5. Research Design

During the research design a number of functions are fulfilled. The research design is a planning phase that determines to a large extent the possible impact of results at the end of the day. The research for this dissertation can be divided into two separate but interdependent research attempts.

1. Research was conducted with corporate personnel at telecommunication firms of South Africa (Telkom, Vodacom, and MTN). This part of the research was done through questionnaires and interviews. The questionnaires are included for completeness as Appendix E (MTN Questionnaire), Appendix F (Vodacom Questionnaire), and Appendix G (Telkom Questionnaire). The collected data was integrated into the analysis of Chapter 6. An information gathering exercise was done on background information for all three companies and was described in Chapter 2. The formal research design process was not followed for the first part of the research because the research targets (telecommunication companies: Telkom, Vodacom, and MTN) were already defined with one representative from each, selected to represent the whole company in each interview. The author apologizes for information on MTN being limited in some instances. The reason therefore was that MTN provided incomplete cooperation.

2. Research was conducted in a rural area to determine the current telecommunication technology utilization situation in South Africa's underdeveloped areas. The rural region research furthermore served as an evaluation of the needs and a gathering on information about the rural citizen's expectations and aspirations. For this part a systematic research design process was followed which includes:

   - Postulate
   - Sample survey design:
   - Taking precautions to assure reliability of the collected data

5.1. Postulate

A research postulate was set on the hand of the technology transfer model described in chapter 4. A number of postulates were defined beforehand to do an analysis on telecommunication technology transfer and find problems that exist in the processes the industry use. Four postulates were formed. These are:

5.1.1. Level of education

Hypothesis: "Rural communities in South Africa are poorly educated and the situation is hindering technology utilisation." Without proper education the rural regions will always stay dependant on developed areas and sustainable development will stay a distant fairytale never to be realized. This is an area to which, not only the government should grant more attention and allocate more resources, but also one where the telecommunication industry should get more actively involved. The use of high-tech equipment can never clearly be explained to uneducated people. Telecommunication offers a number of advantages apart from a medium to keep in contact socially with friends and relatives. Without adequate education, people will never be able to grasp the opportunities and advantages made available through telecommunication.

5.1.2. Level of knowledge on telecommunication services

Hypothesis: "Service providers are not informing users enough on services, products and advantages." If people don't know how to utilize or don't understand advantages of a certain technology, the technology will never be effectively put to work to solve society's problems at a reasonable social and economic cost. Only when a rural citizen is aware of the possibilities vested within a technology can needs and aspirations be clearly expressed and defined.

5.1.3. Prioritisation of underserved rural areas

Hypothesis: "A means for prioritisation is needed to assist the telecommunication industry when doing network expansion." Any kind of rural network expansion is extremely expensive because of the remoteness and geographical profile of such areas. If guidelines can be set to prioritise regions according to differences in telephone use on the basis of specific economic and social characteristics of villagers before doing expansion, the investment can be done more effectively and to a higher level of need satisfaction for both the industry as well as the rural community.

5.1.4. Spending patterns of rural citizens

Hypothesis: "Rural communities spent money insufficiently, and the illiterate's priorities are incorrectly formed, this aspect limits their ability to make use of telecommunication technology's advantages." The rural communities have always had a different perspective about money and the way one should manage funds. People in underdeveloped regions have, for a long time, had no access to telecommunication services and a lifestyle was created where money in household budgets were spent unbalanced in the favour of regular entertainment (including liquor and gambling).

5.2. Sample Survey design

Since observations cost money, a design that provides a precise estimator of the parameter of interest for a fixed sample size yields a savings in cost to the experimenter. The objective of a sample survey is to make an inference about the population of interest based on the information contained in a sample [45]. The purpose of sample survey design is thus to maximize the amount of information for a given cost. The Sample survey design is concerned with the following aspects:

- Division of South Africa into regions
- Selecting the region for the field research
- Information gathering on the selected region
- Selecting a sampling technique
- Determining the sample size using the selected sampling technique.

5.2.1. Division of South Africa into regions

All the information on population density, expenditure, and educational level can be obtained at a magisterial district level. A magisterial district was, at the time of Census ’96, the basic administrative area, as determined by the Department of Justice. Census ‘96 [46] was a process of counting the number of people, living in South Africa during 1996, collecting information about their demographic, social and economic characteristics. The information collected was then processed, analysed and disseminated. South Africa (consisting of nine provinces) was divided into 365 magisterial districts. Existing information is available on a magisterial district level (as indicated in Figure 5.1) and this division was thus also used for dividing South Africa into researchable regions.

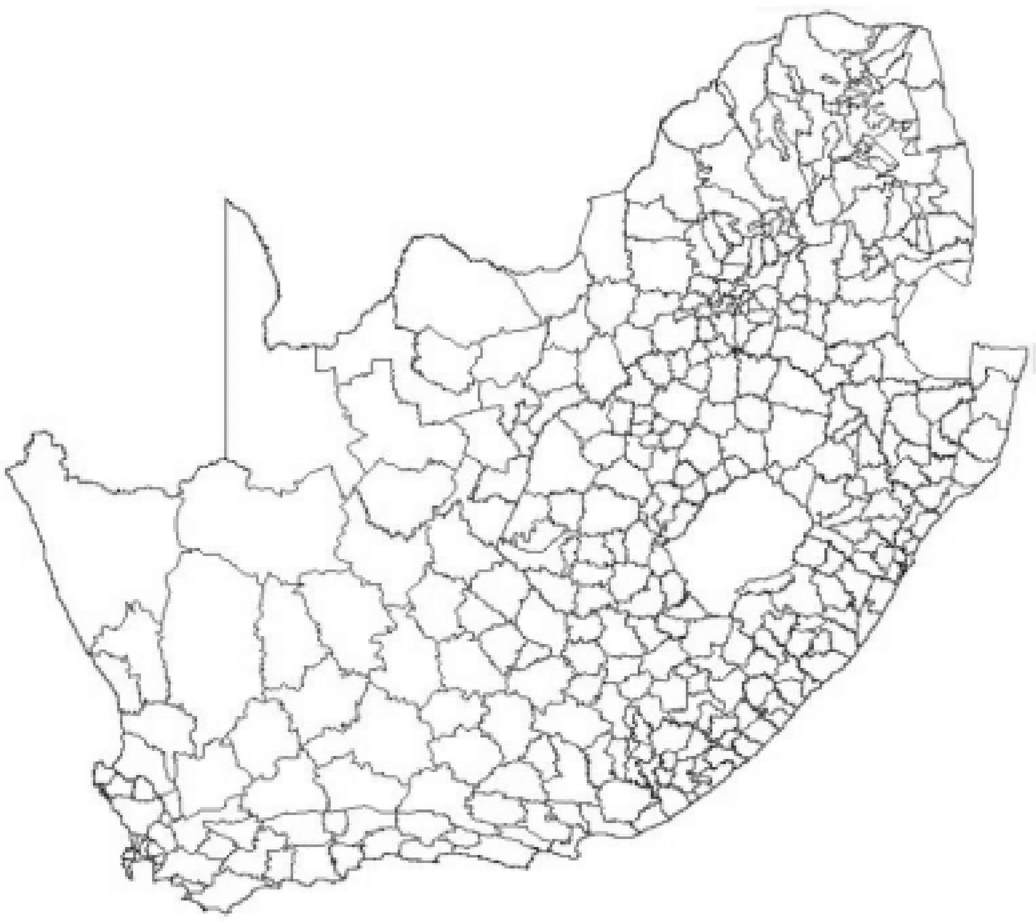

Figure 5.1. Map of South Africa divided into magisterial districts

5.2.2. Selecting the region for the field research

For the selection of a region to perform the field research, the rural areas have been prioritised on the bases of a survey done in Costa Rica [12] This criterion have been applied to the underdeveloped areas (regions with no/limited cellphone coverage) in South Africa when considering the coverage maps of MTN and Vodacom (mobile telecommunication service providers). Telkom is able to offer fixed-line telecommunication services anywhere in South Africa and was thus not used as a criterion. A short description of the survey done in Costa Rica [12] follows:

5.2.2.1. Rural Village Public Call Office Benefit Regression Analysis

In a survey done in Costa Rica in 1976 [12], a cross section of sixty-four villages in rural areas was taken and data gathered on public telephone use. The data came from an official government census, rural telephone traffic (collected by the national telecommunications entity), and survey data about individual telephone users compiled by telephone concessionaires.

Several models were specified and statistical regression estimated in which telephone traffic or telephone use variables were used as the dependent variable. It was hypothesized that if differences in telephone use could be explained on the basis of the different economic and social characteristics of the villages, then it would be possible to predict which village, then without service, would benefit most from gaining service. Those villages with a high potential to benefit would then be placed high on a priority list for new telephone investments.

The results of the regressions suggested that Public Call Offices benefits tended to be greater in rural Costa Rica villages possessing one or more of the following characteristics:

1. Per capita village income that is higher than the average of all other villages.

2. Villages with a relatively large population.

3. Villages located far from the major economic, social, and government centre of San Jose.

4. Villages with an educational level above average.

5. Villages were the population tended to cluster more around the site at which the telephone would be located.

These findings were applied to the magisterial districts of South Africa to select a region for field-research. The findings of the Costa Rica survey [12] were used to select an area for the field research. The Costa Rica findings were used as follow:

1. ***Per capita village income***

   Mainly, the following question arouses. Which information to evaluate? Income or expenditure? The Alderman's study (*Combining census and survey data to construct a poverty map of South Africa, Chapter 2* [47]) found that expenditure proved to be a more reliable measure than income in estimating economic well-being. Thus expenditure rather than income per household was used for evaluation.

2. ***Population density***

   For the evaluation of regions on the basis of population density, information from the Statistical department of South Africa (Stats SA) was used.

3. ***Villages located far from the major economic, social, and government centre***

   This criterion could be difficult and very time-consuming on a national level. Thus, the criteria can only be applied when a region is selected on the basis of the other criteria.

4. ***Level of education***

   For the evaluation of regions on the basis of educational level, information from Stats SA was again used.

5. ***Population tending to cluster more around the site at which the telephone would be located***

   This issue only becomes active after the installation of the public telephone and will therefore not be included as an evaluation factor.

5.2.2.2. Cellphone coverage in South Africa

Cellphone coverage is an abstract and also extremely important issue and is dependant on atmospheric conditions, building structures, one’s cellphone, topographical, and other factors. Whilst outdoor coverage using a hand held cellphone is generally assured in covered areas, indoor coverage is dependant on the type of building structure. The national cellular coverage maps for Vodacom and MTN are shown in Appendix H (MTN Coverage map) or [48] & Appendix I (Vodacom Coverage map) or [49], [50], and [51].

Hand held phones are usually 2 watt whereas boosters and car phones are usually 5 watt or 8 watt. Whilst 5 watt and 8 watt cellphones should operate in all coverage areas shown, hand held cellphones would operate in more than 90% of the coverage areas indicated [5].

5.2.2.3. Vodacom’s Coverage

Vodacom’s computer generated coverage map is shown in Appendix I (Vodacom Coverage map) or [49], [50], and [51] as on January 2001. In the blue inland areas (within South Africa) it should be possible to make and receive calls on the Vodacom network. Vodacom also guarantees 45 000 km^2 offshore coverage.

5.2.2.4. MTN’s Coverage

In January 2001, MTN's network covered in excess of 804 905 km2, equating to 66% of South Africa's geographic area, and providing cellular telecommunication access to more than 89% of the population [52]. In addition, some 90% of the coastline is provided with coverage, resulting in 75 000 km2 of service area at sea. The network also allows one to make calls along over 19200km of the national roads. The coverage for MTN is shown as yellow areas in Appendix H (MTN Coverage map) or [48].

5.2.2.5. Actual decision on the area for field research

When one uses the criterion as described above, the Magisterial Districts with the highest scores are Sekhukhuneland and Mokerong in the Northern Province of South Africa. These scores for each magisterial district is indicated in Appendix C. Sekhukhuneland was selected as the district for evaluation because of the geographical size of the district being smaller and thus easier to research. The magisterial district Sekhukhuneland is indicated in Figure 5.2. The relative position of Sekhukhuneland is indicated on the small South African map in the right bottom corner of the figure.

Figure 5.2. Sekhukhuneland in the Northern Province of South Africa

5.2.3. Information gathering on the Magisterial District Sekhukhuneland

Sekhukhuneland is a magisterial district located in the Northern province of South Africa as indicated in Figure 5.2. In Sekhukhuneland, the average household expenditure is R1 399.00. The population of 414790 people consists mainly of 99.09% African or Black people. The other 0.91% of the population in compounded as indicated in Figure 5.3.

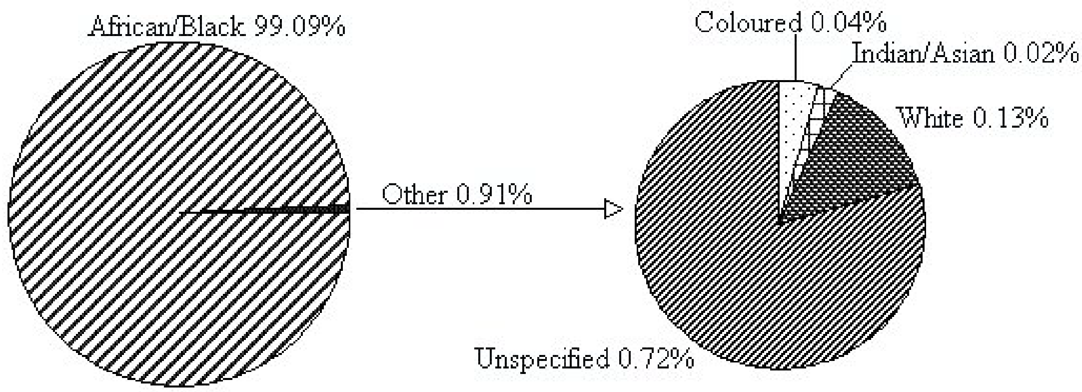

Figure 5.3. The Composition of Sekhukhuneland's 0.81% Non-African or Non-Black Population

During the period of the 6 to 11 February 2000, a serious disaster hit Sekhukhuneland when floods came down on the districts and many where left homeless [53].

Education in Sekhukhuneland

Various educational programs are available in Sekhukhuneland like the Jim Joel Foundation that commissioned JET to evaluate its Sekhukhuneland Educare Project [55]. This evaluation examines the impact of the training of teachers on the teachers' practice and knowledge, their centres, the children and communities.

The people living in Sekhukhuneland have the ability to contribute to the country's economy as two boys showed at the turn of the millennium. Ranti Mothapo beat everybody in South Africa at mathematics [56] when he achieved 100 percent (higher-grade) maths in the 2000 matric examination. Mothapo also scored 99 percent in accounting and 96 percent in physical science, achieved an A for biology and Sepedi and a B for English [56]. Another Sekhukhuneland achiever Mokgome Mogoba's marks showed that he had obtained 100 percent in science, 99 percent in accounting, 98 percent in maths and an A for English. He had Bs for biology and Sepedi.

Writing their matric in rural Sekhukhuneland's St Marks College, these two young men studied by candlelight for at least 10 nights during the examination because of a power failure.

5.2.4. Selecting a sampling technique

5.2.4.1. Sampling Techniques

The probability theory can reduce the chances of getting a non-representative sample and permit precise estimation in the likelihood that a sample differs from the population by a given amount. Probability samples furthermore enables one to calculate sampling error. Sampling error is the extent to which the values of the sample differ from the population from which it was drawn.

Many types of probability samples exist like simple random sampling, systematic sampling, area sampling, and stratified sampling [45]. For the purpose of the project: A

Model for Telecommunication Technology Transfer to the Rural Sector of South Africa, simple random sampling is an adequate sampling technique.

5.2.4.2. Sample size

Selecting a sample size should be done in such a manner that it represents the population from which it was drawn. A larger sample is more representative than a smaller one but deciding on an appropriate sampling size is unfortunately more complicated than this. There are five factors that influence the selection of the sample size. These factors are shown in Figure 5.4 and briefly discussed below.

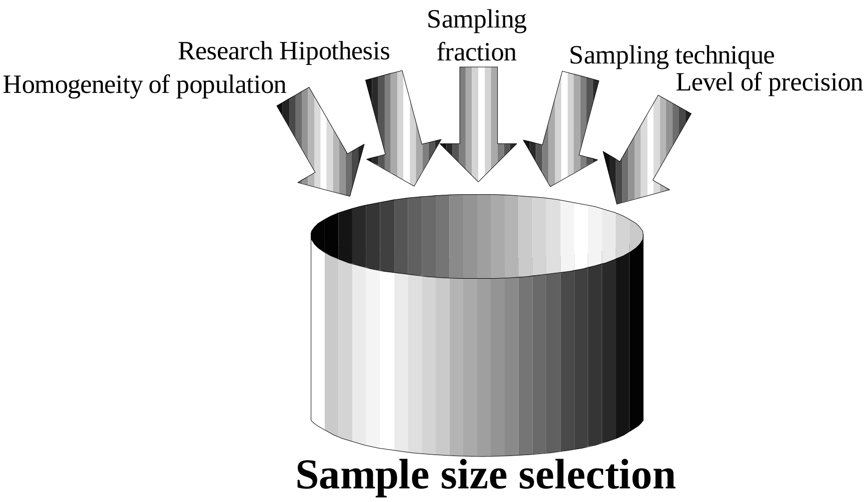

Figure 5.4. Influential factors when considering sample size selection

5.2.4.3. Research Hypotheses

A sufficient number of cases need examining for a specific research hypothesis. For example: A situation where 3 variables with 3 values each exist will have 27 possibilities in a cross tabulation form. Each possibility needs a minimum of cases (e.g. 100 cases generally considered as the bare minimum in the literature) for proper testing [45].

5.2.4.4. Level of Precision

The level of precision (the level of sampling error) one is willing to accept in a research is an important factor, which influences the sample size. In reality, the sample statistic is known but the population statistic is unknown. The question then is how the difference between the sample and the population value can be assessed. To answer this question, the assessment can be done in terms of the likelihood that a sample value differs from the population value. This is done by establishing a confidence interval, i.e. range in which it is fairly certain that the population value lies between [45].

Precision is directly related to the sample size so that larger samples are more precise. The probability theory enables one to calculate the sample size that would be required to achieve a given level of precision [45]. The level of precision thus enables one to say that for a specific research, chances are X percent that if all elements in the population have been surveyed using the same questionnaire, the finding would differ from these poll research findings no more than Y percentage points in either direction [57].

5.2.4.5. Population Homogeneity

The variability of the population to be samples is also a factor, which impacts on sample size. Unfortunately, most of the time researchers know little about the homogeneity of the target population. The probability theory accounts for this problem by assuming maximum variability in the population (i.e. 50% variability) [45]. Such estimates are of course conservative and will result in sample sizes larger than strictly needed for a given level of precision.

5.2.4.6. Sampling Fraction

Sampling fraction is the number of elements in the sample relative to the number of elements in the population (n/N). This can however be ignored with large populations [45] such as the one used for the project: *A Model for Telecommunication Technology Transfer to the Rural Sector of South Africa* as the sample fraction will constitute, by definition, only a small fraction of the population. For large samples, the research hypothesis, sampling error, and population homogeneity are the mostly sufficient to determine sample size.

5.2.4.7. Sampling Technique

Some sampling techniques like simple random sampling, area sampling, or stratified sampling can be used to conduct the sample size determination. Simple random sampling or stratified sampling are mostly used and will briefly be defined:

> ***Simple random sampling*** [45]***:*** If a sample of size n is drawn from a population of size N in such a way that every possible sample of size n has the same chance of being selected, the sampling procedure is called simple random sampling. The sampling thus contained is called a simple random sample.
>
> ***Stratified sampling*** [45]***:*** A stratified random sample is one obtained by separating the population elements into non-overlapping groups, called strata, and then selecting a simple random sample from each stratum.

Simple random sampling, the basic sampling design, often provides good estimates of population quantities at low cost. For the purpose of the survey in Sekhukhuneland for a *Telecommunication Technology Transfer Model*, there is very little data available on the different groups (e.g. urban and rural) existing within the district. When stratified sampling wants to be used, it is almost impossible to assure that a non-overlapping groups are defined because of the freedom all elements in the population have to move around.

It is however almost impossible (and economically totally non-viable) to conduct a perfect Simple random sample with a population of 414790 people when considering that very little information is available about permanent addresses of many. Thus, *An approximate* s*imple random sampling* technique will be used. This implies a convenience sample that is taken with the aim to cover the whole spectrum of people when considering their level of education. The evaluation of the sample size was done using the *Simple random Sample* technique.

5.2.5. Determining the sample size using Simple random sampling

At some point in the design of the survey, a decision about the size of the sample to be selected from the population must be made. Simple random sampling was used to determine the sample size here. The implications of such a decision are obvious. Observations cost money. Hence if the sample size is too large, time and talent are wasted. Conversely, if the number observations included in the sample is too small, we have brought inadequate information for the time and effort expended and have again been wasteful.

The number of observations needed to estimate a population mean μ with a bound on the error of estimation of magnitude B is found by setting two standard deviations of the estimator $\bar{y}$, equal to B and solving this expression for n. Thus, we must solve:

$$2\sqrt{V(\bar{y})} = B \qquad \textbf{(5.1)}$$

With

$$V(\bar{y}) = \frac{\sigma^2}{n}\left(\frac{N-n}{N-1}\right) \qquad \textbf{(5.2)}$$

Hence, the sample size required to estimate μ with a bound on the error of estimation B is:

$$n = \frac{N\sigma^2}{(N-1)D + \sigma^2} \qquad \textbf{(5.3)}$$

where

$$D = \frac{B^2}{4} \qquad \textbf{(5.4)}$$

If N is large (N>1000), as is the case for this survey, the (N-1) can be replaced by N in the denominator of equation 5.3. This approximation will then yield:

$$n = \frac{4N\sigma^2}{NB^2 + 4\sigma^2} \qquad \textbf{(5.5)}$$

Solving for n in a practical situation presents a problem because the population variance σ^2 is unknown. A method for guessing a value of variance σ^2 when very little prior information is available is needed. Based on the normal approximation theory, an acceptable procedure to follow is to estimate the standard deviation by taking one sixth of the range, that is the difference between the largest and the smallest values [57].

$$\hat{\sigma} = \frac{Maximumvalue - Minimumvalue}{6} \qquad \textbf{(5.6)}$$

For this survey, the level of education plays the most important role in determining the area that will benefit most from a new telecommunication system. Another important aspects namely income (expenditure) is correlated to level of education when one assumes that racial discrimination does not play an active role. Education was thus used as the main criterion for evaluation here. The problem that needs to be evaluated here can be seen as follows:

It is necessary to establish the average level of education μ for the population of the magisterial district Sekhukhuneland in the Northern Province of South Africa. To estimate the level of education variance σ^2, it is known that the population's level of education can be measured in years of educational experience. A certain amount of years are then associated with each qualification as indicated in Table 5. 1**.**

Highest qualification	**Associated years of education**
Grade 0	1 year
Grade 1	2 years
Grade 2	3 years
Grade 3	4 years
Grade 4	5 years
Grade 5	6 years
Grade 6	7 years
Grade 7	8 years
Grade 8	9 years
Grade 9	10 years
Grade 10	11 years
Grade 11	12 years

Highest qualification	**Associated years of education**
Less than matric & certificate/dip	13 years
Grade 12 or Matric only	13 years
Matric & certificate	14 years
Matric & diploma	15 years
Matric & Bachelors degree	16 years
Matric & Bachelors & diploma (dip)	17 years
Matric & Bachelors & honours	18 years
Matric & Masters degree	20 years
Matric & Doctors degree	24 years
Matric & Other qualification	14 years
Unspecified	no education

Table 5. 1. Years of education associated with qualifications

When the population's level of education lie within a range from 0 to 24 years, an estimate of σ^2, the population's level of education variance can be made through the use of equation 5.6 repeated here for convenience:

$$\hat{\sigma} = \frac{Maximumvalue - Minimumvalue}{6}$$

Thus:

$$\hat{\sigma} = \frac{24 - 0}{6}$$

$$\hat{\sigma} = 4$$

There are N = 414790 elements (people) in the population of Sekhukhuneland. The sample size can now be calculated to estimate μ with a bound on the error of estimation B = 6months or ½ a year (2.083% thus 97.917% accurate) through the use of equation 5.5 again repeated here for convenience:

$$n = \frac{4N\sigma^2}{NB^2 + 4\sigma^2}$$

$$n = \frac{4 \times 414790 \times 4^2}{(414790 \times 0.5^2) + (4 \times 4^2)}$$

n = 255.84 ~ 256

5.3. Taking precautions to assure reliability of the collected data

As Sekhukhuneland is a typical rural region of South Africa and perfect Random Sampling is almost impossible one should try to obtain results as accurate as possible. The level of education was used as the most important variable and also to calculate the sample size earlier. The level of education for the population of Sekhukhuneland is therefore shown in Table 5. 2. To make a representative survey of Sekhukhuneland, the number of questionnaires that needs to be filled in should correlate to Stats SA's data to the same percentages for citizens in each group. For this purpose the needed questionnaires at each level of education are indicated in the right column of Table 5. 2.

Education			
Maximum educational level obtained	**Number of people**	**% Of Sekhukhuneland's population**	**Questionnaires needed**
No schooling	138204	38.62%	99
Grade 0	191	0.05%	0
Grade 1	1409	0.39%	1
Grade 2	2862	0.80%	2
Grade 3	11411	3.19%	8
Grade 4	21751	6.08%	16
Grade 5	19882	5.56%	14
Grade 6	18819	5.26%	13
Grade 7	23173	6.48%	17
Grade 8	22979	6.42%	16
Grade 9	18088	5.05%	13
Grade 10	19539	5.46%	14
Grade 11	21629	6.04%	15
Less than matric & certif./dip	802	0.22%	1
Matric only	20688	5.78%	15
Matric & certificate	305	0.09%	0
Matric & diploma	3109	0.87%	2
Matric & Bachelors degree	432	0.12%	0
Matric & Bachelors & diploma	84	0.02%	0
Matric & Bachelors & honours	18	0.01%	0
Matric & Masters degree	11	0.00%	0
Matric & Doctors degree	10	0.00%	0
Matric & Other qualification	232	0.06%	0
Unspecified	12225	3.42%	9

Table 5. 2. The level of education of the population of Sekhukhuneland

Questionnaires were created to test certain aspects of rural South Africa on the basis of the Telecommunication Technology Transfer Model defined in Chapter 4. An example of the questionnaire is shown in Appendix D. Qualified personnel asked the questions and interpreters were often used. The interviewer then also filled in the answers by the interviewee on the questionnaire. The research was done using 258 questionnaires over a period of 10 days during July 2001.