STRATEGY FOR THE SUSTAINABLE DEVELOPMENT OF THERMAL SPRINGS: A CASE STUDY FOR SAGOLE IN LIMPOPO PROVINCE

by

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DECLARATION

I declare that **STRATEGY FOR THE SUSTAINABLE DEVELOPMENT OF THERMAL SPRINGS: A CASE STUDY FOR SAGOLE IN LIMPOPO PROVINCE** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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ABSTRACT

This research aims to investigate the diverse uses of thermal springs and to develop strategies to identify those most appropriate for Sagole with due regard given to the economic, social and environmental aspects. The aim specifically determines the optimum use of the Sagole thermal spring. The following potential uses for Sagole were identified, discussed and analysed in terms of the environmental, social and economic aspects: tourism, aquaculture and geothermal education. The potential cost and benefit of each were also analysed. According to the research finding, the establishment of a Geothermal Education Centre appears to be the most sustainable project with the highest Feasibility Index. It is followed by Health Tourism and then Aquaculture.

Key terms

Thermal springs; Sagole Spa; direct uses; health tourism; aquaculture; geothermal education; environmental, social and economic impact; cost and benefit; feasibility index; development strategy.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Thermal springs develop when surface water descends into the earth and encounters hot volcanic masses of rock. The water is heated and returns along faults to the surface of the earth as hot water. The same process occurs when rainwater penetrates the ground, descends to great depths where it becomes heated, and then returns to the earth's surface while it is still hot (Higgins & Higgins, 1996).

People have used geothermal spring waters for different purposes for thousands of years. Documentary and oral history reveal that thermal springs were used for bathing and for medicinal, religious, hygienic and social purposes in India, Crete, Egypt, Turkey, Japan and North America (van Vuuren, 1990; Lund, 2000). Native American Indians considered their hot springs to be sacred sites and neutral ground to which Indian warriors could travel to rest and recuperate from battle in safety without being molested by other tribes (Lund, 2000).

More recently, geothermal fluids have been used for other purposes, which include the generation of electricity, agricultural uses, space heating and cooling, industrial processing, balneological use (that is, using natural mineral water for the treatment and cure of disease), recreation and tourism development (Armstead,1978; Rinehart, 1980; Lund, 1993; Lund, 2000; Kristmannsdottir & Bjornsson, 2003). The countries most involved in the exploitation of geothermal fluids include Japan, Russia, the USA, Italy, Hungary, Iceland, New Zealand, Mexico, China, and Turkey. According to Lund and Freeston (2001), China, Iceland, the USA, Japan, and Turkey account for over 63,5% of the world's geothermal energy utilization. The exploitation of geothermal fluid in Africa is limited to Algeria, Egypt, Kenya, Tunisia, Ethiopia, Morocco, Tanzania, and Uganda

(Lund and Freeston, 2001). Resource-based geothermal science education is also offered in some countries such as Iceland and New Zealand (Jonsdottir, 2010:1).

Thermal springs in rural areas have the potential to generate economic and social benefits for local communities providing that they are used sustainably. The Brundtland Commission defines ‘sustainable development as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations Economic Commission for Europe, 2004-2005). The weakness of this definition is that it is too broad and general. It defines what to aim for without clearly stating how it should be achieved in specific social, ecological, economic, cultural or historical situations (Rist & Dahdouh-Guebas, 2006).

The definition of sustainable development was modified and extended by development economists as follows: “an improvement in the quality of human life while living within the carrying capacity of supporting ecosystems” (Quaddus & Siddique, 2004:4). In this second definition, improvement in the quality of human life is the focus and it is subject to environmental constraints. This may mean that, while development is essential to satisfy human needs and to improve the quality of human life, it must be based on the efficient and environmentally responsible use of the society’s natural, social and economic resources (Grubb *et al*, 2005).

On the African continent, South Africa is one of the countries rich in thermal springs. The majority of the springs are used for bathing and swimming (tourism and recreation). In the rural areas of the Limpopo Province, for example, there are twenty-three thermal springs, but of these twenty-three thermal springs, only ten have been developed. These include Aventura Tshipise, Bela-Bela, De Oog, and Aventura Eco Eiland (Boekstein, 1998).

1.2 RATIONALE AND MOTIVATION FOR THE STUDY

As indicated above, South African thermal springs are generally used for tourism and for recreational purposes.

According to Hall, Kirkpatrick and Mitchell (2005), tourism is one of the most labour-intensive industries and it contributes substantially towards job creation and economic development in rural areas. Tourism is viewed as the linchpin of many rural development strategies: “It has proved to be a powerful engine for economic growth – transferring capital, income and employment from industrial, urban and developed areas to non-industrial regions” (Organization for Economic Co-operation and Development (OECD), 1994:5-7). This was confirmed by Opperman and Chon (1997) who consider it an economic panacea for developing countries. They also see it as “a vital development agent and an ideal economic alternative to more traditional primary and secondary sectors” (Opperman & Chon 1997:1). Williams (2004) stated that, at the turn of the twenty-first century, tourism attracted 665 million people to travel internationally. Tourism triggers important processes of capital formation and the wider distribution of economic wealth. Globally, tourism contributes 10,7% to Gross Domestic Product (GDP) and 10,7% to employment. Estimated figures for the Middle East-Africa region show that tourism generated 9,8 % of the GDP in 1996 (Creemers & Wood, 1997).

Tourism has been identified by the South African Government as one of the pillars on which development rests, and so there is a call at the national level for the promotion of tourism in South Africa.

The development of thermal springs as tourist destinations in the Limpopo Province has the potential to alleviate poverty and create jobs for the local communities, the province, and the country as a whole. It is important to note that Sagole is one of the thermal springs located along the well-known Ivory Route of the Limpopo Province. However, this has not materialised at some spring resorts, such as Sagole.

The Sagole thermal spring is located at Tshipise Tsha Sagole, in the Tshikundamalela Tribal Authority area of the Vhembe district of Limpopo Province. It falls under the authority of the Mutale Municipal Council. The income of this predominantly rural and economically poor area is based on pensions, subsistence farming and the earnings of migrant labourers.

According to Mphephu (1988), the Sagole Spa resort was officially opened by His Excellency Khosikhulu PR Mphephu, former State President of the Republic of Venda, in 1988. During the period 1979-1993, the Venda Development Corporation (VDC) and the Venda Tourism Department operated in partnership at the resort. During that time more than fifty local people were employed. The infrastructure included conference halls, chalets, the kitchen, sleeping accommodation, and swimming pools. The area became a centre for small group visits for students, teachers, government officials, and clients of Mr. Tshikovha, a well-known traditional healer, who stayed close to the Sagole thermal spring.

The situation changed when South Africa was transformed into a democratic state in 1994. The Venda Development Corporation (VDC) was dissolved, and the Limpopo Economic Development Enterprise (LimDev) was established by the new government of Limpopo Province. LimDev leased the resort to a private person. The employees were reduced from a team of fifty to a staff of only four.

The maintenance, and hence the quality, of the infrastructure started to decline. Some accommodation halls were closed. The furniture in the accommodation halls gathered dust and it seemed as if no one cared for them. The swimming pools, the pavilion and the lawns deteriorated. The gardens and swimming pools are neglected and in a shockingly and unacceptably poor condition. The number of visits to the centre declined accordingly.

Considering the former reputation of Sagole as a clean, beautiful, interesting, enjoyable and flourishing tourism and recreational centre, two questions come to mind: What was the reason for this extreme decline? and How can Sagole be redeveloped for the social and economic benefit of the local community and all interested stakeholders without harm to the environment? The former question is the subject of another study (Tuwani, 2011), while the second question receives attention in this thesis.

Barring the use of thermal spring as tourism destinations, geothermal water and steam, at different temperatures, can be used for a variety of purposes depending on the available technology of a country. At temperatures between 100°C and 180°C, for example, saturated steam can be used to dry organic materials such as seaweed, grass, or vegetables, to make concentrations of saline solution, for evaporation in sugar refining, to dry farm products, to dry fish meal and timber, for the evaporation of highly concentrated solutions and for refrigeration by ammonia absorption. At temperatures between 20°C and 90°C, permissible uses of thermal spring water may include fish farming, balneological bathing, soil warming, mushroom growing, animal husbandry, greenhouse warming, refrigeration, space heating and the drying of stock fish (Rinehart, 1980; Lund, 2000; Lund & Freeston, 2001;Saba *et al*, 2004). Since the water from thermal springs might be rich in valuable minerals, 'mining' the water for rare minerals is an economically viable option. Internationally, for example, boric acid, carbon dioxide and silica from geothermal fluid are extracted (New Zealand Geothermal Association, at: http://www.nzgeothermal.org.nz.)

The majority of South African thermal springs have characteristically low temperatures. However, if some of the above-mentioned uses could be implemented in South Africa, especially at Sagole, it may create job opportunities and improve the well-being of many unemployed South Africans.

In order to realise the potential benefits of thermal springs, it is necessary to conduct a detailed study of the thermal springs in Limpopo. The uses, and the potential economic, social and environmental benefits and limitations, and the necessary development strategies, need to be investigated. Sagole thermal spring, one of the least developed in the northern Limpopo Province, will be used as a case study.

Sagole is located 53 kilometres north-east of Thohoyandou. The grid reference is the 22,53° line of latitude and the 30,66° line of longitude (Index Mundi, 2006). Tshipise Tsha Sagole is in the Tshikundamalela Tribal Authority area of the Vhembe district of the Limpopo Province.

1.3 RESEARCH GOAL/ AIMS AND OBJECTIVES

Aim: To determine the optimal use for the Sagole thermal spring

This research aims to investigate the diverse uses of thermal springs and to identify the uses most appropriate for Sagole with due regard given to the economic, social and environmental aspects.

The aim of the study will be realised by investigating the following research objectives:

Research Objective 1

Identify the uses of thermal springs and the physical requirements for each use.

Research Objective 2

Assess the Sagole thermal spring in terms of the identified criteria for each of the uses and their physical requirements in order to identify potential uses for development at Sagole.

Research Objective 3

Determine economic, environmental and social impacts of each of the selected potential uses in order to identify their optimal use for Sagole.

1.4 OUTLINE OF THE STUDY

The **introductory orientation** sets out the basic background, rationale and motivation, research goal/ aims and objectives and the area for the study. **Chapter Two** gives the origin of thermal springs, which is followed by a discussion on the uses of thermal springs. **Chapter Three** presents the location, physical, and socio-economic characteristics of the study area. The characteristics of Sagole are given in terms of its historical development, infrastructure, management, physical and chemical characteristics of the spa waters. This is followed by an outline of the research design and methodology used. **Chapter Four** addresses objective 2 in that it compares the characteristics of Sagole's water to the potential uses discussed in chapter 2. Those with the highest potential are identified for further study. **Chapter Five** discusses the concepts of tourism and health tourism and the selection of the type of tourism suitable for Sagole. **Chapter Six** explores aquaculture or fish farming production. The exploration includes the selection of the fish crop, tilapia production and designing the near-ideal development system. **Chapter Seven** discusses the concept of a Geothermal Science Education Centre (GSEC) and its importance. This is followed by discussions on the selection of the type of geothermal education for Sagole. Chapter 5, 6 and 7 follow a similar outline in that the requirements for the selected use are identified; the suitability of Sagole with respect to these requirements, are assessed; and the impacts of such a development - and hence its feasibility - evaluated. The environmental, social and economic factors are used for these assessments and evaluations. **Chapter 8** is composed of three sections. Section 1 (8.2) comprises a comparison of the feasibility ratings and indices for the three types of development. In section 2 (8.3), the results are presented of a survey conducted at Sagole to determine the opinions of the community regarding the type of development that they would prefer. In the final section (8.4), the results of the scientific evaluation of the developments' feasibilities are compared with the perceptions of the community and a possible way forward is presented. **Chapter Nine** gives the summary, conclusion and recommendations of the study.

CHAPTER TWO

THERMAL SPRINGS AND THEIR POTENTIAL USES

2.1. INTRODUCTION

The main purpose of this study is to investigate the possible uses of thermal springs in order to determine which will be the best use, or uses, for the development of the Sagole thermal spring in the Limpopo Province. The research problem is formulated in the following question:

What is the best use and strategy for the development of the Sagole thermal spring in Limpopo Province?

In the previous chapter, the introduction, background, rationale, research aims and objectives, research methodology and outlines of the study were given.

This chapter describes the origin and diverse uses of thermal springs.

2.2 ORIGIN OF THERMAL SPRINGS

Thermal springs are either of volcanic or meteoric origin. A brief discussion of the genesis of each type of thermal spring follows:

2.2.1 Thermal springs of volcanic origin

According to Scheffel and Wernert (1980) thermal springs occur in volcanic areas where reservoirs of molten or slowly cooling magma lie close to the surface and have heated the rocks above. The water is heated as it flows through cracks in the rocks, and if the passage of the water to the surface is unobstructed, the heated water continuously bubbles up to the surface and so forms a thermal spring.

2.2.2 Thermal springs of meteoric origin

Thermal springs of meteoric origin are formed due to the effect of geothermal gradient rather than due to volcanic activity. Temperature increases with increasing depth in the earth. Cold water from rain, rivers or lakes may descend along a fault to a depth of several kilometres. This underground water is heated due to the geothermal gradient of 2,5 - 3^{o}C per 100 m, which causes it to expand and rise up another fault and so create a convection system (Hoole, 2000; LaMoeaux & Tanner, 2001). Figure 2.1 below illustrates diagrammatically how meteoric and volcanic hot springs are formed.

Meteoric **Volcanic**

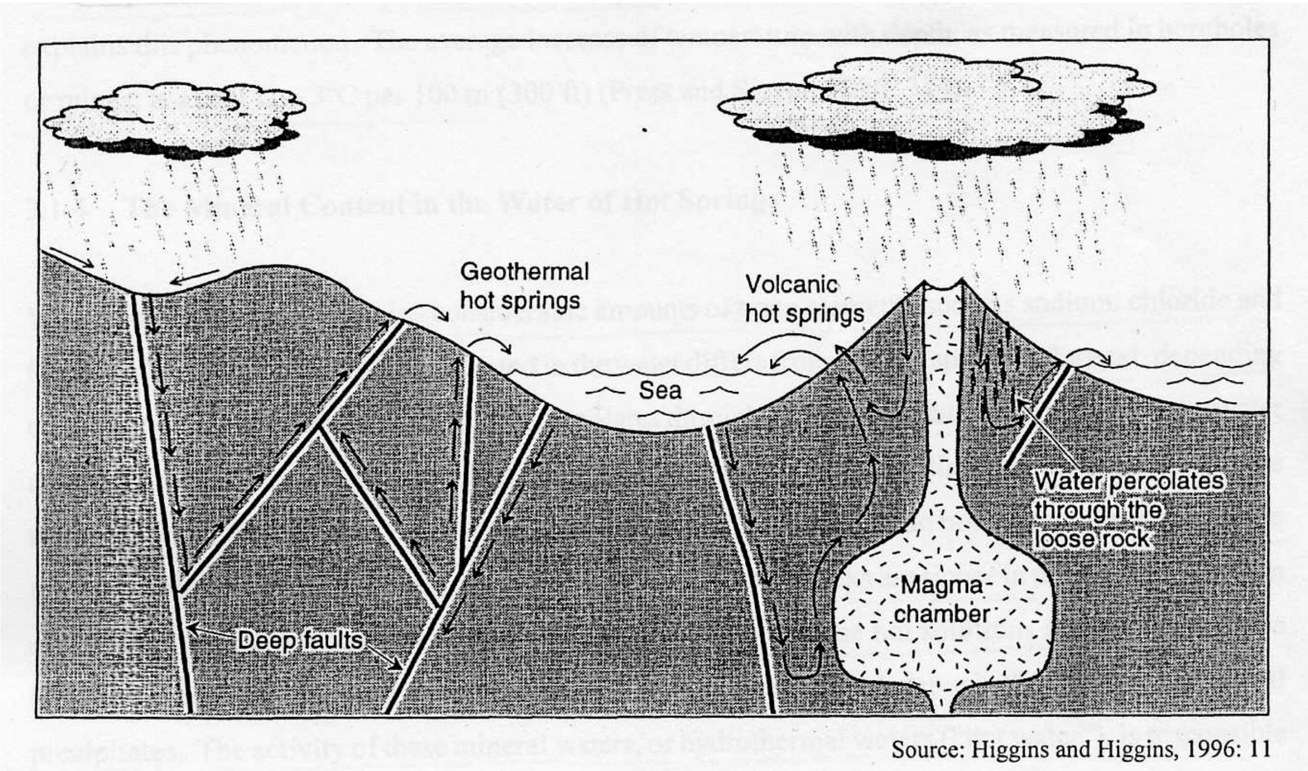


Figure 2.1 Diagrammatic representation of the origin of thermal springs.

The source of water for all hot springs in South Africa is meteoric rather than magmatic, and is generally associated with faulting and shearing (Kent & Groeneveld, 1962; Gevers, 1963; Visser, 1989, in Hoole, 2000:29).

According to Witcher (1981:3), thermal springs originate from a combination of special conditions. Four basic elements of these conditions are:

- a heat source;
- a recharge source;
- a circulation framework or storage reservoir, and

- a discharge mechanism.

The heat source is the most basic element because it is the one that separates thermal springs from other springs.

2.3 USES OF THERMAL SPRINGS

2.3.1 Geothermal resources

Geothermal resources can be classified as low temperature (less than 90°C), moderate temperature (90°C -150°C) and high temperature (greater than 150°C) (European Commission (EC), 1999; Geo-Heat Centre, 2005).Table 2.1 below shows temperature of geothermal fluids required for various uses.

Table 2.1 Temperatures of Geothermal Fluids Required for Various Purposes

($0^{o}C$) Degrees	Use
180	Evaporation of highly concentrated solution; Refrigeration by ammonia absorption; Digestion in paper pulp, craft;
170	Heavy water via hydrogen sulphide process; Drying of diatomaceous earth;
160	Drying of fish meal; Drying of timber;
150	Alumina via Bayer's process;
140	Drying farm products at high rates; Canning of food;
130	Evaporation in sugar refining; Extraction of salts by evaporation and crystallization;
120	Fresh water by distillation; Most multiple effects evaporation; Concentration of saline solution;
110	Drying and curing of light aggregate cement slabs;
100	Drying of organic materials, seaweeds, grass, vegetables, etc.;
90	Drying of stock fish; Intense de-icing operations;
80	Space heating, greenhouses by space heating;
70	Refrigeration (lower temperature limit);
60	Animal husbandry, greenhouses by combined space and hotbed heating;
50	Mushroom growing, balneological baths;
40	Soil warming;
30	Swimming pools, biodegradation, fermentations, warm water for year around mining in cold climates, de-icing;
20	Hatching of fish, fish farming.

Saturated steam (100–180)
Water (20–120)
Conventional power production

(Adapted from Lindal, 1973, in Rinehart, 1980:176)

Table 2.1 indicates that geothermal water and steam at different temperatures can be used for different purposes depending on the technology available to a country. Other uses that are not included in Table 2.1 include the following: bottling for commercial use, mining rare minerals/ elements or chemical extraction, the agricultural production of algae and geothermal education (Stahrl & Adam, 1979; Rinehart, 1980; Lund, 2000a; Lund & Freeston, 2001).

For a geothermal reservoir to be commercially exploitable it must meet the following standards:

- It must have an adequate heat source to maintain the geothermal fluid at a temperature suitable for the application at hand: high (150°C) for power generation, or considerably lower, as low as 40°C, for space heating, and some industrial, agricultural and recreational purposes.
- It must be obtainable at a relatively shallow depth of 3000 metres or less.
- The reservoir must be large and sufficiently permeable to allow water or steam to flow out continuously at a high rate or to be stored.
- It must have capping rocks of low permeability which inhibit the flow of water and heat to the surface.
- Sufficient water is necessary to recharge or maintain production over many years (Reinhart, 1980:175; Vimmerstedt, 1998:10).

When developing a strategy for a geothermal project, Popovski and Vasilevska (2003) recommend that the project be well defined in terms of technical/ technological and economic feasibility studies, concrete plans of action and sources of investment funds.

South African hot springs are of meteoric origin. The hottest geothermal spring in South Africa is Siloam (67.5^{o}C) in Limpopo Province. Siloam is located on the Nzhelele fault in a relatively active geological area. Before 2000, the temperature of the water was considerably lower in the area. However, after a period of extremely heavy rain, the Siloam hot spring emerged with a water temperature measuring 67.5^{o} C.

South African hot springs can thus be classified as low temperature geothermal resources and can be used for activities that require temperatures below 70^{o}C as indicated in Table 2.1. However, in this study, discussions on the generation of electricity are included to cover other geothermal resources that may develop surface water temperatures above 80^{o}C, or if boreholes are sunk into some of these geothermal resources, water with a temperature above 80^{o}C may be released. For the purpose of this study, the following uses of thermal springs will therefore be discussed:

- Medicinal (balneological) uses;
- Recreation and tourism;
- Agricultural uses (aquaculture and mushroom farming)
- Bottling for commercial use;
- Generation of electricity; and
- Mining rare minerals/ elements or chemical extraction.

A discussion of the above-mentioned uses follows below.

2.3.2 Balneological/ medicinal use

2.3.2.1 Balneology

One of the direct uses of geothermal resources is balneology. Lund (2000a:2) defines balneology as “the practice of using natural mineral water for the treatment and cure of disease”. The term ‘balneology’ is derived from the Latin word ‘balneum’ which means bath. The term is generally used for therapy based on warm thermal water for internal and external diseases, using whole and partial treatment baths, showers, mud and drink as cures (Murken, 2006:4).

2.3.2.2 Brief history of the balneological use of geothermal water

Archaeological findings in Britain indicate that development around the hot springs began about 8 000 years B.C. (White, 2000:12). Sofia, the capital city of Bulgaria, was established close to thermal springs by Thracian tribes in the third century BC.

According to Bojadgieva *et al.,* (2002) there is evidence that thermal water was used both for healing and heating in the Roman baths from the first to fourth century AC. Great European spas with histories stretching back to Roman times include Bath (England), originally known as Aquae Sulis; Baden-Baden known as Aquae Aureliae (Germany); and Aix-les-Bains known as Aquae Allobrogum (France).

Records indicate that American Indians used hot spring waters for over 10 000 years. They considered hot springs as sacred places of ‘Great Mystery’ and believed in the miraculous healing powers of the heat and mineral waters. American hot springs were also known as ‘neutral ground’ where warriors could retreat, assured they would remain unmolested by other tribes (Rindl, 1936; Lund, 2000).

The Greeks, Turks and Romans were known for their development and use of spas from Persia to England. No one knows the exact origin of the word “spa”. There are two main theories that explain the etymology. One is that the word “spa” comes from a Latin abbreviation: S = *salud*, P = *per* and A = *aqua*, which means “health through water”. Others believe the origin of the word “spa” comes from the Belgian town of Spa, known since Roman times for its baths (Brown, 2007). Spa became so popular that, in English, the word ‘spa’ became the common designation for similar health resorts around the world (Lund, 1996; Lund, 2000a; van der Linden & van Tubergen, 2002).

Some spas were social and cultural centres for the European nobility in the 19th century. Spas were also considered as places for balneological treatment. Some spas in France, Germany and Britain attracted many visitors to their centres. The thermal spa business fuelled the economy and has resulted in a steady increase of population density near hot springs since the end of the 19th century (Sanner, 2000). Active development of spa systems took place between 1970 and 1980. These are used for a wide range of ailments such as chronic respiratory malfunctions, diseases of the peripheral nervous system, syphilis, rheumatism and disorders of the digestive system (Lund, 2000; Bojadgieva *et al.,* 2002).

Today's spas are centres to heal and nourish mind, body and spirit. However, the strict definition of a spa has been diluted over the years and has given rise to health and beauty "spas" that have nothing to do with thermal water or balneology. Currently people visit spas for diverse reasons, some of which include the following: fitness, stress management, peace of mind, pampering and pleasure, health and wellness (Sarnoff, 1989; Register, 2007)). Soanes and Stevenson (2006:1380) define a "spa" as "a mineral spring considered to have health giving properties". It may be a place, resort or commercial establishment that has such a spring and offers health and beauty treatments. According to Sparrow (2007/08:24) a spa "aims to encourage relaxation and overall wellbeing to renew body, mind and spirit". It is not limited to water-based treatment. It can include the various massages, facial and water-based treatments on offer at a hydro. Soanes and Stevenson (2006:698) define "a hydro as a hotel or clinic originally providing hydropathical treatment" (the treatment of illness through the use of water, either internally or externally). According to Sparrow (2007/08), a hydro aims to restore physical, mental and emotional health in a calming environment and beautiful, natural surroundings through detoxification, healthy eating, mild exercise and relaxation. Hydro treatments include jacuzzis, hot and cold plunge pools, flotation tanks, hydrotherapy baths, indoor and outdoor swimming pools, hydro-oxygen baths and steam rooms. The main difference between a spa and hydro according to Soares and Stevenson is that a spa uses mineral water while any water can be used at a hydro.

In the context of this study the concept "spa" refers to naturally heated mineral water (geothermal resources) used for medical purposes and aimed specifically at improving health or relaxation.

Countries that use medically supervised spas include the following:

- The former Soviet Union which has 3 500 spas;
- Czechoslovakia has 52 mineral water health spas and more than 1900 mineral springs;
- In New Zealand, the Queen Elizabeth Hospital has used various mineral waters and mud from the hot springs for medicinal purposes since World War II;
- In Japan there are more than 1 500 spas that are used by more than 100 million visitors per annum;
- In Bulgaria, about 40 resorts of local and international significance were actively operating in 1990 (Bojadgieva *et al*., 2002);
- In Israel, 6 thermal springs are used for bathing and swimming, including balneology (Greitzer & Levitte, 2000).

Countries per continent that reported bathing, swimming and balneological use at the World Geothermal Congress 2000 held in Japan include the following:

Africa: Algeria, Egypt, Ethiopia, Mozambique, South Africa and Zambia; *Central America and the Caribbean Islands*: Guatemala, Honduras, and the Caribbean Islands; *North America*: Canada, Mexico, and the United States; *South America*: Argentina, Columbia, and Venezuela; *Asia*: China, India, Indonesia, Israel, Japan, Jordan, Korea, Nepal, Turkey and Yemen; *Europe*: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Germany, Greece, Hungary, Iceland, Italy, Macedonia, Poland, Portugal, Romania, Serbia, Slovak Republic, Slovenia, Switzerland, and the UK; *Commonwealth of Independent States*: Armenia; *Oceania*: Australia (Swarieh, 2000; Lund & Freeston 2001).

The economic value of spas includes saving on electricity as the water is naturally heated. They are also sources of income and employment (Edgell, 2006).

2.3.2.3 The curative properties of geothermal waters

Mineral and thermal waters are a special kind of groundwater, distinguished by specific chemical or physical properties such as higher mineralisation, the concentration of certain constituents, dissolved gas, radioactivity, or temperature (Laboutka & Vylita 1983:403; Wang Sumei & Xie Guiyin, 2003). Different minerals and gases within the geothermal waters are claimed to have different curative powers. Murken (2006) stated that treatment with natural thermal water was not primarily intended for external ailments of the musculoskeletal system and skin only, but diseases of the heart, stomach, intestines, bladder and kidneys are claimed to have been alleviated by thermal spa therapies thousands of years ago.

According to Murken (2006:2), five essential principles that help explain the complex interactions taking place between the human body and the thermal water therapy in its diverse applications are as follows:

- The body is relaxed by heat.
- The blood circulation to the skin, muscle joints and internal organs is favourably affected by the warm mineral water.
- The heat exerts a calming effect on the peripheral and central nervous system, and thus alleviates pain.
- The hormonal system is positively stimulated, which promotes the release of endogenous biochemicals such as endorphins, the steroid hormone cortisone and other hormones which have anti-allergenic properties or help to reduce inflammation and pain.
- The buoyancy afforded by the thermal bath permits painless movement which facilitates rehabilitation.

Skapare (2001:240) claims that the mechanical force caused by the movement of water molecules provides a micro-massage to the skin. As a result of this, capillary dilation and blood circulation improve, oxygen supply is increased and the metabolic processes are intensified in the skin and subcutaneous cells.

Waters high in mineral salts are believed to have different beneficial chemical effects on diseases through the absorption of the dissolved minerals via the skin. The use of carbolic water is thought to have significant medical importance for circulatory and heart disorders. Sulphated water may heal hepatic insufficiency and problems with the accumulation of organic waste. Bicarbonated water may relieve gastro-intestinal illness, hepatic insufficiency and gout. Sodium chlorinated water may cure chronic infection of the mucous membrane (Ledo, 1996; Lund, 2000; Skapare, 2001; Skapare *et al.*, 2003).

Drinking mineral water is recommended for diseases such as gout, urinary and kidney stone complaints, which are accompanied by severe attacks of pain (Murken, 2006).

2.3.2.4 Development strategy for balneological industry

A development strategy for a balneological industry should consider a number of factors which include the following:

- Physical factors such as temperature, water quality, as well as the flow rate of the spring water;
- Chemical and mineral composition of geothermal water, total dissolved solids (TDS), contamination and the pH value should be measured to ensure health safety (Babelek & Ciezkowski 1989, Samsudin *et.al.*, 1997; Kristmannsdottir & Bjornsson, 2003); and
- Economic feasibility measures may include site accessibility, surrounding attractions, current as well as potential markets and the development status of the site.

2.3.3 Recreation and tourism

Definitions of "tourism" are diverse and have been the subject of colourful and vigorous debate for years (Dredge & Jenkins, 2007:11). Academics generally agree that tourism may be thought of as "the relationships and phenomena arising out of the journeys and temporary stays of people travelling primarily for leisure or recreational purposes" (Pearce, 1987, in Dredge and Jenkins, 2007:11). According to Ryan (2003:23), tourism can be defined as "the demand for, and supply of, accommodation and supportive services for those staying away from home, and the resultant patterns of expenditure, income creation and employment". Forestry Tasmania (1995) in Page and Connell (2008:130) defined "tourism" as "a recreation activity requiring information or support services to enhance the quality experience". It can be concluded from these definitions that tourists are travellers, staying away from home, who need accommodation and support services to enhance the quality of their experiences.

Recreation is defined as "activities undertaken in leisure times" (Tribe *et al.*, 2000:206). Soanes and Stevenson (2006:1202) describe recreation as "an enjoyable leisure activity".

"It is a means by which people achieve desired objectives for their leisure life" (Peterson *et al*., (1990) quoted in Page and Connell (2008:130)). Forestry Tasmania (1995) described recreation as "a leisure activity which does not require information or support services to ensure a high quality of experience" (Page and Connell, 2008:130). It is in this definition that we see the distinction between a tourist and a recreationist. A tourist generally requires a greater level of information and more support services.

Recreational activities may include but are not limited to: recreational trips, bathing, swimming, sightseeing, mountain hiking, birdwatching, game viewing and photography. Recreation and tourism are very closely related and are discussed under the same subheading in this discussion. Tourists, for instance, are generally engaged in recreational activities (Rebeck, 1998; White, 2000).

2.3.3.1 Brief historical overview of recreation and tourism related to hot springs

People have used geothermal and mineral water for recreation and tourism for many thousands of years. Through the centuries, the hot baths of Roman times and the use of hot thermal springs in Japan have been used mainly for recreation and tourism (Rinehart, 1980:175). The Chinese, the Ottomans, the Japanese, and Central Europeans have bathed in geothermal waters for centuries (Lund, 2005). According to White (2000), there is archaeological evidence that the human settlement centred around the hot springs upon which the city of Bath is built began in about 8000 years BC. In AD 43, the Romans developed “Aquae Sulis” as a sanctuary of rest and relaxation through the taking of waters. In AD 70, the Romans started to build a series of baths around the hot springs. As a result, visitors from across Britain and Europe were drawn to Aquae Sulis as a tourist attraction. During the Elizabethan Era (1558-1603), the three baths – Kings’ Bath, Cross Bath and Hot Bath – continued to attract visitors. In 1574, Elizabeth I visited Bath. The visits of Queen Anne in the 1690s and 1700s started a period of development which resulted in the City of Bath becoming “the premier resort of frivolity and fashion.”

Recreational activities for tourists at hot spring centres included guided bathhouse tours, outdoor and wildflower and birding walks, tours of thermal features, campfire programmes, gambling, music festivals, swimming and tennis courts (Croutier,1992; Uhler, 1997).

2.3.3.2 South African hot springs used for recreation and tourism

The table below lists South African hot springs that are used for recreation and tourism or as resorts. Soanes and Stevenson (2006:1225) defined a resort as “a place frequented for holidays or leisure activities”. The province where the spring is situated, the name of the hot spring, the nearest town and the surface temperature at the source of each thermal spring are given.

Table 2.2 South African hot springs resorts.

Province	**Name of Hot Spring**	**Nearest Town**	**Temperature °C**
Western Cape	The Overberger Country Hotel	Caledon	49
	ATKV Goudini Spa	Worcester	40
	Brandvlei	Rawsonville	64
	Avalon Springs	Montagu	43
	Warmwaterberg Spa	Barrydale	43
	Calitzdorp Spa	Calitzdorp	51
	The Baths	Citrusdal	43
Eastern Cape	Aliwal Spa	Aliwal North	34
	Badfontein Guest Farm	Aliwal North	30
	Cradock Spa	Cradock	31
Northern Cape	Riemvasmaak	Kakamaas	39
North West	Protea Hotel Christiana Spa	Christiana	16
Free State	Florisbad	Bloemfontein	29
KwaZulu-Natal	Thangami Safari Spa	Vryheid	41

	Natal Spa	Vryheid	44
	Shu Shu Hot Spring	Kranskop	52
Gauteng	Mabalingwe	Pretoria	36
Mpumalanga	Aventura Badplaas	Carolina	50
	Falcon Glen Lodge	Machadodorp	42
Limpopo	Bela-Bela	Warmbaths	52
	Zimthabi Holiday Resort	Thabazimbi	32
	Die Oog Hot Spring Resort	Naboomspruit	40
	Rhemardo Holiday Resort	Naboomspruit	38
	Mphephu Hot Spring Resort	Makhado	43
	Sagole Spa	Thohoyandou	45
	Forever Resort Tshipise	Musina	58
	Eiland Spa & Eco Park	Tzaneen	43
	Lekkerdus	Naboomspruit	46
	Makutsi Safari	Tzaneen	35

Adapted from Boekstein (1998) Hoole (2000) and Olivier, Van Niekerk and van der Walt (2008).

Only 31 out of more than 90 South African hot springs are used for recreation and tourism purposes.

Recreational and tourism facilities and activities in South African hot spring resorts include the following facilities and activities: exercise areas, rest areas, restaurants, ladies' bars, shops, solariums, camping facilities, conference facilities, cocktail lounges, picnic sites, golf courses, tennis and squash courts, volleyball, snooker and pool, bowls, heated and cold swimming pools, hot mineral pools, jacuzzis, paddle boats, caravan and camping, game drives, birdwatching, and horse riding (www.foreverresorts.co.za).

2.3.3.3 Benefits of hot springs resorts

According to Hall *et al.,* (2005), tourism is one of the most labour intensive industries that has great potential to contribute to job creation and economic development in rural areas, and tourism is seen as a linchpin in many rural development strategies: “It has proved to be a powerful engine for economic growth – transferring capital, income and employment from industrial, urban and developed areas to non-industrial regions” (Organization for Economic Co-operation and Development (OECD), 1994:5-7). This was confirmed by Opperman and Chon (1997) who consider it as an economic panacea for developing countries. They also see it as “a vital development agent and an ideal economic alternative to more traditional primary and secondary sectors” (Braamwell, Henry, Jackson, Prat, Richards & van der Straaten, 1996, Opperman & Chon 1997:1; Edgell, 2006:1).

Globally tourism contributes 10,7% to Gross Domestic Product (GDP) and 10,7% to employment. In 2002, for example, unemployment dropped from 25% to 7% in Argentina within a period of four years due to development in the tourism industry (Pesce, 2002; Ghosh, Siddique & Gabby, 2003). Estimated figures for the Middle East-Africa region reveal that tourism generated 9,8% of the GDP in 1996 (Creemers & Wood, 1997; Edgell, 2006).

International travel for tourism involved about 665 million people at the turn of the twenty-first century. It triggers important processes of capital formation and the distribution of economic wealth (Williams, 2004). Hot spring resorts create jobs, foster commercial growth, promote rural development, pay taxes and attract tourists.

2.3.3.4 Sustainable recreation and the tourism industry

According to Swarbrooke (1999) and Edgell (2006), a condition for sustainable tourism is a balance in the management of three basic elements: the economic, environmental and social elements. Based on these three basic elements, Swarbrooke (1999: 13) defined sustainable tourism as "tourism which is economically viable but does not destroy the resources on which the future of tourism will depend, notably the physical environment and the social fabric of the host community." Edgell (2006:4) defined sustainable tourism as "achieving quality growth in a manner that does not deplete the natural and built environment and preserves the culture, history, and heritage of the local community." Edgell's definition is more comprehensive, and further discussion in this study will be based upon that definition.

The development and management of sustainable recreation and tourism is a complex issue which may include devising forward-looking policies and sound management strategies that uphold good working relationships between local communities, government representatives and the private sector in activities that protect the natural, built, and cultural environments in a way that is compatible with economic growth (Edgell, 2006).

2.3.3.5 Strategies for developing a sustainable recreation and tourism industry

It is essential to develop strategies and guidelines for a sustainable recreation and tourism industry. The concept of "strategy" is used in the comprehensive sense to embrace both policy and implementation (Lickorish, Jefferson, Bodlender & Jenkins, 1991). Tribe *et al*., (2000) recommend the use of the Environmental Management

System (EMS). According to Tribe, a management system is defined as “a method of structuring and processing the planning and day-to-day practices of a company or a section within a company” (Tribe *et al*., 2000:72). An EMS is a tool that can be used to ensure that the company complies with environmental legislation and minimises its negative environmental impact. It stems from the management philosophy called the “Deming Cycle” which is based on four points of simple and sound management practice: Plan-Do-Check-Act (Tribe *et al*., 2000).

Kepinska (2002) and Edgell (2006) recommended guidelines for the development of a sustainable recreation and tourism industry which include the following measures:

- Policy formulation. Planning and policy processes must be based on a strategic vision that combines past, current and future circumstances.
- To conduct an inventory, to assess, and to develop as many tourist attractions as possible that have roots in the local community. Categories of tourist attractions may include historic attractions, natural, scenic or environmental features, cultural and ethnic attractions, and special events to entertain tourists.
- Community involvement is essential to the ultimate success of any development projects.
- To carefully measure and weigh development in the light of environmental and social costs against benefits to the local community.
- The creation of partnerships or strategic alliances is very useful in this regard. Partnerships should include all stakeholders who will be affected by the development. Government, the private sector, the local community, and tour operators are examples of stakeholders who must be involved.
- Development should preserve the uniqueness and good condition of the local environment.
- The introduction of developmental, educational and awareness programmes to help educate the public or visitors about the sustainable use of natural resources.

- Marketing tourism using e-commerce tools such as, for example, database marketing or online booking and payment facilities. Effective promotional, commercial and management skills are indispensable, and it is essential to develop strategies to inform the general public of the benefits of thermal waters. This includes holding technical meetings, tourist fairs, and developing web sites focused on linking people, organisations, and tourist agents (Pesce, 2002).

Carefully planned and managed recreation and tourism destinations can fulfil economic, environmental, and social goals and maintain cultural identity and an ecological balance at the same time.

2.3.3.6 Facilitating successful recreation and tourism at thermal spring resorts

The temperature, flow rate, and physical and chemical properties of thermal water can determine the success or failure of hot spring resorts. Some geothermal fluids are too toxic to be used for recreation and tourism purposes. Chemical analyses must, therefore, be carried out to ensure the health and safety of all the people working at and visiting the hot spring resorts.

Sustainable hot spring resorts for recreation and tourism should include a variety of facilities and excellent service to ensure visitor satisfaction.

Experienced landscape architects should be commissioned to design the buildings, pools and surrounding landscape to ensure a quality environment that is aesthetically pleasing (Woodruff & Takahaski, 1993; California Energy Commission, 2005; Davidson, 2006).

2.3.4 Agriculture

Agricultural uses associated with thermal spring water may be subdivided into the following activities:

- agricultural crop drying,
- aquaculture: (a) Fish farming, and (b) Spirulina,
- mushroom farming, and
- heating greenhouses and irrigation.

According to the European Commission (1999), agriculture used 25% of direct heat produced (11% for aquaculture and 14% for the heating of greenhouses). Iceland, for example, uses geothermal fluid for agricultural purposes (Rinehart, 1980). Geothermal hot waters were used to heat greenhouses in which vegetables, fruit, mushrooms, and flowers were raised in a country where such produce could not be farmed under natural conditions owing to the prevailing inhospitable and cold climate. Currently countries are using geothermal resources to support such agricultural activities as: irrigation, crop drying, the cultivation of tomatoes, cucumbers, other vegetables and flowers, aquaculture, dairy farming, egg incubation and poultry farming, among numerous others (Christopher & Armstead, 1978; Mohamed, 2002). Temperatures required for various agricultural activities are given in Table 2.3.

Table 2.3 Temperatures required for various agricultural activities

Use	**Temperatures in ^{o}C**
Soil heating	20 – 35
Heating greenhouses	35 – 95
Food processing	35 – 95

Aquaculture	20 – 40
Biogas processing	35 – 50
Mushroom cultivation	45 – 65
Drying fruits and vegetables	65 – 95
Pasteurisation	50 – 70
Beet sugar extraction	60 – 85
Blanching and cooking	70 – 100
Sugar pulp drying	110 – 125

Source: Popovski & Vasilevska, 2003.

In this study, the use of geothermal energy for crop drying, fish farming, algae cultivation, mushroom farming, heating greenhouses and irrigation will be investigated. This is because, currently, the hottest thermal spring has a temperature of less than 70^{o}C. Such temperatures lend themselves to a variety of agricultural uses.

2.3.4.1 Agricultural crop drying

Various vegetable and fruit products can be dried with air temperatures ranging from 40° to 100^{o}C. At present, geothermal energy is used for drying various grains, vegetables, and fruit crops. Examples include the drying of tomatoes (Greece), seaweed (Iceland), onions and garlic (United States), wheat and other cereals (Serbia), coconut flesh (Philippines) and timber (New Zealand, Romania, and Mexico). There is great potential for the use of geothermal energy to dry crops in tropical regions where field spoilage occurs rapidly (Lund & Freeston, 2001; Andritsos, Dalampakis & Kolios, 2003; Bang, 2004; Lund, 2005).

2.3.4.2 The cost of using geothermal heat

According to Chandrasekharam (2001), the use of geothermal heat in India for the dehydration of fruits is relatively cheaper compared to the use of conventional energy. Food drying lowers the cost of storing, packaging and transportation. Geothermal dehydration is a good method as it retains the colour, nutrients and flavours of the product, and the geothermal drying of fruits and vegetables can be accomplished even by low temperature geothermal resources (Andritsos, Dalampakis & Kolios, 2003).

The table below compares the cost of dehydrating fruits by the conventional heating system versus geothermal heat.

Table 2.4 The cost of dehydrating fruits using conventional or geothermal heat.

Product	**Capacity (kg)**	**Time (hrs)**	**Heat cost (in US$) for geothermal system**	**Heat cost (in US$) for conventional system**
Pineapple	800	18	19	104
Apple slices	700	16	17	93
Apple cubes	900	16	17	93
Banana	800	24	27	125
Plantain	700	30	31	135

Courtesy: M/s Eco Fruit Agro Industry, Guatemala, Central America: Costs in US$ (Chandrasekharam (2001:9)).

All South African thermal springs are classified as low temperature geothermal resources. There is real potential for some of these geothermal resources to be used to dry locally produced fruits and vegetables. A majority of thermal springs are located in rural areas, and utilizing these resources can benefit the rural communities and improve the socio-economic status of the rural population.

2.3.4.3 Aquaculture (a): Fish farming

Aquaculture is the production and sale of farm-raised aquatic plants and animals. This section will focus on the production of fish. Low temperature geothermal water is suitable for fish farming as long as the water is not toxic. Geothermal energy has been used to raise, for example, cat fish, shrimp, tilapia, eels, lobster, crabs, crayfish, prawns and tropical fish (Lund & Lienau, 1992; Lund & Boyd, 2003; Gill, 2004).

The use of geothermal heat allows better control of pond temperature, and optimises fish growth. Crops can be produced faster than by the conventional method.

Sixteen countries reported on agricultural activities at the 2000 World Geothermal Congress held in Japan. These countries included: China, Iceland, Georgia, Israel, Turkey, Jordan, and the United States (Lund & Lienau, 1992; Carella & Sommaruga, 2000; Swarieh, 2000; Lund & Freeston, 2001; Gill, 2004).

According to the World Bank (1991:5), production increases in aquaculture can result from either extensification or intensification:

- Extensification refers to the expansion of existing systems into new areas, and
- Intensification refers to the increase in stock density within a farming system. In this regard the use of geothermal energy can optimise fish growth in aquaculture.

A knowledge of water chemistry in freshwater aquaculture is important. Water quality factors that can affect the growth of aquaculture species include temperature, dissolved oxygen, total ammonia-nitrogen (ionized and unionized), pH, alkalinity, hardness, chlorine, carbon dioxide, salinity, and hydrogen sulfide (Buttner, Soderberg & Terlizzi, 1993). These factors are discussed below.

Temperature

Temperature has an influence on all biological and chemical processes in an aquaculture operation. Each fish species has its own optimum temperature where it thrives best. Growth rate is therefore reduced when the temperature is above or below that optimal point.

Dissolved oxygen

The minimum safe level of dissolved oxygen in water is dependent on the temperature and, to a certain extent, the fish species. Warm water fish can tolerate lower levels of dissolved oxygen than cold water fish. The recommended level is above 3.0 ppm for warm water fish and 5.0 ppm for cold water fish (Buttner *et al*., 1993; Boyd & Rafety, 1998).

Nitrogen waste

Some fish excrete ammonia as their principle nitrogenous waste. The temperature and pH level cause the proportion of total ammonia nitrogen (TAN) to vary. Ammonia is removed by bacteria that first convert it into nitrite and subsequently into nitrate. High levels of nitrite cause “Brown Blood” disease and it is toxic to fish. When the concentrations of nitrites are 0.5 ppm or higher, reduced growth and death result.

pH

Fish grow best when the pH level is between 6 and 9 (Buttner *et al*., 1993).

Alkalinity

Alkalinity is a measurement of carbonate and bicarbonate ions dissolved in the water. Changes in the amount of carbon dioxide dissolved in water changes the pH level of the water. A suitable range of alkalinity for most fish species is 20 to 300 ppm. Alkalinity in fish ponds can be increased by adding agricultural limestone (Boyd & Rafferty, 1998).

Hardness

Hardness measures the positive ions (calcium and magnesium) in water. For fish species such as striped bass and catfish, hardness of water is essential for growth. The preferred range for most species is above 50 ppm. Lime or calcium chloride can be added to fish ponds to modify the water's level of hardness (Boyd & Rafferty, 1998).

Carbon Dioxide

Fish give off carbon dioxide during the respiration process. When carbon dioxide dissolves in water, it produces carbonic acid, which lowers the pH of the water. In order to keep carbon dioxide within acceptable levels, processes such as aeration, oxygenation or buffering the water help to manage carbon dioxide levels (Boyd & Rafferty, 1998).

Salinity

Salinity is the total concentration of all ions in the water. Fish species tolerate different levels of salinity. Some fish species, such as channel catfish and large mouse bass, grow well in slightly salty water. It is important to check if the water is suitable for the culture of the fish species under consideration (Buttner *et al*., (1993).

Chlorine

Generally, municipal water is treated with chlorine at 1.0 ppm. If geothermal water is mixed with municipal water, the residual chlorine, if any, must be removed by aeration with chemicals such as sodium thiosulfate. The health of certain fish can be threatened by a chlorine concentration as low as 0.02 ppm (Boyd & Rafferty, 1998).

Hydrogen Sulphide

Hydrogen sulphite has the familiar rotten egg smell and may be toxic to fish. It can be released when the floors of oxygen-poor ponds are disturbed. Afflicted ponds should be drained and exposed to air in order to correct the problem (Boyd & Rafferty, 1998).

The above-mentioned parameters should be monitored continuously in order to keep the water quality at an acceptable level for healthy fish growth.

Other important criteria to be considered for fish pond farming include the topography and inputs from agricultural by-products that can be used as feed. A slope gradient less than 8% is required, and availability of agricultural farm products that can be used as feed, such as rice, maize, pearl millet, sorghum, sweet potato, cassava and soybeans are recommended by the Food and Agriculture Organisation of the United Nations for fish farming (FAO, 2002, & Kapetsky, 1994).

Table 2.5 Water quality factors commonly used for monitoring procedures, and preferred ranges for fish culture.

Water quality factor	Preferred ranges for fish culture
Temperature	Species dependent
Dissolved Oxygen	>4-5 ppm for most species
Total Ammonia-Nitrogen (ionized and unionized)	NH_3<0.02
Nitrite	<1ppm; 0.1ppm in soft water
pH	Between 6-9
Alkalinity	50-300ppm
Hardness	>50ppm, preferably >100ppm
Carbon dioxide	<10 ppm
Salinity	Species dependent, typically <0.5-1.0ppm (For fresh water fish)
Chlorine	<0.02 ppm
Hydrogen Sulphide	No detectable level

Source: Boyd & Rafety, 1998: 2.3

Factors that must be taken into consideration when planning an aquaculture venture are:

- A study of the market potential and distributors for the type of fish you want to introduce.

- Determine the water temperature in which the type of fish will gain maximum growth, i.e., the optimum thermal environment.
- Determine the quantity and quality of water available.
- Conduct both a bioassay and chemical analysis of the water. The bioassay is used to determine whether the fish species can live and grow in the water. It is conducted by obtaining a few of the young organisms and rearing them in aquariums filled with the source water. The organisms can be observed for a period of 15 to 60 days to determine whether they can safely live and grow in the water.
- To reduce the construction cost of an aquaculture venture, the location of the ponds should be a flat area or on a gentle slope.
- A discharge pipe and gate should be placed in the pond to allow for complete drainage when necessary.
- Due to the initially high capital outlay for an aquaculture venture, it is advisable to do a feasibility analysis of a smaller operation for the first year (Smith, 1981).

South Africa has many thermal springs with surface temperatures of above 27^{o} C. Aquaculture can use geothermal water temperatures between 21^{o} and 27^{o} C (Lund & Lienau, 1992). There are many socio-economic benefits if South Africa can use its available resources to develop the fish farming industry.

2.3.4.4 Aquaculture (b): Growing micro-algae (Spirulina)

Definition of terms

According to Bowles (2007:9), “Micro-algae are microscopic photosynthetic organisms that are found in both marine and freshwater environments”. They grow well in environments where they have access to water, sunlight, carbon dioxide and other nutrients that contribute to the conversion of solar energy into biomass. There are many species of micro-algae. Species that are produced for commercial purposes are:

Isochrysis, Chaetoceros, Chlorella, Dunaliella and Arthrospira (Spirulina). This section focuses on the production of Spirulina, an edible micro-alga.

Spirulina is "a photosynthetic, filamentous, spiral-shaped, multi-cellular and green-blue micro-alga" (Sanchez, Bernal-Castillo, Rozo and Rodriguez (2001:1).

Reasons for focusing on the cultivation of Spirulina:

- the technology for mass production is well tested,
- in recent years the cost of production has dropped from US$11-15 per kg to US$6 per kg,
- it is a versatile product as it serves both as a human health food and as an animal feed (Li & Qi, 1997),
- a variety of useful products such as medicine, cosmetics and food supplements can be produced from the micro-algae biomass (Li & Qi, 1997; Bowles, 2007; European Geothermal Energy Council, 2007).

Historical development of the production of Spirulina

Spirulina has been harvested by various people for hundreds of years. Archaeological evidence indicates that micro-algae have been used as a source of food for more than 1000 years in China (Tseng, 2001).

In the sixteenth century, the Aztecs were already harvesting Spirulina from Lake Texcoco in Mexico. For many generations, dried Spirulina has been used as food by the Kanembu tribe along the shores of Lake Chad in Central Africa (Round & Chapman, 1983; Richmond & Vonshak, 1988). Currently, Spirulina is commercially cultivated in several countries of the world. The production in the world exceeds 3000 tons on a dry weight basis (Shimamatsu, 2004). Countries that produce Spirulina for commercial purposes are: Mexico, Thailand, Japan, Israel, USA, Taiwan, India, and China (Shimamatsu, 2004).

Applications

Spirulina can be applied as food, forage, and medicine. A brief discussion of these applications follows below:

Spirulina as food

Spirulina is purported to be an excellent source of proteins, vitamins, minerals and biologically active substances (Switzer, 1980 in Sanchez *et al*. 2001).The protein concentration was found to constitute 60-70% of its dry weight. It is claimed to be useful in human nutrition since it contains a high quality and quantity of protein. It contains essential amino acids: the highest values are leucine (10.9% of total amino acids), valine (7.5%), and isoleucine (6.8%). Currently, food containing Spirulina ingredients are eaten in the form of noodles, nutritious blocks, beverages and cookies (Li & Qi, 1997).

Spirulina as forage

Spirulina is used as forage for prawns, abalone, high value fish, poultry and livestock in China, Japan, Taiwan and the USA. The use of Spirulina forage has been found to promote the growth, immunity and viability of prawns; it improved the survival rate of high value fish from 15% to 30%, and improved the growth rate of poultry and livestock (Li & Qi, 1997; Sanchez *et al*., 2001).

Sipirulina as medicine

According to Li & Qi (1997), clinical trials in China have shown that Spirulina can be used as a cure for many diseases. Spirulina capsules lower blood lipid levels, decrease white blood corpuscles after radiotherapy, lower immunological function and combat fatigue. Extracts from Spirulina neutralise the poisonous effect of heavy metals and have shown anti-tumour activity. It is a common ingredient in skin care products, shampoos, dyes, masks, creams and tonics. Internationally, countries that market Spirulina products include Australia, New Zealand, Chile, France, Cuba, Germany, Switzerland, Spain, Portugal, Sweden, Holland, Belgium, Denmark, and the United Kingdom (Sanchez *et al.*, 2001).

Environmental conditions required for the production of Spirulina

The quality and economic efficiency of the production of micro-algal biomass is said to be site specific and highly dependent on climate, water carbon dioxide content, overall environmental conditions, know-how and technology (Fournadzhieva, *et al.*, 2003).

Temperature is one of the important factors that should be considered in the production of Spirulina. An optimal growth temperature of between 35^{o} C and 37^{o}C is essential. The maximum temperature that blue-green algae can tolerate is 85^{o} C (Vymazal, 1995). For open pond systems the minimum temperature that allows growth is around 18^{o}C (Torzillo, Sacchi, Materassi & Richmond, 1991; Zitteli, Tomasello, Pinzani & Tredici, 1996). Therefore, Spirulina will flourish well in tropical and subtropical climates.

The intensity of solar irradiance and the duration of the cells' exposure to light intensity determine the growth rate of Spirulina (Richmond & Vonshak, 1988). High intensity solar irradiance leads to the rapid growth of Spirulina. In open pond systems, the Spirulina culture is continually mixed, and in this process the Spirulina cells are illuminated intermittently. Other factors include dissolved solids (10-60 g/l), pH (8.5-10, 5), water quality, and the presence of macro- and micro-nutrients (C, N, K, S, Mg, Na, Cl, Ca and Fe, Zn, Cu, Ni, Co, W). A higher "flow speed" of the culture is recommended for effective photosynthesis (Borowitzka, 1999; Sanchez, 2001; Shimamatsu, 2004).

The use of thermal water, geothermal energy and carbon dioxide for micro-algae cultivation optimizes the yield of biomass and reduces the production costs (Bojadgieva *et al*., 2000; Fournadzhieva *et al*., 2003). Three basic benefits for the application of geothermal resources in the production of Spirulina are:

Geothermal CO_2 and energy optimises photosynthesis. In geothermal water, enough CO_2 is naturally present; there is no need to add more CO_2 so this reduces the cost of production.

- Geothermal water is used for nutritional algal media preparation, and
- Geothermal energy is used for algal biomass drying (Fournadzhieva *et al.*, 2003: 4).

The production of Spirulina at plants in Musina, Limpopo, South Africa and in Imperial Valley, California, stops during the winter months because the water temperature falls below acceptable levels (California Energy Commission, 2005; Lebogang, 2005). When geothermal water was used in Bulgaria, the surface temperature reached its optimum for algal growth even during winter months and increased production by 20%, and reduced the production cost by 40% (Torzillo, Materassi & Richmond, 1991; Bojadgieva, Hristov, Hristov & Benderev, 2000; Fournadzhieva *et al*., 2003; Bojadgieva *et al*., 2005).

The production system of Spirulina

Figure 2.4 Illustration of the production system of Spirulina.

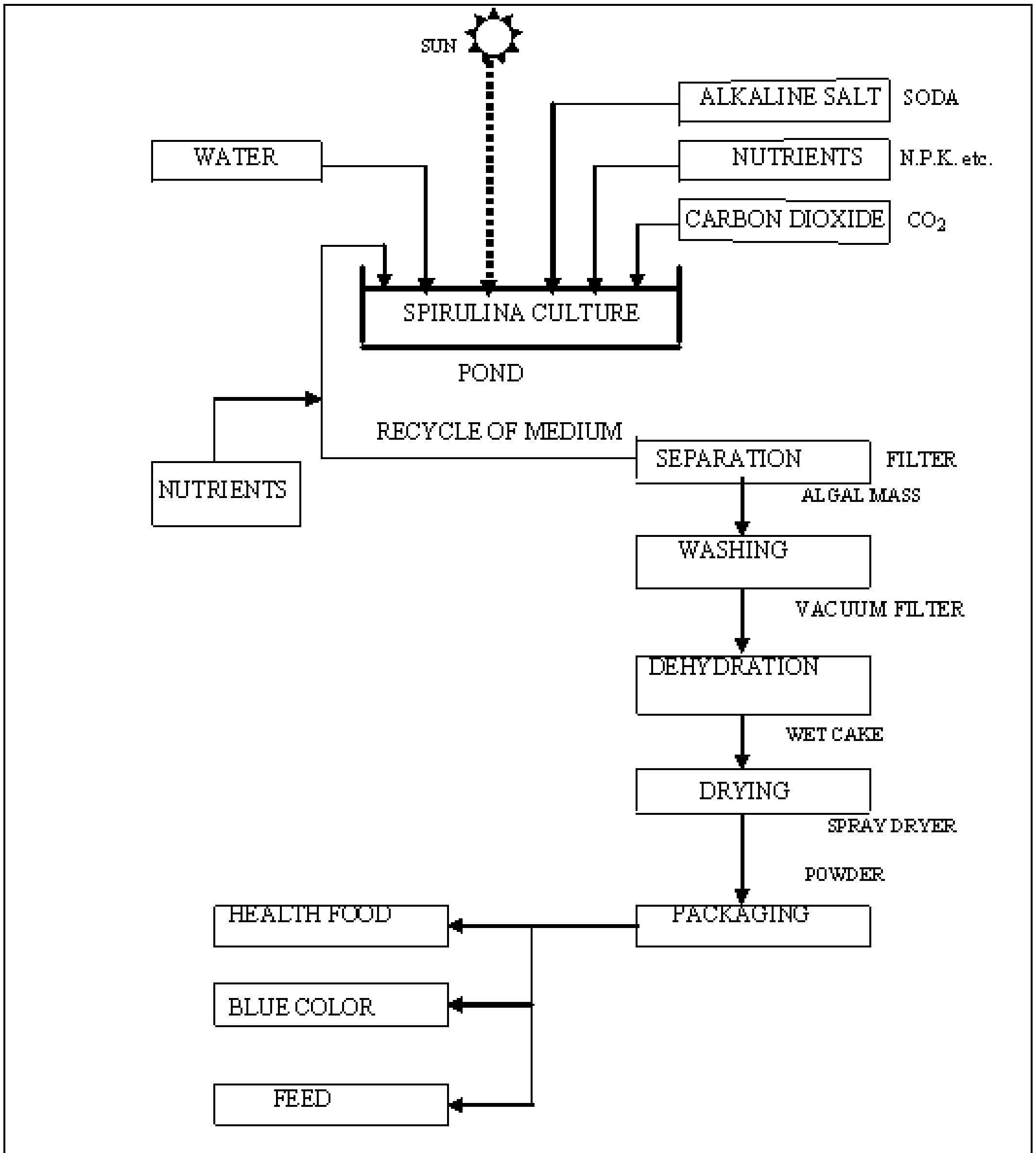


Figure 2.4 A schematic diagram of the production system of *Spirulina* (Shimamatsu, 2004:40).

Figure 2.4 A schematic diagram of the production system of *Spirulina* (Shimamatsu, 2004:40).

Inputs into the Spirulina culture open pond include water, sunlight, alkaline salt, nutrients and carbon dioxide, and a paddle wheel to generate a circulation flow in the pond. The algal mass is harvested by filtration equipment, such as vibrating screens, and is further concentrated into a wet algal cake by vacuum filters. The algal cake is dried into powder by a spray dryer and packed into oxygen barrier bags to prevent spoilage (Richmond & Vonshak, 1988; Sanchez *... et al*., 2001; Shimamatsu, 2004).

2.3.5 Mushroom farming

Brief historical development of mushroom farming

According to Levin, Branch, Rappoport and Mitchell (1985), mushrooms, a form of fungi, were known to very early civilisations. Around 460 BC, Hippocrates wrote about using the mushroom as medicine. People had both negative and positive attitudes towards mushrooms. Mushroom poisoning was first recorded during the time of Euripides, the famous Athenian playwright, when a woman and her children died after eating mushrooms (Levin*et al.*, 1985). In later ages, mushrooms were thus given evil names such as 'Devil's Boletus', 'Witches Butters' and 'Devil's Puffbox' (Levin *et al.,* 1985:11). Wealthy Romans were great mushroom eaters. Martial, the famous writer of epigrams, described the temptation of mushrooms as follows: "It is easy to despise gold and silver but exceedingly difficult to refuse a plate of mushrooms" (Levin *et al.,* 1985:8). Around 460 BC, people gained better knowledge about mushrooms, their form, structure and sexual reproduction. Through mycology, the importance of fungi as food and medicine has been recognised since 1800.

The first recorded commercial production of mushrooms was in 1780 in France, when a French gardener began growing mushrooms in the underground quarries near Paris. The first structure for commercial mushroom growing was built in Pennsylvania in 1894. Currently, mushrooms are grown all over the world. Countries producing mushrooms commercially include Belgium, Denmark, France, Germany, the UK, Ireland, Italy, Poland, Spain, China, India, Japan, Korea, Canada and the USA, Australia and South Africa (Kues & Liu, 2000).

Basic requirements for growing mushrooms

Mushrooms grow well in dark, moist environments. They grow on dead and decaying plant matter, or on very fertile ground. Commercial mushrooms grow best in well prepared conditions such as on wheat straw, hay, corn cobs, veld grasses, bean straw, soy pulp, cotton seed hulls, gypsum, poultry litter, horse manure, and more (Haase, 2003; American Mushroom Institute, 2006). Two basic requirements for commercial mushroom farming are:

- the capacity to control temperature and moisture, and
- the ability to inhibit the growth of competing, undesirable mushrooms which can contaminate the commercial product (Rangel, 1998:14).

Basic procedure for growing mushrooms

The following steps are recommended for the general production process of mushrooms:

Making mushroom compost

Mushroom compost is prepared by using a substrate, which is the material or growth medium whose degradation sustains the growth of the mushrooms. The substrate may include a mixture of wheat straw, chicken manure, gypsum, alfalfa seed screening, stubble, hay, and crushed corn cobs.

Substrate treatment

The substrate is pasteurised by immersing it in 90^{o}C water for two hours. This eliminates sugars, removes waxy layers, starts the decomposition of cellulose and assures a growth medium free of competing organisms.

Seeding

Seeding is done by mixing the mycelium or inoculums with the substrate. For a good seeding, the temperature should be in the 20-21^{o}C range. The seeded area should be clean to prevent contamination. Moisture in the substrate should be around 75%.

Incubation

During the first 24 hours, the mushroom grows slowly while adapting to the growing medium. Faster growth starts 48 hours after seeding. During this vegetative state, the temperature needs to be controlled to between 22^{o} and 26^{o}C. The incubation period should last for about 22 days.

Production

The primordia of fruiting structures appear within a few days in substrates with fully developed mycelia. At this stage the temperature should be controlled at the 24–26^{o}C range. The primordia start growing and fruiting bodies appear in about five days.

Harvesting

The fruiting bodies are harvested when they are fully developed. The bodies are removed by cutting the base of the stalk with a clean sharp blade. The next sprouts start to appear 4-6 days after harvesting. A 15 kg substrate may produce three to four harvests (Staments, 1998; Beyer *et al*., 1999; Culver, 2004).

Geothermal utilisation

The geothermal water used for pasteurisation must reach a temperature of 90^{o} C. From seeding to production, the room temperatures should be controlled to stay within the 20-26^{o}C range (Rangel, 1998; Stamets, 1998; Beyer, Fleischer & Wuest, 1999; Culver, 2004).

The use of geothermal energy (instead of fossil fuel and or electricity) in mushroom farming reduces the pasteurisation, incubation and production costs. Operating costs for geothermal energy are minimal. The main costs incurred are the heat exchanger and small piping (Culver, 2004).

2.3.6 Heating greenhouses and irrigation

Greenhouses are constructed of either a galvanised steel or an aluminium frame, usually mounted on a concrete strip foundation. The most common greenhouse structures are covered by glass, plastics or fibreglass (Kevin & Rafferty, 1990). Glass and plastics are used to trap heat (long wave radiation) inside the house or structure. In the past some greenhouses were heated by propane, electricity, gas or oil (Culver, 2004). Vegetables, flowers and fruits can be grown in greenhouses.

Geothermal utilization in greenhouses

Greenhouses that use geothermal water are currently in operation in many parts of the world. According to Popovski and Vasilevski (2003), about 75% of geothermal energy was used to heat greenhouses in 2000. Countries which have made maximum use of geothermal energy for heating greenhouses include China, Georgia, Hungary, Iceland, Italy, Russia, the United States of America, Greece and Slovenia (Lund & Freeston, 2000). Leading geothermal greenhouse operations include California, Idaho, Montana, New Mexico, Oregon, South Dakota and Utah in the USA (Lienau, 1997). Other places include Taupo and Kaweru in New Zealand, Tunisia, Spain, Israel and many more (Popovski & Popovska-Vasilevska, 2001).

Geothermal water in greenhouses is used for a number of things which include: irrigation, warming the greenhouse and to sterilize soil and plastic flower pots. Some farmers use hot water as a weed killer on the ground between benches. Vapour is also used for seed germination (Lund, 1994). Greenhouses themselves are specifically used to raise bedding plants and perennials, tomatoes, lettuce, green beans, peppers, cucumbers, herbs, corn, squash, raspberries, geraniums, poinsettias, diverse fruits and many more (Blackett & Lund, 2004; Allred, 2004; Lund, 2006).

Benefits of the use of geothermal water in greenhouses

According to Popovski, Rodrigues and Popovska-Vasilevska (1998:17) the possible benefits of using geothermal water are:

- protected crop cultivation within a controlled climate (greenhouses) leads to higher productivity, and better quality crops;
- crops are protected from external climate factors such as heavy rains, strong winds and severe cold or snow;

- internal climate control by geothermal energy can shorten the normal growing period of the plants and offers more control of the time when harvesting takes place;
- geothermal energy may be comparatively cheaper compared to fuel energy overseas. It presents an opportunity to avoid fuel expenses (Allred, 2004);
- different commercial crops can be raised in greenhouses. This makes geothermal resources in cold places more attractive because plant growth can be optimised in a controlled environment (Lund & Boyd, 2003);

- low temperature geothermal resources are common in many countries;
- geothermal energy requires relatively simple heating installations, but advanced computerised installations can be added later for total control of the interior climate of the greenhouse;
- the economic competitiveness of geothermal energy for greenhouse heating, especially in colder climates;
- strategic importance of energy sources that are locally available for food production; and
- using a geothermal resource in combination with an existing fossil fuel system for peak heating (Lund & Boyd, 2003:14-15).

An experiment conducted in Tunisia using geothermal water for heating plastic greenhouses, and for irrigation, was very encouraging. In comparison with unheated greenhouses, the geothermally heated greenhouses generated better quality and higher yields and also resulted in the earlier ripening of crops. Crops that were produced include cucumbers, tomatoes, melons, watermelons, and peppers. Geothermal water is also used for the irrigation of date palms, apples, grapes, apricots and vegetables (Mohamed, 2002). Date palms occupy the first priority in the agricultural sector in Tunisia due to their social and economic interests. The social interest is due to the fact that more than 80% of the population (farmers and families) depends directly or indirectly on them. The economic interest is due to the fact that a high level of employment and profitability is generated by this sector. In the year 2000, for example, a total of 31 000 tonnes of dates were exported, mostly to Europe, and generated an income of US$52 million (Mohamed, 2002). If geothermal water can be used to irrigate crops in greenhouses, local communities can be employed in this business.

2.3.7 Bottling for mineral water

Mineral and thermal waters are distinguished from other waters by their specific chemical or physical properties such as higher mineralisation, concentration of certain constituents, and dissolved gas radioactivity (Laboutka & Vylita, 1983:403).

2.3.7.1 Historical development of the bottled water industry

The history of the development of the bottled thermal water industry started with the French. France became the leader in production, consumption and export (LaMoreaux & Tanner, 2001:107). Other countries that joined the industry include the USA, Germany, Italy, Hungary, China, Russia, Croatia and Poland (Marovic, Sencar, Franic & Lokobauer, 1996; Carella & Sommaruga, 2000b; Baradacs, Hunyadi, Dezso, Csige & Szerbin, 2001).

In the USA, bottled thermal water was sold for 10 cents per bottle in 1885 at the Cascade Springs Hotel near Bonneville Hot Springs. The bottled water was recommended to barrooms, clubs, restaurants and hotels (Bloomquist, 2006b:4). In the past, Saratoga Springs (New York) and Calistoga Springs (California) had commercially bottled thermal water industries.

In Italy, for example, several million m^3 of mineral water are bottled annually for table use. Ten hot springs in Montecatini and Chianciano with a temperature range of between 23^{o}C and 36^{o}C produce drinking water (Carella & Sommaruga, 2000). In Russia, mineral water has been bottled at Borjomi, Georgia, since the 19th century. Water is pumped from boreholes with temperatures ranging from 19^{o}C to 40^{o}C (Bagdavadze, Beon, Hrkal, Laurendon, Puyoo & Santrucek, 2008).

By the 19th century, the bottling of thermal water was a well-established American industry that provided water for table use. Today, there is an increasing popularity of commercially bottled water as a result of public awareness of the importance of the quality and reliability of drinking mineral and thermal water.

Bottled mineral and thermal water is consumed by people in every nation of the world. Currently, there are hundreds of bottled water companies in the world and the industry has become a multi-billion dollar business (Sumei & Guiyin, 2003; LaMoreaux & Tanner, 2001).

2.3.7.2 Water quality for naturally occurring drinking water

As already indicated, water quality is a very important factor that must be considered for all drinking water. Before thermal water is bottled for commercial sale, it must be tested for harmful chemicals in laboratories for consumer health reasons. Guideline values for naturally occurring chemicals that are of health-related significance in drinking water are outlined by the World Health Organisation (WHO: 2000). Criteria that should be considered when deciding to bottle drinking water for commercial purposes are: water appearance, taste, odour, and chemical contents (WHO, 2006; WHO, 2000). The table below gives guideline values for some of the naturally occurring chemicals in water.

Table 2.6 Guideline values for naturally occurring chemicals in drinking water.

Chemical	**Guideline value (mg/litre)**
Arsenic	0.01
Barium	0.7
Boron	0.5
Chromium	0.05
Fluoride	1.5
Manganese	0.4
Molybdenum	0.07
Selenium	0.01
Uranium	0.015

Adapted from: World Health Organisation, 2006:186

2.3.8 Generation of electricity

Geothermal heat in hot spring areas has been exploited for many years to generate electric power. The geothermal electricity system works as follows: high temperature geothermal resources generally produce either steam or a mixture of steam and water from production wells. The steam piped to the power station drives one or more turbines. The turbine is attached to and spins a generator to produce electricity (Saba *et al*., 2004).

2.3.8.1. Brief overview of geothermal power generation

According to DiPippo (1999), electricity was first generated from geothermal energy in the Tuscan village of Larderello in Italy more than 100 years ago when Prince Piero Gonori Conti powered a ¾-horsepower reciprocating engine to drive a small generator. Prince Piero was able to light a few bulbs in his boric acid factory situated amid the boron-rich geothermal steam field. He upgraded the power system to 20 kW in 1905. In 1914, geothermally-generated electricity of 250 kW capacity from Larderello provided electricity to the cities of Volterra and Pomarance for the first time. The Larderello plant was generating 136 800 kW of power when it was destroyed during the Second World War in 1944. After the war, the plant was rebuilt. In 1999, over 740 MW of electricity was generated at Larderello for Tuscany (Fridleifsson, 2001).

In 1958, New Zealand became the first country to operate a commercial geothermal power plant using a liquid-dominated, hot water type reservoir at Wairakei. In 1960, when the United States used geothermal energy to generate electricity with the inauguration of the 11 MW Geyser Unit 1 by the Pacific Gas & Electric Company it became the third country to employ geothermal power. By 1999, the United States of America became the largest generator of geothermal electricity with an installed capacity of 2850 MW (DiPippo, 1999, Dickson & Fanelli, 2004).

There are presently many geothermal power plants. A list of operational plants in early 2005 is supplied in Table 2.7.

Table 2.7 Worldwide geothermal power generation in early 2005 (Bertani, 2005:653)

Country	Installed capacity (MWe)	Running capacity (MWe)	Annual energy produced	Number of units	% National	% National

			(GWh/year)		capacity	energy
Argentina	0.2	0.1	0.5	1	negligible	negligible
Australia	1.2	1.1	3.2	2	negligible	negligible
China	28	19	96	13	30%of Tibet	30%of Tibet
Costa Rica	163	163	1145	5	8.4	15
El Salvador	151	119	967	5	14	22
Ethiopia	7.3	7.3	0	2	1	n/a
France	15	15	102	2	9	9
Germany	0.2	0.2	1.5	1	negligible	negligible
Guatemala	33	29	212	8	1.7	3
Iceland	202	202	1483	19	13.7	17.2
Indonesia	797	838	6085	15	2.2	6.7
Italy	791	699	5340	32	1.0	1.9
Japan	535	530	3467	19	0.2	0.3
Kenya	129	129	1088	9	11.2	19.2
Mexico	953	953	6282	36	2.2	3.1
New Zealand	435	403	2774	33	5.5	7.1
Nicaragua	77	38	271	3	11.2	9.8
Papua New Guinea	6	6	17	1	10.9	n/a
Philippines	1930	1838	9253	57	12.7	19.1
Portugal	16	13	90	5	25	n/a

Russia	79	79	85	11	negligible	negligible
Thailand	0.3	0.3	1.8	1	negligible	negligible
Turkey	20	18	105	1	negligible	negligible
USA	2564	1935	17917	209	0.3	0.5
Total	8933	8033	56 786	490		

Source of data: Bertani, 2005:655.

Bertani (2005) reviewed all the Country Update papers submitted for the World Geothermal Conference held in Antalya, Turkey from 24 April to 29 April 2005. Some conclusions regarding trends in international geothermal development are:

- 24 countries currently generate electricity from geothermal resources;
- the total installed capacity is about 8930 MWe. The installed capacity (MWe) is defined as “the reference value for the power plant set by the manufacturer as its target output when the plant is operating under design conditions” (Bertani, 2005:652). The total running capacity is about 8030 MWe. The running capacity (MWe) is “the highest average value over 1-h period during the time of investigation of the output from the power plant as measured at the generator transformer supply voltage terminals, when operating at its stated design conditions” (Spielberg-Planer *... et al*., 2001 in Bertani, 2005). The annual energy produced was about 57 000 (GWh/year). This is a great achievement compared to the 7974MWe in 2000;
- since 2000, Costa Rica, France, Iceland, Indonesia, Italy, Kenya, Mexico, Nicaragua, Russia, and the USA increased the capacity of their power installation by 10%;
- only two countries in Africa reported on geothermal power generation in 2005. These are Kenya (129 MWe) and Ethiopia (7.3 Mwe);
- New countries that generate electricity from geothermal resources are Austria (0.1MWe), Germany (0.2MWe) and Papua New Guinea (6MWe) (Bertani, 2005).

No geothermal power has ever been generated in South Africa. Research in this area will therefore be necessary.

2.3.8.2 Countries generating geothermal power in 2010

Table 2.8 shows countries generating power in 2010. Twenty-four countries are ranked according to the installed capacity (MW) (Holm, Blodgett, Jennejohn & Gawell, 2010:71).

Table 2.8 shows countries generating power in 2010

Country	Installed capacity (MW)	Rank
United States	3,086	1
Philippines	1,904	2
Indonesia	1,197	3
Mexico	958	4
Italy	843	5
New Zealand	628	6
Iceland	575	7
Japan	536	8
El Salvador	204	9
Kenya	167	10
Costa Rica	166	11
Nicaragua	88	12
Russia	82	13
Turkey	82	14
Papua New Guinea	56	15
Guatemala	52	16
Portugal	29	17
China	24	18
France	16	19
Ethiopia	7.3	20
Germany	6.6	21
Austria	1.4	22
Australia	1.1	23
Thailand	0.3	24

The USA continues to lead the world in geothermal power generation with 3086MW. Even though Philippines is ranked 2nd, its production has declined from 1930MW in 20005 to 1904 in 2010. In Africa, Kenya takes a lead with 167MW.

2.3.8.3 Power generation technology and resource type

Two basic technologies are used for power generation, namely:

- Flash steam system, and
- Binary cycle.

A brief discussion of these two systems follows:

Flash steam system/ plants

Flashing (flash steam) is defined as “steam produced when the pressure on a geothermal liquid is reduced” (Saba *et al*., 2004:37). The steam may come directly from the geothermal well, or when extremely hot and highly pressurised water is depressurized to produce steam. The flash steam system uses steam produced from the geothermal fluid to turn the turbine which drives the generator that generates electricity. After leaving the turbine, the steam is condensed and creates a partial vacuum and thereby maximizes the power generated by the turbine-generator. Steam is condensed either in a direct contact condenser or a heat exchanger type condenser. In a direct contact condenser the cooling water from the cooling tower is mixed with the steam. The condensed steam forms part of the cooling water circuit and a small amount of steam is emitted into the atmosphere through the cooling tower. Excess cooling water is disposed of into re-injection wells. In instances where shell and tube type condensers are used, condensed steam does not come into contact with the cooling water and is disposed of in re-injection wells (Vimmerstedt, 1998; DiPippo, 1999; European Commission (EC), 1999; Saba *et al*., 2004).

Figure 2.5 below illustrates how a flash steam system operates.

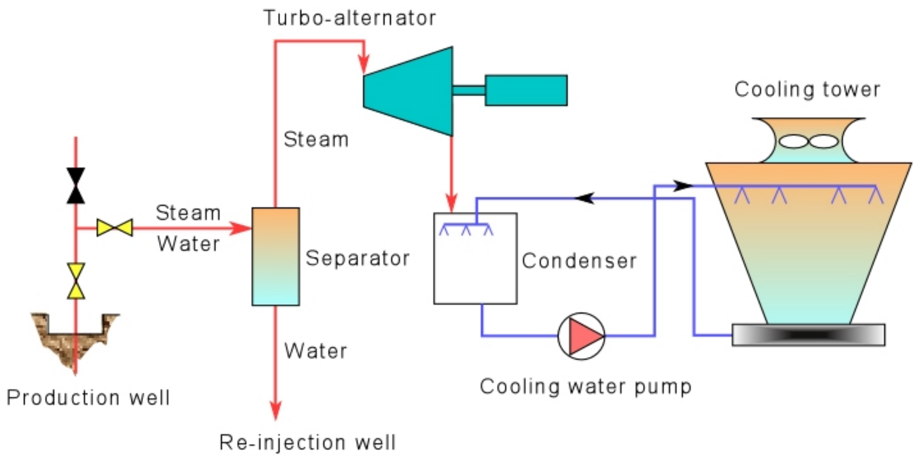


Figure 2.5 Schematic representation of a flash steam geothermal power plant. (Source: Dickson & Fanelli 2004).

The advantages of flash steam systems include the following:

- relative simplicity and low cost of the plant. Energy produced by this systm costs about 4 to 6 cents per kWh. Currently, the cost stands at $0.03-S0.035kWh at The Geysers (Shibaki & Beck, 2003);
- in contrast to binary plants, they require no secondary working fluid (DiPippo, 1999).

Disadvantages of flash steam systems include the following:

- when the geothermal fluid is flashed to steam, the solids that precipitate can foul equipment and pose health, safety and disposal problems;
- the steam that contains contaminants can pose an air quality problem if released directly into the atmosphere:

- treating non-condensable gases in the condensing design can add complexity, maintenance and disposal problems;
- flash steam systems require higher resource temperatures of above 150^{o}C (Vimmerstedt, 1998);
- very few places in the world have geothermal resource temperatures above 150^{o}C. South Africa, for example, has no thermal spring with a temperature higher than 70^{o}C.

Binary-cycle plant

A binary-cycle plant is defined as “a geothermal electricity generating plant employing a closed-loop heat exchange system in which the heat of geothermal fluid (the primary fluid) is transferred to a lower-boiling-point fluid (the secondary or working fluid), which is thereby vaporized and used to drive a turbine/generator set” (Afgan & Carvalho, 2002; Saba *et al*., 2004:35).

Binary-cycle plants are often used where geothermal temperatures are typically less than 220^{o}C, but greater than 100^{o}C. The European Commission (1999) recommended a temperature range of 85^{o}C and 170^{o}C. However, in Alaska, the Chena Geothermal Power Plant is currently operating at 74^{o}C (Bogo, 2008). Figure 2.6 below illustrates how a geothermal binary power plant works.

The geothermal fluid, steam or water, is passed through a heat exchanger which heats a secondary working fluid with a lower boiling point. The secondary fluid is usually a hydrocarbon (an organic fluid), such as isopentane, isobutane or a refrigerant such as R-134a, that is vaporised and used to turn the turbine which drives the generator. The vapour exits the turbine to the condenser where it is converted back to a liquid. The fluid is recycled back to the heat exchanger to form a closed loop. Cooled geothermal fluid is re-injected back into the reservoir (DiPippo, 1999:4).

Figure 2.6 below illustrates how the binary-cycle system operates.

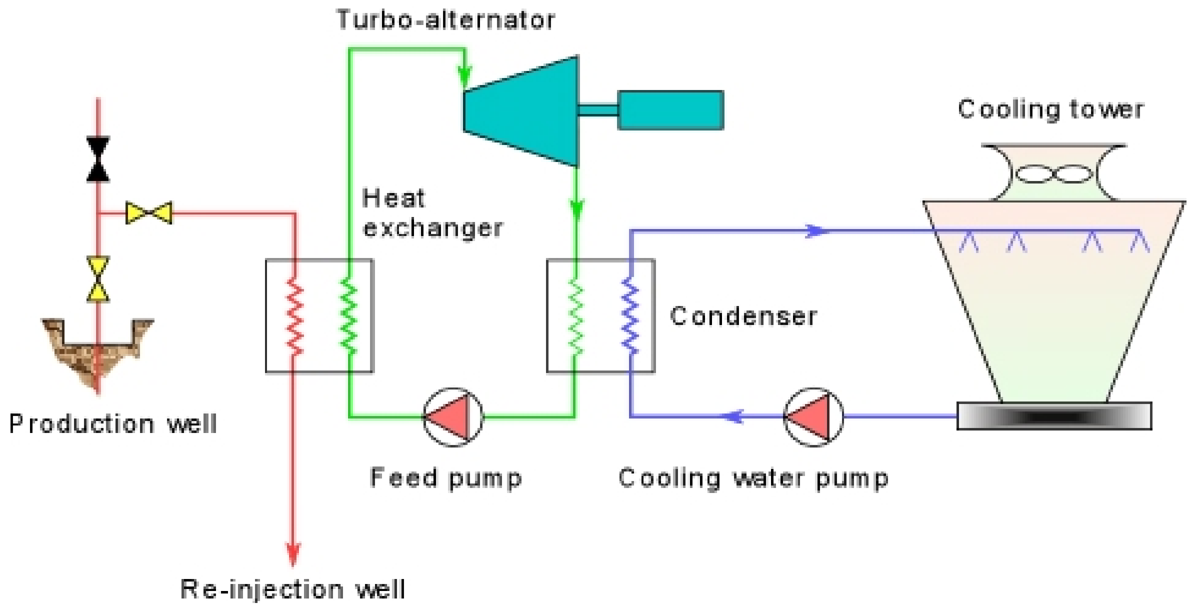


Figure 2.6 Schematic representation of a binary-cycle geothermal power plant. (Source: Dickson & Fanelli 2004)

Advantages of binary cycle plants include the following:

- because binary plants use a self-contained cycle, no air pollutants are emitted;
- precipitation and environmental effects of the geothermal fluid can be controlled;
- energy produced by this system currently costs about 5 to 8 cents per kWh; and
- because lower temperature reservoirs are more common, binary plants are therefore more prevalent.

Disadvantages of binary cycle plants include the following:

- secondary working fluids may be hazardous and difficult to supply;
- these plants have higher capital costs and complexity (Vimmerstedt, 1998).

Research results indicate that binary plant technology is a very cost-effective and reliable means of converting water-dominated geothermal resources into electricity.

According to Saba *et al.* (2004), two prerequisites must be fulfilled in order to generate electricity from geothermal hot water. These are: adequate technology, and an abundant supply of high temperature water or steam.

2.3.8.4. Economics of geothermal power

According to DiPippo (1999:6), the costs associated with building and operating a geothermal power plant vary widely and depend on factors which can include: resource type (steam or water), resource temperature, reservoir productivity, power plant size (rating), power plant type (single-flash, binary, etc.), environmental regulations, cost of capital and cost of labour.

Resource type, temperature and productivity influence the number of wells that must be drilled for a given plant capacity. DiPippo (1999) further estimated that a single well could cost $100-400/kW using typical costs and power potential for production wells. Power plant size, power plant type and environmental regulations determine the capital cost of the energy conversion system. The cost of capital and labour also affects the running costs of the plant.

The following questions need to be answered when planning for a geothermal electrical plant:

- Where will the drilling take place?

- Which technology will be preferable: the flash steam or the binary-cycle system?
- What will the system cost? (Saba *et al*. 2004).

When new plants are to be built, it is advisable that they should demonstrate an economic advantage over alternative systems. Current geothermal power plant installation costs are in the range of $1000-$3000/kW (Saba *et al.*, 2004). DiPippo (1999) confirmed that geothermal energy was a proven alternative energy source for power generation because of its economic competitiveness in many situations, the operational reliability of the plants, and its environmentally friendly nature.

2.3.8.5 Sustainable management of geothermal resources

Sustainable geothermal utilisation involves energy production at a rate which may be sustained for a long period of time. Axelsson *et al.*, 2001 (in Rybach and Mongillo, 2006:1084) define sustainable production from a geothermal system as follows:

> *For each geothermal system and for each mode of production, there exists a certain level of maximum energy production, below which it will be impossible to maintain constant energy production from the system for a very long time (100-300 years).*

It is therefore concluded that a balanced fluid/ heat production that does not exceed the recharge level can be considered fully sustainable. This requires appropriate and efficient management in order to avoid the overexploitation of groundwater. Efficient utilisation of energy, re-injection of thermal water, and careful monitoring and modelling are regarded as essential ingredients in sustainable management (Axelsson & Stefansson, 2003).

2.3.8.6 Possible generation of electricity from geothermal resources in South Africa

The temperatures of South African geothermal resources fall below 70°C. They are classified as low temperature geothermal resources. They do not fulfil the two prerequisites required for generating electricity from geothermal hot water or steam which are: adequate technology, and an abundant high-temperature water or steam (Saba *et al*., 2004). However, drilling into the earth in hot springs such as Siloam (67.5^{o}C) one may encounter temperatures above 74^{o}C which may be suitable for the generation of electricity by the binary-cycle system.

2.3.9 Minerals/ elements or chemical extraction

2.3.9.1 Brief overview of mineral extraction from geothermal resources

Engineers have started extracting valuable minerals from geothermal resources with temperatures above 250^{o}C. According to Clutter (2000), the CalEnergy Operating Corporation (CalEnergy) has started a project to mine commercial grade zinc from geothermal brine. CalEnergy is a subsidiary of the Mid-American Energy Holdings Co. CalEnergy currently operates eight geothermal power plants at the Salton Sea in California.

By 1997, CalEnergy funded a $200 000 mineral recovery project that would produce 30 000 metric tonnes of 99.99 per cent pure zinc annually for Cominco Ltd. It was claimed that the facility was the lowest cost producer of zinc in the world, and the first and only operation specifically designed to harvest minerals from high temperature geothermal brine. From 1997 to 1998 CalEnergy successfully produced 18 597 kg of high grade zinc at its small demonstration Elmore power plant in California.

Other mineral extraction projects include the following: The extraction of gold and silver at Kawerau geothermal field in New Zealand (Brown and Roberts, 1988), the extraction of silica at the Mammoth Lakes, California (Parker, 2005), the extraction of silica from a hydrothermal heat carrier in Russia (Potapov *et al.*, 2007) and gold extraction in Nevada, USA.(National Geothermal Collaborative, http://www.geocollaborative.org/publications/geothermal_Direct_use-pdf.)

2.3.9.2 Economics of extracting minerals from geothermal resources

CalEnergy has created an average of 700 construction jobs and employed a total of 220 staff over the life of the project. Its expansion could create more jobs and business development in the area (Clutter, 2000). As technology develops, it may be possible to recover other valuable minerals from geothermal reservoirs. Selling such minerals can make power plants more profitable and provide another base of economic activity for communities.

South Africa's geothermal resources fall within low temperatures geothermal resources and with current technology cannot be used in mineral extraction since the minimum temperature requirement is 250^{o}C.

2.3.10 Geothermal Science Education

Countries such as Iceland, USA, Germany and others have introduced geothermal science education near geothermal resources (Fridleifsson, 2003; Arslan & Huber, 2010; Geothermal Energy Association, 2010). The centres introduced geothermal education at different levels and with different focuses. Training is in the form of workshops, short courses, and graduate studies. Some centres simply disseminate geothermal knowledge and information to high school learners and the public. Visitors are given opportunities to learn and experience geothermal energy by walking through geothermal areas, laboratory experiments, and teaching on the relation of geology, tectonics, volcanic activity and microbiology to geothermal activity (Jonsdottir, 2010:2). Education programmes can be designed to suit the needs of the people. The establishment of a geothermal education centre in South Africa can help primary and secondary school learners to experience science and improve their pass rate.

2.4 SUMMARY

In this chapter, the origin of thermal springs and their potential uses were discussed. It was also concluded that for each potential use, there are specific and general requirements that must be met. In Chapter 4 the specific requirements for these activities will be compared with those of the study area so as to identify those that could be economically viable.

CHAPTER THREE

METHODOLOGY AND STUDY AREA

Contrary to popular convention, this chapter commences (section 3.1) with an overview of the methodology used. The study area is discussed thereafter (sections 3.2 and 3.3), since some of the techniques described in 3.1 were required to elucidate the characteristics of the study area.

3.1 METHODOLOGY

3.1.1 Introduction

The aim of the research is to determine the optimum use for the Sagole thermal spring. It therefore focuses on the investigation of the possible diverse uses of thermal springs and strategies to identify the most appropriate use for Sagole with regard to economic, social and environmental aspects. The research methods used in the present study included the literature study, site visits and observation, personal communication, laboratory experiments, focus group interviews and an education and skills survey. The section below explains how the data was collected using these research methods in order to address the following objectives:

- identify uses of thermal springs and physical requirements for each use;
- assess Sagole thermal spring in terms of identified criteria for each of the uses and their physical requirements in order to identify potential uses for development at Sagole;

- determine economic, social and environmental impacts of each of the selected potential uses in order to identify their optimal use for Sagole.

3.1.2 Literature review

An extensive literature survey was conducted in order to address the objectives mentioned above. The survey included articles from journals, secondary data, and websites. Articles by Bond (1946) and Olivier, van Niekerk and van der Walt (2008) provided information on the chemical properties of the Sagole hot spring and the map showing the locations of the thermal springs in the Limpopo Province, South Africa, adapted from Kent (1949) and Boekstein (1998). The Google Scholar search engine was used to access online articles on the topic, while the Geo-Heat Center website provided valuable information on the diverse uses of geothermal resources.

3.1.3 Site visits and observation

In order to collect realistic data on the uses and physical requirements for each use, national and international geothermal resource sites, resorts and projects were visited. These included the Sagole Spa itself (the subject of the case study), Siloam hot spring, Mphephu resort, Forever Resorts Tshipise, Forever Resorts Bela-Bela (Warmbaths) in Limpopo Province, and Huka Prawn Park and Wairakei Geothermal Power Station (Taupo in New Zealand) and Liskey Farms for aquaculture (fish farming and spirulina production) and greenhouses near Merrill in the Lower Klamath Valley in South Oregon, Oregon Institute of Technology, and Klamath Falls for geothermal power systems (USA) and Canby for aquaculture and geothermal power systems (Northern California, USA).

The physical and chemical characteristics of Sagole hot spring were obtained by measuring the temperature of the water at the source of the spring using a quality glass mercury thermometer. Water samples were also collected at source and stored at low temperatures (around 4^{o}C) in 1 litre sample bottles before being submitted to the Council for Geosciences laboratory for chemical analysis.

3.1.4 Personal communication

Personal communications with managers and administrators of hot spring resorts, developers, project managers, local municipal managers and communication officers, tourist attraction officers and employees, and traditional leaders were conducted. Table 3.5 below lists the name of the person interviewed, the name of the place visited and contact information.

Table 3.5 Personal interviews conducted

Person interviewed	**Name of Site/organisation**	**Type of function**	**Date**	**Contact information**
Mr H Odendall (General Manager)	Forever Resorts Tshipise	Hot spring resort	29/072005	**015 539 1634**
Malan Du Toit (Project Manager: Tourism)	Limpopo Economic Development Enterprise (LimDev)	Development agent	23/09/2005	**015 633 4720**
Ms S Ravele (Administrator)	Mphephu Resort	Hot spring resort	28/09/2005	**015 973 0282**

Mr WA Basson	Bela-Bela (Warmbath)	Hot spring resort	24/10/2007	**084 581 1492**
Mr Mutshinyalo	Sagole Spa	Hot spring resort	29/10/2007	**073 659 7936**
Ms M Nengudza	Siloam hot spring	Hot spring	29/10/2007	**072 340 4090**
Mrs S Ravele	Mphephu Resort	Hot spring resort	30/10/2007	**082 638 3835**
Ms Nengudza	Siloam hot spring	Hot spring	22/06/2009	**072 340 4090**
Mr Ravhura	Mutale Local Municipality (Communication Officer)	Rural development	24/06/2009	**082 417 4427**
Ms L Sebola	Musina Spirulina	Spirulina production	22/09/2009	**083 679 5906**
Dr J Lund and Tonya Boyd	Oregon Institute of Technology (OIT) Geo-Heat Centre	Geothermal energy system	21-30/07/2009	**541 885 1750**
Mr R Barns	Liskey Farms	Fish farming and greenhouses	24/07/2009	**541 885 1750**
Mr K Scott	OIT (Geothermal System Engineer)	Geothermal energy system	27/07/2009	**Scott.keiffer@ Oit.edu**
Mr Ron Ketler	Aquaculture Canby	Fish farmer and exporter of tilapia	29/07/2009	**ketler@citlink.net** **530 233-2356**
Mr Dale Merrick	Canby Geothermal Energy System	Geothermal energy system	29/07/2009	**canbygeo@gmail.com**
Mr A Mashapha	Dept. Of Agriculture	Fish farming	22/09/2009	**082 220 2722**
Ms F Khorommbi	Campbell Musina	Fish project	22/09/2009	**076 580 1604**

Johan Theron (Lecturer)	University of Limpopo	Aquaculture Research Unit	08/09/2009	**015 268 2295**
Mr Tshikovha Mulaudzi	Traditional healer	Uses thermal water for agriculture	13/07/2010	**No phone**
Mr AC Mphaphuli	Mutale Local Municipality	LED Officer	15/07/2010	**015 9679656** **mphaphulia@mutale.gov.za**
Chief Muvhango	Tshikundamalema Tribal Authority	Development in Tshipise		

3.1.5 Sample collection and analysis

Research trips were undertaken (2005-2010) to the Sagole thermal spring where the temperature was measured at the source. Water samples were also collected at source and stored at low temperatures (around 4°C) in 1 litre sample bottles before they were submitted to the Council for Geosciences (CGS) laboratory for chemical analysis in Pretoria. The following chemical elements were measured by the CGS: bromine, selenium, strontium, molybdenum, cadmium, antimony, tellurium, iodine, barium, lanthanum, tungsten, platinum, lithium, beryllium, boron, titanium, vanadium, chromium, manganese, cobalt, nickel, copper, zinc and arsenic. Thereafter, the characteristics of thermal water at Sagole were compared with the criteria needed for each of the uses. A preliminary identification of the possible uses for Sagole was thus obtained. Thereafter, more detailed comparisons were conducted to identify the potential for specific uses. The comparison includes drinking water standards by the World Health Organisation (WHO), the European Union (EU) and South Africa.

For the purposes of triangulation, the measurements were compared with the chemical analysis by Bond (1946).

3.1.6 Focus Group interviews

Focus group interviews were conducted at Tshipise Village with various structures or groups. A focus group pilot study was conducted with women from the local tribal council (Zwigodini village). After the pilot study, questions and questioning strategy were modified. The groups interviewed included the educators of the Madifha Primary School and the Hanyani Secondary School, farmers, tribal authorities, water committees, women, clinics, the South Africa National Civic Organisation (SANCO) and the Mutale Local Municipality Executive Committee. A digital recorder was used to record the focus group discussions. The interview process included a presentation of potential uses at Sagole. Participants were requested to express their views and indicate their alternative/s choice for development project in the area. They were also requested to prioritise the projects presented. Appendix 1 gives the questionnaire for the Focus Group Interview.

3.1.7 Projects rating and education and skills surveys

Survey was conducted at Sagole with the following two objectives. The first objective was to rate the potential projects for development. The second objective was to identify the available knowledge and skills within the local community. Out of four hundred households, two hundred people were selected at random to participate in the survey. Four young people (two males and two females) from the local community assisted in data collection as research assistants. All of them had a minimum Grade 12 level of education and were identified by the local civic organisation committee. They were trained in data collection skills by the researcher. The survey tools are given as Appendix 10 and Appendix 11. Education and skills survey results are illustrated in Section 3.3.

3.1.8 Calculation of feasibility of potential projects

Three potential projects were identified for development at Sagole. Potential impacts of each of the uses identified in chapter 4, were scored according to the given scale (-4 to +4), where -4 indicated high negative impact and +4 indicated high positive impact. The total weighted score and the mean score of each of the environmental, social and economic feasibility were calculated as follows:

Total weighted score =

The mean score = ———

Where   = Environmental, social and economic impact scores

Where   = Number of weighted scores

N= Number of occurrences

How the Feasibility Index was determined

To quantify the estimated costs and benefits of the project, the feasibility index was calculated in which the mean feasibility rating was multiplied by a factor reflecting the inverse of the potential costs of the development. This gives an indication of the costs and benefits of the projects.

3.1.9 Summary

This section explained how the research data were collected by means of a literature review, site visits and observation, personal communication, laboratory experiments and focus group interviews and an education and skills survey. The next part of this chapter will describe the characteristics of the study area in general as well as of Sagole spa, in particular.

3.2 STUDY AREA

3.2.1 Physical Characteristics

3.2.1.1 Location

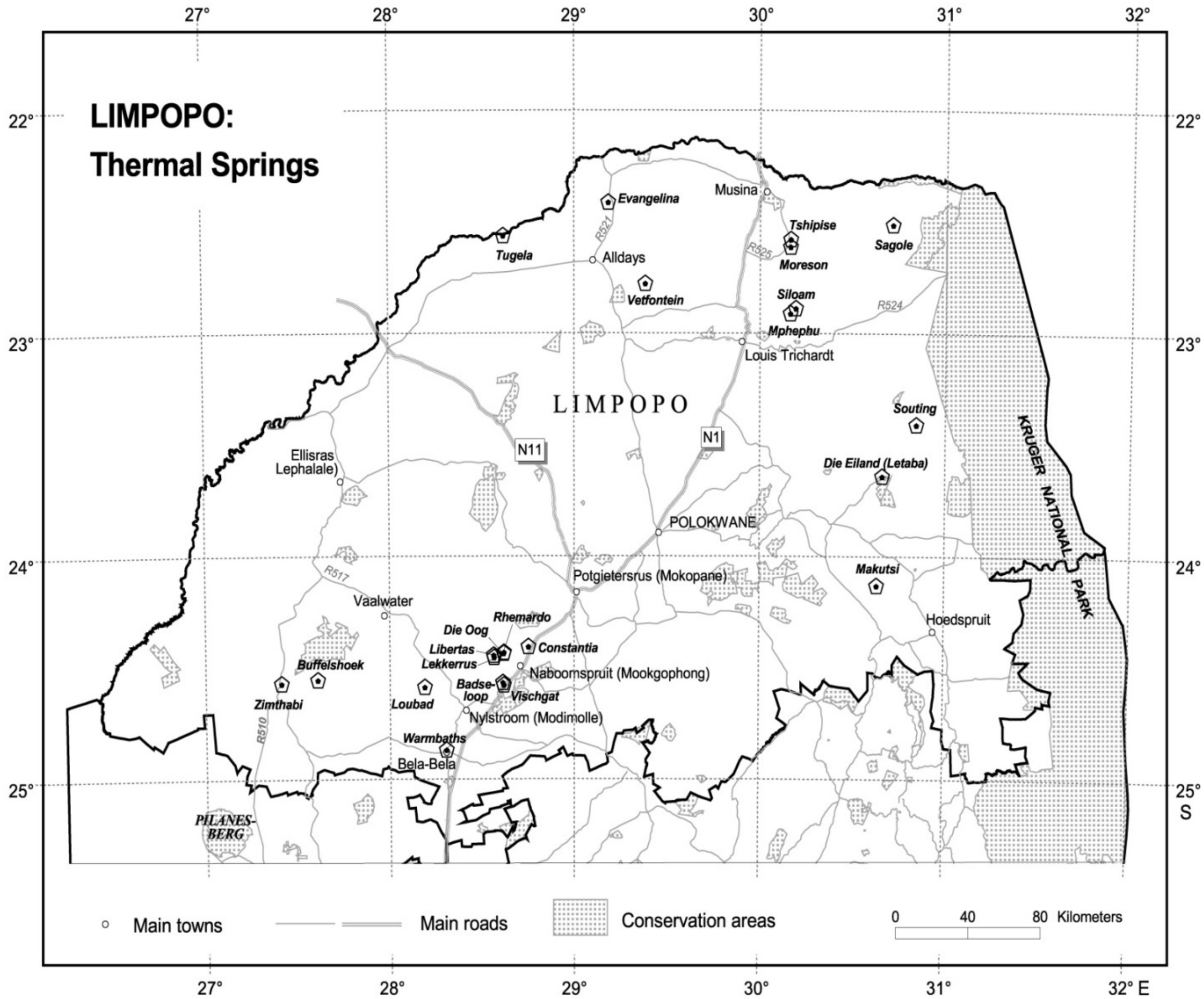


Fig 3.1 Location of thermal springs in Limpopo Province, South Africa (Olivier, van Niekerk and van der Walt, 2008:166)

Fig. 3.1 indicates that Sagole Spa is located in the north-eastern part of Limpopo Province. Sagole Spa (previously known as Klein Tshipise) is in the Tshikundamalela Tribal Authority area of the Vhembe district of the Limpopo Province. It falls under the authority of the Mutale Municipal Council. Figure 3.2 presents the location of Sagole Spa within the Mutale municipality.

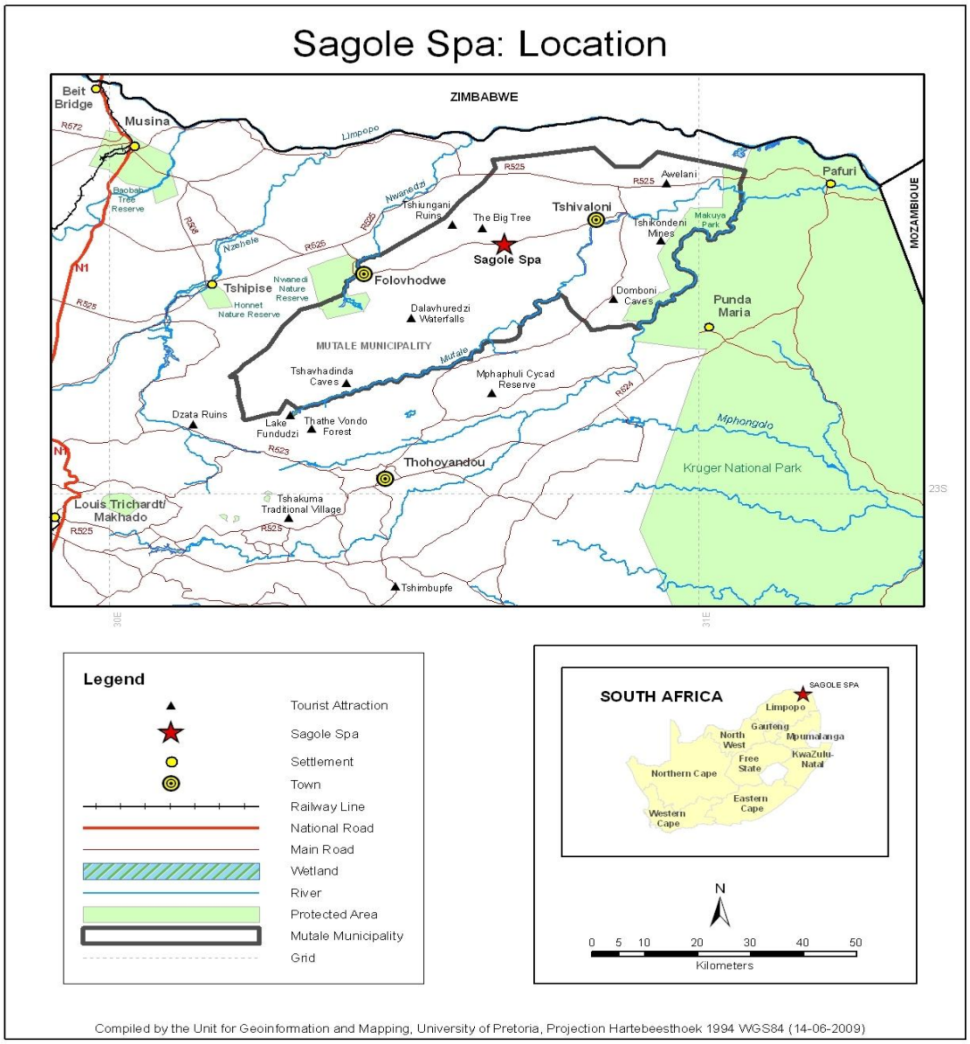


Figure 3.2 Sagole Spa: Location

The Mutale Local Municipality borders Musina Local Municipality and Zimbabwe in the north, the Kruger National Park and Mozambique in the east, Makhado Local Municipality in the West and Thulamela Local Municipality in the South. The thermal spring is found at about 53km north-east of Thohoyandou. Other nearby towns are Musina in the north-west, and Tshilamba in the south-west (about 50 km from Sagole), the commercial centre of the municipality. The absolute location according to the grid reference is the 22°, 31’ 30’’ South and the 30°, 40’ 40’’ East (Winfield, 1980).

3.2.1.2 Geology and morphology

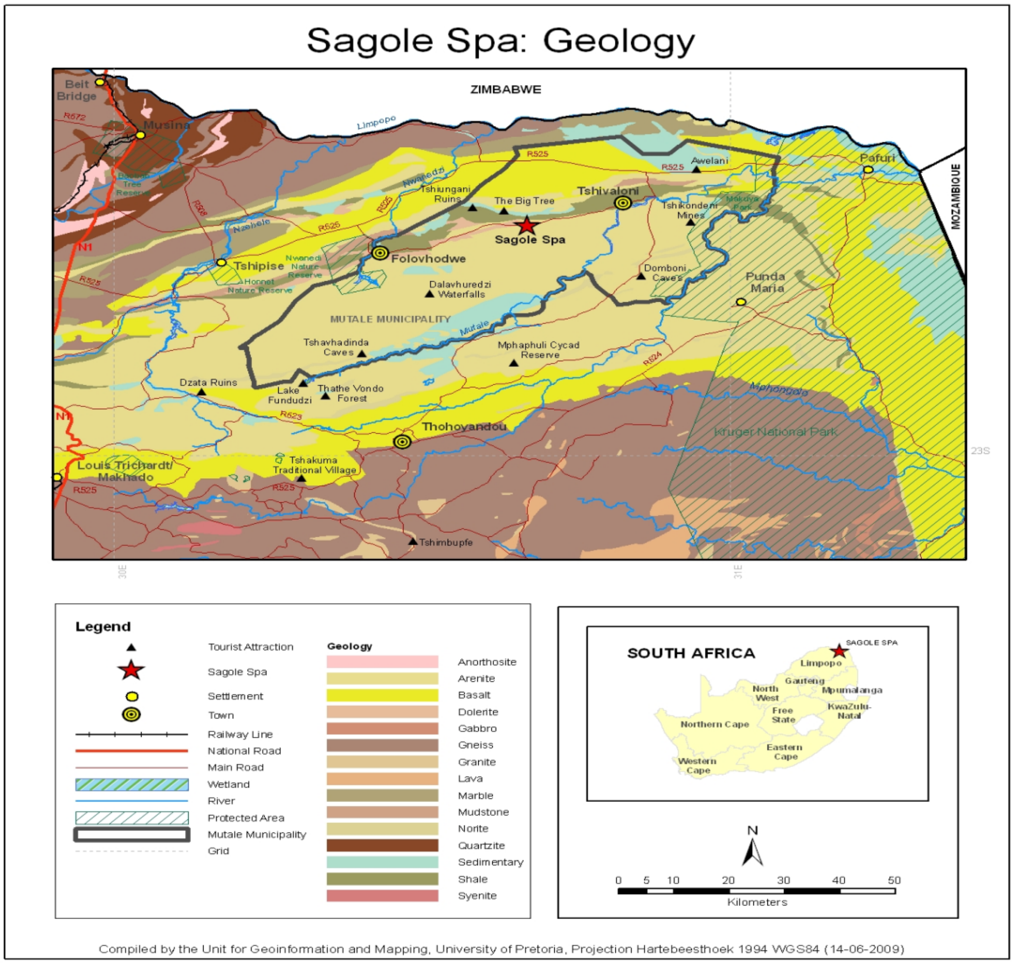


Figure 3.3 Sagole Spa: Geology

The section below provides a brief overview of the geology and morphology of the study area.

Figure 3.3 gives the geology of Sagole Spa and the surrounding areas. The geology consists mainly of igneous rock. The following types are dominant: **norite**, a granular igneous rock consisting of a mix of light and dark minerals (http://dictionary.reference.com/brouse/norite), **basalt**, a dark dense igneous rock of lava flow or minor intrusions (http://dictionary.reference.com/brouse/basalt) and **shale**, a fine grained sedimentary rock consisting of compacted and hardened clay, silt or mud.

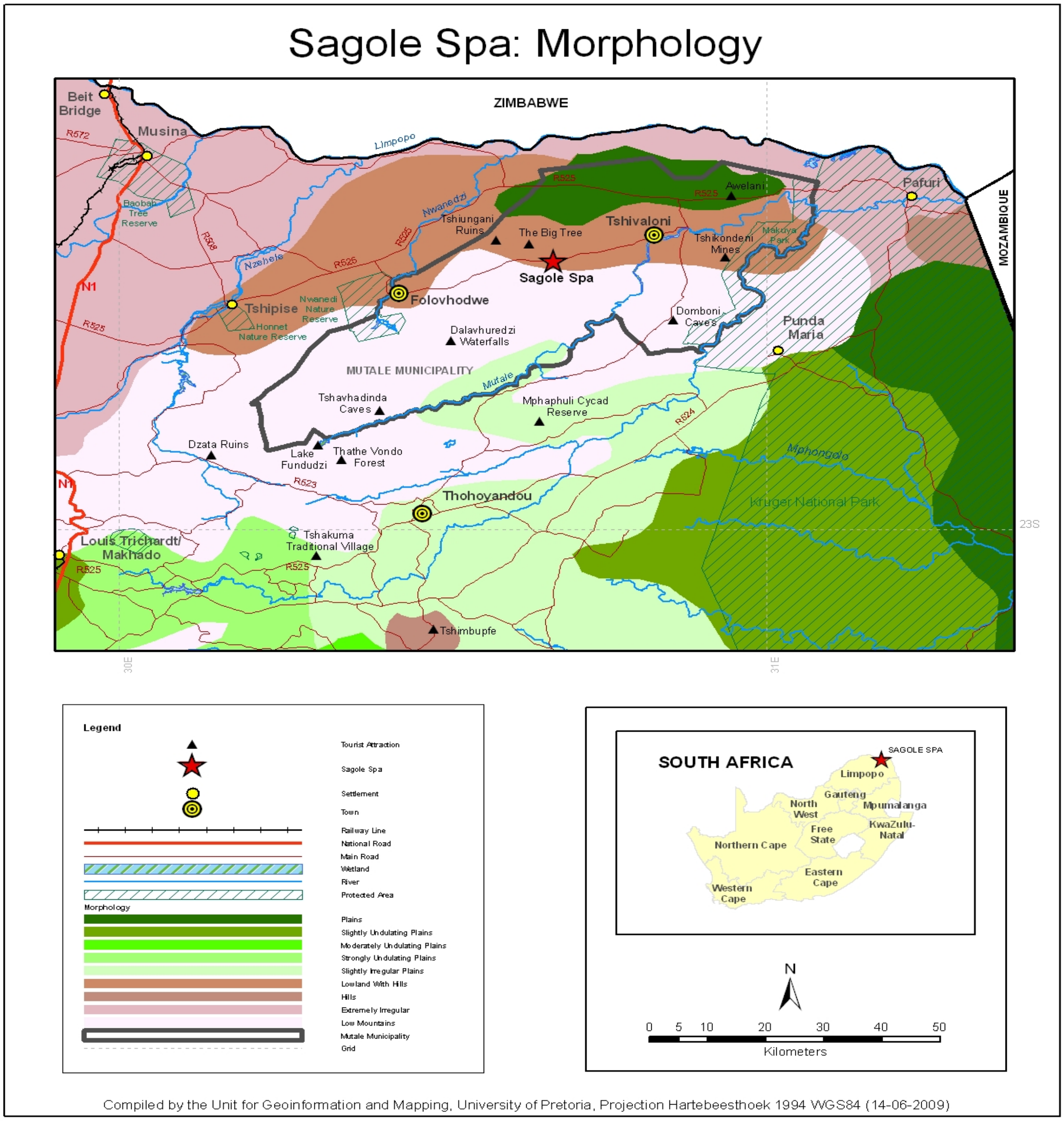


Figure 3.4 Sagole Spa: Terrain Morphology

Figure 3.4 illustrates the terrain morphology of Sagole Spa and the surrounding areas. The morphology is characterised by hills and mountains with moderate high relief and lowland hills. The conspicuous features are the Soutpansberg mountain range which extends south, south-east and south-west of the spa towards Makhado Local Municipality. Rocky outcrops, lithosols (thin soil with poorly defined layers consisting mainly of partially weathered rock fragments) and steep inclines are common within the area (Development Bank of Southern Africa, 1989).

3.2.1.3 Land cover

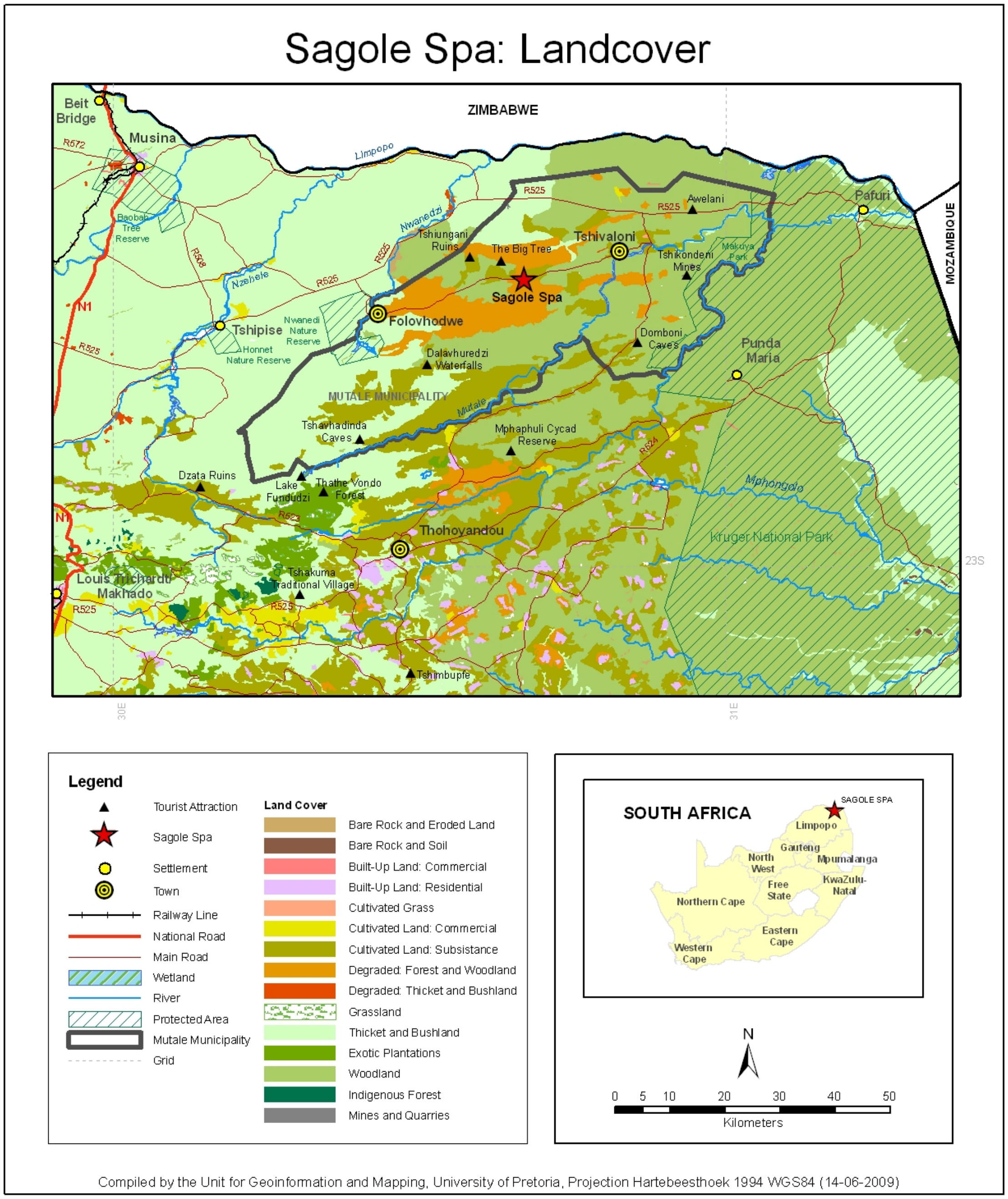


Figure 3.5 Sagole Spa: Landcover

The general land cover of the study area is shown in Figure 3.5 above. The area is mainly covered by degraded land, woodland, cultivated subsistence land, thicket and bushland, and some small patches of cultivated commercial land north-east of Sagole.

3.2.1.4 Climate: Precipitation, temperature and winds

The section below describes the precipitation, temperatures and characteristic wind circulation in the study area.

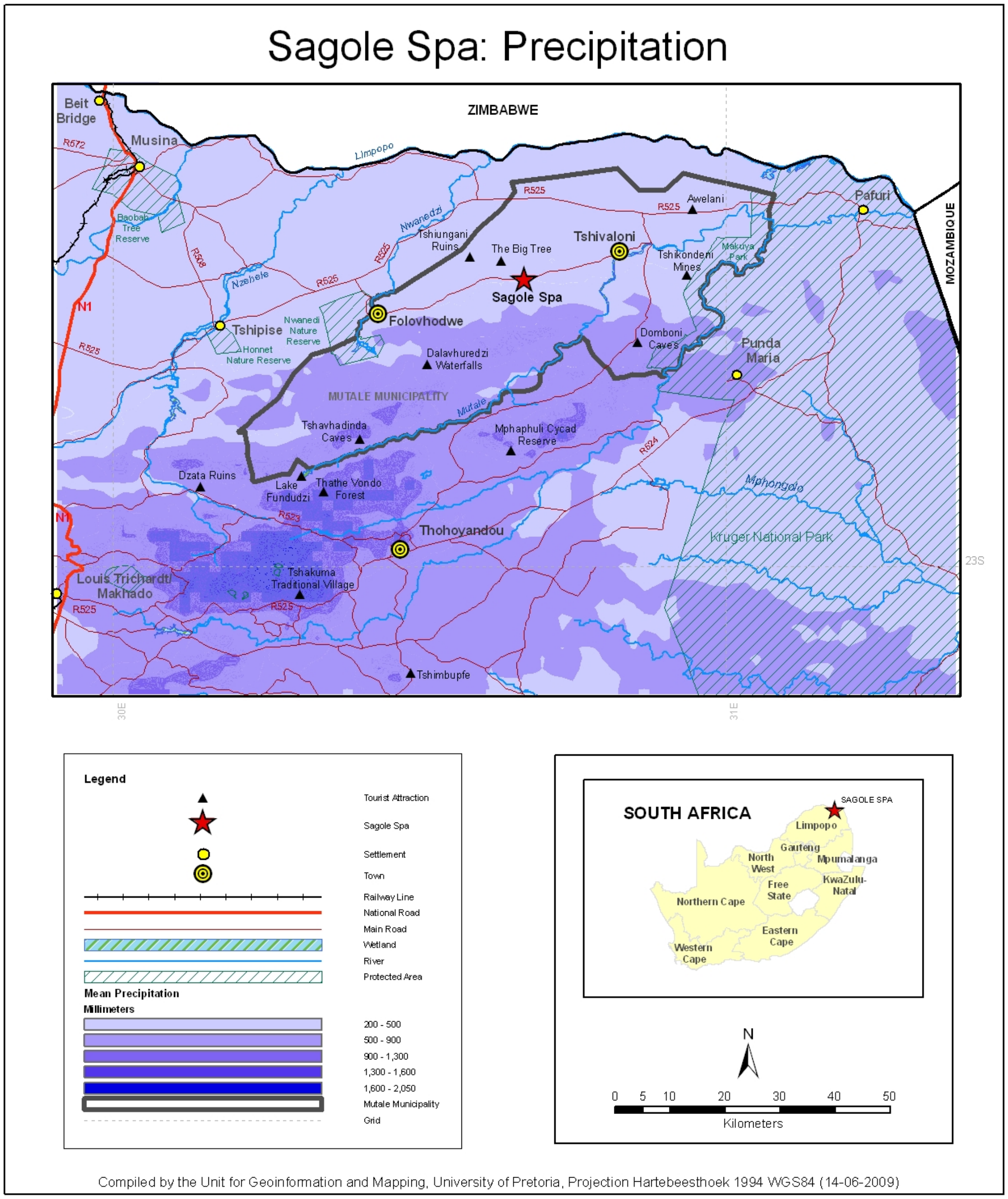


Figure 3.6 Sagole Spa: Precipitation

The general rainfall (precipitation) distribution is illustrated in Figure 3.6. The north and north-eastern part of the spa receives an average annual rainfall of between 200 mm and 500 mm, while the southern part receives between 500 mm and 900 mm. Rain usually falls in summer which extends from October to the end of March. It is generally dry from April to October. During this time people and livestock depend on water from the hot spring. The mean annual evaporation rate is 2500 mm. The relative humidity (that is, the amount of moisture in the air as compared with the maximum amount that the air could contain at the same temperature, expressed as a percentage) at 14h00 from April to September is 35% and it is 50% during the October to March period. The area is prone to significant drought and flood events which impact severely at the local community level. It is frost-free throughout the year and, therefore, irrigated crops grow well throughout the year (Development Bank of Southern Africa, 1989; Department of Water Affairs 1996 in Kabanda, 2004:14).

The section below describes the temperature distribution in the study area.

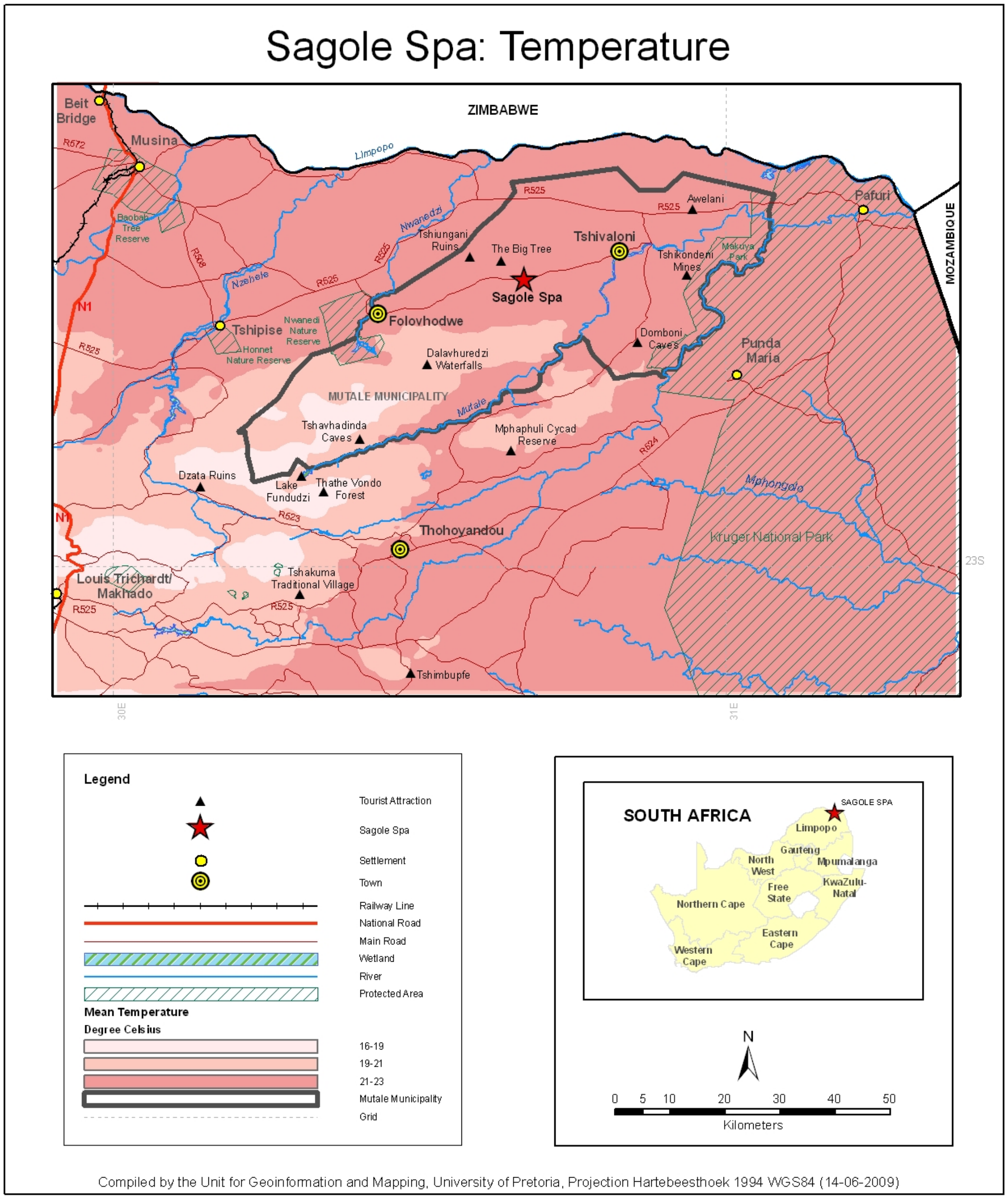


Figure 3.7 Sagole Spa: Temperature

Average temperature distribution in the study area is given in Figure 3.7 above. The study area is generally hot. Sagole Spa and the area north and north-east of the spa receive mean annual temperatures of between 21^{o}C and 23^{o}C while the south and south-western part receives 16^{o}-21^{o}C. Around Sagole Spa the mean monthly minimum temperature of the coldest month of the year is 7,5^{o}C, while the mean monthly maximum temperature of the hottest month of the year is 40^{o}C (Kabanda, 2004).

The prevailing winds are mainly light to moderate, blowing predominantly from the north-easterly direction to the south-westerly direction.

3.2.1.5 Vegetation and hydrology

The vegetation and hydrology of the study area is described below.

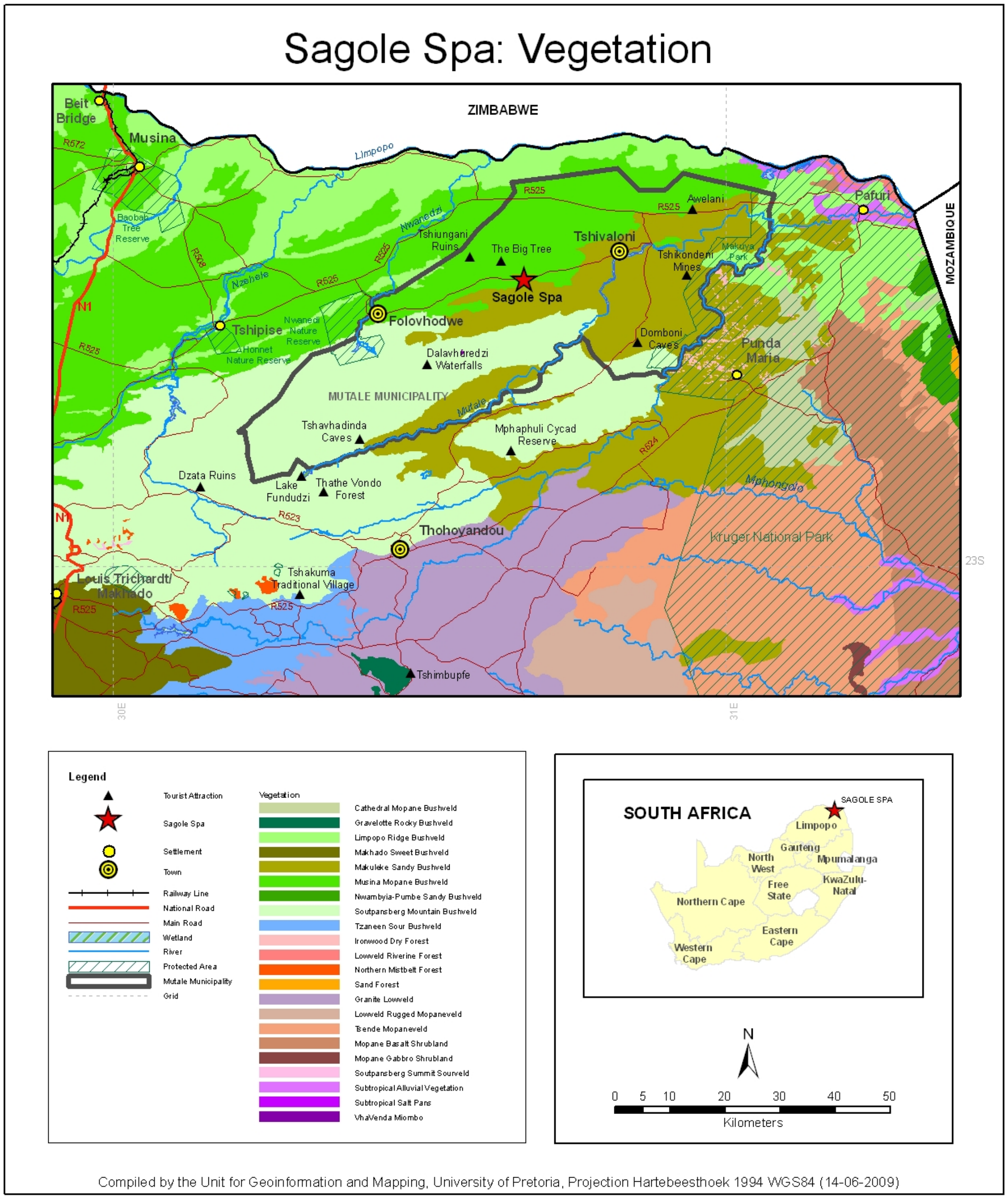


Figure 3.8 Sagole Spa: Vegetation

According to Figure 3.8, Sagole Spa and the area north of the spa are covered by sandy bushveld, while the area to the south of Sagole is dominated by Limpopo ridge bushveld. The vegetation types in the surrounding area include the mopani veld, mixed bushveld and sourish mixed bushveld (Development Bank of Southern Africa, 1989).

The Northern Region of Limpopo Province supports different plant species which include *Acacia tortolis* (the main dominant species), *Adonsonia digitata*, *Sclerecaria birrea, Terminelia prunoides, Colophospermum mopane* (mopani) and grass species such as *Patilena cofandum* (Kabanda, 2004) Baobab trees or *Adonsonia digitat* are common around Sagole Spa. They make the area unique and extremely beautiful as may be seen from the photograph below (Figure 3.9):

Figure 3.9 A Baobab tree surrounded by low-growing vegetation. Source: South African National Parks (2009) SANParks.org forums.

The hydrology of the area is as follows: it falls within the catchment area of the Limpopo River. The main river is Mutale and it is one of the tributaries of the Limpopo River. The main dam found in the area is Nwanedzi. Figure 3.2 provides the location of the Limpopo River, Mutale River, Nwanedzi River and Nwanedzi Dam.

3.2.2 Socio-economic characteristics

The economy in the Northern region of Limpopo, including Sagole village, is still subsistence based. Hunting, gathering, pastoralism and horticulture supplement seasonal crop production (Kabanda, 2004). Participation by the local community in the formal economy has declined from 76% in 1980 to 60% in 1991 (Erasmus, 1995 in Kabanda, 2004). The area is mainly inhabited by Blacks. The main population group is the Vhavenda tribe. The income of this predominantly rural and economically poor area is based on pensions, subsistence farming and the incomes of migrant labourers. The main source of energy is wood or paraffin (Mutale Municipality, 2008/09).

3.2.2.1 Social characteristics

Table 3.1 gives age by population group and gender at Mutale Local Municipality (Statistics South Africa, 2007). Africans (Blacks) dominate the local municipality. Few Whites between the ages of 20 and 54 are found within the area. According to the 2001 National Census, the following population groups were given: Africans (78 456), Coloureds (29), Indians (16) and Whites (421), and the total population was 78 922 in 2001.

Table 3.1 Population groups by age and gender

Category	Black Male	Black Female	White Male	White Female	Total Male	Total Female
0 - 4	6469	7518	-	136	6469	7655
5 - 9	8818	7365	-	-	8818	7365
10 - 14	8154	8016	-	-	8154	8016
15 - 19	6332	7123	-	-	6332	7123
20 - 24	4309	5725	-	85	4309	5810
25 - 29	2832	3471	85	60	2917	3530
30 - 34	2671	3434	-	-	2671	3434
35 - 39	2022	2975	60	-	2082	2975
40 - 44	1920	2802	-	-	1920	2802
45 - 49	1092	2720	-	-	1092	2720
50 - 54	1204	1608	85	85	1289	1692
55 - 59	737	1055	-	-	737	1055
60 - 64	482	781	-	-	482	781
65 - 69	942	1024	-	-	942	1024
70 - 74	257	818	-	-	257	818
75 - 79	183	810	-	-	183	810
80 - 84	78	517	-	-	78	517
85+	295	1063	-	-	295	1063

Source: Statistics South Africa, 2007.

There is a sudden drop around the age 20 and 45 compared to the number of young people under the age of 20. This may be caused by the rural-urban migration for job opportunities in urban areas.

3.2.2.2 Economic characteristics

The individual monthly income for the 2007 census is shown in Table 3.2 below. It is clear that the majority of people earn below R1600 per month. A total number of 14 881 people are employed while 9 005 are unemployed (Statistics South Africa, 2007: Mutale Municipality, 2008/09).

Table 3.2 Individual monthly income per category

Category	**2007 (number)**
None	1797
R1- 400	3 589
R401- 800	2 535
R801- 1 600	2 020
R1 601- 3 200	1 519
R3 201-6 400	17 02
R6 401- 12 800	734
R12 801- 25 600	-
R25 601- 51 200	117
R51 201- 102 400	-

R102 401- 204 800	117
R204 801 or more	-
Response not given	749
Total	14 881

Source: Statistics South Africa, 2007; Mutale Municipality, 2008/09.

Children and elderly people are not included in the table above

3.2.3 Tourism potential

Table 3.3 provides the sites with tourism potential in the Mutale Municipality.

Table 3.3 Potential tourism sites

Tourism Attraction	Destination	Exclusiveness
The Big Tree	Zwigodini Village	Biggest tree in Africa
Domboni Caves	Domboni Village	Hiding place during tribal wars
Sagole Spa	Tshipise	Warm baths and accommodation
Lupepe Nwanedi Nature Reserves	Folovhodwe	Animal viewing, fishing and accommodation
Makuya Park	Adjacent to Kruger National Park	Animal viewing, fishing, accommodation, close to Kruger National Park

Source: Mutale Municipality 2008/2009

Mutale has excellent tourism potential and a number of strategically sited attractions. The Big Tree is fenced and access to the tree is controlled. It is the world's largest and oldest Baobab tree. It is estimated to be more than 3 000 years old with a base circumference of 43 metres. People can eat the fruits and leaves of baobab trees while water can be tapped from the roots. Seeds can be used to produce oil and can be roasted to make coffee (Eco Products, 2006). The Big Tree is also a nesting place for a bird called the Mottled Spinetail which is endemic to the area. Recent developments by the Mutale Local Council include the construction of security gates, braai stands, lapas, ablution blocks, landscaping and caravan parks. Lupepe Nwanedzi Nature Reserve has high quality conference and accommodation facilities. The resort is located about 80km from Thohoyandou, north of the Soutpansberg mountains. Catering is also provided. Makuya Park provides accommodation and fishing facilities. Currently the lack of reliable energy supply and potable water hinder the growth of the tourism industry (Mutale Municipality 2008/2009).

3.2.4 Agricultural potential

Table 3.4 lists the area of agricultural land use at Mutale in 1989. It is clear from the table that 82% of the land is used for grazing. Cattle and goats do well in the area.

Table 3.4 Agricultural land use of Mutale

82%	Grazing veld
11%	Arable land
3%	Nature conservation
1%	Forestry

Source: Development Bank of South Africa, 1989.

Crop farming and livestock farming are prevalent in the eastern areas of Mutale, which includes the Sagole area. Primary agriculture in the area focuses on raising animals (goats and cattle) as well as ploughing, planting and maintaining crops. Crops such as bananas, mangoes, pawpaws, ground nuts, tomatoes, avocadoes, litchies, tea, oranges, morula, and maize do well in the south and south-western parts of the municipality (Mutale Municipality, 2008/09).

3.3 CHARACTERISTICS OF SAGOLE SPA

3.3.1 *Historical development*

Sagole thermal spring was discovered by Mr Netshipale, a leader of the Tshipale clan. Mr Netshipale comes from a nearby village called Tshilamusi and it is not known when the spring was discovered. The Netshipale clan relocated to the area around the spring in order to have access to water. They were allowed to settle in the area by Chief Gonono Tshikundamalema. The Chief informed the Netshipale family that the area originally belonged to the Headman Netshipise, who abandoned the site due to the many lions roaming around in the area. The Netshipale clan used the thermal spring for domestic purposes and for watering their stock.

The Europeans, or settlers, that arrived in the area were mainly interested in stock farming. One of the settlers was named “Mandevhele” by the local communities and he owned cattle ranches around Tshipise. He hired local people to look after his stock. Mr Sagole from Lukahu village was one of the people hired to look after his stock. Apparently Mr Sagole came across the thermal spring for the first time while chasing a kudu. The kudu got stuck in the mud and he had to pull it out. When he got into the water, he was shocked to discover that the water was hot. Mr Sagole explained the discovery to “Mandevhele” who became interested in the hot spring, and Mr Sagole was full of pride and afterwards introduced himself as Sagole of Tshipise. The area became famous and was known as Tshipise tsha Sagole or Sagole Spa as it is known today (Netshipale, 2008).

According to Mphephu (1988), the Sagole spa resort was officially opened by His Excellency, Khosikhulu PR Mphephu, former State President of the Republic of Venda, in 1988. During the period 1979-1993, the Venda Development Corporation (VDC) and the Venda Tourism Department operated in partnership at the resort. During that time more than fifty local people were employed. The infrastructure included conference halls, chalets, the kitchen, sleeping accommodation, and swimming pools. The area became a centre for small group visits for students, teachers, government officials, and clients to Mr. Tshikovha, a well-known traditional healer who stayed close to the Sagole thermal spring.

The situation changed when South Africa was transformed into a democratic state in 1994. The Venda Development Corporation (VDC) was dissolved, and in its place, the Limpopo Economic Development Enterprise (LimDev) was established. LimDev leased the resort to a private person who failed to maintain the infrastructure and the general surroundings. The employees were reduced from a team of fifty to a staff of only four.

The maintenance, and hence the quality, of the infrastructure started to decline. Some accommodation halls were closed. The furniture in the accommodation halls gathered dust and it seemed as if no one cared for them. The condition of the swimming pools, the pavilion and the lawns also deteriorated. The number of visits to the centre declined accordingly.

When the Sagole thermal spring was visited in 2005, hot water was still bubbling actively from the ground as shown in Figure 4.1 (hot spring source). However, the gardens and swimming pools were neglected, and in a shocking and unacceptably poor condition, especially considering the former reputation of Sagole as a clean, beautiful, interesting, enjoyable and flourishing tourism and recreational centre.

Figure 3.10 The source of the hot spring at Sagole.

3.3.2 Infrastructure

There are two villages in the immediate vicinity of Sagole. These are Zwigodini and Tshipise. A newly constructed tarred road now links Thohoyandou, Tshandama and the Sagole Spa. There is one clinic, two primary schools (Tshipise Primary School and Madifha Primary School at Zwigodini), one secondary school (Hanyani Secondary School), one café, a general dealer, a drinking lounge, a butchery and a petrol station.

The infrastructure at Sagole Spa includes a conference hall, 6 chalets (rondavels), one big modern kitchen, 2 x 40 sleeping halls, 2 x 8 sleeping houses, two private swimming pools, two public swimming pools (one for males and the other for females), one pavilion and one administration office. Figure 4.2 shows one of the chalets at Sagole.

Figure 3.11 A chalet at Sagole.

Beds

In each chalet there are two single beds, a shower and toilet. Figure 4.3 below shows the furnishings in each chalet.

Figure 3.12 Furnishings in a chalet.

Figure 3.13 below shows one of the 2 x 8 dormitory blocks.

Figure 3.13 Sagole Spa: 8 sleeper dormitory block.

There are self-catering appliances in the dormitory block. These include a gas stove, and a refrigerator. Figure 4.5 below displays the kitchen facilities.

Figure 3.14 Kitchen facilities in the dormitory house.

Mphephu Youth Centre is adjacent to the Spa. It has modern conference halls, lecture rooms, bedrooms, offices and a modern kitchen with cold storage rooms. Currently many of the facilities are not used. Some offices are leased to the Department of Education in Limpopo (Nedombeloni, 2008).

Private swimming pools

There are two private swimming pools at Sagole Spa as shown in Figure 4.6. The two pools were dry when the photo was taken.

Figure 3.15 Swimming pools at Sagole.

Public pools

There are two public pools constructed for the local community. Figure 4.7 provides one of the public swimming/bathing pools. The pool is used by women for bathing, soaking and washing clothes.

Figure 3.16 Protected public pool for women only at Sagole.

3.3.3 Management

During the period 1979-1993, the Venda Development Corporation (VDC) and the Venda Tourism Department operated in partnership at the resort. During that time more than fifty local people were employed.

When South Africa was transformed into a democratic state in 1994 the Venda Development Corporation (VDC) was dissolved, and in its place, the Limpopo Economic Development Enterprise (LimDev) was established. LimDev leased the resort to a private person who failed to maintain the infrastructure and the general surroundings. The employees were reduced from a team of fifty to a staff of only four.

The maintenance, and hence the quality, of the infrastructure started to decline. Some accommodation halls were closed. The furniture in the accommodation halls gathered dust and it seemed as if no one cared for them. The condition of the swimming pools, the pavilion and the lawns also deteriorated. The number of visitors to the centre declined accordingly.

3.3.4 Education and skills for people at Sagole

Section 3.1 explained how the education and skills survey was conducted. Two hundred respondents participated in the education and skills survey. Their ages ranged between 18 and 58 years. The results of the education and skills survey are given in Figure 3.17.

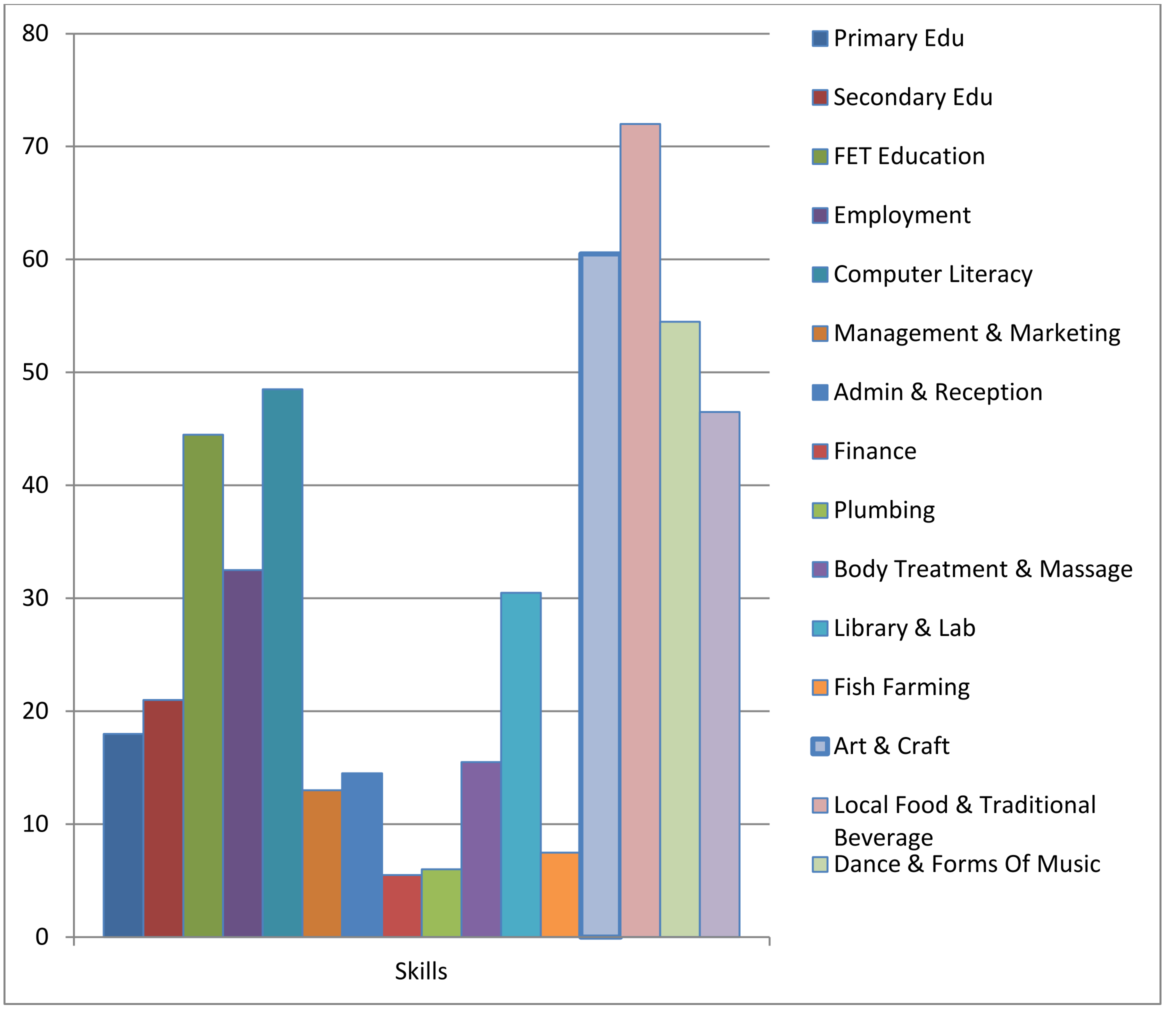


Figure 3.17 Education and skills survey.

The results as to the level of education received by the respondents are as follows: 18% had primary education, 21% had secondary education and 44,5% had further education and training, 48,5% were computer literate and 32,5% of the respondents were employed.

The professional skills survey scored below 20%; for example, management and marketing (13%) and administration and reception (14,5%); finance scored the lowest (5.5%), followed by plumbing skills (6%), body treatment and massage (15.5%) and library and laboratory skills (30, 5%); fish farming skills scored only 7.5%; cultural skills scored between 50% and 72%; arts and crafts skills were prevalent (60.5%), as were local foods and traditional beverages (72%), traditional dance and forms of music (54,5%); and hospitality and catering scored an encouraging 46.5%.

3.4 SUMMARY

This chapter gives an overview of the methodology used, and discussed the characteristics of the study area. The following chapter (4) discusses the potential uses and requirements for each use. It concludes by identifying potential development projects for Sagole.

CHAPTER FOUR

IDENTIFICTION OF POTENTIAL USES OF THERMAL SPRING WATER AT SAGOLE

The uses of thermal springs are defined by the physical and chemical properties of the water. This chapter commences with an overview of these characteristics at Sagole. This is followed by the requirements for the alternative uses as mentioned in Chapter 2. The chapter concludes with the identification of specific uses which could be viable at Sagole.

4.1 PHYSICAL AND CHEMICAL CHARACTERISTICS OF SPRING WATERS

4.1.1 Physical characteristics

According to Winfield (1980), the physical characteristics of the Sagole waters are as follows: the absolute location of the spa is 30^{o} 03’ 40” S and 22^{o} 31’ 30” E. The hot spring is located near a fault between the rocks of the Waterberg System, forming broken ground to the south and Karoo shale to the north. The hot spring issues from a sand-covered plain overlying Karoo shale and lies at 433 metres above sea level. There is one “eye” from which about 12 000 litres of water issues per hour. The water temperature at the source of the spring is 45,9^{o}C (Winfield, 1980). According to Kent’s thermal scale, this water is classified as “hot” (Kent, 1949).

4.1.2 Chemical characteristics

4.1.2.1 Chemical properties of the hot spring water

Table 4.1 below gives the major elements of the chemical properties of Sagole hot spring and the measurements are given in milligram per litre units.

Table 4.1 Chemical properties of Sagole hot spring

Minerals in water	**Mg/l**
SAR	8.11
TDS	173.98
Conduct.(mS/m)	33,00
pH	8.72
pHs	8.91
Silica ($Si0_2$)	-
Sodium (Na)	58.46
Chloride (Cl)	44,09
Carbonate ($C0_3$)	16,50
Bicarbonate ($HC0_3$)	64.05
Sulphate ($S0_4$)	17.78
Potassium (K)	1.05
Calcium (Ca)	3.93
Magnesium (Mg)	0.00
Fluoride (F)	0.72
Phosphate	0.10

Source: Olivier, 2008.

The chemical classification of Sagole hot spring water is alkaline sodium carbonate water (Bond, 1946). Alkalinity is defined as a measure of the capacity of water to neutralize acids (Johnson & Scherer, 2009:3). Alkaline water is also associated with high pH values, hardness and excess dissolved solids (Johnson & Scherer, 2009). Water at Sagole has a high alkalinity (pH 8.72) which indicates that the water is hard. Hard water does not pose a health risk. A brief discussion of the main chemical properties at Sagole hot spring will include the Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), pH, Sodium, Chlorine, Carbonate, Sulphate, Potassium, Calcium, Magnesium and Fluoride.

Total Dissolved Solids (TDS)

According to the World Health Organization (2003:1), a total dissolved solid (TDS) is "the term used to describe the inorganic salts and small amounts of organic matter present in solution in water". The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulfate and nitrate anions.

Total dissolved solids (TDS) at Sagole are 173,98mg/l. According to Bond's (1946) classification, the measurement is above pure water classification (limited to <150mg/l). The water at Sagole is therefore highly mineralized compared to pure water. It is claimed that alkaline water helps to neutralize acids and remove toxins from the body. It also acts as a conductor of electrochemical activity from cell to cell (Bridgeford, 2006). Water at Sagole meets the South African TDS limit of 450 mg/l for Class 0 of water quality. Class 0 water is described as ideal water quality suitable for lifetime use, with no adverse health effects on the user (Kempster, van Vliet and Kuhn, 1997). Higher concentrations of TDS (above 500 mg/l) may affect taste adversely and cause plumbing and appliances to deteriorate (Johnson & Scherer, 2009).

*Sodium Adsorption Ratio (SAR)*Sodium Adsorption Ratio is the amount of sodium relative to calcium and magnesium in the water. Water with high levels of SAR can damage the soil structure, and reduce permeability and crop productivity. The SAR value at Sagole is 8.11mg/l which is ideal for most plants. Levels above 9 can cause severe problems in some soil types. The fact that it is below 9 at Sagole makes the water suitable for the irrigation of most plants (Johnson and Scherer, 2009).

pH

pH is a measure of the concentration of hydrogen ions in water. The pH value determines whether water is hard or soft. A pH value of 7 is neutral or indicates pure water. Water with a pH value lower than 7 is considered acidic, and higher than 7 indicates alkalinity. The ideal pH level for drinking water (Class 0) is between 6.0 and 9.0 (Kempster *et al*., 1997). No adverse health effects are expected in this range. The pH value for water at Sagole is 8.72 which is within the recommended ranges for Class 0 drinking water. Therefore the water is safe for drinking. According to Johnson and Scherer (2009) water with a pH value above 8.5 may require more chlorine treatment for the destruction of pathogens.

Mineral concentrations

Sodium

Sodium is a common salt found in ground water which can impart a salty taste at concentrations of over 250 mg/l. It can contribute to hypertension and these high levels of sodium in drinking water should be noted by users on low sodium diets. A slight taste may be apparent above 100 mg/l (Class 0) (Johnson and Scherer, 2009). The sodium concentration at Sagole hot spring is 58.46 mg/l which is lower than the Class 0 level limit. The water at Sagole is therefore suitable for drinking by all (including individuals on salt-restricted diets).

Potassium

Potassium is a common salt found in ground water, which is essential in the human diet. Excessive amounts in drinking water may have a laxative effect on humans. Acceptable concentrations in drinking water can range from 0 to 8 mg/l. The concentration at Sagole is 1.05 mg/l. This concentration falls within the acceptable range of drinking water, so water at Sagole is safe for human consumption (Johnson and Scherer, 2009).

Calcium and magnesium

Calcium is a naturally occurring metal essential to the human diet and is common in groundwater. Calcium concentration alone is not of major concern but with magnesium, they are the main contributors to the hardness of the water. According to Johnson and Scherer (2009), maximum limits have not been established for calcium. However, magnesium concentrations above 125 mg/l may cause diarrhoea in some people. Calcium concentrations at Sagole are 3.93 mg/l and the magnesium is 0.00 mg/l. At these levels, the concentrations cannot cause health risk to users (Johnson and Scherer, 2009).

Fluoride

Fluoride is a non-metal which occurs naturally in ground water. It promotes dental health at concentrations of between 0.7 and 1.5 mg/l. At concentrations above 1.5 mg/l, dental fluorosis (a brownish staining of the teeth) may occur. The fluoride concentration at Sagole is 0.72 mg/l. As the concentration falls within the recommended range for drinking water, thermal water at Sagole is suitable for drinking. This is one of the few thermal springs in Limpopo with fluoride levels below the recommended limit (Olivier, 2008).

Chloride

Chloride is commonly found in ground water. High concentrations of chloride ions can cause water to have a salty taste, corrode hot water plumbing systems and have a laxative effect on some people. A concentration of below 200 mg/l has no undesirable health effects. The chloride concentration at Sagole thermal spring is 44.09 mg/l, which is suitable for drinking without further treatment (Kempster *et al*., 1997; Johnson & Scherer, 2009).

Sulphate

Sulphate is a common salt found in ground water which can impart a salty taste. Drinking water with high quantities of sulphate can result in diarrhoea. With a concentration of 0 to 200 mg/l (Class 0) sulphate, no adverse health effects are anticipated. Sulphate concentration at Sagole is 17.78 mg/l, which is within the recommended value for drinking water. In this regard, water at Sagole is safe for drinking purposes (Johnson and Scherer, 2009).

In general, the chemical properties discussed above fall within acceptable standards for drinking water, therefore the water can be used for a variety of purposes such as drinking, cooking, irrigation and aquaculture.

4.1.2.2 Trace elements

This section discusses the concentration of trace elements that are acceptable or unacceptable in drinking water. Table 4.2 lists the trace elements and their concentrations at Sagole Spa.

Table 4.2 The trace elements and their concentrations at Sagole Spa.

ELEMENT	UG/L (UNIT OF MEASUREMENT)
Antimony	1.16
Arsenic	4.25
Barium	1.17
Beryllium	0.03
Boron	29.85
Bromine	72.61
Cadmium	0.09
Chromium	6.01
Cobalt	0.02
Copper	0.69

Iodine	340.79
Lanthanum	0.01
Lead	2.51
Lithium	16.31
Manganese	4.26
Mercury	0.00
Molybdenum	1.64
Nickel	0.00
Platinum	0.11
Selenium	6.66
Strontium	59.01
Tellurium	0.56

Source: Olivier, 2009 and Venter & van Wyk, 2008.

Antimony

Antimony is a silvery white earth metal which can be toxic at high concentrations. It occurs naturally in the environment. Exposure to antimony at high concentrations in drinking water can result in a variety of adverse health effects such as stomach pain, ulcers, diarrhoea and vomiting (MedicineNet.com, 2010). The guideline value for antimony is 0.02mg/l. The concentrations of 1.16 ug/l at Sagole meet the requirement for drinking water quality according to the WHO guidelines (WHO, 2008). Therefore the water at Sagole Spa is safe for drinking purposes.

Arsenic

Arsenic is a metallic element that forms a number of poisonous compounds. A high concentration of arsenic in drinking water can cause cancer, nausea, vomiting, diarrhoea, and decreased production of red and white blood cells, and damage to blood vessels (MedicineNet.com, 2010). The guideline value is 0.01mg/l (Health Canada, 2009; WHO, 2008). The concentration of arsenic at Sagole Spa is 4.25 ug/l. The concentration meets the requirements of drinking water quality. Water at Sagole is therefore harmless to drink.

Barium

Barium is a metallic element belonging to the alkaline earths. It is present as a trace element in both igneous and sedimentary rocks. Its guideline value in drinking water is 0.7mg/l (WHO, 2008). There is no evidence that the barium is carcinogenic (causing cancer) or mutagenic (causing changes in genetic mutation). The greatest concern to humans is its potential to cause hypertension (WHO, 2008). The concentration of barium at Sagole spa is 1.17 ug/l and is therefore non-toxic for drinking purposes.

Beryllium

Beryllium is an organic metallic element which does not degrade nor can it be degraded. It occurs naturally in drinking water. The primary concern with beryllium exposure is the lung disease caused by inhaling beryllium, and intestinal lesions. According to the United States Environmental Protection Agency (EPA) the maximum contaminant level (MCL) of beryllium is 0.004mg/l (New Hampshire Department of Environmental Services, 2007). The beryllium concentration at Sagole Spa is 0,03 ug/l, which is within the acceptable level for safe drinking water. The water at Sagole Spa can therefore not pose a health threat.

Boron

Boron is a soft, brown crystalline nonmetallic element extracted chiefly from kernite and borax. It is found naturally in groundwater. Its provisional guideline value is 0,5mg/l. EPA recommends concentrations below 0.6mg/l for lifetime exposure to boron in drinking water (Usuda, Kono, Dote, Watanabe, Shimizu, Tanimoto and Yamadori, 2007). Boron compounds are believed to have a low acute toxicity. The concentration of boron at Sagole Spa is 29,85 ug/l, which is within the acceptable level of drinking water quality.

Bromine

Bromine is a dark red toxic liquid halogen with a choking, irritating smell (Soanes and Stevenson, 2006). The concentration of bromine at Sagole is 72, 61µg/l (Olivier, 2009) and 0, 0µg/l (Venter & Van Wyk, 2008). Further analysis should be done to confirm current concentration at Sagole. WHO (2009) did not establish a guideline value since it occurs in drinking water at concentrations well below those at which toxic effects may occur.

Cadmium

According to WaterUK (2001:1), “Cadmium is a rare natural element which is widely distributed in the earth’s crust in very small amounts”. It is a soft, bluish-white metal. Its guideline value is 0.005mg/l (Health Canada, 2009). Swallowing large amounts of cadmium can result in unpleasant effects such as vomiting, diarrhoea, and kidney damage (WaterUK, 2001). The concentration of cadmium at Sagole Spa is 0, 09 ug/l, which meets the guideline value for drinking water quality.

Chromium

Chromium is a metal found in natural deposits as ores containing other elements. The guideline value is 0.05mg/l (WHO, 2008). Chromium has the potential to cause the following health effects from long-term exposure at levels above the maximum contaminant level (MCL) set by EPA: damage to the liver, kidney, circulatory system, nerve tissues and skin irritation. The concentration of chromium at Sagole Spa is 0.01ug/l. This level cannot cause health problems to people drinking water at Sagole Spa.

Copper

Copper is a reddish metal that occurs naturally in rocks, soil, water, sediment and air (Wisconsin Department of Natural Resources, 2003). It is both an essential nutrient and a drinking water contaminant (WHO, 2008). The guideline value is 2mg/l. According to the Wisconsin Department of Natural Resources (2003), the immediate effects of drinking water with concentrations higher than 1,000ug/l include: vomiting, diarrhoea, stomach cramps, kidney and liver damage in infants. The concentration level of copper at Sagole Spa is 0.69ug/l. The concentration level meets the conditions for safe drinking water according to the WHO guidelines.

Iodine

"Iodine is a non-metallic, dark-grey/purple black, lustrous, solid element" (Lenntech, 1998-2009:1). It is slightly soluble in water. It is used in medical treatment as tincture (medicine made by dissolving a drug in alcohol). Iodine is a building material for thyroid hormones that are essential for growth, the nervous system and the metabolism. Lack of iodine in humans leads to the swelling of the thyroid gland. All iodides are toxic if taken in excess. The Australian guideline value is 0.5mg/l (National Health and Medical Research Council (NHMRC), 2004). The concentrations of iodine in the Sagole Spa water is 340,79 ug/l and this satisfies the Australian guideline value. The presence of iodine may make the water suitable for medicinal use.

Lanthanum

Lanthanum is a white soft metallic element that tarnishes readily. It occurs in rare earth minerals and is classified as a rare earth mineral (Wordnik, 2010). It is used to produce catalysers and to polish glass. It can be a threat to the liver when it accumulates in the human body. In marine animals, lanthanum can destroy the cell membrane, which may have negative consequences for reproduction and the functions of the nervous system. At Sagole Spa, the concentration of lanthanum in the water is 0, 01 ug/l. The Australian guideline value is 0.002mg/l (NHMRC, 2004). The concentration level at Sagole is non-toxic to both humans and marine animals.

Lead

Lead is a metal found in natural deposits as ores containing other elements. It is generally used in household plumbing materials. The United States Environmental Protection Agency (EPA) has set the Maximum Contamination Level (MCL) at 0mg/l because it believes the level of protection would not cause health problems (EPA, 2009; APEC, 2010). Exposure at levels above the MCL has the potential to cause strokes, kidney disease and cancer. The Australian drinking water guideline value is 0.01mg/l (NHMRC, 2004). The concentration of lead at Sagole Spa is 2,51 ug/l and so meets both the MCL standards and the Australian guideline value. The water at Sagole is, therefore, safe for drinking purpose.

Lithium

Lithium is defined as “a soft, silvery white metal that becomes yellowish upon exposure to moist air” (Salocks and Kaley, 2003:2). Lithium carbonate and lithium salts are used in medicine to treat bipolar disorder and as an antidepressant. Physical tolerance differs between individuals. Ingested in excessive amounts lithium is toxic. At 10mg/l one is mildly poisoned (Lenntech, 1998-2009). Its effects on humans include abdominal pain, nausea, vomiting and diarrhoea, loss of muscle coordination, muscle rigidity and exaggerated reflexes. Mineral waters contain 0.05-1mg/l. At the Sagole Spa the lithium concentration is 16.31 ug/l or 0.016mg/l. The water at Sagole spa might be used for health purposes because of its antidepressant qualities.

Manganese

Manganese is a naturally occurring metal important in the human diet. According to Johnson and Scherer (2009), a high concentration of manganese does not appear to cause a health hazard. However manganese concentration greater than 0.05ml/l can cause brown and black stains on laundry, plumbing fixtures and sinks. The guideline value for drinking water is 0,05mg/l for Class 0 (Kempster *et al.*, 1997). The manganese concentration at Sagole is 4, 26 ug/l, and falls within the acceptable levels for the quality of drinking water.

Mercury

“Mercury is a liquid metal found in natural deposits as ores containing other elements” (APEC, 2010:1). It is generally used in the electrolytic production of chlorine and in electrical appliances. The WHO (2008) guideline value for drinking water is 0,006mg/l. Mercury concentration above the guideline value can cause kidney damage in humans and animals. The concentration of mercury at Sagole Spa is 0,00mg/l. The zero concentration of mercury makes the water at Sagole Spa safe for drinking purposes and for aquaculture.

Molybdenum

Molybdenum is a silvery white metal which can be attacked slowly by acids. It is a valuable alloying agent. It is an essential element in plant nutrition. Some plants can have up to 500ppm of the metal when they grow in alkaline soil (Lenntech, 1998-2009). According to (Lenntech, 1998-2009) the recommended daily intake for the mineral is 75ug as a food supplement. Doses larger than 200ug may cause kidney problems and copper deficiencies. The WHO (2008) guideline value is 70ug/l, while the National Health and Medical Research Council (NHMR) (2004) of Australia set the guideline value at 0,05mg/l. The concentration of molybdenum in the water at Sagole is 1, 64 ug/l, which makes the water safe for drinking.

Nickel

Nickel is a silvery white, hard, malleable and ductile metal. It occurs in very low levels in the environment. It is generally used as an ingredient in the steel and other metal products. It may be found in slate, sandstone, clay minerals and basalt. It is a dietary requirement for many organisms. Nickel concentrations in plants are 1ug/g. Concentrations of nickel higher than 50ug/g can be toxic (Lenntech, 1998-2009). The human body contains about 10mg of nickel. The recommended daily intake by Lenntech (1998-2009) is 1 mg. The guideline value for drinking water is 0.02mg/l (NHMRC, 2004). The nickel concentration at Sagole Spa is 0,00 ug/l, so it does not pose a health risk in drinking water.

Platinum

Platinum is a lustrous, silver-white, malleable and ductile metal. It is resistant to corrosion and tarnishing. Platinum has many uses which include making fine jewellery; its alloys are used in surgical tools, laboratory utensils, and electrical resistance wires. Platinum bonds are applied in medicine to cure cancer. Platinum compounds are used in tumour therapy (Alt, Eschnauer, Mergker, Messerschmidt and Tolg, 1997). Platinum salts can cause several negative health effects such as hearing damage, DNA alterations, and can cause cancer and damage to organs such as the intestines and the kidneys, and to bone marrow (Lenntech, 1998-2009). According to WHO (2008), there is no guideline value that is recommended for platinum concentrations in water. The concentration of platinum in the water at Sagole spa is 0. 11ug/l.

Selenium

Selenium is a non-metallic chemical element found in natural deposits as ores containing other elements (George, 2003; Lenntech, 1998-2009). The major use of selenium is as an alloying additive in the metallurgical industry to improve the properties of copper, lead and steel. The toxic effects of long-term selenium exposure in humans are manifested in nails, hair and liver. In drinking water, a health-based guideline value of 0.01mg/l is given (WHO, 2003). At Sagole Spa the concentration of selenium is 6.66 ug/l, which is within the WHO guidelines for drinking water quality. The water at Sagole Spa can therefore not cause health hazards after consumption. According to George (2003) the use of selenium's antioxidant and curative properties as a dietary supplement has shown a positive effect on the following health problems: acquired immune deficiency syndrome (AIDS), arthritis, asthma, cancer, cardiovascular diseases, reproduction, thyroid and viral infections.

Strontium

According to Skoryna (1981) stable strontium is a naturally occurring trace element in the diet and body. It is a soft silver-yellow, alkaline earth metal (Lenntech, 1998-2009). It is a widely distributed element in the geosphere, natural water and human tissues. Its compounds are used to colour television picture tubes and to produce the colour red in fireworks (Usuda *et al.*, 2007). There is no evidence of strontium toxicity, but there are reports from a strontium-rich area in Turkey that when ingested in excessive amounts, strontium caused rickets. Clinical observations in Turkey noted a marked reduction in bone pain for patients suffering from osteoporosis (a medical condition in which the bones become brittle from loss of tissue) and a significant clinical improvement in patients with postmenopausal osteoporosis. The United States EPA has recommended that the level of strontium in drinking water should not exceed 4mg/l (Usuda *et al*., 2007). The concentrations of strontium at Sagole Spa is 59,01 ug/l, which is well within the acceptable level for drinking water quality and for medical purposes.

Tellurium

According to Lenntech (1998-2009:1) “tellurium is a semi metallic, lustrous, crystalline, brittle, silver-white element”. It has the properties of both metals and non-metals. It is used as an additive to steel and is alloyed to aluminum, copper, lead or tin. Ingestion even in small amounts can cause dreadful halitosis and body odour.

It is not harmful to the natural environment. Currently, there is no guideline value for drinking water. The concentration of tellurium in Sagole Spa is 0,56 ug/l.

4.2 POTENTIAL USES AND THEIR REQUIREMENTS

There are general and specific water requirements for the development of each of the potential uses or applications of geothermal resources. A summary of these follows in Table 4.3.

Table 4.3 is a summary of potential uses, physical and chemical requirements and references

POTENTIAL USE	SPECIFIC REQUIREMENT/S	REFERENCES
Generation of electricity	Temperature: >74^{o}C (for binary system plant) >150^{o} C (for flash steam plant)	Rinehart, 1980
Medicinal use	40-50^{o}C for hydrotherapy At least drinking water quality for drinking Minerals with curative power	Rinehart, 1980
Recreation and tourism	30^{o}C ;	Rinehart, 1980
Bottled water	At least drinking water quality Water appearance, taste, odour, and Low levels of arsenic, barium, boron, chromium, fluoride, manganese, molybdenum, selenium, uranium, br	WHO (2006)
Minerals extraction	Temperature: > 250^{o}C	Rinehart, 1980
Crop drying	100^{o} C temperature range	Rinehart, 1980
Fish/ prawn farming	Specific for type of fish. water quality & quantity, temperature Dissolved oxygen: > 4-5ppm pH : 6-9, Alkalinity, Hardness, Chlorine, Carbon-dioxide, Salinity, & Hydrogen Sulfide.	Boyd & Rafferty, 1998
Spirulina	Climate: tropical and subtropical, water carbon dioxide content, environmental conditions, dissolved solids (10-60gl) pH (8,5-10,5) Temperature: 26 ^{o}C-37^{o} C	Fournadzhieva, *et al.*, 2003).

	High solar radiation Macro- & micronutrients present (C,H,Mg, S, Na, Cl, Ca, fe, Zn, Cu,Co & W)	
Mushroom farming	Temperature: 50^{o}C Dark and moist environment, very fertile ground,	Rinehart, 1980
Greenhouse irrigation	Temperature: 60^{o}C	Rinehart, 1980
Geothermal education	Geothermal resource (hot spring)	Jonsdottir, 2010

4.3 IDENTIFICATION OF POTENTIAL DEVELOPMENT PROJECTS FOR SAGOLE

4.3.1 Potential development projects for Sagole

Chapter 2 of the study discussed diverse uses of geothermal resources. Table 4.3 above gives specific and general requirements of each potential use. In this section, the potential development projects are selected from potential uses. This is done by comparing the physical and chemical characteristics of Sagole's waters with the requirements of each use. Table 4.4 below gives the potential use, Sagole characteristics, acceptance/rejection and reason for rejection or acceptance.

Table 4.4 Comparison of required and actual conditions as a basis for acceptance or rejection of use

Potential use	**Sagole characteristics**	**Acceptance:✓**	**Reasons for**

		Rejection:✕	selection/rejection
Balneology and medicinal tourism	Thermal water	✓	Curative water
Recreational Tourism	Spa resort	✕	Avoid competition with Tshipise
Fish farming	Water not toxic	✓	High water quality
Spirulina	Thermal water	✕	Low flow rate
Mushroom	Temperature: 45 °C	✕	20-90°C needed
Electricity generation	Temperature: 45°C	✕	Temperature: low
Mineral extraction	Temperature: 45°C	✕	250°C needed
Water bottling	Water quality good except for br which is 72.61 µg/l	✓	Local people are drinking the water without adverse effect
Geothermal education	Thermal water	✓	Thermal water available

From Table 4.4, it is clear that there are three potential uses for Sagole. These are health spa tourism, aquaculture and geothermal education. These will be discussed in Chapters 5, 6 and 7, respectively.

4.4 SUMMARY

This chapter discussed the historical development, the infrastructure, management, physical and chemical characteristics and potential uses of Sagole thermal spring. The next chapter will focus on the potential for spa tourism at Sagole.

CHAPTER FIVE

TOURISM

5.1 INTRODUCTION

Chapter 4 of this study discussed the characteristics of Sagole Spa. An historical development, infrastructure, management and physical and chemical characteristics of thermal spring water were undertaken. This was followed by followed by an analysis on potential uses and the identification of potential development project. Tourism was identified as one of the potential development projects for Sagole.

In this chapter, tourism, with specific reference to health tourism is defined and the importance and types of health tourism is discussed. The type of health tourism suitable for Sagole is identified. The characteristics and facilities required for health spa tourism are elaborated upon. The near-ideal development model for Sagole is given. This is followed by discussions of the suitability of health spa tourism for Sagole and its potential impacts. After this, the feasibility and sustainability of health spa tourism at Sagole were explored. The chapter concludes by giving the cost-benefit analysis and the SWOT analysis for Sagole.

5.2 TOURISM: AN OVERVIEW

5.2.1 Definitions

The definitions of the concept ‘tourism’ and ‘sustainable tourism’ were given in Chapter 2. To recap on the meaning of the concepts, it is important to note that tourists are travellers staying away from home, who need accommodation, and support services to enhance the quality of their experiences. Sustainable tourism on the other hand includes a balance in the management of three elements: the environment, social and economic elements. According to Swarbrooke (1999:13) sustainable tourism is “tourism which is economically viable, but does not destroy the resources on which the future of tourism will depend, which is the physical and social environment of the host community”. Because countries could not agree on one definition of tourism, the World Tourism Organisation in 1994 proposed the following international definition: “Tourism is the set of activities of a person travelling to a place outside his or her usual environment for less than a year and whose main purpose of travel is other than the exercise of activity remunerated from within the place visited” (Smith, 1995: 22). This is the definition that is embraced within this study.

5.2.2 Importance of tourism

According to Smith (1995), tourism is regarded as a major force in global trade. It plays a very important role in the social, cultural and economic development of most nations. In 1993, the World Travel and Tourism Council (WTTC) has estimated the impact of global tourism as follows:

- Tourism provided direct and indirect employment for more than 200 million people (one in every nine workers globally);
- The number of tourist related jobs would rise to 350 million by 2005;
- Tourism generates 10.3 per cent of global wages (US$1.7 trillion);
- Tourism is responsible for 10.1 per cent of direct and indirect world Gross Domestic Product (GDP) (US$3.4 trillion); and
- Tourism accounts for 11, 0 per cent of all consumer spending (Smith, 1995: 1).

Table 5.1 below gives the estimates and forecasts of the global economic impacts of tourism for 2011 and 2021.

Table 5.1 Global economic estimates and forecasts for tourism

	2011			2021		
World	USDbn	% total	Growth	USDbn	%total	Growth
Direct contribution to GDP	1 850.0	2.8	4.5	2 860.5	2.9	4.2
Total contribution to GDP	5 991.9	9.1	3.9	9 226.9	9.6	4.2
Direct contribution to employment	99 048	3.4	3.0	120 427	3.6	2.0
Total contribution to employment	258 592	8.8	3.2	323 826	9.7	2.3
Visitor exports	1 162.7	5.8	5.5	1789.2	4.7	4.3
Domestic spending	2 636.6	4.0	3.8	4 127.6	4.3	4.3
Leisure spending	2 962.6	4.5	3.8	4 603.6	4.7	4.3
Business spending	899.0	1.4	6.1	1 401.7	1.5	4.3
Capital investment	650.8	4.5	4.6	1 123.7	4.6	5.4

It is evident from Table 5.1 above that contribution of tourism to the global economy is highly significant. Investment in tourism at Sagole can be encouraged as the growth estimates of all factors are positive.

5.3 SELECTION OF THE TYPE OF TOURISM SUITABLE FOR SAGOLE

5.3.1 Selection of the type of tourism suitable for Sagole

According to Smith (1995:30), there are around 6 groups of tourisms that can be classified according to the purpose of trips. These are the (1) leisure, recreation and holidays, (2) Visiting friends and relatives, (3) Business and professional, (4) health treatment, (5) Religious, pilgrimage and (6) Other.

Brief discussions of the above-mentioned groups are as follows:

(1) Leisure, recreation and holidays.

This group of tourism is characterised by sightseeing, shopping, attending sporting and cultural events, recreational and cultural activities and many more.

(2) Visiting friends and relatives.

This group includes visiting friends or relatives, attending funerals and weddings.

(3) Business and professional

This group is characterised by activities such as installing equipment, inspection, attending meetings, conferences and congresses, giving lecture, programming tourist travel, guiding tours, participating in professional sports, education and research, and many more.

(4) Health treatment

This group is characterised by spas, fitness, thalassotherapy, health resorts, and other treatments,

(5) Religious pilgrimage

The group is characterised by attending religious events or going on a pilgrimage.

(6) Other

This group includes aircraft and ship crews on public carriers, transit activities and other or unknown activities.

In order to identify the appropriate tourism for Sagole, the characteristics of each group of tourism is compared with the physical and chemical characteristics of the hot spring at Sagole. Table 5.2 gives the comparison of Sagole and the tourist group characteristics.

Table 5.2 Comparison of Sagole with tourist groups

	Sagole	
Tourist Group	Selected:✓ Rejected:✕	Reason for acceptance/rejection
Leisure/Recreation	✕	Competition with Tshipise Forever Resort
Visiting friends	✕	Not a residential place for friends/relatives
Business/Professional	✕	No business enterprises
Health treatment	✓	Purported health benefits from thermal water
Religion/Pilgrimage	✕	Not a religious centre
Other	✕	No flights or navigable water

From Table 5.2, heath treatment group is the only selected option for Sagole. Since the thermal water is purported to have chemicals/minerals with curative power, health conscious people can benefit from bathing and drinking the water. Health treatment group is characterised by spas, fitness, thalassotherapy, health resorts, and other treatments. It can be concluded that health tourism is appropriate for Sagole. However, there are different types of health tourism. The following section discusses different types of health tourism, and the selection of the one suitable for Sagole.

5.3.2 Health tourism and its importance

5.3.2.1 Definitions

A range of definitions on health tourism have been suggested in the literature. The International Union of Official Travel Organisations, a precursor of the World Tourism Organisation (WTO), has defined health tourism as “the provision of health facilities utilizing the natural resources of the country, in particular of mineral water and climate” (International Union of Official Travel Organisations (1973) in Vajirakachorn (2004:8)). Pollock and Williams (2000:165), also in Vajirakachorn (2004:8), defined health tourism as “leisure, recreational, and educational activities removed from the distractions of work and home that use tourism products and services that are designed to promote and enable customers to improve and maintain their health and well-being”. Kusen (2002:178) gave a broad definition of health tourism which can be paraphrased as follows: health tourism is a complex economic activity that aims to foster the skilled, controlled use of natural health remedies, as well as medical practices and physical activities for the purpose of maintaining and improving the physical, psychological and spiritual health of tourists and thereby contributing to quality of their lives.

In his conclusion, Vajirakachorn (2004:45) defines health tourism as “a form of tourism which attempts to attract tourists who travel for their health purposes by providing health facilities and activities that suit health tourists’ needs. The health tourism accommodations, therefore, should provide a multiplicity of services such as medical supervision, natural remedies, fitness and other health promotional programmes”.

Hot spring health resorts encompass different concepts of spa services which include facilities such as club spas, day spas, medical spas, mineral spring spas, resort/hotel spas and destination spas (those providing lifestyle improvement and health enhancement through professionally administered spa services, physical fitness, educational programmes and site accommodation).

Based on the above definitions, it is clear that the explanation of the concept has become more complex depending on the researchers and their research goals. In this study health tourism will include illness prevention and wellness, “an active process through which people become aware of, and make choices towards, a more successful existence” (The National Wellness Institute (2007) in Smith and Puczko (2009:55)). Wellness focuses on the physical, spiritual, intellectual, emotional, social and occupational aspects of life. It is pursued by healthy people with the aim of prevention (Mueller & Kaufmann, 2001). According to Smith and Puczko (2009:84), a spectrum of health tourism includes physical healing, beauty treatments, relaxation/rest, leisure/entertainment, life/work balance, psychological and spiritual activities. Some of the elements of this spectrum will be considered for the Sagole spa.

5.3.2.2 Importance of health tourism

There are many benefits related to health tourism. According to Smith and Puczko (2009:75-76), the importance of health tourism includes: addressing the problem of obesity among young people, special fitness especially for older adults, functional fitness to improve performance for activities of daily living, strength training, mind/body exercise for physical improvement in muscular strength, aerobic capacity, flexibility and balance, weight loss, disease management and changes in negative lifestyle behaviours.

According to World Bank estimates, health and wellness tourism worldwide exceed US40 billion a year, an increase of 30% per annum, while the tourism industry as whole, is growing at a rate of 4-5 % annually (Caribbean Export, 2008:4).

5.3.3 Health tourism suitable for Sagole

5.3.3.1 Selection of the type of health tourism suitable for Sagole

In order to identify the type of health tourism that is suitable for Sagole, different types of health tourism should be discussed, the physical and chemical characteristics of Sagole should be compared with the requirements of each type of health tourism. The following section discusses the types of health tourism in brief:

5.3.3.2 Types of health tourism

There are many types of health tourism. They include spa tourism, leisure and recreation tourism, thalasso tourism, holistic tourism, yoga and meditation, spiritual tourism, occupational wellness, and medical tourism (Smith and Puczko, 2009). Brief explanations of these types of health tourism follow below:

Spa tourism

Spa tourism is “tourism which focuses on the relaxation or healing of the body using mainly water-based treatments; such as mineral or thermal pools, steam rooms; and saunas. Emphasis tends to be focused on curing, rehabilitating, or resting the body” (Smith and Puczko, 2009: 85).

Spa tourism is known as the best form of wellness tourism. According to the International Spa Association (ISPA) 2007, in Smith and Puczko (2009), spa tourism is defined by the following key elements: relax, reflect, revitalise and rejoice. Spas offer different services, but they have one thing in common, which is the desire to improve health and wellness. Water-based spas use mineral, thermal and healing waters.

Balneology falls within this group of health tourism. Ten segments of the spa industry are as follows: the waters; food, nourishment, diet, and nutrition; movement, exercise, and fitness; touch, massage and body work; mind, body and spirit; aesthetics, skin care, and natural beauty agents; physical space, climatology, and global ecology; social, cultural arts and values, and spa culture; management, marketing and operations and time, rhythm, and cycles (Smith and Puczko, 2009:86). It is important to note that not all spas contain every domain.

ISPA (2007) and the *Spafinder Magazine* (2007) in Smith and Puczko, 2009:87) gave the most comprehensive spa categorisations as follows: club spa (fitness and wellness); day spa (beauty, fitness and wellness programmes; spa hotel (hotel accommodation and physical, spiritual and mental balance programme); holistic spa (therapy and diet); medical spa (traditional and complementary therapeutic and health protection treatments; bath spa (hydrotherapy); resort spa (wide range of wellness services and programmes); sports spa (spa services and special sport programmes), and structured spa (attainment of a specific objective, e.g. weight loss).

Leisure and recreation tourism

These are spas which offer attractions and services to the whole family. They have separate sections targeting kids, e.g. baby pools and other fun elements, and parents with silent areas and pools, sauna park and treatment sections. They mix local leisure guests with visiting tourists.

Thalasso tourism

Thalasso tourism is defined as “tourism that provides attractions by services based on the sea. Water, algae, and salt are all used in the products”. Thalassotheraphy (a variety of treatments that use seawater, and seaweed to revitalise the body and skin, to tone, moisturise, and improve circulation) was founded in France in the late1950s. It can be found anywhere where there is a seacoast. Packages offered by thalassotherapy spas include underwater showers, mud baths, massage, seaweed, mud and algae wraps.

Holistic tourism

Holistic tourism is “tourism that provides the visitor with a range of activities and/or treatments which are aimed at balancing the body-mind-spirit” (Smith and Puczko, 2009:92). It is a purpose-built centre, aimed at learning (e.g. dance, painting, creative writing, and singing) and the improvement of body, mind and spirit.

Yoga and meditation tourism

Yoga is “a spiritual practice which can lead to self-knowledge, and create harmony with others and the world around us” (Smith and Puczko, 2009:95). Yoga and meditations are said be a subset of holistic tourism or spiritual tourism. Types of yoga are many, but popular ones include hatha yoga which emphasises standing physical postures, breathing and meditations; and ashtanga yoga which is more dynamic and needs physical strength to move from posture to posture within one and half hours.

Spiritual tourism

Spiritual tourism is “tourism that focuses on the spiritual quest of the individual leading to transcendence or enlightenment. This may or may not have a religious affiliation, but is often likely to include rituals, ceremonies, and traditions that are derived from different religions” (Smith and Puczko, 2009:97). Spiritual tourists visit spiritual or sacred landscapes such as mountaintops, deserts and oceans. Some attend spiritual courses in yoga, meditation and chanting. Others bathe in healing waters that are believed to be spiritual. They believe that water absorbs uttered words, healing thoughts and intentions. It can be done anywhere where there is market for such needs.

Occupational wellness

Occupational wellness tourism or holidays has to do with the satisfaction and enrichment that people receive through work. It includes one's perception of work, the workplace and co-workers, the sense of belonging, involvement and challenges, career ambitions, personal performance, and the degree to which work-life balance is achieved. Workshops and life-coaching at these venues focus on stress management, team building, balancing work with social life, family and other commitments, and becoming a better communicator/manager/employee. Lack of occupational wellness holidays results in burn-out.

Medical tourism

Medical tourism can be defined as "travel to destinations to undergo medical treatments such as surgery or other specialist interventions" (Smith and Puczko, 2009:101). There are two major forms of medical tourism, namely, surgical (involving operations) and therapeutic (involving participating in healing treatments). Surgical medical tourism includes repeated and multiple operations to look younger, slimmer and more beautiful. The spectrum of medical tourism ranges from the necessary operations for life-threatening diseases such as cancer, to more aesthetic, but necessary, practices such as orthodontic dentistry, to physically non-essential but psychologically boosting cosmetic surgery.

Therapeutic medical tourism includes medical checkups and diagnoses. It can be based in a medical hotel, and would require a series of treatments and checkups. It also uses natural resources that have healing powers. It includes medical wellness, which is a product half-way between medical and wellness tourism. It is meant for people who are not sick, but who want to maintain or improve their health (Kristmannsdottir, 2010).

5.3.3.3 Comparison of Sagole with the requirements of each type of health tourism

In order to select the suitable health tourism for Sagole, Table 5.3 compares the characteristics of Sagole with the requirements for each type of health tourism. Factors in column 1 were obtained during the site visit at Sagole.

Table 5.3 Comparison of Sagole with the requirements of each type of health tourism

Sagole characteristics	Spa	Leisure & Recreation	Thalasso	Holistic	Yoga & Meditation	Spiritual	Occupation	Medical
Thermal spring	✓	✓	✓	✓	✓	✓	✓	✓
Curative water	✓	×	×	✓	×	✓	×	✓
Thermal pools	✓	✓	×	✓	×	×	×	✓
Natural beauty	✓	✓	×	✓	×	×	×	×
Physical space	✓	✓	✓	✓	✓	✓	×	✓
Cultural art	✓	×	×	×	×	×	×	×
Accommodation	✓	✓	×	✓	✓	✓	✓	✓
Scores	7	5	2	6	3	4	2	5

It is evident from Table 5.3 that health Spa tourism meets all the characteristics of Sagole. It integrates aspects of a holistic experience. Therefore Health Spa Tourism can be developed at Sagole.

5.3.4 Health spa tourism and its development

5.3.4.1 Characteristics of health spa tourism and resorts

The ten domains of spa tourism are discussed above under the definition of spa tourism. These domains can be described as the characteristics of health spa tourism. The ten domains correlate well with DeVierville's (1998) in Lund (1999) basic requirements for health spa resorts. These basic requirements are: water, food or nutrition, exercise or movement, massage or body work, mind-body physical, natural therapeutic agents (muds), environment – area, climate, cultural aspects, management and staff (marketing),and lifestyle pattern or rhythm (time). The ten domains also match well with Kusen's (2002:177) characteristics of the so called "new" tourism which include massage, a health and fitness club, diet programme with psychotherapy, beauty treatments, spa baths, hydrotherapy, and relaxation techniques.

Treatments found in health spa tourism are many. Some of the treatment programmes are: preventative health care, herbal remedy programmes, fitness programme, balneotheraphy (underwater massage), hydrotherapy, wellness and health programmes (focusing on "whole life attitude), indoor and outdoor thermal swimming pools, various baths, saunas, stop-smoking programmes, relaxation techniques, de-stressing treatments, detoxification programmes, vitamin complex treatments, dietary programmes, beauty treatments, recreational activities (Goodrich, 1993; Spivack, 1997; Kusen, 2002; Snoj & Mumel, 2002; Bennett, King & Miller, 2003; World Media Partners, 2008).

Internationally known spa resorts generally provide the following facilities: accommodation, restaurants, facilities for conferences and functions, camping and caravan parks, hot, warm and cold swimming pools, different kinds of health, beauty and body treatments (body massage, facial, foot and hand) and indoor bathing or soaking pools (Snoj and Mumel, 2002). The following are internationally known health tourism resorts and hotels: the Huaging Aegean International Hot Spring Resort in China, the Taipei Hot Spring Resort, Tabacon Grand Spa Thermal Resort in Costa Rica, the Sungai Klah Hot Spring Park in Malaysia, the Peninsular Hot Spring in Australia, and the Felix Spa in Rumania (Sinohotelguide, 2000; Tabacon Grand Spa, 2010; Farcas, Antics, Gabor, & Tiurbe, 2010; Stowers, 2010). Table 5.2A lists the facilities available at these resorts. This table was compiled using information from Sinohotelguide (2000); Pesce (2002); The Baths (2003); Minervini (2005); Spicer & Nepgen (2005); Farcas, Antics, Gabor & Tiurbe, 2010); and Tabacon Grand Spa (2010).

In general, all international health spa tourism resorts and hotels include some of the above-mentioned facilities. However facilities differ from one country to another and from one resort to another (World Media Partners, 2008).The differences are brought about by the target market or the level of service they are able to provide. In the context of this study, health spa tourism uses naturally heated mineral water (geothermal fluid and mud) for medical purposes and aimed specifically at preventing and improving health. This is possible by participating in a number of activities and treatments mentioned above. Table 5.4 below gives the main facilities found in international and South African spa resorts.

Table 5.4 Facilities available at selected international and South African spa resorts

Facilities	Accommodation (chalets/hotels)	Camping & Caravan Park	Restaurants	Swimming Pools (hot /cold)	Conferencing & Functions	Sports & Games	Thermal Spas & Hydros	Hot Mineral Water	Sauna/Jacuzzi	Body Treatment & (Beauty Massages)	Nearby Attractions
A International Resorts											
Felix Spa: Rumania	✓	✕	✓	✓	✓	✕	✓	✓	✓	✓	✓
Huaging Aegean: China	✓	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sungai Klah Hot Spring: Malaysia	✓	✕	✓	✓	✕	✕	✓	✓	✓	✓	✓
Peninsular Hot Spring: Australia	✕	✕	✓	✓	✕	✓	✓	✓	✓	✓	✓
Tabacon Grand Spa: Costa Rica	✓	✕	✓	✓	✕	✓	✓	✓	✓	✓	✓
Blue Lagoon Spa: Iceland	✓	✕	✓	✓	✓	✕	✓	✓	✓	✓	✓
B South African Resorts											
Avalon Springs: Montagu	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bela-Bela: Warmbath	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Camelot: Caledon	✓	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓
De Eiland: Tzaneen	✓	✓	✓	✓	✓	✓	✓	✓	✓	✕	✓

Sagole Spa: Thohoyandou	✓	✓	×	✓	×	×	×	✓	×	×	✓
The Baths: Citrusdal	✓	✓	✓	✓	×	✓	✓	✓	✓	×	✓

Symbols: ✓= Facility present. ×= Facility absent.

Five of the six international spas are natural hot spring resorts and provide accommodation in the form of hotel rooms and chalets. The Peninsular hot spring resort in Australia is the only one without its own accommodation. It uses nearby accommodation at Mornington Peninsular. In Stage 3 of its development, 126 rooms will be built (Peninsular Hot Springs, 2010).

South African hot spring resorts include The Baths Natural Hot Water Springs Resort in Citrusdal, Camelot of the Caledon in Caledon, and Avalon Springs in Montagu, Western Cape. Forever Resorts Tshipise, Bela-Bela and Eiland are well-developed spa resorts in the Limpopo Province. However, they are not health spa resorts. Like the international hot spring resorts, they too provide almost the same facilities such as accommodation, ranging from flats, self-catering chalets, apartments, to luxury suites (Table 5.2B). Restaurants, facilities for conferences and functions (birthday parties, weddings and baby showers), camping and caravan parks, different kinds of massages, pools and baths (jacuzzis, Turkish steam baths, hydros or indoor spa pools and outdoor warm pools) are provided. Other sports and entertainment facilities generally include a golf course, tennis courts, quad biking, bicycle hire, horse riding, fun runs, a casino and games (Spicer and Nepgen, 2005).

About 92% of all the hot spring resorts provide restaurants and thermal spas or hydro’s. A very interesting thing is that none of the international health spas mentioned above provide camping and caravan park facilities. However, there are other international health spas with camping facilities, for example, Vertientes de la Concordia, Complejo

Termal Chajari and Termas del Almiron in Uruguay (Pesce, 2002). All South African health spas, except Camelot at Caledon, provide camping facilities. All the health spa resorts and hotels provide hot swimming pools. All the health spas provide body treatments which include different types of massages and beauty treatments. C

Conference and functions facilities are provided by 58% of all the spas. All hot springs have hot mineral water. About 92% of all the spas provided either a sauna or Jacuzzi, or both. All health spas have nearby attractions. About 67% of all the hot spring spas entertain their visitors with sports or games such as tennis courts, golf courses and many more.

Of the six South African spas listed, only Avalon springs, Bela-Bela and Camelot offer any kind of treatment. From brochures it appears that the treatments are beauty- rather than health related. It is thus questionable whether any of the resorts can be classified as being truly *health* spa resorts. The development of a health spa at Sagole could thus make it unique in South Africa.

5.3.4.2 Ideal development for health spa tourism (near-ideal model)

This section investigates the possibility of designing and specifying a model that could be profitable based on information gathered from the literature study, on-site observation at Sagole, water sample analyses, education and skills surveys and visits to leading spa resorts in South Africa such as Forever Resorts Bela-Bela, Forever Resorts Tshipise , and Eiland in the Limpopo Province. Favourable conditions for health spa tourism that indicate the potential for profit and sustainability can be identified and incorporated into the so-called “near-ideal model”. The main objective of the near-ideal model is to reduce costs and maximise profit. Recommendations that can help to accomplish this are noted below. In health spa tourism planned development rather than organic is recommended. Other recommendations are as follows:

- Accommodation facilities should meet the highest expectations of hygiene, and create a welcoming and comfortable atmosphere;
- The location and atmosphere of the area should aim for real relaxation;
- Main roads should be designed around the health spa centre, and pedestrian paths should be made within the centre;
- All polluting activities should be minimised within and around the centre.
- The environment should be protected;
- Catering should provide healthy food or the diet prescribed by the local doctor (Smith & Puczko, 2009:166);
- Health improvement facilities and treatments should be made available;
- Health facilities should include: individual small thermal pools at each chalet, hydrotherapy baths: indoors pools (rheumatism bath) and outdoors pools; cold plunge pools; hydro-oxygen baths, micro massage mineral mud bath; Jacuzzis, steam rooms, Tshivholovholo (African sauna), massage rooms, and bottling mineral water.

Architecture and design of the near-ideal health spa

According to Smith and Puczko (2009:173), a well-designed health spa should be “modern, simple, unassuming, clean, airy, light, calm, uncluttered, in harmony with nature, inviting, functional, and inclusive”. The design should promote creativity, intimacy, personal calm and a sense of meaning

In summary, the near-ideal system would have the following characteristics: low cost of construction; maximised productivity of the business; efficient electrical use (solar energy); use of the interdependence and synergy approach (use of different facilities under one roof such as thermal spas, beauty spas, body and soul fitness facilities (Smith & Puczko, 2009:171).

5.3.4.3 Designing the near-ideal model

A potential layout for the near-ideal health spa model is illustrated in Figure 5.1 below:

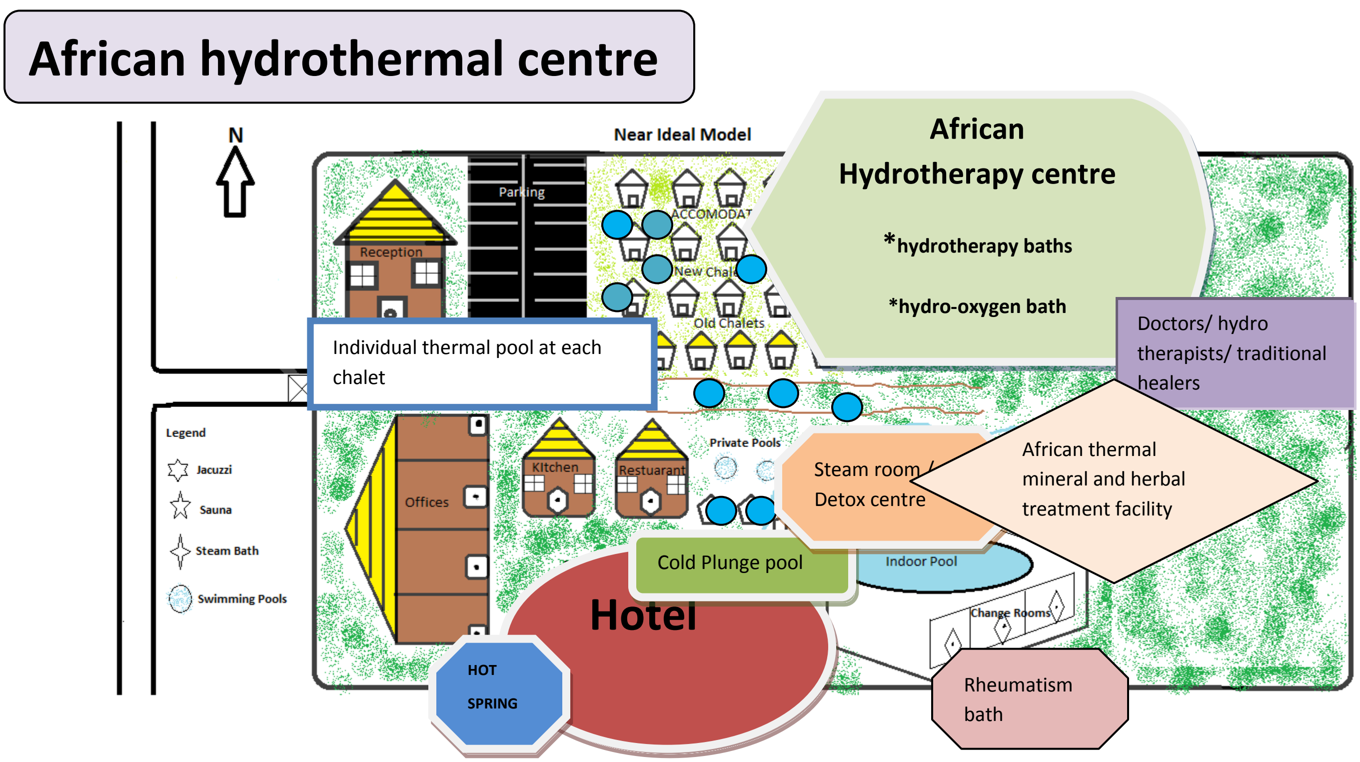


Figure 5.1 Layout of the proposed near-ideal health spa model

Components of the near-ideal health spa model illustrated in Figure 5.1 are as follows:

- Accommodation (chalets /hotel rooms) for sleeping, relaxation, recuperation and rehabilitation;
- Administration block (offices) for management, administration, reception and enquiries;
- Outdoor pools for swimming; and cold plunge pools;
- Indoor pools or rheumatism bath;
- (African herbal (homeopathic) centre)
- Sauna, steam bath, and jacuzzi for hydrotherapy;
- African Hydrotherapy centre
- Visitors' parking
- Ablution and toilet facilities

5.4 SUITABILITY OF HEALTH SPA TOURISM AT SAGOLE

Table 5.5 below gives some chemicals and trace elements found in thermal water at Sagole (Column 1). The potential curative power or essentials of these elements in human health are explained in Column 2. The benefits can be experienced by drinking bottled thermal water, bathing or soaking.

Table 5.5 Medicinal chemical/trace elements in thermal water

SAGOLE SPA

Chemical/Trace Elements	**Potential Curative power/Essential in human health**
Calcium and Magnesium	Essential in human diet
Fluoride	Promotes dental health
Carbolic water	Have significant medical importance circulatory and heart disorders
Sulphated water	May heal hepatic insufficiency (inability of the liver to function properly) and problems with the accumulation of organic waste
Bicarbonate water	May relieve gastrointestinal illness, hepatic insufficiency and gout
Sodium Chlorinated water	May cure chronic infection of mucous membrane (ledo, 1996)
Mineral water	Recommended for diseases such as gout, urinary and kidney stone complaints (Murken, 2006)
Trace elements	
Selenium	Essential for AIDS, arthritis, asthma, cancer, cardio vascular diseases, reproduction, thyroid and viral infections
Strontium	Reduction in bone pain from patients suffering from osteoporosis Improvement to patients with postmenopausal osteoporosis
Iodine	It builds thyroid hormones, the nervous system and metabolism
Lithium	Lithium salts treat manic-depressive illness, (bi-polar disorders) or used as antidepressant.
Manganese	Important in human diet
Molybdenum	Can be used as food supplement mineral
Nickel	Dietary requirement for many organisms
Platinum bonds	Applied as medicine to cure cancer. Compounds are used in tumour therapy

This section discusses the suitability of Sagole for health spa tourism in terms of environmental, social and economic aspects. In this context, thermal water at Sagole is to be used for medicinal purpose and specifically for improving health or relaxation. The section also discusses the development plan for Sagole.

5.4.1 Environmental factors

5.4.1.1Climate

The climate of Sagole was described in Chapter 3. It is mainly characterised by low summer rainfall and dry, frost-free winter. European visitors prefer warm dry climate with long annual hours of sunshine and scant rainfall (Rodriguez, Fernandez-Mayoralas, & Rojo, 2004). In the United States, patients diagnosed with chronic pain such arthritis reported that cold weather and changes in barometric pressure increased pain (Jamison, Anderson and Slater, 1995:310). Sagole with its mild temperature and dry climate can be cherished by visitors from Europe.

5.4.1.2 The terrain features.

The terrain (topography) of Sagole is discussed in Chapter 3. Figure 5.2 gives a general picture of the flat environment. It is suitable for the proposed health promoting activities such as walking and riding bicycles.

Figure 5.2 Flat land dominated by baobab trees

The flat land shown in Figure 5.2 indicates that constructions costs would be cheaper than in mountainous sites. The baobabs are uniquely interesting and make the area beautiful and attractive to anyone who loves the natural environment. The physical space makes the site more suitable for health spa tourism.

5.4.1.3 The physical and chemical characteristics of water at Sagole

The general physical environment of Sagole is discussed in Chapters 3. This section discusses the potential of the site for health spa tourism. In Chapter 2, and in this chapter, the curative properties of geothermal waters are discussed. Different beneficial chemical effects on diseases are also explained. For example, lithium is used in medicine to treat manic-depressive illness. Alkaline water has the capacity to neutralise acids and remove toxins in the body. These qualities make the thermal water suitable for health spa tourism.

5.4.2 Social factors

5.4.2.1 Willingness of stakeholders

The following stakeholders should be involved in the development of health spa tourism: the national government, the provincial government (Limpopo Tourism, Limpopo Economic Development Enterprise (LimDev), the local municipality, the local community and researchers).

According to Keyser (2009:40), the White Paper on the Development and Promotion of Tourism in South Africa described the roles and responsibilities of stakeholders as follows:

- The tourism industry should promote a balanced and sustainable tourism, which should focus on environmentally based tourism activities;

- Government and business should involve the local communities through the development of meaningful economic linkages;
- Tourists, business and government should respect, invest and develop local cultures;
- Local communities to become actively involved in tourism industry, and ensure safety and security of visitors, and
- The government's willingness to support and promote tourism is demonstrated by the development of *National Responsible Tourism Guidelines* in 2001 (Keyser, 2009:41).
- The stakeholders are willing and ready to use tourism as a job creating strategy for South Africa.

5.4.2.2 Skills requirements/human resources

In the skills survey conducted at Sagole, the skills identified are shown in Table 5.6 below.

Table 5.6 Skills and their percentage at Sagole

Skills	**Percentage of Representation %**
Management and marketing	13
Administration and reception	14,5
Hospitality and catering	46,5
Art and craft	60,5
Local food and traditional beverages	72
Traditional dances and music	54,5

Table 5.6 shows that there are low percentages of people with professional skills such as management, marketing and administration. Some of these people are already employed; therefore, it is possible that certain advanced skills would need to be imported for the venture. Other skills that are needed include: massage, beauty treatments, physiotherapy, water bottling and maintenance for Jacuzzis, saunas, steam baths and indoor pools. Social and cultural skills are readily available as shown in Table 5.6.

Fortunately the local community already have skills that could be used for the health aspects of such a development. The local traditional healer has been curing patients using the thermal water and indigenous medicinal plants. Local people have knowledge of indigenous medicinal plants that can cure different diseases. For instance, Mpesu and Tshitunde tsha Pfene, Dzovhelo (a mixture of mageu and medicinal plant) keeps all men, young and old, sexual active. Other medicinal indigenous plants include Mukulungwane, and Tshishengaphofu cures mouth rash. Migraine headache is cured by small cuts and the application of special indigenous minerals from stones (Magidimisha, 2011).

5.4.3 Economic potential

5.4.3.1 Potential funding organisations

According to the South African Government Information (1996), and the Department of Environmental Affairs and Tourism (2005), the South African Government has established the following institutions to fund tourism:

The Industrial Development Corporation, the Development Bank of Southern Africa, Khula, the Independent Development Trust, the Small Business Development Corporation, the Kagiso Trust, the provincial Development Corporations, commercial banks and community-based organisations to fund and promote tourism in South Africa. These, and others not mentioned are the potential funders for health tourism at Sagole.

5.4.3.2 Potential market

Health spa tourism is generally driven by diversified group of people. They include, wealthy, matured, individuals, couples, small groups, elderly and middle-aged “empty nesters” (adults whose children have left home) (Mueller & Kaufmann, 2001:10). . They are well-educated and affluent professionals. The age group of 50-65 remains the one with the greatest potential. As majority of these suffer from chronic pains. They tend to stay longer in health spas as they have more time (Mueller & Kaufmann, 2001). Sagole can also target international visitors in need of curative treatments and health spa facilities. International visitors to the Kruger National Park can benefit from the health facilities at Sagole. The distance from Sagole to Pafuri Gate is about 55km. At national and provincial level, local professional people who are health-conscious could make use of the health improving activities at Sagole. Targeting the above-mentioned customers could make health spa tourism a suitable option for Sagole. However, there is a need for the present infrastructure to be improved.

5.4.3.3 The existing infrastructure at Sagole Spa

The current infrastructure at Sagole Spa includes a conference hall, 6 chalets, one big modern kitchen, 2 x 40 sleeping halls (which can be changed into hotel room), 2 x 8 sleeper chalets, two private swimming pools, two public swimming pools (one for males and the other for females), one pavilion and one administration office. The available accommodation is ideal for individual, couple or group visits.

5.5 DEVELOPMENT PLAN FOR HEALTH SPA TOURISM AT SAGOLE

This section discusses how the development plan for health spa tourism will be organised. The development plan is in three phases. Phase 1: Preliminary activities, Phase 2: Renovation of existing infrastructure and construction of new buildings and Phase 3: Buying equipment, putting systems in place and hiring staff. Details of activities and cost are given in section 5.7.2

5.5.1 Phase 1: Preliminary activities

Phase 1 will consist of the following activities:

- Hold meeting with all interested stakeholders. Carry out an environmental impact assessment (EIA);
- Secure funding; and hire the renovation and construction companies.
- Hire an architect

5.5.2 Phase 2: Renovation of existing infrastructure and construction of new buildings

Phase 2 will consist of the following activities:

- Renovation of chalets, kitchen, open swimming pools, ablution, and the drainage system;

- Clearing site for new building infrastructure;
- Construction of new buildings such as new chalets, restaurant, administration office block, laundry, showers and baths;
- Construction of natatorium (indoor pools) and the fitness centre. These will include the massage rooms, sauna, Jacuzzi, steam rooms, hydrotherapy baths, hydro-oxygen baths, and change rooms;
- Hire the senior management staff.

5.5.3 Phase 3: Buying equipment, putting systems in place and hiring staff

- Buying and install office equipment, computers, telephones, and stationary;
- Equip the natatorium and the fitness centre;
- Hire the general staff;
- Educating and training the staff;
- Hire medical staff and beauty therapists;
- After training operation starts

5.6 POTENTIAL IMPACTS OF HEALTH SPA TOURISM AT SAGOLE

During the construction and operational stage of health spa tourism, both negative and positive impacts are possible. These may be economic, socio-cultural and environmental impacts. The following section discusses the potential benefits and/or negative impacts for the development of health tourism at the Sagole Spa.

5.6.1 Environmental impacts

The development of a health spa tourism project can sometimes have significant local environmental impacts with regard to air and water pollution, noise, changed land use, and impacts on the aesthetic qualities of the landscape (Chandrasekharam & Bundschuh, 2002). Brief discussions of these potential environmental impacts follow.

5.6.1.1 Air pollution

Since no drilling is going to take place in the area, emissions of hazardous gases will not take place. However, a certain amount of dust emission would be generated by ground disturbing activities related to the transport of workers and equipment to the site and the clearance of the land for site development. Grading of land can cause soil disturbance and fugitive dust. Protection measures that can be implemented to minimise dust include:

- Watering any dry soils prior to ground disturbance to reduce fugitive dust emissions.
- Use water, venting, or any other precautions to prevent particulate matter from becoming airborne in handling dusty materials to open stockpiles and mobile equipment, and
- Maintenance of roadways in a clean manner.

Air quality impacts would be localised and temporary as the construction would last about six months (Chandrasekharam & Bundschuh, 2002; Geo-Heat Center, 2008).

5.6.1.2 Water pollution

There is sufficient tap water at Sagole Spa for the proposed facility. Storm water run-off could become contaminated with petroleum fuel, oil and grease from the construction vehicles and equipment used during the construction stage. However, contruction will take place away from the spring to prevent contamination of the spring water. Chlorinated water from pools and aromatherapy oil can be drained to outdoor pool where it can be cleaned and recycled to avoid contamination. The hot spring cannot be contaminated since development will take place away from the source. Access to the hot spring will be strictly controlled. Waste and contaminated water from Jacuzzi and swimming pools will be treated, recycled, re-used and discharged. Possible contamination from people using indoor pools and Jacuzzi are skin diseases. However, private Jacuzzi can be used by people with infectious diseases.

5.6.1.3 Noise pollution

During the construction of a health spa tourist site at Sagole, potential noise sources would include the use of heavy equipment in the construction area. The construction activities may result in elevated noise levels for the duration of the construction. Noise protection measures may include installing a temporary noise and dust wall around the construction area. The wall can be removed after the construction is complete(Beech & Chadwick, 2006; Geo-Heat Center, 2008).

5.6.1.4 Solid wastes

Solid wastes are generated during the construction *and* operation of commercial enterprises such as a health spa. These could include general garbage, food wastes, and office and workshop wastes. The improper disposal of litter can detract from the aesthetic quality of the local environment (Cooper, Fletcher, Fyall, Gilbert, and Wanhill, 2008). Solid waste can be minimised by reducing waste, reuse and recycling of the waste footprint (the environmental, economic and social impacts that results from the waste created by man. Examples include scarred landscapes, and all wastes visible in landfill sites.   Litter bins should be made available at the spa. The disposal of litter and other wastes should be transported to the landfill site where biogas can be generated (Hoole, 2000; Chandrasekharam & Bundschuh, 2002).

5.6.1.5 Land and biological resources

Natural resources such as biological (plants and animals) may become altered, and depleted during the construction and operational stage. The land under construction should be rehabilitated immediately after construction. However, wild plants and animals can be conserved during the operational stage. This is possible through environmental awareness and conservation programme.

5.6.1.6 Aesthetic impacts

Many geothermal resources are located in places that are considered to be of great natural beauty or areas considered to be aesthetically valuable. Sagole Spa is also valued as an important environmental asset with intrinsic value as a natural phenomena and it also possesses economic value for tourism. The construction of new buildings may have a detrimental effect on the perceived beauty of the Sagole Spa environment. The use of locally available building materials such as rocks in some of the structures can help to maintain the indigenous building style of the area. Mitigation at Sagole can be possible by professional design and siting of new buildings. According to Sama (2000:6), “a properly sited and designed project is the best way to mitigate potential impacts”.

Improving the quality of buildings and the immediate surroundings can enhance the aesthetic beauty of the area. This may attract more visitors to the health spa tourism centre. Health tourism at Sagole can therefore be used as a catalyst to revitalise and improve degraded environments in the area. The preservation of natural resources such as the hot spring is an example of the positive impact of tourism.

Table 5.7 below gives a summary of potential environmental impacts at the different development stages of a construction project and potential measures during the development and operation of the project.

Table 5.7 Potential impacts, stage of development and measures

Potential impacts	**Stage of development**	**Measures**
Air pollution (fugitive dust)	Construction	Watering any dry soils prior to ground disturbance to reduce fugitive dust emissions
Water pollution (storm water run-off contaminated with oil and grease from construction vehicles and water contamination by aromatic oil, chlorine, pools and Jacuzzi)	Construction/operational	The construction of containment berms (raised banks) around hazardous material storage areas. Contaminated water to be collected, treated, re-used and discharged.
Noise pollution (Source: use of heavy equipment in the construction area)	Construction	Installation of a temporary noise wall around the construction area
Solid waste	Construction/operation	Waste prevention, minimisation, collection, recycle, re-use and disposal
Aesthetic impacts	Construction/operation	Landscape aesthetically well designed and maintained
Hazardous materials (fuels and oils)	Construction	All hazardous material storage to be surrounded by containment berms and drained
Human waste	Construction/operation	Waste collection, recycling, re-se and disposal

Soil erosion	Construction	All disturbed areas to ne reclaimed to prevent future erosion. Top soil to be stockpiled

5.6.1.7 Summary: Environmental impacts

Table 5.8 gives a summary of environmental impacts discussed above. Both positive and negative impacts are scored according to the given scale (-4 to +4). Factors used within each table were obtained from sources referenced in the discussions.

Table 5.8 Summary: Environmental impact scores

Bad ←						**→ Good**			
Rating scale	**-4**	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**
Environmental Factors (indicators):									
Climate : Air quality				✓					
: Dust				✓					
Geology: Seismicity					✓				
: Soil				✓					
Biological Resources:									
:Vegetation							✓		

: Wildlife							✓		
Water resources:									
Surface water hydro					✓				
Ground water hydro					✓				
Water quality				✓					
Hot spring					✓				
Aesthetics								✓	
Total Score	0	0	0	4	4	0	2	1	0

5.6.2 Social impacts

5.6.2.1 Impact on employment

Tourism brings economic gains, such as job opportunities, income to businesses and more taxes to the local authorities (Keyser, 2009:395). The local community at Sagole can therefore expect to be employed in some of the jobs at the centre.

5.6.2.2 Impact on cultural aspects

The development of health tourism at Sagole has the potential to involve the local people in the production and selling of crafts, operating craft shops at the centre, exhibit traditional, cultural and historical attractions, and possible performances of traditional dancing and singing. The local people can display Tshikona, Malende, Tshifase, Tshigombela and cultural games such as Mufuvha and many more. Traditional art and handicraft sold to tourists can lead to the renewal of an awareness and pride for the local culture and traditions of the community of Sagole. When the local people perform traditional dances wearing traditional dress, it helps to maintain the continuation of traditional dress within the community which has a great positive impact on tourism in the host community and, to a degree, supports the preservation of certain aspects of traditional culture for future generations. The potential visits of tourists to the traditional healer, Mr Tshikovha, who is known for healing sicknesses including mental illnesses, can make tourists aware of the power and wealth of indigenous knowledge in this regard.

5.6.2.3 Impact on health

The introduction of hygiene, the importance of drinking alkaline water and health treatments available at Sagole are some benefits of health spa tourism. The importance of bathing in geothermal water was discussed in Chapter 2. The benefits of using in indoor pools, Jacuzzi, steam baths, and sauna are known as therapeutic effects, reduction of incidence of cold and chronic pain, increase respiratory oxygen uptake, effective for appetite loss and mild depression. Both visitors and the local staff will benefit from these programmes.

5.6.2.4 Impact on the lifestyle of the local community.

The negative impact of tourism on local communities is that local people sometimes emulate the culture and lifestyle of tourists so much that they begin to be dissatisfied with their own. The encounter of tourists and hosts generally initiates cultural exchanges and social relationships.

5.6.2.5 Summary: Social impact

Table 5.9 gives a summary of social impacts discussed above. Both positive and negative impacts are scored according to the given scale (-4 to +4).

Table 5.9 Summary: Social impact scores

Bad ←				**→ Good**					
Rating scale	**-4**	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**
Social factors:									
Employment									✓
Cultural aspects								✓	
Human health								✓	
Emulate tourists lifestyle				✓					
Total score	0	0	0	1	0	0	0	2	1

5.6.3 Economic impacts

5.6.3.1 Revenue generation

The economic impacts of health tourism are not easy to assess. Keyser (2009:309) identified the following monetary benefits related to the development of tourism:

revenue generated from the spending of tourists; government revenue; balance of payment contribution and Gross Domestic Product (GDP) impact. GDP is the total value of products and services produced in a country over a period of one year. When health spa tourism business operates at Sagole, government receives revenue from company tax, payroll tax, personal income tax and VAT on goods bought. New businesses can also be attracted to the centre. In this regard, the Local Municipality and the Limpopo Province can benefit from the revenue that can be generated by health tourism at Sagole.

5.6.3.2 Jobs and income generation

It is believed that health tourism has the potential to generate income to the host community. Jobs can be created at Sagole ranging from managers to administrators, waiters and waitresses, and from booking clerks to cleaners and maintenance staff (Hoole, 2000). There are opportunities for the community at Sagole Spa to be employed during the construction and operational stage of the centre. During the upgrading and construction stage, labour can be provided for unemployed men and women from the host community. During the operational stage unemployed youths with Grade 12 qualifications can be trained and employed in areas such as administration and as clerks, receptionists, and maintenance staff. Mature men and women can be employed to disseminate indigenous knowledge system and as cleaners and in the catering service. An electrician will be needed for electricity maintenance, and a plumber for all the plumbing needs of the spas, swimming pools and to maintain all pipes and sewage facilities. The need for labour described above confirms that health tourism is a labour-intensive enterprise. Using indigenous knowledge to heal, traditional healers will gain income from international visitors.

5.6.3.3. Tourism multipliers

Tourism has an expansive and “multiplier” effect upon the host community.

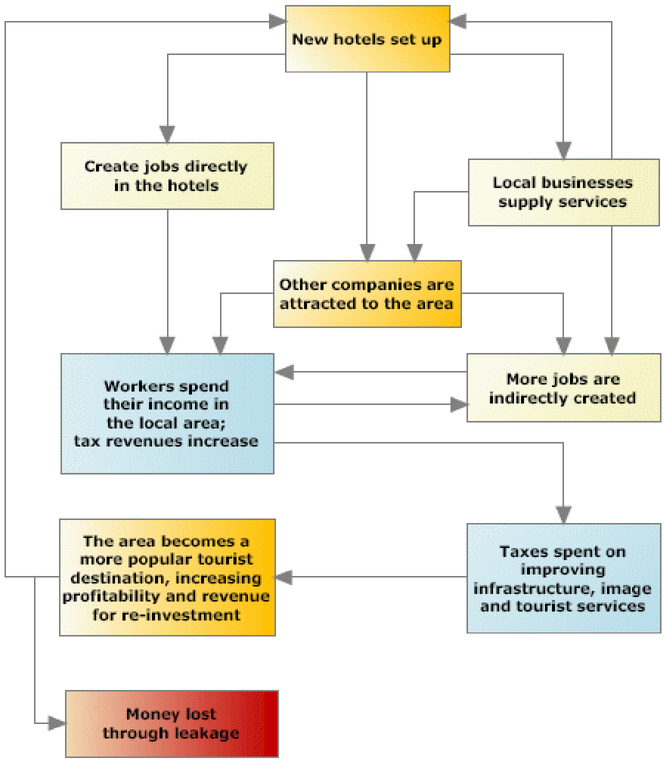


Figure 5.3 Tourism multiplier effect

Source: Geographyfieldwork.com (2010).

Money spent by visitors in a destination area has thus both direct and indirect economic benefits (Rowe, Smith & Boerein, 2002).

5.6.3.4 Impact on other industries and infrastructure

Tourism has a positive impact on other industries such construction, transport and agriculture. For example, the construction industry builds infrastructure, the transport industry transport tourists, and the agricultural industry supply foods to tourists. Tourism development at Sagole can be accompanied by investments in infrastructure, roads, water and sewage facilities, telecommunications and other public utilities (Keyser, 2009).

In the Sagole Spa area, accommodation and attractions such as the Big Tree will benefit directly from tourist spending. The petrol station, the restaurant, the clinic and the traditional healer and his clients can likewise benefit from the tourist spending. The Sagole Spa management will use money to pay its staff and suppliers. Workers at Sagole Spa will spend their money in local shops while the suppliers will be paying their own staff. In this way money will be circulating in the area and will create more wealth for the host community and suppliers outside the local community. Money spent to the suppliers outside the Sagole area will be lost through what is called “leakage” as illustrated in Figure 5.3.

5.6.3.5 Generation of foreign exchange

Tourism is known as a major generator of foreign exchange. Since the target market includes international tourists, there is the potential for Sagole to attract foreign currency and contribute to the overall wealth of South Africa.

5.6.3.6 Rural development

Health tourism can bring development to rural areas such as Sagole which do not have many economic opportunities other than subsistence farming.

5.6.3.7 Summary: Economic impact

Table 5.10 gives a summary of economic impacts discussed above. Both positive and negative impacts are scored according to the given scale (-4 to +4).

Table 5.10 Summary: Economic impact and scores

Bad ←					→ Good				
Rating scale	**-4**	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**
Economic Factors:									
Generation of revenue							✓		
Generation of foreign exchange						✓			
Job & income generation									✓
Tourism multiplier effect								✓	
Impact on other industries and Infrastructures								✓	
Rural development							✓		
Total scores	0	0	0	0	0	1	2	2	1

5.7 FEASIBILITY OF HEALTH SPA TOURISM

In section 5.5, the total scores were calculated for the environmental, social and economic impacts. If any of these were negative, they would also have a negative influence on the feasibility of establishing a health spa tourism enterprise. Thus by implication, if the environmental, social and economic impacts are positive, the establishment of the enterprise will be promoted.

5.7.1Environmental, Social and Economic feasibility

In this section, the total weighted score and the mean score of each of the environmental, social and economic impacts are calculated.

Total weighted score =

The mean score = Total weighted score/N =

5.7.1.1 Environmental feasibility

As shown in Table 5.8, there will be no environmental impacts on seismicity (drilling will not take place), wildlife (new buildings will be built on open site), surface water hydro (no other rivers close to the site), ground water hydro (no drilling for borehole) and on hot spring (new infrastructure far from the hot spring). There will be minor temporal negative impacts during the renovation and construction of the new building infrastructure on the environment. Air quality will be affected by dust, soil erosion can occur, some vegetation can be destroyed, and water quality can be affected during the construction and operational stage by swimming and bathing in pools.

Table 5.11 gives the environmental feasibility rating (total weighted score). The mean score is also calculated below. The rating scale ranges between -4 (bad or low feasibility) and +4 (good or high feasibility).

Table 5.11 Environmental feasibility rating

Rating

Rating scale	**-4**	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
Total Score (from Table 5.8)	0	0	0	4	4	0	2	1	0		
Total weighted score	0	0	0	-4	0	0	+4	+3	0	=	+3

Total weighted score = +3

N=11

Mean score= +3/11 = +0.27

The overall mean value indicates that the health spa operation will have a positive environment feasibility rating (+0.27). There will be some temporal negative impacts during the renovation and construction of the new infrastructure. The period of clearing the field and the construction of new infrastructure can last for around four weeks only.

5.7.1.2 Social feasibility

As shown in Table 5.9, there can be some negative social impacts if the local people can emulate the lifestyle of tourists at the expense of their own lifestyles. However, education and training of the host community can alleviate such a problem. There are positive social impacts on employment, cultural aspects and human health.

Table 5.12 gives the social feasibility rating for health spa tourism. The mean score is also calculated below. The rating scale ranges between -4 (bad or low feasibility) and +4 (good or high feasibility).

Table 5.12 Social feasibility rating

Rating

Rating scale	**-4**	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
Total score (from Table 5.9)	0	0	0	1	0	0	0	2	1		
Total weighted score	0	0	0	-1	0	0	0	+6	+4	=	+9

Total weighted score = +9

N= 4

Mean score = +9/4 = 2.25

The overall mean value indicates that the health spa operation will have a positive social feasibility rating (2.25). Therefore the establishment of health spa tourism can be promoted at Sagole.

5.7.1.3 **Economic feasibility**

As shown in Table 5.10, there are no negative impacts for establishing health spa tourism at Sagole. Positive economic impacts identified include the generation of revenue, foreign exchange, jobs and income, the tourism multiplier effect, impact on other industries and infrastructure, and impact on rural development.

Table 5.13 gives the economic feasibility rating for health spa tourism. The mean score is also calculated below. The rating scale ranges between -4 (bad or low feasibility) and +4 (good or high feasibility).

Table 5.13 Economic feasibility rating

Rating scale	**-4**	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
Total scores (From Table 5.10)	0	0	0	0	0	1	2	2	1		
Total weighted score	0	0	0	0	0	+1	+4	+6	+4	=	+15

Total weighted score = +15

N = 6

Mean score = +15/6 =+ 2.5

The overall mean value indicates that the development of a health spa at Sagole has a positive economic feasibility rating (2.5). Therefore the establishment of health spa tourism can be promoted in the area. Generally, the government, other businesses and the local community will benefit from such an enterprise.

Table 5.14 below gives a summary of feasibility ratings in terms of the environmental, social and economic aspects.

In terms of these three factors, it appears that the establishment of health spa tourism enterprise at Sagole has positive impacts. There are minor and temporal negative environmental impacts during the renovation and construction period.) The enterprise is feasible in terms of social and economical aspects.

5.7.2 Cost-benefit analysis

5. 7.2.1 Cost

Cost benefit analysis is a technique used by decision- makers to compare the various costs associated with an investment or project with the potential benefits that it proposes to return. A project should be undertaken if expected benefits exceed costs (Department of Environmental Affairs and Tourism (DEAT), 2004:4).

The costs and benefits of the proposed project in hot spring health tourism are analysed in this section. There are Phase 1 and Phase 2 Projects. The Phase 1 Project is mainly focused on the renovation of the existing infrastructure, and the Phase 2 Project is focused on the building of new infrastructure and introducing new facilities and treatments.

Phase 1 Project

The Phase 1 project focuses on the renovation of the existing infrastructure, adding new buildings, buying new office furniture, computers and communication equipment. Hiring and training of new management and administration staff is part of the Phase 1 project.

Appendix 1 shows the estimate of costs for the Phase 1 Project. The total costs for renovation amount to R220 000. The costs for new requirements amount to R1 359 000, while the total costs for labour per annum amount to R1 418 000. The above-mentioned funds should be made available either from government or the NGOs before the operation starts.

Phase 2 Project

The Phase 2 Project will focus on the building of chalets, natatorium and fitness centre. Details of all the requirements and costs are shown in Appendix 5. The total cost for the Phase 2 Project is about R7 770 000.00. Quotations of the above prices were obtained from the following companies: The Spa Company (Germiston), Cashbuild (Pretoria West) and Game (Menlyn, Pretoria). Table 5.14 shows a summary of estimated costs.

Summary Table of costs for health spa tourism Table 5.14

Phase 1	R C
Renovation, new buildings, equipment, labour and training	3 033 000.00
Phase 2	
New building and equipment	7 770 000.00
Total	**10 803 000.00**

5.7.2.2 Financial benefits

Suppose 90 people are accommodated (bed and breakfast) in the health tourism centre for 30 days during peak times (December/January), paying R500 each, and an average of 50 people are accommodated for 20 days per month at R400 per person per day, and 20 bicycles were hired per month at R50 per day for 12 months, the financial benefits can be calculated as shown in Appendix 6. Appendix 6 gave the labour costs (from Appendix 4) and benefits estimates (income) for Sagole Spa health tourism project. The benefits of having such a project far outweigh the costs. The surplus of R3 944 000 is big enough to cover maintenance and other services in the health tourism venture.

5.7.3 Summary: Business Analysis for Sagole

In this section, the SWOT analysis will be used to explain the business potential for health tourism at Sagole Spa. The acronym SWOT stands for *Strengths, Weaknesses, Opportunities* and *Threats* for business enterprises of organisations. *Strengths* and *Weaknesses* refer to internal elements of an organisation, while *Opportunities* and *Threats* have to do with external factors (Academy for Organisational Change, 2010:34; Gross, 2010). The SWOT analysis for Sagole Spa follows.

5.7.3.1Strengths

The following are the strengths of the Sagole Spa:

(a) The water temperature is about 46°C

Table 5.15 Typical natatorium design conditions

Type of pool	**Air Temperature °C**	**Water temperature °C**	**Relative Humidity %**
Recreational	24-29	24-29	50-60
Therapeutic	27-29	29-35	50-60
Whirlpool/spa	27-29	36-40	50-60

Source: Lund (2009).

The water temperature (46°C) can be controlled to meet the requirements of typical natatorium (indoor swimming pool) design conditions as illustrated in Table 5.15. The water temperature therefore meets the requirements for the recreational, therapeutic, and whirlpool/spas. Developers are not limited to a specific type of pool because of the temperature advantage.

(b) The water chemistry

The water contains minerals that are claimed to cure rheumatism, skin diseases and other ailments. The chemical properties of hot spring water and trace elements present in the water of the Sagole Spa are given in Chapter 4 in sections 4.4.2.1 and 4.4.2.2. Minerals and trace elements with curative powers are also explained in Table 5.5. The available minerals and trace elements can contribute to making Sagole a unique spa. The concentrations of the minerals and trace elements meet the international and local guideline value for drinking water quality according to the WHO, the EU and SA standards.

(c) Water at Sagole Spa is classified as alkaline.

The alkaline water is said be good for human health, especially as an antioxidant.

(d) The water is non-toxic and can be used for drinking purpose.

Water in other hot springs in the Limpopo Province is not suitable for drinking purpose; so this makes Sagole a unique spring in this regard.

(e) Electricity

Electricity was connected to the Spa in November, 2010 (Gadabeni, 2010). Electrical appliances can be used. Communication and marketing by means of computers will be possible.

(f) The road leading to the spa is tarred and is well maintained.

The resort is linked by tarred roads to such fast growing towns as Thohoyandou and Tshilamba.

5.7.3.2 Weaknesses

Current weaknesses for Sagole Spa are as follows:

(a) Poor organisational leadership

The current leadership at Sagole Spa is unable to lead, manage, market or maintain the Spa.

(b) Small client base

Very few people are visiting Sagole Spa at present due to its declining infrastructure and poor service.

(c) Dated and worn equipment

The kitchen equipment has not been used for years, some pipes have worn out and sometimes hot water cannot reach the private swimming pools.

(d) Inconvenient business location

Sagole Spa is located in a rural area, far away from towns and cities. The nearest town is Thohoyandou, which is about 80 km from the Spa (Gross, 2010). This may also be an advantage for people who want to get away from the hustle and bustle of cities.

(e) Limited funds

Lack of funds seems to be one of the key reasons for the declining infrastructure.

(f) Lack of skilled people.

At present, the local people lack many of the skills required to successfully run the Spa.

(g) Water and Sanitation.

Any new development will need an improved water and sanitation system.

5.7.3.3 Opportunities

Opportunities for the Sagole Spa are as follows:

(a) Visitors can change from using inorganic products to the use of organic and natural products for healthy living, for example, the use of natural mineral water for curing ailments.

(b) Bottle thermal mineral water for drinking purpose.

(c) Proximity to the Kruger National Park (Sagole is 55 km from the Pafuri Gate of the Kruger National Park). Many visitors to the Kruger National Park are potential clients for Sagole Spa.

(d) Potential to market all things African at the Spa. This may include indigenous knowledge system, African culture, foods, cuisine, and cures.

(e) An opportunity to introduce the first health tourism centre in South Africa, since there is none at the moment.

5.7.3.4 Threats

Threats facing the Sagole Spa are as follows:

(a) Competitors

Forever Resorts Tshipise and Mphephu Resorts are two hot spring resorts located fairly nearby, within a radius of about 100 kilometres. Fortunately, Sagole will not cater for the same market since its main focus will be on medical treatment and the improvement of health.

(b) Budget constraints

Funding for the construction of buildings, pools, employment and training of staff, will need a lot of capital outlay which may be difficult to raise.

(c) Land ownership

New building structures may need more land for expansion. Land can be made available if the local authority and the tribal council agree. However, the refusal of plans for future building expansion can be problematic (Bizhelp24, 2010).

(d) Thermal water sustainability

If the hot spring were to dry up, the entire enterprise would come to a halt. The water table needs to be monitored and protected continuously. It is unlikely that this can happen.

5.8 SYNTHESIS

In this section, health spa tourism is identified as a suitable tourism for development at Sagole. In general, a health spa development at Sagole is environmentally, socially and economically feasible. The weaknesses and threats are not insurmountable provided that there is local buy-in and funds and expertise can be procured.

CHAPTER SIX

AQUACULTURE

6.1 INTRODUCTION

In Chapter 4, aquaculture (fish farming) was identified as one of the viable uses for Sagole. This chapter explores the feasibility of establishing a sustainable geothermal aquaculture venture at Sagole. A concise overview of the aquaculture industry is given, followed by an explanation of the selected specific fish crop that could be cultivated at Sagole. The production requirements of the fish crop are also discussed in this section. Section 6.4 deals with the suitability of Sagole for aquaculture with respect to environmental, social and economic factors. The penultimate section focuses on the enviro-socio-economic impacts that could arise if an aquaculture industry were established at Sagole. The chapter culminates in an analysis of the feasibility of establishing a sustainable aquaculture venture at Sagole plus the SWOT analysis.

6.2 AQUACULTURE: AN OVERVIEW

6.2.1 The importance of aquaculture

Fish is a major source of proteins to a large proportion of the world's population. Medical research has indicated that the omega 3 fatty acids and protein found in most fish help reduce cancer and promote healthy brain tissue. Fish and aquatic species in general are a much healthier source of protein than red meat (Jobmonkey.com, 2011).

The problem of declining supplies of fish from captured fisheries (wild fisheries) can be solved by aquaculture.

Aquaculture is ‘the farming of aquatic organisms including fish, molluscs, crustaceans, and aquatic plants with some sort of intervention in the rearing process to enhance production, such as hatching, stocking, feeding, rearing to marketable size, protection from predators, etc. (FAO, 2008a:15).

It is the fastest growing type of food production in the world (Lapere, 2010:7). Nearly 50% of the fish consumed by humans is farmed. Aquaculture plays an important role in satisfying the present and future demand for food. It also contributes to the economy by supplying high quality foods and other fish products, such as fishmeal which is a valued agricultural fertiliser (Wyatt, 1990).The aquaculture industry can contribute to economic development of other businesses that supply materials to it or use agricultural products as inputs, such as the manufacturers of feeds, tanks, pipes etc. It also generates jobs, creates income and is responsible for rural development in many developing and developed countries. It has been estimated that global aquaculture production has increased from 38.9 million in 2003 to 52, 5 million in 2008. The value of its production was estimated at $98.4 billion in 2008 (FAO, 2008b: xvi). The total South African aquaculture production in 2008 was 3654 tons with a value of R327 million (Lapere, 2010).

The type of aquatic organism used as a crop is dependant on a number of physical environmental, social and economic factors (FAO, 2008a:15). One of the most important of these is the temperature of the water. The use of geothermal energy is a possible source of heat for raising the temperature of cold water. Sipe (2010:1) defines ‘the raising of aquatic life forms in water that is heated or cooled by energy drawn from the earth’ as geothermal aquaculture’. The advantages of using geothermal heat in aquaculture are the better control of pond temperature and the optimisation of fish growth. Temperature has a great influence on all biological and chemical process in an aquaculture venture. Each fish species has its own optimum temperature where it can grow best. Growth rate can be reduced when the temperature is above or below the optimum point. In extreme conditions mortality can occur (Boyd and Rafertty, 1998:2.1). Fish grown in geothermal heated ponds, where temperature can be controlled, grow faster than fish in unheated ponds (Clutter, 2002). Moreover, geothermal heated fish pond makes it possible to grow fish in water when it ordinarily would be possible (Digtheheat.com, 2011). Another advantage is that farmers using geothermal water save electricity costs because there is no need to heat the water.

Both direct and indirect geothermal energy sources are currently being used for aquaculture. Countries leading in the use of geothermal energy are the USA, Philippines, Mexico, Italy, Japan, Indonesia, New Zealand, Iceland, Nicaragua, Costa Rica, El Salvadore and Kenya (Lund, 2007:5). Geothermal aquaculture is currently used for the cultivation of cat fish, shrimp, tilapia, eels, lobster, crabs, crayfish, prawns and tropical fish (Lund & Lienau, 1992; Lund & Boyd, 2003; Gill, 2004). In Japan, carp and eels are the most popular aquaculture species. Water temperature is held at 23°C by mixing hot spring water with river water (Lund (2002) in Chandrasekharam and Bundschuh, 2002:156)). In the USA, aquaculture projects using geothermal water are found in Idaho, Oregon and California. Channel catfish are reared in Idaho (27-29°C), giant fresh water prawns and tropical fish (27-30°C) are reared in Oregon and a catfish raising operation in California (27°C) is very successful (Chandrasekharam & Bundschuh, 2002).

According to Hecht and Britz (1990), aquaculture in South Africa was established as a small and dynamic industry in the 1980s. Due to inexperience and lack of supporting infrastructure, development has been slow. In 1988, the total aquaculture production was 3094 tons valued at R45,8 million. The main species produced were the mussels, trout, oysters, waterblommetjies, and catfish (Hecht & Britz, 1990:19). Current production status is as follows: In 2008, Abalone represented 81% of the rand value of aquaculture produced, trout represented a further 8,5% while the remaining fish crops which were koi, ornamentals, oysters and mussels represented 10,5% of the rand value of the total production (Lapere, 2010:8).

South African aquaculture enterprises are relatively young businesses with 50% being younger than 10 years old, 31% less than five years and about 20% older than twenty years. About 76% of these are small businesses with a turnover of less than R5 million. (Lapere, 2010:8). At present, thermal spring waters have not been used for aquaculture in South Africa.

6.3 SELECTION OF FISH CROP FOR AQUACULTURE AT SAGOLE

6.3.1 Selection of crop

Water quality factors that can affect the growth of aquaculture species such as temperature, dissolved oxygen, total ammonia-nitrogen, pH, alkalinity, hardness, chlorine, carbon dioxide, salinity, and hydrogen sulphide were discussed in Chapter 2. In order to identify the appropriate crop for Sagole, the water quality factors and the physical characteristics of the hot spring at Sagole hot spring (discussed in Chapters 4 and 4) were compared with the water quality requirements for each fish species. Table 6.1 gives the comparison of the water quality factors and species requirements. The following sources were used to compile Table 6.1: Lewis and Morris (1989); Klontz (1991); Peteri, Nandi & Chowdhury (1992);Tucker (1991); Ghate, Burtle & Smith (1993); Boyd and Rafferty (1998:2.3); Molony (2001); Lund (2002) in Chandrasekharam & Bundschuh (2002:158); FAO (2002c); Silva (2005) and Lapere (2010:12) The following water quality factors for potential fish species were selected and analysed (Table 6.1): Temperature, dissolved oxygen, pH, hardness, Total Dissolved Solids (TDS), chloride, and nitrite.

Table 6.1 Comparison of Sagole, water quality factors and species requirements.

Water quality Factors	Sagole	Species Preferred Ranges				
		Prawns	**Tilapia**	**Carp**	**Cat fish**	**Trout**
Temperature (°C)	45	27-30 ✓	24-29 ✓	23-30 ✓	27-29 ✓	10-18 ×
Dissolved oxygen	9.9	5ppm ✓	4-6mg/l ✓	3-5mg/l ✓	6mg/l ✓	6-8 ✓
pH	8.72	7.0-8.5 ×	6.5-9 ✓	8.5 ✓	7-8.5 ×	7-7.5 ×
Hardness	9.91mg/l	30-150ppm ×	35mg/l ×	300-500mg/l ×	20mg/l ×	200mg/l ×
TDS	173	217mg/l ×	149-160mg/l ×	160-175mg/l ✓	105-200mg/l ✓	12-900ppm ✓
Chloride	44.09mg/l	40-225ppm ×	22mg/l ×	10mg/l ×	22mg/l ×	10mg/l ×
Nitrite	0	<2 ✓	<1 ✓	0.07-0.1mg/l✓	0.3mg/l ✓	0.55mg/l ✓
Total		3	4	4	4	3

Key: ✓ Meets requirements ✕ Does not meet requirements

Temperature: Preferred range for temperature is species dependent. All the warm-water species (prawns, tilapia, carp and cat fish) are advantaged by this factor except trout which is a cold water species (Molony 2001).

Dissolved oxygen: Dissolved oxygen at Sagole is 9.9mg/l. All the five fish species can be reared at Sagole since their requirements are below 9.9mg/l. Compared to the other four species, carp can tolerate dissolved oxygen as low as 3mg/l. It is therefore advantaged in this regard.

pH: The pH concentration at Sagole is 8.72. Tilapia can tolerate pH between the ranges 6.5-9. In this regard, Sagole meets the requirement for Tilapia. The other species given above cannot tolerant the pH above 8.7.

Hardness: Not all the fish species can survive well at Sagole (9.91mg/l), therefore, water hardness will have to be controlled to meet the preferred ranges for the selected species. The cat fish can tolerate water hardness as low as 20 mg/l (Tucker, 1991).

The *chloride level* at Sagole is 44, 09 mg/l. The preferred ranges of all four fish species are below the concentration level at Sagole while the chloride concentration can be tolerated by prawns. For the other species, the Cl concentration would have to be controlled.

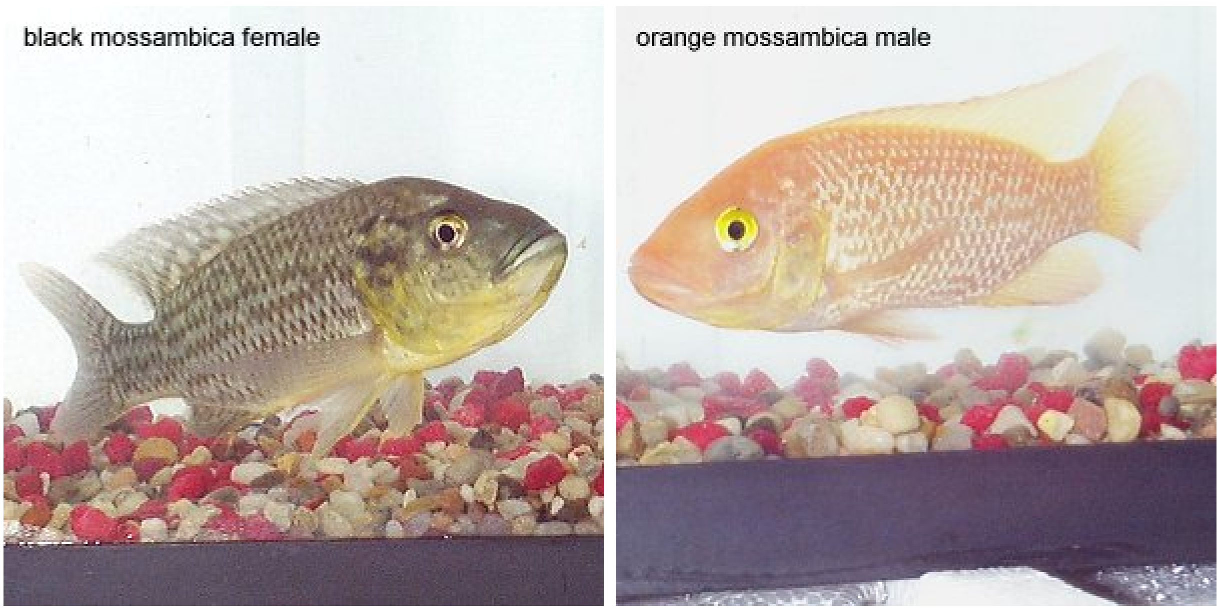
The *nitrite level* is 0 mg/l at Sagole, therefore all the fish species can grow well in the water.

Based on the information supplied in Table 6.1, prawns, Tilapia, carp and cat fish scored 4 compared to trout which scored 3. It therefore appears that prawns, Tilapia, carp and cat fish could be used for an aquaculture enterprise at Sagole.

However, since Tilapia's maturity period in ponds is the shortest (5-6 months) compared to prawns (9-12 months), carp (1-3years), cat fish (7-10 months) and trout (1-2 years), it might be economically advantageous to select Tilapia for this venture.

6.3.2 Tilapia and its production

There are three types of the Mozambique tilapia. These are the black, orange and red mossambicus. Figure 6.1 are pictures of tilapia (a) black mossambica (female) and (b) orange mossambica (male).



(a) (b)

Figure 6.1 Tilapia (a) Black (Oreochromis) mossambica female, (b) orange (Oreochromis) mossambica male.

Source: Mike Sipe in *Aquatext* (2011).

Tilapia belongs to a group of fish called cichlids (a perch-like freshwater fish of a large tropical family). They can be identified by an interrupted lateral line, which is a characteristic of the cichlid family of fishes. They are flat-sided and deep-bodied with long dorsal fins. The front portion of the dorsal fin is spiny while the rear is soft rayed. Spines can also be observed on the pelvic and anal fins (Nandlal and Pickering, 2004:2)

According to Gupta and Acosta (2004) Tilapia fish is native to Africa and the Middle East. However, according to Nandlal and Pickering (2004), Tilapia originated from the Nile Valley and spread to central and Western Africa. Its introduction to Asia and some Pacific Island countries started in the 1950s. Tilapia farming is currently expanding world-wide in both developing and developed countries. This is because the fish can be cultured under very basic conditions and as such its farming can be ideal for both rural subsistence farming and to more sophisticated, market-oriented commercial farming (Nandlal and Pickering, 2004:1). Tilapia farming requires minimal management and energy input. It is one of the most productive and internationally traded food fish in the world. Tilapia farming is the second most important farmed fish globally after carp, and is described as the most important aquaculture species of the 21st century (Sheldon (2002) in Gupta and Acosta (2004)). The fish is farmed in about 85 countries of the world and about 98% is produced outside their original habitats. Figure 6.2 illustrates the global aquaculture and capture production of Tilapia from 1950 to 2006.

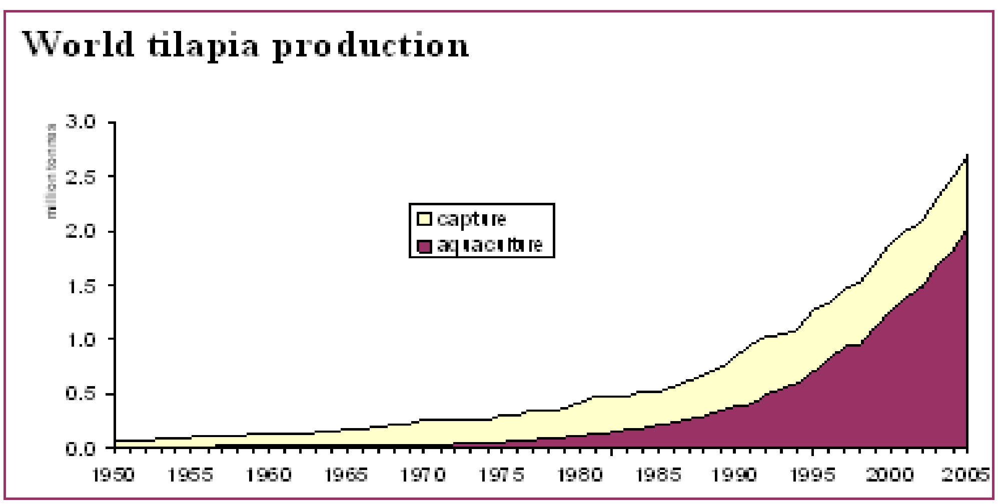


Figure 6.2 Aquaculture and capture production of tilapia by continent 1950-2006

Source: The FishSite (2011).

The graph in Figure 6.2 clearly shows that aquaculture is mainly responsible for the increase in production, while capture fisheries of tilapia stayed more or less stable over the years.

Table 6.2 gives the top ten cultured Tilapia producing countries or territories in the world from1970 to 2002 and the amount produced in tons.

Table 6.2 Top ten cultured tilapia producing countries/territories in the world, 1970-2002 (production in tons).

1970		1980		1990		1995		2000		2002	
Country	Production	Country	Production	Country	Production (	Country	Production	Country	Production	Country	Production
Taiwan POC	11 287	Taiwan POC	33 712	PR China	106 071	PR China	314 903	PR China	629 182	PR China	706 585
PR China	5 828	Indonesia	14 901	Philippines	76 142	Philippines	81 954	Egypt	157 425	Egypt	167 735
Egypt	2 500	Philippines	13 214	Indonesia	53 768	Thailand	76 383	Philippines	92 579	Philippines	122 390
Nigeria	2 129	PR China	9 000	Taiwan POC	52 047	Indonesia	74 125	Indonesia	85 179	Indonesia	109 768
Thailand	1 732	Egypt	9 000	Egypt	24 916	Taiwan	46 293	Thailand	82 581	Thailand	100 576
Philippines	1 417	Thailand	8 419	Thailand	22 895	Egypt	21 969	Taiwan POC	49 235	Taiwan	85 059
Israel	1 400	Mexico	6 907	Japan	5 825	Colombia	16 057	Brazil	32 459	Brazil	42 003
Indonesia	1 191	Nigeria	2 952	Mexico	5 000	Brazil	12 014	Colombia	22 870	Lao PDR	26 872
Hong Kong SAR	450	Israel	2 512	Israel	4 795	Malaysia	8 866	Lao PDR	18 928	Colombia	24 000
Mexico	200	Japan	2 392	Sri Lanka	4 500	U.S.A.	6 838	Malaysia	18 471	Malaysia	20 7

Source: FAO, 2002.

It is evident from Table 6.2 that Asia-Pacific countries are the main producers, with China taking a lead from 1990 to 2002. Production in the Far East is followed by the Caribbean, Latin America and by countries where thermal or geothermal water is available.

6.3.2.1 Characteristics of Tilapia and its requirements

Tilapia is an omnivorous freshwater fish. It is a tropical fish that needs warm water to survive. The optimal water temperature range for growth is 24-29°C. Water temperature below 20°C may cause a sharp decline in the growth rate. Characteristics that make it attractive for tank or pond culture include the following: It is a hardy fish, and can breed readily in almost any type of water body. Because it is omnivorous, it does not require a high percentage of protein in its diet compared to carnivorous species (Lapere, 2010). It can feed on a wide variety of foods such as phytoplankton, aquatic plants, small invertebrates, and benthic fauna (Nandlal and Pickering, 2004). Available agricultural farm products such as maize, sorghum, sweet potato, and soybeans can be used as feed. Tilapia can tolerate the high levels of crowding and handling required in recirculating aquaculture systems. It has a heavy slime coat that protects the body from abrasion and bacterial infection and is thus highly resistant to viral and bacteriological and fungal conditions. They can grow well even when stocked under high density conditions (Lapere, 2010:11).Under controlled open pond conditions, they can grow up to 1000g (Business Africa, 1997-2011).

Biological constraints to the development of commercial Tilapia farming include the following:

- They are unable to withstand continued exposure to low water temperatures. Activities and feeding are reduced below 20°C.
- They reach sexual maturity at an early stage in the life cycle of the fish, which leads to spawning before reaching the preferred market size.

- Fingerlings cannot tolerate salinity above 14ppt (Nandlal and Pickering, 2004; Lapere, 2010).

Water quality and quantity are important factors affecting the success of Tilapia aquaculture. Table 6.3 gives a guide to the recommended water quality ranges for Tilapia. Some of these parameters are discussed in Table 6.1.

Table 6.3 Guide to recommended water quality ranges for Tilapia.

Parameter	Unit	Tilapia
Temperature	°C	24-29
Oxygen	mg/l	4-6
Carbon dioxide	mg/l	40-50
Total suspended solids	mg/l	<80
Total ammonia nitrogen	mg/l	<3
Ammonia	mg/l	<0.6
Nitrite	mg/l	<1
Chloride	mg/l	>200

Source: Lapere, 2010 (as adapted from Timmons & Clark, 2009).

It is evident from Table 6.3 that tilapia can withstand relatively low concentrations of dissolved oxygen and carbon dioxide. Tilapia needs low levels of suspended solids (<80 TDS) and total ammonia nitrogen. Continuous monitoring of suspended solids and ammonia nitrogen in fish ponds is therefore recommended.

6.3.2.2 Production cycle in captivity

Figure 6.3 illustrates the production cycle of tilapia. The species of tilapia considered in this study is *Oreochromis mossambicus (O.mossambicus)*. It is not one of the fastest growing species of Tilapia, but due to the South African government's ban on the farming of alien species, farming with *O. mossambicus* is lawful (De Wet, 2010, in Lapere (2010:9).

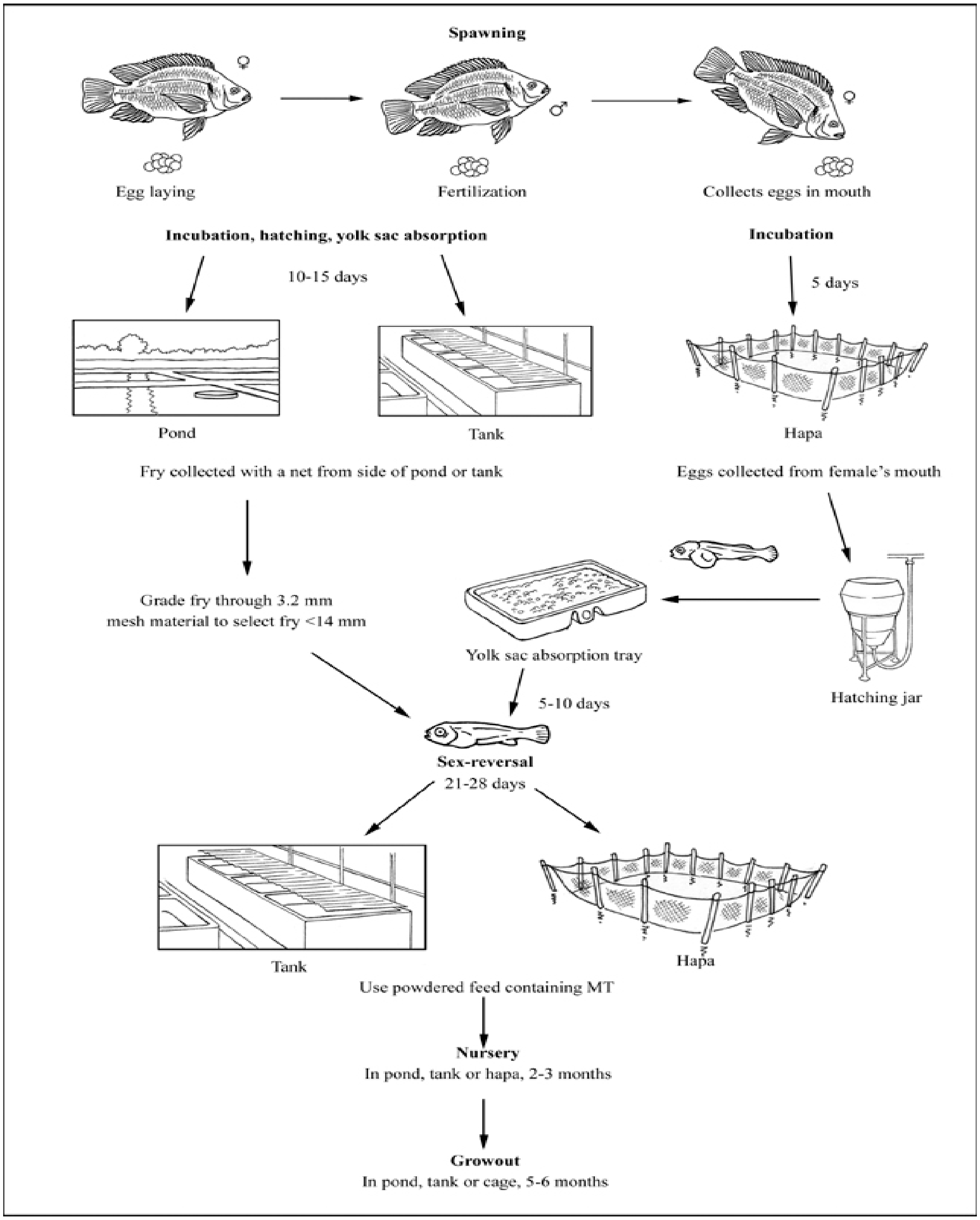


Figure 6.3 Production cycle of Tilapia

Source: FAO, 2002.

The production cycle illustrated in Figure 6.2 can be summarised as follows:

- The female lays the eggs on the bottom of the tank, where they are fertilised by the male.
- The female collects the eggs into her mouth and incubates them.
- The eggs hatch in the mouth of the female after 5 days (depending on the temperature) and the hatchlings remain in the mouth while they absorb their yolk sac. The egg-sac provides the hatchlings with nutrition during their early life.
- To better manage the breeding process, eggs are removed from the female's mouth before they hatch and are placed into the artificial incubator or hatching jar as shown in Figure 6.3
- After the eggs have hatched, the hatchlings swim to the top of the incubator and can be easily transferred into another breeding tank.
- When the hatchlings have absorbed their egg-sacs, they are called "fry". The fry are fed with a powdered mash at 40% of body weight until they reach fingerling size. When the fish has grown to a bigger size, resembling the length and shape of a human finger, it is called a fingerling.
- After 2-3 months, fingerlings can be transferred into the rearing or grow-out ponds (Nandlal and Pickering, 2004; Lapere, 2010).
- The eggs of a female are stimulated to develop once the previous batch of offspring are released, and thus after a period of recovery, the female returns to spawn within four weeks (Davis, 2011).

6.3.2.3 Tilapia farming in South Africa

According to Britz, Lee and Botes (2009) in Lapere (2010)) the market for tilapia in South Africa is almost non-existent. However, there are a few cases that show that the market is increasing. In 2008, for example, a pilot tilapia aquaculture farm was established in South Africa. It produced about 10 tons of tilapia valued at R300 000.

Some organisations in aquaculture have stopped producing because their operations were not financially viable. Regulatory problems in the country also contributed to the stoppage. At present, the government is encouraging small-scale farmers in the country. Free training is provided to new small-scale entrants into the aquaculture industry. For example, Madzivhandila Agricultural College is training aquaculture farmers in Limpopo (Mashapha, 2011).

Another challenge facing aquaculture in South Africa is temperature control. The growth rate is reduced when the temperature is above or below the optimum point (Boyd & Rafferty, 1998). Figure 6.4 illustrates the time taken to reach harvest size for a smaller range of temperature to get a better ideal time taken under a likely range of temperature. It takes about 9 months to harvest (O. Mossambicus) if water temperature is 30°C. Geothermal water can be mixed with cold water in breeding and rearing ponds at Sagole to create an optimal temperature for grow at no cost.

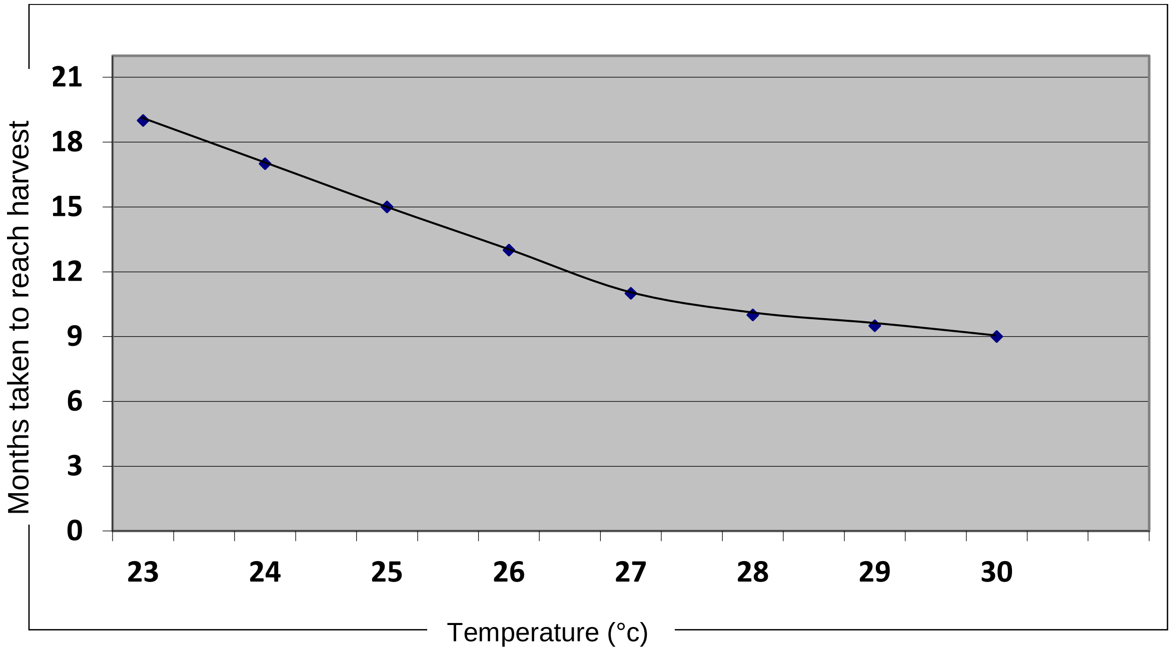


Figure 6.4 Months taken to reach harvest size at varying temperature level.

Source: Adapted from Timmons & Ebeling (2007) in Lapere (2010:95)

6.3.2.4 Ideal development ("near -ideal system")

Favourable characteristics of aquaculture systems that would cause them to maximise production can be identified and incorporated into the so called 'near-ideal system'. The main objective of the near-ideal system is to show which entities of the project should be maximised and which should be minimised. According to Lapere (2010:106), the following recommendations can help to accomplish this:

- "Capital costs should be minimised such that it comprises a smaller percentage of the cost of sales of the system.
- The system should make maximum use of cheap or available energy such as solar to replace electricity. In this regard, geothermal energy can be used to heat breeding and rearing ponds while solar energy can be used for aerators.
- Chicken manure can be used to fertilise rearing ponds.
- The system should be designed such that it is less sensitive to an increase in daily operating costs, to accommodate unforeseen costs.
- The effect of the economies of scale should be taken into account" (Lapere, 2010:106).

6.3.2.5 Designing the near- ideal system

Lazur & Britt (1997) indicate that a near-ideal system (illustrated in Fig. 6.5) should have the following components:

- Nursery and breeding tanks: The nursery encloses the breeding tanks, where fingerlings can be raised;
- Rearing ponds: Production or grow out ponds where fish are raised;
- Brood pond: Pond in which brooding fish are kept (male and female);

- Aerator: To increase oxygen concentration and water circulation in pond (shown by arrows). The water circulation forces solids to collect to a central drain of each pond (Lazur and Britt, 1997). It is also a water quality management tool.
- Drain (not shown in Figure 6.5): Each pond should have a central drain which collects solids and helps with harvesting fish stock and with cleaning of the bottom of the pond.
- Drainage outlet: Solids collected and water can be drained out through the drainage outlet. This is possible during harvesting fish stock or cleaning the bottom of the pond.
- The reservoir in which hot and cold water can be mixed is not reflected in the layout.

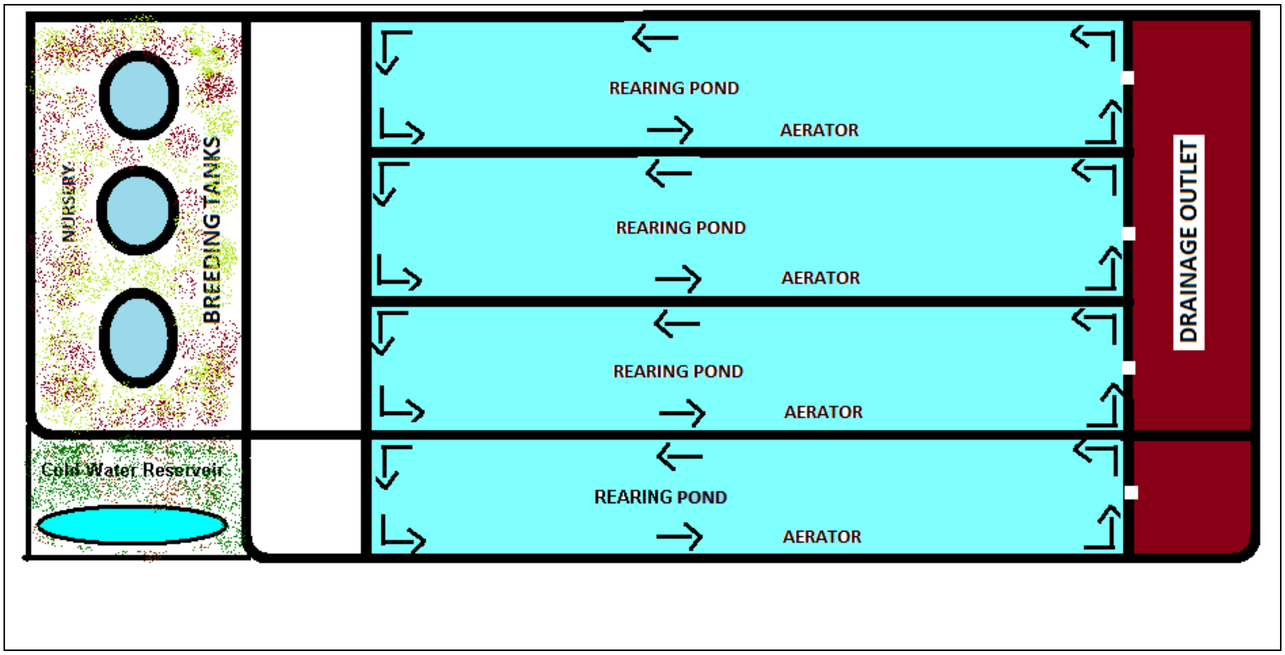


Figure 6.5 Layout of the proposed near-ideal system (adapted from Lazur & Britt, 1997).

Furthermore, the capital cost should be minimised. Based on studies conducted by Lapere (2010:106), the capital cost is limited between the following ranges: R100 000 and R250 000. It is based on the financial indicators for the profit-making case study in the Western Cape, South Africa (Lapere, 2010:125). Maximum productivity can be achieved by using low-cost materials with acceptable wear and tear rates, and personally overseeing the construction of the system instead of outsourcing it. Fish ponds are heated with geothermal water from the hot spring to save on electricity costs (Clutter, 2002:6). Water from the hot spring to the fish ponds will flow by gravity rather than by costly pumps.

To sum up, the near-ideal system would have the following characteristics:

Low cost construction; maximised productivity of the system; optimal water temperature using geothermal heat energy; substitute pellet feed with locally available agricultural farm products such as maize, sorghum, sweet potato, and soybeans as recommended by the Food and Agriculture Organisation of the United Nations (FAO,2002); tilapia (O. mossambicus) with strong genetics to be farmed; efficient electrical use (solar energy); guaranteed market for goods with potential price premium and best management practices (Lapere, 2010: 107-108).

6.4 SUITABILITY OF SAGOLE FOR TILAPIA PRODUCTION

This section discusses the suitability of Sagole for tilapia farming in terms of environmental, social and economic aspects. A development plan for the establishment of tilapia aquaculture is also discussed in this section.

6.4.1 Environmental factors

6.4.1.1 Climate

The climate of Sagole was discussed in Chapter 3. In summary, the area receives summer rainfall. The average annual rainfall is between 500-900mm. Relative humidity is 35% in winter and 50% in summer. The mean annual temperature ranges between 21-23°C. The mean monthly minimum temperature of the coldest months is 7,5°C, while the mean monthly maximum temperature of the hottest months is 40°C. Summer temperature is generally favourable for tilapia farming (21-23°C), but the mean temperature of the coldest months (7,5°C) is too low for growth. The use of geothermal energy in ponds and tanks can therefore raise the water temperature for optimum growth.

6.4.1.2 Physical and chemical characteristics of Sagole spring water

The suitability of Sagole's spring water was discussed in section 6.3.2.1. Sagole water meets the requirements for Tilapia production with respect to temperature, pH, etc. It has been mentioned in section mentioned above that **'**One of the greatest drawbacks of farming the species is its inability to withstand continued exposure to cold water temperatures. This makes the use of thermal spring water ideal for tilapia production**'.** However, the temperature of the spring water is 45°C, while Tilapia requires only 24-29°C. Sagoles water is thus too hot and will have to be cooled with the addition of cold water from the cold water reservoir.

6.4.1.3 Terrain features

The physical environment of Sagole was discussed in Chapters 3 and 4. Figure 6.6 shows the topography of Sagole by means of contour lines. It is evident from the map (the contours are far apart from each other) that the area is flat. This is an advantage as the construction costs can be less than on steeply-sloped areas. The suggested location of the tanks and ponds is indicated in Fig. 6.6. The area required for the project is about 3500 m^2. At present the proposed area is unused. The site is also suitable since it is at a lower elevation than the hot spring fountain. The level at which the tilapia production site would be located is lower than the level at which the hot spring is located, therefore water can flow by gravity to the fish ponds which saves costs on electricity by pumping.

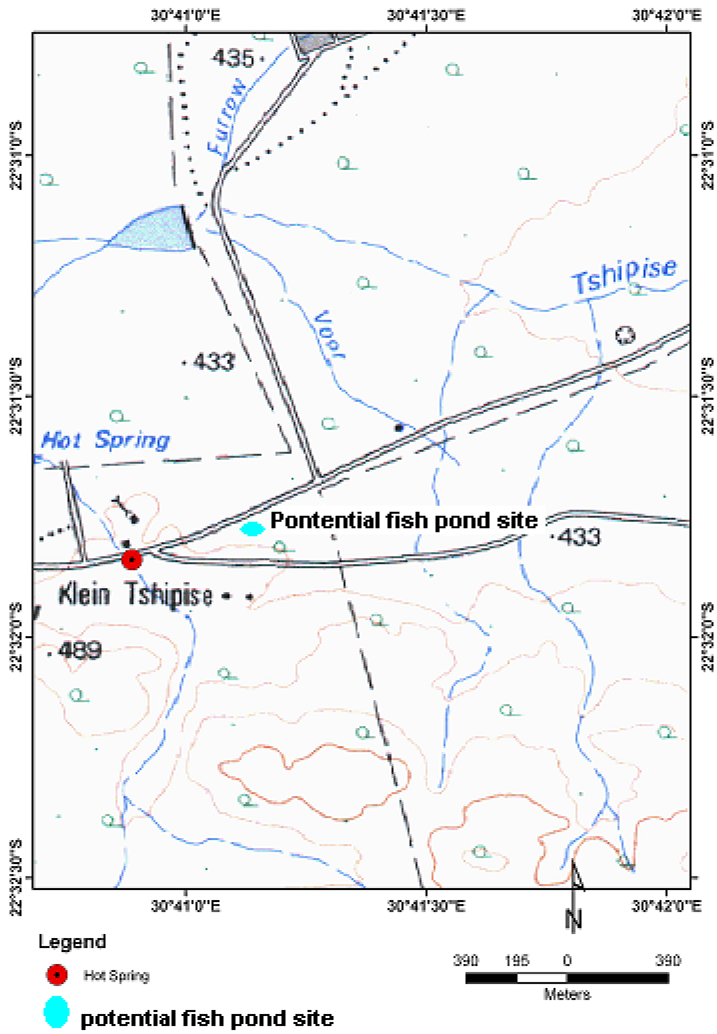


Figure 6.6 Topography, hot spring and potential location of fish ponds.

Source: Nyabeze P (2010)

6.4.2 Social factors

The following stakeholders need to be involved in the development of the aquaculture venture: the national and provincial government, the local municipality and the local community.

6.4.2.1 Willingness of stakeholders

In 2007, the Environmental Affairs and Tourism Minister Marthinus van Schalkwyk announced the South African government's plan to allocate R100 million into fish farming projects (*Cape Argus*, 2007). The announcement was welcomed by pressure groups representing traditional fishing communities. In Limpopo Province, the government has been training small-scale aquaculture farmers at Madzivhandila Agricultural College (Mashapha, 2011). The Mutale local municipality and Sagole tribal council are in favour of aquaculture projects as a way that can generate jobs for the local community. This was brought to light during the focus group interviews conducted at Sagole.

6.4.2.2 Skills requirements/human resources

The socio-economic characteristics of the local municipality were discussed in Chapter 3. Around 9 000 people are unemployed. The majority of those employed earn below R1600 per month. The results of the education and skills survey conducted in January 2011 at Sagole are as follows: 18% had primary education; 21% had secondary education: 44, 5% had further education and training; 48, 5% had received some computer literacy training and 32, 5% of the respondents were employed. Some people therefore need training in certain skills. For example, the results of the professional skills survey scored below 20%. Management and marketing scored (13%); administration and reception (14, 5%); finance scored the lowest (5,5%); plumbing (6%)

and fish farming skills scored only 7,5%. Management and administration skills are essential in all business projects of this nature. In this instance, some people need to be trained in the management, administration, and the operation of the aquaculture project. Some special skills such as finance can be imported from outside the village.

There is therefore a need for local people to be trained in tilapia farming. The following training is therefore essential: how to use brood ponds, nursery ponds or tanks, and rearing ponds; how to weigh, feed and handle fingerlings, how to use and manage the water supply and aeration systems.

6.4.3 Economic potential

6.4.3.1 Potential funding organisations

For the rural development project such as this, the Limpopo Economic Development Enterprise (LimDev) can be used to recommend and identify NGOs that can participate in the venture. Government/international funders for specifically rural development are potential funders. As discussed above, the South African government has already put R100 million aside for supporting fish farming projects.

6.4.3.2 Potential market for tilapia

According to Lapere (2010:20), the South African population is unfamiliar with the tilapia species. Therefore, a good marketing strategy should be developed at Sagole. An effective strategy could be to enter markets that are not in direct competition with large-scale aquaculture. Fortunately at present there is no large-scale tilapia farming in South Africa. The population of Mutale Local Municipality was given in Chapter 3. According to the 2001 National Census, the following population groups were given: Africans (78 456), Coloureds (29), Indians (16) and Whites (421), and the total population were 78 922. This local population makes a good potential market.

Local people and the fish and chips restaurants are potential clients for fish products. Sagole, Zwigodini and Mbodi villages have more than 1000 households who can access the site without additional transport cost. Nearby towns such Tshilamba, Thohoyandou, Musina and Makhado (Louis Trichardt) can benefit from the fish project at Sagole. The Kruger National Park and its visitors can buy fresh fish from Sagole. Contracts can be signed with potential buyers such as supermarkets and hotels. At present many supermarkets are importing Tilapia from Zimbwabwe and selling them at about R90/kg. The Vhembe District as a whole can benefit economically from the aquaculture venture. Figure 3.2 in Chapter 3 shows the location of Sagole Spa and the villages and towns mentioned above.

6.4.4 Development plan for an aquaculture enterprise at Sagole

This section discusses how the development plan for Sagole aquaculture can be organised. The development plan is in three phases: Phase 1: Preliminary activities, and Phase 2: Setting up of infrastructure and Phase 3: Operational phase.

6.4.4.1 Phase 1: Preliminary activities

Phase 1 will consists of the following activities:

- Hold meeting with all interested and affected stakeholders. Do Environmental Impact Assessment (EIA). Application for licence from the government (Water Affairs);
- Secure funding;

- Clear site for breeding tanks and rearing ponds;
- Buy materials for building ponds, tanks and nursery structure, water supply systems, water pipes, electrical equipment, and feed.
- Interview and employ staff. Employed staff will receive training before the project starts.

6.4.4.2 Phase 2: Setting up of infrastructure

- Erect tanks, construct the nursery structure, digging and building ponds;
- Install the water supply systems (aeration, drainage), water pipes, and electrical equipment;
- Tanks and ponds filled with water and water parameters checked;
- Fertilise the ponds.
- Conduct a bioassay. The bioassay was discussed in Chapter 2. It is used to determine whether the fish species can live and grow in the water;

6.4.4.3 Phase 3: Operational stage

- Feed, monitor and observe the introduced species and, if satisfied, introduce fingerlings for business;
- Monitor fish growth and diseases. Fully-grown fingerlings are transferred to rearing ponds;
- Management, administration and marketing continues;
- Harvest and distribute the market size tilapia (Fortes, 2000; Sandhyarani, 2010; McNamara, 2011).

6.5 POTENTIAL IMPACTS OF TILAPIA FARMING AT SAGOLE

If the near-ideal system is erected at Sagole, there can be certain environmental, social and economic impacts. This section discusses these potential impacts. According to the FAO (2008:15-21), the common environmental, social and economic impacts of aquaculture include the following:

6.5.1 Environmental impact

6.5.1.1 Impact on land and land-based habitats

Land is a valuable resource and, before aquaculture farms and the necessary infrastructure can be set up, land is essential. Setting up tanks, constructing the nursery structure, and digging and building fish ponds will change the natural condition of the environment from its original state. The fauna and flora on the terrain to be used for the enterprise can be destroyed. However, the vegetation and wildlife will be conserved for sustainability.

In order to supply aquatic protein aquaculture at Sagole can make use of land that is unsuitable for other agricultural activities.

The aquaculture production system and technologies can have a negative impact on the quality of land. For example, inappropriate use of chemicals could be toxic and render the land (soil and water) unsuitable for agriculture.

On land, aquaculture can compete with other activities such as agriculture, livestock farming, recreation, settlement and conservation. At the same time, the same activities can benefit from aquaculture. For example, aquaculture can be part of recreation and tourism. Tourists can be taken on a short excursion to facilities and process explained. The Prawn Park in New Zealand is an example of an aquaculture venture which includes recreation and tourism (Lund and Klein, 1995).

6.5.1.2 Impact on water

Injudicious use of aquaculture can have a negative impact on the supply and quality of water. For example, excessive use of underground water in Taiwan has caused a reduction of fresh water supply for agricultural, industrial and communal use. At Sagole hot spring water will be mixed with water from the fresh water reservoir. The fresh water reservoir is situated on top of the hill, and south-west of the hot spring. The fresh water in the reservoir is pumped from the ground. To avoid water shortage for the community, water recirculation system can be used in fish ponds. The use of trash fish (less desirable fish used as feed), shellfish, medicines, disinfectants, antiseptics and artificial feed can result in the degradation of water and sediment quality if discharged into the water.

6.5.1.3 Impact on wild fish stock

Aquaculture products can help reduce the pressure on fishing wild fish from Mutale River. In this way wild fish stock can be preserved. However, the use of wild fish for feeds in aquaculture can have a negative impact on wild fish stock and is discouraged. Fish escaping from the ponds into natural water bodies can negatively affect wild species stocks by spreading diseases, genetic contamination, and competition for food. This can happen during heavy flooding, but can be avoided by proper planning of rearing ponds.

6.5.1.4 Summary: environmental impact

Table 6.4 gives a summary of the environmental impacts discussed above. Both positive and negative impacts are scored according to the given scale (- 4 to + 4).

Table 6.4 Summary: Environmental Impact

Bad ←						**→ Good**			
Rating scale	-4	-3	-2	-1	0	+1	+2	+3	+4
Environmental Factors									
Climate : Air quality					✓				
Dust emitted during construction				✓					
Geology:									
Seismicity during construction				✓					
Soil erosion				✓					
Land degradation				✓					
Biological Resources									
Fauna and flora destruction									✓
Water Resources									
Surface water hydro					✓				
Underground water extraction (not at site)					✓				

Chemicals degrade water quality				✓					
Waste water can irrigate vegetables							✓		
Total score	**0**	**0**	**0**	**5**	**3**	**0**	**1**	**0**	**1**

6.5.2 Social impact

6.5.2.1 Impact on employment

Commercial aquaculture has the potential to provide jobs in farming activities (for example, chicken manure is needed in fertilizing fish ponds) and employment opportunities in aquaculture support businesses such as wholesalers, restaurants, and supermarkets (Strombom & Tweed, 1992). The local communities as well as people outside the area with special skills could benefit from the aquaculture venture at Sagole.

6.5.2.2 Impact on food supply

Aquaculture can provide much needed high quality protein and other essential nutrition to the poor rural communities such as Sagole. In 2004, 106 million tonnes of fish was produced globally (FAO, 2008:19. Of this production, 43% was produced by aquaculture. However, aquaculture's use of the land can deprive other agricultural activities of the land resources. This cannot happen at Sagole since the potential land to be used is not in competition with any other agricultural use.

6.5.2.3 Impact on food quality and safety

Aquaculture can enhance food quality by influencing the nutrition value, colour and appearance, smell and taste, texture and other characteristics of aquatic products under culture. This is possible by the type of feed used or by cross-breeding. Since aquaculture products are produced in a controlled environment, they are safe from contamination by hazardous chemicals compared to wild fish from rivers. On the other hand, the use of inappropriate feed in aquaculture can negatively affect the taste and nutrition of the product. It could also kill the fish.

6.5.2.4 Impact on food access

According to USAID (1995, in FAO (2008:20)), food access means "access by households and individuals to adequate resources to acquire appropriate foods for a nutritious diet". High production of fish in aquaculture can positively influence food access by lowering the prices, and making fish more affordable to the poor. Because it can generate money, it can positively affect food access by improving the buying power of households (FAO, 2008:20).

6.5.2.5 Impact on food stability

The stability of local food supply can be affected by natural disasters, diseases, and food price shocks nationally or internationally. Aquaculture can therefore increase the stability of domestic food supplies and increase the district's resistance to short-term disturbances that have negative impacts on food security. Commercial aquaculture can guarantee the incomes and employment of its workers and strengthen the resistance of their households against unexpected food insecurity.

6.5.2.6 Impact on human health

As already discussed above, aquaculture products have the potential to provide good quality protein and other nutrients that are essential to human health. By providing incomes, households can buy goods and services which they could otherwise not afford.

6.5.2.7 Impact on education and training

"Training provided by aquaculture farms and related businesses improves human capital" (FAO, 2008:21). Aquaculture gives its employees training, for example, on-the-job training is possible when they participate in regular workshops to learn about proper health and occupational practices (Karmokolias, 1997 in FAO, 2008:21).

6.5.2.8 Impact on population and demography

Unemployment in rural areas generally goes hand in hand with migration. People leave the rural areas to seek employment in urban areas. Commercial aquaculture at Sagole can reverse the situation by creating jobs and businesses related to aquaculture. In this way, the local workforce can be protected from the need to migrate elsewhere in order to survive economically. These employment opportunities can also attract scarce skills to the area and lead to the skilling of the local people.

6.5.2.9 Impact on water availability

Aquaculture can have a negative impact on water use. If water is used for aquaculture, then it won't be available for drinking or swimming. It is therefore important to monitor, and control water use for sustainability.

6.5.2.10 Impact on cultural aspects

At present, the water at Sagole is used for drinking, washing, bathing and irrigating vegetable gardens. The use of water for aquaculture will make water unavailable for other cultural activities. To avoid conflicts, all interested stakeholders should participate in decision-making related to such a venture.

6.5.2.11 Summary: Social impacts

Table 6.5 below gives a summary of the social impacts discussed above. Both positive and negative impacts are scored according to the given scale (-4 to +4).

Table 6.5 Summary: Social impact.

Bad ←						**→ Good**			
Rating scale	-4	-3	-2	-1	0	+1	+2	+3	+4
Social factors									
Employment									✓
Food supply								✓	
Food quality								✓	
Food access							✓		
Human health									✓
Education &training								✓	
Water availability		✓							
Total score		**1**	**0**	**0**	**0**	**0**	**1**	**3**	**2**

6.5.3 Economic impacts

6.5.3.1 Impact on other industries

Aquaculture has the potential to influence the development of other industries in its sphere of influence. Businesses such as fertilizer, and lime manufacturers, chicken farming (providing chicken manure for fertilizing ponds) can flourish near aquaculture farms. Food businesses can provide meat, rice, maize meal, vegetables and other items to the aquaculture farm workers. Although aquaculture can compete with agriculture and tourism for they utilize the same natural and environmental resources, it can also complement these activities.

6.5.3.2 Impact on income

Commercial aquaculture can generate income for its stakeholders such as the government, private companies or businesses, and the local community. Income is generated in the form of wages, interests, profits, tax revenue and the sale of value-added products from fish farming activities (FAO, 2008:18). On the other hand aquaculture can negatively affect the income of the industries with which it competes such as agriculture and tourism. As explained above, they compete for land and water resources. However, at Sagole, the potential land for aquaculture is unused.

6.5.3.3 Impact on infrastructure and other facilities

Aquaculture development especially in rural areas can help promote the expansion and improvement of roads, electricity supply, water supply, telephone lines and other communication and transportation infrastructure. This can be possible at Sagole since the aquaculture venture will need such support. The road infrastructure to Sagole is new, and the available electricity supplies, water supplies, telephone and communication and transportation infrastructure need to be improved.

6.5.3.4 Summary: Economic impact

Table 6.6 below gives a summary of economic impacts discussed above. Both positive and negative impacts are scored according to the given scale (-4 to +4).

Table 6.6 Summary: Economic impact.

Bad ←						→ Good			
Rating scale	-4	-3	-2	-1	0	+1	+2	+3	+4
Economic Factors									
Other industries								✓	
Income									✓
Infrastructure								✓	
Total scores	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**

6.6 FEASIBILITY OF THE AQUACULTURE VENTURE

In section 6.5, the total scores were calculated for the environmental, social and economic impacts. If any of these were negative, they would also have a negative influence on the feasibility of establishing an aquaculture enterprise. Thus by implication, if the environmental, social and economic impacts are positive, the establishment of the enterprise will be promoted.

6.6.1 Environmental, social and economic feasibility

In this section, the total weighted score and the mean score of each of the environmental, social and economic impacts are calculated.

Total weighted score =

The mean score = Total weighted score/N =

Where = Environmental, social and economic impact scores

Where = Number of weighted scores

N= Number of occurrences

6.6.1.1 Environmental feasibility

The scores in Tables 6.4, 6.5 and 6.6 reflect the discussion in section 6.5. They reflect the positive and negative impacts of environmental, social and economic aspects of aquaculture. Some factors used were obtained from the Geo-Heat Center (2008). The factor with the highest positive impact is scored +4 and the factor with the highest negative impact is scored -4. Most of the negative scores (climate, geology, biological resources) reflected in Table 6.4 are temporal. They will occur during the clearing of the field and the construction of the ponds and nursery structure. Underground water extraction will not take place at the centre. There is a fresh water reservoir for the community that will supply cold water to the fresh water reservoir at Sagole (Figure 6.5).

Since many of the impacts are temporary the project can be environmentally feasible as shown by the scores in Table 6.7. Table 6.7 gives the environmental feasibility rating for aquaculture. The mean score is also calculated below.

Table 6.7 Environmental feasibility rating for aquaculture (from Table 6.4)

Rating

Rating scale	-4	-3	-2	-1	0	+1	+2	+3	+4		
Total score (from table 6.4)	0	0	0	5	3	0	1	0	1		
Total weighted score	0	0	0	-5	0	0	+2	0	+4	=	+1

Total weighted score = 1

N = 10

Mean Score = 1/10 =+ 0.1

The overall mean value indicates that the aquaculture operation has a low positive environmental feasibility rating (+0.1). Conservation of the environment is essential to make the project sustainable.

6.6.1.2 Social feasibility

Table 6.5 scores factors related to the social impacts of the project at Sagole. Almost all the social factors are positive except water availability which has a negative score. This is because water used for aquaculture would not be available for drinking or swimming. The project can therefore be feasible in terms of social factors as reflected by scores in Table 6.8. Table 6.8 gives the social feasibility rating for aquaculture. The mean score is also calculated below.

Table 6.8 Social feasibility rating for aquaculture (Total social scores from Table 6.5)

Rating

Rating scale	-4	-3	-2	-1	0	+1	+2	+3	+4		
Total score		1	0	0	0	0	1	3	2		
Total weighted score		-3	0	0	0	0	+2	+9	+8	=	+16

Total weighted score = +16

N = 7

Mean score = +16/7 = 2.3

The overall mean value indicates that the establishment of aquaculture at Sagole has a positive social feasibility rating (+2.3). While there may be some negative impacts, an aquaculture enterprise at Sagole will be socially feasible. There are more positive impacts than negative ones.

6.6.1.3 Economic feasibility

Table 6.6 scores factors related to the economic impacts of the project at Sagole. All the three economic factors have positive impacts. As mentioned in the previous section, some industries can benefit from aquaculture. New jobs can be created and new infrastructure can be erected. The project can therefore be feasible as shown in the scores provided in Table 6.6 in terms of other industries, income and infrastructure. Table 6.9 gives the economic feasibility rating for aquaculture at Sagole. The mean score is also calculated below.

Table 6.9 Economic feasibility rating for aquaculture (from Table 6.6)

Rating

Rating scale	-4	-3	-2	-1	0	+1	+2	+3	+4		
Total scores	0	0	0	0	0	0	0	2	1		
Total weighted score	0	0	0	0	0	0	0	+6	+4	=	+10

Total weighted score = +10

N = 3

Mean score = +10/3= +3,3

The overall mean value indicates that the development of aquaculture at Sagole has a high positive economic feasibility rating (+3.3). There are only positive economic impacts for aquaculture enterprise at Sagole. Therefore, the establishment of the enterprise will be economically feasible.

In terms of these three factors, it appears that the establishment of aquaculture at Sagole is environmentally feasible. (Minor negative impact can occur during the construction period on the environment). The enterprise is highly feasible in terms of social and economical aspects.

6.6.2 Cost-benefit analysis

Cost benefit analysis is a technique used by decision-makers to compare the various costs associated with an investment or project with the potential benefits that it proposes to return. A project should be undertaken if expected benefits exceed costs

(Department of Environmental Affairs and Tourism (DEAT), 2004:4). Recommended procedures to determine the feasibility of an aquaculture project includes the calculation of the growth projection of the fish species, and the system requirements; calculation of the capital and operational costs of the system; project the sales and calculate whether the project will be financially viable (Lapere, 2010:70). The values used in Appendix 4 were obtained from aquaculture experts in the USA, extension farmers in Limpopo, Madzivhandila Agricultural College, University of Limpopo, and from the literature study.

Appendix 4 gives the fixed costs, human resource and variable costs and financial benefits for selling 10 000 fish for the first year harvest x R80 per fish (low price estimate as current price is R88/kg). No profit will be made during the first year. However during the second and third year three harvests could be made per annum. Three harvest per year (R800 000 x 3 = R2 4 000 000) can make a profit of about 1,4 million. Fixed costs were not considered in this calculation. The assumption is that the national government will provide the budget as explained in section 6.4.2.1.Summary of costs for aquaculture project are shown in Table 6.10

Table 6.10 Summary of aquaculture costs.

Costs	R
Fixed cost	820 000
Variable cost	70 000
Humana Resource (labour)	900 000
Total	1 790 000 (about 2million)

6.6.3 Business analysis for Sagole aquaculture farming

The information on the characteristics of SWOT analysis was obtained from EconSearch (2002). The information obtained includes examples of strengths, weaknesses, opportunities and threats for starting an aquaculture project at Sagole.

Table 6.11 therefore gives a summary of the SWOT analysis for business potential for Sagole. A SWOT analysis is an effective way of identifying strengths, weaknesses, opportunities and threats facing a project (Wikianswers, 2011). The difference between strengths and opportunities, weaknesses and threats are explained in Chapter 5.

Table 6.11 Business analysis for Sagole aquaculture

Strengths	**Weaknesses**
• Geothermal water (heat) available • Production throughout the year • High water quality • Good access to product site	• Local community's lack of experience in the business • Budget constraints • Management and administration staff will need training • Lack of basic facilities • Water recirculation system expensive
Opportunities	**Threats**
• Tourist market available, e.g. Kruger National Park • No competitor in geothermal aquaculture in South Africa • Producing and selling Tilapia to the inland shops • Rising demand for fish (white meat) which is good for health • Fish price cheaper compared to meat • Education and training already exist at Madzivhandila Agricultural College	• Lease/ licence approval by government • Fish sold in streets from Nandoni Dam (70km from Sagole) • Competition from shops such as Shoprite, Spar and Pick 'n' Pay selling frozen fish

A brief discussion on SWOT analysis follows:

Strengths

The availability of high quality geothermal water will save costs on energy and water treatment. Geothermal energy will make it possible to produce aquaculture products throughout the year. The hot spring with temperature measuring about 45°C will make it possible to control breeding and rearing ponds temperatures at optimum level for tilapia during winter and summer months. Currently there is no competitor in geothermal aquaculture in Limpopo. Therefore Sagole will be the first project in the area. The area around Sagole Spa is generally flat, so there can be easy access to the production site.

Weaknesses

The aquaculture venture can be a new business in the area. Lack of experience in the type of business at Sagole may need to draw upon skills outside the area. Buying and installing the basic equipment mentioned in Table 6.7 can be costly. Funding for the project needs to be secured.

Opportunities

There are many opportunities for the project which include the tourist market as the venture is near the Kruger National Park and selling tilapia to the inland retailers, such as large food retail stores. Aquaculture education and training is readily available at Madzivhandila College of Agriculture.

Threats

Identified threats can be minimized by education and training, community involvement, doing an environmental impact assessment, and continuous monitoring of the resource use. Since this is a new venture, it may be difficult to obtain the necessary funding, but the government's promotion of aquaculture in South Africa can be a motivating factor. Competition from retail shops can be overcome by introducing lower prices. Current prices of Tilapia that are imported from Zimbabwe are around R80/kg. Lowering prices from R80/kg to R50/kg can put Sagole in a favourable position.

6.7 SYNTHESIS

This chapter discusses aquaculture and its importance, types of aquaculture and the selection of an appropriate crop for Sagole. The characteristics of tilapia, its requirements, production cycle, and the near-ideal development system are explored. The suitability of tilapia production for Sagole is dealt with in terms of environmental, social and economic aspects. It further examined the potential impacts of tilapia farming, feasibility and sustainability, and business potential (by SWOT analysis) at Sagole.

CHAPTER SEVEN

EDUCATIONAL CENTRE

7.1 INTRODUCTION

Chapter 1 alluded to the variety of uses for geothermal springs, and the use of a site with a geothermal spring as a setting for an educational centre was also mentioned. This chapter will focus on the potential of Sagole's for use as a natural resource-based educational centre.

This chapter follows the same basic pattern as the previous two chapters in that it commences with a discussion of the importance of resource-based educational centres in South Africa, the requirements of such a centre and the extent to which Sagole meets these requirements. In this chapter, the near-ideal development model for a natural resource-based educational centre is discussed for the different market segments, namely, primary and secondary schools, tertiary education and as an information centre for tourists. This is followed by discussions of the suitability of such a project for Sagole and its potential impacts. After this, the feasibility and sustainability of a geothermal education centre at Sagole were explored. The chapter concludes by providing a cost-benefit analysis and a SWOT analysis for Sagole.

7.2 NEED FOR EDUCATION: AN OVERVIEW

Education is an important ingredient for the development of any society (Articlebase, 2008). It improves social status, mental state, knowledge, skills and the ability to face practical life situations. It is the weapon that one can use to destroy ignorance and fight unawareness. It is widely regarded as “the route to economic prosperity, the key to scientific and technological advancement, the means to combat unemployment, the foundations of social equity, and the spread of political socialization and cultural vitality” (Chimombo, 2005:129) In South Africa, the quality of education in rural areas is generally poor (Medupe, 1999). A number of the problems in education stem from the discrepancy between educational quality in urban areas and in rural areas. Specific problems commonly found in rural areas include overcrowding, poor school infrastructure, high student teacher ratio, and lack of educational materials (Room to Read, 2011).

7.2.1 The need for science education

The importance of science and technology is overwhelming in the world. According to the Guyana Chronicle (2009) the application of science and technology has the potential to transform the world through advances in all fields of study. Many countries are being transformed from poor feudal types of economy through the application of science and technology. There is a positive correlation between science and technology and economic and industrial development (Guyana Chronicle, 2009). According to Yager and Yager (2002) science and technology education are central to living, working, leisure, international competitiveness and resolution of personal and societal problems. By teaching and learning the interdependency of all living things upon each other and on the physical environment, science fosters a respect for nature that informs decisions on the wise use of technology (American Association for the Advancement of Science, 1990:1). It can therefore be concluded that science education is not an option but an imperative to human development. A ‘science education centre’ specialises in creating environments conducive for active learning. These include scientific activities, hands-on workshops, teacher training programmes, multimedia development and laboratory experiments (Science Education Centre, 2009). The centre explores the objectives of science teaching and learning carefully in order to identify optimal activities and experiences from all modes of instructions that will best facilitate the identified objectives (Hofstein & Luneta, 2003).

7.2.2 Science education in South Africa

The situation of education in South Africa, especially in science education, is exacerbated by the old Apartheid policies under which Black learners were actively disempowered in science subjects (Medupe, 1999). Under Apartheid's divisive education system, Black schools were so under-funded many of them could not afford the necessary equipment or laboratories for teaching science. In many cases, under-qualified teachers were expected to teach and motivate learners. According to Medupe (1999:64), science was not accessible to learners; for example, the country's heritage and resources were not used to make science education accessible to African learners. According to Kahn and Rollnick (1993:266), the system of Black education is in total chaos. The following problems were identified: high enrolment, unqualified teachers, scandals connected to the supply of textbooks, corruption, political disturbance, underprepared science teachers, indiscipline and rote learning (Kahn and Rollnick ,1993).

7.2.3 Improving science education in South Africa

According to Muwanga-Zake (2001) the South African government has committed itself to improve the quality of science education in South Africa. This is demonstrated by the creation of the Ministry of Science, Technology and Culture which declared 1998 and 2000 as years of Science and Technology. Other efforts include the following:

- Prioritising research in science, by the National Research Foundation (NRF);

- Increasing the focus on science by the Universities of Venda and the North in Limpopo, and of Cape Town and Fort Hare;
- Further Diploma in Education in Science Education (FDE), now the Advanced Certificate of Education (ACE) for retraining science teachers;
- The Department of Education (DoE) commissions to improve science education;
- Scholarships for science teachers, for example by ESCOM;
- Manufacture of science teaching equipment, for example, Somerset Educational;
- Media interventions such as the SABC Education and Liberty Life programmes on science;
- Creation of NGOs such as Centre for the Advancement of Science and Mathematics Education (CASME) and All Saints (Roman Catholic Church science initiatives) specifically for science education;
- Outreach programmes by ZENNEX and ABSA to equip schools with Somerset micro science kits;
- Science centres such as the Interactive Science Centre in Cape Town, Vuwani in Limpopo (attached to the University of Venda), Marang Centre at Wits University, UniZul Science Centre (University of Zululand), and the Potchefstroom Science Centre attached to the North-West University (SouthAfrica Info, 2011).
- Science centres that are not linked to the universities include the following: Boitjorisong Science Education Resource Centre (Sasolburg, Free State); Bokamoso Science and Technology Education Centre (Bochum, Limpopo); Boyden Science Centre (Bloemfontein, Free State); Escom Expo for Young Scientists (Boksburg, Gauteng); FOSST Science Centre (Alice, Eastern Cape); Hermanus Magnetic Observatory Science Centre (Hermanus, Western Cape); Mittal Science Centre (Sebokeng, Gauteng); Mittal Science Centre (Saldanah Bay (Western Cape); Mondi Science Centre (Piet Retief, Mpumalanga); MTN Science Centre (Cape Town, Western Cape); National Science and Technology Forum (Pretoria, Gauteng); Old Mutual Science Centre (Umhlanga, Kwazulu-Natal); Osizweni Education and Development Centre (Secunda, Mpumalanga); Sci-Bono Discovery (Johannesburg, Gauteng); Sci-Enza Science Centre

(Pretoria, Gauteng); South African Agency for Science and Technology Advancement (Johannesburg, Gauteng) and South African Agency for Science and Technology Advancement (Pretoria, Gauteng) (Department of Science and Technology, 2011).

- Research conferences on science education such as the South African Association for Research in Science and Mathematics Education (SAARMSE); and
- The SYSTEM initiative by the DoE aimed at increasing the number of scientists.

Many of the science centres are established in urban areas while few are found in rural areas. There is therefore a need for more science centres in rural areas.

Despite the interventions mentioned above, Muwanga-Zake (2001:2) says “science education appears to be experiencing problems that could lead to a crisis”. The situation is worse in rural areas compared to urban areas. Table 7.1 gives the 2010 grade 12 results for Mathematics and Physical Science subjects in Limpopo Province with specific reference to Niani Circuit in the Vhembe District. The Table reflects students’ achievements in nine secondary schools. In Mathematics 44,7% of students achieved the requirements but at low level, while 55,3% failed to meet the minimum requirements (Table 7.1a). The highest failure rate is at Dyelamananga where 83,3% of the learners did not pass mathematics. The same school obtained the highest failure rate in Physical Science at 100% (Table 7.1b). An intervention by the establishment of a science education centre can improve the situation reflected in these two tables (Limpopo Provincial Department, 2011).

Table 7.1a Achievement in Mathematics

School	No. Wrote	No. Achieved	%	No. Not Achieved	%
Dzimauli	5	2	40	3	60
Dyelamanavha	6	1	16.7	5	83.3
Fhetani	11	2	18.2	9	81.8
Hanyani	14	6	42.9	8	57.1
Lwaphungu	19	11	57.9	8	42.1
Niani	20	9	45	11	55
Ratshibvumo	3	2	66.7	1	33.3
Ratshisase	23	16	69.6	7	30.4
Tshikundamalema	22	6	27.3	16	72.7
Totals	123	55	44.7	68	55.3

Table 7.1b Achievement in Physical Science

School	No. Wrote	No. Achieved	%	No. Not Achieved	%
Dzimauli	0	0	0	0	0
Dyelamanavha	1	0	0	1	100
Fhetani	8	7	87.5	1	12.5
Hanyani	12	6	50	6	50
Lwaphungu	16	6	37.5	10	62.5
Niani	17	2	11.8	15	88.2
Ratshibvumo	3	2	66.7	1	33.3
Ratshisase	15	12	80	3	20
Tshikundamalema	6	6	100	0	0
Totals	78	41	52.6	37	47.4

Source: Limpopo Provincial Government (2011)

7.3 RESOURCE-BASED EDUCATION

According to Campbell, Flageolle, Griffith and Wojcik (2002), resource-based learning is an educational model designed to actively engage students with multiple learning resources. Well planned authentic tasks around the available resources give students opportunities to develop the skills and techniques necessary to become autonomous, self-directed learners and effective users of information. It provides learners with a more interactive environment which allows them to collaborate with peers, teachers, facilitators and the community to find answers from varied information resources. Benefits of resource-based learning include the following:

- Learners have the opportunities to interact with resources that address their individual learning needs;
- Learners are provided with opportunities to acquire critical and creative thinking skills and apply them in new situations;
- Learners have an increased motivation for learning when they are engaged in resource-based learning activities.

Overseas geothermal resources (hot springs) are utilised to teach science only at tertiary level. They give students opportunities to have hands-on experience of applied science such as engineering. There are many thermal springs in South Africa used for recreation and tourism. The use of geothermal resources to teach science in South Africa is overlooked. Resource-based (geothermal) science education can help learners gain insights when they use visualisation to link situations (Resnick, 2007). The next section discusses the geothermal education centres and their characteristics. The section elaborates on the establishment of a geothermal science education centre at Sagole, its development, potential impacts, suitability and feasibility at Sagole, and discusses the cost-benefit analysis.

7.4 GEOTHERMAL EDUCATION CENTRE: AN OVERVIEW

7.4.1 Explanation of the concepts ‘geothermal’ and ‘geothermal education centre’

“Geothermal” comes from the Greek words “geo” (earth) and “therme” (heat), so, geothermal means earth heat (Geothermal Education Office, 2000). Figure 7.1 below illustrates the source of earth heat by means of the cross-section through the earth’s interior

A geothermal education centre is a type of resource-based education centre. It comprises all the characteristics of resource-based education as explained above. The unique difference is that a geothermal education centre uses a geothermal resource such as a hot spring for teaching and learning science. Resource-based teaching and learning activities are designed to engage learners actively with multiple learning resources. In this section, the concept of a geothermal science education centre will be used to denote a resource-based geothermal science education centre (GSEC).

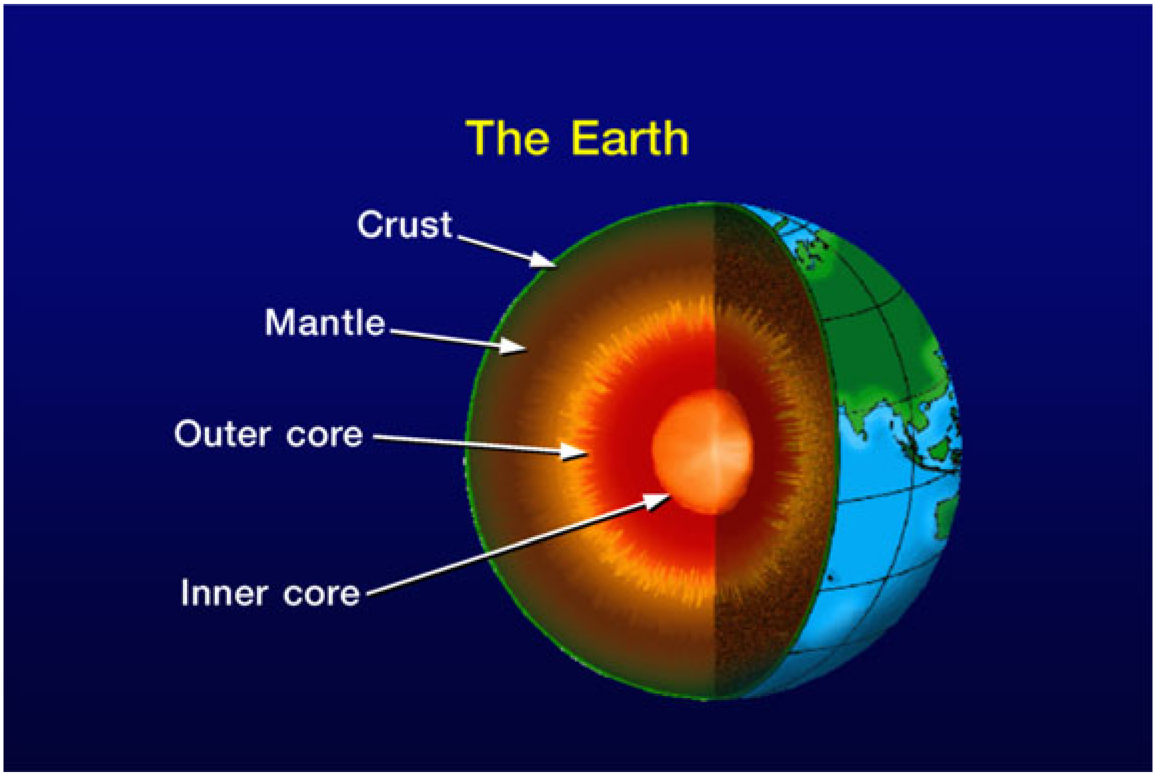


Figure 7.1 A cross-section of the earth's interior.

Source: Geothermal Education Office (2000).

7.4.2 Characteristics of a Geothermal Science Education Centre (GSEC)

Generally, geothermal science education centres include, but are not limited, to the following: scientific experiments, research and development, use of computer technology, presentation of scientific topics, demonstration of concepts, group discussions, teaching and facilitation of workshops, professional development of teachers and provision of a variety of teaching and learning resources (Lund: 2009; ANOVA Science Education, 2010-2012; Homi Bhabha Centre for Science Education, 2011; Science Learning Centres, 2011). For a resource-based (geothermal science education) centre, active geothermal areas have to exist where hot water can move naturally from the ground to the surface (Jonsdottir, 2010:1).

7.4.3 Geothermal Science Education Centre (GSEC) in South Africa

At present there are no geothermal science education centres in South Africa. Many science education centres in South Africa are not resource-based. Some of them are linked to tertiary education institutions and others are independent, so a gap exists for the establishment of such a centre.

7.4.4 Ideal development of a Geothermal Science Education Centre

Chapters 5 and 6 discussed the characteristics of the near-deal development model. This section discusses the near-ideal model specifically for a geothermal science education centre. Recommendations for such a model are as follows:

- The accommodation facilities should include: lecture halls, discussion rooms, a laboratory, science library, computer centre, research facilities, multimedia facilities and equipment;
- The infrastructure should include: administration offices, restaurant, kitchen, sleeping accommodation, ablution facilities and parking;
- Human resources should include: management, administration, teaching and technical staff;
- Primary and secondary school programmes that engage, enthuse, and educate learners and teachers about science and its application;
- Provision of innovative and engaging science activities;
- Run excellent hands-on science classes and workshops for learners and teachers;
- Programmes should cover a wide range of fields of study which include: Biology, Microbiology, Geology, Geography, Physical Science, Chemistry, Biodiversity, Ecosystem, Meteorology and many more;

- The environment should be protected, and all polluting activities should be minimized (CSIRO Education, 2011).

7.4.5 Designing the near-ideal model of a GSEC

The potential layout of the near-ideal geothermal science education centre (GSEC) is illustrated below. It is based on the near-ideal model discussed in Chapter 6 (Lapere, 2010). The model is designed to cater for the following potential market segments: primary and secondary learners and teachers, researchers from tertiary institutions and visiting international geothermal experts, and the general public or tourists. Primary and secondary school learners, together with their teachers can visit the centre and spend a day or days in the centre. They can be engaged in teaching and learning activities that can improve their understanding of the sciences. They need accommodation, access to a library and a laboratory, and food during their stay. Researchers from tertiary institutions and geothermal international experts also need access to a library and a laboratory, a restaurant, presentation hall and discussion rooms. They can be accommodated outside the centre (there are comfortable chalets at Sagole). The general public or tourists need presentation halls, discussion rooms, a restaurant and tour guides in the centre. The near-ideal model was designed to cater to the above-mentioned market segments. Figure 7.2 is an illustration of the near-ideal model.

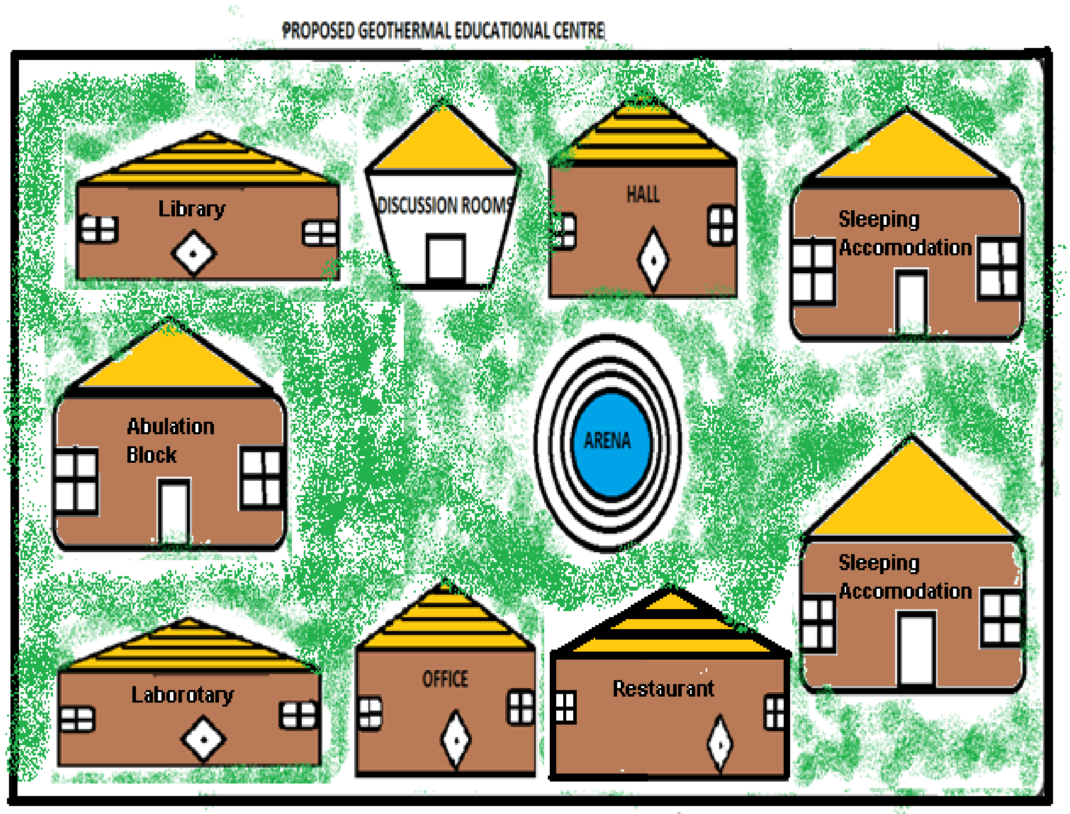


Figure 7.2 Layout of the proposed near-ideal GSEC model.

Basic facilities to be found in the near-ideal model include the following: laboratory, library, presentation hall, discussion rooms, computer centre, accommodation for visitors, offices, restaurant, kitchen, ablution block and parking area.

7.5 SUITABILITY OF SAGOLE AS A SITE FOR A GSEC

7.5.1 Environmental factors

7.5.1.1 Climate

The climate of Sagole is mainly characterised by low summer rainfall and dry, frost-free winters. Individual and group transport visiting the centre will rarely be interrupted by heavy rains or frost. Thermal water at the hot spring cannot be diluted by prolonged heavy rain, therefore the climate is good for individual and group visits throughout the year.

7. 5.1.2 Physical characteristics of the area around the spring

The general physical environment of Sagole is discussed in the previous chapters. This section discusses the potential of the site for a geothermal education centre. The area around the stream is fenced, and the source of the hot spring is covered by natural indigenous trees. The trees provide shade to the spring which reduces the evaporation rate and can provide shelter from the severe heat of summer common to this area for visiting schoolchildren.

The chemical characteristics of the water at Sagole are different from normal water and hence make the centre an interesting place to do research. In Chapter 3, the geology, morphology, land cover, vegetation and hydrology of the area was described. Experiments and other learning activities related to these topics can be included as part of the holistic research. The area provides good learning environments for teaching and learning biology, microbiology, geography, ecology, geosciences, environmental science, geothermal energy and many more. School children can visualise, touch, smell and experience science in this area. Schoolchildren and tourists can also learn how the indigenous knowledge system is used to conserve the ecosystem. For example, the fountain of the spring is a sacred area and a centre of worship for one of the local community's families. Boreholes near the spring are not allowed. Reptiles found near the spring may not be killed.

7.5.1.3 The terrain features

The flat land shown in Figure 5.2 is ideal for easy movement whether for walks or drives. Staff or visitors living with disabilities can also move about or be transported around the area with ease. Likewise, the carrying of scientific measuring equipment for outdoor learning activities can be conducted with ease at the site. Visiting individuals and groups can enjoy walks on the even terrain at Sagole. These features add to the suitability of Sagole as a location for a GSEC.

7.5.2 Social factors

7.5.2.1 Willingness of local stakeholders

The stakeholders at Sagole, which include the Mutale Local Municipality, the Tshikundamalema Tribal Council, the Civic Association, the local farmers, the women and youths of the community. The local community are delighted by the possibility of this proposed project.

7.5.2.2 Skills requirements/ human resources

The nature of a geothermal education centre requires high professional scientific knowledge and skills in order to be sustainable. There is a need for science educators (Biology, Microbiology, Geology, Hydrology, Geography, Environmental Science, etc.), for lecturers, researchers, trained facilitators, management and working staff. The education and skills survey conducted in the area revealed a lack of scientific knowledge and skills, so there is a need for science skills to be imported from other areas in the Limpopo Province or for training to be provided in the centre.

7.5.3 Economic potential

7.5.3.1 Potential funding organisation

The Department of Science and Technology in collaboration with institutions such as the National Research Foundation, Science in Africa, the Shuttleworth Foundation and other organisations mentioned in section 7.2.3 are potential sources of funding for the geothermal education centre (Shuttleworth Foundation, 2009; Department of Science and Technology (DST) (2011;). The World Bank and the United Nations University also offer funding for science-related projects. The following African countries have benefitted from the United Nations University funding: Algeria, Burundi, Egypt, Ethiopia, Kenya, Rwanda, Tanzania, Tunisia, Uganda, and Zambia (Mwangi, 2003; Fridleifsson, 2010; Georgsson, 2010; World Bank, 2011).

7.5.3.2 Potential market

Sagole is located within the Vhembe district. There are three circuit offices that can benefit from the establishment of the Geothermal Science Education Centre. The first circuit to benefit is Niani. It is located around 500 metres from Sagole Spa. It serves primary and secondary schools within a 50km radius. There are 36 primary schools and 9 secondary schools. The second circuit office that would benefit is Tshilamba. There are 30 primary schools, 4 combined schools and 10 secondary schools. The schools are around 70km from Sagole. There are 39 schools in the Sibasa Circuit, and of these, 26 are primary schools, 2 are combined schools and 11 are secondary schools. They are found around 70-90 km from Sagole (Department of Education, 2009)

Generally, the rural schools in the area are not performing well in the sciences as shown in Table 7. Researchers from higher education institutions are a further potential market. The University of South Africa, the University of Pretoria and the University of Venda have already started doing research at Sagole. The general public are likely to be interested in scientific, yet accessible, explanations about the origin of hot springs, learning more about the indigenous perception of hot springs and the educational value of a visit to Sagole.

7.5.3.3 Available infrastructure

The following facilities are available at Sagole (Mphephu Youth Centre) and are under-utilised at present. Niani Circuit office is currently using some of the office space while waiting to relocate to their new office which is under construction.

- Accommodation: There are five dormitories that can accommodate 80 learners and 10 bedrooms that can accommodate 10 teachers without sharing.
- Hall: A large hall that can accommodate 80 people.
- Discussion rooms: There are eight group discussion rooms.
- Administration offices: There are five administration offices.
- One well-equipped kitchen.

Arena: The arena is situated in the centre of the infrastructure with a geothermal pool. The following infrastructure needs to be made available:

- There is a need for a laboratory and library building. Two separate buildings are recommended since laboratories have a high risk of fire or explosion.
- Ablution and toilet facilities. Current ablution and toilet facilities need to be upgraded.

The above-mentioned infrastructure makes Sagole a suitable place for the Geothermal Science Education Centre.

7.6 DEVELOPMENT PLAN FOR GSEC

7.6.1 Development options

There are two options available for the development of a geothermal education centre at Sagole Spa. The first option is to develop the centre at Mphephu Youth Centre (the near-ideal option). The advantages of using the facilities at Mphephu Youth Centre are the following:

- Availability of the infrastructure mentioned in section 7.5.3.3 that is currently underutilized. The cost of renovating the facilities would be minimal.
- There is a borehole that produces hot water at the same temperature as the hot spring water at Sagole Spa. The borehole can be used to monitor the water table.
- Proximity: The Mphephu Youth Centre is located just east of Sagole Spa, and the two centres are adjoining and are separated only by a fence. Figure 7.3 below shows part of the Mphephu Youth Centre.

Figure 7.3 Part of Mphephu Youth Centre. Foreground (arena) shows a borehole surrounded by a recreational pool. In the background is a lecture hall.

Figure 7.4 The discussion rooms at the Mphephu Youth Centre. Each room can accommodate a maximum of 15 seated participants.

Option 2 (not the near-ideal option) is the construction of a new building which should include a hall, discussion rooms, a laboratory, library and offices. This option is costly in terms of financial resources since it will need a new plan and construction which can also destroy the environment (fauna and flora). This option is not discussed below.

In order to realize Option 1, the development would require a phased process. The phases are described below.

7.6.2 Phase 1: Preliminary activities

Phase 1 will consist of the following activities:

- The meeting with all interested stakeholders;
- The application for permission from the Department of Education to use the facilities at the Mphephu Youth Centre;
- Secure funding;
- Arrange an environmental impact assessment (EIA);
- Select and appoint staff to plan and oversee development;
- Hire an architect; and
- Hire the renovation and construction companies.

Estimated time for this phase could be 6-12 months.

7.6.3 Phase 2: Renovation of the existing infrastructure

Phase 2 will consist of the following activities:

- Renovation of the hall, discussion rooms, kitchen, sleeping accommodation, offices, ablution facilities and sewage;
- Clear the site for the new buildings (laboratory and library);
- Construction of the new buildings (laboratory and library);
- Hire the senior management staff.

7.6.4 Phase 3: Buy equipment, put systems in place and employ the professional staff

Phase 3 will consist of the following activities:

- Hire the professional staff;
- Buy and install office equipment, computers, telephones, stationery;
- Buy the library and laboratory equipment, projectors, generator and screens;
- Equip the laboratory and library centre;
- Put the communication, information and security systems in place;
- Hire the general staff;
- Educate and train the staff;

- Develop teaching and learning material and launch the operation.

The project will be marketed and advertised through such media as the TV, newspapers, online advertisements and conference exhibitions. Green education and the use of clean energy will be emphasized.

7.7 POTENTIAL IMPACT OF A GSEC AT SAGOLE

7.7.1 Environmental impact

7.7.1.1 Climate: Air pollution

During the renovation of the older buildings and the construction of the laboratory and library buildings, dust can be emitted into the air by construction vehicles. However, the emission of dust will be for a short period of time (a maximum of three months). Thereafter air pollution will be minimised by tarring and paving the road between the main road and the centre.

7.7.1.2 Water Resources: Water pollution

Surface water sources:

There is no river or furrow passing through the Mphephu Youth Centre so fortunately no water pollution can occur. Exposure to the public can increase the possibility of pollution. However, strict measures can be enforced to prevent contamination.

Groundwater:

Underground hydrology: The hot water borehole at the centre should be used with caution; otherwise, the water from the natural hot spring should be used for teaching and learning. The hot spring will be preserved in a near natural state, but will be made accessible by teachers, learners and researchers. The borehole can be used to monitor the water table, fill the recreational pool and irrigate lawns and vegetable gardens.

7.7.1.3 Geology: Seismicity and soil

No drilling will take place at the site and therefore seismicity would not pose a problem. Temporary soil erosion can take place when the land is cleared for construction purposes.

7.7.1.4 Noise pollution

Noise can be generated by the construction vehicles during the construction phase. However, during the operational stage, minimal noise can be generated by vehicles entering and leaving the centre. During breaks, strict measures will be put in place to control noise. Lectures and discussion classes will occur indoors once the centre is established.

7.7.1.5 Solid wastes

Solid wastes generated during the construction, and renovation, of buildings will be collected, recycled and deposited at a waste dump site. During the operational stage, solid waste can be generated from paper, glass, and food waste, among other things. As a matter of policy and principle, any waste that can be recycled should be disposed of separately for recycling. The construction of a Ventilation Improved Pit (VIP) is recommended during the construction phase. The VIP toilet is a more sophisticated form of sanitation than the ordinary pit latrine. The toilets are constructed with an external ventilation pipe which draws air through the toilet when the wind blows. This process keeps the toilet odourless. Flies are generally not attracted to the VIP toilets since they are odourless. The advantages of the VIP toilets include the following: They are odourless, hygienic, environmentally friendly, cost-effective and human waste is decomposed.

7.7.1.6 Biological resources: Vegetation and wildlife

A certain amount of land degradation and the clearing of some plants are likely during the construction of the new buildings. The Environmental Impact Assessment (EIA) will indicate if there are any additional flora and fauna that need to be taken into account in the renovation, construction and operational phases. The available vegetation and wildlife will be preserved.

7.7.1.7 Aesthetic impact

The clearing of land for the construction of new infrastructure can affect the aesthetic beauty of the centre. At the Mphephu Youth Centre, an estimated area of 1800 square metres would be cleared. Big trees will not be affected. An active environmental conservation programme will be introduced. New infrastructure can enhance the beauty of the area.

7.7.1.8 Summary: Environmental impact

Table 7.2 gives a summary of the environmental impacts discussed above. Both positive and negative impacts are scored according to the given scale (-4 to +4).

Table 7.2 Summary: Environmental impact scores.

Bad ←							→ Good		
Rating scale	-4	-3	-2	-1	0	+1	+2	+3	+4
Environmental Factors (indicators):									
Climate : Air quality					✓				
Dust				✓					
Water resources:									
Surface water hydro					✓				
Groundwater hydro						✓			
Geology: Seismicity					✓				
: Soil				✓					
Noise pollution				✓					
Solid waste				✓					
Biological Resources:									
:Vegetation								✓	
: Wildlife								✓	
Aesthetic impact						✓			
Total Score	0	0	0	4	3	2	0	2	0

7.7.2 Social impact

7.7.2.1 Impact on employment

There are opportunities for the local community and professionals outside the community to be employed at the centre. These people can be employed in administration, management, marketing and research, in the laboratory and the library, in workshop facilitation, as professional and indigenous knowledge system (IKS) lecturers, as technicians and tour guides, in the kitchen and in the cleaning services.

7.7.2.2 Impact on culture

Visitors to the centre will be interacting mainly with the working staff and not the local community in general. Since experts in the field can be invited from overseas, the staff can have an opportunity to learn more about their culture and language, and vice versa.

Sharing of indigenous knowledge system (IKS): There are medicinal indigenous plants used by the local community. For example, some plants are used to boost men's sexual drive. Baobab fruit seeds are used as oil. Some wildlife in the area such as pythons may not be killed – it is believed that if they are killed the hot spring will dry up. The hot spring site is a place of worship for the Netshipale family. Legend says the hot water flows from the mouth of a python underground.

7.7.2.3 Impact on science education

As already indicated, a geothermal education centre can cater for school learners, teachers, and researchers from universities and the general public. The differences in the information given to the above-mentioned stakeholders will vary according to the depth and the level of information they require, and will be appropriate to the purpose of the visit.

According to the US Energy Information Administration (2010), the main topics for primary and secondary learners fall under the subject of "Geothermal Basics". Topics to be covered in this regard include:

- What is geothermal energy?
- From where is the energy generated?
- Internal cross-section of the earth showing the inner core, outer core, mantle and crust.
- Where are geothermal resources found, for example, in "the ring of fire"?
- Geothermal resource manifestations: volcanoes, fumaroles, hot springs and geysers. Sagole can be used as an example of a hot spring.

- Uses: Electricity generation and direct uses.
- Geothermal energy and the environment, and many more.

These may also be used at Sagole.

Teachers mainly focus on the content and on the teaching and learning resources, while tertiary institutions focus on researching their areas of interest. Examples can include: Biology, Microbiology, Geography, Environmental Science, Geology, Geophysics, Meteorology, etc. Pilot research projects at the centre could focus on direct uses of hot springs such as spirulina production or mushroom farming to name a few.

7.7.2.4 Impact on research output

Advanced research areas relevant for researchers from tertiary institutions may be based on “Geothermal Energy Facts” (Geothermal Education Office, 2000), and the fields of research mentioned above. The following topics on geothermal energy facts may be included:

- Earth’s heat and volcanic regions;
- Formations of geothermal reservoirs;
- Generation of electricity and geothermal power plants;
- Direct uses of geothermal resources;
- Renewability and sustainability;
- Geothermal technology (Nemzer, Carter & Nemzer, 1997-2000); and
- Geothermal exploration (Kepinska, 2003).

Conferences, workshops and seminars can be organized for academics from tertiary institutions. Guest lecturers on different geothermal topics could be invited to facilitate the workshops. Research papers can be read at conferences or articles can be submitted to scientific journals.

7.7.2.5 Summary: Social impact

Table 7.3 gives a summary of the social impacts discussed above. Both positive and negative impacts are scored according to the given scale (-4 to +4).

Table 7.3 Summary: Social impact scores.

		Bad ←					→ Good		
Rating scale	-4	-3	-2	-1	0	+1	+2	+3	+4
Social factors:									
Employment									✓
Cultural aspects								✓	
Science education								✓	✓
Research output								✓	
Total score	0	0	0	0	0	0	0	3	2

7.7.3 Economic impact

7.7.3.1 Impact on income

In section 7.2.3 the South African government, the Department of Science and Technology and other funding organisations for science education are mentioned. Through these organisations (public, private, government) income can be generated for the centre. School groups will pay entrance fees**.** Spending by visitors in the centre, and the stores and restaurants surrounding Sagole can boost local businesses. During the construction and operation of the education centre, temporary and permanent jobs can be created that will generate income for the local community and outside experts. An estimated number of 50 jobs can be created, ranging from cleaners to professionals.

7.7.3.2 Impact on infrastructure

The renovation and building of new infrastructure, such as the library and science laboratory and gardens at Sagole, will certainly enhance the quality, beauty and usefulness of the infrastructure. Generated waste will need to be collected and recycled in time to prevent any negative impact on the beauty of the infrastructure.

7.7.3.3 Summary: Economic impact

Table 7.4 gives a summary of the economic impacts discussed above. Both positive and negative impacts are scored according to the given scale (-4 to +4).

Table 7.4 Summary: Economic impact and scores.

	Bad ←						→ Good		
Rating scale	-4	-3	-2	-1	0	+1	+2	+3	+4
Economic Factors:									
Income generation									✓
Impact on infrastructure								✓	
Total scores	0	0	0	0	0	0	0	1	1

7.8 FEASIBILITY OF A GEOTHERMAL SCIENCE EDUCATION CENTRE AT SAGOLE (GSEC)

In section 7.5, the total scores were calculated for the environmental, social and economic impacts of a GSEC centre at Sagole. If any of these were negative, they would also have a negative influence on the feasibility of establishing a geothermal science education centre (GSEC). Thus, by implication, if the environmental, social and economic impacts are positive, the benefits of establishing the centre can be promoted.

7.8.1 Environmental, social and economic feasibility

In this section, the total weighted score and the mean score of each of the environmental, social and economic impacts are calculated.

Total weighted score =

The mean score = Total weighted score/N =

Where = Environmental, social and economic impact scores

Where = Number of occurrences

7.8.1.1 **Environmental *feasibility***

Table 7.5 gives the environmental feasibility rating for a geothermal education centre. The mean score is also calculated below. The rating scale ranges between -4 (bad or low feasibility) and +4 (good or high feasibility).

Table 7.5 Environmental feasibility rating.

Rating

Rating scale	**-4**	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
Total Score (from Table 7.2)	0	0	0	4	3	2	0	2	0		
Total weighted score	0	0	0	-4	0	2	0	6	0	=	+4

Total weighted score = +4

N=11

Mean score= +4/11 = +0.36

The overall mean score value (+0.36) indicates that a geothermal science education centre has a low positive environmental feasibility score. Temporary negative impact will occur mainly during the renovation and construction of the new infrastructure. The period of clearing the land and the construction of new infrastructure would last for around four weeks only. Preservation of the vegetation and wildlife will occur throughout the lifespan of the project.

7.8.1.2 Social feasibility

Table 7.6 gives the social feasibility rating for the geothermal education centre. The mean score is also calculated below. The rating scale ranges between -4 (bad or low feasibility) and +4 (good or high feasibility).

Table 7.6 Social feasibility rating

Rating

Rating scale	**-4**	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
Total score (From Table 7.3)	0	0	0	0	0	0	0	+3	+2		
Total weighted score	0	0	0	0	0	0	0	+9	+8	=	+17

Total weighted score = +17

N= 5

Mean score = +17/5 = +3.4

The overall mean score value indicates that the geothermal education operation has a high positive social feasibility rating of +3.4. Therefore, the establishment of a geothermal education centre can be promoted at Sagole.

7.8.1.3 Economic feasibility

Table 7.7 gives the economic feasibility rating for the geothermal education centre. The mean score is also calculated below. The rating scale ranges between -4 (bad or low feasibility) and +4 (good or high feasibility).

Table 7.7 Economic feasibility rating

Rating

Rating scale	**-4**	**-3**	**-2**	**-1**	**0**	**+1**	**+2**	**+3**	**+4**		
Total scores (From Table 7.4)	0	0	0	0	0	0	0	1	1		
Total weighted score	0	0	0	0	0	0	0	+3	+4	=	+7

Total weighted score = +7

N = 2

Mean score = +7/2 =+ 3.5

The overall mean score value in Table 7.7 shows that the development of a geothermal education centre has a high positive feasibility rating of +3.5.This rating indicates that the Geothermal Education operation is highly feasible at Sagole. Therefore the establishment of the centre can be promoted in the area. Generally, school learners, teachers, researchers and the general public can benefit from the establishment of the centre.

In terms of these three factors, it appears that the establishment of a GSEC at Sagole is environmentally, socially and economically feasible even though temporary negative impacts on the environment can occur during the renovation and construction period. There is high positive feasibility in terms of the social (+3.5) and economic (+3.5) mean scores.

7.8.2 Cost-benefit analysis

The estimated costs are based on the development of the geothermal science education centre at the Mphephu Youth Centre (the near-ideal model). Estimated costs are reflected in Appendix 8.

7.8.2.1. Development of the GSEC at Mphephu Youth Centre

Detailed discussions of the development based on option 1 and its advantages are given above in section 7.5 “Development plan for GSEC”. As already indicated above, there can be great financial savings if option 1 is taken. There will be minimal costs on the renovation of the centre. The projected costs for bricks, cement, sand, building sand, paint and labour are given in Appendix 8 , which breaks down the estimated costs for option 1.

The estimates were obtained from Muswodi Brick Making (Mutale), Cashbuild (Thohoyandou) and Incredible Connections (Pretoria). The cost of bricks includes transport. The total estimated cost amounts to R 548 000.00.

7.8.2.2 Development the GSEC at Sagole Spa

This is a more expensive option because it demands the construction of a new building with the hall, laboratory, library and discussion rooms. Appendix 9 shows the estimated costs for constructing a new building for option 2. The total estimated costs for option 2 are R2 588 000.00. This cost is R2 040 000 higher compared to the first option (the near-ideal option).

7.8.3 Business analysis

The strengths, weaknesses, opportunities and threats for the proposed geothermal education centre are discussed below.

7.8.3.1 Strengths

- The presence of a hot spring makes the venture a resource-based geothermal education centre.

- The presence of the built facilities (hall, discussion rooms, and offices) in relatively good condition at the Mphephu Youth Centre (earmarked in option 1 for the development of a geothermal education centre).
- The good condition of the tarred road to the hot spring makes the centre accessible by road transport.
- The University of South Africa (Unisa) is currently doing research at Sagole Spa. The Council for Geosciences and the University of Pretoria have joined Unisa in doing on site research. The site is rich in research opportunities and available research reports can be shared with potential visitors.
- Microbiology studies are being carried out by staff and students from the University of South Africa.
- Currently, there are a number of Masters and PhD students from Unisa conducting research on the hot spring.
- The proximity of the proposed geothermal education centre to tourist attractions such as The Big Tree, the Tshiungani Ruins, the Domboni Caves and the Kruger National Park can help to attract visitors to the centre.
- Knowledgeable locals such as the traditional healers (Tshikovha Family) have valuable indigenous knowledge of indigenous plants and the uses of geothermal fluid.

7.8.3.2 Weaknesses

- No formal agreement with government agencies, educational institutions and NGOs on the establishment of the centre exists yet.
- No funding for the development of the project has yet been obtained.

7.8.3.3 Opportunities

- This would be the first geothermal science education centre in Africa.

- Temporary jobs will be created during the construction of the centre, and permanent and contract jobs will be created during the operational stage of the project.
- Teachers, locally and further afield, will be assisted with in-service learning opportunities for teachers and the teaching of the science syllabus.
- The knowledge base in science and technology will be broadened.
- Young people will be attracted to the study of sciences (earth sciences, renewable energy, etc.).
- Indigenous knowledge related to geothermal energy and uses will be researched and shared with visitors.
- The pass rate in sciences at the local rural schools may be improved.
- There are many rural primary and secondary school learners that can benefit from the project.
- The availability of overnight accommodation can generate income for the centre.

7.8.3.4 Threats

- Generally there is no competitive threat since this is the first venture of its kind in South Africa.
- The current lack of funding for the proposed project poses a serious threat.
- The current lack of buy-in from the Department of Education and the rural development unit of the Office of the President may augur a lack of official support. This could change once the proposal for this development has been submitted to the appropriate office.
- The Environmental Impact Assessment is not yet done and the impacts are not yet known.
- Buy-in from the local community is not yet certain.

From the SWOT analysis given above, the proposed project has more strengths and opportunities than weaknesses and threats. Therefore, the chances that the proposed project can be successful would appear to outweigh the chances of failure. However, the procurement of sustainable funding is a serious problem. A proposal for funding would need to be prepared.

7.9 SYNTHESIS

In this chapter, a Geothermal Science Education Centre (GSEC) is evaluated and assessed as a suitable geothermal education centre for development at Sagole. In general, the development of a GSEC centre at Sagole is environmentally, socially and economically feasible. The weaknesses and threats are not insurmountable provided that there is local buy-in, and that funds and expertise can be procured. In the next chapter, the discussion will turn to the development at Sagole

CHAPTER EIGHT

DETERMINATION OF OPTIMAL DEVELOPMENT AT SAGOLE

8.1 INTRODUCTION

In Chapters 5, 6 and 7, the feasibility and suitability of potential aquaculture (fish farming), tourism and geothermal education ventures were discussed and analysed. These ventures were evaluated in terms of the environmental, social and economic aspects of the projects, as well as their costs and benefits.

This chapter is composed of three sections. The first section (8.2) comprises a comparison of the feasibility ratings for the three types of development. These ratings are weighted using the inverse of the potential costs of the development so as to obtain an indication of the cost and benefits of the projects, i.e. the Feasibility Index. The second section (8.3) presents the results of a survey conducted at Sagole to determine community opinion regarding the type of development that they would prefer. In the final section (8.4), the results of the scientific evaluation of the feasibility of the developments are compared with the perceptions of the community and a possible way forward is presented.

8.2 COMPARISON OF THE FEASIBILITY OF THE POTENTIAL PROJECTS

8.2.1 Environmental feasibility

The environmental feasibility ratings of the three potential projects (as obtained from the relevant sections of Chapters 5, 6 and 7) are summarised in Table 8.1 below.

Table 8.1 Summary: Environmental feasibility ratings for the types of development.

Potential projects	Feasibility ratings
Health Tourism	0.27
Aquaculture	0.1
Geothermal Education	0.36

All three types of development have a positive environmental feasibility rating – albeit very low values. The development of a geothermal educational centre appears to be the most environmentally friendly option. This is followed by the establishment of a health tourism resort. The positive environmental effects can probably be ascribed to the environmental conservation initiative that will accompany these activities. The negative impacts during the construction phases will be temporary in nature. The establishment of an aquaculture enterprise holds potentially greater negative impacts since it is more invasive and it will not necessarily incorporate a conservation component.

Moreover, there is already some infrastructure available for the education centre and the health tourism facilities. Renovation of existing infrastructure is less intrusive than the construction of new buildings. Less construction will be required for these two developments than for the establishment of an aquaculture enterprise, and thus there will be fewer construction activities and less negative environmental impact. In addition, the preparation and construction of fish ponds may degrade the land and could cause soil erosion. Vegetation and wildlife can also be affected and feed and chemicals used in ponds could contaminate the water and soil.

8.2.2 Social feasibility

The social feasibility of the three potential projects is shown in Table 8.2.

Table 8.2 Social feasibility ratings of the three potential projects

Potential projects	**Mean feasibility ratings**
Health Tourism	2.25
Aquaculture	2.3
Geothermal Education	3.4

Geothermal education has the highest social feasibility score (3.4). Its establishment can address the highest need in this rural area (Mutale Local Municipality), namely, the lack of scientific knowledge and skills, which lead to a poor pass rate for Grade 12 in the local schools. It can also create job opportunities at the professional level.

Aquaculture scored the second (2.3) feasibility rating since its establishment would have many positive impacts on the people at Sagole. It can improve human health by providing high quality protein and protect the local workforce from migration.

Health tourism has the lowest feasibility rating (2.25). However, it can give local people the opportunity to sell their crafts, and would support the preservation of aspects of traditional culture for future generations. The use of hot and mineral water also improves human health.

8.2.3 Economic feasibility

The economic feasibility of the three projects are shown in Table 8.3 below.

Table 8.3 Economic feasibility of the three projects

Potential projects	**Mean feasibility ratings**
Health Tourism	**2.5**
Aquaculture	**3.3**
Geothermal Education	**3.5**

Here too, geothermal education takes the lead in the feasibility ratings. Its economic feasibility rating is 3.5. This is because it offers high opportunity for potential funders, who include the government and the private sector. It has a huge market which includes all schools in the Vhembe district, a rural area where schools are not performing well in the sciences. The infrastructure is readily available and few additions are needed. Researchers from tertiary institutions have already started doing research at Sagole.

The mean feasibility rating for aquaculture is relatively high at 3.3. Economically it has the potential to impact positively on other industries, and to generate income in the form of wages, interests, profits and tax revenue. It can also support other businesses such as restaurants, and supermarkets and can improve communication and transportation infrastructure.

The feasibility rating of health tourism is 2.5. This is still a high positive feasibility rating. It has the power to generate revenue and foreign exchange. It can generate jobs at different levels. It also has the multiplier effect and impacts positively on other industries, especially transport and agriculture.

8.2.4 Mean feasibility ratings

The following feasibility ratings were derived from Tables 8.1, 8.2, and 8.3. To obtain the mean feasibility ratings for environmental, social and economic aspects for each of the types of development, the three mean ratings need to be divided by 3 as follows:

Table 8.4 Summary: Mean project ratings for the three types of development.

	Health Tourism	**Aquaculture**	**Education Centre**
Environmental	+0.27	+0.1	+0.36
Social	+2.25	+2.3	+3.4
Economic	+2.5	+3.3	+3.5
Total scores	5.02	5.7	7.26
Mean project rating	**1.67**	**1.90**	**2.42**

As shown in Table 8.4, geothermal science education (2.42) has the highest mean project rating in terms of environmental, social and economic aspects. The high rating confirms the statement that education is widely regarded as “the route to economic prosperity, the key to scientific and technological advancement, the means to combat unemployment, the foundations of social equity, and the spread of political socialization and cultural vitality" as stated in Chapter 7. It is followed by aquaculture (1.9) and health tourism (1.67) respectively.

8.2.5 Feasibility Index

The mean ratings calculated above reflected the feasibility of the development in terms of positive or negative impacts on the environment, society and economic factors. However, the cost of the development is a crucial aspect which must be taken into account when making final decisions on the type of development to be implemented. In order to quantify this, the feasibility index was calculated in which the mean feasibility rating was multiplied by a factor reflecting the inverse of the potential costs of the development. This gives an indication of the costs and benefits of the projects.

Table 8.5 below shows the estimated costs of the different developments as given in the respective chapters.

Table 8.5 Estimated costs of development.

Development	**Education Centre**	**Health Tourism**	**Aquaculture**
Cost (in millions of Rands)	0.5	10.7	2.0
Ratio	1	21.4	4

The inverse of these ratios are used as the weighting factors for the calculation of the Feasibility Index (Table 8.6). The weighting factor is based only on the costs and not on the possible benefits because it is not certain when benefits will occur. The costs are from Appendix 4 and 5 health tourism (R10, 7m), Appendix 7 aquaculture (about R2m), and Appendix 8 Education Centre (R0.5m).

Table 8.6 Feasibility index of developments at Sagole

Type of Development	**Mean Feasibility Rating**	**Weighting Factor (from Table 8.5)**	**Feasibility Index**
Health Tourism	1.67	1/21.4=0.05	0.08
Aquaculture	1.90	¼ = 0.25	0.48
Education Centre	2.42	1	2.42

These results indicate that, in terms of cost and benefit, the establishment of an educational centre should receive top priority followed by aquaculture and then health tourism enterprise.

8.3 COMMUNITY VIEWS ON DEVELOPMENTS

Two issues were discussed with the focus groups, namely:

- The current development status at Sagole, including barriers to development, and
- The perceived ideal type of development. The different types of development for which Sagole might be suitable were mentioned to the groups. These included aquaculture, spirulina production, mushroom farming, tourism and an education centre.

Four Focus Group interviews were conducted with the following groups of the local community:

1. The women of Zwigodini Village;
2. Integrated group of Farmers, Women's Committee, Youth Committee, Civic Association and Clinic Committee;
3. Madifha Primary School teachers; and
4. Hanyani Secondary School teachers.

Personal Communications were conducted with the following representatives:

5. Representatives from the Mutale Local Municipality; and from the
6. Tshikundamalema Tribal Council.

Personal communications were also conducted in South Africa at national level with representatives from:

7. Hot spring resorts (Tshipise, Bela-Bela and Mphephu);
8. Limpopo Economic Development Enterprise (LimDev);
9. Department of Agriculture (Limpopo), Musina Spirulina; and
10. University of Limpopo (Aquaculture Research Unit).

Further communications were conducted overseas (at international level) with representatives from:

11. Oregon Institute of Technology (Geo-Heat Center); and

12. Liskey Aquaculture Farms (USA) and Canby Aquaculture (California).

Comments on the present status of Sagole elicited the following responses:

Focus group meetings with groups (1), (2), (3) and (4) indicated that:

(1) The leaseholder is unable to develop and maintain the spa. Workers at the spa are reduced to four.
(2) There was a need for the spa to be returned back to the community. LimDev was identified as the organisation to manage the transfer on behalf of the Limpopo Provincial government.
(3) Lack of funding for development was identified.
(4) Tourism was identified as the main type of development that can be pursued.
(5) Many cultural activities that can be introduced to entertain visitors were mentioned. These include cultural dances, sports and foods.
(6) Potential development projects were discussed with the community and they showed enthusiasm for: fish farming, spirulina production, and recreation and tourism, but the mushroom project was rejected because some mushrooms are said to be toxic.

Personal communications (5) and (6) indicated that Sagole Spa is currently leased to a private business person. The Municipality and the Tribal Council have no authority to develop the spa. They expressed the need for the lease to be terminated in order for the local Municipality and the Tribal Council to initiate the development process. They were not aware of other development projects that can be sustainable at Sagole. The research results (health tourism, aquaculture and geothermal education) were an eye opener to these groups since they did not have any concept of development other than tourism. Personal communications (7), (8), (9) and (10) (at the national level) identified recreation and tourism as a possibility, but competition with Forever Resorts Tshipise was highlighted as a negative factor. Personal communications (11) and (12) (at international level) highlighted the potential for aquaculture.

With regard to the type of development (health tourism, aquaculture and an educational centre) the questions posed to the respondents and their responses were as follows:

Question 1: Of the three projects, which one will you choose for development at Sagole? A (Health Tourism) B (Aquaculture) C (Educational Centre)

The results were as follows:

55.4% of the 200 participants choose Project A (Health Tourism).
33.3% of the 200 participants chose Project C (Geothermal Education Centre) and
11.3% of the 200 participants chose Project B (Aquaculture)

Question 2: Rate the following projects according to their economic importance to you. The project valued most highly will be rated 1 and the project of lowest value will be rated 3.

This question sought to determine alternative developments should the first choice prove too expensive or unsustainable. The results are shown in Table 8.7 and Figure 8.1 below:

Table 8.7 Projects rating in percentages.

Ratings	**1 (highest value)**	**2**	**3 (lowest value)**	**%**
A. Health Tourism				
% ratings	55	36	9	100%
B. Aquaculture				

% Ratings	8.4	10.5	81.1	100%
C. Geothermal Education				
% Ratings	40	51.6	8.4	100%

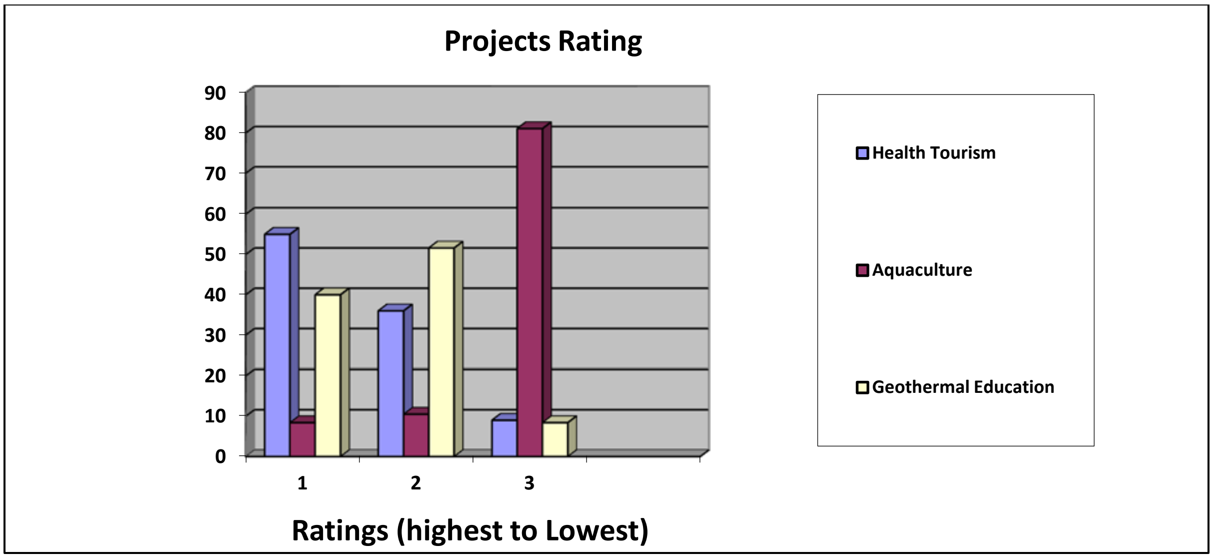


Figure 8.1 Graph representing most popular projects.

From both Table 8.7 and Figure 8.1 it is clear that the most popular of the options for development was that of health tourism (55%). Alternatively, a geothermal education centre would be acceptable (51.6%). The lowest rated project is aquaculture (81.1% respondents rated it as the third project).

Question 3: Indicate the project you may choose to work for: A B C.

The results were as follows: A (Health Tourism) scored 71%, B (Aquaculture) 4% and C (Geothermal Education) 25%.

Question 4: Give reasons for your answer in 3 above. The results were as follows:

A (Health Tourism): More job opportunities; infrastructure available; need renovation to start the project (1).

B (Aquaculture): No reason was given (3).

C (Geothermal Education): Opportunity to study science; science exposure; education is important (2).

8.4 THE WAY FORWARD

According to the research findings, the establishment of a Geothermal Education Centre appears to be the most sustainable project with the highest Feasibility Index value of 2.42. It is followed by Aquaculture (Feasibility Index = 0.48) and then Health tourism (Feasibility Index = 0.08). The research rated geothermal education first because it has more positive environmental, social and economic impacts while the initial capital costs are relatively low, especially since the Mphephu Youth Centre is already in existence. This would require refurbishment rather than the construction of new facilities. Moreover, education is widely regarded as the route to economic prosperity and a means to fight unemployment. However, it should be noted that if the Mphephu Youth Centre is not available for development, the costs would escalate, decreasing the weighting factor significantly. This will result in a much lower Feasibility Index. Aquaculture was rated second because of its low capital costs and relatively high environmental impact. Health tourism is rated last because of its extremely high cost of development and the specialised Human Resource required to run the health centre.

The results of the research and those of the survey differ to some extent. The community preferred Health tourism followed by the Educational Centre and then Aquaculture.

Reasons for these conflicting ideas include the following: Members of the community do not have a deeper understanding of the environmental and social impacts of developments nor of their capital costs. The potential benefits of the health tourism is probably a deciding factor in community perceptions. Furthermore, the community at Sagole is only familiar with tourism - and by association with health tourism – in view of the past development at Sagole and the current situation at Tshipise. The community also focused on job opportunities because of the high level of unemployment in the area. The community's perception is that professional staff from 'outside' will be required for the geothermal education centre and as they would not be qualified to be employed there, they would favour the opportunities for unskilled labour required at a health spa.

Aquaculture is rated last by the community but second in the evaluation. The community indicated that fewer people can be employed in an aquaculture project and that it takes a long time (about nine months) before the first crop is harvested and income is received.

Possible solutions to these conflicting ideas include: a visit by the researcher to the community to disseminate the findings. It is possible that once the community understands the reasons behind the findings, they would be in agreement and lend support to the establishment of a Geothermal Education Centre. The importance and value of indigenous knowledge systems should be emphasised so that the members of the community can see a role for themselves in addition to that of unskilled labour, as holders of cultural knowledge who can be employed at, and who are vital to the success of, the Centre.

A second option is to re-examine the factors that mitigate against the development of a Health Tourism spa. Actions can then be implemented to eliminate negative factors and enhance the positive aspects of the development.

The third option is to reach a compromise and implement the development in phases where all three types of development will eventually be implemented. Availability of the necessary funding would play a fundamental role in the roll-out of the developments.

8.5 SUMMARY

This chapter analyses the development projects in terms of environmental, social and economic aspects. Mean feasibility ratings and feasibility index are also calculated. Community views on development are also explored. It concludes by giving development options. The next chapter provides the conclusions of the research study conclusion and recommendations.

CHAPTER NINE

CONCLUSION AND RECOMMENDATIONS

9.1 SUMMARY

Thermal springs have been used for religious, medicinal and economic purposes for thousands of years. Over the last few decades, this has expanded to include geothermal energy production, the extraction of minerals, agriculture and aquaculture and tourism. The aim of this study was to identify the uses most appropriate for the Sagole thermal spring in terms of economic, social and environmental impacts. It comprised three objectives, namely, to identify the uses of thermal springs in general, to determine potential uses for Sagole and identify the optimal use for Sagole in particular.

The study commenced with a literature study aimed at identifying the requirements for each of the current uses of thermal springs world-wide. This was followed by the collection and analysis of water samples and the measurement of the physical characteristics of Sagole spring waters. Since the temperature of the spring waters at Sagole is only 45°C, uses such as mineral extraction, electricity generation, greenhouse heating and mushroom farming were rejected. Spirulina production is not viable because of the low flow rate. Mushroom farming was rejected during preliminary meetings with the community due to traditional beliefs and caution regarding the toxicity of many mushroom species. Furthermore, water at a temperature of 90°C is required to pasteurise substrate for mushroom growing. Thus, of the many possible uses, only tourism and aquaculture were identified as having development potential. However, during the review of the literature it became evident that numerous educational centres have established institutes specialising in geothermal education in order to cater for the burgeoning use of these resources world-wide and the shift to the use of green energy. This study therefore included the establishment of an educational centre as a possible use at Sagole.

Objective 3 was achieved by analysing the economic, environmental and social feasibility of each of the selected potential uses (health tourism, aquaculture and geothermal education) in order to identify their optimal use for Sagole. These were discussed in chapters 5, 6 and 7 respectively. The chapters followed the same basic pattern in that the requirements of the specific use were discussed. Thereafter the suitability of Sagole was assessed for each of these requirements. The environmental, social and economic impacts were evaluated and a basic cost-benefit analysis conducted for each use. Since the feasibility of a development is largely dependant upon the impact of the development, a feasibility index could be determined using weighted mean scores for environmental, social and economic impacts, and incorporating the estimated net cost of the venture. The Feasibility Index could be used to compare the feasibility of the three uses, and hence, to identify the optimal use at Sagole.

Application of the above technique resulted in a Feasibility Index value of 2.42 for the use of the spring as an educational centre focussing on geothermal and other natural resources at Sagole; a value of 0.08 for a health-based tourist resort; and 0.48 for a tilapia aquaculture venture.

9.2 CONCLUSIONS AND RECOMMENDATIONS

These results indicate that, in terms of environmental, social and economic factors (including cost and benefit), the establishment of an educational centre should receive top priority followed by an aquaculture and then health tourism enterprise. Although health tourism did not fare as well as the other two uses, all three types of developments have minimal environmental impacts while offering considerable benefits to the local community.

It should be noted that during the focus group meetings which were held at the early stages of the study, the local community indicated that health tourism would be the most sustainable type of use, followed by geothermal education and then aquaculture.

It is recommended that the researcher visits the community to report back on the findings of the study with the aim of reaching a compromise on which project to develop. Once a compromise has been reached and the type of development prioritised, the community should be assisted to draw up a proposal so as to secure funding for the project.

A second option is to view the development at Sagole from a holistic point of view, where all three projects can be implemented, but in phases, starting with the type of development as prioritised by all parties concerned. This seems to be the most advantageous option since all three projects offer potentially positive impacts to the rural community at Sagole. In addition, funding generated by the earlier phases could be used to assist in providing funding for the later developments. Such a multi-phased development would ensure that the advantages of all the projects could be realised.

It is further recommended that the uses which were not included in this study should be evaluated.

- Since the bottling and selling of bottled water of the spring waters would support the health tourism development, this should receive attention.
- The use of spring water for agricultural development should also be investigated. The nitrogen-rich waste products from the aquaculture ponds could be used for the cultivation of crops while compost and manure generated by agricultural activities could be used as fertilisers for the fish.
- In the research, the potential for Spirulina production was rejected due to the low flow rate of the spring. However, it is possible that spring water can be

supplemented by other sources. It is therefore recommended that a small pilot project is erected at Sagole to investigate this as a possible further step in the cascade of uses.

- The potential for mushroom farming should be researched. The negative views of the community might be altered when presented with more information on the mushroom industry.

An added advantage to establishing a multiple-use development is that any additional development at Sagole spring would widen the scope of courses offered at the Educational Centre and act as draw-cards for tourists. In this way, a cascade of uses would maximise environmentally-friendly use of the natural resources at Sagole.

It is essential that, once the developments have been implemented, they are continuously evaluated so as to ensure that the original goal-posts of low environmental impacts and high social and economic benefits are met.

9.3 SIGNIFICANCE

This study was important since it brought the following to light:

- Generally all developed thermal springs in South Africa are used for bathing or swimming. This study identified other potential uses for low temperature geothermal resources.
- The study proposes the establishment of a first geothermal education centre in South Africa, which can teach and disseminate resource-based science and indigenous knowledge system to learners, researchers, and the public.
- The Feasibility Index used in this study is simple, easy to use and can be applied to identify the optimal type of development at other thermal springs and could possibly also be used for the evaluation on other natural resource developments.

- Involving the local community in this type of research is essential since valuable information on who they are and what they want can be obtained. Thermal springs are valuable natural resources with potential environmental, social and economic benefits that are possible if optimal uses are identified. All efforts should be made to identify potential uses of thermal springs in South Africa.
- A development strategy for thermal springs that considers environmental, social, economic, costs and benefit factors is essential for the sustainable development of natural resources.

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Appendix 1

A STRATEGY FOR THE SUSTAINABLE DEVELOPMENT OF THERMAL SPRINGS A CASE STUDY FOR SAGOLE IN LIMPOPO PROVINCE

FOCUS GROUP INTERVIEW QUESTIONNAIRE

NB. The interview is confidential and that you participate at your own free will

Question 1

Explain your view of development at Sagole Spa.

Question 2

What are current challenges facing the development at Sagole

Question 3

Explain your view of the potential impact of the following projects:

(a) Recreation and tourism;

(b) Aquaculture (1) fish farming and (2) Spirulina production;

(c) Mushroom farming

(d) Bottling water for commercial purpose

Appendix 2. Sagole Education and skills survey

Sagole Education And Skills Survey																	
No.	Gender/ Age		Education			Professional					Cultural			Geothermal Education	Aqua Culture	Health Tourism	
	Male\Female	Age	Primary	Secondary	FET Education	Computer Literacy	Management And Marketing	Admin And Reception	Finance	Plumbing	Art & Craft	Local Food & Traditional Beverages	Dance & Forms Of Music	Library And Lab Skills	Rearing Fish	Hospitality	Body Treatment & Massage
1																	
2																	
3																	
4																	
5																	
6																	
7																	
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25																	

Appendix 3

PROJECTS RATING

NB. The interview is confidential and you participate of your own free will.

No	DESCRIPTION OF RESAERCH RESULTS	
A	**HEALTH TOURISM**	
	It includes the following: • Accommodation facilities; • Bottling medicinal water for drinking purpose; • Fitness centre (gym); • Indoor and outdoor pools, Jacuzzi, sauna and steam bath.	
B	**AQUACULTURE**	
	It includes the following: • Tilapia fish farming	
C	**GEOTHERMAL EDUCATION CENTRE**	
	It includes the following: • Science education for primary and secondary learners, and researchers; • Geothermal energy awareness to the public and • Indigenous knowledge system	
D	**QUESTIONS**	
1	Of the three projects which one will you choose for development: A B C	
2	Rate the following projects according to their economic importance. The project valued most highly will be rated 1 and project rated as lowest value will be rated 3	
	Projects	Rating 1 to 3
	A. Heath tourism	
	B. Aquaculture	
	C. Geothermal Education	
3	If unemployed for which project will you like to work for?	A B C
4.	Give reasons for your answer in 3 above.	

Appendix 4 Health tourism: Costs estimates for Phase 1 Project

Infrastructure	Task	Estimated Cost	R C
6 chalets	Renovation	6 xR10 000 each	60 000.00
1 kitchen	Renovation	1x R10 000	10 000.00
2 x 4 sleeper chalets	Renovation	2 x R10 000	20 000.00
2 swimming pools	Renovation	2 x 25 000	50 000.00
Ablution/showers	Renovation	R30 000	30 000.00
Sewage/drainage	Renovation	50 000	50 000.00
Total Renovation costs			**220 000.00**
New requirements			
Restaurant	Build, cold room, purchase fridges, stoves, pots	Build: R150 000 Others: R150 000	300 000.00
Administration office	Build (8 rooms)	R400.000	400 000.00
Toilets	Buy/build	15 x R1000	15 000.00
Laundry	Buy/build	4 x R5 000	20 000.00
Showers and baths	Buy/install	6x R2 000	12 000.00
Office equipment			
Furniture (office/restaurant)	Buy	R300 000	300 000.00
6 air conditioners	Buy	6 x 10 000	60 000.00
6 TV sets	Buy	6 x 15 000	90 000.00
Computer equipment			
5 Computers with Internet	Buy	5 x R10 000	50 000.00
Website design	Design	1 x R12 000	12 000.00
2 Printers/faxes	Buy	2 x R5 000	10 000.00
2 Photocopiers/scanners	Buy	2 x R 40 000	80 000.00

5 Telephones	Buy	5 x R500.00	2 500.00
5 Cell phones	Buy	5 x 1500.00	7 500.00
Total cost			**1 359 000.00**
Labour/Staff		**Monthly salary**	**Annual salary**
2 managers (management and marketing)	Hire	2 x 250 000	500 000.00
2 Personal assistants	Hire	2 x R90 000 pa	180 000.00
2 Office Administrators	Hire	2 x 75 000pa	150 000.00
2 Receptionists	Hire	2 x R54 000 pa	108 000.00
2 Electricians	Hire	2 x R60 000pa	120 000.00
2 IT technicians	Hire	2 X R 60 000pa	120 000.00
1 plumber	Hire	1x R60 000	60 000.00
5 cleaners	Hire	5 x R36 000pa	180 000.00
Total labour costs			**1 418 000**
Training of staff	Outsource	18 staff X R2000	R36 000

Appendix 5 Health tourism: Costs estimates for Phase 2 Projects

Requirements	**Task**	**Estimate Costs**	**R C**
15 chalets	Building	Details on quote	
Pool spa (natatorium)	Building	"	
Pool spa roof & building	Building	"	
Sauna	Building & fittings	"	
Jacuzzi	Construct	"	
Steam room	Fittings	"	
Change rooms	Building & fittings	"	
Total cost of the above			**5 700 000.00**
15 beds	Buy	15 x R 4 000	60 000.00
15 lounge sets	Buy	15 x R15 000	225 000.00
15 baths/showers	Buy	15 x R4 000	60 000.00
15 fridges	Buy	15 x R7 000	105 000.00
15 Air conditioners	Buy	15 x R10 000	150 000.00
Fitness centre	Build	1 x R1 000 000	960 000.00
12 Exercise machines	Buy	12 machines	49 000.00
5 Massage rooms	Build	5 x R40 000	200 000.00
10 massage chairs	Buy	10 x R15 000	150 000.00
10 massage tables	Buy	10 x R2 000	20 000.00
30 bicycles for hire	Buy	30 x R1 700	51 000.00
Water bottling equipment	Buy	1 x machine/bottles	40 000.00
Total costs			**2 070 000.00**
Grand total			**7 770 000.00**
Medical consulting room	Hire/outsource		N/A
One physiotherapist	Hire/outsource		N/A
2 professional nurses	Hire/outsource		N/A

Appendix 6 Health tourism: Labour costs and benefits estimates

Visits	**Days of visits**	**Cost per person**	**Income**
90 (Dec/Jan)	30	R500/person/day	R1 350 000
50 (Feb-Nov)	200 (20 x 10 = 200)	R400/person/day	R4 000 000
Bicycle hire	20 bicycles/months 20 x R50 x 12	R50/per/day	R 12 000
Total benefits			R5 362 000
Minus labour cost			R1 418 000
Surplus/Deficit			**R3 944 000**

Appendix 7 Aquaculture: Estimate costs and benefits at Sagole Spa

Fixed costs	**Description**	**Unit**	**Quantity**	**Price/Unit**	**Total Cost** **R C**
Ponds	Rearing/brood ponds		4	R50 000	200 000.00
Tanks	Breeding tanks		4	R30 000	120 000.00
Equipment:	Aerators, drainage systems, water supply systems’ electrical equipment for aerators				500 000.00
Total fixed cost					**820 000.00**
Variable Costs	One harvest				
Fingerlings	Hatchery-raised	n/al	10 000	R2	20 000.00
Feed and chemicals	Pellet	Kg	6250	R8	50 000.00
Fertilizer	Chicken manure	kg	50	n/a	free
Total variable costs					**R70 000.00**
Human Resource	Manager		1		R350 000pa
Outsourced	Marketing manager		1		R250 000pa
	Administration clerk		1		R50 000pa
Outsourced	Biologist		1		200 000pa
	Laborers		5		50 000pa
	Training (Madzivhandila)			free	free
Total HR costs					**900 000**
Grand Total	**Fixed, variable & Hr**				**1 790 000**

Benefits					
Total Selling Price	10000 X R80 (Current price R88/kg)		10 000	R80	R800 000pa
Minus HR & variable costs					R970 000
Surplus/Deficit					**-170 000**

Appendix 8

Education centre: Cost estimates for renovating the Mphephu Youth Centre

Items	Estimated costs	R C
10 000 standard bricks (including transport)	10 000 x R3	30 000.00
10 000 face bricks (including transport)	10 000 x R4	40 000.00
Building sand	10 loads (3ton) x R700	7 000.00
Sand	10 loads (3 ton) x R 800	8 000.00
Cement	100 bags x R70	7 000.00
Paint	10 x 20l x R600	6 000.00
Laboratory equipment		50 000.00
Library equipment & books/journals		100 000.00
Computers and Internet	10 x R15 000	150 000.00
Furniture		50 000.00
Labour		100 000.00
Total estimated costs		548 000.00

The above estimates were obtained from Muswodi Brick Making (Mutale), Cashbuild (Thohoyandou) and Incredible Connections (Pretoria). The cost of bricks includes transport. The total estimated cost amounts to R 548 000.00.

Potential benefits for the Education Centre at Mphephu Youth Centre

It is assumed the Government will provide the budget for Human resource (Director and staff)

Type of visit	No. of visits	Payment calculation	R
School visits: Primary	25 visits pa	80 children x R30 x 25	60 000
School visits: Secondary	20 visits pa	50 learners x R50 x 20	50 000
Researchers	20 visits pa	20 x R2000.00	40 000
International conference	100 participants	100 x R5 000.00	500 000
Tourists	60 pa	60 x R200.00	12 000
Donations	n/a	n/a	R1 000 000
Total income			**R1 662 000**

Appendix 9

Education centre: Cost estimates for the development at Sagole Spa

Items	**Estimated costs**	**R c**
100 000 standard bricks (including transport)	100 000 x R3	300 000.00
100 000 face bricks (including transport)	100 000 x R4	400 000.00
Building sand	100 loads (3 ton) x R700	70 000.00
Sand	100 loads (3 ton) x R800	80 000.00
Cement	400 bags x R70	28 000.00
Paint	100 x 20l x R600	60 000.00
Roofing		400 000.00
Electrification		200 000.00
Plumbing		150 000.00
Laboratory equipment		50 000.00
Library equipment		100 000.00
Computers and Internet	10 x R15 000	150 000.00
Furniture		100 000.00
Labour		500 000.00
Total estimated costs		2 588 000.00