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Sagole Spa Resort, Current and Potential Uses

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ABSTRACT

South African geothermal spring resources are either undeveloped or developed as family tourism facilities. Some of these are successful, while others are in a state of decay. A case in point is that of the Sagole spa in South Africa.

Sagole Spa is located at Tshipise Tsha Sagole, within the Mutale Local Municipality of the Limpopo Province in South Africa. The spa resort flourished during the 1980s as a tourism and recreational centre. Conference halls, chalets, the kitchen, sleeping accommodation and swimming pools were built. Currently the maintenance and infrastructure has declined. The swimming pools, the pavilion and the lawns have deteriorated.

The aim of the study is to investigate the diverse uses of thermal springs in order to determine the optimum use for the Sagole thermal spring. The literature study is used to identify potential uses while a checklist is used to compare the characteristics of Sagole with respect to those required for each potential use. Once the optimum use is identified, the development projects that can create jobs for the local community will be initiated.

This paper examines the potential of Sagole's geothermal thermal resource in terms of tourism, bottling water for commercial purpose, aquaculture in general, and specifically for fish farming and the cultivation of Spirulina.

1. INTRODUCTION

1.1 Background of the study

South Africa is relatively well endowed with thermal springs. The Limpopo province has more than any of the other provinces. A number of thermal springs are developed for recreational and tourism purposes while others, especially those found in previous homeland areas are not. Sagole Spa is one of those found in rural areas and is currently in a state of collapse.

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 Mutale population is characterized by poverty, illiteracy and lack of employment. The income of this predominantly rural, and economically poor area is based on pensions, subsistence farming and migrant labour. The municipality has been identified as having potential in mining, agriculture and tourism (Mutale Municipality, 2008/09).

1.2 Historical development of Sagole Spa

During the period 1979-1993, the Venda Development Corporation (VDC) and the Venda Tourism Department operated in partnership at the resort and was officially opened by His Excellency, Khosikhulu P R Mphephu, the former State President of the Republic of Venda, in 1988 (Mphephu, 1988). 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 to clients and patients of Mr. Tshikovha, a well-known traditional healer who lives 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 number of employees was 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 the swimming pools, the pavilion and the lawns deteriorated. The number of visits to the centre declined accordingly.

However, thermal spring resources can be used for many purposes that can benefit the local communities. The potential uses depend mainly on the physical characteristics of the geothermal spring resource.

The aim of the study is to investigate the diverse uses of thermal springs in order to determine the optimum use for the Sagole thermal spring. The two objectives related to the aim are:

1. To identify uses of thermal springs and physical requirements for each and

2. To determine the potential of the spring for tourism, bottling, aquaculture in general and specifically for fish farming and the cultivation of Spirulina.

A literature study is used to identify potential uses of thermal springs. A checklist is used to compare the characteristics of Sagole thermal spring with respect to those required for each potential use. Once the optimum use have been identified, development projects can be initiated. This could result in job creation and the alleviation of poverty in the local community.

The following section gives an overview of South African hot springs, their origin, distribution, diverse uses as well as the physical and chemical properties of Sagole thermal spring.

2. SOUTH AFRICAN THERMAL SPRINGS

2.1 Origin

It is generally accepted that all South African thermal springs are of meteoric origin (Kent, 1949). This is because there is no evidence of recent volcanic activity. The origin of each thermal spring is attributed to the local presence of deep geological structures such as folds, faults and dykes that provide a means for the circulation to depth and the return of heated water to the surface (Olivier et al., 2008). Since temperature increases with increasing depth in the earth, cold water from rain, rivers or lakes may descend down a fault to a depth of several kilometres. This underground water is heated due to the geothermal gradient, expands and rises up another fault, creating a convection system (Hoole, 2000; LaMoreaux & Tanner, 2001).

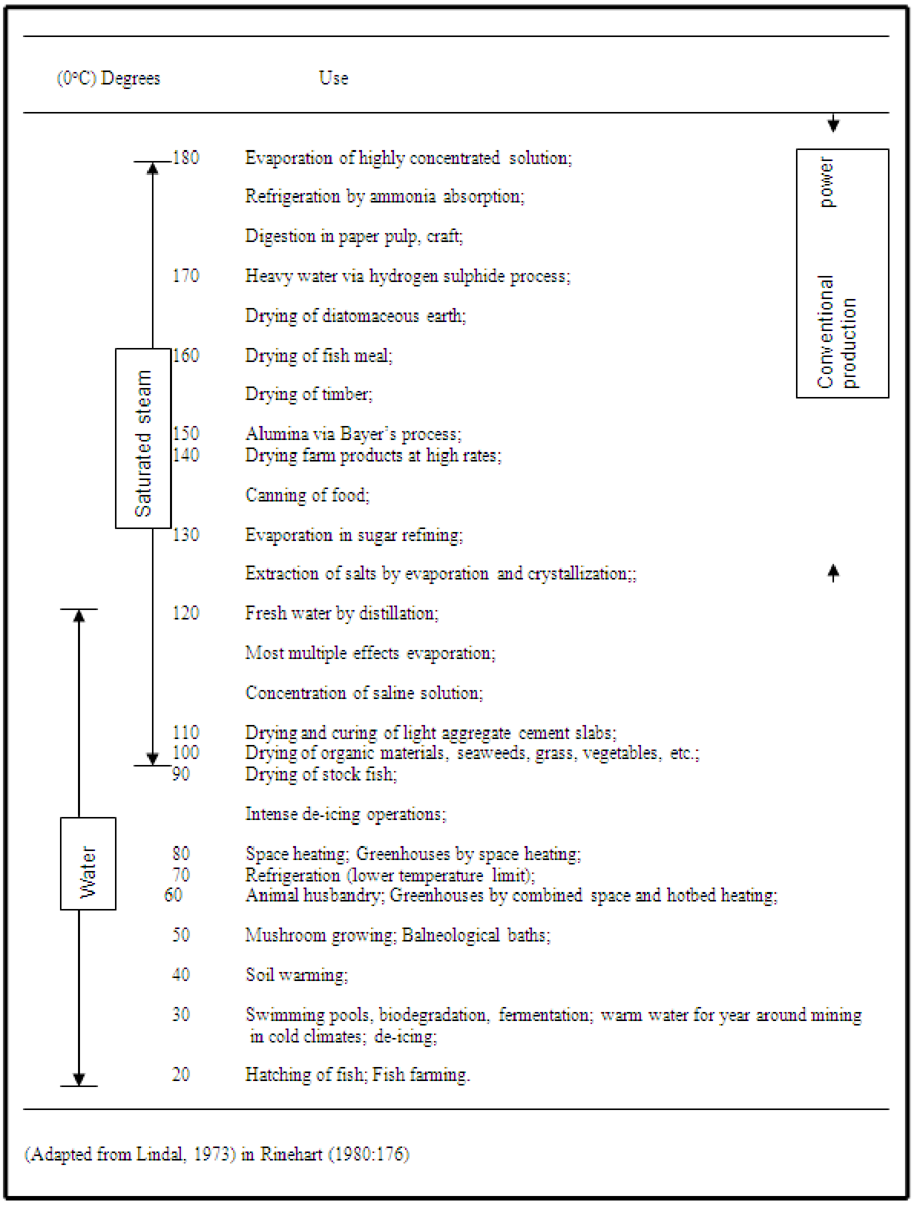
2.2 Distribution

Generally, thermal springs in South Africa are confined to a broad band (400 km wide) extending across more than half of the country. They extend from the Western Cape through Kwazulu-Natal, the Free State and Gauteng up to the Soutpansberg in Limpopo (Olivier et al., 2008).

2.3 Uses of thermal springs

Geothermal resources at different temperatures can be used for various purposes (Rinehart, 1980). These uses, together with the required thermal characteristics, are listed in Figure 1. Other uses that are not included in Figure 1 include: Bottling for commercial use, mining rare minerals/elements or chemical extraction, and the agricultural production of algae (Stahrl & Adam, 1979; Rinehart, 1980; Lund, 2000; Lund & Freeston, 2001).

Figure 1 Temperature of geothermal fluids required for various purposes



The following section discusses the study area, geographic location, the physical and chemical characteristics, socio-economic characteristics and historical development.

3. STUDY AREA

3.1 Geographical location

Figure 2 shows the location of thermal springs in Limpopo, South Africa. Sagole thermal spring is located in the extreme north-east section of the Limpopo Province. The Mutale Municipality boarders Musina Municipality and Zimbabwe in the north, Mozambique in the east, Makhado Municipality in the West and Thulamela Municipality in the South. The Northern part of the Kruger National Park lies east of Sagole Spa. The thermal spring is found at about 53 kilometres north-east of Thohoyandou, the previous capital of the Venda Homeland. Other nearby towns includes Musina in the north, and Tshilamba (about 50 km from Sagole) which is 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 (Olivier et al., 2008).

3.2 Physical and chemical characteristics

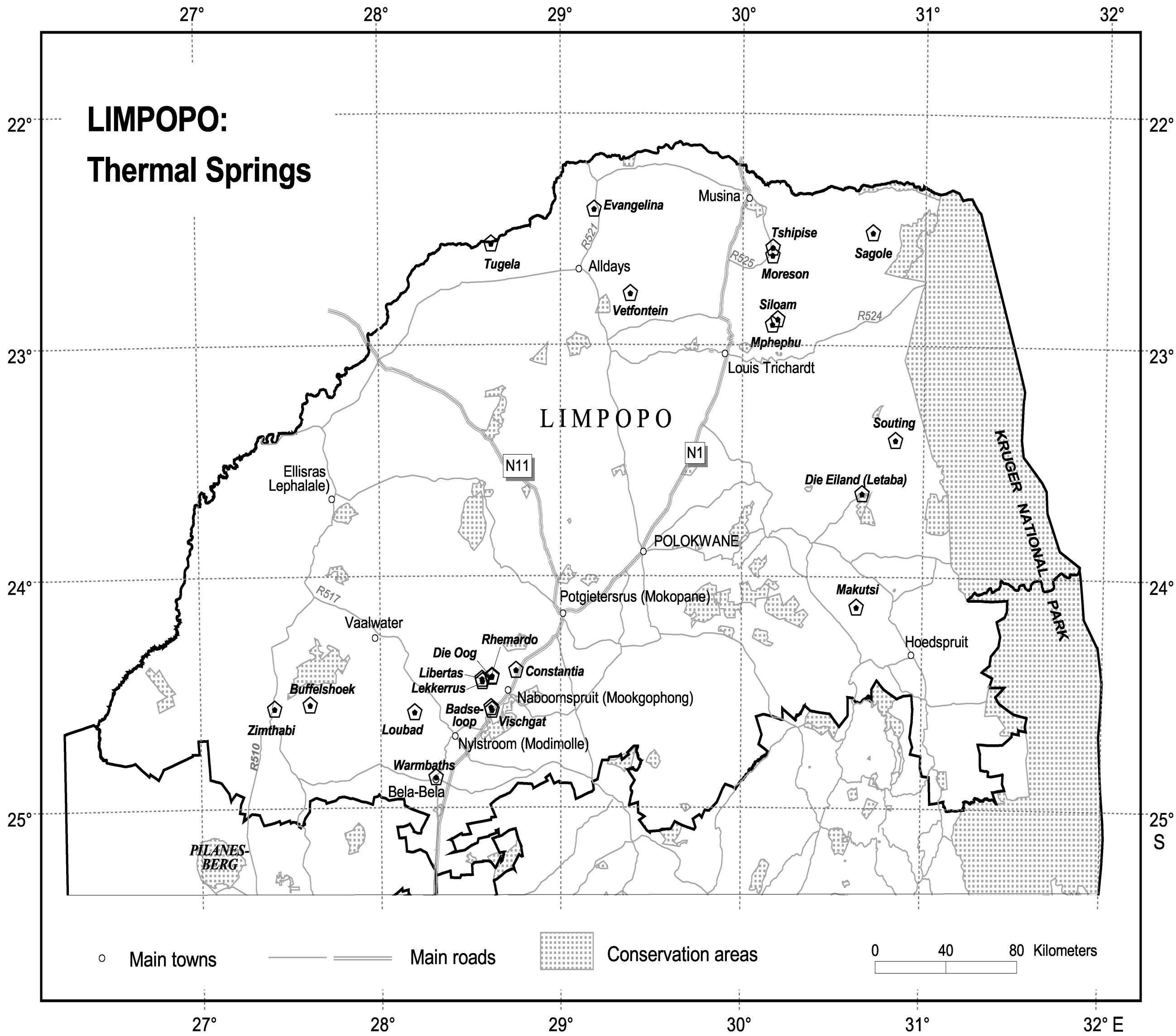
3.2.1 The terrain

The terrain morphology consists of closed hills and mountains with moderate and high relief and lowland hills. The area is underlain by igneous rock, while the earth's surface consists of rocky outcrops, lithosoils, and deep steep inclines.

Vegetation

The vegetation types in the surrounding area include the mopani veld, mixed bush veld and sourish mixed bushed (Development Bank of Southern Africa, 1989).

Figure 2. The location of thermal springs in Limpopo Province, South Africa



Source: Olivier et al., 2008.

Table 1 Population Groups by Age and Gender

Age	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.

Figure 3 Type of vegetation in the area

Source: South African National Parks (2009) SANParks.org forums.

3.2.2 Climate

The Sagole 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 falls in summer and it extends from October to the end of March. It is generally dry from April to October. The local community uses the hot spring water for drinking and all domestic uses (Development Bank of Southern Africa, 1989).

The average annual temperature is 22 ℃. Summers are very hot and dry while winters are cool and dry.

The following section provides information on the socio-economic characteristics of the study area.

3.3 Socio-economic characteristics

3.3.1 Population

Table 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), Colored (29), Indians (16) and Whites (421), and the total population were 78 922.

3.3.2 Monthly income

Table 2 below shows the individual monthly income for the 2007 census. The majority of persons are still earning below R1000 per months. A total number of 14 881 are employed, 9 005 unemployed and 31 144 not economically active. In general, the majority of people are poor and unemployed (Statistics South Africa, 2007: Mutale Municipality, 2008/09).

3.3.3 Economic activities

Very little economic activity occurs in this region. Some extensive farming (crop and livestock) is more prevalent in the eastern areas. Other agricultural activities in the area include orchards, chicken production, and farming with maize. Favourable crops in the area include: bananas, mangoes, pawpaw, ground nuts, tomatoes, avocados, litchis, tea, oranges, and marula, (Mutale Municipality, 2008/2009).

Table 2 Individual Monthly Income Profile

Category	2007 (number)
None	1797
R1- 400	3 589
R401- 800	2 535
R801- 1600	2 020
R1601- 3200	1 519
R3201-6400	1 702
R6401- 12800	734
R12801- 25600	-
R25601- 51200	117
R51201- 102400	-
R102401- 204800	117
R2048001 or more	-
Response not given	749
Total	14 881

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

Sagole Spa area is accessible through a new tarred road. Electricity is available in the area but not yet connected to the Spa. The bus and taxi transport is not well developed.

The following section discusses the data and methodology used in this study.

4. DATA AND METHODOLOGY

The aim of the research is to determine the optimum use for the Sagole thermal spring.

An extensive literature survey was conducted and visits were undertaken to the Musina Spirulina plant (Musina, South Africa), the Liskey Farms (Oregon), the Geo-heat Center (Klamath Falls, USA), Canby (California), and Prawn Park (Taupo, New Zealand) and Wairakei (New Zealand so as to gather information on the use of thermal springs for the growing of Spirulina, aquaculture, Geothermal Energy production.

Research field trips were undertaken to Sagole thermal spring where the temperature was measured at Source and water samples collected for later analysis by the Agricultural Research Council in Pretoria.

Thereafter, the characteristics of thermal waters at Sagole were compared with the criteria needed for each of the uses. A preliminary identification of uses for Sagole was thus obtained. Thereafter, more detailed comparisons were conducted to identify the potential for specific uses.

5. ANALYSIS

5.1 Chemical Properties of Sagole Spring

Table 3 gives the physical and chemical properties of the hot spring.

Table 3 Chemical properties of Sagole hot spring.

Minerals in water	Mg/l
Temperature ^{o}C	45,9
SAR	8.1
TDS	173.9
Conduct.(mS/m)	33.0
pH	8.7
pHs	8.9
Silica ($Si0_2$)	75.0
Sodium (Na)	58.5
Carbonate ($C0_3$)	16.5
Bicarbonate ($HC0_3$)	64.1
Sulphate ($S0_4$)	17.8
Potassium (K)	1.1
Calcium (Ca)	3.9
Magnesium (Mg)	0.0
Fluoride (F)	0.7
Chloride	44.1
Phosphate	0.1

Sources: Olivier et al., 2008

The water temperature at the source is 45,9 ^{o}C. The chemical analysis of the water indicates that the water is not highly mineralized since the Total Dissolved Solids content is only 173.98 mg/l. According to Bond's (1946) classification system, Sagole spring water is alkaline sodium bicarbonate and carbonate water with pH 8.72. The principal constituents in water are: silica, sodium, bicarbonate, carbonate, chlorine, and sulphate. The water is potable and is used by the local community as their main source of domestic supply (Kent, 1962; Winfield, 1980).

5.2 Potential Uses of Sagole Spa

Table 4 gives the summary of some uses of geothermal resources with specific requirements for each.

Temperature criteria were used to identify potential uses for Sagole Spa (45,9^{o}C). Since the spring water at Sagole is around 46^{0}C, the following uses could be rejected: power generation (74^{o}C), mineral extraction (250^{o}C) and greenhouse irrigation (60^{o}C). For mushroom farming (20-90^{o}C), and crop drying, Sagole's water will have to be heated further to reach the maximum level required. Areas where conditions at Sagole and the requirements coincide include recreation and tourism, balneology, fish farming, spirulina production and bottling for commercial use.

The following section analyses data for the potential of Sagole, namely, recreation, tourism, balneology, aquaculture (fish farming and spirulina production) and bottling for commercial purposes.

5.1.1 Recreation, tourism and balneology

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). This was confirmed by Opperman and Chon (1997) as they considered 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 et al., 1996, Opperman & Chon 1997; Edgell, 2006).

In 2002, unemployment dropped from 25% to 7% in Argentina within a period of four years due to development in the tourism industry (Pesce, 2002; Ghosh et al., 2003). Estimated figures for the Middle East–Africa region show that tourism generated 9,8% of the Gross Domestic Product (GDP) in 1996 (Creemers & Wood, 1997; Edgell, 2006).

Tourism involved about 665 million people in international travel 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.

According to Wilson et al., (2001) requirements for successful rural tourism include factors such as good leadership, support and participation of local government, sufficient funds for tourism development, strategic planning, coordination and cooperation between business and local leadership, coordination and cooperation between rural tourism entrepreneurs, information and technical assistance, widespread community support for tourism and a complete tourism package. All these factors are important for all forms of tourism. For family tourism, the availability of diverse recreational facilities is necessary for success.

Table 4 A summary of uses and their specific requirements.

Potential Use	Specific requirement/s
Generation of electricity	Temperature: 74° C (for a binary system plant) >150° C (for Flash steam plant) flow rate
Medicinal use (bathing and soaking)	Water quality, high mineral content, carbonic, sulphurated, bicarbonate, and sodium chlorinated water.
Recreation and tourism	Recreational facilities available Temperature (30°C), high flow rate, chemical properties conform to criteria for bathing
Bottled water	High water quality, high mineral content, suitable water appearance, taste, odour. Chemical aspects (Maximum acceptable limits WHO Levels (units: µg/l): Arsenic: 10; barium: 700; boron: 300; chromium: 50; manganese: 500; molybdenum: 70; selenium: 10; uranium: 15; and fluoride: 1, 5 (mg/l).
Minerals extraction	Temperature: > 250 °C
Crop drying	40 – 100° C temperature range.
Fish/ prawn farming	Water quality, quantity and temperature important. Dissolved oxygen: > 4-5 ppm; pH: 6-9; alkalinity, hardness, chlorine, carbon-dioxide, salinity, & hydrogen sulfide should be controlled.
Spirulina	Climate: tropical and subtropical. Water carbon dioxide content (to be controlled) dissolved solids (10-60 g/l); pH: 8,5-10,5; Temperature: 26°C-37°C; high solar radiation; macro & micronutrients presence (C, H, Mg, S, Na, Cl, Ca, Fe, Zn, Cu, Co & W)
Mushroom farming	Temperature: 20 - 90°C, Dark and moist environment, very fertile growing medium, High temperature required for pasteurisation of substrate
Greenhouses irrigation	Temperature: >60° C (hotbed heating included)

The strengths of Sagole Spa Resort as a recreation and tourism centre are as follows: The basic infrastructure such as an administration office, chalets, sleeping accommodation halls, houses and a modern kitchen are available, albeit in a dilapidated state. The road infrastructure between Thohoyandou (main urban centre) and Sagole Spa Resort has been tarred. Its close proximity to other recreation and tourism areas such as The Big Tree, Kruger National Park, Tshiungani Ruins, and the Nwanedi Resort are further plus factors.

Challenges facing the redevelopment include: A champion to lead the redevelopment process (good leadership) as well as a development strategy that should include all interested stakeholders such as the local communities, local municipality, national government and the private sector (strategic planning), and a widespread community support for tourism.

The potential economic, socio-cultural and environmental advantages are as follows:

- Economic: An increase in overall employment and a diversification of local economic activities.
- Socio-cultural: Strengthening the local culture and identity through promoting local products and services, decreased migration of young people, together with an improvement of the quality of life.
- Environmental: Protection and preservation of the rural cultural/natural heritage, less environmental impact due to the small-scale character of rural tourism entrepreneurs, and minimizing waste and safeguarding environmental qualities and preserving biodiversity (Sharpley, 2002; Lordkipanidze et al., 2005).

5.1.2 Aquaculture: 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, catfish, 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.

According to the World Bank (1991), 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 et al., 1993).

Table 5 lists the preferred water quality ranges for fish culture.

One advantage of Sagole thermal spring is that its water is not toxic. The water quality is high and has been used for drinking since the area was inhabited. Comparison of the chemical characteristics of water at Sagole (Table 3) with the requirements for fish production (Table 5) reveals that water Sagole meets the majority of criteria. However, the chlorine level (44.1 mg/l) is above the acceptable level and needs to be controlled. Tests on alkalinity, hardness, carbon dioxide and salinity also still need to be done.

The available open land at Sagole can be used for fish ponds. Jobs can be created to the local community.

5.1.3 Aquaculture: Growing micro-algae (Spirulina)

According to Bowles (2007), 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 for instance *Isochrysis, Chaetoceros, Chlorella, Dunaliella* and *Arthrospira* (Spirulina). This section focuses on the production of Spirulina, an edible micro-alga. According to (Sanchez et al., (2001), Spirulina is "a photosynthetic, filamentous, spiral-shaped, multi-cellular and green-blue micro-alga".

There are a number of reasons for focusing on Spirulina. These include, inter alia, the technology for mass production is well tested; the cost of production has dropped from US$11-15 per kg to US$6 per kg in recent years; Spirulina is versatile as it serves both as a human health food and as an animal feed (Li & Qi, 1997); and various 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).

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).

Table 5 Water quality factors commonly used for monitoring procedures, and preferred ranges for fish culture.

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

Source: Boyd & Raffety, 1998

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, a Spirulina culture should be continually mixed so that all the cells are illuminated intermittently. Other important factors include: dissolved solids content (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 hence reduces the production costs (Bojadgieva *et al*., 2002; Fournadzhieva *et al*., 2003). Another benefit for using geothermal resources in the production of Spirulina is that geothermal CO_2 and energy optimizes photosynthesis. In geothermal water, enough CO_2 is naturally present and there is no need to add more CO_2 - so this reduces the cost of production. Furthermore, geothermal water can be used for nutrition algal media preparation, and for algal biomass drying (Fournadzhieva *et al*., 2003).

A sub-tropical to tropical climate is beneficial to high Spirulina production rates. The production of Spirulina at plants in Musina, Limpopo, South Africa and Imperial Valley in California stops during winter months because the water temperature falls below acceptable levels (California Energy Commission, 2005; Sebola, 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 et al., 1991; Bojadgieva et al., 2000; Fournadzhieva. *et al*., 2003; Bojadgieva *et al*., 2005).

Sagole Spa meets most of the requirements as indicated in Table 6. For example, the mean monthly temperature of the coldest month is 7.5^{o} C and the mean monthly maximum temperature of the hottest months is 40^{o}C. High solar radiation occurs throughout the year, with the area receiving less than 25 days of cloud cover per annum (Grobbelaar, 2008).

Growing micro-algae for Spirulina at Sagole Spa Resort can create jobs for the poor rural community in the area.

5.1.4 Bottling water for commercial purpose

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).

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 Organization (WHO: 2000), European Union and South Africa (Mamba et al., 2008). Criteria that should be considered when deciding to bottle drinking water for commercial purposes are: water appearance, taste, odour, and chemical aspects (WHO, 2006; WHO, 2000). Table 6 gives guideline values for some of the naturally occurring chemicals in water.

When thermal spring water at Sagole is compared with guideline values for the World Health Organization, the European Union and South Africa (as indicated in Table 6), it is clear that Sagole meets all the requirements for drinking water

Table 6 Health related chemical parameters in drinking water.

Chemical	**Unit**	**WHO**	**SA**	**EU**	**Sagole Spa**
Arsenic	µg/l	10	10	10	**4.25**
Barium	µg/l	700	-	-	**1.17**
Boron	µg/l	300	-	-	**29.85**
Chromium	µg/l	50	100	50	**6.0**
Chloride	Mg/l	250	200	250	**44.09**
Fluoride	Mg/l	1.5	1	1.5	**0.72**
Lead	µg/l	10	20	10	**2.51**
Manganese	µg/l	500	100	50	**4.2**
Molybdenum	µg/l	70			**1.6**
Selenium	µg/l	10	20	10	**6.6**
Sulphate	Mg/l	500	400	250	**17.78**
Uranium	µg/l	15	-	-	

Adapted from: World Health Organisation, 2006; Mamba, Rietveld & Verberk 2008

6. DISCUSSION AND CONCLUSION

The current infrastructure at Sagole which includes a tarred road, offices, 6 chalets, 2 x 40 beds dormitories and 2 self-catering cottages and hot water bubbling out at about 46°C, are strengths for redevelopment for recreation balneology and tourism. A strategy needs to be developed for tourism management and marketing. Local people, the municipality, national and provincial government and the private sector need to work together to address challenges facing the Spa.

For the use of Sagole thermal spring water for aquaculture (fish farming and spirulina), the high quality water, a water temperature of 46 °C and the availability of land are strengths. Collaboration with the local community, municipality, private sector, Musina Spinrulina, institutions of higher learning, provincial and national government can initiate pilot projects in this area.

The bottling of water for commercial use is also feasible since the water quality standards for drinking water are met.

Sagole is be suitable for all the four potential uses. However, considering the availability of infrastructure, redevelopment for recreation and tourism should be the first priority.

It is vital that, before any development projects are considered, a detailed cost-benefit analysis needs to be done for all relevant economic, social and environmental factors.

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