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174

Smallholder Irrigation Schemes in the Limpopo Province, South Africa

Barbara van Koppen, Luxon Nhamo, Xueliang Cai, Mary Jean Gabriel, Mosibudi Sekgala, Sydney Shikwambana, Khathu Tshikolomo, Shalon Nevhutanda, Boshomane Matlala and David Manyama

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Project

This study, *Irrigated Area Mapping in the Limpopo Province, is part of the DAFF-supported project Revitalization of Smallholder Irrigation in South Africa.* It is a part of the CGIAR Research Program on Water, Land and Ecosystems (WLE).

Collaborators

This research study is a collaboration of the following organizations:

International Water Management Institute (IWMI)

Department of Agriculture, Forestry and Fisheries (DAFF)

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Summary

As part of the 'Revitalization of Smallholder Irrigation in South Africa' project, the International Water Management Institute (IWMI), the Department of Agriculture, Forestry and Fisheries (DAFF), South Africa, and the Limpopo Department of Agriculture and Rural Development (LDARD) jointly conducted a survey of 76 public smallholder irrigation schemes in the Limpopo Province. The aim was to establish a baseline of key scheme characteristics, including smallholders' perceptions of main limitations. This Working Paper presents the following findings.

Focusing on the dry winter season of 2015, 28 schemes were not utilized; in 28 schemes, all area equipped for irrigation was utilized; and 22 schemes were partially utilized. While no and low utilization are clearly concerns, it is noted that the non-utilization of irrigation schemes is widespread, for example, 69% of large-scale center pivots in the Limpopo Province were not utilized.

Most characteristics were quite similar across the non-utilized, partially utilized or fully utilized schemes. The farm size (which was on average 2.6 hectares [ha]), gender, or age of the registered members did not affect whether a scheme was utilized or not. There were hardly any differences in marketing strategies either. Unlike the belief that smallholders are not 'commercial' and primarily produce for subsistence and own consumption, the opposite belief was found to be a fact. In spite of problems with lack of access roads, expensive transport, market gluts and middlemen, marketing was the most important aim, and informal markets were the main outlet. One difference was that schemes with trees as first crop were less utilized than those with vegetables as first crop. The five joint ventures in the sample functioned in two cases; but had collapsed in three cases, after which a few new producers had started using a small portion in two of the three cases.

The overarching limitation appeared to be the poor status of irrigation infrastructure, fencing and tractors. This was not only the main reason for non-utilization, which in half of the cases was compounded by flood damage without repair. Dilapidated infrastructure was also perceived to be the major limitation in partially and fully utilized schemes.

In addressing the poor status of infrastructure, the study recommends overcoming the build-neglect-rebuild syndrome, by deeper study and action on the multifaceted causes of infrastructure disrepair and the resulting vicious circle. Causes can be partly technical, which may warrant more participatory planning and appropriate technology choice. Social and institutional causes require transparency about the factual cultivators, including women and youth, and – if needed – dispute resolution on land tenure. Institutional support should enable the many forms of collective action required. Agronomic and cost-benefits analyses need to be deepened for support to improve productivity. Strengthened marketing and higher income, especially in informal markets, will drive further utilization of schemes.

Lastly, this study recommends extending research on smallholder irrigation to include informal, self-financed irrigation. As the joint research conducted by IWMI, DAFF and LDARD on irrigated area mapping showed, the area under informal irrigation is three to four times as large as the area equipped in public irrigation schemes. A comparative analysis will generate new lessons that can inform government about a broad range of measures to revitalize irrigation, boost broad-based economic growth, create employment and alleviate poverty.

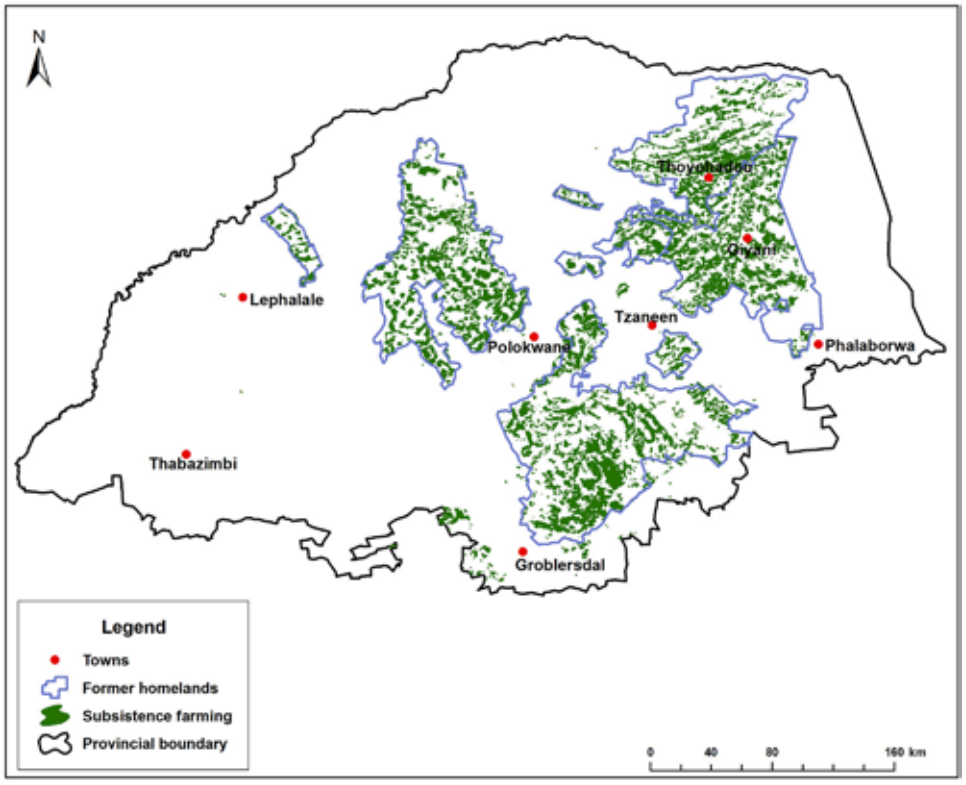
1. INTRODUCTION

1.1 Rationale

The Government of South Africa supports smallholder irrigation as a means to create jobs, alleviate poverty and boost pro-poor sustainable agricultural and economic growth (NPC 2012; DAFF 2015a). Led by the Department of Agriculture, Forestry and Fisheries (DAFF), irrigation expansion is supported through the revitalization of pre-1994 smallholder schemes and initiation of new smallholder schemes, especially in former homelands. The Limpopo Province, the focus of this Working Paper, with 5.8 million inhabitants, has the country's highest poverty rates, especially in former homelands. The overall aim of this study is to explore any untapped potentials to improve food security and employment through smallholder irrigation in the province's former homelands.

Knowledge about smallholder agriculture in general and smallholder irrigation in particular in this province and elsewhere in South Africa is limited. For example, in the national mapping of agricultural field boundaries (DAFF 2015b), all agriculture in former homelands is categorized as 'subsistence' (see Figure 1). The blanket term 'subsistence' not only overgeneralizes but also suggests there is hardly any marketing of produce.

FIGURE 1. Map of subsistence agriculture in the Limpopo Province with former homeland boundaries.

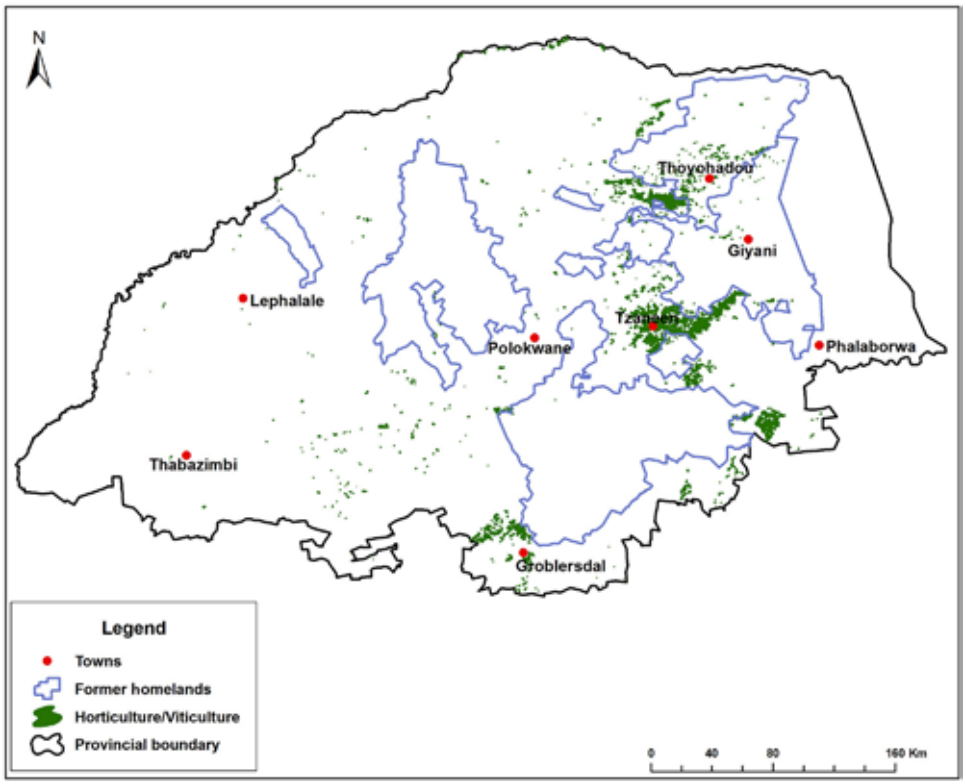


Source: DAFF 2015b.

Even less is known about irrigated agriculture. The DAFF national field boundary map gives an indication by assuming that horticulture/viticulture is irrigated, as in Figure 2a, in addition to center pivots as in Figure 2b, mapped by the International Water Management Institute (IWMI) (Cai et al. 2017). However, this estimate suggests that irrigation primarily takes place in the former white areas.

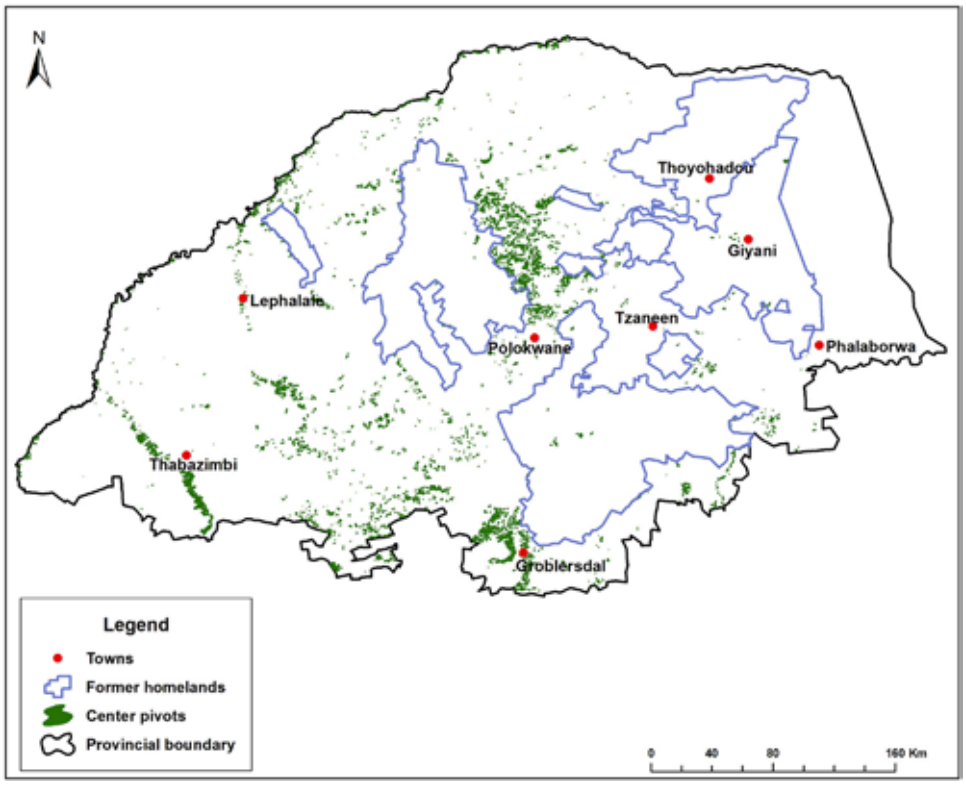
FIGURE 2(a). Map of horticulture/viticulture, and (b) area equipped with center pivots.

(a)



Source: DAFF 2015b; Figure 2(b): Cai et al. 2017.

(b)

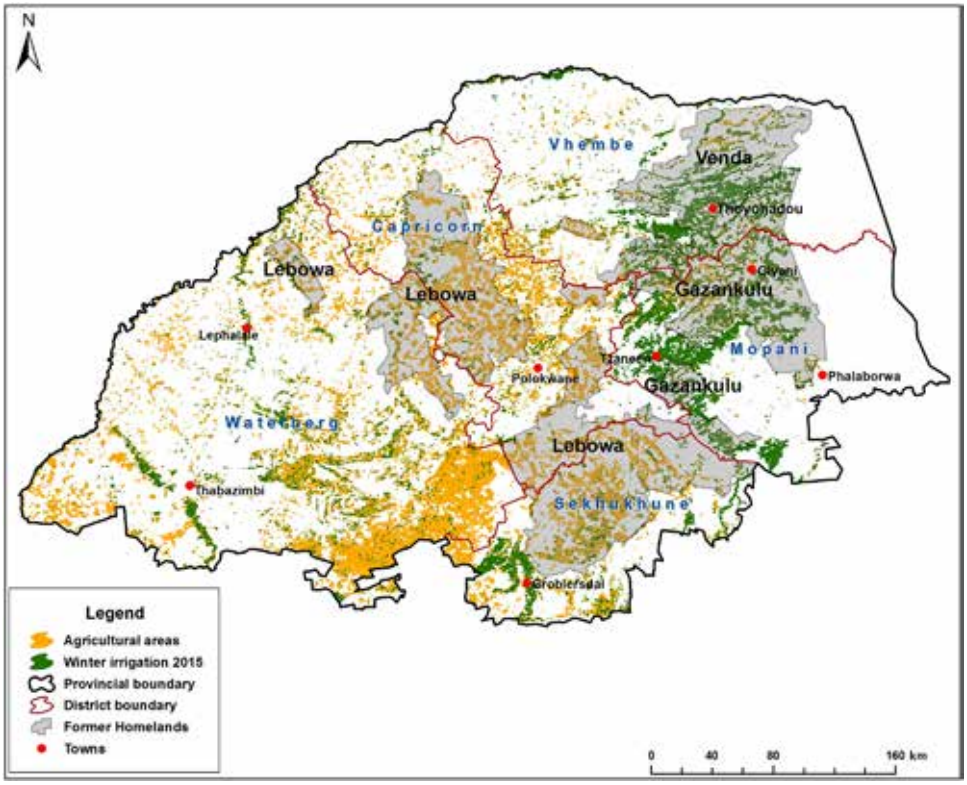


Source: Cai et al. 2017.

Yet, the potential of smallholder irrigation has already been tapped at much larger scales than what was known before. This was the finding of remote sensing mapping by IWMI, DAFF, and the Department of LDARD[1] (Cai et al. 2017). These findings give a very different picture (Figure 3). Figure 4 summarizes the findings in a graph: it presents the total cropped areas, and the cropland actually irrigated in the winter of 2015 in the former homelands. This shows almost 100,000 ha of irrigated area. Moreover, the proportions of irrigated land of total cropped areas are extraordinarily high in the former Venda (46%) and Gazankulu (25%) homelands. Unlike common perceptions, there is hardly any difference between the proportion of cropland that is irrigated in former homelands (15%) and in the former white areas (17%).

This level of irrigation in former homelands underscores that irrigation is already an important contribution to livelihoods, food security, and self-employment. As part of this, irrigation takes place in the public irrigation schemes that are overseen by DAFF. The DAFF database of the 180 public irrigation schemes in the Limpopo Province indicates that the total area equipped for irrigation of these government-supported public irrigation schemes is an estimated 20,788 ha. This implies that out of the total irrigated area of 97,471 ha, the difference of some 76,683 ha (so 79%), or more because not all public schemes equipped for irrigation were factually irrigated in 2015, consists of informal irrigation by private investors. Most investors, if not all, are likely to be small-scale private investors. They can invest in irrigation as individual households, or they can organize themselves in small groups. They can irrigate through gravity river diversions, lifting from streams or from groundwater with buckets or manual or motorized pumps, through wetlands, or using other methods.

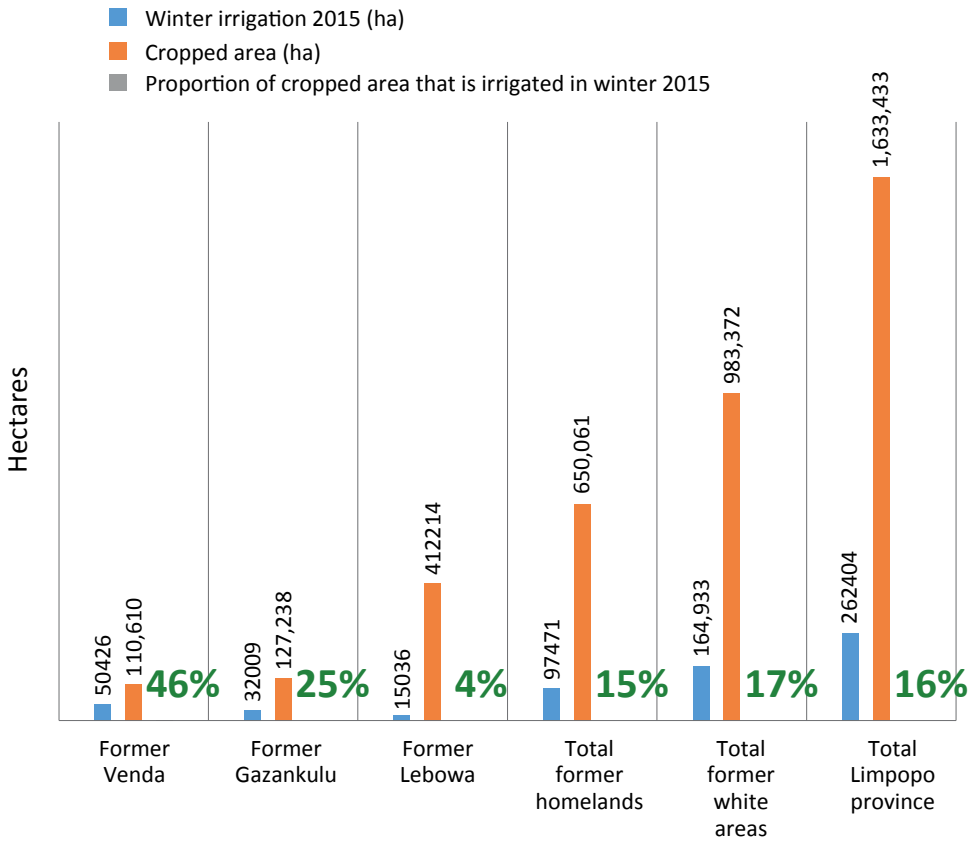
FIGURE 3. Irrigated areas in winter 2015.



Source: Cai et al. 2017.

[1] The names DAFF and LDARD have somewhat changed since 1994. Here we use these current names.

FIGURE 4. Cropped and irrigated (winter 2015) areas in former homelands and white areas of the Limpopo Province.



Data source: Cai et al. 2017.

The numbers of benefitting smallholders may be significant. Assuming that the average size of these informal irrigation plots is the same as the average found in this study (2.6 ha: see below), there would be close to 30,000 informal irrigators in the Limpopo Province. These investments in irrigation in just one of South Africa's nine provinces already contribute significantly to the aims of the National Development Plan (NPC 2012), which envisages an additional 500,000 ha of irrigated agriculture nation-wide.

In fact, this finding is not so surprising compared to other low- and middle-income countries. Across Africa, Latin America and South Asia, informal and private irrigation also covers larger areas than government-supported schemes (Yoder and Martin 1998; Boelens and Bustamante 2005; Shah 2007; Sokile 2006; Giordano et al. 2012; Woodhouse et al. 2016). The present study, however, focuses on a sample of the government-supported public irrigation schemes.

1.2 Research Aims

The DAFF, LDARD and IWMI undertook a study with the following two aims:

- Contribute to a baseline database.
- Explore untapped potentials of government-supported schemes in former homelands as engines of livelihood improvement, food security, poverty alleviation and agricultural growth.

1.3 Research Design and Method

A team by DAFF, LDARD, and IWMI compiled a questionnaire of key scheme characteristics. The questionnaire largely consisted of closed questions. Some questions were open, especially on the limitations that farmers encountered (see Annex). The interviewers also made observations.

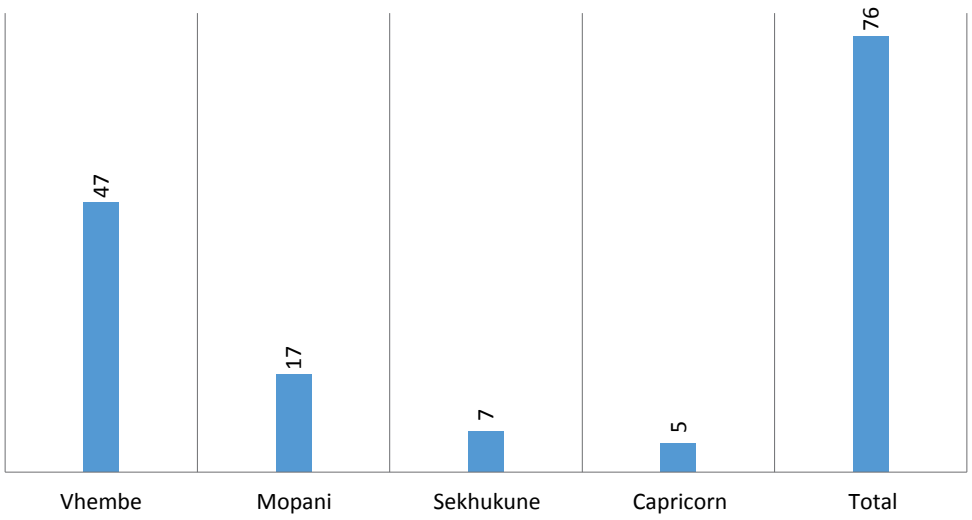
The Limpopo Province has 180 schemes, with an area of 20,788 ha according to the DAFF database. Altogether, 76 smallholder schemes were selected. The priority in the sampling was for schemes of which government had the least information. This was particularly the case in Vhembe and Mopani districts, which also have a large number of schemes. The distribution of the 76 schemes by district and the number of schemes in the sample are given in Table 1 and Figure 5.

TABLE 1. Smallholder irrigation schemes in the Limpopo Province.

District	Number of public smallholder irrigation schemes	Sample	Schemes covered by the field survey
Capricorn	21	7	33%
Mopani	39	17	44%
Sekhukhune	45	5	11%
Vhembe	69	47	68%
Waterberg	6		0%
Total	180	76	42%

Source: DAFF. No date.

FIGURE 5. Distribution of the sampled schemes by district.



The focus on Vhembe and to a lesser extent on Mopani implies that the results primarily reflect the situations of schemes in these districts. The team conducted the survey in the period March-April 2016. Respondents were scheme committee members or other members, and extension staff.

Altogether 40 extension staff worked in these 76 schemes, and provided vital information and logistical support to the research team.

The area equipped for irrigation surveyed was 13,217 ha with the 5,008 plot holders. The average plot size was rounded to 2.6 ha.

2. SOCIAL FEATURES: UTILIZATION, SIZES, GENDER AND AGE

2.1 Scheme Utilization

The first step in the analysis was to rank the schemes according to their degree of utilization. This degree was defined as: *the proportion of area equipped for irrigation that was factually irrigated in the winter season of the preceding year, 2015*.

Thus, four categories of schemes were defined. In Figures 6(a) and 6(b), the sites of the schemes surveyed are indicated with colours according to their degree of utilization.

- No utilization: 0-9% of area equipped for irrigation that was irrigated in winter 2015 (red).
- Low utilization: 10-49% of area equipped for irrigation that was irrigated in winter 2015 (orange).
- Moderate utilization: 50-89 % of area equipped for irrigation that was irrigated in winter 2015 (yellow).
- Full utilization: 90-100% of area equipped for irrigation that was irrigated in winter 2015 (green).

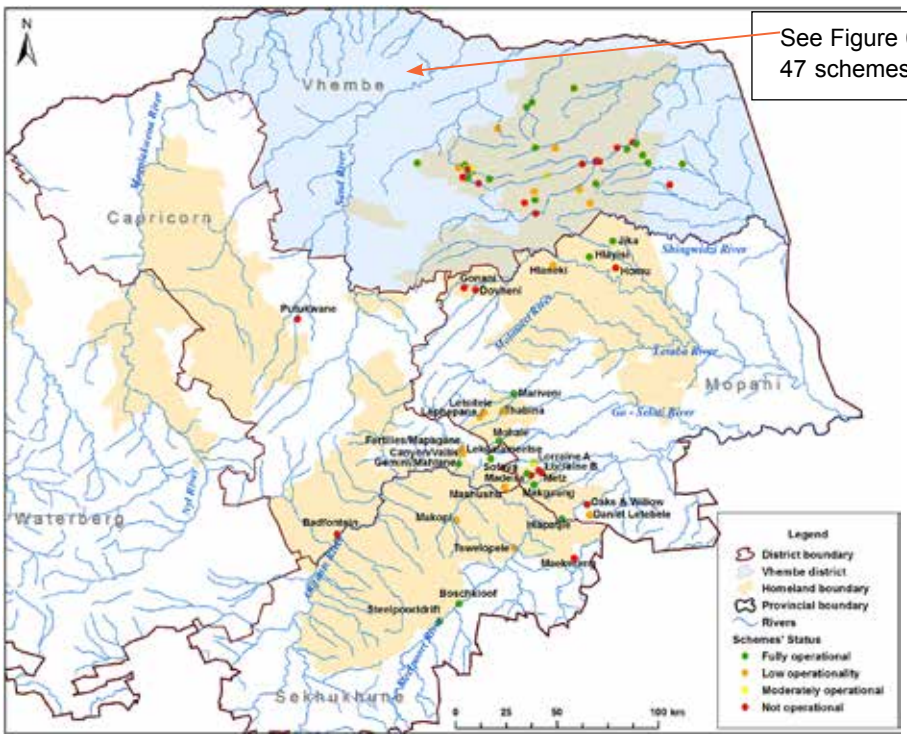
Figure 7 presents the utilization of schemes by district. Overall, this shows that there were as many non-utilized schemes as fully utilized schemes in winter 2015 (both 37%), where, 37% equals 4,890 ha. This proportion of schemes equipped for irrigation that are not utilized may seem high, but it is to be compared with the finding that 69% of area equipped with center pivots in the Limpopo Province (largely outside former homelands) was unused as well (Cai et al. 2017). The remaining 26% schemes were low- or moderately utilized. Also, each of the districts had a more or less similar pattern. No district stood out as biased either towards many non-utilized or towards many fully utilized schemes. In non-utilized or partially utilized schemes, information about cultivation practices was based on earlier seasons or years of utilization, where possible.

We remind that this definition of 'utilization' is a once-off snapshot; scheme utilization changes over time. For example, some schemes were irrigated in the winter 2015 but not in 2014 and vice-versa. Moreover, this definition only looked at the extent to which schemes were used for irrigation or not. It is silent about the productivity of the irrigated cropping. Also, rain-fed agriculture in the schemes was not further investigated, although many schemes without irrigation in the dry season were still used for rain-fed agriculture. Lastly, in incidental cases, the assessments of both the area equipped for irrigation and the area irrigated in 2015 were only rough estimates by the respondents.

Nevertheless, utilization is an obvious key aspect of irrigation scheme performance. The categorization also allows a comparison of schemes that are not used at all (28 schemes) with those of schemes with low-utilized (16 schemes), moderately utilized (4 schemes) or fully utilized (28) schemes. This and the following sections (2 to 4) analyze these differences between schemes with regard to the respective variables, either between all four categories, or by comparing within one category. Section 5 presents the main limitations cited by the respondents, both at the aggregate level and for each individual scheme. Conclusions are drawn and recommendations are proposed in section 6.

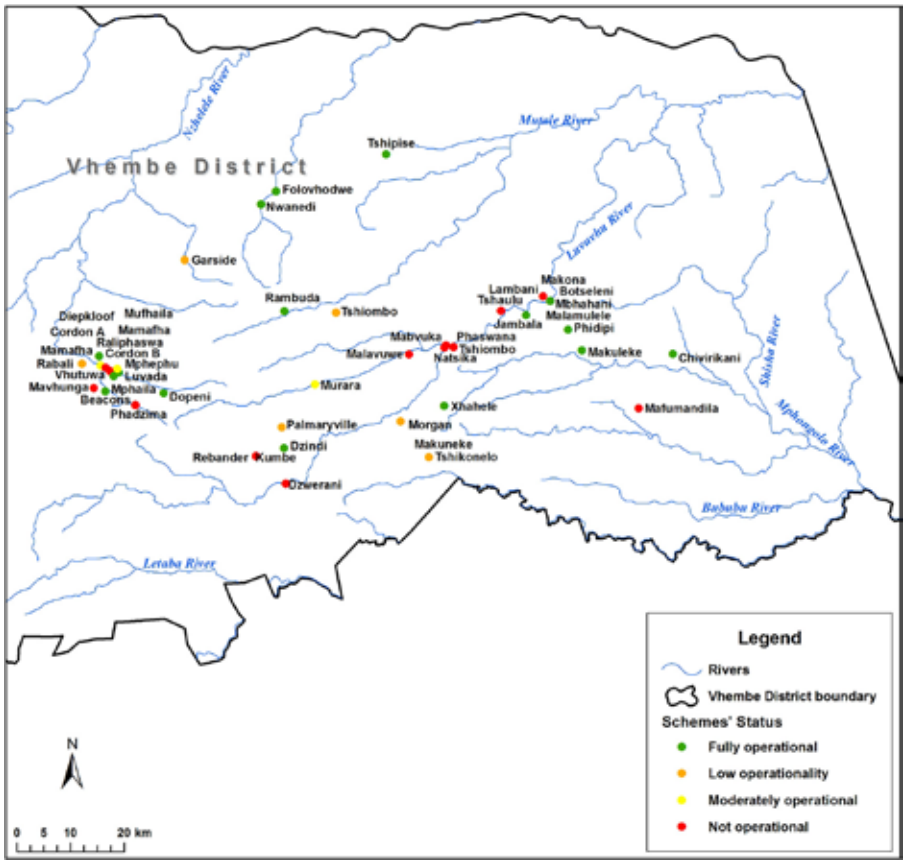
FIGURE 6. (a) Schemes of the field survey analysis by utilization, and (b) 47 schemes in Vhembe District.

(a)



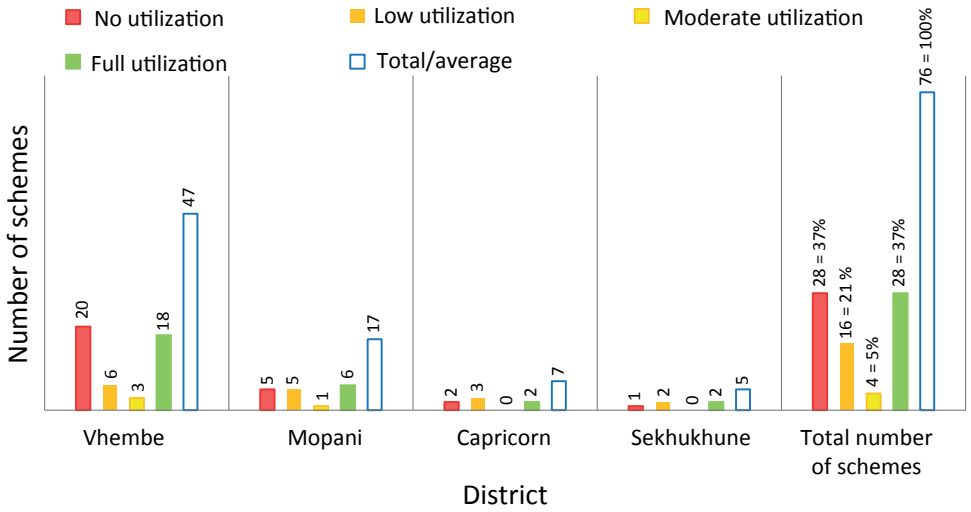
Source: Nhamo, based on data from the field survey.

(b)



Source: Nhamo, based on data from the field survey.

FIGURE 7. Scheme utilization by district.



Source: Field survey (n=76).

2.2 Year of Construction

One variable was the year of construction. Before 1994, the apartheid and homeland governments and parastatals invested in smallholder irrigation schemes in the former homelands. Post-1994, the new democratic government, through DAFF and LDARD, took over these schemes and invested in new schemes. Figure 8 depicts the year of construction of the irrigation schemes, showing a steady expansion from the 1950s, with a slowdown after the 1990s. New construction picked up thereafter. The proportion of non-utilized schemes out of all schemes constructed (the dots of the line in Figure 8) is not very different for the older schemes of the 1950s and those of the 1980s. However, this proportion is high in the 1990s; none of the five schemes of that period were utilized in 2015. This may reflect problems during the transition period in which the apartheid government structures were dismantled and the new democratic government departments were still being established.

We lack information about the total number of schemes constructed in the various periods. Many may have disappeared altogether in the meantime. On the other hand, recently constructed schemes are likely to be utilized; their sustainability of utilization can only be judged after several years.

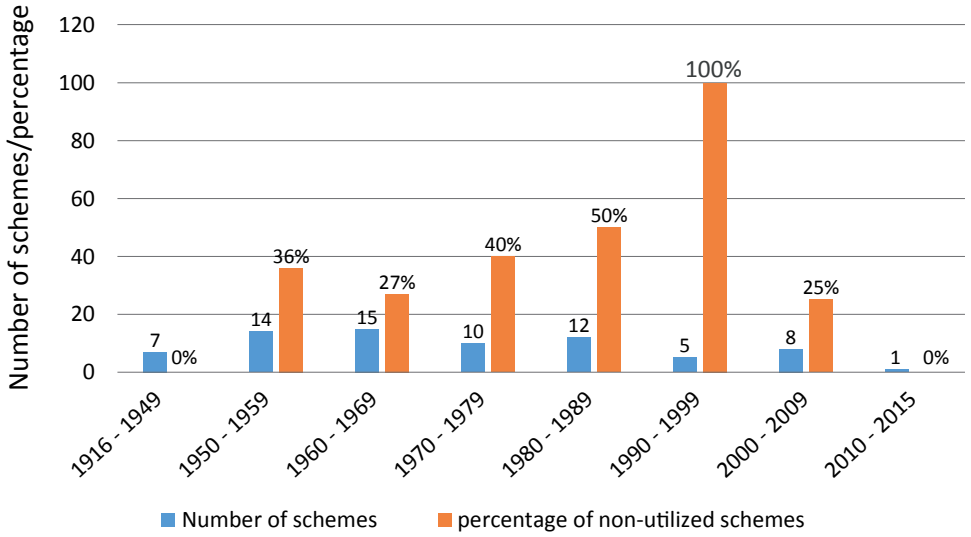
Further, the survey found that from 1956 onwards, farmers were the main initiators in ten schemes. Four of these schemes were initiated after 2000, which may reflect that farmers are articulating a stronger voice after 1994. As citizens' strong initiative is key to the sustainability of irrigation schemes, we explored whether the utilization of these farmer-initiated schemes was higher than the average of fully utilized schemes (37%). Indeed, six out of the ten schemes were fully utilized. Only one scheme with a strong farmer initiative was not utilized. However, this conclusion remains speculative: the numbers are small and many other factors than farmers' initiative influence whether a scheme is used or not.

2.3 Scheme, Group and Plot Sizes

The size of the area equipped for irrigation, the number of farm households, and - related to that - the plot size for each household, have been widely debated as factors that would influence

the utilization (and productivity) of schemes. In South African policy discourse, many assert that there is a minimum size below which agriculture and irrigation will never be 'viable'. In sharp contrast, others assert that smaller farm sizes are more productive and viable, because with limited land, the incentives to use that land as productively as possible are higher (Berry and Cline 1979; Woodhouse et al. 2016). Moreover, even if smaller plot sizes are equally productive or less so than larger plots, smaller plots ensure that many more farmers can benefit from government investments. This avoids the widening of the gaps between the 'haves' and 'have-nots'. However, large schemes with many farmers are also complex because they require considerably higher transaction costs to collaborate around shared water infrastructure and other collective actions (Shah et al. 2002). A smaller group would lead more easily to effective utilization. The following analysis of survey findings sheds more light on these questions.

FIGURE 8. Construction year and proportion of non-utilized schemes (%).

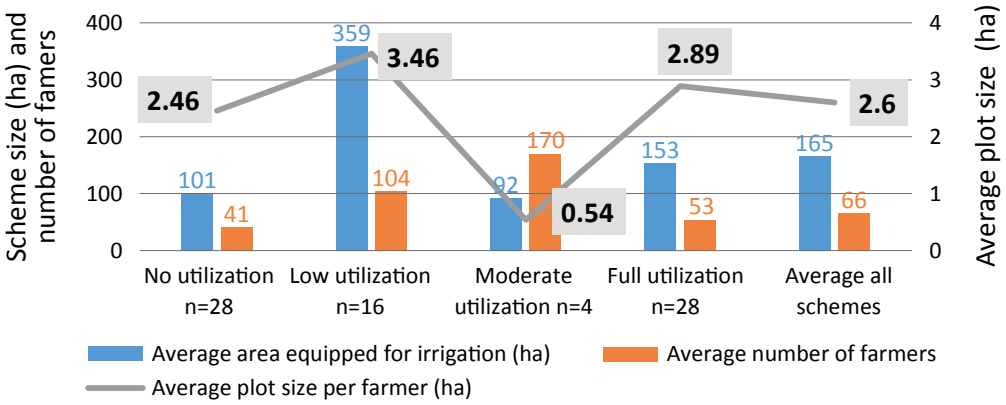


Source: Field survey (n=72).

Figure 9 shows that the scheme sizes (areas equipped for irrigation) are largest in low-utilized schemes (359 ha on average). These schemes also have the largest average plot size of 3.46 ha. At both ends of 'non-utilized' and 'fully utilized' schemes, the findings are relatively similar: average scheme sizes (101 and 153 ha), numbers of farmers (41 and 53) and average plot sizes (2.46 and 2.89 ha). These findings suggest that there are no apparent links between scheme utilization and scheme size, number of farmers and plot size. If any link, the utilization of the largest schemes with the largest plot sizes was relatively low.

The above-mentioned analysis was based on the calculated average plot size, assuming that land in a scheme is equally distributed among all farm households each registered as a 'member'. While this is valid as a proxy, in reality, plot sizes tend to vary. Further, there may be important differences between the registered farmers and farmers factually cultivating. By definition, in the non-, low- and moderately utilized schemes, only part of the farmers took up cultivation and they may have cultivated more land than their own plots. Also, there were five joint ventures in the survey, in which the strategic partner managed all cultivation. Their performance is discussed in section 5.

FIGURE 9. Scheme utilization by scheme size, number of farmers and plot size.



Source: Field survey (n=76).

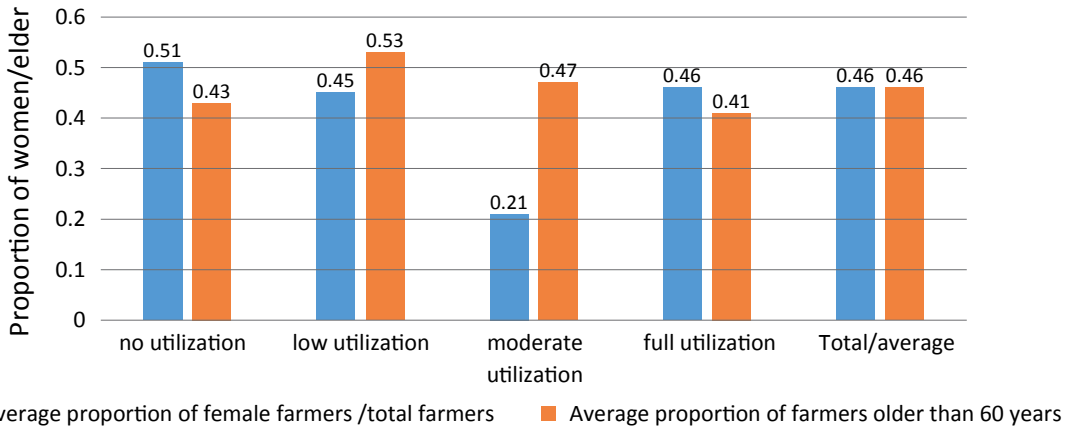
2.4 Gender and Age

It is often believed that a high proportion of women and a high proportion of elder smallholders hamper the utilization (and productivity) of smallholder irrigation. The survey found no evidence for this. As shown in Figure 5, the average proportion of women farmers was 0.46. This hardly differed for the non-, low- and fully utilized schemes. In the four moderately utilized schemes, the majority were men.

In interpreting these findings, one needs to realize that the proportion of women factually cultivating is considerably higher than that of those officially registered as members. This is because membership as well as the Permission to Occupy for irrigated plots are still typically registered in the name of the primary adult male of the household as supposed 'household head'. The Mpaila Scheme, which is a fully utilized and productive scheme, is an example. The field survey researchers found that the scheme was mainly cultivated by women. Yet according to the official membership, there were 52 men and 10 women. Women's second position behind 'male household heads' in formal, registered membership implies that women cultivators are often also excluded from collective irrigation decision-making.

Figure 10 shows that the average proportion of farmers older than 60 years varied only slightly, and that there was *no* relation with the utilization rate of the scheme. However, in the case of age,

FIGURE 10. Scheme utilization by gender and age.



Source: Field survey.

it may well be that elder farmers are the official members, while their children are the factual cultivators. Or elder plot holders may have leased their land out.

3. PHYSICAL FEATURES: WATER RESOURCES AND INFRASTRUCTURE

3.1 Water Resources and Energy

Moving to the physical factors now, it is obvious that water resource availability and water storage, conveyance and application infrastructure are key to the utilization of irrigation schemes.

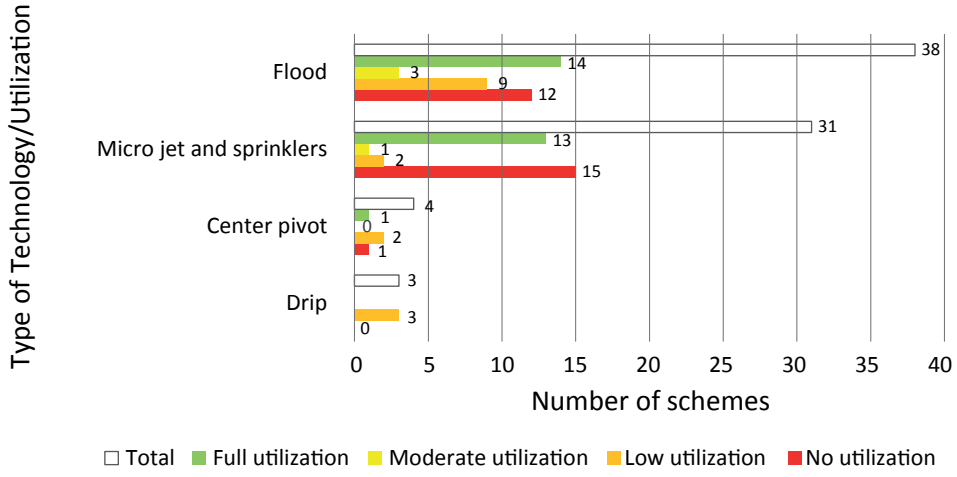
Surface water from streams, with or without dams, was the sole water source in 63 (83%) of the 76 schemes. Only seven schemes fully depended on groundwater; six schemes used groundwater and surface water conjunctively. Significantly, out of these 13 groundwater-dependent schemes, nine (69%) were fully utilized. This is higher than the above-mentioned 37% of all schemes surveyed that were fully utilized. This may indicate the reliability of groundwater even though pumping costs are high.

The energy source in 40 surface water schemes was gravity. All other schemes depended on pumping. Pumping from rivers with diesel engines occurred in only four cases. Electric pumps were used in all other 32 cases of surface water pumping and all groundwater pumping.

3.2 In-field Water Application

The in-field water application method of the 76 schemes varied, as shown in the totals of Figure 11: flooding (38 = 50%), micro-jets and sprinklers (31 = 41%), pivots (4 = 5%) and drip (3 = 4%). Figure 11 also highlights there was no field application technology that performed significantly better than others in terms of degree of scheme utilization. Flood irrigation was the most widely used, and slightly more often fully utilized (14) than non-utilized (12). However, the

FIGURE 11. Type of technology and utilization (n=76).



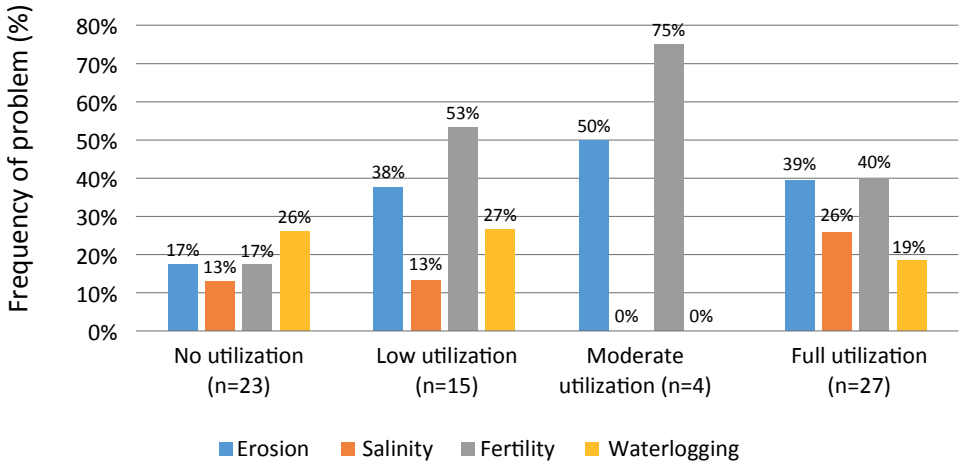
Source: Field survey.

utilization of nine flood irrigation schemes was low. Schemes with micro-jets and sprinklers were less frequent and slightly more often non-utilized (15 schemes) than fully utilized (13 schemes). So both water application technologies perform more or less equally in terms of the rate of utilization. It is noted that center pivots and drip were rare.

3.3 Soil and Water Quality Problems

The survey included questions about the prevalence of soil and water-quality problems (erosion, salinity, fertility and waterlogging). Figure 12 shows the percentage of respondents who affirmed they encountered that particular problem (the total number of respondents answering this question is also indicated). Remarkably, in utilized schemes, erosion, salinity, and low fertility were cited more often than in non-utilized schemes. Only waterlogging was mentioned more or less equally in all categories of schemes. This suggests that these soil- and water- quality problems need to be addressed across utilized and non-utilized schemes.

FIGURE 12. Proportion of respondents encountering soil and water problems, by scheme utilization.



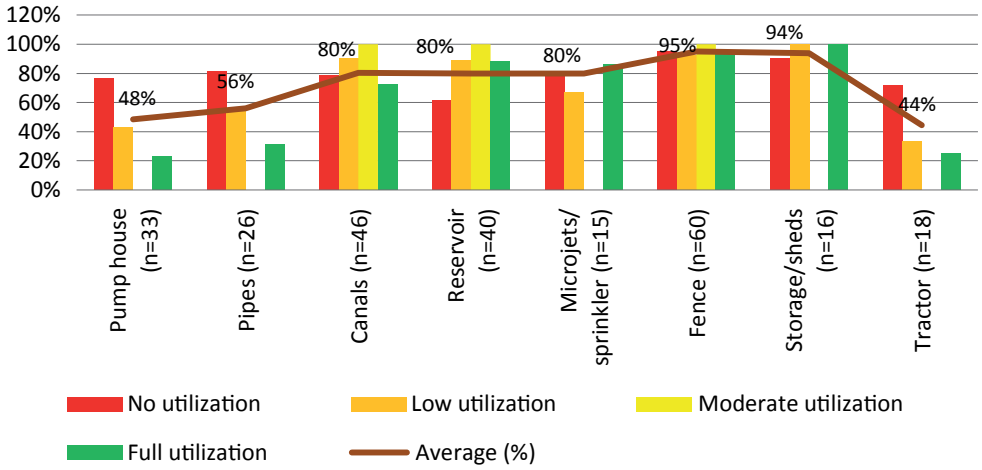
Source: Field survey (n=76).

3.4 The Condition of Infrastructure

Respondents were also asked about their perception of the condition of the various types of infrastructure. The total numbers of answers are indicated as 'n'. The number of answers depended on the prevalence of that type of technology; moreover, a few respondents failed to answer this question. Respondents answered either with 'poor' or with 'average'/'good'. Figure 13 shows the percentage of respondents who answered 'poor', indicating that their scheme's infrastructure was in a poor condition. Figure 13 reveals two issues. First, on average, pump houses, pipes and tractors were in poor shape in about half the cases. For all other technologies (canals, reservoirs, micro-jets/sprinklers, fences and storage/sheds), 80% and more of the respondents marked their status as 'poor'. This is very high. Second, the differences in the condition of the non-utilized infrastructure of schemes, compared with schemes that were fully utilized were minor for most technologies. Only pump stations, pipes and tractors were clearly in a poorer condition in non-utilized schemes than in fully utilized schemes. So the poor condition of these particular technologies might have contributed to their non-utilization. The finding that there is not much difference in the poor

state of infrastructure between schemes with no, low, moderate or full utilization, suggests not only that it is possible to irrigate in spite of their bad condition, but also that there is a need for improvement of infrastructure across all schemes. However, there may have been some over-reporting, because respondents may have used the opportunity of the interviews to negotiate construction and rehabilitation of infrastructure, as this is the support that the government used, and still uses, to give.

FIGURE 13. Proportion of infrastructure in poor condition (%0 by scheme utilization.



Source: Field survey.

3.5 Rehabilitation

Respondents in 27 schemes mentioned that their schemes had been rehabilitated, out of the total of 64 schemes where this question was asked and answered. Reportedly, farmers had been strongly involved in nine cases. In all cases, DAFF and LDARD provided significant support. In almost all cases (24), rehabilitation happened after 1993. Rehabilitation has not necessarily led to full operation (as yet). Rehabilitation had occurred in about half of the cases (50%) of schemes that were still low-utilized, 50% of moderately utilized schemes, and 42% of fully utilized schemes. In the non-utilized schemes 36% had been rehabilitated. On the other hand, the temporary process of rehabilitation itself contributed to non-utilization in three cases. In Badfontein and Matsika rehabilitation during winter 2015 stopped production temporarily. In Tshikonelo, the rehabilitation by a defaulting contractor stopped cultivation.

4. AGRONOMIC AND MARKETING FEATURES

4.1 Crop Choice

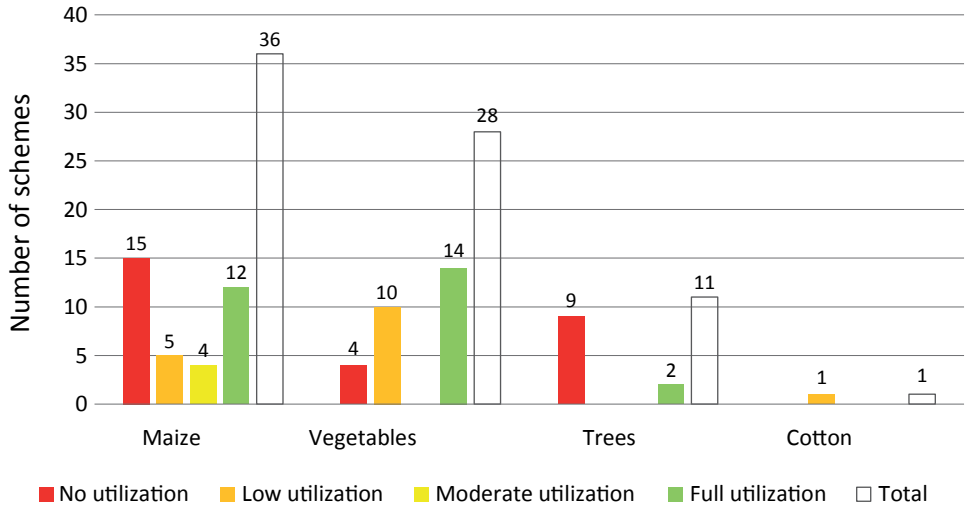
The findings on crop choices and marketing debunk any assumption that irrigation in the former homelands of the Limpopo Province is primarily ‘subsistence’, mainly focusing on own household food security.

The main crops cultivated were: maize; vegetables (including tomato, onion, peas, butternut, dry bean, groundnut, and nuts); and trees (banana, mango, avocado, other fruits). Incidentally, cotton, sorghum or tobacco was also grown. Most often, the crop choice was mixed. When

respondents mentioned maize as the first crop (in 36 cases), vegetables were always the second or third crop. In the 28 schemes that grew vegetables as the first crop, half of those schemes had maize as the second or third crop. Vegetables were the sole crop in only seven of these 28 vegetable schemes. Most of the 11 schemes with trees as the first crop, grew other crops as well, but these were most often other trees. The single cotton scheme had maize and vegetables as the second and third crop.

As Figure 14 shows, there were differences in utilization depending on the first crop. Maize schemes were more often not utilized (15 schemes) than fully utilized (12 schemes). However, maize in these schemes may well be cultivated as a rain-fed crop in the rainy season; rain-fed cultivation was not addressed in this study that focused on the winter irrigation in 2015 (or earlier years in schemes that were not utilized in 2015). The 28 vegetable schemes were nearly always utilized, although utilization was low in 10 schemes. Trees appeared a difficult crop: nine schemes with trees as the most important crop were not utilized, while only two irrigated orchards were utilized. So a scheme with vegetables as the first crop seems more likely to be utilized than a scheme with maize, and much more likely than an orchard.

FIGURE 14. First crop by scheme utilization.

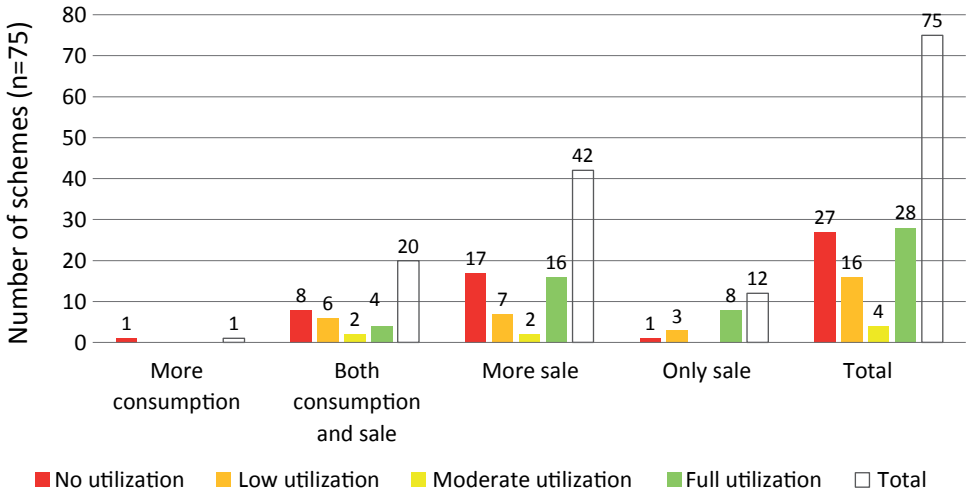


Source: Field survey.

4.2 Crop Use

The commercial orientation of smallholder irrigation emerged from the answers to the question how crops were used (Figure 15): only for own consumption, more for own consumption than for sale, equally for consumption and sale, more for sale than for own consumption, and exclusively for sale. Sale appeared a more important or exclusive goal in 54 (72%) of the schemes, and equally important as own consumption in 20 schemes (27%).

FIGURE 15. Use of crop for consumption or sale by scheme utilization.



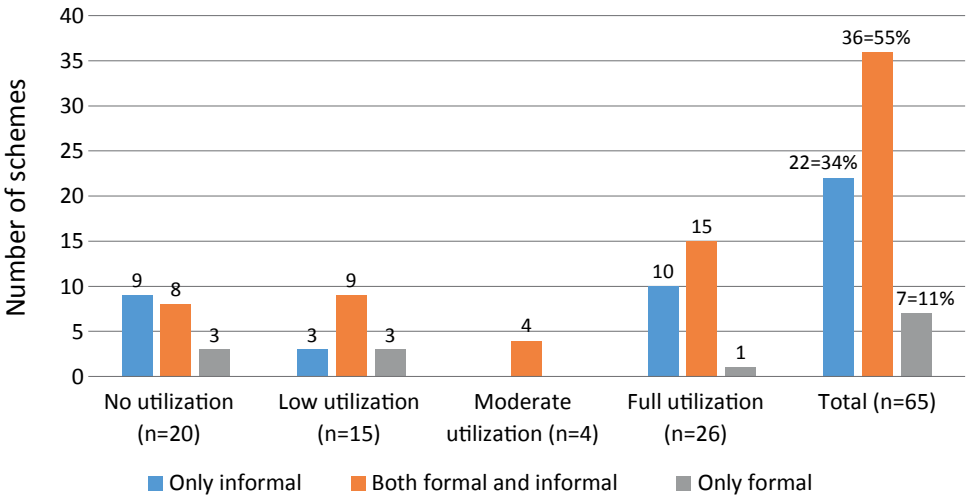
Source: Field survey.

4.3 Marketing

Crops were marketed informally (locally, with ad hoc arrangements, including with middlemen) and formally (contract farming in towns and at larger distances, for example Johannesburg's fresh market). As shown in Figure 16, combinations of the two are the most frequent (55% of schemes). Schemes exclusively marketing in formal markets were rare: 11%. Significantly, such formal marketing had mainly occurred in non-utilized or low utilized schemes. Only one of the 26 fully utilized schemes with data on this issue, exclusively depended on formal markets. There are no data on prices gained; these might have been higher in formal markets.

Table 2 lists the answers to the question about the main challenges in marketing. Solutions that the respondents proposed are listed in Table 3 as a percentage of the total responses obtained. The findings highlight that the remoteness of the irrigation schemes from markets was most often seen as the main problem. Market gluts and middlemen were most often mentioned as the next problem. Only few respondents mentioned a range of other challenges.

FIGURE 16. Formal and informal markets by scheme utilization.



Source: Field survey.

TABLE 2. Main challenges in marketing perceived by proportion of total respondents.

Main challenge in marketing	Proportion of respondents (n=44)
Poor accessibility: distance, transport costs, no roads	57%
Market is flooded with same produce; agents dump produce	16%
Middlemen and hawkers: they weigh the produce at the market and not locally; unclear determination of the volumes of crates; demanding bribes; stealing.	9%
Prices at local market are low	5%
There is no formal market	5%
Milling price is high	2%
Grading is challenging	2%
Lack of pack house	2%
Lack of packaging material	2%
Total	100%

Source: Field survey.

TABLE 3. Solutions identified to improve marketing, by proportion of respondents.

Proposed solutions for improved marketing	Proportion of respondents (n=45)
Build a local depot/pack house (also as a way to avoid middlemen)	50%
Get rid of middlemen	11%
Develop alternative markets, for example closer, or build new market place	9%
More extension support	7%
Contract marketing	7%
Tar roads	4%
Subsidize transport	4%
Local weighing house	2%
Ensure fixed market prices	2%
Regulate milling prices	2%
Add value at the farm	2%
Total	100%

Source: Field survey.

Accordingly, respondents proposed one main solution, as in Table 3. A local depot or pack house was the preferred solution for half of the respondents, even though such lack of a pack house did not come out as the main challenge. This may reflect respondents' perception on the type of support they expected to receive from government. Independence from middlemen was the second most cited solution. Various other suggestions to render marketing easier and more profitable were also made.

In the foregoing, we described the key social, physical and agronomic features and main limitations of the 76 schemes surveyed, and we tried to explore whether those factors helped explain why schemes are non-, low, moderately or fully utilized by comparing the totals of each category. We now turn to the analysis of respondents' perceptions of main limitations of their scheme. Section

5.1 analyzes the aggregated limitations mentioned. Section 5.2 focuses on the main limitation of each specific scheme in the four categories of degree of utilization.

5. SCHEME LIMITATIONS

5.1 Aggregate Limitations

The interviews were concluded by asking the respondents in all 76 schemes to provide their views on the four to five main limitations of their schemes in order of priority. The respondents gave 304 answers about such limitations. Table 4 gives an overview of the aggregated frequencies of the limitations identified, irrespective of priority.

The limitation that was cited most often was about water infrastructure and related water availability (32%). This corresponds with the general poor condition of infrastructure across all schemes, as mentioned above. The next challenge identified by many respondents concerned the non-availability of mechanized plowing (15%) and proper fencing (12%). Again, this may reflect high expectations with regard to technological fixes and the hardware support from governments. Lastly, unlike the widely held belief about lack of interest among youth, lack of successors was mentioned in only 2% of the total limitations identified.

TABLE 4. Main limitations identified by proportion (%) of total responses.

Limitations identified	Proportion of responses (n=304)
Infrastructure (canals, pumps, dams, pipes, boreholes) dilapidated, too small, silted, blocked	32%
Tractors and discs unavailable	15%
Security: Fence is lacking or in poor condition	12%
Security: Theft and vandalism of infrastructure and crops	6%
Storage or pack house is lacking	6%
No or poor infield and access roads	5%
Lack of management skills	4%
Lack of funds for inputs	3%
Security: Intrusion of wild animals and livestock	2%
Transport to market costly	2%
No successors	2%
High electricity pumping costs (30 schemes)	2%

Notes:

< 2%: soil erosion – salinity; high costs and lack of availability of inputs; poor farm methods; conflict with the strategic partner; high costs of wage laborers; insecure and variable prices; the miller is dishonest; conflict with external developers; aged trees; lack of interest; canal is too small for many farmers: injustice by chief.

5.2 Main Limitations in Individual Schemes

In this section, we analyze smallholders' responses on the limitations in another way: we look at the main limitation mentioned and further information or observations in each scheme in order to further explore reasons why some schemes are fully utilized and others are only partially utilized or not utilized at all.

5.2.1 Non-utilized Schemes (28)

Out of the 28 non-utilized schemes listed in Table 5, dilapidated infrastructure was the major cause of non-utilization for 11 schemes that were damaged by the 2000 floods. These floods had mainly occurred in those areas. The authors are not aware of any disaster management or other type of intervention that repaired the damage. Dilapidated infrastructure was also the main limitation mentioned in 11 other schemes.

Two schemes were under construction, so their non-utilization was temporary. Four schemes collapsed primarily as a result of social conflicts within the community or between the community and outsiders.

TABLE 5. Main limitations cited in 28 non-utilized schemes.

Limitations cited in non-utilized schemes		Number of schemes
Infrastructure (often pump station) destroyed by 2000 floods	Botseleni Cordon A Cordon B Lambani Makona Malavuwe Malumalele Mbhahani Phadzima Phaswana Mafumandila	11
Dilapidated irrigation infrastructure/ water shortage	Dhoveni (no water in winter; broken pump) Diepkloof-Mavhunga (dam silted; utilized in April 2016) Dzwerani Khumbe Rebander Madeira (dam too small) Maekereng Metz Tshaulu Vhutuwa nga dzebu Lorraine B	10
Intra-community conflicts	Gonani (electricity transformer stolen in 2011) Oaks and Willows (two groups claiming citrus farm; now leased out) Putukwane (two groups claiming land)	3
Under construction in winter, 2015	Badfontein Matsika	2
Failing joint venture with strategic partner/no water	Homu	1
Failing contractor	Tshikonelo	1
Total		28

5.2.2 Low-utilized Schemes (16)

For the 16 low-utilized schemes, Table 6 also suggests a role of dilapidated infrastructure. Social conflicts occurred in one case.

TABLE 6. Main limitations cited in 16 low-utilized schemes.

Limitations cited in low-utilized schemes		Number of schemes
Dilapidated irrigation infrastructure	Lephephane Makumeke (pump) Mashushu Garside Canyon/Vallis (also lack of successor farmers) Fertilies-Mapagane (also lack of successor farmers) Morgan (pump) Thabina (vandalism, water shortage) Rabali Hlaneki (dam not filled) Letsitele Cooperative (three farmers) Makopi (boreholes needed)	12
Failing joint venture with strategic partner	Tswelopele (few individuals with pump irrigation) Tshiombo block 2	2
Intra-community conflicts	Palmaryville (land encroachment and intimidation of farmers by elite and chief)	1
Individuals taking over	Daniel Letebele (15-year lease, rotational 5 ha irrigation, still under development)	1
Total		16

5.2.3 Moderately Utilized Schemes (4)

The four schemes with moderate utilization respondents noted poor infrastructure as the main limitation (see Table 7).

TABLE 7. Main limitations cited in four moderately utilized schemes.

Main limitations cited in utilization schemes		Number of schemes
Dilapidated infrastructure	Lorraine Agricultural Murara Mphephu Raliphaswa	4
Total		4

5.2.4 Fully Utilized Schemes (28)

As presented in Table 8, in 16 out of the 28 schemes that were fully utilized, respondents still pointed at infrastructural flaws as an important limitation. This was likely to affect their productivity to some extent. It was only in nine schemes that other limitations were seen as more important. In one scheme, one large-scale farmer had taken over production. In one of the two schemes with a functioning joint venture, farmers were not happy with the partnership.

TABLE 8. Main limitations cited in fully-utilized schemes.

Main limitation in fully utilized schemes		Number of schemes
Dilapidated or sub-optimal infrastructure	Mamvuka Beacons Fields Boschkloof Chivirikani Folovhodwe Gemini/Mahlane Jambala Agric. Cooperative Jika Cooperative Makgaung Mamapha Mohale S.M. Mphaila Pfuxanani Orchards Phidipi Organic Farmers Tshipise Xihahele Agric. Cooperative	16
Other main limitations	Dopeni (management skills, successors, sand mining) Dzindi (management skills, headman gives plots for residency) Hlapatjie (lack of interest; yet productive) Lekgalameetse Malta BSKT (aged trees; extension needed) Luvada (roads, inputs, fence, storage) Nwanedi (market, high electricity costs) Phidipi Organic Farmers (management, farming skills) Sofaya (soil erosion)	8
Individual taking over	Hlayisi, T.C. (rich, local businessman)	1
Strategic partner	Makuleke - no trust and lack of capacity building (Tapela 2016) Mariveni (packing facility)	1 1
Stopped after April 2016	Steelpoortdrift	1
Total		28

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study analyzed key historical, social, institutional, water resource, infrastructure, agronomic and marketing features of 76 smallholder irrigation schemes in the former homelands, in particular the former Venda and Gazankulu homelands, in the Limpopo Province, South Africa. Public irrigation schemes contribute to achieving the Presidency's goals to use irrigation for broad-based economic growth, job creation, and poverty alleviation, in spite of a series of obstacles. By addressing these obstacles, public irrigation schemes can further contribute to the goal of adding 500,000 ha of smallholder irrigation.

Of the schemes 28 were found to be fully utilized during the 2015 winter irrigation season; 28 were not utilized; and the utilization of 22 schemes was low or moderate. This finding is in line with earlier studies, for example by Denison and Manona (2007). As expected, a multitude of factors played a role. The comparison between the non-, low, moderately and fully utilized

schemes confirmed that most factors were distributed quite evenly over these four categories of schemes. There were a few exceptions, though. The following conclusions can be drawn about general patterns, the implications of the absence of patterns, and the meaning of the few exceptions.

Above all, the study debunked the myth that smallholder irrigation is primarily for subsistence and own consumption. The majority of smallholders with small plots (on average 2.6 ha) were clearly commercially oriented. Crop sale was the more important or even the exclusive goal in almost three quarters of the schemes, and equally important as own consumption in the other quarter. Markets were largely informal or combinations of formal and informal markets. The relative importance of informal markets was further confirmed by the finding that out of the seven schemes that fully depended on formal markets, only one was fully utilized. Respondents' solutions to address marketing challenges included improved access roads and pack houses or storage sheds and overcoming market gluts and improved transparency by middle men.

The finding that plot size, gender and age (in terms of formal, registered members) had no influence on the degree of scheme utilization, also challenged several beliefs. First, schemes with smaller farm sizes were used to a similar degree as schemes in which farmers operated larger plots. Second, almost half of the registered members (46%) were women (although more were the actual cultivators). Schemes with a majority of women farmers were utilized to the same extent as those in which men were the majority of farmers. Third, schemes with many youngsters were also utilized to a similar extent as those in which the elderly dominated. Although the average proportion of farmers younger than 60 years was 0.54, only one respondent referred to a lack of successors as one of the limitations for irrigated agriculture.

There were a few differences between schemes that were not utilized compared to those that were utilized to some or full extent (in addition to the above-mentioned non-utilization of most schemes depending on formal markets). First, none of the five schemes constructed in the 1990s was utilized. This may be linked to the profound changes in government structure during the transition to democracy in that era. Second, trees seem a difficult 'crop'; nine schemes with trees as the most important crop were not utilized, while only two such schemes were utilized. In contrast, schemes with vegetables as the first crop were generally well utilized. However, while these differences seem significant, the total numbers remain small, so that no conclusions about firm, statistically significant patterns can be drawn.

The answers to the survey questions about the condition of the infrastructure and to the question about the main limitations for irrigation predominantly pointed at dilapidated infrastructure. This was reported across non-utilized and utilized schemes alike. However, even rehabilitated schemes were not always utilized.

A scheme-specific analysis of the 28 non-utilized schemes also revealed dilapidated infrastructure as the main reason for failure. This was not only the case for 11 non-utilized schemes that were damaged during the floods of 2000 and were not repaired, but also for 11 other schemes. Another reason for non-utilization was temporary: two schemes were being rehabilitated in winter, 2015, which temporarily stopped irrigated cultivation. Social conflicts within communities and with outside contractors or strategic partners halted functioning of four schemes.

With regard to the five joint ventures with strategic partners in the sample, the Marveni Cooperative and Makuleke Scheme were fully utilized, but mistrust prevailed in Makuleke (Tapela 2016). The Tswelopele and Tshiombo Block 2 joint ventures had collapsed, and were subsequently utilized by a few farmers only (low-utilization). The Homu Scheme had stopped functioning because of both smallholders' frustrations vis-à-vis the strategic partner and lack of water. This reflects similar findings of other studies by IWMI and others on the mixed results of joint ventures in the Limpopo Province (Tapela 2009; Mapedza et al. 2016; Nowata 2014; van Koppen et al. Forthcoming).

6.2 Recommendations

The survey findings provide a baseline assessment for the sampled 76 schemes; a similar baseline can be established for other schemes in the Limpopo Province and elsewhere. Such a baseline not only allows following basic trends over time but also helps identifying untapped potentials of public irrigation schemes to further contribute to achieving national goals of expanding smallholder irrigation for broad-based economic growth, employment creation and poverty alleviation. This survey points at further investigation and action in the following directions.

Given the overwhelming perception of a poor state of infrastructure, not only in non-utilized schemes but even in fully utilized schemes, further analysis needs to unravel its causes, and the resulting vicious circle of lower productivity, lesser commitment of farmers, vandalism, and animal intrusion. The underlying causes may be technical, but analyses and actions should go beyond a 'build-neglect-rebuild' syndrome. Instead, more participatory planning and participatory choice of more appropriate, flood-prone technologies (Denison and Manona 2007), as well as more technical capacity-building, may be required. Smallholders and government may agree that government continues its commitments for certain major works, such as rehabilitating schemes, including fencing, or desilting dams of schemes. However, the extent of such government commitment needs to be clear and consistent from the outset. This clarity could also encompass ownership issues of the infrastructure.

Some causes of both a poor status of infrastructure and low utilization are likely to be institutional and social as well. After the dismantling of the pre-1994 top-down, disciplined and authoritarian management practices, alternative arrangements are still being developed. The composition of irrigators, land tenure and land rentals is changing (Manona et al. 2010); and encroachment by the elite is reported. On the basis of inventories of the tenurial arrangements and factual land users and cultivators, including women and youngsters, membership of the factual cultivators can be consolidated and their land rights protected (Manona et al. 2010). Addressing these intra-household and intra-community relations ensures that support agencies target the right persons and mediate in land-tenure disputes as needed. Clarity about membership allows forging legitimate governance and executive structures to implement the many collective tasks in these schemes: water distribution, maintenance, fee collection, security, conflict resolution and possibly joint input provision and marketing. Training not only in roles and functions of leaders and members but also in accountancy skills and conflict resolution will enhance transparency and accountability among members, and between members and committees.

At the supply side, productivity limitations pointed at a need to improve plowing services, whether public or private. Other productivity issues were not explicitly addressed in this survey and were not raised either in the period of open questions. These require further research: financing facilities, input provision and agronomic training. For this baseline assessment, a 'functioning' scheme was defined according to a basic variable: extent of utilization. Further research should deepen issues of yields and cost-benefit analyses. At the demand side, improvements in marketing should primarily focus on the main outlet of smallholder irrigation schemes: informal markets.

A last recommendation is to deepen smallholder irrigation research and intervention by better comparing public irrigation schemes and widely practiced informal, self-financed irrigation. Important lessons can be learnt about irrigated production and marketing across all forms of smallholder irrigation. Forms of self-organization in informal irrigation (and other activities) can inform institutional models for public irrigation schemes. By anchoring government support in existing 'good practice' initiatives in both formal and informal irrigation, support will be more effective and sustainable and will reach many more citizens.

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ANNEX

Questionnaire - Irrigated Area Mapping in Limpopo (March-April 2016)

A. **General Information**

Survey ID: _____

District: _____ Municipality: _____
Village:_____

Name of Extension Officer: _____

Name of Farmer: _____ **Male__ Female**:
Phone_____

1. Number of irrigation schemes in the village: _____, of which _____collectively owned, and _____ are individually owned. Total area:_____(ha), of which GW irrigated area_____ (ha).

2. Coordinates of the visited irrigation plot: **X**_____ **Y**_____

3. Household size: Women_____ Men _____ Total _____ Woman-headed: **Yes** (___). **No** (___)

4. Plot size: Irrigated _____ (ha). Rain-fed _____ (ha).
Grazing land _____(ha).

5. Coordinates of the visited irrigation plot: **X**_____ **Y**_____

B. **Crop and water management**

1. **Irrigated crop types:** _____

2. **Crop seasons:**

   a. **Crop 1**: From _____month to _____month

   b. **Crop 2**: From _____month to _____month

3. **Crop yield**: Crop 1_____tons/ha, Crop 2 _____ tons/ha, Total yield _____tons/ha.

4. **Water sources**:

   c. Surface water (___). River (___). Dam (___). Other (specify)_____

   d. Groundwater (___) Conjunctive use (___).

5. **Irrigation methods**:

e. Sprinkler (___). Pivot (___). Flooding (___). Furrow (___). Drip (___).
Other (specify) _____

6. **Irrigation season**: _____ month to _____ month

7. Tick if irrigated in: 2015-16 (___), 2015 winter (___), 2014-15 (___), 2014 winter (___).

8. Irrigation tariffs: Water_____ R/season; Electricity_____ R/season; diesel _____ R/season

9. **Groundwater (where applicable)**

   a) What is the **depth to the water table** (in meters)? Please provide the minimum_____, maximum_____ depths below the surface.

   b) What time of the year do you experience low groundwater availability? _____

   c) How frequent does the low groundwater availability occur? _____

   d) Any years that were particularly critical? _____

   e) What are the **two main problems related to groundwater use** in your area?

      1. _____

      2. _____

   f) If groundwater availability is low, what causes you to stop pumping for irrigation: Pump starts taking in air ____ Fear of damaging the pump ____ Fear of not having water for livestock or other uses ____ Cost of pumping becomes prohibitive ____ Groundwater level goes below a certain level that I measure ____ Water quality

10. **Rain-fed crop types**: _____

   a. Crop seasons: _____month to _____ month

   b. Crop yield: _____ tons/ha

11. Do you have a water licence for your irrigated crops? **Yes** _____ **No**_____

   a. If yes (Licence (__), General Authorization (__), Schedule One (__), Existing Lawful Use (__)

   b. If not, are you aware of the process of water use authorization? **Yes** (___) **No** (___)

   c. What type of water use authorization would you prefer for your farm? (_____)

d. What are the advantages and disadvantages of the type of water use authorization mentioned in c?

C. **Construction**

12. When was the scheme constructed? _____ (*if year not known, ask for decade)*
Who constructed it?

i. Private: Name and gender _____

ii. Public: (which company or department)? _____

iii. If scheme was built by white farmers but taken over by the homeland government, which company or department took over? _____

D. **Market**

a. Use of the irrigated crop produce:
Family consumption (___), sale (___) exclusive sale (___), more sale (___), both equally (___), more family consumption (___), exclusively for family consumption (___)

b. If sale: where is the produce sold? _____

c. Do you face problems in marketing your produce? **Yes** (___), **No** (___)

d. If yes, what are the marketing problems? _____

If yes, what should be done to solve the problem? _____

E. **In case of a collective scheme:**

a. Number of farmers; _____, No. of men _____, No. of women _____

b. How many farmers are older than 40? _____

c. Is there a management committee for the scheme? **Yes** (___), **No** (___)

If yes, what is the gender composition of the committee: **No. of men** _____,
No. of women _____

d. Name and telephone numbers of two active committee members

1. Name: _____. Phone: _____

2. Name: _____ .Phone: _____

F. **Operation**

Who does work below operations?

a. Land preparation: Name_____, Gender **M** (___) **F** (___)

b. Crop selection and planting dates: Name_____, Gender **M** (___) **F** (___)

c. Irrigation scheduling and application: Name_____, Gender **M** (___) **F** (___)

d. Fertilizer and weed management: Name_____, Gender **M** (___) **F** (___)

e. Harvesting: Name_____, Gender **M** (___) **F** (___)

G. **Maintenance**

a. Who pays for maintenance of the scheme? _____

b. Who does the maintenance? _____

c. When was the last rehabilitation (comprehensive maintenance/significant upgrade)? _____

d. Who did the comprehensive maintenance? _____

H. **What is the condition of the system (both question and observation)?**

(*Bad, good or average*)

a. Infrastructure: canals: (_____), wells (_____)

b. Equipment (for example, pumps, pipes, tractors, sprinklers): _____

c. Land and soil (erosion, salinity, fertility, waterlogged):_____

I. **What are two major problems that the irrigation scheme is facing?**

1.

2.

J. **General comments/observations**

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