not scheduled. Many of the cash crop farmers involved in the growing of maize and wheat in the Northern Cape indicated savings on the annual irrigation requirements of between 60-70 mm/ha for the growing of maize (average production yield = 12t/ha) and approximately 100 mm for wheat (average production yield = 6t/ha). It was however found that farmers do not schedule all their fields due to relative high consultancy fees perceived, but rather tend to schedule one or two fields that are representative of the rest, and then use these measurements and recommendations for irrigation management decisions.

Table 9. 10: The perceived contribution of aspects of on-farm irrigation scheduling to on-farm production efficiency expressed as mean scale point (*)(N= 134)

Contributors that influence production efficiency	Cash crops (n=92)	Intensive/ high value crops (n=76)	Pastures (n=16)
Saving on irrigation water	6.6	6.5	6.0
Increasing of production yields	8.4	7.6	4.8
Improvement of quality of crops	5.1	7.9	4.4
Saving on electricity operational costs	6.7	7.2	5.7
Increase of profitability	6.8	7.4	4.5
Optimal use of nitrogen	7.0	7.3	5.1

**10 point semantic scale with 1=not important, 10=very important*

Fruit growers and producers of high value/high input crops perceived mainly the improvement of quality and shelve life of the crop, increasing of production yields and improvement of efficiency of the management of nutrients in the orchards as main contributors to production efficiency subsequent to the introduction of on-farm irrigation scheduling (Table 9.10). Opinion leaders and advisors in the fruit industry referred to the ineffective water management practices of some of the fruit growers especially during spring when the majority of growers are either under or over irrigating. "*The most common mistake made by many fruit growers is the tendency to over estimate spring water use by the crop and apply too much water. Spring is a difficult time of the year to make irrigation management decisions as it is complicated by varying weather conditions, relative low vine and fruit water use and together with differences in soil types between the different production fields, impacts on the soil readily available water (RAW). This usually leads to a position where a farmer "runs out of irrigation water" (exhausting water allocation).*

Careful spring irrigation management is critical for the successful production of fruit and grapes (wine and table)" (Stander, 2004).

Farmers growing pastures perceived the saving of water, saving on electrical operational costs and efficient use of fertilisers as the major contributors to production efficiency subsequent to the implementation of irrigation scheduling (Table 9.10).

Irrigation farmers and managers enter a learning cycle as soon as they adopt the application of objective irrigation scheduling. For many farmers the learning curve is perhaps too steep, and they cannot learn and apply what is expected from the recommended irrigation scheduling approach, while others quickly benefit from the new approach and adapt their management system accordingly. One such farmer is a citrus/table grape grower in the Western Cape, who made use of tensiometers installed on three different depths in the orchard. This farmer perceived an increase in average production of approximately 10% and an improvement of quality of fruit between 10-15% since irrigation scheduling 8 years ago. This is one of the exceptional cases where an irrigator was found to be very positive about the use of tensiometers and was still willing to use them for his daily irrigation management decisions.

c) Interrelationship between perceived improvement of production efficiency and on-farm irrigation method

Irrigation scheduling forms part of a package of innovations that a farmer must adopt, and the selection of appropriate irrigation systems is but one of these innovations that determine the success of the implementation of on-farm irrigation scheduling. The relationship between the perceived improvement of production efficiency and the on-farm irrigation method used was tested and is indicated in Figure 9.7.

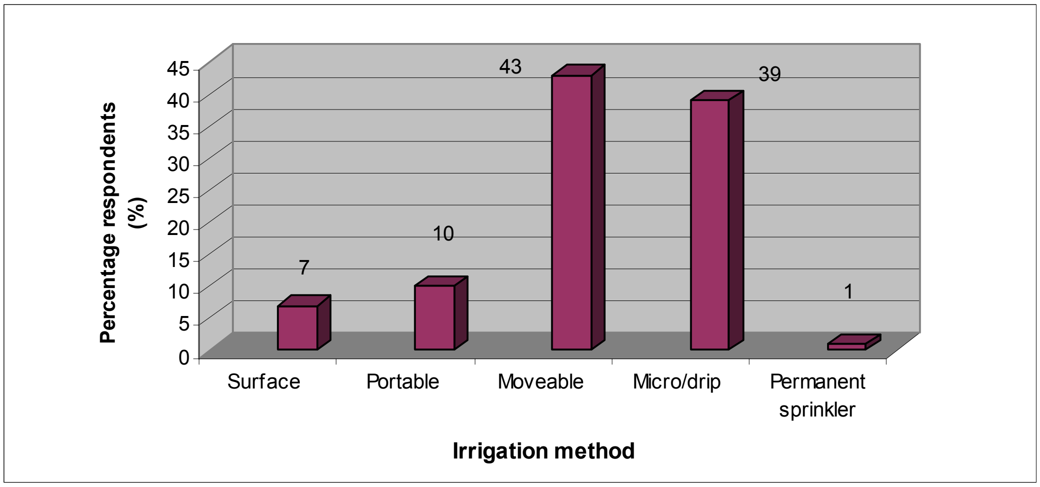


Figure 9. 7: **Percentage distribution of respondents according to their perceived improvement of production efficiency and irrigation methods used on the farm (N=84)**

It is clear from the findings in Figure 9.7, that it was mainly respondents irrigating with moveable irrigation systems like centre pivots (43%) and micro or drip irrigation systems (39%) that perceived improvements in production efficiency since the introduction of objective irrigation scheduling on the farm. These irrigation systems belong to the group called short cycle irrigation systems, which have greatly simplified irrigation management. The relationship between perceived improvement of production efficiency and the on-farm irrigation method is shown (Table 9.11).

Table 9. 11: **Relationship between perceived improvement of production efficiency and on-farm irrigation method as reflected in a test of association (N=134)**

Irrigation method	**Association**				
	χ^2	**df**	**p**	**r**	**P**
Furrow/flood irrigation system	5.1	3	0.433	0.319	0.339
Portable irrigation system	6.2	3	0.188	0.512	0.089
Moveable irrigation system	4.6	3	0.036	0.186	0.046
Micro /drip irrigation system	6.4	3	0.072	0.264	0.017
Permanent irrigation system	Not calculated			Not calculated	

Table 9.11 shows that significant relationships exist between the perceived improvement of production efficiency subsequent to the implementation of on-farm irrigation scheduling and the use of moveable irrigation systems for example centre pivots (r=0.186, p=0.046) as well as the use of micro/drip irrigation systems (r=0.264, p=0.017). These associations provide evidence in support of Hypothesis 1.1, which states that environmental factors like the type of on-farm irrigation method selected by the farmer influence the adoption behaviour of the farmer with regard to on-farm irrigation scheduling.

d) Farmers' awareness of in-field application efficiency

Part of the innovation package implies the application of water in the most efficient way possible to prevent unnecessary losses and water wastage. In order to achieve this, the uniformity with which irrigation systems apply water will have to be high and the distribution uniform (Reinders, 2003). Poor maintenance of irrigation systems in general will increase the operational costs of irrigation and also influence the efficiency of irrigation efficiency.

Often a farmer is unaware of the performance capability of the irrigation system on the farm. This can induce severe variance between the amount needed to apply as determined with the help of objective irrigation scheduling methods (soil water measurement) and the actual amount of water applied. Farmers' perception in regard to awareness and inclusion of regular monitoring and evaluation of irrigation distribution uniformity and the application rate on pressurized irrigation systems are shown in Table. 9.12.

Thirty eight percent of the respondents indicated that distribution uniformity is evaluated only once a season, while 20 % of respondents, mainly those farmers using objective scheduling methods, indicated more regular frequency of evaluation (Table 9.12). Eighteen percent of the respondents reported no evaluation of distribution uniformity, of which 78 percent respondents make use of subjective scheduling methods. It was obvious that although farmers in general were aware of the need for regular evaluation and maintenance of their irrigation systems, many failed to implement it.

Table 9. 12: Percentage distribution of respondents according to their frequency of testing for distribution uniformity (N=122)

Intervals between measuring distribution uniformity (C_u)	Objective scheduling		Subjective scheduling		Total number respondents	
	(n)	%	(n)	%	(N)	%
More frequently than once per season	16	21	8	17	24	20
Once per season	30	49	16	35	46	38
Once per 3 years	7	9	5	11	12	9
Once per 5 years	15	20	3	7	18	15
Not at all	8	11	14	30	22	18
Total	**76**	**100**	**46**	**100**	**122**	**100**

This was confirmed by a specific respondent who had two centre pivots on the farm operating for the last 13 years without the replacement of the sprinkler packages. This farmer also admitted that he had never evaluated the application rate or distribution uniformity of the irrigation systems although he was aware of the importance and advantages thereof. A positive association exists between the implementation of objective irrigation scheduling methods and the implementation of regular irrigation uniformity and application monitoring (χ^2=12.6, df=5, p=0.027; r=0.136, p=0.022), which implies that farmers who make use of this scheduling method tend to be more aware of regular maintenance of their irrigation systems.

Reinders (2003) is of the opinion that regular monitoring of the functioning of sprinklers, and the wear and tear on nozzles, which irrigation farmers often neglect, is one of the most important irrigation management practices. Effective farm irrigation management requires that an irrigation system is capable of applying water in sufficient quantities and with high uniformity and minimum wastage to meet the crop's water requirements. Irrigation systems are more expensive if they are designed to provide a high degree of uniformity. Thus, there is a tendency to sacrifice uniformity when systems are purchased on the basis of competitive bids. The irrigation farmer should recognize that operational costs and possible yield losses would be higher when a system does not apply water uniformly. A lower initial cost system, which sacrifices uniformity of water application, may be false economy according to Reinders (2003).

e) Locality differentials in relative advantage

It is often assumed that the perception of the relative advantage of an agricultural practice like irrigation scheduling, whether positive or negative, is of the same order or magnitude amongst all clients irrespective of locality or community. This is unlikely to be the case and was tested by asking farmers from different localities to indicate the perceived improvement in production efficiency since their adoption of objective irrigation scheduling practices.

Figure 9.8 reveals how farmers from the various provinces and localities differ in their respective perceptions regarding the relative improvement of production efficiency subsequent to the implementation of objective irrigation scheduling on farm. Significant differences exist between irrigators in the different provinces regarding the perceived improvement of production efficiency subsequent to the implementation of objective irrigation scheduling on the farm (χ^2=21.71, df=7, p=0.020). Seven percent of respondents in the Western Cape (mainly fruit and wine grape growers) and six percent of the respondents involved in the production of mainly maize and wheat in the Free State as illustrated in Figure 9.8 perceived substantial improvement in production efficiency (between 11-20%) subsequent to the introduction of objective irrigation scheduling. Thirteen percent respondents from the Eastern Cape and 12 percent respondents from the Northern Cape perceived less than 10% increase in production efficiency subsequent to the introduction of irrigation scheduling. A possible explanation for this finding is that precursor problems like water availability and limitations to the on-farm irrigation methods used by farmers must be dealt with first, before irrigation scheduling could show improvement in production efficiency.

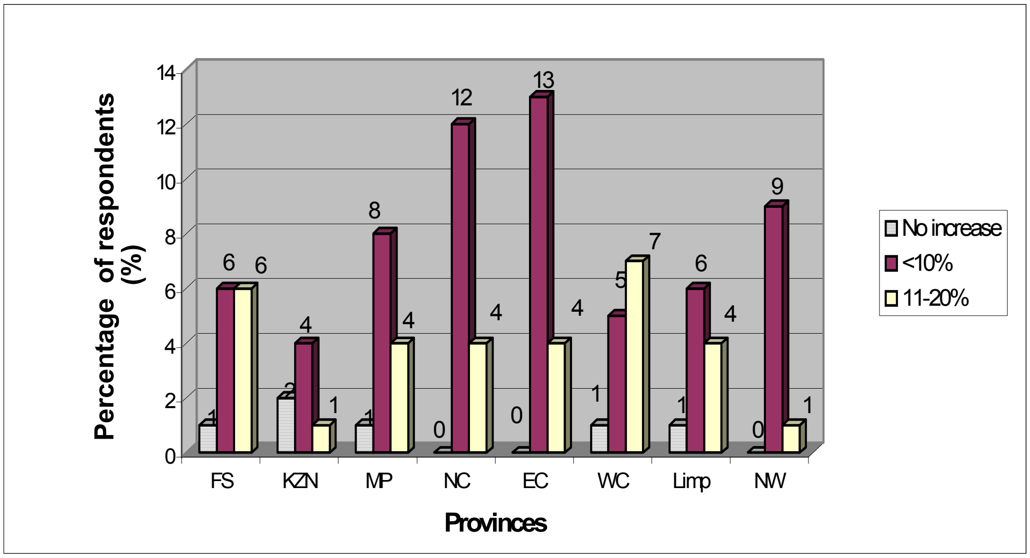


Figure 9. 8 Percentage distribution of respondents from provinces according to their perceived increase in production efficiency due to the implementation of irrigation scheduling (N=84)

9.5.3 Perception regarding the complexity of irrigation scheduling practices

The motivation of a farmer to solve a specific problem or to change current irrigation scheduling practices is affected by the confidence a person has in his own capacity with regard to problem-solving and his perceived self-efficacy (Leeuwis, 2004). Sometimes recommended agricultural practices which appear simple may in fact imply significant and complex changes to the farm production system. How difficult is the new technology to understand and apply? How much additional learning is required? Complexity is clearly related to the level of learning required, and the more difficult it is to understand or to implement the technology, the slower the adoption process is likely to be. Complexity increases the risk of failure and it introduces increased costs in gaining knowledge (Vanclay, 2003).

a) Scale of difficulty

Respondents were asked to indicate the relative easiness of the application of irrigation scheduling on a ten-point scale. The response to this question is illustrated in Table 9.13.

Table 9. 13: The perceptions of respondents related to the easiness of the implementation of irrigation scheduling (N=134)

Perception of the relative scale of easiness of implementation of irrigation scheduling	**Number of respondents**				**Total number of respondents**	
	Objective scheduling		**Subjective scheduling**			
	n	**%**	**n**	**%**	**N**	**%**
Very easy	9	12	5	9	14	10
Easy	53	70	27	46	80	60
Difficult	14	18	22	38	36	27
No response			4	7	4	3
Total	**76**	**100**	**58**	**100**	**134**	**100**

Table 9.13 reveals that the majority of farmers (70%) perceived irrigation scheduling as relatively easy to implement, while 27% perceived it to be difficult to implement. The perceived scale of easiness of implementation of on-farm irrigation scheduling differs between the objective and subjective scheduling groups (X^2=49.06, df=5, p=0.000). Eighty two percent of the objective scheduling group perceives the implementation of on-farm irrigation scheduling to be easy to implement while only 55 percent of the subjective scheduling group share the same opinion.

Although the X^{2-}tests reflect highly significant differences between the scheduling groups, no statistical significant relationship exists between perceived easiness and the implementation of soil water monitoring on the farm (r=0.046, p=0.092). However, a significant negative relationship (r=-0.248; p=0.004) exists between the perceived easiness of implementing irrigation scheduling and the use of scheduling models on the farm, which implies that irrigation farmers without the support of competent professionals cannot apply irrigation scheduling models.

b) Knowledge level needed for the implementation of irrigation scheduling

Knowledge can be seen as the basic means through which we understand and give meaning to the world around us. According to Leeuwis (2004), concepts like “perception”, “interpretation” and “understanding” all refer to the outcome or applying of knowledge. It is generally accepted that farmers or irrigation managers responsible for irrigation scheduling should at least have a workable knowledge of the following aspects: plant-soil-atmosphere continuum, operation and capacity of the irrigation system and essential managerial skills necessary for the implementation of appropriate irrigation management practices. The perception of respondents regarding the minimum required knowledge level for the efficient implementation of irrigation scheduling was tested across the two categories, objective and subjective irrigation scheduling. Four different knowledge levels were identified as items of a knowledge scale:

- **Knowledge level 1:** no special knowledge required for application of irrigation scheduling (“common sense”)
- **Knowledge level 2:** where one of the four elements (soil, plant, water and management) for an effective knowledge basis was mentioned
- **Knowledge level 3:** where at least three of the four elements of an effective knowledge basis were mentioned
- **Knowledge level 4**: where all four elements of an appropriate knowledge level were mentioned

Table 9. 14: **Percentage distribution of respondents' perception regarding the required level of knowledge needed for effective on-farm irrigation scheduling (N=134)**

Knowledge level of irrigation scheduling	Number of respondents				Totalnumber of respondents (N=134)	
	Objective scheduling (n=76)		Subjective scheduling (n=58)			
	n	%	n	%	N	%
Knowledge level 1	6	8	9	16	15	11
Knowledge level 2	34	45	33	57	67	50
Knowledge level 3	26	34	16	27	42	31
Knowledge level 4	10	13	0	0	10	8
Total	**76**	**100**	**58**	**100**	**134**	**100**

The findings reflected in Table 9.14 reveal that different groups of farmers perceived different prerequisite levels of knowledge to be successful in the implementation of irrigation scheduling (X^2=148.1, df=8, p=0.000). As far as the minimum expected knowledge level for the efficient implementation of irrigation scheduling is concerned (Table 9.14), 73 percent of farmers from the subjective scheduling group perceive either no special knowledge or limited knowledge is required. In comparison, 47 percent of the farmers involved in objective irrigation scheduling perceive a more specialized knowledge level required for the successful implementation of irrigation scheduling.

This positive association between the implementation of objective scheduling and the perceived required knowledge level for implementation is supported with a significant correlation (r=0.223, p=0.011). These findings illustrate that different irrigation scheduling groups have different "theories of knowing" or epistemic cultures (Knorr-Cetina, 1981), which provides evidence in support of Hypothesis 3, namely that these different epistemic cultures of farmers determine farmers approaches to problem solving, and therefore the on-farm irrigation scheduling.

9.5.4 Perception regarding the compatibility of irrigation scheduling practices

Another critical aspect of the farmers' perception is whether the innovation is perceived to be compatible with the farmer's personal objectives? This refers to the extent to which a new practice fits in with the existing knowledge and social practice. If a new idea fits in easily into an existing system it will be adopted more quickly.

There are usually two systems according to Vanclay (2003) against which the farmer judges the compatibility of irrigation scheduling: the current system of farming (biophysical) and the social system embracing the farming community or broader cultural beliefs and values. An apparent example of objective irrigation scheduling practices not compatible was observed amongst farmers in the Upper Orange water management area who have fixed water turns that occur according to a predetermined timetable of water distribution in the canal. Respondents were asked to indicate some of the problems (barriers) that they experience with the implementation of on-farm irrigation scheduling methods in an attempt to determine the perceived compatibility of the selected irrigation scheduling practice (Table 9.15).

Table 9.15 shows that 57 percent respondents indicated that they were satisfied with the current irrigation scheduling methods and tools implemented on the farm and that it was compatible with the current farming system. Significant differences exist with regard to the perceived problems experience with the implementation of on-farm irrigation scheduling between irrigation farmers from the objective and subjective scheduling groups (χ^2=8.62, df=2, p=0.013). Eighty four percent farmers from the subjective scheduling group perceived no problems with the implementation of on-farm irrigation scheduling practices, while only 35 percent of the objective scheduling group indicated their satisfaction with implementation of on-farm irrigation scheduling.

Table 9. 15: Percentage distribution of respondents according to the perceived problems experienced with the use of on-farm irrigation scheduling methods (N=134)

Perceived problems with implementation of irrigation scheduling	Objective scheduling (n=76)		Subjective scheduling (n=58)		Number of respondents	
	(n)	%	(n)	%	(N)	%
No problems experience with implementation	27	35	49	84	76	57
Uncertain about the accuracy of measurement	30	39	8	14	38	28
Not easy to understand and apply on the farm	15	20	6	10	21	16
Variability in climate and soil types on the farm complicate the efficient use and interpretation of data	8	11	4	7	12	9
Very expensive	6	8	2	3	8	6
Uncertainty - novelist to irrigation scheduling	2	3	0	0	2	2
Not enough time available	3	4	0	0	3	2
Lack of flexibility (irrigation system, management)	2	3	0	0	2	2
No support or help available from irrigation consultants	1	1	0	0	1	1
New extensionist (personality, communication skills)	1	1	0	0	1	1
Health risk (i.e. neutron probe)	1	1	0	0	1	1

An important finding is the fact that 39 percent of farmers using objective scheduling techniques are uncertain about the accuracy of measurement. These farmers often use an objective scheduling method as second opinion, to confirm their intuitive decisions. This was a most common perception amongst farmers who made use of irrigation consultants who were still new to a specific irrigation area and where credibility was still lacking. Many of this latter group of farmers therefore implement “insurance irrigation” by applying a little more irrigation water than was recommended by consultants, to avoid any risk be taken.

9.6 ADOPTION AND/OR DISCONTINUANCE OF ON-FARM IRRIGATION SCHEDULING

Farmer's decision to adopt new agricultural technology depends on complex factors after analyzing and trialling and is indeed a social process. Adoption according to Vanclay (2003) is not only including irrational responses to new information but also a deliberate decision by an individual farmer in response to a wide range of issues.

9.6.1 Perceived usefulness of irrigation scheduling models

Irrigation scheduling models can either be used for tactical or strategic purposes. In the first instance, the question is: how large an area to irrigate, which crop to plant, and how to distribute the available water supply over or during the season (Huygen *et al.,* 1995)? For the majority of crop farmers this is a major problem they are encountering, and real time scheduling is found to be even more important where farmers are scheduling high valued crops like table grapes, deciduous fruit, subtropical fruit and cut flowers. Hubona & Gertz (1997) indicated that farmers adopt irrigation scheduling models for tactical decisions, if enough compatibility exists between technology characteristics, perceived task to be completed and individual needs.

Twenty six percent of the commercial farmers that implement objective scheduling on the farm indicated the use of irrigation scheduling models either for trial basis or for full implementation (Table 9.16). Although all the farmers interviewed have access to a computer, farmers are more likely to routinely use simple monitoring techniques like the soil auger or shovel to determine the soil water content. Farmers, however, indicated that they have difficulty in using models for real time decision-making, and therefore the majority of them need professional support to be able to apply models at a farm-level (Chapter 4). Farmers in general clearly indicated that the use of irrigation scheduling models are dependent upon capable and willing irrigation consultants and extensionists to help and support the farmer with the use of the model and computer program as well as with the interpretation of the data to be used for irrigation management decisions. Some models were perceived by some respondents to be easier to understand and to apply than others.

Table 9. 16: Percentage distribution of respondents' use of computer models and programs for on-farm irrigation scheduling (N = 20)

Use of computer irrigation scheduling models	**Objective scheduling (n=76)**	
	n	**%**
Use computer model as part of on-farm objective scheduling	20	26
Computer models not used on-farm	56	74
Total	**76**	**100**

Significant differences in the general awareness about irrigation scheduling models available for irrigation scheduling exist between farmers involved with objective irrigation scheduling and those involved in subjective irrigation scheduling (X^2=6.92,df=1,p=0.008). Twenty nine percent of the respondents using objective irrigation scheduling are aware of the relevant models for irrigation scheduling, while only five percent of the farmers involved in subjective scheduling could mention any model or computer program available for irrigation scheduling. The irrigation farmers involved with the production of high value crops are in general more positive about the use of irrigation scheduling models than irrigation farmers involved in cash crop production (X^2=58.19,df=8, p=0.049). These findings provide evidence in support of Hypothesis 3, namely that the business characteristic as well as the technology level of the farmer determines the approach to on-farm irrigation scheduling.

a) *Need tension with regard to the use of computer models and programs for use in irrigation scheduling*

Figure 9.9 illustrates that farmers perceived the effectiveness and accuracy of irrigation scheduling models relatively low as an irrigation scheduling aid. Sixty two percent respondents rated the effectiveness of scheduling models as decision support systems for on-farm irrigation management below 40 %, with only 25% of the respondents perceiving it to be effective (>60%). These differences are highly significant (X^2=21.99, df=8, p=0.005).

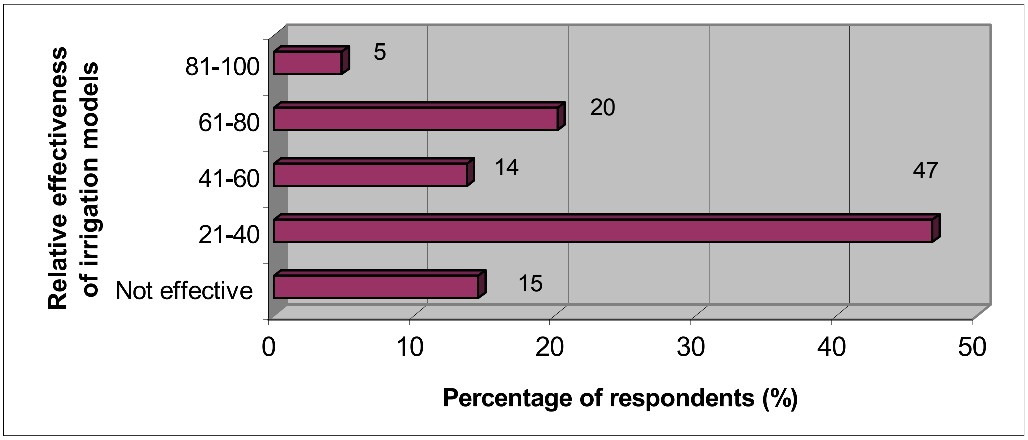


Figure 9. 9: Percentage distribution of respondents according to their perceived effectiveness of irrigation scheduling models (N = 76)

Fifteen percent of the respondents condemn the use of models and computer program as being inappropriate for implementation on the farm. This group of respondents is of the opinion that models and computer programs can only provide generic guidelines to the potential user and are not flexible to suit actual farm contextual factors. They are of the opinion that models and programs are generally not adapted and flexible enough for specific situations and conditions on the farm and need to be more flexible to fit the specific farming system, and management capacity of the farmer. This group of respondents is of the opinion that models often include various assumptions (e.g. about the biophysical processes and the interrelations) that may be valid for the locality of those that developed the model, but which are not always accurate in other contexts. These respondents also indicated that they be short of the necessary trust and confidence in irrigation consultants and extensionists for their interpretation of the data for making daily irrigation management decisions.

b) Reasons for general lack of aspiration to use computer models and programs

Farmers who are not using irrigation models provided the following reasons why they lacked any aspiration or need to introduce irrigation models on the farm. Table 9.17 reflects some of the perceptions of the respondents in this regard.

Table 9. 17: Percentage distribution of respondents according to their perceived reasons for the lack of aspiration to use computer models for on-farm irrigation scheduling (N=99)

Reason for the lack of aspiration to use models for irrigation scheduling	% Respondents
Too difficult for the farmer to use	37
Not practical enough for application on farm-level	35
Lack the necessary computer skills	25
Not aware of appropriate models	12
Time consuming	10
Not enough professional support available to help with the implementation on the farm	7
No need – satisfied with current information sources	6
Unit of farming too small to implement models	3
Too expensive	3
Lack of flexibility (irrigation system)	2

It is apparent from Table 9.17 that respondents who have no aspiration to use irrigation scheduling models, either perceive them as being too difficult (complex) to use and to implement on the farm (37%) or perceive the models as a “black box” and not useful for implementation because of the problems experienced with the interfacing with the on-farm situation and the terminology used in the models and scheduling programs (35%). The need was expressed to incorporate more farmer-friendly language in the programs. Some of the measurements used in irrigation scheduling programs are often not familiar to farmers like “litres per second” rather than m^3/ha. The interpretation of the inputs and outputs of the model or programme used, often cause problems to some farmers and therefore make it difficult for them to understand the concepts used in the program and to learn from them. The use of visual imagery and interpretation of the output of many of the programs help users to better understand some of the recommendations made for a specific field situation. These farmers commented that many of the irrigation software packages offered could not be incorporated into other farm management computer software packages and therefore are limited in their use and purpose.

Twenty five percent of the respondents indicated their general lack of the necessary computer skills to apply the recommended models. Many of the latter group of respondents belong to the age group of fifty one and older and a significant negative relationship exists between the age of farmers and the perceived effectiveness of computer models on-farm with regard to irrigation management (X^2=9.69, df=5, p=0.076; r= -0.243; p=0.005). Also included in this group of farmers are those who favour working outside and this group in general perceives office work and the use of computers as not “real farm work”. Perhaps this perceived split between “inside” and “outside” work explains why some farmers are willing to integrate computers in their daily farm management and why others only use computers for daily bookkeeping.

Twelve percent of the respondents were unaware of appropriate computer programs and models available for use in irrigation scheduling. This finding emphasizes the need for improved information channels of communication to effectively disseminate information regarding irrigation management. The majority of commercial irrigation farmers rely on extensionists from agricultural cooperatives (or private companies currently), fellow farmers, private consultants and sales representatives from irrigation companies to inform them on new irrigation technologies (Part Five). These service providers play an important role in the deployment of research findings, especially in the case of irrigation scheduling practices and tools.

9.6.2 Reasons for changing irrigation scheduling practices

Farmers' perception with regard to the importance of the implementation of objective scheduling on the farm and their need tension change as farmers go through the learning process of evaluation, trialling and appraising whether a specific irrigation scheduling method is suitable for the specific farming system and whether it would help them to reach their personal goals.

Fifty nine percent of the respondents indicate that their perceptions had changed since they started with irrigation scheduling. The majority (71%) of farmers, who changed their irrigation scheduling methods subsequent to the introduction of it, belong to the group using objective irrigation scheduling. Figure 9.10 shows the time lapse since respondents started to implement irrigation scheduling practices and a significant change in implementation of objective and subjective irrigation scheduling approaches over different periods of time happened (X^2=8.07, df=1, p=0.004).

A clear tendency exists with farmers who usually start with the use of more objective scheduling methods but gradually change to rely more on the use of intuition than on objective scheduling as more first–hand experience, confidence and experiential knowledge is gained. Relatively more experienced farmers often use objective scheduling methods only to monitor their current irrigation management practices and to confirm that current irrigation practices and decisions are satisfactory in terms of what the crop water requirements demand.

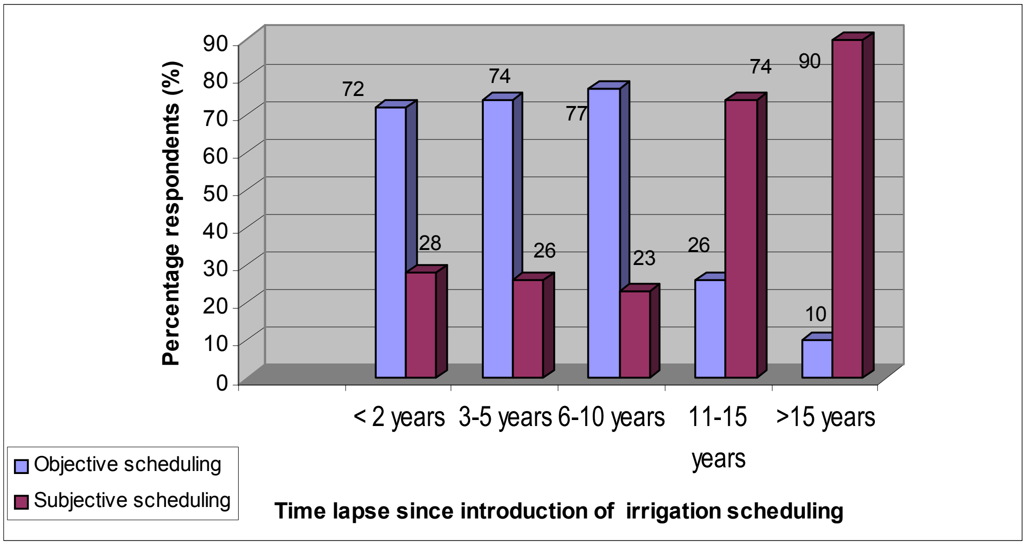


Figure 9. 10: Percentage distribution of respondents according to the time lapse since the inception of irrigation scheduling (N=90)

Consultants also reported that farmers often are more prepared to make use of scheduling consultancy services due to the uncertainty and risk that prevail during the start of a drought or when climatic conditions are subnormal. Many farmers interviewed are of the opinion that the service of consultants and use of objective irrigation scheduling is of utmost importance especially for a new farmer in irrigation or where enterprises changed from rain fed to irrigation. The tendency reflected in Figure 9.10 is that the respondents perceived approximately ten years to be a definite turning point from the use of predominantly objective scheduling methods to a situation where irrigators will rely more on the use of subjective irrigation scheduling. This is a general tendency that will differ from one situation to another and from person-to-person depending on the learning curve a farmer is willing and able to follow.

Respondents were asked to indicate reasons for changing irrigation scheduling methods, either from a subjective approach to a more objective approach, or *vice versa.* The findings are illustrated in Table 9.18.

Table 9. 18: Percentage distribution of respondents' perceived reasons for the need to change irrigation scheduling practices (N=134)

Reasons perceived for changing irrigation scheduling	Objective scheduling	Subjective scheduling	Total number of respondents	
	(n)	(n)	(N)	%
Measurement and/or predictions not accurate (tensiometers and certain computer irrigation models)	54	12	66	49
Too much irrigation recommended with some computer programs and specific situations and daily atmospheric fluctuations not taken into account	44	10	44	33
Time consuming	21	9	30	22
Capital and operational cost of irrigation scheduling too high	18	7	25	19
Irrigation scheduling method too complicated	15	5	20	15
No perceived advantages from practicing irrigation scheduling	11	4	15	11
Gained enough experience and knowledge	6	9	15	11
Size of property increased and necessitated change	0	5	5	4
Lost interest in specific method and returned to "traditional method"	0	4	4	3
Change of on-farm irrigation method	2	1	3	2
Health risk associated with specific method (neutron probe)	1	1	1	1

According to Table 9.18 significant differences occur between farmers that make use of objective versus subjective scheduling irrigation scheduling methods with regard to the perceive reasons for changing from on-farm irrigation scheduling methods (X^2=18.08, df=8, p=0.021). The majority of respondents (49%) changed practices because of the change in perception with regard to the accuracy of irrigation scheduling. Eighty percent of this group respondent makes use of objective irrigation scheduling and referred to their rather disappointing experiences with the use of tensiometers in the past. Apart from being site specific it was clear that many farmers struggled to learn enough to gain confidence in the use of tensiometers for making daily irrigation management decisions.

Thirty three percent of the respondents perceive some computer models and programs to have “misled” farmers in the past with recommendations not adapted to a specific farming system and for a specific area. The perception among these respondents is that some models underestimate evaporation grossly for warmer areas and crops like certain fruit tree cultivars that have higher water requirements than predicted by the model. Respondents also referred to recommendations with regard to irrigation that were made without taking into account a specific irrigation systems’ capacity as well as the management capacity of farmers. These changes in perception as experienced by farmers through experience and on-farm trialling, is showing significant variation.

Twenty two percent of the respondents also emphasized that sophisticated irrigation scheduling practices were very time consuming, while 19 percent indicated that the cost effectiveness of objective scheduling was perceived to be low. If farmers are unable to perceive any observable relative advantages (as been reflected in Figure 9.4) for their effort put into this exercise, they are likely to opt for an alternative that is more compatible with their personal needs. These findings confirm the conclusions reached by Kaine *et al.*, (2005) and Lineham, Kristic & Kaine*.* (2005), who showed that farmers are more interested in saving time and increase flexibility than saving water on the farm.

9.6.3 Reasons for discontinuing objective irrigation scheduling methods

Discontinuance is a decision to reject irrigation scheduling after having previously adopted it. Two types of discontinuance of irrigation scheduling were observed:

- The first type is where an irrigation scheduling method was rejected in order to adopt another method that supersedes the previous one.

- The second type of discontinuance is the decision to reject irrigation scheduling as a result of dissatisfaction with its performance (inappropriateness or the farmer did not perceive any relative advantages attached to the specific scheduling method).

Twelve percent of the respondents indicated their discontinuance of objective irrigation scheduling because of the reasons indicated in Table 9.19.

Table 9.19: Reasons given by respondents for their discontinuance of objective irrigation scheduling (N=16)

Reason for discontinuing of irrigation scheduling	% Respondents
Gained enough experience, confidence and experiential knowledge regarding irrigation scheduling	69
Not practical enough for implementation on farm	63
Time consuming	50
No relative advantages perceived	44
Too expensive to continue	31
Too difficult to apply	25
Need professional support to be able to implement on the farm- not available	19
Not accurate enough and too fragile device for practical implementation	13
Discontinued when consultancy came to a halt	12
ET ref figures available from WUA	6

Table 9.19 shows the perceived usefulness of the implementation of objective scheduling on the farm by farmers changed significantly over time (χ^2=66.39, df=48, p=0.040). Sixty nine percent of the respondents indicated that they had gained enough knowledge, confidence and first hand experience after a certain period of time lapse, to be able to continue without objective scheduling.

Fifty percent of the farmers indicated that irrigation scheduling is time consuming, and scheduling is low in priority compared with other activities like markets, pests and diseases and varieties, etc as indicated in Section 9.4.

Sixty three percent respondents indicated that they found the practical implementation of objective irrigation scheduling troublesome. It appears that the scientific and extension communities have not been able to demonstrate how the irrigation scheduling technology can be effectively implemented.

Thirty one percent of respondents stopped the irrigation scheduling practices because the irrigation consultancy service was perceived to be too expensive. Six percent of the respondents indicated that they discontinued the use of objective irrigation scheduling since the local WUA started with the regular provision of ET ref figures to its clients. These figures are usually incorporated in the semi-fixed programs and irrigation calendars which farmers are following.

Private consultants and extensionists are in general expected to simplify and “translate” research information and to offer of the information in an effective and understandable way to the farmers. Nineteen percent of the respondents claimed that appropriate consultancy are lacking is some areas. Furthermore some advisors often lack the necessary capabilities (technical knowledge and communication skills) and were unable to help farmers to interpret and adapt data for the use in daily irrigation decisions.

9.7 SUMMARY

Irrigation farmers and farmers in general have traditionally been able to achieve productivity gains through the adoption of new technical products and processes. Increases in efficiency must however be pursued on a much wider front if productivity growth and sound water management are to be achieved. The farming environment has become more complex. In addition to the adoption of new irrigation technologies, irrigation farmers must also pay attention to investment in human skills, the uptake, analysis, and use of information, the management of risk, the production, quality and marketing of their products, the financial and personal management skills of their staff, and the institutional organization and structuring of their industry. This involves complicated social, institutional and economic decisions and requires a mind shift in the case of some farmers, but more importantly they must be prepared to engage in continuous, lifelong learning. This will also require a new willingness from support workers and organizations to enter into a cooperative dialogue and networking with the farmers and groups of common interest.

The findings indicated that farmers not merely perceive the implementation of irrigation scheduling as a technical issue, but also it must make sense within the social, economic and wider structural constraints of the society (institutions):

- Farmer-related factors include beliefs and opinions of the irrigation scheduling practice, perception of relevance, motivation and attitude to risk. It was evident that farmers with relatively more experience are more willing to rely on their own first-hand experience, knowledge, observations and intuition than on using objective scheduling methods. A minority of irrigation farmers were found that really understand and schedule according to the strict definition as been developed by science.

- The majority of respondents (60%) perceived the efficient use of irrigation water on the farm and not water saving *per se*, as the main reason for the implementation of irrigation scheduling. The improvement of the quality of the crop, saving on electricity costs and the effective management of nutrients were perceived as being important motivational “drivers” for the implementation of objective irrigation scheduling.

- Accuracy, reliability, easiness of implementation, affordability and initial capital costs involved, are some of the important technology characteristics of scheduling methods and devices which were identified to influence the adoption of a specific irrigation scheduling method. The characteristics were analyzed with respect to relative risk, investment, complexity and profitability of the new technology compared to the traditional methods used on the farm.

- Cash crop growers and producers of high value crops have differential perceptions with regard to the substantial improvement of production efficiency since the introduction of objective irrigation scheduling practices.

- Irrigation farmers usually start off by using proportionately more objective scheduling methods in an approach to gain experience and knowledge regarding irrigation scheduling. However, as farmers gradually gain more confidence, experience and knowledge in the application of irrigation scheduling they are prepared to make more use of intuition. Many of the experienced farmers reveal that they often used objective scheduling methods only to monitor their present irrigation practices and if necessary to do the required attuning to the scheduling program.

- Significant differences exist in the general awareness about computer models between farmers belonging to the objective irrigation-scheduling group and farmers from the subjective irrigation scheduling group. Some of the models that exist for implementation of irrigation scheduling were perceived by some respondents to be easier to apply than others. The majority of computer models and programmes available to irrigators, however, reflect implicitly the modes, reasoning, concerns and context of those that developed them (usually scientists) and are perceived to fail to anticipate the diverse logic and local context of irrigation farmers. The important role of competent professional advisors to support and guide irrigation farmers with the implementation of scheduling models was emphasized, since it cannot function in a *stand-alone mode*.