Locating a dairy plant in the Western Cape of South Africa

From a transport cost minimization point of view

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Preface

This report is the result of an MSc thesis at the Business Economics Group at the Wageningen University and Research Centre in collaboration with the Landbou Ekonomie Group at the University of Stellenbosch. I would like to thank the cooperation of experts from different companies and institutions who provided information for its fulfilment. Specifically, the SSK for the information provided in particular, Casper Swart for his cooperation. I appreciate the supervision work carried out by: Dr Miranda Meuwissen, Dr Theo Kleynhans and Mnr. Neil Jacobs. Their supervision made this report as it is.

Thanks to the friends I made during my stay in South Africa, who did way these four months unforgettable. Specifically, the effort carried out by Ms. Noa Simon Delso was essential for the fulfilment of this study.

Thanks for the dearest friends I made during my study in Wageningen and to my dearest friends in Blokzijl, they really motivated me to carry out two years of MSc. I am glad to say that I have a lot of precious friendships to be thankful for.

Finally, I would like to thank my family in particular,r for their support during the periods of my life. I would have never reached where I am without them.

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Summary

There is a world tendency to milk shortage, which can also be seen in the South African situation. South African retailers import a lot of dairy products and import increases of specialised products like SMP (skim milk powder) and WPC (whey protein concentrates) are expected in the coming years. Currently, milk and whey powder sector is still not very developed in this country, forcing to cover demand with imported products. The future challenge is to develop a dairy factory dealing with such products in South Africa going alternatives to add value to milk.

SSK (Sentraal-Suid Koöperasie) is a cooperative that provides services for farmers in the regions of Swellendam and Heidelberg (Western Cape, South Africa). Lately a demand of adding value to milk has been noticed in its area of influence, reason why the cooperative intends to develop a plan to build a milk processing factory. Swellendam and Heidelberg has been the chosen locations to build up this milk processing factory. The challenge of this study is to examine the total transport costs of collecting raw milk from dairy farms and decide, which of them is the best option from a transport costs minimization point of view. Other research questions are: Which areas could be added to expand the collection area? What cost factor is the most determent one concerning the two locations and which location is most sensitive concerning future developments?

Several categories have been reported as important in selecting locations for a new plant. Infrastructure has been found as critical in locating food processing plants, in particular for milk processing plants. For instance, for milk processing plants, appropriateness of raw milk is less important than availability of raw milk supplies. Therefore, distance in the collection of the raw material is an important element. Travel distances depend on the locations, and starting and ending point of routes. Routing is translated into costs and considered to be modifying to determine the location with the minimum transport costs for collecting the raw milk.

The area is classified in several road types, each of them with specific average speeds. Milk producers that could supply milk to a new milk processing plant are located in service area from the SSK. In order to expand the milk collection area, two more potential areas are considered of interest. Standard procedures with a certain amount of time are considered to

assemble raw milk from dairy farms to a dairy factory like emptying and cleaning a milk tanker. Two types of trucks are used in the model; a five axle combination of 27 Tons volume and a seven axle combination of 34 Tons volume. Additionally equipment is needed for milk tanker, as a filling pump and milk sampling equipment. Basic salary was used for 9 hours per day, while overtime rates were calculated at 150% base salary. Drivers could work a maximum of 12 hours per day. Raw milk is collected daily to guarantee good milk quality.

Farms are mapped, distances to both destinations are measured and farms clusters are visually made by Mapsource®. Spreadsheet is used to calculate the time needed for each collection route. Routes are made and compared to each other, selecting for the model those with the shortest collection time and transport distances, and the milk volume that most efficiently use the volumes of the trucks. For each location, a combination of routes is made with a maximum travel time of 16 hours per combination and with a similar amount of collected milk per route. For each combination one milk tanker is fit to the concerning combination. The amount of km per combination are calculated and multiplied by the related annual variable costs per km then the annual fixed costs of the trucks and the additional equipment were counted up. All combinations are compounding and spare tankers are added to the model to substitute the trucks that need to undergo maintenance. A sensitivity analyses is implemented to study the effect of increasing fuel and salary costs, and decreasing interest rate.

As a result Heidelberg is the best location from a transport costs minimization point of view. Riversdale is the best potential option to expand the collection area. The variable costs per km and the costs of labour concerning overtime are most modified for this model. Swellendam is less sensitive to future developments like fuel and salary price increases.

Recommendations for further research would be to achieve a better interaction between science and milk transport industry. Furthermore, further research could focus more on the quality of raw milk and the impact of increasing the collection area. Finally, further studies could focus on the possibilities and implications to develop a training centre for truck drivers.

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1 Introduction

Dairy industry

The world market of the dairy industry has been turbulent over the past year, with both milk prices and international demand increases. As a result, there is a world tendency to milk shortage. Dairy markets in India, China and Australia share a growing trend in dairy product consumption (Maas, Pers. Com.; Winters, Pers. Com.), introducing opportunities for milk production and processing expansion.

During the last two years, there has also been a shortage of milk on the dairy market of South Africa. Both production and consumption increased in this country with respect to the previous year, the former being 2.32 and 2.42 billions litres of milk in 2005 and 2006 respectively (this production excludes milk retained on the farm). Milk consumption was 2.34 and 2.44 billions litres in 2005 and 2006 respectively, which results in a shortage of 0.02 billion litres of milk in 2006. Coetzee *et al*. (2007) described an expected shortage of 0.11 billion litres of milk in 2007 with a rise in consumption, while growth of the milk production was expected to decrease.

South African retailers import a lot of dairy products (Maas, Pers. Com.). These dairy products are mainly milk, cream, buttermilk, yoghurt, and milk and whey powders, which prices are lower in comparison with the domestic ones. Therefore, the South African dairy industry must compete against import prices of dairy products (Kleynhans, 2006). Furthermore, an increase of 1% to 3% is expected in the coming years for specialised adding-value products, namely SMP (Skim Milk Powder), WPC (Whey Protein Concentrates) and FCMP (Full Cream Milk Powder) (Maas, Pers.Com.). Currently, the milk and whey powder sector is still not very developed, forcing to cover demand with imported products. For these reasons the future challenge is to develop a dairy factory dealing with such products in South Africa in order to create alternatives to add value to milk.

SSK

SSK (Sentraal-Suid Koöperasie) is a agricultural cooperative that provides services for farmers in the regions of Swellendam and Heidelberg (Western Cape, South Africa; Appendix II). Its agricultural section includes a dairy, arable and agricultural economics department. They also promote the interests of farmers-members of the cooperative, interacting with them in order to gain insight in their demands like anticipating on market developments. Consequently, a demand of adding value to milk has lately been noticed, reason why the cooperative intends to develop a plan to build a milk processing factory in their service area.

Service area

The SSK's service area is extended to the borders of the regions Swellendam and Heidelberg (Appendix II). The cooperative has a historical bond with Swellendam and Heidelberg and a social responsibility to help and create more jobs for their habitants. Therefore, either Swellendam or Heidelberg has been the chosen locations to build up this milk processing factory. These two districts account with a rather high milk production density within the Western Cape, with 80.7 and 88.6 litres per km^2 for Swellendam and Heidelberg respectively (Coetzee *et al*. 2007).

Facility location planning

Travel distance between farm location and dairy processing plant plays a major role when evaluating a location, since the cost of material handling is often directly proportional to this distance (Francis *et al*., 1992). Travel distances are translated into costs, being of great importance to minimize them. That is why the approach of this facility location problem has been done from a transport costs minimization point of view. From a cost minimization point of view it is expected that number, size and location of milk processing facilities is critical (Conner *et al*., 1976). Costs of raw milk collection, specifically, contribute significantly to the ultimate determination of optimum number, size, type and location of milk processing facilities.

Current situation

Currently 10 dairy factories belonging to national and multinational dairy companies collect raw milk from the service area of the SSK as shown in table 1. From those companies, Parmalat has the largest share in this area. 45% of the milk producers in the service area were interested to get involved in a new dairy processing plant and to sell their milk to another milk buyer. Furthermore, many milk producers showed sympathy to the idea of changing to another milk buyer if they receive more money for their milk (SSK, 2007).

Table 1. Current milk buyers with the number of milk producers in the service area (SSK, 2007).

Milk buyer	**Number of milk producers**[a]
Parmalat	57
Nestle	9
Ladismith Kaas	9
Butlers	1
Morning milk	2
Vasco Cheese	2
Mooivallei	2
Fair Cape	1
Samelko	1
Clover	1
Total	**85**

a Based on 45% of dairy farms in the service area of the SSK

Objective[1]

The aim of this MSc thesis is to examine two different locations from a transport cost minimization point of view, answering the following questions:

- What are the total transport costs of collecting raw milk from dairy farms to the location Swellendam and to the location Heidelberg?
- What potential areas could be added to expand the collection area if larger amount of raw milk is needed and what are the influences concerning transport costs for Swellendam and Heidelberg?
- What is the most important cost factor regarding the determination of the location?
- What location is most sensitive concerning future developments?

Outline of thesis

This MSc thesis is built into four different chapters, which start describing the South African situation in order to make a presentation of the country and its dairy sector. Secondly, existing literature regarding location problems and how to handle them has been reported as an introduction to the material and methods used in the development of the present study. Finally, the results have been reported followed by the discussion and conclusions.

[1] At first, the objective of this MSc thesis was to make a comparative market analysis of milk components between the Netherlands and South Africa. Due to the difficulty of gathering information about the Dutch ingredient market and specially the South African ingredient market, the objective has been changed into the current objective.

2 Situation in South Africa

2.1 General view of South Africa

South Africa has a surface of 1,221,037 km^2 (29 times The Netherlands) and is divided into nine provinces. It is a warm, sunny and in general mainly a dry country. Its summer period corresponds with the winter period of the northern hemisphere, being the time of the year with large rainfall. More to the western part of the country, the rainfall is more divided during the year. The temperature is on average 20^oC during the summer and on average 10^oC during the winter.

Gross domestic product (GDP) of South Africa was forecasted to be 256.7 milliard US dollars in 2007. The agricultural sector contributes 2.7% to the GDP, which is for 41% due to the dairy industry (EVD, 2008). With a production of 2,970,965 kg cow milk in 2006 (FAOSTAT, 2007), South Africa is the third largest milk producer in Africa.

2.2 South African dairy chain

The South African milk market is divided into a formal market and an informal market. In 2006, the latter had a contribution of the total milk market of 3%; this market is used by small farmers to sell the produced milk that is not used for own consumption. This not controlled informal market is most common in poor areas, like townships and rural areas. 8% of the milk market was used for own consumption and calves (Coetzee *et al*, 2007; Kleynhans, Pers. Com.). In 2006, 89% of the produced milk was directed to the formal market; reaching the milk processing industry, which consists of a few large processors operating nationally and a large number of small processors who operate in specific areas.

The dairy industry has 864 milk processors, from which 444 produce their own milk and distribute it directly to the retailers or consumers. The remaining 420 milk processors buy the milk from milk producers and process it into dairy products (Coetzee *et al*, 2007).

The retail sector is dominated by two main companies: Shoprite Checkers and Pick & Pay. They share 75% of the retail market. The size and buying power enable them to obtain local and overseas products at significantly reduced prices. Consequently, this leads to a situation where it is hard for other retailers to compete with them. Besides, small and medium sized dairy processing companies are excluded from obtaining shelf space from these retailers. This is a result of shelf space payment requirements, return policy and payment policy. (Kleynhans, 2006)

2.3 South African dairy farming

In South Africa, managing of dairy farms can be distinguished in two different systems: pasture based and dry based systems. The formers use irrigation to increase pasture production by grazing. Dry based systems are based on a total mixed ration, which is fed outside or inside a shed. These systems are mainly situated on sandy areas with no possibilities for grazing (Blanckenberg, Pers. Com.; Stevens, 2007).

In the last ten years, the number of milk producers has declined by 45% and it continues to decrease. However, the production per producer has increased 66% in the same period. Annual milk production has increased over time, but this has been at a lower rate (10%). The consumption of dairy products in South Africa has grown due to the rise in consumers, personal incomes. The expected rate of increase in milk production is lower than the expected rate of increase in consumption. Therefore the current shortage of milk, abovementioned is forecasted to grow in the coming years.

Conventional products like milk and cream, yoghurt and other fermented products, and cheese share already a mature position at the market as shown in table 2. Functional products are a minority and are mainly imported. Potential growth for South African milk ingredient market is expected to be 1% to 3% for some of the companies operating within the South African ingredient market (Maas, Pers. Com.).

Table 2. Production, consumption and trade of milk and dairy derivates (kg) in South Africa during 2006 (Joubert, 2007; Trade map, 2007).

Products	**Production 10^3 Tons**	**Consumption 10^3 Tons**	**Import 10^3 Tons**	**Export 10^3 Tons**
Liquid milk and cream	807.2	-	4,9	9.9
Special milks[a]	-	-	4.5	0.9
Yoghurt	117.5	-	0.03	4.5
Cheese	89	-	4.5	1.5
Cheddar	27.7	-	n.a.	n.a.
Gouda	16.4	-	n.a.	n.a.
Butter	3.4	-	3	0.6
Buttermilk (powder)	2.5	-	1.5	0.5
Butteroil (AMF[b])	0	-	0.2	0.2
Full fat milk powder	14.6	-	3	2.5
Skim milk powder	12.3	-	5.8	1.5
Whey powder	10.1	-	12.5	2.4
Demineralised whey	-	7	0.4	n.a.
Lactose	-	7	7.5	0.1
Casein and caseinates	-	2.9	2.9	n.a.
WPC[c]	-	2.1	2.1	n.a.
MPC[d]	-	0.01	0.01	n.a.
Liquid whey	1.2	n.a.	n.a.	n.a.

a Includes preparations of cereals, floer, starch/milk for infant use.

b Anhydrous milk fat.

c Whey powder concentrates.

d Milk powder concentrates.

n.a. not available

3 Literature review

This study focuses on the calculation of transport costs to assembly raw milk in order to decide the best possible location of a processing factory between two possibilities: Heidelberg or Swellendam (Western Cape, South Africa; Appendix II). Literature regarding location problems has been reported as an introduction to the material and methods. Transport is not the only factor to consider in facility location problems. Other factors are known and described in the following section.

3.1 Facility location

There are several approaches to facility location problems, which can be categorize into two classifications, i.e. qualitative and quantitative. The latter is described in the next section. The former carries out a qualitative analysis of the factors influencing the location decision between different options. A widely known problem is selecting a location for a new plant. There are several factors which influence this decision and the analysis needs to involve a comparison of these factors in a discriminative way. Selecting a location of a new plant is a challenging problem and the identification of several factors can be of big influence (Sule, 2001).

After factor identification, they should be ranked. In most discussion of ranking factors, their costs play a very dominant role. The ultimately objective of any business is to provide goods or services at a profit, the site that can minimize the operational costs and, at the same time, satisfy other subjective criteria would be a natural choice. In this way, the quantitative approach is an important approach for evaluating factors that will influence the final decision (Sule, 2001). For example, use of sensitivity testing to solve transportation problems to locate beef slaughter plants (Toft *et al*. 1970). However, different factors have to be determined before evaluating them.

Different factors were determined by different researchers. The importance of these factors was dependent on what kind of facility has to be located, how large is the facility and in which area would it be located. To show these concepts, an example regarding poultry processing firms can be considered in which environmental factors are the most important ones, like the availability of waste treatment, the availability of disposal facilities and wastewater disposal costs (Carpentier *et al*., 2004). Taking the example of an ambulance location problem, factors within an infrastructure category are critical like the average response time to emergency calls and reducing citywide inequities in ambulance availability (Rushton, 1989). Infrastructure factors are also of importance in locating food processing plants. Turhan *et al*. (2007) and Stegelin *et al*. (1997) examined infrastructure for food processing plants as an important category within six categories:

- Market
- Infrastructure
- Raw material
- Labour (qualified)
- Personal
- Environmental

Carpentier *et al*. (2004) determined 7 categories, where a fiscal category was added to the previously mentioned ones. However, all of them found for food processing plants infrastructure as the most important category within these categories. More specifically, in locating milk processing plants infrastructure is also the most important category (Carpentier *et al*. 2004).

3.2 Infrastructure

Different categories are used to divide factors within facility location. Nonetheless, as already mentioned, infrastructure is the most important category in determining food processing plants. Besides, Turhan *et al*. (2007) found the same important category for milk processing plants. Infrastructure is divided into factors, which depend on the area where the facility could be located. In Georgia, Stegelin *et al*. (1997) found different factors of importance for locating food processing plants ranked as follows, starting with the most important ones:

- Availability and quality of water
- Cost of property and real estate
- Availability and cost of electricity
- Availability and cost of waste treatment and waste disposal facilities
- Availability of ground transportation (truck and rail services)
- Availability and cost of natural gas
- Construction costs

However, availability of an existing facility was determined as the most important factor affecting location decisions for food-processing plants in the Mid-Atlantic States, United States (Carpentier *et al*. 2004) and in the South Marmara Region, Turkey (Turhan *et al*. 2007). Other factors for locating milk processing plants are:

- Proximity to markets
- Availability and quality of water
- Availability of raw agricultural supplies.

3.3 Routing

Firms make strategic choices about location factors, where to locate the food processing plant is a critical decision in managerial economics and transportation is an essential component of this decision. A food processing plant has to be located close to the agricultural raw material or close to the market for finished goods. This decision depends on the characteristics of the agricultural raw material and its transformative process, as well as on the costs and availability of transportation services. For milk processing plants, appropriateness of raw milk is less important than availability of raw milk supplies because it has to be standardized before process can take place, due to its structural characteristics (Turhan *et al*., 2007).

The concept of distance is a basic element in the formulation of location problems. Consider approaches for distance measurement in a short and a long distance measure. Former is a straight-line distance between two points. A long distance measure refers to movement along different paths between such points. There can be two different paths with the same distance. For example, one of which requiring more time, due to influences, like road type. Travel distance plays an important role in evaluating facility layouts, since the cost of material handling is often directly proportional to travel distance; the longer a material handling transport, the larger it costs. Travel distances depend on locations, and starting and ending points of routes (Francis *et al*, 1992).

Consequently, for these routes it has to be noticed that these dependences are depending on different route designs that has to be taken into account. Sule (2001) pointed about tour development that truck routing problems deal with different limitations, namely:

- Territory over which the truck has to operate
- Load type and equipment required for such loading or unloading operation as part of the truck
- Truck capacity in weight and volume
- Maximum number of stops desired on a route
- Maximum travel time or mileage that should be allowed
- Any federal, state, or local requirements

In summary, this study focuses on the infrastructure of this location problem. Therefore, routing is translated into costs and considered to be modifying to determine the location with the minimized transport costs for collecting the raw milk. Former categories described, such as environmental and personal, are considered to be less relevant for locating a milk processing plant.

4 Material and methods

4.1 Material

Area

The research area has a width of 140 km and a length of 70 km. The elevation varies from 2 to 1,400 meters above mean sea level which influences the average speed on certain roads. The average speed is determined in accordance with the possibility of a truck. The roads at the studied area can be classified in four different types (table 3); untarred road, minor tarred road, major tarred road and highway (Jacobs, Pers. Com.; Haasbroek, Pers. Com.). Although Haasbroek (Pers. Com.) classifies the roads in four different types, the average speed differs for each type compared to those described by Jacobs (Pers. Com.); roads are classified with an average speed of 35 km/h, 40 km/h, 70 km/h and 76 km/h respectively. Other authors classify roads in three different types, namely gravel road, 2nd tarred road and major National road, with average speeds of 60 km/h, 95 km/h and 95 km/h respectively (Butler, Pers. Com.).

Table 3. Relevant road types and average speed.

Road type	**Average speed (km/h)**
Untarred road	20
Minor tarred road	30
Major tarred road	40
Highway	55

Source: Jacobs (Pers. Com.), Haasbroek (Pers. Com.)

Milk producers

A questionnaire (Appendix I) was designed by the SSK to gain insight into the producers' opinion regarding the establishment of an alternative milk buyer at the areas of Montagu, Bredasdorp, Swellendam, Heidelberg and Riversdale situated in the Western Cape (Appendix II). The 5th of October 2007, 187 questionnaires were sent to milk producers, from which 85 farms answered. It contained questions related to the following points:

- Interest in another dairy processing plant
- Current milk production level per day
- Current number of milking cows
- Expected number of cows in the next coming 5 years
- Distance to the current milk buyer
- Current milk buyer

All the 85 milk producers were interested in another milk processing plant, therefore all these farms are of interest for this study. Current total milk productions per day and number of milking cows were used to calculate the production per cow. Dairy farms were also asked if they had plans to increase their farms in the future and how many milking cows they expected to have in the future. Based on the current milk production per cow and the expected milking cows in the future, an estimation of the future milk production was calculated.

In future perspectives, another 55 farms could be included from the areas Swellendam and Heidelberg, as shown in table 4. The current milk production level per day has been estimated from these farms (Swart, Pers. Com.). The 85 dairy farms which responded to the questionnaire of the SSK plus the added 55 dairy farms would be all potential milk suppliers for a milk processing plant in this area.

Table 4. Farms situated in the different areas included in the research.

Description	**Number of farms**
SSK survey in area: Montagu, Bredasdorp, Swellendam, Heidelberg, and Riversdale[a]	85
Remaining farms in the region Swellendam and Heidelberg[b]	55
Extra farms in the area Bredasdorp[c]	30
Extra farms in the area Riversdale[d]	38

a SSK, 2007
b Swart (Pers. Com.)
c Laubscher (Pers. Com.)
d Burger (Pers. Com.)

If a milk processing plant would be built in Swellendam or in Heidelberg, two potential areas could be of interest if more raw milk is needed because these two areas are closely situated to the central areas regarding Swellendam and Heidelberg (Appendix II). Therefore two potential areas are added (Laubscher, Pers. Com.; Burger, Pers. Com.) Bredasdorp includes 30 potential dairy farms (Laubscher, Pers. Com.) and is east located to the area of Swellendam. Riversdale includes 38 potential dairy farms (Burger, Pers. Com.) and is situated on the Westside from Heidelberg. From these milk producers the current amount of cows has been estimated by Laubscher (Pers Com.) and Burger (Pers. Com.). Data extracted from MPO (2007) registered an average milk production of 15 litres per cow per day in these two areas (Bredasdorp and Riversdale). Milk production per farm has been calculated based on the estimated amount of cows and the average milk production per cow per day of these two areas.

Distances

The current average distance milk producer – milk buyer from the dairy farmers who responded on the questionnaire has been investigated, as well as the average distance from the milk producers to the location Swellendam and from the milk producers to the location Heidelberg (table 5). The average distance of the replying dairy farms to the current milk buyer is on average 87 km within a range of 16 till 260 km (SSK, 2007). The average distances to Swellendam or Heidelberg are almost equal; respectively 46 km and 45 km. Likewise, the range around the two locations are 3 to 96 km for the Swellendam location and 1 to 98 km for the Heidelberg location. Distance calculations have been done with Mapsource® (version 6.5). If raw milk would be transported from the replying milk producers to the location Swellendam or to the location Heidelberg, the average distances would be shorter in comparison with the average distances of the current collection of raw milk.

Table 5. Distances (average, min, max) from farms to factories.

			Range (km)	
	N	**Average distance (km)**	**Min**	**Max**
Current dairy factory[a]	85	87	16	260
Swellendam[b]	85	46	3	96
Heidelberg[b]	85	45	1	98

a SSK , 2007

b Based on Mapsource®, version 6.5

Collection time

Butler (Pers. Com.) and Haasbroek (Pers. Com.) described standard procedures for raw milk collection, which are the following:

1. Arrival at the farm and situate the milk tanker in front of the storage tank. The time required to do so depend on the accessibility of the farm yard.
2. Connection of milk tanker to storage tank at the farm.
3. Stirring of raw milk in storage tank. The time required to stir is an obligated procedure with a fixed amount of time.
4. Temperature and visual control. Temperature and visual control can be done while stirring the storage tank.
5. Take a milk sample from the storage tank.
6. Filling of milk tanker. Time required to empty the storage tank depend on the amount of litres stored in the storage tank.

7. Record the amount of raw milk collected.
8. Disconnection of milk tanker from storage tank at the farm.
9. Departure from farm, the time to do so depends on the accessibility of the farm yard.
10. Emptying milk tanker at dairy factory. The time required to do so depend on the pump capacity and the amount of litres stored in the milk tanker.
11. Cleaning milk tanker. Is done followed by a Clean-In-Place (CIP) program.

Table 6 gathers time specifications for these procedures. As shown, some procedures are combined because they can be carried out during the same time. Some other procedures need some more clarification. The storage tank has to be stirred for 5 minutes before carrying out an alizarol test. This is done to analyse and evaluate the quality of raw milk in terms of its protein stability. Regulations related to milk transport a milk tanker driver has to carry out an alizarol test (68 percent alcohol) on a sample of the milk to be loaded. When milk is treated with a solution of alizarin in 68% alcohol, the coloration of the mixture gives an indication of the existence of fermentation if any, that has taken place in the milk, for example acidification of milk (Morres, 1911). Furthermore, a driver has to control the temperature of the milk in the storage tank. If the alizarol test is positive and the temperature exceeds 5^{o}C, the raw milk should not be accepted for transport (Regulations, 2002).

Table 6. Time needed for the different procedures regarding collection of raw milk from a dairy farm.

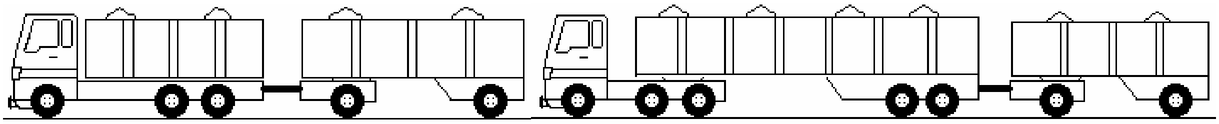
Procedures	**Time (minutes)**
Drive in front of storage tank and connect tanker to storage tank	4
Stir storage tank plus temperature and visual control	5
Take a sample from storage tank	1
Fill tanker (pump capacity)	500 litres per minute
Disconnect	2
Empty tanker at dairy factory (pump capacity)	500 litres per minute
Clean tanker at dairy factory by Clean-In-Place (CIP) system	30

Source: Butler (Pers. Com.); Haasbroek (Pers. Com.)

Trucks

There are three different truck types used for transport of raw milk in South Africa (Jacobs, Pers. Com.; Butler, Pers. Com.; Haasbroek, Pers. Com.). One of them is only used to transport raw milk among different factories, reason why it is not used in this model. The remaining two truck types have a capacity of 27 and 34 Tonnes respectively as shown in figure 1. Technical characteristics are further described in table 7. For the model, no restrictions have been made for the number of trucks necessary. Data used, as shown in table 7, are benchmarks used by the transport industry in South Africa (Road Freight Association, 2007). Their annual fixed costs consist of: cost of capital, depreciation, insurance, overheads and licence. Variable costs consist of: fuel, lubricants, maintenance and tyres. Milk tankers are used 16 hours per day, starting at 05:00 in the morning till 09:00 in the evening. In South Africa night collection is not frequent (Butler, Pers. Com.). Milk producers do not want to have any trucks at their farm yard to avoid strangers. Besides, the storage tank needs to be cleaned after emptying and farmers prefer to do it during daylight.

Figure 1. Two truck types used with a capacity of 27 and 34 Tonnes respectively.



In general, tankers can be used for 260 days annually (Road Freight Association, 2007). More specifically milk tankers are used for 330 days annually, being the remaining 35 days used for annually service (Jacobs, Pers. Com.; Haasbroek, Pers. Com.). Milk tankers need additionally a filling pump and milk sampling equipment. In the market, filling diesel pumps exist with a capacity of 20,000 to 30,000 litres per hour (Olivier, Pers. Com.). The investment costs of the pump are 40,000 to 50,000 ZAR, respectively, with a depreciation calculated in 5 years and a salvage value from 20 to 30%. Electric pumps used for the collection of raw milk have a capacity of 30,000 litres per hour (Haasbroek, Pers. Com.). Investment costs are 80,000 ZAR, with 5 years depreciation and no residual value. Nowadays milk tankers use usually the second ones. Sampling equipment cost 500 ZAR which is depreciated over 5 years with no salvage value.

Table 7. Volumes and costs of two different truck types used for the collection of raw milk in South Africa (Road Freight Association, 2007).

Truck type		**Five axle combination 6x4 rigid + 2 axle trailer**		**Seven axle combination Five axle artic + 2 axle trailer**
Volume (litres)		27 Tons		34 Tons
Cost price total combination (excl. VAT)		989,520		1,277,923
Prime mover	811,790		922,225	
Trailer(s)	177,730		355,698	
Total annual fixed costs (ZAR)		368,622		456,834
Cost of capital (finance)[a]	61,845		79,870	
Depreciation[b]	122,901		152,509	
Insurance[c]	69,771		86,952	
Overheads - Administration	61,544		74,164	
Overheads - Operational	41,029		49,443	
Licence	11,532		13,896	
Total variable costs (ZAR per km)		5.82		6.18
Fuel[d]	3.84		4.13	
Lubricants[e]	0.08		0.08	
Maintenance	1.28		1.22	
Tyres	0.62		0.75	

a Interest rate is 12.5%.

b Depreciation time for a prime mover is 5 years with a salvage value of 25%; for a trailer the time is 10 years with no salvage value. Depreciation time for a trailer is 10 years with no salvage value.

c Insurance costs for a prime mover are 7.5% of the cost price; for a trailer the percentage is 5%.

d Fuel price at the second of February 2008 was 724.3 ZAR cent per litre.

e Lubricants are 2.5% of the fuel costs.

Labour

A certain amount of hours is needed for the collection of milk. Therefore the labour approach has been done based on the amount of working hours needed per day. Drivers work 45 hours per week divided into 5 days every week. They receive 100% salary for 9 hours per day and overtime is paid at 150% salary (Jacobs, Pers. Com.; Kleynhans, Pers. Com.). The maximum amount of hours a driver works depends on the time required completing a route, but it would be never more than 12 hours per day. If a route takes more than 9 hours, the extra hours are counted as overtime. Overtime is a normal issue in the transport industry (Jacobs, Pers. Com.). Basic salary has been set at 21.40 ZAR per hour (Coleen, Pers.Com.). Overtime salary has been set at 32.10 ZAR per hour.

Collection frequency

Tankers for milk transport should be insulated in a way that the content temperature should not increase by more than one degree Celsius over a 24 hours period from time of pickup (Robinson, 2002). Therefore transport time is not a limiting factor to ensure good milk quality. A more important factor determining milk quality is storage temperature at farm level which should be always under 5°C (Robinson, 2002). This temperature avoids microbial growth and ensures milk quality preservation. Therefore, it is important to have insulated milk tankers, which maintain milk under 5°C during transport time and milk quality is not damaged by bacterial development. This also affects milk collection frequency of the raw milk. Milk producers with a daily production lower than 1,200 litres per day is collected every second day. Raw milk from producers with a production of more than 1,200 litres per day is collected daily (Kleynhans, Pers. Com.). To guarantee milk quality and due to the minority of the milk producers produce more than 1,200 litres per day, raw milk is assumed to be collected daily in this model, for all the farms, independently from their size.

4.2 Method

Mapsource®

Garmin Mapsourse® is a program that provides digital geographic data. Firstly, the program was used to situate the milk producers in the areas of study. After mapping the dairy farms, the distances from the farms to the two locations considered, Swellendam and Heidelberg, are determined. Road classification is done visually in the program Mapsource®. It differentiates four different road types, as shown in table 3. In summary, Mapsource® is used for:

- Mapping dairy farms
- Developing farm clusters
- Identifying road types

Spreadsheet

Farm clusters are developed visually grouping milk producers located close to each other. After developing the clusters per scenario visually in Mapsource®, the amount of milk produced for each dairy farm is counted up in a spreadsheet and considered to be enough to fill a milk tanker either 27 Tons or 34 Tons (Table 8). Consequently, clusters made can be more than 34 Tons. If this is the case:

- Clusters are reduced
- Farms in the cluster are replaced to less producing ones
- Various farms are replaced by one farm.

Routes are developed for each cluster. The model includes only routes that could be fulfilled by trucks according to their technical (i.e. weight) and mobility characteristics. Distances between farms are done in the same way as formerly described. However, its only done between farms concerning one cluster. Highway and major tarred roads are considered as main roads to drive on. Less quality roads are avoided because it is not realistic to use minor tarred and untarred roads as main roads. In other words, if farms can be reached by a visually shorter route, but the truck has to drive mainly on less quality roads, it is not realistic to design a route in this way.

Distance data and road type information were processed in a spreadsheet model. The next step was the calculation of time needed for each route. This time includes:

- Travel time calculated from data about distance (km) and average speed (km/h) allowed by the roads.
- Collection time needed for each farm, as shown in table 6.
- Time emptying the tanker at the dairy factory.

Different options for collection routes are considered and compared to each other, selecting for the model those routes with:

- Sufficient milk volume concerning the volume of the trucks; 27 or 34 Tons
- Shortest collection time required with a maximum of 12 hours
- Shortest transport distance
- Logical route driven by a milk tanker (visually)

For the two locations considered, Swellendam and Heidelberg, routes are combined per location. Consequently, for each location different combinations of routes are made. The routes are visually developed by Mapsource® and optimised by the spreadsheet. Criteria considered to design the best combinations include:

- Time, maximum travel time per combination of 16 hours
- Volume, amount of collected litres per route

Per combination, one milk tanker with the regarded volume is included in the model. Per combination, different steps are done to calculate the annual costs, which are the following:

- Amount of km calculated per year
- Annually km multiplied by the related annual variable costs per km

- Sum up the annual variable costs, the annual fixed costs of the milk tanker and the annual costs of the additional equipment

All the combinations are compounding. Spare tankers are added to the model. The amount of spare tankers needed depends on the amount of maintenance required for the trucks of the model. Every combination has 35 days of annually service days and 330 working days, as former described. The service days are multiplied by the amount of trucks needed for fitting all combinations. If the service days required for all the trucks are summed up and not exceed 330 working days, one spare milk tanker is needed. The annually variable costs for a spare tanker are calculated by the amount of km it has to fulfil during the 35 service days of the other trucks. These amounts of km are summed up from each truck which is needed in the model.

Table 8. Different processes considered with their criteria and explanation.

	Criteria	**Explanation**
Clusters	Milk volume	Sufficient volume
	Distribution milk producers	Farms are located close to each other
Routes	Road qualification	The roads are qualified in four different types
	Transport time	Distance is translated into time by average speed
	Collection time	Time needed per farm plus emptying at dairy factory
	Logical order farms	Visually route determination
	Maximum time of 12 hours	Each route has a maximum time of 12 hours
Combination of routes	Similar volume	Routes combined with 27 Tons and/or 34 Tons
	Maximum time of 16 hours	Routes combined with a maximum time of 16 hours
	Truck selection	Select a sufficient truck per combination of routes

Scenarios

This research investigates the location opportunities for a dairy factory in the area Montagu, Bredasdorp, Swellendam, Heidelberg and Riversdale (Western Cape, South Africa; Appendix II). In order to bear in mind future possible opportunities for such a factory in this area, six different scenarios have been considered (Table 9). The first scenario is calculated based on the 85 milk producers which replied to the questionnaire distributed by SSK. The second scenario includes these 85 milk producers with their expected future production, founded on their expected number of cows. Milk produced per cow is calculated and multiplied by this expected number for every farm. The third scenario is based on the 85 milk producers with their expected future milk production plus the additional 55 dairy farms in the Swellendam and Heidelberg area. The fourth scenario is based on the previous scenario plus the 30 milk producers from the area Bredasdorp. The calculation of the milk production of these additional dairy farms has been done with the estimated amount of milking cows multiplied by the average milk production in Bredasdorp. Therefore the amounts of cows are multiplied by the daily milk production of 15 litres per cow. In Riversdale the average milk production per day is also 15 litres per cow per day. Therefore the amounts of cows from the 38 milk producers from the Riversdale area which are added in the fifth scenario are also multiplied by the daily production of 15 litres per milking cow. The sixth scenario is based on the 85 milk producers with their expected milk production inclusive the 55 dairy farms in the Swellendam and Heidelberg area plus the 30 milk producers from Bredasdorp and the 38 milk producers from Riversdale.

Table 9. Six scenarios used for the model.

Scenarios	Description
1[a]	85 milk producers which replied on the survey from the SSK
2[a]	Scenario 1 plus their expected future production
3	Scenario 2 plus the additional 55 milk producers[b]
4	Scenario 3 plus the additional 30 milk producers in Bredasdorp[c]
5	Scenario 3 plus the additional 38 milk producers in Riversdale[d]
6	Scenario 3 plus the additional 68 milk producers in Bredasdorp and Riversdale

a SSK , 2007

b Swart (Pers. Com.)

c Laubscher (Pers. Com.)

d Burger (Pers. Com.)

5 Results

5.1 Scenarios

Total annual costs

Table 10 shows the transport costs per scenario. Costs per 1,000 litres vary from 55.98 (Scenario 2) to 75.75 ZAR (Scenario 6). Total costs of the second scenario are in comparison lower than the remaining scenarios, for both locations considered, Swellendam and Heidelberg, 60.52 and 55.98 ZAR respectively. On the other hand, scenario six has the highest transport costs, 75.75 and 75.52 ZAR respectively. The third scenario shows an increase in the total annual costs compared to the second one. In the case of Heidelberg, these costs increase even more than those of Swellendam, reaching a similar value. Although the costs are almost equal, Heidelberg still has the lowest annual costs. The costs of both fourth and fifth scenario resulted as expected, being the costs of the fourth lower for Swellendam and those of the fifth lower for Heidelberg. While Bredasdorp is further from Heidelberg than from Swellendam, Riversdale borders with the Heidelberg area. If all the milk produced in the whole area is collected, as it happens in scenario 6, the total transport costs are almost similar for both locations. Average transport costs for all scenarios are calculated as 69.46 ZAR per 1,000 litres of milk.

Trucks

According to the results for all scenarios, milk collection and transport to factory can be done more efficiently if it would be located in Heidelberg. One milk tanker can be spared in comparison with the amount of tankers needed for Swellendam, for the first 2 scenarios and two tankers for the remaining ones. Spare tankers must be able to replace the biggest trucks, needed in the model. Therefore, these tankers have a capacity of 34 Tons. Within the model the majority of the milk tankers are 34 Tons. A second spare tanker needed is also 34 Tons because a spare tanker of 27 tons is not able to satisfy their replacement.

Transport costs

Apart from one spare tanker needed for both locations, six milk tankers are required to collect the milk taken to Heidelberg, three of them with a capacity of 34 Tons and the other three of 27 Tons (Scenario 1). In contrast, five 34 Tons and two 27 Tons capacity tankers are needed to carry the milk to Swellendam. Consequently, fixed costs are lower for Heidelberg, being the variable costs higher due to the higher amount of Km of its routes. Heidelberg demands longer both basic and overtime hours. When considering the future production in these two areas (Scenario 2), the same amount of trucks is required for the both locations, despite their capacity is 34 Tons in all cases. Therefore the volumes of the milk tankers are better used in scenario 2, what results in a lower cost price. The amount of hours and Km increased in the second scenario because milk tankers are filled earlier and there is a need of more routes. Although Swellendam uses one more truck for milk collection in the third scenario, it has less overtime and distances to cover. For this location two milk tankers of 27 tons are used what results in lower variable costs. The costs for the fourth scenario are higher for Heidelberg, as former described. As a result, the variable costs as well as the time needed to cover the routes are higher for Heidelberg in the fourth scenario. The opposite situation occurs with Heidelberg in the fifth scenario. For Swellendam variable costs and labour costs are lower, still the raw milk collected to Heidelberg has the lowest transport costs.

Table 10. Annual transport costs of six scenarios for Swellendam and Heidelberg in ZAR per 1,000 litres of milk.

		Scenario 1				Scenario 2				Scenario 3			
		Farms which responded				Farms which responded + future production				All farms in Swellendam & Heidelberg + future production			
Location:		Swellendam		Heidelberg		Swellendam		Heidelberg		Swellendam		Heidelberg	
		Amount	Value	Amount	Value	Amount	Value	Amount	Value	Amount	Value	Amount	Value
Litres of milk collected per day:		274,200		274,200		378,476		378,476		499,976		499,976	
Collection km's per day:		1,495		1,544		1,701		1,633		2,274		2,333	
Collection hours per day:		81		84		94		94		134		135	
Equipment													
Trucks	Annual fixed costs	2 x 27t	34.75	3 x 27t	29.31	7 x 34t	26.46	6 x 34t	23.15	2 x 27t	31.58	10 x 34t	30.04
	Annual variable costs	5 x 34t	33.12	3 x 34t	33.84	1 x spare	27.78	1 x spare	26.66	9 x 34t	27.87	2 x spare	28.84
	Filling pump + sampling	1 x spare	1.29	1 x spare	1.13		0.93		0.82	2 x spare	1.15		1.06
Labour costs													
	Basic salary (100%)	96.50%	6.19	96.32%	6.38	97.08%	5.20	95.87%	5.14	92.43%	5.41	83.29%	5.10
	Overtime (150%)	3.50%	0.22	3.68%	0.24	2.92%	0.16	4.13%	0.22	7.57%	0.44	16.71%	1.02
Total annual costs (ZAR/1,000 L)			**75.58**		**70.89**		**60.52**		**55.98**		**66.45**		**66.06**

		Scenario 4				Scenario 5				Scenario 6			
		Potential areas								All farms & potential areas in Swellendam, Heidelberg, Bredasdorp & Riversdale			
		Bredasdorp area				Riversdale area							
Location:		Swellendam		Heidelberg		Swellendam		Heidelberg		Swellendam		Heidelberg	
		Amount	Value	Amount	Value	Amount	Value	Amount	Value	Amount	Value	Amount	Value
Litres of milk collected per day:		584,476		584,476		596,476		596,476		680,976		680,976	
Collection km's per day:		3,024		3,443		3,069		2,783		3,819		3,893	
Collection hours per day:		168		176		170		166		204		207	
Equipment													
Trucks	Annual fixed costs	4 x 27t	32.61	2 x 27t	31.29	2 x 27t	32.76	13 x 34t	31.47	4 x 27t	33.50	2 x 27t	32.37
	Annual variable costs	10 x 34t	31.49	11 x 34t	35.99	12 x 34t	31.59	2 x spare	28.83	13 x 34t	34.24	14 x 34t	34.98
	Filling pump + sampling	2 x spare	1.21	2 x spare	1.13	2 x spare	1.18		1.11	2 x spare	1.23	2 x spare	1.17
Labour costs													
	Basic salary (100%)	87.81%	5.62	76.47%	5.35	86.33%	5.50	83.50%	5.24	83.65%	5.67	77.61%	5.44
	Overtime (150%)	12.19%	0.78	23.53%	1.65	13.67%	0.87	16.50%	1.04	16.35%	1.11	22.39%	1.57
Total annual costs (ZAR/1,000 L)			**71.71**		**75.41**		**71.92**		**67.69**		**75.75**		**75.52**

5.2 Total annual investments per scenario

The total annual investments vary from 7,095,284 ZAR (Scenario 1) to 18,828,078 ZAR (Scenario 6). The first scenario showed the lowest investment, with a daily milk collection of 274,200 litres of milk per day, as shown in table 11. In the second scenario the total annual investment increases, while the costs per 1,000 litres of milk decreases. Although the total annual costs per 1,000 litres are almost similar, the total annual investment costs differs 71,519 ZAR beneficially for Heidelberg (Scenario 3). When potential areas are added to the model, the investment for scenario 4 is 791,151 ZAR adversely for Swellendam. If Riversdale would be added, the investment for Swellendam is 919,718 ZAR higher than Heidelberg (Scenario 5). The maximum annual investment for Swellendam is 18,828,078 ZAR and for Heidelberg 18,771,029 ZAR, as shown for the sixth scenario.

Table 11. Total annual investment per scenario and location.

Scenario	Location	Liters of milk collected per day	Total annual costs (ZAR/1,000 ltr)	Total annual investment (ZAR)
1	Swellendam	274,200	75.58	7,564,231
	Heidelberg		70.89	7,095,284
2	Swellendam	378,476	60.52	8,360,598
	Heidelberg		55.98	7,733,640
3	Swellendam	499,976	66.45	12,125,996
	Heidelberg		66.06	12,054,477
4	Swellendam	584,476	71.71	15,297,100
	Heidelberg		75.41	16,088,251
5	Swellendam	596,476	71.92	15,656,973
	Heidelberg		67.69	14,737,255
6	Swellendam	680,976	75.75	18,828,078
	Heidelberg		75.52	18,771,029

5.3 Sensitivity analyses

Energy prices tend to increase worldwide, which could result in a higher fuel price. Therefore, a fuel price of 8 ZAR per litre diesel is used in the model (Table 12) compared to a fuel price of 7.24 ZAR per litre, which was the real price in the moment the study was carried out (Table 7). If the fuel price would increase, it would be adversely for Heidelberg. However, the costs increase equally for both locations (Scenario 4). Nevertheless the transport costs are lower for Heidelberg in comparison to Swellendam, except for scenario 4 as similar to the basis situation.

Furthermore, the economical expectations of South Africa is expected to improve, therefore the interest rate will decrease. The interest rate added in the model is 5% lower than the basic assumption in accordance to table 7. If the interest rate would be 7.5% the annual transport costs would decrease for all scenarios. In scenario 2, 3, 4 and 6 the interest rate reduction is more beneficial for Swellendam in comparison to Heidelberg. Still the annual transport costs for the former are higher than for Heidelberg, except for scenario 4 as similar to the basis situation.

Consequently, if the economical situation of the country is expected to improve, the salaries would also tend to increase. A basic salary of 25 ZAR per hour is added in the model compared to 21.40 ZAR per hour, mentioned. Above in all scenarios this situation has adverse consequences for Heidelberg. Nevertheless, the annual transport costs for Swellendam increase slower than for Heidelberg. Total transport costs for the latter are lower in comparison to Swellendam, except for scenario 4.

Table 12. Sensitivity analysis for six scenarios for fuel price increase, interest rate decrease and salary rate increase in total annual transport costs per 1,000 litres of milk.

		Basis	Fuel price[a]		Interest[b]		Salary[c]	
Scenario	Location	(ZAR/ 1,000L)	(ZAR/ 1,000L)	Δ%	(ZAR/ 1,000L)	Δ%	(ZAR/ 1,000L)	Δ%
1	Swellendam	75.58	77.88	3.05	75.09	-0.65	76.66	1.43
	Heidelberg	70.89	73.24	3.31	70.15	-1.05	72.01	1.57
2	Swellendam	60.52	62.46	3.20	58.67	-3.06	61.42	1.49
	Heidelberg	55.98	57.84	3.33	54.36	-2.89	56.88	1.61
3	Swellendam	66.45	68.39	2.92	64.25	-3.31	67.43	1.48
	Heidelberg	66.06	68.07	3.05	63.95	-3.18	67.08	1.56
4	Swellendam	71.71	73.42	2.39	69.83	-2.62	72.78	1.50
	Heidelberg	75.41	77.21	2.39	73.62	-2.38	76.59	1.56
5	Swellendam	71.92	73.60	2.34	70.07	-2.56	72.99	1.49
	Heidelberg	67.69	69.41	2.54	65.93	-2.60	68.75	1.56
6	Swellendam	75.75	77.27	2.01	74.14	-2.13	76.89	1.50
	Heidelberg	75.52	77.09	2.08	73.98	-2.04	76.70	1.56

a Fuel price increase to 8 ZAR per litre diesel

b Interest rate decrease of 5 %

c Salary rate increase to 25 ZAR per hour

6 Discussion and conclusions

6.1 Discussion

Transport costs comparison

Transport costs are relatively low in South Africa in comparison to the Netherlands. South African average transport costs found in this study are 69.46 ZAR per 1,000 litres of milk in comparison to 71.82 ZAR/1,000 litres for 1992 as shown in table 13. However, Dutch dairy factories privatised this division. As a result, the assembling of milk could be more efficient nowadays. On the other hand, energy prices increased during the last 15 years. For these reasons, the costs could be higher in the Netherlands as yet other figures were not available.

Table 13. Dutch milk collection costs from 1988 till 1994 per 1,000 litres of milk (Produktschap voor zuivel, 1993).

Year	**Average milk collection costs[a] (ZAR)[b,c]**
1988	60.91
1989	62.27
1990	65.91
1991	66.36
1992	71.82
1993[d]	74.09
1994[d]	76.82

a Till 1990 5 % of company risk is included

b FL 2.00 for intra transport is excluded

c Change rates used are: FL 1.00 = € 2.20; € 1.00 = ZAR 10.00

d Estimated costs

Labour

There are some assumptions made for the calculation of transport costs to assemble raw milk in the present study. First of all, the amount of working hours is used as a maximum of 12 hours per day. If this study would have been carried out in any western country, the amount of working hours would have been a limitation to develop the routes. In reflection of future economical growth, the labour conditions will improve for employees in South Africa. This fact would change the model. Accordingly, labour would become a restriction which would result in a maximum of less than 12 working hours per day. As a consequence, the time to fulfil the different routes could become a limitation. Alternatively, drivers could relieve each other or it could result in more routes needed to collect raw milk. For these reasons, the transport costs would increase. Another assumption was the unlimited availability of qualified truck drivers, who know how to handle with food and its implications regarding quality of products. In South Africa labour with sufficient knowledge to collect raw milk is difficult to find. The milk tankers used are big and truck drivers need adequate training before driving them (Coleen, Pers. Com.), which can only be obtained in a reduced number of training centres. Therefore, the accessibility to high-qualified milk-truck drivers was one of the main concerns and limitations of the present study.

Milk collection

On the other hand, to guarantee milk quality and due to the minority of the milk producers produce more than 1200 litres per day, the raw milk is assumed to be collected daily in this model instead of every second day. With regard to good milk quality at farm level, it would not be problematic to collect raw milk every second day which could result in lower transport costs. Another limitation for the combinations of the routes is the maximum time of 16 hours per day. This includes milking times at farm level, while collecting the milk, which is not considered to be a problem. However, dairy farmers have their own managing system where they start milking the cows at a certain moment of the day. This system has to adapt to the arriving times of the milk tankers on the farm.

Routes determination

The determination and optimisation of the cluster and routes are partly done visually. In this way, the quality of the routes is difficult to evaluate. However, Swart (Pers. Com.) evaluated the routes as it has to be driven by trucks in the area. Additionally, the seasonality of the milk production is not considered in the model, what could influence the daily routing. Besides, variation in daily production has also influence on the daily routing (Heyman, Pers. Com.).

Estimation potential milk suppliers

The estimations of milk quantities and number of cows in the potential areas have been based on estimations (Burger, Pers. Com.; Laubscher, Pers. Com.; Swart, Pers. Com.). However, if specific information about these issues were available, more precise results could have been obtained. Similarly, the average milk production per cow of the total area is used to calculate the production per farm. Data from each of the farms would have given more accurate results.

Milk quality

In South Africa the quality of raw milk has to be considered as an important issue concerning developing a milk processing plant, specifically for milk ingredient production (Britz, Pers. Com.). The quality needs to be guaranteed at farm level and current application of milk quality regulations is deficient (Kleyhans, Pers. Com.). Farmers are responsible to guarantee their own raw milk quality. Furthermore, differences between farming systems are considered to be of influence on the milk quality. Bacteria count per ml milk was higher for sandy areas in comparison to pasture areas (Table 14) (Cousins *et al*. 1981). To deal with these differences and to ascertain good quality milk, milk in dusty areas could be collected every second day in comparison to daily collection of the pasture based systems. Another reason would be that milk tankers do not have to drive in these dusty areas every day, what could be of influence of the raw milk quality in the tanker. Another criteria is the time factor of transport, transport could break down the bacteria of milk to affect the rancidity (Robertson, Pers. Com.). However, Swart (Pers. Com.) and Kleynhans (Pers. Com.) considered milk quality as no issue for milk transport in the studied area. Nevertheless, milk is collected daily in this study, but if the collection frequency would reduce, milk quality should be considered.

Table 14. Influences of the area and the treatment of the teats on the quality of raw milk.

Area	**Treatment teats**	**Bacteria count per ml milk**
Sand	Not washed	31,700
	Washed	15,500
Pasture	Not washed	4,200
	Washed	3,500

Source: Cousins *et al* . (1981)

6.2 Conclusion

Based on the results of the present study the following conclusions could be drawn:

- Heidelberg is the best location from a transport cost minimization point of view. Heidelberg is for all scenarios, except scenario 4, the location with the lowest transport costs. Additionally, the fourth scenario is concerning Bredasdorp is not the first potential area to expand the assembling area.
- Riversdale is the best potential option to expand the collection area. This area has the lowest costs if added as potential area in comparison to Bredasdorp, either for Swellendam or Heidelberg.

- Annual variable costs are most modified for the total annual transport costs, in particular the variable costs per km and the costs of labour concerning overtime. These costs are also most sensitive to future developments as increasing fuel and salary prices.
- Swellendam is less sensitive than Heidelberg to future developments because of the influence on the variable costs. However, by decreasing the interest rate, the fixed costs are reduced instead of the variable costs.

6.3 Further research

Recommendations for further research would be:

- Better interaction between science and milk transport industry of South Africa should provide insight into the transport industry, which could be interpreted in the present study.
- Further research could focus on the quality of the raw milk from the collection area. This could be a good starting point of investigating the possibilities of reducing the collection frequency.
- Further studies could focus on the possibilities to develop a training centre for truck drivers, especially for milk tankers.

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Appendix I Questionnaire designed by the SSK

5 Oktober 2007

Geagte Suiwelprodusent

SSK SUIWEL ONDERSOEK

SSK is besig met 'n suiwel ondersoek in sy groter bedieningsgebied. Ten einde sinvol te beplan benodig ons sekere inligting en daarom hierdie vraelys aan suiwelprodusente in die gebied. Let egter daarop dat SSK geensins enige verwagtinge wil skep nie en hierdie slegs deel van 'n ondersoek na die bedryf en suiwelverwerking is.

Indien dit vir u van belang en waarde kan wees, sal ek dit dus waardeer indien u onderstaande vraelys kan voltooi en aanstuur (vir aandag Casper Swart, SSK, Posbus 12, Swellendam, 6740 of per faks 028 5142490) voor 26 Oktober 2007. Indien u van ander suiwelprodusente weet wat nie die vraelys ontvang het nie en ook mag belangstel, sal ek dit waardeer indien u dit ook vir hulle aanstuur.

By voorbaat dank

H DE BEER
HOOFBESTUURDER: PRODUKTE & LANDBOUDIENSTE

VRAELYS

Naam: ……………………………………………………………………………………………

Plaasnaam: ……………………………………………………..……………………………

Lidnommer indien lid van SSK is: ………………………………………………………………

Vraag 1: Sal u belangstel om by wyse van aandeelhouding betrokke te raak by 'n suiwelaanleg wat melk vanuit hierdie streek (die groter Bonnievale, Riviersonderend, Swellendam, Heidelberg, Riversdal, Albertinia, ens) verwerk?

Ja	Nee

Vraag 2: Moet SSK by wyse van aandeelhouding betrokke wees by so 'n suiwelaanleg?

Ja	Nee

Vraag 3: Moet so 'n suiwelaanleg voorsiening maak vir SEB by wyse van aandeelhouding vir u as suiwelprodusent se plaaswerkers?

Ja	Nee

Vraag 4: Sal dit vir u aanvaarbaar wees dat suiwelprodusente 'n minderheidsaandeelhouding in so 'n suiwelaanleg het?

Ja	Nee

Vraag 5: Sal dit vir u aanvaarbaar wees dat SSK en suiwelprodusente saam ‘n minderheidsaandeelhouding in so ‘n suiwelaanleg het?

Ja	Nee

Vraag 6: Sal dit vir u aanvaarbaar wees dat SSK, u plaaswerkers en suiwelprodusente saam ‘n minderheidsaandeelhouding in so ‘n suiwelaanleg het?

Ja	Nee

Vraag 7: Indien u aandele in so ‘n onderneming kan opneem, sou u ‘n kontantbydrae daarvoor maak of sou u verkies om dit by wyse van ‘n heffing op melklewerings af te betaal?

Kontantbydrae	Heffing op lewerings	Kombinasie

Vraag 8: Hoeveel liter melk produseer u gemiddeld per dag?

Vraag 9: Wie is u huidige melkkoper?

Vraag 10: Hoe vêr (km) is u ongeveer vanaf u huidige melkkoper?

Vraag 11: Hoeveel produserende koeie is in u suiwelkudde?

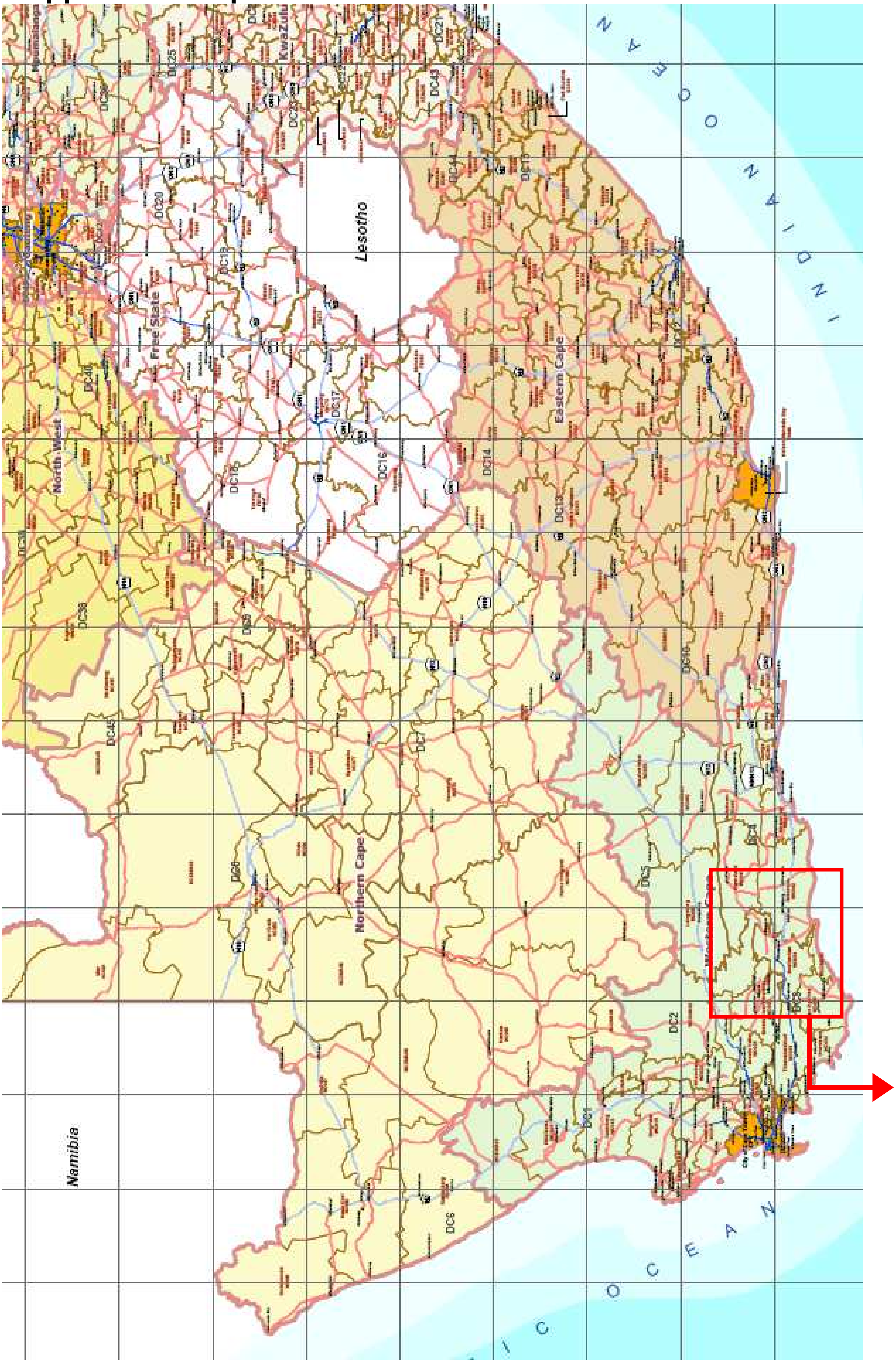
Vraag 12: Hoeveel verse is in u suiwelkudde?

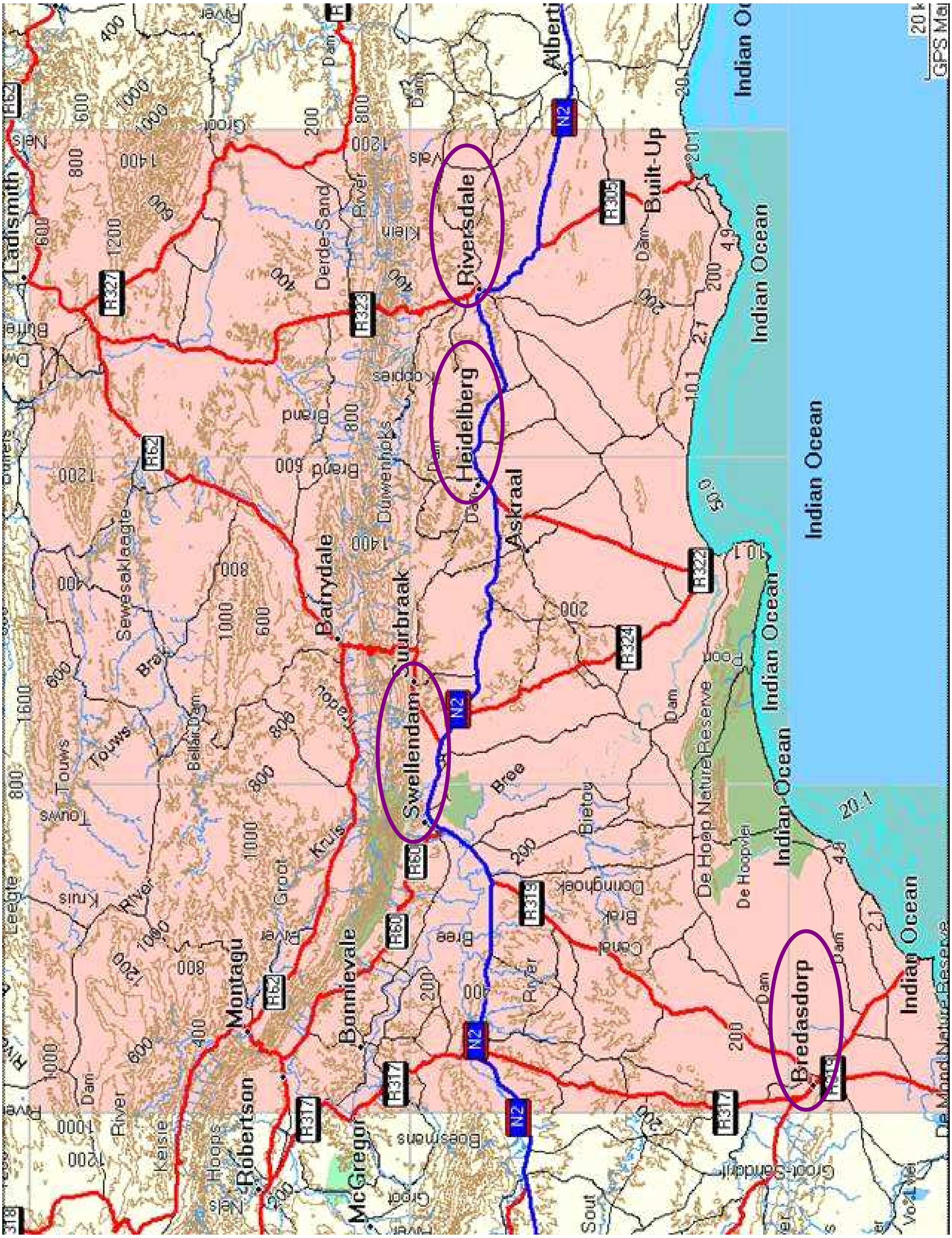
Vraag 13: Uit watter ras bestaan u suiwelkudde oorwegend? Jersey, Fries, .. en ander?

Vraag 14: Voorsien u om u kudde verder uit te brei en indien wel, hoe groot sal u ideale kudde wees?

Ja	Nee

Appendix II Maps of research area





Ladismith
Riversdale
Heidelberg
Swellendam
Bredasdorp
Barrydale
Suurbraak
Askraal
Montagu
Bonnievale
Robertson
McGregor
Albertinia
Built-Up
Indian Ocean
De Hoop Nature Reserve
De Mond Nature Reserve
N2
R62
R60
R317
R319
R322
R323
R324
R327
R305
Bree
Touws
Sewesaklaagte
Duiwenhoks
Groot
Kruis
Brak
Boesmans
Sout