# A TRANSDISCIPLINARY EXPLORATION OF RESILIENCE: THE CASE OF THE PARYS WATER SUPPLY AND SANITATION SYSTEM

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## SOLEMN DECLARATION

I declare herewith that the mini-dissertation entitled:

**A transdisciplinary exploration of resilience: the case of the Parys water supply and sanitation system**

which I herewith submit to North-West University in completion of the requirements for the degree Magister Artium in Development and Management (Water Studies) is my own work and has not been submitted to any other university.

I understand and accept that the copies that are submitted for examination are the property of the university.

Signature of candidate: _____

University student number: 12393568

Signed at _____ this ____ day of _____

Declared before me on this_____ day of _____

Commissioner of Oaths:

## DEDICATION

This mini-dissertation is dedicated to

God the Father,

the Son

and the Holy Spirit.

I appreciate your constant support from the beginning to the end of this study.

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My first acknowledgement goes to God for promising me things in advance so that I could through faith accomplish them. The promises made me bold in the face of obstacles. It does take a village to raise a child. I would also like to acknowledge the following people, who enabled me to start, continue and complete this research:

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## ABSTRACT

The community of Parys is experiencing persistent water and sanitation problems despite various interventions. The problems are interconnected and emanate simultaneously from the human (individual, social and government), the support (economic and infrastructure) and the natural (environment and resource) systems. These systems are coupled and referred to as a social-ecological system.

The major finding was that the reason behind the persistence of the problems is the so-called “Nature flat view” that stakeholders have of the Parys water and sanitation system (WSS) which is a social-ecological system. This view is not an ideal foundation from which to address the WSS problems since it does not adequately consider the complexity and dynamics of the WSS. The research highlights a more appropriate approach, i.e. the emerging Nature evolving view of social-ecological systems. Its concepts of adaptability, transformability, resilience, the adaptive cycle and panarchy were used to explore the WSS problems and to propose interventions. The interventions focus on stakeholder comprehension of the complexity and the dynamics of the WSS as well as its management through managing its resilience.

A transdisciplinary research approach was used to explore the loss, creation and maintenance of resilience of the WSS. It was supported by the selected research paradigm (constructivism), design (qualitative) and strategies (phenomenological and case study). The data-capturing methods involved stakeholders’ participation through semi-structured interviews (12 stakeholders); visits to municipal works (12 stakeholders); meetings with municipal workers (7 stakeholders); multi-stakeholder workshops (64 stakeholders) and a feedback meeting (28 stakeholders).

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| | |
|---|---|
| CBD | Central Business District |
| CFM | Community Feedback Meeting |
| CG | Claudia Gouws |
| COD | Chemical Oxygen Demand |
| CRS | Catholic Relief Services |
| CoGTA | Department of Cooperative Governance and Traditional Affairs |
| CuDyWat | Cultural Dynamics of Water |
| DAF | Dissolved Air Flotation |
| DPLG | Department of Provincial and Local Government |
| DW | Dalcroze Workshop |
| DWAF | Department of Water Affairs and Forestry (amended to: DWA) |
| DWA | Department of Water Affairs (amended to: DWS) |
| DWS | Department of Water and Sanitation |
| EPWP | Expanded Public Works Programme |
| FV | Facilitated Visit |
| FWM | First Work Meeting |
| FMW | First Multi-stakeholder Workshop |
| GM | Ginster Martin |
| IDP | Integrated Development Plans |
| IWRM | Integrated Water Resource Management |
| LED | Local Economic Development |
| LHWP | Lesotho Highland Water Project |
| MDG | Millennium Development Goal |
| MiG | Municipal Infrastructure Grant |

| | |
|---|---|
| MNWFM | Minutes of Ngwathe Water Forum meetings |
| NT | Notes on Thesis |
| NWU | North West University |
| OA | Oral Archive |
| P | Participant |
| PMS | Performance Management System |
| RDP | Reconstruction and Development Programme |
| RSA | Republic of South Africa |
| SAVE | Save the Vaal Environment |
| SES | Social-Ecological Systems |
| SFV | Second Facilitated Visit |
| SMMEs | Small, Medium and Micro enterprises |
| SSI | Semi-Structured Interviews |
| StatsSA | Statistics SA |
| SWM | Second work Meeting |
| SMW | Second Multi-stakeholder Workshop |
| TMR | Terblanche Maite Ruth |
| TWB | The World Bank |
| UN | United Nations |
| UNCED | United Nations Conference on Environment and Development |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNWCED | United Nations World Commission on Environment and Development |
| WSS | Water and Sanitation System |

# CHAPTER 1

# CONTEXT OF THE PARYS WATER AND SANITATION PROBLEMS

The chapter outlines the existence of a real-world problem in the form of the Ngwathe Local Municipality not providing adequate water and sanitation services to the community of Parys. It provides a background to the current water and sanitation situation in Parys through an empirical literature review which contextualises the research title by indicating that the water and sanitation problems stem simultaneously from the social and ecological aspects within and outside the system on various scales, i.e. individual to global. The chapter presents the potential for further research to find solutions. The emerging concepts of social-ecological systems, adaptability, transformability, resilience, the adaptive cycle, panarchy and transdisciplinary research are proposed as viable means to address the challenges of the Parys water and sanitation system (WSS). The framework within which the new research is performed is provided in the form of research questions, objectives, hypothesis, methodology, knowledge sources and ethical considerations.

## 1.1 Orientation and rationale

### 1.1.1 Challenges of the Parys water and sanitation system

Ngwathe Local Municipality, which falls under the Fezile Dabi district municipality in the Free State province, is one of a number of South African municipalities grappling with the problem of providing satisfactory water and sanitation services to towns under their jurisdiction, e.g. Parys (Ngwathe Local Municipality, 2006: 28; Tempelhoff *et al.*, 2008: 17; Ngwathe Local Municipality, 2010: 5; Ngwathe Local Municipality, 2011: 16). Ngwathe Local Municipality is classified as a type B3 municipality, which

means that it encompasses small towns (Parys, Koppies, Edenville, Vredefort and Heilbron) with relatively small populations and a significant proportion of urban residents, but with no large town as a core centre (RSA, 2009: 16; Municipal Demarcation Board, 2013: 9; Lemeko, 2011: 2) (see Figure 1).


**Figure 1:** Fezile Dabi District Municipality, Ngwathe Local Municipality and the town of Parys (Main, 2015: 1)

According to the Ngwathe Local Municipality annual report of 2005/6 (Ngwathe Local Municipality, 2006: 5), the population of Parys was as follows: Parys town area (10 950 with an annual growth rate of 0.5%); Tumahole (61 160 with an annual growth rate of 5%); and Schonkenville (840 with an annual growth rate of 5%) However, the 2012/17 Integrated Development Plan (IDP) indicated the population of the Parys town area as 44 744, which was projected to rise to a mere 49 906 by

2030 (Ngwathe Local Municipality, 2012: 28). These figures do not correspond to those given in the 2005/6 annual report.

The Parys WSS, which is the focus of this study, comprises an ecological system in the form of a section of the Vaal River from the raw water abstraction point for the Parys water purification plant just below the Vaal River Barrage to the discharge point of the wastewater treatment plant. The Vaal River forms the northern boundary of the town and also serves as a boundary between three provinces, namely the Free State, Gauteng and North West (Ngwathe Local Municipality, 2006: 4) (see Figure 2).

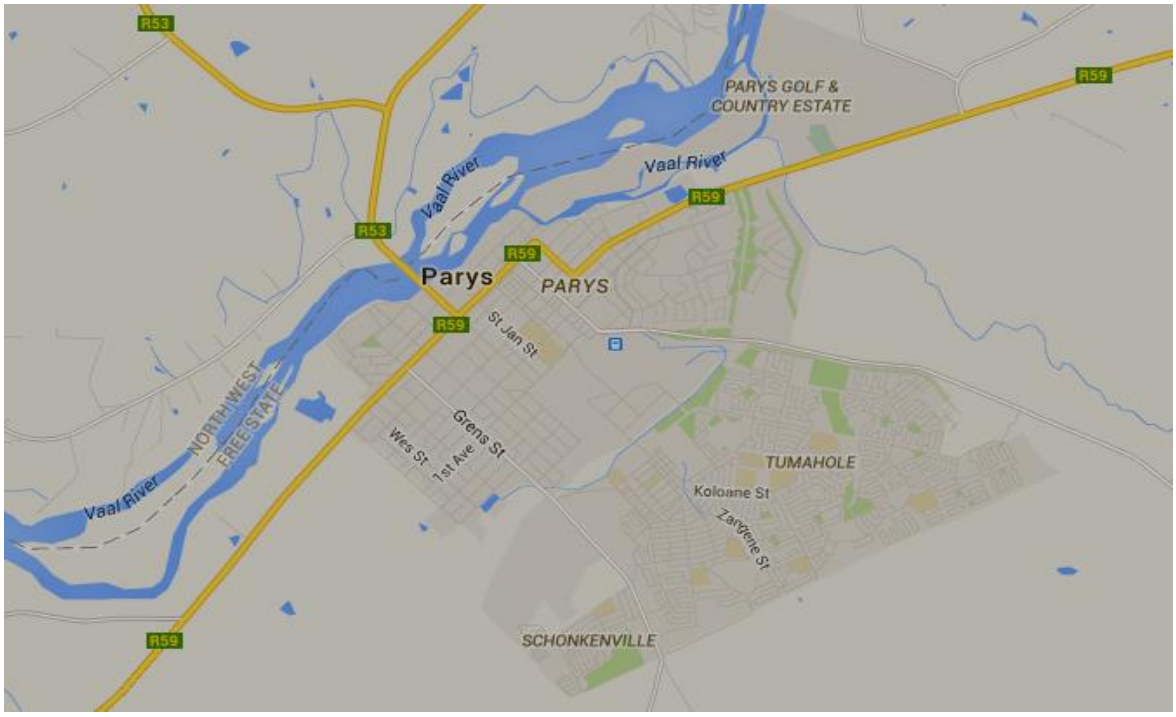


**Figure 2:** The Vaal River and the town of Parys (Google maps)

The social system consists of Ngwathe Local Municipality and the Parys community. Ngwathe Local Municipality includes the human resources (management and workers), the water and sanitation infrastructure as well as the management and technical processes. The Parys community includes households, businesses and industry in the Parys town area, Tumahole and Schonkenville. Tumahole is referred to by the community as a township, and is separated into what they call locations (TMR. OA. FV1. Operator 1. 11 October 2013; TMR. OA. FV2. Operators 2 and 3. 6 June 2014; TMR. OA. FV3. Operator 4. 6 June 2014; TMR. OA. FV4. Operators 5 and 6. 6 June 2014; TMR. OA. FWM. 13 June 2014; TMR. OA. SWM. 13 June 2014; TMR. OA. SMW. 1 August 2014) (see Figure 3).

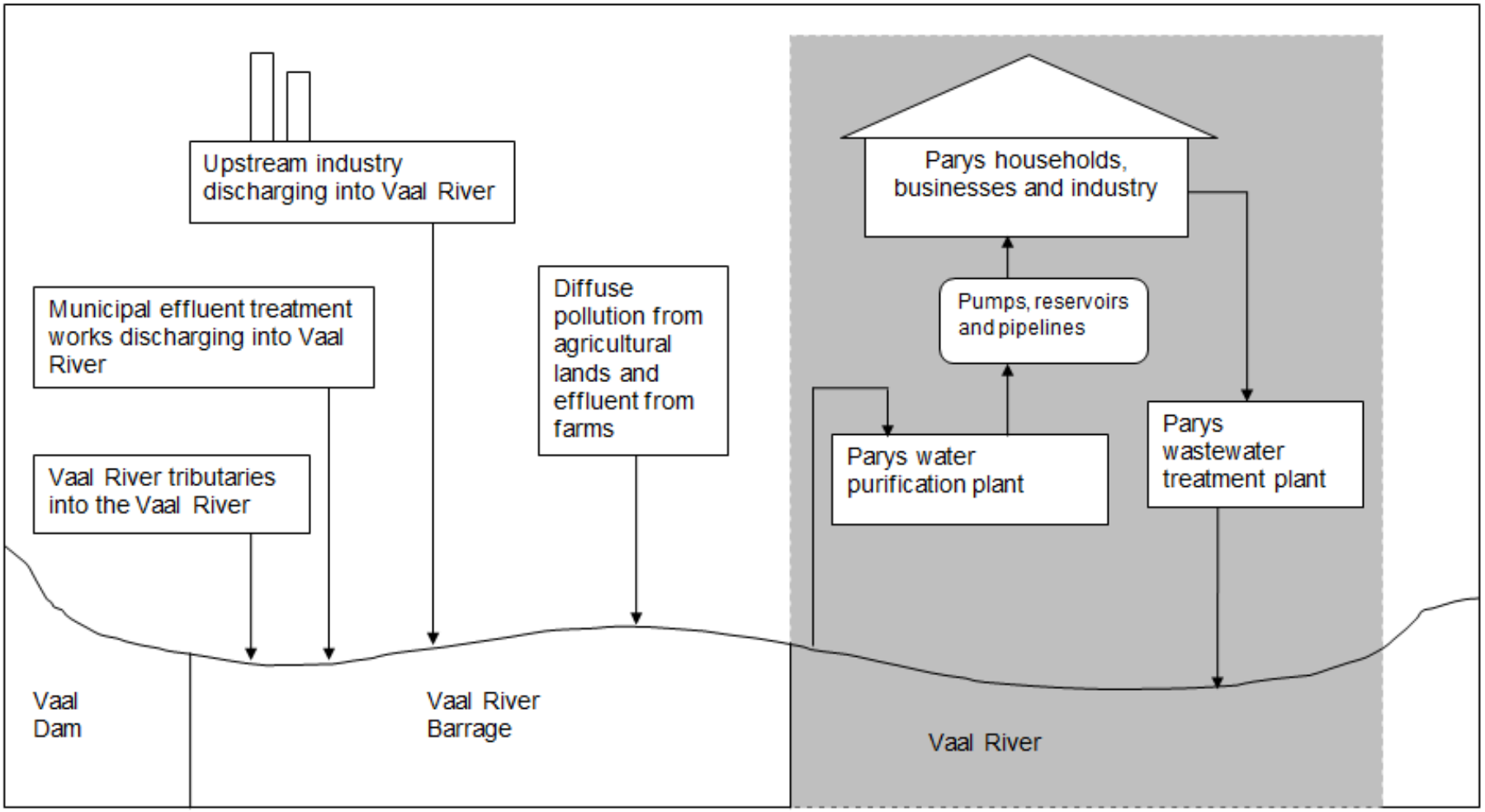


**Figure 3:** Spatial boundary of the Parys water and sanitation system

In 2008, the community of Parys staged a protest against their local authority, Ngwathe Local Municipality, as a result of poor water and sanitation service delivery. The issues highlighted during the protest were: intense pollution of the Vaal River water in the vicinity of the town and unacceptable potable water quality delivered by the water purification works (Tempelhoff *et al.*, 2008: 13; Van Riet & Tempelhoff, 2009: 35).

Several years have passed since that significant water and sanitation service delivery protest, but the water and sanitation problems remain. According to successive Ngwathe Local Municipality annual reports (2005/6, 2009/10, 2010/11) and the 2012/17 IDP, Ngwathe Local Municipality is contending with the following water and sanitation problems: potable water supply and water quality issues; sanitation problems in most towns under its jurisdiction; housing shortfalls; continued disclaimer of the Auditor-General's reports; low revenue base; a high rate of poverty; unemployment, especially among the youth; and cable theft leading to power outages (Ngwathe Local Municipality, 2006: 28; Ngwathe Local Municipality, 2010: 5; Ngwathe Local Municipality, 2011: 16; Ngwathe Local Municipality, 2012: 4; Ngwathe Local Municipality, 2012: 16).

### 1.1.2 The South African and global context of the Parys water and sanitation problems

Gunderson & Holling (2002: 7), maintain that complex problems associated with sustainable development are not just ecological, economic or social, but that they are a combination of the three. The works of various researchers covering the period from the establishment of Parys as a town to date highlight the environmental,

economic and social challenges relevant to the Parys WSS. They provide an historical trajectory of the Parys WSS to its current situation. Bohensky (2008: 3) states that the lingering consequences of past management actions are one of the factors affecting the ability of the current managers to attain sustainable development.

Funke *et al.* (2007: 12) give a broad description of changes in patterns of water resource usage in South Africa covering the time period from when Parys was established in 1876 (Ngwathe Local Municipality, 2010: 9). The patterns include: the altruistic approach of reciprocation with regard to natural resources by the Khoisan who led a subsistence and nomadic lifestyle; the formal system of private land ownership established by the Dutch emigrants; the permanent land tenure and riparian principle introduced under the British rule, which led to the Irrigation Act of 1912; the Water Act of 1956 under apartheid which disempowered non-white South Africans with regard to access to water in what were demarcated as areas of exclusive white ownership; and finally the transformation of water legislation under the present democratic dispensation. The apartheid Population Registration Act (30 of 1950) defined a white person as a person who appeared white and was generally accepted as a white person. All other people were seen as non-white.

#### *1.1.2.1 The pre-apartheid period*

The town of Parys depended on the Vaal River as a source of water from its beginning (Van Riet & Tempelhoff *et al*., 2009: 35). However, other water resources were also explored by the farming community. These included fountains, farm dams on and off the river, wells in the vicinity of the river or on top of fountains and

boreholes (Gouws, 2013: 304). In the year of its establishment the town council of Parys began addressing the hurdle of distributing water from the Vaal River to the town via irrigation channels, which were later replaced with asbestos water pipelines around 1948 (Gouws, 2013: 344). To overcome the problem the council focused on damming the water upstream of Parys (Gouws, 2013: 321).

Damming the Vaal River upstream of Parys was done by building weirs across the river at different times from 1887 (Gouws, 2013: 321; CG. OA. NT. 6 March 2015). The water was mostly for farm irrigation and household needs; however, the Parys weir of 1920 was built to dam the water for water sports and related tourist activities (CG. OA. NT. 6 March 2015). These structures point to the beginning of an engineered system built to connect the community of Parys (a social system) with the Vaal River as a natural resource (ecological system) to meet societal needs.

Water problems in Parys started before the development of the Vaal River as a water resource to supply Johannesburg with potable water in the early twentieth century. Prior to the developments, the residents of Parys and local irrigation farmers experienced water shortages during winter periods (Tempelhoff, 2003: 53). On farms, boreholes were sunk to lessen the impact of the 1933 drought, which resulted in the Vaal River running dry (Gouws, 2013: 315). By the 1960s rain water harvesting was added to the list of water sources used by people in the area (Gouws, 2013: 308).

The demand for water from the Vaal River increased from 1915 due to industrial activities, first on the Witwatersrand and subsequently in the Vaal Triangle upstream

of Parys. The Vaal River Barrage (completed in 1923), the Vaal Dam (1938–83) and the Lesotho Highland Water Project (LHWP) from 1998, were used to access more water from the Vaal River for the on-going developments (Tempelhoff *et al*., 2007: 116). As the upstream demand for water from the river increased, the Parys community had to negotiate for its portion of access to the natural resource (Tempelhoff, 2003: 53).

Another ecosystem service requirement, which has increased alongside the demand for more water, has been the need for the Vaal River to dilute, treat and transport wastewater. The deterioration of the quality of South Africa's water resources, such as the Vaal River, is a result of the following: wastewater from industrial development; legacies of gold and coal mining; diffuse pollution by the agricultural sector; and dysfunctional municipal wastewater treatment works. The deterioration manifests itself in the form of eutrophication of surface waters; heavy metal contamination; acid mine drainage; increased salinity; increased suspended solids levels; the presence of bacterial and viral pathogens; pesticide/insecticide contamination; and contamination by estrogen as well as estrogen-mimicking substances (Munnik *et al*., 2011: 3). This indicates how heavily dependent economic and social development are on the ecological system.

In 1930, Steynberg and Viljoen (1930: 518) reported on the impact of the imposition of a 1 mg orthophosphate effluent discharge standard on the quality of water in the Vaal River Barrage. The standard was meant to address algal growth at the Rand Water abstraction point for potable water preparation. They indicated that only 24% of wastewater treatment plants were able to comply with the standard. Furthermore,

the 58% reduction in orthophosphate loads that was achieved was eroded to 24% by diffuse pollution. This indicates that pollution of water in the Vaal Barrage has been a persistent problem facing the downstream town of Parys. Social-ecological systems depend on the capacities of their environments to provide resources and to absorb waste. These systems fail when the constraints of their environments are not respected (Bossel, 2001: 5).

According to Van Eeden (cited by Gouws, 2013: 320), the quality of the Vaal River water in Parys was already described as unhealthy and bad in 1902 when a soda water factory was established in the town to provide an alternative source of drinking water. Riparian owners used alternative water sources for domestic needs as the Vaal River water was muddy (Gouws, 2013: 344). Some people in the farming community downstream of Parys resorted to purifying their water by adding a teaspoon of lime per 13.6 litres of water (Gouws, 2013: 320). This indicates that the Vaal River water may have inherently been not suitable for drinking.

By 1940 the community of Parys started experiencing problems with water quality in and below the Vaal River Barrage due to anthropogenic factors (Van Riet & Tempelhoff, 2009: 34). Van Riet & Tempelhoff (2009: 35) alluded to the fact that in 1941 Rand Water declined a request by the town fathers to link Parys to the Rand Water supply network. They rather supported the option of Parys constructing its own water purification works through funds from the government.

#### *1.1.2.2 The apartheid era*

Apartheid was a systematic way in which the National Party, which came into power in 1948, formalized racial segregation through laws. The legal instruments enabled apartheid in the following manner:

- They prohibited extra-marital sex and marriages between white and non-white races, based on a national register in which every citizen's race was recorded.
- They mandated segregation in all public services, public buildings, and public transportation. Physical separation was forced by creating different residential areas for different races and separate native homelands. Forced relocation of non-whites from publicly and privately owned land was allowed. The definition of the category of natives who had the right of permanent residence in towns was narrowed. Natives were required to carry passes in urban areas.
- They provided inferior education for native people. It was a criminal offence for a native person to perform any skilled work in urban areas except in those sections designated for native occupation. Natives were prohibited to strike.
- They outlawed communism in South Africa and denied non-whites the right to vote (Boddy-Evans, 2015: 1).

During the apartheid era (1948–1994), the focus was on water resource management in the form of large government-funded water schemes to support economic development. These resulted in significant degradation of South Africa's primary water resources (Funke *et al.*, 2007: 14; Tempelhoff, 2011: 115). Bohensky (2008: 3), looking at South Africa as a social-ecological system, indicated that the apartheid policies encouraged large dam projects and unsustainable use of land and water. Although the system was in an unsustainable regime it was resilient due to

the legal framework, subsidies for agriculture and service delivery aimed at the minority of the population who supported the white regime. As stated in the preamble of the National Water Act (36 of 1998), the racially based discriminatory laws and practices of the apartheid government prevented equal access to water resources as well as water and sanitation services.

#### *1.1.2.3 The democratic period*

South Africa's water legislation was transformed by the new multi-racial democratic dispensation that started in 1994. The national government has the overall responsibility for and authority over, the nation's water resources, according to the preamble of the National Water Act (36 of 1998). Chapter 1 of the National Water Act (36 of 1998) highlights sustainability and equity as the central guiding principles for the protection, use, development, conservation, management and control of water resources.

An integrated water resource management (IWRM) approach forms part of achieving sustainable and equitable water use, according to Chapter 2, section 6 of the National Water Act (36 of 1998). Görgens *et al.* (1998: 2), define IWRM as a philosophy, a process and an implementation strategy to attain sustainable use of water resources and to ensure equitable access to them by all stakeholders at catchment, regional, national and international levels, while maintaining the characteristics and integrity of water resources at the catchment scale within agreed limits.

The principle of sustainability is captured in Chapter 3, Parts 3 and 4 of the National Water Act (36 of 1998). Part 3 stipulates the need for a reserve encompassing human and ecological needs. Part 4 requires a person conducting an activity that leads to water resource pollution and the catchment management agency to take measures to prevent pollution. The principle of equity is captured in the Bill of Rights in Chapter 2 section 24 of the South African Constitution (Act 108 of 1996), which stipulates that people living in South Africa have a right to live in a protected and healthy environment and have access to adequate housing, food and water. It is also provided for in section 227 of the South African Constitution, which entitles local municipalities to funds from the fiscus to cover the cost of supplying water and sanitation services to indigent households.

In 2007, a study aimed at providing a historical overview of the Vaal River Barrage, suggested that it was essential to connect relevant stakeholders to take the responsibility of addressing the pollution situation prevailing in the Vaal River Barrage upstream of Parys (Tempelhoff *et al*., 2007: 116). A transdisciplinary research approach was used for the study (Tempelhoff *et al*., 2007: 108).

In the same year, Ochse (2007: 63) completed research on seasonal rainfall influences on the main pollutants in the Vaal River Barrage. She highlighted the importance of the Upper Vaal Water Management Area to the economy of South Africa, and also stated that the greatest threats in the Vaal River Barrage to potable water preparation were posed by phosphates, conductivity (which is a measure of total dissolved solids) and sulphates. The same author identified sources of the pollutants as high volumes of effluents from upstream sewage treatment plants, mine

water and discharges from industries. She recommended more stringent phosphate limits to be imposed in the water use licences of those discharging phosphate-containing effluents.

In 2008, an investigation was conducted into the environmental health of the Vaal River in the vicinity of Parys. This investigation captured a moment in time when the problems of the Parys WSS had reached a new level. The community expressed their discontent with the water and sanitation service in the protest mentioned above. A transdisciplinary research approach was applied to conduct this research (Tempelhoff *et al.*, 2008: 8). The complexity of the Parys water and sanitation issues emerged in the form of multiple stakeholders and multiple causes ranging from infrastructural to chemical to relational (Tempelhoff *et al.*, 2008: 33).

In 2009 Van Riet collaborated with Tempelhoff to explore slow-onset disaster and sustainable livelihoods associated with the Vaal River in the vicinity of Parys. This investigation was part of a 2008 research project commissioned by Fezile Dabi District Municipality. It looked at the impact of ongoing Vaal River pollution on the livelihoods of the community (Van Riet & Tempelhoff, 2009: 29). They reiterated the complexity of the problem and recommended that a water forum be established to facilitate communication between the municipality and the community on water and sanitation issues. Their findings and recommendations were based on a transdisciplinary research approach to identify and describe the problems (Van Riet & Tempelhoff, 2009: 31).

In 2010, Booyens collaborated with Visser to look at the development of tourism small, medium and micro enterprises (SMMEs) in Parys. They indicated that Parys had experienced elevated levels of tourism since 2005 that had resulted in local economic growth (Booyens & Visser, 2010: 369). The reason for this positive development was attributed to the strategic location of Parys. The town is in close proximity to Johannesburg, the Vaal River and the Vredefort Dome, and is a key urban node on the Vaal River boundary between the provinces of the Free State and North West. Parys is connected to the greater Johannesburg Metropolitan area via the N1 freeway and route R59 and an airfield (Ngwathe Local Municipality, 2006: 7). The Johannesburg Metropolitan area is part of South Africa's economic hub, and therefore, it provides a potential market for Parys in the form of weekend tourists with disposable income. The Vaal River offers aesthetic and recreational facilities. The Vredefort Dome, one of the centrepieces of South Africa's heritage, was declared a World Heritage Site in 2005 by the United Nations Educational, Scientific and Cultural Organization (UNESCO) (Booyens & Visser, 2010: 373).

In 2011 Munnik's research group, which included members of North-West University's Research Niche for the Cultural Dynamics of Water (CuDyWat), investigated the potential of civil society organisations to contribute to monitoring and improving water quality. They pointed out that voluntary catchment forums were starting up in the Upper Vaal water management area due to water pollution challenges. The forums were operating in terms of the National Water Act 36 of 1998 and the National Water Resource strategy of 2004, which outlined the usefulness of forums as a foundation for catchment management agencies and in addressing local water management challenges (Munnik *et al.,* 2011: 4).

The same source indicated that the quality of water in the Vaal River Barrage was influenced by the Blesbokspruit, Rietspruit, Klip River and Leeu-Taaibosspruit catchments (Munnik *et al.,* 2011: 29). The Blesbokspruit was experiencing acid mine drainage problems, while the Rietspruit was being polluted by effluent from a steel mill. Furthermore, the water of the Klip River was being polluted by gold mining and effluent from domestic wastewater treatment plants, and the Leeu-Taaibosspruit was being impacted by the chemical industrial complex in Sasolburg. All four catchments each had a forum to discuss water-related issues (Munnik *et al.,* 2011: 28).

In 2011 Motingoe investigated a performance management system (PMS) as an implementation tool for IDPs in Ngwathe Local Municipality. He found that despite the existence of a dedicated administrative unit and portfolio committee for PMS in the municipality, there was little and varied understanding of PMS as well as poor implementation of the PMS to support the municipality's IDP. He recommended that these problems be addressed through the creation of a common understanding of PMS in the municipality, as well as the development of a PMS implementation checklist to ensure that the system was utilised at the management, supervisory and staff levels of the municipality (Motingoe, 2011: 121).

Also in 2011, Lemeko assessed the disaster preparedness of Ngwathe Local Municipality with regard to floods. She indicated that the community of Parys was vulnerable to floods due to its proximity to the Vaal River. The local municipality's inability to enforce building codes and by-laws was identified as a weak link in preparing for flood disasters (Lemeko, 2011: 3). Looking at the health sector in

Parys, Lemeko described the clinics as “appalling” (Lemeko, 2011: 29). She also mentioned the following important issues regarding the Parys WSS: the raw water quality from the Vaal River was bad (hard, scale forming and contaminated with algae); the maintenance of the treatment plants was non-existent; and the Parys water and sanitation works would not meet the future water requirements without expansion (Lemeko, 2011: 23). She indicated gaps in the town’s preparedness for floods by referring to an incident recorded in the 2011 Fezile Dabi District Flood Report, which described the destruction of the urban irrigation infrastructure, bridges, RDP (Reconstruction and Development Programme) houses and shacks in Parys by the floods of that year (Lemeko, 2011: 50).

In 2012, Van Zyl, an environmental health practitioner of Fezile Dabi District Municipality, investigated collaborative transboundary water quality monitoring as a strategy for effective Vaal River water quality monitoring in the vicinity of Parys. Strategic transboundary monitoring was proposed as a tool to address the issue of intense pollution of the Vaal River and its tributaries (Van Zyl, 2012: 3). This investigation emphasised an integrative approach to a common natural resource by various stakeholders. The researcher also used a transdisciplinary research approach in this study (Van Zyl, 2012: 10).

#### *1.1.2.4 Global influence through the Millennium Development Goals*

In 2000 the United Nations (UN) globally launched the Millennium Development Goals (MDG). The seventh goal was the imperative for countries worldwide to meet the water and sanitation needs of their peoples (UN, 2005: 35). The MDGs have been criticised for their bias towards human development without proper

consideration of natural capital and ecosystem services (Noström *et al.,* 2014: 1). This criticism is relevant when it is considered that sustainable development in the form of WSSs meeting the needs of communities cannot be attained without taking into consideration the limits of the ecological systems on which they depend.

South Africa fully subscribes to the realisation of the MDGs (RSA, 2010: 4). In order to translate legislation into tangible water and sanitation services for communities, the South African government has at its disposal a three-tier government structure comprising national, provincial and local governments as well as provisions for 19 catchment management agencies (Tempelhoff, 2011: 124). Chapter 7, section 152 of the Constitution clearly states that local government exists to:

- provide democratic and accountable government for local communities;
- ensure the provision of services to communities in a sustainable manner;
- promote social and economic development;
- promote a safe and healthy environment; and
- encourage the involvement of communities and community organisations in matters of local government.

The reasons for local municipalities being unable to provide adequate and consistent water and sanitation services include the following:

- Mature WSSs are expected to cater for:
    - escalating developmental needs for water (DEA, 1993: 11; DWAF, 2004: 26; Van Rooyen & Versfeld, 2009: 16);
    - all South Africans, not only the minority that these plants were originally built to service (Van Zyl, 2012: 4);

- a growing and urbanising population (Monkam, 2011: 12; Cessford & Burke, 2005: 9; Pollard *et al.*, 2008: 9; Van Riet & Tempelhoff, 2009: 12).

- Raw water quality is expected to remain compatible with old water purification technologies, despite evidence of escalating water resource pollution (DEA, 1993: 18; DWAF, 1994: 30; DWAF, 2002: 6; DWAF, 2004: 5; Van Rooyen & Versfeld: 15; Cessford & Burke, 2005 15; Van Zyl, 2012: 104; Kings, 2013: 1).
- WSSs are expected to continue functioning without proper funding, due to factors such as communities not paying for services and evidence of corruption in municipalities (Funke *et al.*, 2007: 12; CoGTA, 2009: 8; Monkam, 2011: 12; Department of National Treasury, 2013: 22).
- Municipal personnel without the relevant skills are expected to manage, develop, maintain and operate WSSs (DWA, 2009: 15; Gouws *et al.*, 2010: 4; Tempelhoff, 2011: 117; Grobler, 2012: 4).

### 1.1.3 Emergent sustainable development concepts and Parys's water and sanitation challenges

In recent years, new thinking has emerged advocating the management of systems that comprise human and natural (non-human) aspects through an integrated, holistic and systems approach (Gunderson & Holling, 2002: 7; Glaser, 2006: 142; Pollard *et al.*, 2008: 9; Folke *et al*., 2010: 2; Resilience Alliance, 2010: 6). Glaser (2006: 132) describes social-ecological systems as consisting of the following aspects: (a) the human system, comprising individual development, and the social and government subsystems; (b) the support system with the economic system and the infrastructure system as subsystems; and (c) the natural system with the environment and the resource system as subsystems. Halliday & Glaser (2011: 1)

view a social-ecological system as a commitment to adopt a holistic, systemic approach towards human and non-human elements in a given problem situation. This research was built on the contemplation of a community WSS in the town of Parys from the perspective of a social-ecological system (see Table 1).

**Table 1:** The Parys water and sanitation system as a social-ecological system in a panarchical cascade of smaller and larger systems

| **Domain** | **Scale** | **Scale description** |
|---|---|---|
| **Social** | Larger | Provincial and national government |
| | Large | Fezile Dabi District Municipality |
| | *Focal* | *Parys community and Ngwathe Local Municipality* |
| | Smaller | Individuals |
| **Ecological** | Larger | Vaal River catchment |
| | Larger | Upper Vaal River water management area |
| | *Focal* | *Vaal River section from Parys raw water abstraction point to effluent discharge point* |

The concept of social-ecological systems emerges within an established concept of sustainable development (Becker, undated: 1; Clifton, 2010: 2; Jahn *et al*., 2009: 1; Nealer & Naudé, 2011: 105). Clémençon (2012: 312) quotes Rio+20 in defining sustainable development as encompassing the simultaneous pursuit of three dimensions: social, economic and environmental. Berkes *et al.* (2003: 2) and Walker *et al.* (2002: 1) link social-ecological systems and sustainable development by explaining that maintaining the capacity of ecological systems to support social and economic systems is in effect sustainable development.

Pollard *et al.* (2008:7), view social-ecological systems as an improvement on the natural resource management framework. They argue that sustainable development, without integrating resource management and the socio-political context, is not possible because humans and ecosystems are in an infinite cycle of resource use by humans and corresponding ecosystem response. According to Cote & Nightingale (2012: 484), resilience thinking provides a middle ground between social and environmental science as well as between science and policy. It enables knowledge integration and enhances understanding of social-ecological challenges.

Social-ecological systems are complex because they exhibit uncertainty, non-linear feedbacks, cross-scale interactions, self-organisation and emergence (Glaser, 2006: 132). Walker *et al.* (2004: 1), Gunderson & Holling (2006: 1), Abel *et al.* (2006: 1), and Folke *et al.* (2010: 1), indicate that the dynamics and development of complex social-ecological systems can be described through the concepts of adaptability, transformability and resilience, as well as the adaptive cycle and panarchy models. These concepts and models were used to describe the Parys WSS and its dynamics.

Adaptability is the capacity of stakeholders in a social-ecological system to build resilience through intentional collective action. Transformability is the capacity of stakeholders to create a fundamentally new social-ecological system when ecological, political, social or economic conditions make the existing system unsustainable (Walker *et al.*, 2004: 3; Folke, 2006: 262). Resilience is the capacity of a system to absorb disturbances and reorganise while undergoing change so as to

retain the same function, structure, identity and feedbacks (Gunderson & Holling, 2002: 28; Resilience Alliance, 2007b: 16).

Social-ecological systems are managed by assessing and managing their resilience (Walker *et al.*, 2002: 1; Pollard *et al.,* 2008: 7). The reason for assessing the resilience of the Parys WSS was to enable its stakeholders to understand the dynamics of their system and to manage its resilience to achieve the objective of the sustainable development of the system. The resilience of a social-ecological system can be enhanced within desirable regimes as opposed to undesirable regimes. However, the adaptive cycle indicates the fact that the resilience of the social-ecological system in a regime is not a fixed quantity of the system. It contracts during periods of growth and stability and expands during periods of change and variability (Gunderson & Holling, 2002: 47). Panarchy explains how a social-ecological system can be simultaneously creative and conserving, existing in a nested hierarchy of systems at different scales (Holling, 2001: 390; Gunderson & Holling, 2002: 72; Holling *et al.,* 2002: 403; Resilience Alliance, 2007a: 58).

## 1.2 Problem statement

The review of the empirical literature indicates that past research work relevant to the Parys WSS was performed in both disciplinary and transdisciplinary settings. The research work identified social, economic and environmental issues that have led to the current Parys WSS condition. The investigations also looked at relevant stakeholders and their interests. Recommendations were made and some actions were taken to address the various aspects of the Parys WSS problems.

The gap that remains is that the same WSS problems persisted years after the investigations had been conducted. The researcher identified two important aspects that were not adequately covered by previous research:

1. The investigations did not provide a framework which would allow the Parys stakeholders to understand the complexity and dynamics of their WSS.
2. There was no framework strategy to steer the WSS (a social-ecological system) towards a sustainable regime.

This investigation was therefore, aimed at addressing these two gaps.

In addition to confirmation by the empirical literature review, the existence of the WSS problems was also confirmed through semi-structured interviews of Parys community members. Semi-structured interviews conducted in October 2013 indicated that the water and sanitation problems of Parys had still not been resolved (TMR. PA. SSI. P1 to P8. 5 October 2013; TMR. PA. SSI. P9 to P11. 11 October 2013). The problem was identified as persistent water and sanitation issues in Parys despite efforts to address them.

### 1.3 Research questions

The researcher aimed to qualitatively establish the effectiveness of a transdisciplinary approach to enable the process of assessing the resilience of the Parys WSS. In order to reach the research objectives, the following questions had to be answered:

- What is the context of the Parys water and sanitation problems?
- What is the resilience of a social ecological system?

- How can the resilience of a social-ecological system be understood through a transdisciplinary research approach?
- How resilient is the Parys WSS within the current regime, and how should it be managed?
- What recommendations can be made on the use of a transdisciplinary approach to assess the resilience of the Parys WSS?

## 1.4 Research objectives

The following research objectives were aimed at effecting the collaborative exploration of the Parys WSS and identifying relevant interventions in the context of the emerging concept of social-ecological system resilience to address the water and sanitation problems of Parys:

- Provide a context of the Parys water and sanitation problems.
- Provide an outline of the resilience of a social-ecological system.
- Indicate how the resilience of complex social-ecological systems can be understood through a transdisciplinary research approach.
- Provide an exposition of the resilience of the Parys WSS within the current regime and potential strategies for managing it.
- Make recommendations on using a transdisciplinary approach to assess the resilience of the Parys WSS.

## 1.5 Basic hypothesis

Based on the consideration of the empirical information on Parys and the theoretical exploration of the resilience theory and the methodology of transdisciplinarity, the hypothesis of the study is formulated as follows:

*A transdisciplinary approach is effective in assessing the resilience of a social-ecological system such as the Parys WSS.*

## 1.6 Research methodology

A transdisciplinary research approach was used to assess the resilience of the Parys WSS. This research approach integrates knowledge from researchers and stakeholders. It involves researchers from various relevant disciplines working together with actors from various sectors in the life world to solve problems encompassing a number of fields (Hirsch-Hadorn *et al*., 2008: 33).

Berkes *et al*. (2003: 2), Hirsch-Hadorn *et al.* (2008: 16) and Tempelhoff (2011: 336) endorse a transdisciplinary approach as appropriate for problems stemming from complex systems. Jahn *et al*. (2009: 4), describes transdisciplinary research as providing a hermeneutic framework where problem solving involves reflection, transformation of attitudes, development of personal competencies, ownership, capacity building, institutional transformations, technological development and mutual learning between academic disciplines and life-world actors. In other words, the transdisciplinary process becomes part of addressing the Parys WSS problems.

Pollard *et al.* (2008: 10), point out that conventional linear cause-and-effect thinking, quantitative methods and single-perspective approaches are inadequate for solving social-ecological system problems such as a WSS failing to meet the needs of a community. Consequently, a constructivist research paradigm and a qualitative research design were paired with phenomenological and case study research

strategies to explore the resilience of the Parys WSS. They support real-world transdisciplinary research which focuses on the participation of stakeholders to solve a practical societal problem as articulated and represented by participant stakeholders (Bergmann *et al.*, 2012: 32).

## 1.7 Secondary and primary sources

Much of the factual evidence in this study is based on primary sources. The primary data, generated by the present researcher and other North-West University (NWU) researchers during the research period (2013/4), are referenced appropriately in the text of the study. The empirical, theoretical and methodological literature reviews were conducted based on secondary sources such as relevant journal articles, reports, course materials, books and legislation. The journal articles were sourced from the NWU library's electronic database. Reports were sourced from relevant organisations and government websites; books were purchased or sourced from NWU's libraries at the Vanderbijlpark and Potchefstroom campuses. The legislation was sourced from relevant government websites. The sources of information used in the study were quoted in accordance with the 2012 NWU reference guide to avoid plagiarism.

## 1.8 Research ethics

The research was guided by the 2010 NWU ethics guidelines, which stipulate that all research involving people must be approved by the Research Ethics Committee before the study may commence. However, a research project being performed under a broader research programme may utilise the ethics approval of the latter. The ethics approval number **FH-SB-2012-0031** of the CuDyWat research

programme was used on informed consent forms prior to semi-structured interviews of random members of the Parys community. Signed permission was obtained from each stakeholder prior to the semi-structured interviews. The permission document gave the name and contact details of the researcher, the title, purpose, duration and procedures of the research. The implications of participating in the study such as benefits, possible risks, confidentiality and voluntary participation were explained to the stakeholders. Permission was also secured in advance for follow-up evaluation (see Appendix A).

Verbal and written permission was granted by the Ngwathe municipal officials, which enabled the researcher to undertake visits to the municipal works, conduct meetings with the officials and facilitate multi-stakeholder workshops. The primary information generated was consolidated in a personal archive. The identities of the stakeholders participating in the research were not revealed in the study except where the stakeholders are public figures. Instead, the stakeholders were each assigned a number which was used for reference purposes.

### 1.9 Chapter layout

The proposed chapter layout reflects the sequence of research activities in answering the research questions and meeting the research objectives.

**Chapter 1:** Context of the Parys water and sanitation problems

**Chapter 2:** An outline of the resilience of a social-ecological system

**Chapter 3:** Understanding the resilience of complex social-ecological systems through a transdisciplinary research approach

**Chapter 4:** An exposition of the resilience of the Parys water and sanitation system and potential strategies for improvement

**Chapter 5:** Conclusions and recommendations with regard to utilising a transdisciplinary approach to assess the resilience of the Parys WSS

## 1.10 Chapter summary

The community of Parys is experiencing persistent water and sanitation problems despite various interventions to address them. According to empirical literature review, these problems arise from the social and ecological aspects of the Parys WSS within a bigger South African and global context. They are linked to persistent water pollution in the Vaal River Barrage due to upstream developments which was already identified in the 1930s, and to political changes affecting legislation pertaining to the rights of South Africans regarding economic participation, land ownership, mobility, access to water resources, water and sanitation.

The need for problem-solving approaches that take into consideration the complexity of the problems associated with a WSS is highlighted. Emerging concepts within the framework of sustainable development, such as social-ecological systems, adaptability, transformability and resilience, as well as the adaptive cycle and panarchy models, are proposed as new ways of looking at the persistent problems of the Parys WSS. The applicability of these concepts to the current situation of the Parys WSS is explained in detail in Chapter 2. A transdisciplinary research method is proposed to address the Parys WSS in a collaborative manner with relevant stakeholders. This research approach integrates the researcher's and the stakeholders' knowledge in addressing real-world problems.

# CHAPTER 2

# AN OUTLINE OF THE RESILIENCE OF A SOCIAL-ECOLOGICAL SYSTEM

Chapter 2 explains how sustainable development, which seeks to simultaneously address social, economic and environmental challenges, can be better understood through a lens that sees social-ecological systems as evolving. This view best approximates the dynamics and complexity of observed social-ecological systems (Gunderson *et al.*, 2002: 13). It encompasses the concepts of social-ecological system resilience, adaptability and transformability, as well as the adaptive cycle and panarchy models. Viewing social-ecological systems as evolving forms a basis from which the dynamics and complexity of the Parys WSS and its persistent problems can be explored and explained.

## 2.1 Social-ecological systems

Our contemporary understanding of sustainable development, from which the concept of social-ecological systems is derived (see Figure 4), came about as a result of various milestone events that emphasised the negative impact of people and industry on the environment. Rachel Carson, in *Silent Spring* highlighted the environmental problems caused by synthetic pesticides and insecticides (Carson, 1962: 15). In 1968, in *The Tragedy of the Commons*, Garrett Hardin described the risk that overpopulation posed to limited resources shared by multiple stakeholders (Hardin, 1968: 1243).

From 1972, environmental issues were addressed on global platforms such as the United Nations Conference on the Human Environment (Stockholm Conference)

(Clémençon, 2014: 319). In 1987 the Brundtland Commission highlighted in *Our Common Future* the fact that the development of the current generation must not impede the ability of future generations to also develop (UN WCED, 1987: 16). In 1992, world environmental issues were discussed at the United Nations Conference on Environment and Development (UNCED) also known as the Rio Summit, Rio Conference or Earth Summit (Clémençon, 2014: 313). UNCED produced Agenda 21, which provides direction on the international, regional and local levels with regards to sustainable development and environmental protection (UNCED, 1992: 14).

The UN and other international organisations have emphasised the attainment of sustainable development through the achievement of the Millennium Development Goals (MDGs). This strategy has not always been successful due to the interconnected challenges that require to be simultaneously addressed to achieve real progress (Gilioli *et al.*, 2014: 43). Gunderson *&* Holling (2002: 10) argue that the reason why sustainable development remains elusive despite concerted efforts on global, national and local levels is people's views on the dynamics of social-ecological systems. The views are a departure point from which they attempt to understand systems to achieve sustainable development. This then typically explains why sustainable development of a local social-ecological system such as the Parys WSS proves difficult to achieve despite various interventions.

Ordinary people, e.g. local residents (as stakeholders) and officials of the local authority (as service providers) find it difficult to establish a link between sustainable development and the water and sanitation-related problems experienced at

grassroots level. There appears to be a disconnection between real life and the policies, government structures, local and district actions, as well as various research interventions.

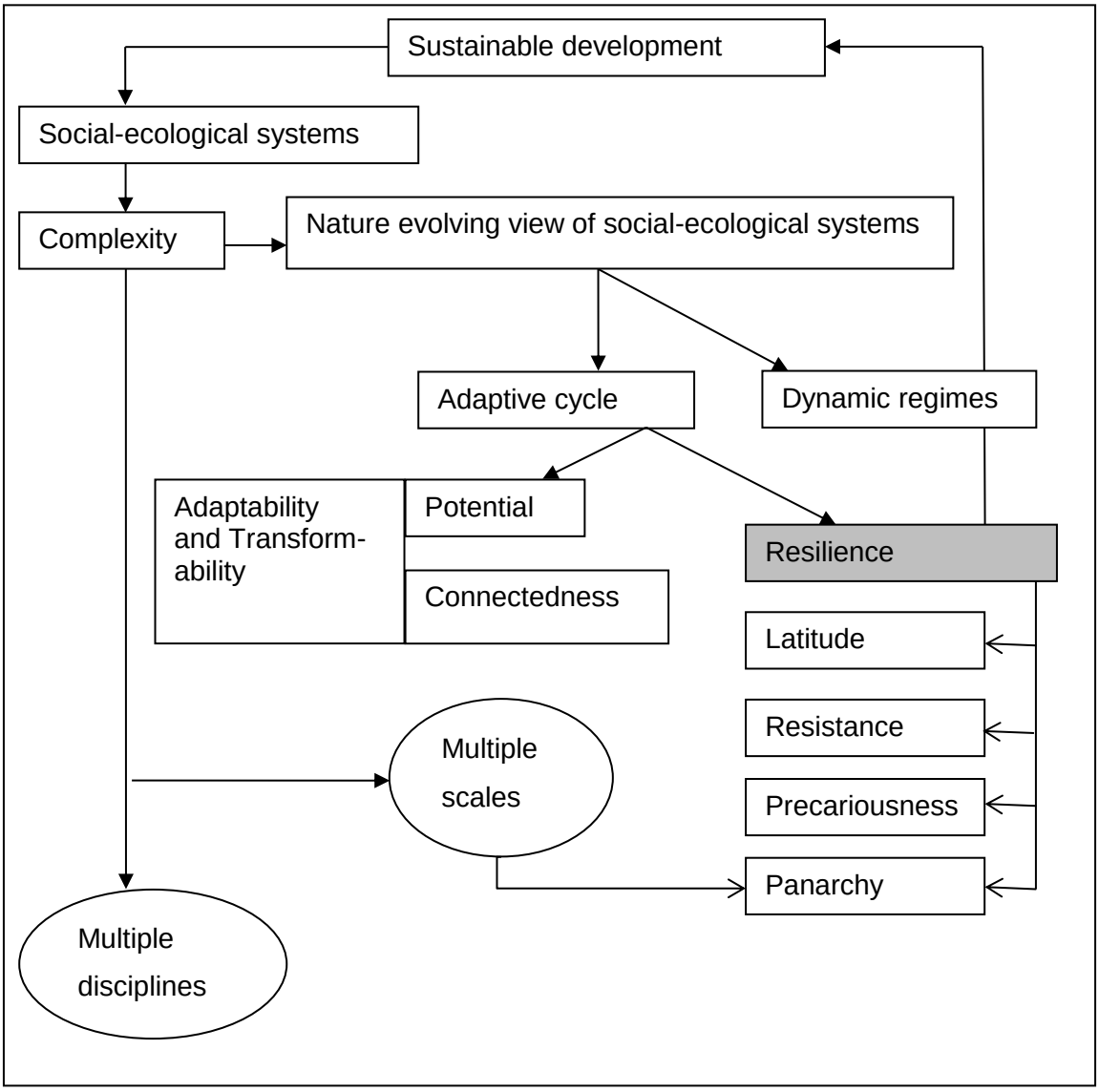


**Figure 4:** Map of research concepts

Gunderson & Holling (2002: 11) use stability landscapes to describe five different views from which people see social-ecological systems. The views are stated in order of increasing fit to real-world observations of social-ecological systems. The

first landscape (Nature flat) depicts a view of social-ecological systems where there are no feedbacks or consequences from nature linked to human action. People who see social-ecological systems from a Nature flat point of view tend to focus exclusively on human action to remedy social-ecological system problems. The solutions typically rely on community activism, stakeholder control or human ingenuity without acknowledging the limits of nature. The policies applied are random, yielding mixed results associated with successive processes of trial and error.

The second landscape (Nature balanced) describes a social-ecological system view where nature returns to default equilibrium after disturbances. People who see social-ecological systems from a Nature balanced point of view tend to impose static goals such as maximum sustainable yields and fixed carrying capacities on a dynamic system. They advocate policies that focus on optimisation and a return to equilibrium, which surprises them when there is no return to the expected equilibrium (Gunderson & Holling, 2002: 12).

The third landscape (Nature anarchic) describes a view of social-ecological systems as unstable. In this landscape, growth is inevitably followed by collapse, increase by decrease. Those who see social-ecological systems from a Nature anarchic point of view tend to support the precautionary principle-type policies and attempt to maintain the status quo (Gunderson & Holling, 2002: 13).

The same source describes a fourth landscape (Nature resilient), which is a view of social-ecological systems with stationery multi-stable regimes between which it can

alternate or within which it can be trapped. Policies and management approaches based on this view are adaptive. However, the consequences of this view include structural surprises from the overlooked dynamics of the regimes (Gunderson & Holling, 2002: 13).

In the fifth landscape (Nature evolving), social-ecological systems have dynamic multi-stable regimes, which give rise to abrupt and transforming change (Gunderson & Holling, 2002: 14). A regime is an identifiable configuration of a social-ecological system, which has a specific structure, function, feedbacks and identity (Resilience Alliance, 2007a: 49). Gunderson & Holling (2002: 21) point out that the dynamics of an evolving social-ecological system require it to conserve its ability to adapt to change as well as its ability to respond in a flexible manner to uncertainty and surprises.

Gunderson & Holling (2002: 14) propose the Nature evolving view of social-ecological systems as the one that best fits real-world systems (see Figure 4). They describe the type of policies that would flow from a Nature evolving foundation as actively adaptive and probing with active learning and new institutions. Walker *et al.* (2004: 4) and the Resilience Alliance (2007b: 16) utilise the Nature evolving stability landscape to explain the concepts of regime shifts and resilience in a regime (see Figure 5).

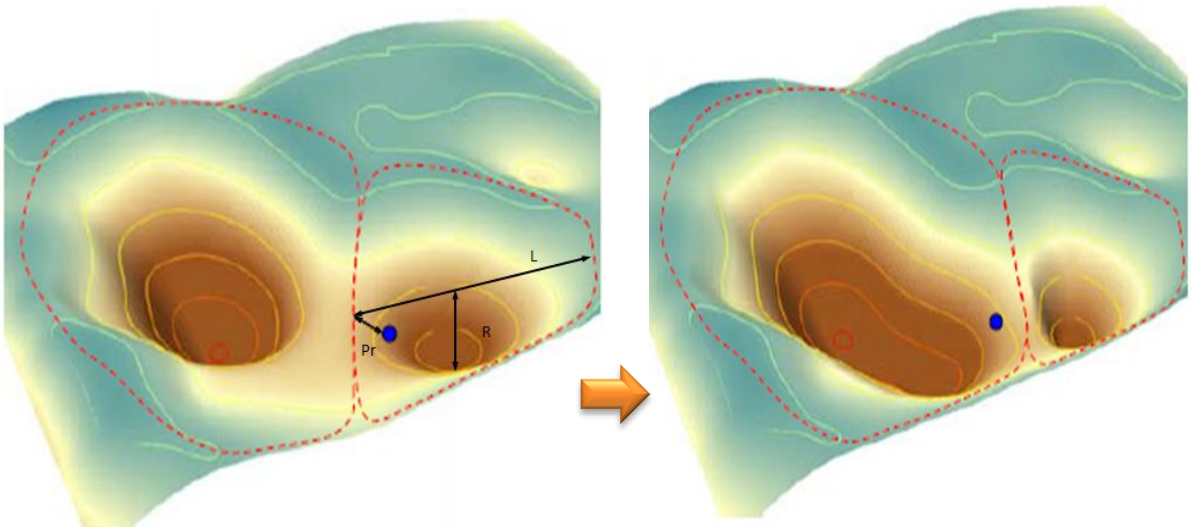


**Figure 5:** Depiction of Nature evolving stability landscape with dynamic multi-stable regimes. The three aspects of resilience are: L = latitude, R = resistance, Pr = precariousness (Walker *et al.,* 2004: 2)

## 2.2 The dynamics of social-ecological systems

A Nature evolving approach views social-ecological systems as existing in a stability landscape with dynamic multi-stable regimes separated by thresholds (Gunderson & Holling, 2002: 14). A regime is made up of a set of states within which a socio-ecological system has specific essential structure, function, feedbacks and identity (Resilience Alliance, 2007b: 15). According to the Nature evolving approach, social-ecological systems have three inherent dynamics that describe its movement: 1) the dynamics of the regimes, i.e. the changes in the latitude and resistance of the regimes, as well as the changes in the number and position of the regimes and thresholds on a stability landscape due to exogenous drivers and endogenous processes (see Figure 5) (Walker *et al.,* 2004: 3; Gunderson & Holling, 2002: 14); 2)

the dynamics of the system as it is driven towards a specific regime by disturbances and interventions (Resilience Alliance, 2007b: 19); and 3) the dynamics of the social-ecological system as it goes through the developmental phases of the adaptive cycle in a specific regime (Gunderson & Holling, 2002: 47).

Berkes *et al.* (2003: 6), state that complex systems operate around one of several possible regimes. The feedback loops tend to maintain the system in its current regime when conditions change. However, at thresholds which separate the different regimes in a stability landscape, the system can change rapidly. Walker *et al.* (2002: 4), Garmestani and Benson (2013: 2) and the Resilience Alliance (2007a: 49) indicate that thresholds exhibit lagging and irreversible changes and that resilience management should focus on identifying and understanding the processes driving the system towards thresholds and the associated regime shifts. According to Garmestani and Benson (2013: 2), thresholds represent upper and lower-level indicators that can be translated into social-ecological system management goals indicating the condition of the system.

The dynamics of social-ecological systems can be described through the concepts of adaptability, transformability and resilience (Walker *et al.*, 2004: 1; Gunderson & Holling, 2006: 1; Folke *et al.,* 2010: 1) (see Figure 4). Adaptability and transformability are associated with actors within the social-ecological system. The actors can influence the resilience of the system through its four aspects of latitude, resistance, precariousness and panarchy (Walker *et al.,* 2004: 2) (see Figure 5).

Adaptability refers to the capacity of people to manage ecological resilience by building various types of capital within the system, i.e. social, human, natural, infrastructural, financial, institutional and governance. It is an essential requirement of managing resilience (Walker *et al*., 2004: 3; Folke, 2006: 262). It is enhanced through commonality of understanding of the system among different stakeholders (Abel, 2006: 2). People should be able to learn, adapt and self-organise to generate more appropriate responses to the challenges posed by change (Bossel, 2001: 5; Folke *et al*., 2010: 1). Adaptability involves processes such as monitoring, assessing, responding, recovering and renewing following disturbances (Resilience Alliance, 2007a: 62). The goal of the collective action may be to avoid crossing into an undesirable regime or crossing back into a desirable one (Walker *et al*., 2004: 3).

Transformability is the capacity of people to create a fundamentally new social-ecological system when ecological, political, social or economic conditions make the existing system unsustainable (Walker *et al.*, 2004: 3; Folke, 2006: 262). It is the capacity to cross thresholds into new development trajectories. Radical change is applicable when the option of resolving focal system problems through adaptation is no longer feasible. This is when system thresholds cannot be managed or engineered to prevent a shift into undesirable regimes. In this case the focus of interventions must be to re-define the system to become a different kind of system (Resilience Alliance, 2007: 48).

Transformative changes require the development and nurturing of alternative forms of capital, new approaches, mental models and reframing of issues. Transformative change can be facilitated through disturbances, a shared understanding by

stakeholders and change in institutions (Resilience Alliance, 2007b: 49; Resilience Alliance, 2007a: 62). Transformational change at smaller scales enables resilience at larger scales. The capacity to transform at smaller scales draws on resilience from multiple scales, making use of crises as windows of opportunity for novelty and innovation, and recombining sources of experience and knowledge to navigate social-ecological transitions (Folke *et al.*, 2010: 1).

## 2.3 The resilience of social-ecological systems

The resilience of a social-ecological system is the capacity of a system to continually change and adapt yet remain within critical thresholds (Folke *et al.,* 2010: 1). It is the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain the same structure, function, feedbacks and identity (Gunderson & Holling, 2002: 51; Walker *et al.*, 2004: 6). Resilience encompasses four main components: latitude, resistance, precariousness and panarchy. Latitude is the maximum amount the system can change before losing its ability to recover. Resistance is the ease or difficulty of changing the system. Precariousness relates to how close the system is to a threshold in its current trajectory (see Figure 5). Panarchy relates to influences from larger and smaller systems. It refers to how the latitude, resistance and precariousness are influenced by scales above and below (Walker *et al.,* 2004: 2).

Pollard *et al.* (2008: 10) describe a social-ecological system as resilient in a sustainable regime when there are characteristics that:

- promote and sustain diversity

- embrace and work with ecological variability rather than attempting to control and reduce it
- have policies that focus on slow, controlling variables associated with thresholds which may result in slow creeping changes which can often go undetected
- have tight feedbacks which enable the system to detect thresholds timeously
- have adaptability, linked to social capital promoted by trust, well-developed social networks and leadership
- encourage innovation by emphasising learning, experimentation, locally developed rules and embrace change
- have overlapping polycentric forms of governance
- have development proposals and assessments that take into consideration the unpriced ecosystem services
- have open as opposed to closed biophysical and social systems
- have reserves and reservoirs.

The resilience of a system varies depending on the regime within which it exists at the time (Carpenter *et al.,* cited by Bohensky, 2008: 2). It is also not a static property of the system, but contracts during periods of growth and stability as well as expands during periods of change and variety as described through the adaptive cycle (Gunderson & Holling, 2002: 47). This implies that although the resilience of a system can be increased within a specific regime, it will rise and fall as the system develops within that regime. Pollard *et al.* (2008:15), point out that this variability of a social-ecological system is inherent and should not be viewed as a management problem to be solved.

The adaptive cycle model describes the relationship between potential, connectedness and resilience on the x, y and z axes respectively (Gunderson & Holling, 2002: 51). Potential refers to the capital within the system and connectedness refers to interdependence between elements of the system (Gunderson & Holling, 2002: 40). Different authors define the resilience of the social-ecological system in a similar way. However, there is one area of ambiguity – there is no clarity and alignment as to whether adaptability and transformability are synonymous with potential and connectedness.

In their standard study in the field of panarchy of 2002, Gunderson & Holling addressed social-ecological system dynamics without directly referring to the concepts of adaptability and transformability. They rather referred to potential and connectedness. In 2002 and 2004, Walker *et al.* described the dynamics of social-ecological systems without referring directly to potential and connectedness. They chose to refer to adaptability and transformability. In 2006, Gunderson *et al.* also started referring directly to the concepts of adaptability and transformability in relation to the dynamics of social-ecological systems. The researcher dealt with the first ambiguity by equating adaptability and transformability with potential and connectedness (see Figure 4). This is supported by Abel (2006: 3), who asserts that capital captures both potential and connectedness in social and ecological systems.

The adaptive cycle involves the movement of a system in four phases: 1) a period of rapid growth and exploitation (r) leading to 2) a long phase of accumulation, monopolisation and conservation of structure during which resilience tends to decline (K); 3) a rapid breakdown or release phase (Ω); and finally 4) a relatively short phase

of renewal and reorganisation (α) (Walker *et al.*, 2002: 6) (see Figure 6). The combined growth and conservation phases are known as the front loop. The combined release and reorganisation phases are known as the back loop (Gunderson & Holling, 2002: 47; Resilience Alliance, 2007a: 53).

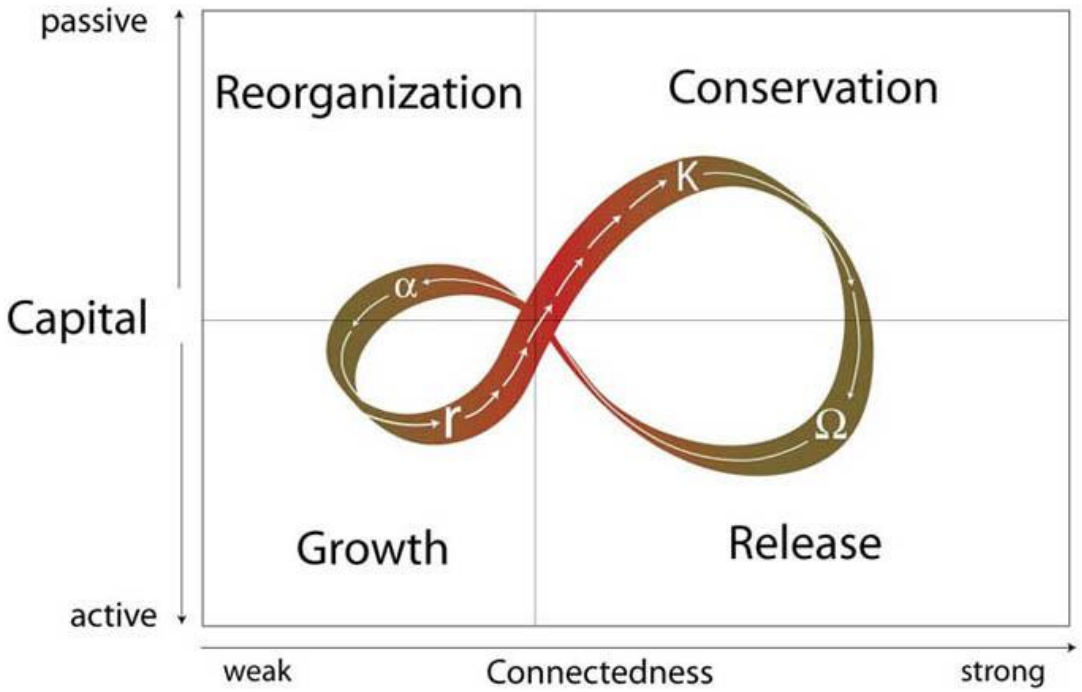


**Figure 6:** The adaptive cycle (Garmestani *et al.,* 2009: 3)

The system's front loop corresponds to managing for production, which is conventional thinking (Pollard *et al.,* 2008: 12). A system can spend most of its time in the front loop, which is characterised by ample resources and fast-growing entities that take advantage of the existing abundance and dominate the system (Resilience Alliance, 2007a: 52). In this period the system typically changes slowly – there are regulatory policies, strong controls and efforts to increase efficiency through careful experimentation. Flexibility and consequently resilience are generally lost in this

phase (Walker *et al.,* 2002: 6; Resilience Alliance, 2007a: 50). The system does not keep on growing indefinitely but tends to reach a limit, a steady state or the carrying capacity. It is at this stage that the system is vulnerable to collapse (Resilience Alliance, 2007a: 51).

The system's back loop corresponds to managing for sustainability. The system spends the least amount of time in the back loop. In this period the system experiences turbulence, rapid changes, no equilibrium, exposure to novelty and susceptibility to regime shift. The release phase is often viewed as a disturbance; however, it can be beneficial at times in providing a window of opportunity to move the system into a new regime when the old one has become undesirable (Gunderson & Holling*,* 2002: 47; Resilience Alliance, 2007a: 53). To reorganise after the release phase, the system relies on its capital in the form of natural capital, financial capital, infrastructure and human capital such as education, trust and networks (Resilience Alliance, 2007a: 50). The system can undergo the adaptive cycle and still remain within the same regime (Walker *et al.* 2002: 6). Often the new adaptive cycle is similar to the old; however, it can at times be very different (Resilience Alliance, 2007a: 50).

The Resilience Alliance (2007a: 49) states that the strategic management of social ecological systems requires knowledge of where the system is in the current adaptive cycle and the course of its previous cycles. Walker *et al.* (2002: 6), elaborate on this by indicating that the usefulness of the adaptive cycle model is in enabling management and policy interventions, tailored to fit the current developmental phase of the social-ecological system.

### 2.3.1 The complexity of social-ecological systems

Social-ecological systems are complex because they involve various disciplines and scales (Gunderson & Holling, 2002: 21; Resilience Alliance, 2007a: 19) (see Figure 4). This results in the exhibition of uncertainty, non-linear feedbacks, cross-scale interactions, self-organisation and emergence (Glaser, 2006: 132). The complexity of social-ecological systems does not necessarily mean that the social-ecological systems are complicated. They often have a basic set of drivers and responses (Pollard *et al.,* 2008: 14). The drivers vary in strength over space and time, producing different combinations of outcomes (Pollard *et al.*, 2008: 9). A few drivers are responsible for most consequences in the system, with many other drivers being entrained or dragged along (Pollard *et al.*, 2008: 3).

The systems thinking that applies to the combination of social and ecological systems also applies to the hierarchical association of social-ecological systems at different scales (Bossel, 2002: 3). Social-ecological systems occur in a nested hierarchy of systems at different scales, which is referred to as panarchy (Pollard *et al*., 2008: 1) (see Figure 7). Panarchy explains how a social-ecological system can be simultaneously creative and conserving (Holling, 2001: 390; Holling *et al.,* 2002: 403; Resilience Alliance, 2007a: 58; Pollard *et al.,* 2008: 1). Bossel (2002: 3) indicates that most systems interact in a hierarchical manner with other systems that are essential to their viability. Each scale is semi-autonomous and operates at its own pace and is protected from above by slower, larger scales, and is invigorated from below by faster, smaller scales (Holling, 2001: 390; Resilience Alliance, 2007a: 58; Pollard *et al*., 2008: 1). The linkages and interactions across scales result in

feedback loops (Walker *et al*., 2002: 6). Cross-scale interactions determine the form of the subsequent adaptive cycle at any particular focal scale (Abel, 2006: 2).

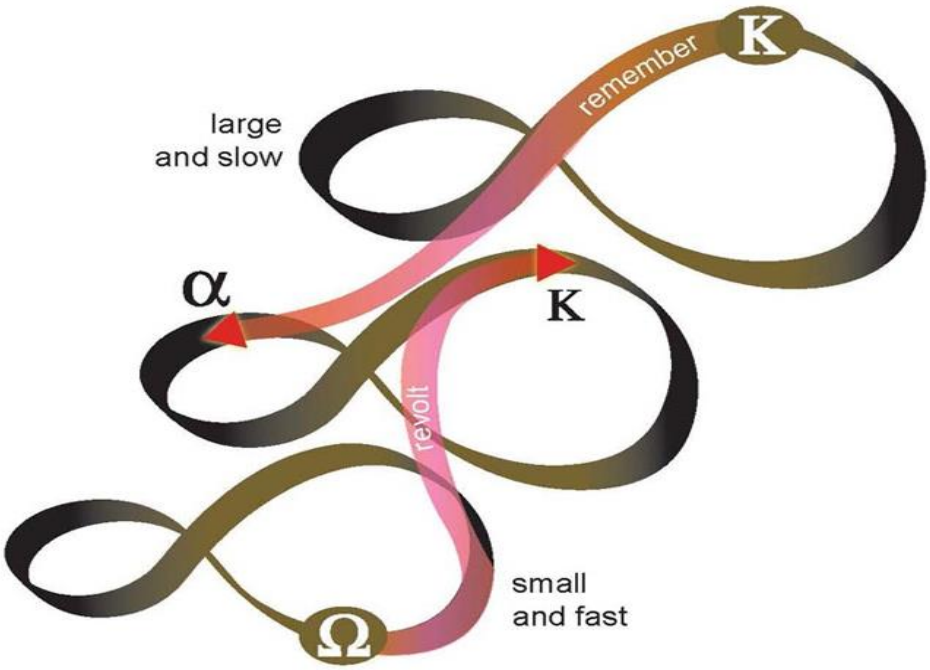


**Figure 7:** A classic representation of a panarchy: a nested set of adaptive cycles (Garmestani & Benson, 2013: 2)

An understanding of the interactions of a focal system with its associated large-scale and smaller-scale systems is required for resilience management of the focal system. These interactions must be viewed simultaneously with the adaptive cycle processes happening at the different scales (Resilience Alliance, 2007a: 56). There are multiple potential connections between phases at one scale and phases at another scale. However, two connections (revolt and remember) are important at times of change in the adaptive cycles. These refer to the transition from growth to collapse (the Ω phase) and the transition from reorganisation to rapid growth (the α

phase). It is at the two-phase transitions between gradual and rapid change and vice versa that the large and slow entities become sensitive to change from the small and fast ones (Holling, 2001: 397; Gunderson & Holling 2002: 75).

When a level in the panarchy enters its Ω phase of creative destruction, the collapse can cascade to the next larger and slower level by triggering a crisis. Such an event is most likely if the slower level is at its K phase, because at this point the resilience is low and the level is particularly vulnerable. This is a revolt connection where fast and small events overwhelm slow and large ones (Gunderson & Holling, 2002: 32). Once triggered, the effect can cascade to still higher, slower levels, particularly if those levels have also accumulated vulnerabilities and rigidities. The remember connection occurs when larger systems constrain change in smaller systems. It is important at times of change and renewal because it draws on accumulated wisdom and experiences of maturity (Gunderson & Holling, 2002: 75). Once a catastrophe is triggered at one level, the opportunities for, or constraints against, the renewal of the cycle are strongly influenced by the K phase of the next slower and larger level (Holling, 2001: 397).

Human systems exhibit at least three unique features that change the character and location of variability within the panarchy and can dramatically enhance the potential of panarchies. These three features are foresight, communication, and technology. Human foresight and intentionality can dramatically reduce or even eliminate the boom and bust character of some cycles. Humans have the ability to communicate ideas and experience over various media. These become incorporated into slower parts of the panarchy, such as cultural myths, legal constitutions and laws.

Technology amplifies the actions of humans so that they affect an astonishing range of scales from the sub-microscopic to the global (Holling, 2001: 397).

### 2.3.2 Resilience assessment

According to Walker *et al*. (2002:1), the management of social-ecological systems to achieve sustainability is made difficult by their complexity. Gunderson & Holling (cited by Walker *et al.*, 2002: 2) indicate that understanding the loss, creation and maintenance of resilience through the process of co-discovery by scientists, policy makers, practitioners, stakeholders and citizens is at the heart of sustainability. Walker *et al.* (2002: 1), view resilience assessment as a basis for resilience management to achieve sustainable development.

Walker *et al.* (2002: 3), indicate that the assessment of resilience enables the identification of where resilience resides in the system and how it can be lost or gained. They mention that building resilience comes at a cost. Therefore, it is important to determine when, where and how to build resilience to achieve best results at sensible cost. According to Walker *et al.* (2002: 1), the goal of resilience management is two-fold: to prevent the social-ecological system from moving into undesirable regimes and to nurture and preserve the elements that enable the system to renew and reorganise itself following a massive change.

The process used by various researchers to assess or analyse the resilience of social-ecological system is similar in terms of their activities and sequence, although they are not exactly the same. Walker *et al.* (2002: 1), used a four-step resilience assessment process to study regional-scale social-ecological systems to understand

how resilience changes and how it might be increased, or lost, through management. The method used by Walker *et al.* is aligned with the resilience assessment method as described in the Resilience Alliance workbooks for scientists and practitioners (see Table 1). Step 1 in resilience assessment is a stakeholder-led development of a conceptual model of the system, including its historical profile and preliminary assessments of the drivers of the supply of key ecosystem goods and services (Walker *et al.*, 2002: 1).

Step 2 deals with identifying the range of unpredictable and uncontrollable drivers, stakeholder visions for the future and contrasting possible future policies, as well as weaving these three factors into a limited set of future scenarios (Walker *et al.*, 2002: 1). Step 3 uses the outputs from steps 1 and 2 to explore the social-ecological system for resilience in an iterative way. It generally includes the development of simple models of the system's dynamics for exploring attributes that affect resilience (Walker *et al.*, 2002: 1). This step is included as part of the second activity in the Resilience Alliance method (see Table 2). Step 4 is a stakeholder evaluation of the process and outcomes in terms of policy and management implications (Walker *et al.*, 2002: 1). This aligns with Activities 3 and 4 in the Resilience Alliance method.

**Table 2:** Activities and sub-activities in assessing the resilience of social-ecological systems according to the Resilience Alliance method

| **Activities** | **Sub-activities** |
|---|---|
| **Resilience assessment** | |
| **Activity 1:** Describe the focal system and the disturbances | A. Identify main issues to be addressed |
| | B. Determine focal system boundaries and key components of the social-ecological system |
| | C. Expand the system into multiple space and scales |
| | D. Describe disturbances, disruptions and uncertainty |
| **Activity 2:** System dynamics | E. Assess alternate regimes, thresholds and scenarios |
| | F. Assess cycles of change through a conceptual model of adaptive cycle and panarchy |
| **Activity 3:** Adaptability and transformative change | G. Evaluate adaptability |
| | H. Consider transformation |
| **Resilience management** | |
| **Activity 4:** Explore interventions and management | I. Interventions<br>J. Adaptive assessment and management |

## 2.4 Chapter summary

Theoretical literature review indicated that the difficulty of achieving sustainable development stems from the views people have of the social-ecological systems being managed. The five different views are described as; as Nature flat, Nature balanced, Nature anarchic, Nature resilient and Nature evolving in order of fit to observed social-ecological system dynamics. A social-ecological systems view that

approaches nature as evolving was adopted for the purposes of this study. Three different dynamics associated with a Nature evolving view of social-ecological systems were identified. They are: the dynamics of the regimes within which a social-ecological system exists; the dynamics of the system as it is driven towards a specific regime by disturbances and interventions; and the dynamics of the social-ecological system as it goes through the developmental phases of the adaptive cycle in a specific regime.

These dynamics, together with the complexity of the social-ecological system, are addressed through the concepts of adaptability, transformability, resilience, the adaptive cycle and panarchy. Adaptability and transformability focus on the capacity of stakeholders to act as a collective to move the system towards a desirable regime, e.g. a sustainable regime. This links to the selected methodology of transdisciplinary research discussed in Chapter 3. This research approach involves the participation of stakeholders in the research process.

# CHAPTER 3

# UNDERSTANDING THE RESILIENCE OF COMPLEX SOCIAL-ECOLOGICAL SYSTEMS THROUGH A TRANSDISCIPLINARY RESEARCH APPROACH

Chapter 3 explains why a transdisciplinary research approach is appropriate for addressing issues emanating from a complex social-ecological system. In the case of Parys water and sanitation system (WSS), a transdisciplinary research approach which relied heavily on the participation of stakeholders was enabled by the research paradigm (constructivism), design (qualitative), strategies (phenomenological and case study) and data capturing methods (interviews, facilitated visits to municipal works, work meetings and multi-stakeholder workshops). Participation entailed collaborating with stakeholders and co-researchers to accumulate systems, target and transformational knowledge to develop solutions for the real-world problem of water and sanitation challenges in Parys. The chapter also highlights the obstacles and opportunities experienced by the researcher in applying a transdisciplinary research approach for research data collection and analysis in the context of a resilience assessment.

## 3.1 Transdisciplinary research

Transdisciplinary research is a concept that emerged at the end of the 20th century as an improvement on the existing disciplinary approach. The disciplinary approach led to successes in technological advances on which industrialisation expanded. However, the advances also brought about a negative impact on social and ecological systems (Hirsch Hadorn *et al.*, 2008: 25). Berkes *et al.* (2003: 2), state that the problems emanating from social-ecological systems cannot be adequately

addressed through a disciplinary approach. Jahn *et al.* (2009: 3) and Scholz (2006: 231) recommend a transdisciplinary approach in attempting to define complex social-ecological problems and solutions in a sustainability framework, especially in the Anthropocene era where nature and society cannot be understood in isolation from each other.

Hirsch Hadorn *et al*. (2008: 16), endorse a transdisciplinary research approach as appropriate for solving real-world problems where there are systems uncertainties and high-decision stakes. A community WSS fits the above criteria for which a transdisciplinary approach is recommended. For example, there are significant uncertainties stemming from a large number of variables and stakeholders, and the decisions stakes are high since the system directly affects stakeholders' health, livelihood and daily quality of life.

The findings of Siebrits (2013: 97) on research methods in South African publications on water from 1977 to 2013 suggest that between 1977 and 2001 the focus was on research to find technical and engineering solutions, from 2001 to 2011 the focus shifted to multidisciplinary studies looking at problems on a catchment scale, and between 2011 and 2013 the focus was more on participation, governance and politics. Carew & Wickson (2010: 1146) agree that messy social and environmental problems are increasingly approached in a transdisciplinary manner. This is due to the fact that the approach includes stakeholder participation, and it therefore, generates socially acceptable solutions.

Görgens *et al.* (1998: 2), highlight the need for people-oriented water management. They criticise the centralistic, technical and bureaucratic approach of the pre-democracy era, which eroded the trust of the public. They point to the fact that South Africans have a growing need to participate in the decision-making processes. They recommend community-friendly approaches to integrated water resource management (IWRM) to ensure that stakeholders can understand and participate meaningfully. Thompson (2006: 252) highlights the link between democracy and public participation by explaining that in a democracy people must be actively involved in actions and decisions that impact their lives. The higher the impact, the more intensely the public should participate. The impact of a water and sanitation system on the quality of lives of people is constant and significant. However, a community cannot meaningfully and constructively participate without an increasing understanding of how their WSS functions. Merely experiencing the system is not sufficient; the community also requires involvement and understanding of why certain things happen (Jain, 2010: 34).

South Africa has been experiencing an escalating number of water and sanitation service delivery protests since the early 2000s (Booysen, 2007: 23; Sinwell *et al.,* 2009: 19; Gouws *et al.*, 2010: 4; Jain, 2010: 30; TWB, 2011: 87; Tempelhoff, 2011: 317; Davids, 2012: 1; Chikulo, 2013: 50; Van Donk & Gaidien, 2014: 56). Jain (2010: 3) determined that the rate of public protests, including water and sanitation service delivery protests, doubled between 2007 and 2010. The water and sanitation service delivery protests have intensified despite the strategic direction provided through water and sanitation legislation, the governance structures in place and the progress made in terms of improving access to water and sanitation. Public protests are used

by communities struggling to make their voices heard in the process of communicating their dissatisfaction with service delivery (Booysen, 2007: 21). A study of service delivery in South Africa indicated that service users see a clear absence of service provider accountability. On the other hand, service providers and politicians do not see service delivery lapses as a major problem (TWB, 2011: 70).

Transdisciplinary research involves transcending boundaries of traditional disciplines and the inclusion of relevant non-academic stakeholders to solve problems involving a number of fields (see Figure 8) (Hirsch Hadorn *et al*., 2008: 386; Bergmann *et al.,* 2012: 32). Bohensky (2008: 2) says that a resilient pathway for a social-ecological system considers changing circumstances and opinions. It also embraces diverse perspectives, even those challenging the dominant discourse.

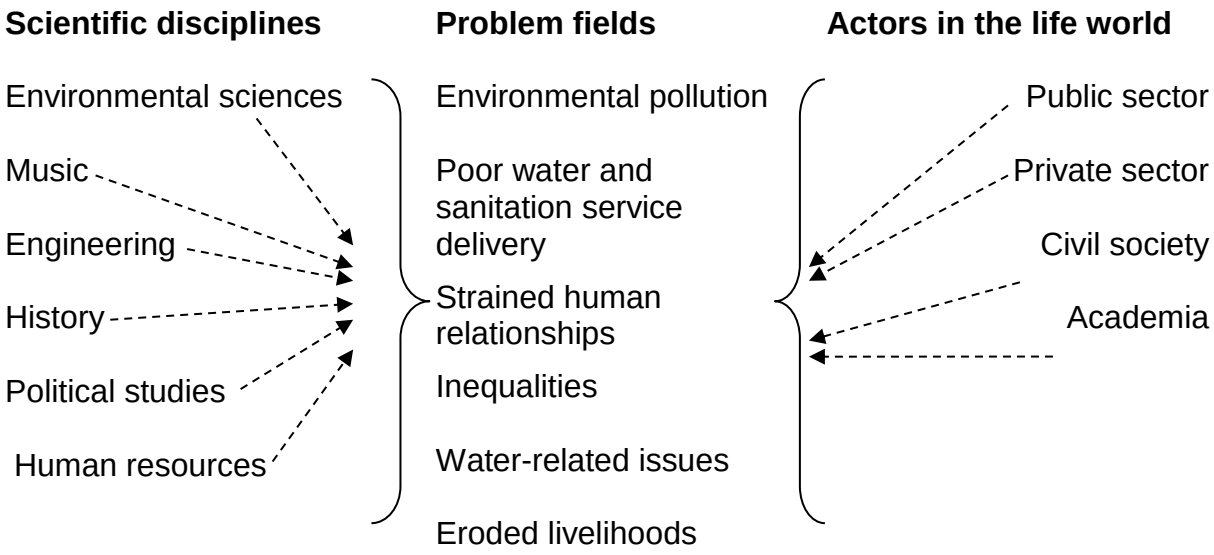


**Figure 8:** Problem identification and structuring in transdisciplinary research (adapted from Hirsch Hadorn *et al*., 2008: 33)

Ravetz (1997: 534) argues that no single stakeholder view can capture the complexity of the reality of a situation; hence it is imperative that diversity should be central in framing research problems and proposing solutions to a complex real-world problem. He adds that these diverse stakeholders contribute their life experiences, insights, views, suggestions and unconventional data. Transdisciplinary research thus democratises research by assigning equal weight to various types of knowledge and prompting researchers, policy makers and laypeople to share decision-making power throughout the research process.

According to Schraw and Olafson (2008: 25), transdisciplinary research takes into account the diverse beliefs about the nature and reality of the problem and desired situation (ontology) and the origin and acquisition of knowledge (epistemology) to facilitate change towards the desired situation. Tempelhoff (2011: 336) believes that transdisciplinary research has the effect of bringing new valuable perspectives from the community, practitioners and other disciplines. He views this as a foundation of functional knowledge which is critical for solving real-life problems.

Hirsch Hadorn *et al.* (2008: 35), indicate that transdisciplinary research relates to three types of knowledge: systems knowledge, target knowledge and transformational knowledge. Systems knowledge answers questions about the start and development of a real-world problem. This knowledge identifies, interprets and structures the problem (Hirsch Hadorn *et al.,* 2008: 4, 431). According to the Resilience Alliance (2007b: 14), the assessment of the resilience of a social-ecological system requires the engagement of practitioners and stakeholder groups to identify issues and problems.

Target knowledge answers questions about the needs, interests and reasons of various practitioners and stakeholders who may be affected directly or indirectly by the problem and envisaged interventions. It aims to define the desired end state, where the problem would be seen as being resolved by stakeholders (Hirsch Hadorn *et al.*, 2008: 35). The desirability of regimes is specific to stakeholders, hence the need to involve all stakeholders in its determination (Resilience Alliance, 2007a: 16). Transformational knowledge provides technical, social, legal, cultural and other possible means of acting that will facilitate movement from the current situation to the desired situation (Hirsch Hadorn *et al.,* 2008: 6, 35).

Bergmann *et al.* (2012: 32), describe three types of transdisciplinary research: science-focused; integrative and a real-world-focused approach. The science-focused approach is applicable to situations where a complex scientific issue needs to be resolved, while the integrative approach is relevant when there is a dual need to solve a combination of societal and scientific challenges (Bergmann *et al.,* 2012: 32).The real-world-focused approach was used in this research, because the driver behind the research was a specific need to provide solutions for a real-world problem of water and sanitation in the town of Parys (see Figure 9).

The real-world-focused transdisciplinary approach emphasises the participation of stakeholders. The research problem is defined societally and it is articulated and represented by societal actors who are stakeholders affected by the problem under investigation. The research team translates the real-world problem into a research object that can be scientifically explored. The research goal in this transdisciplinary

approach is to produce knowledge that can be used to solve a practical problem (Bergmann *et al.*, 2012: 32).

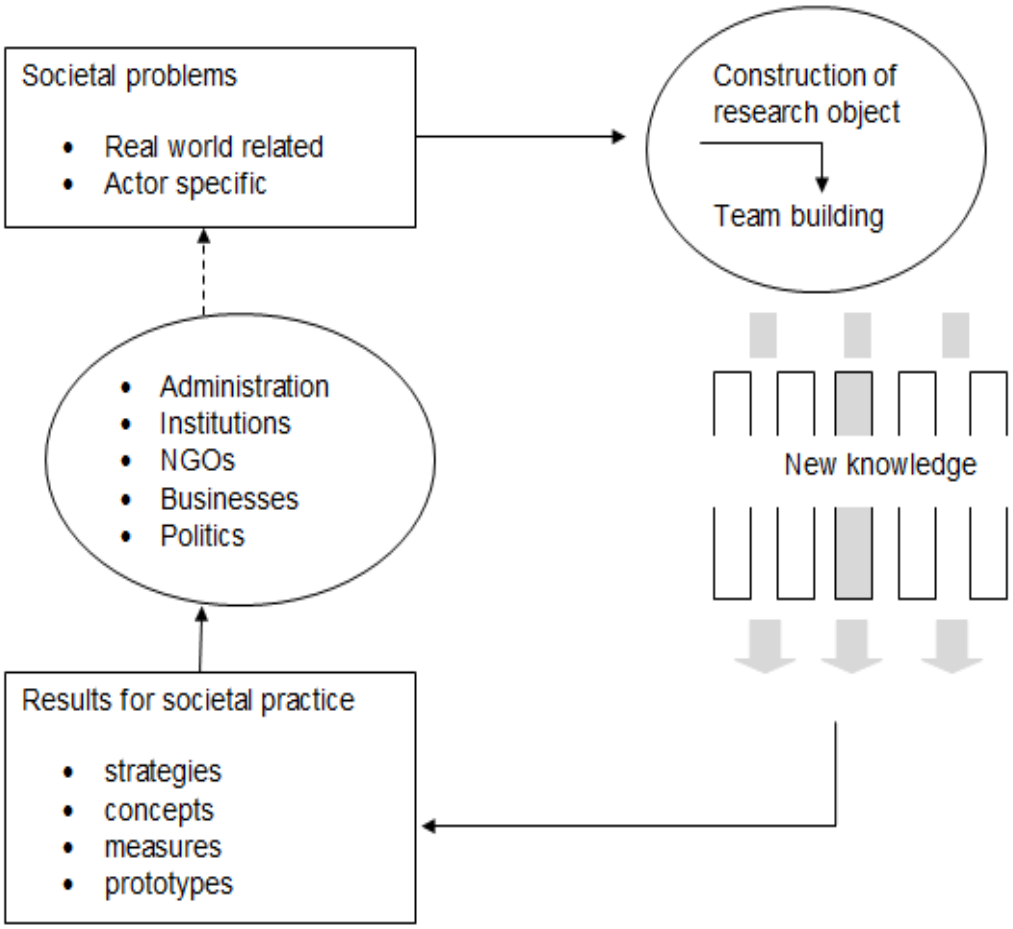


**Figure 9:** Transdisciplinary research process, real-life-focused approach (Bergmann *et al.,* 2012: 32).

The societal problem being addressed was the persistent water and sanitation service delivery problems in the town of Parys. The problem was specific to the residents of Parys, who were afforded an opportunity to define and articulate their experiences of water and sanitation problems. The real-life water and sanitation problems were constructed into a research problem through a research proposal to

view the Parys WSS as a complex social-ecological system which could be managed through its resilience. The resilience could be assessed through a transdisciplinary process, which includes stakeholders as collaborators (see Figure 9).

The transdisciplinary research team included representatives of Parys's residents, officials of Ngwathe local and Fezile Dabi district municipalities, members of the Ngwathe Water Forum and members of North-West University's Research Niche for the Cultural Dynamics of Water (CuDyWat). New knowledge in the form of systems, target and transformational knowledge was collected as research data through research team interactions. The knowledge was used to collaboratively assess the resilience of the Parys WSS. The results of the resilience assessment are meant to support the community in managing the resilience of the WSS to bring about the change they desire (see Figure 9).

A real-life-focused transdisciplinary research approach was enabled by the selected research paradigm (constructivist), design (qualitative), strategies (phenomenological and case study) and data-capturing methods (interviews, facilitated visits to municipal works, work meetings and multi-stakeholder workshops).

## 3.2 Research paradigm

The concepts of research paradigms, research design, research strategies and research methods are used interchangeably by various authors (Creswell, 2009: 3). Fouché *et al*. (2011: 142), also point out misalignment, specifically with regard to the

definition of research design. The researcher chose to follow Creswell's use of the concepts. Creswell (2009: 6) describes a paradigm as a worldview and a fundamental set of beliefs that guide action. He identifies four main paradigms as participatory advocacy, pragmatism, post-positivism and social constructivism. According to Delport *et al*. (2011: 297), a researcher should select and communicate his or her paradigm as part of research methodology. He further indicates that a researcher's choice of paradigm is not necessarily true or false but can be enabling or disabling.

Advocacy is a worldview which typically supports qualitative research design. In this worldview, research is expected to be intertwined with politics and to have an agenda which is politically relevant to issues of the day. This type of research focuses on the needs of marginalised individuals and groups in society (Creswell, 2009: 9). A pragmatic paradigm concentrates on what works in a particular situation and is not bound to any one system of philosophy and reality. Qualitative and quantitative methods are mixed to meet the need at hand (Creswell, 2009: 10). None of these paradigms were selected for this research. Key to the research project was to view the Parys WSS as a complex social-ecological system. Politics and a political agenda were not seen as critical to finding solutions to the water and sanitation challenges in Parys. The researcher particularly wanted to focus on collaboration and engagements with the community of Parys in the process of conducting the research project.

A post-positivist worldview is aligned with traditional and quantitative forms of research. A post-positivist researcher looks for evidence through measurements and

observation to explain and describe causal relationships (Creswell 2009: 7). The researcher's background discipline is natural science (chemistry) with work experience in the environmental field, specifically in water and effluent treatment within the context of a petrochemical industry. Natural scientists tend towards a post-positivist worldview which, according to Creswell (2009: 6), focuses on determinism, reductionism, empirical observation and measurement, as well as theory verification. However, this approach is inadequate for addressing complex social-ecological system problems (Pollard *et al.,* 2008: 10).

Notwithstanding the researcher's background, a constructivist paradigm was deliberately selected for this study. Social constructivism is also another typical paradigm under which qualitative research is performed. It assumes that individuals develop subjective meanings towards objects in their quest to understand their world. Therefore, the stakeholder's views, which are shaped by the individual's historical and social perspective, are central to the situation under investigation (Creswell, 2009: 8). A constructivist worldview supports real-world-focused transdisciplinary research as described by Bergmann *et al.* (2012: 32), who explain that a real-world-focused transdisciplinary approach focuses on the participation of stakeholders to solve a practical societal problem as articulated and represented by the stakeholders (see Figure 9).

### 3.3 Research design

The selection of the research paradigm directed the choice of the research design. Creswell (2009: 3) describes research designs as plans that encompass the procedures, decisions, assumptions and detailed methods of data collection and

analysis. He identifies three types of research designs on a spectrum ranging from quantitative, to mixed to qualitative methods. The inherent difference between a qualitative and quantitative research design is that the former does not have a fixed step-by-step recipe. The quantitative research design determines the researcher's choices and actions while the qualitative research design is determined by the researcher's choices and actions (Fouché & Schurink, 2011: 312).

A reductionist quantitative approach disables systems thinking and would be inadequate to holistically capture multi-faceted aspects associated with persistent problems of a complex WSS (Ravetz, 1997: 537; Resilience Alliance, 2007b: 4). A qualitative research design was selected because it is applicable to social phenomena, situations and processes that involve people. It highlights diverse stakeholder perspectives and assists the researcher to understand people and their behaviour in a specific social, cultural and economic context (Hazzan *et al.,* 2014: 1).

### 3.3.1 Research strategies

According to Creswell (2009: 11), a research strategy is a specific type of research design that provides a specific direction for the procedures used in the research. He mentions five research strategies relevant to qualitative research, namely narrative research, phenomenology, ethnographies, grounded theory studies and case study. Phenomenological and case study research strategies were used in this research. Phenomenological research strategy concentrates on the essence of human lived-experiences of a phenomenon of their own description (Creswell, 2009: 3).

The researcher and members of CuDyWat used phenomenological research strategy in a transdisciplinary context to understand how various stakeholders experienced being part of the Parys WSS and the meaning they attributed to their experiences and various aspects of the system. In addition to capturing the stakeholder experiences, a case study strategy was used to analyse the dynamics of the Parys WSS within the framework of social-ecological system resilience.

Creswell (2009: 3) describes a case study as a research strategy that focuses in depth on a programme, event, activity, process or individual(s). Scholz (2006: 227) asserts that case study research is at times viewed with scepticism. However, he is of the opinion that transdisciplinary case studies in particular are powerful tools for research on complex environmental problems. He says that although they are unique, e.g. they focus on a specific community WSS, they always relate to something general, i.e. a WSS in general. The researcher applied the case study strategy to:

- collect research data focusing on an in-depth understanding of the Parys WSS,
- categorise data collected using a phenomenological research strategy into systems, target and transformational knowledge,
- utilise the categorised data for resilience assessment.

### 3.3.2 Research methods

According to Creswell (2009: 15), the methods of qualitative research include emerging methods; open-ended questions; interviews; observations; documents; audio-visual, text and image analysis; as well as themes and pattern interpretation.

Bergmann *et al.* (2012: 30), indicate that although transdisciplinary research presents new ways of acquiring knowledge (epistemological opportunities), it also presents new methodological challenges. Integration is the emerging methodology for executing transdisciplinary research. It is expected to meet the dual targets of integrated research results that bring a solution to societal problems and academic gains in terms of new methods, concepts and theories (Hirsch Hadorn *et al*., 2008: 89) (see Table 1).

Bergmann *et al.* (2012: 28), write that to make the integration of knowledge possible, the involved disciplines, the terms and concepts and the theoretical frameworks used must be recognised and acknowledged. They also highlight the fact that in problem-oriented research the integrative methods and instruments used are context specific (Bergmann *et al.* 2012: 29). Integration is important throughout the research process: in problem identification and structuring, in problem analysis as well as in implementation. It takes relevant heterogeneous perspectives on complex practical issues into account. It also links and restructures concepts, methods and results from heterogeneous bodies of knowledge (Hirsch Hadorn *et al*., 2008: 412).

Integration was applied with common group learning as a form of collaboration and mutual understanding as a means of integration (Hirsch Hadorn *et al*., 2008: 145). Common group learning means that integration takes place as a learning process of the whole group (Hirsch Hadorn *et al*., 2008: 415). Mutual understanding as a means of integration involves effective communication by using everyday language and terms with fixed meanings that are comprehensible and understood by all collaborators (Hirsch Hadorn *et al*., 2008: 416).

Semi-structured interviews, facilitated visits to the municipal water and sanitation works, work meetings with municipal workers and multi-stakeholder workshops were used in series as data-collection methods (see Figure 10). The methods enabled stakeholder participation, which was central to the research methodology. The researcher aimed to understand the context of the stakeholders by visiting this context and gathering information personally. The data collection methods were aligned with constructivism, where the researcher asked broad questions which allowed the stakeholders to construct the meaning of the situation. From a constructivist research point of view, the focus was on listening carefully to what the stakeholders were saying and doing, as well as on the processes of interaction among individuals (Creswell, 2009: 8).

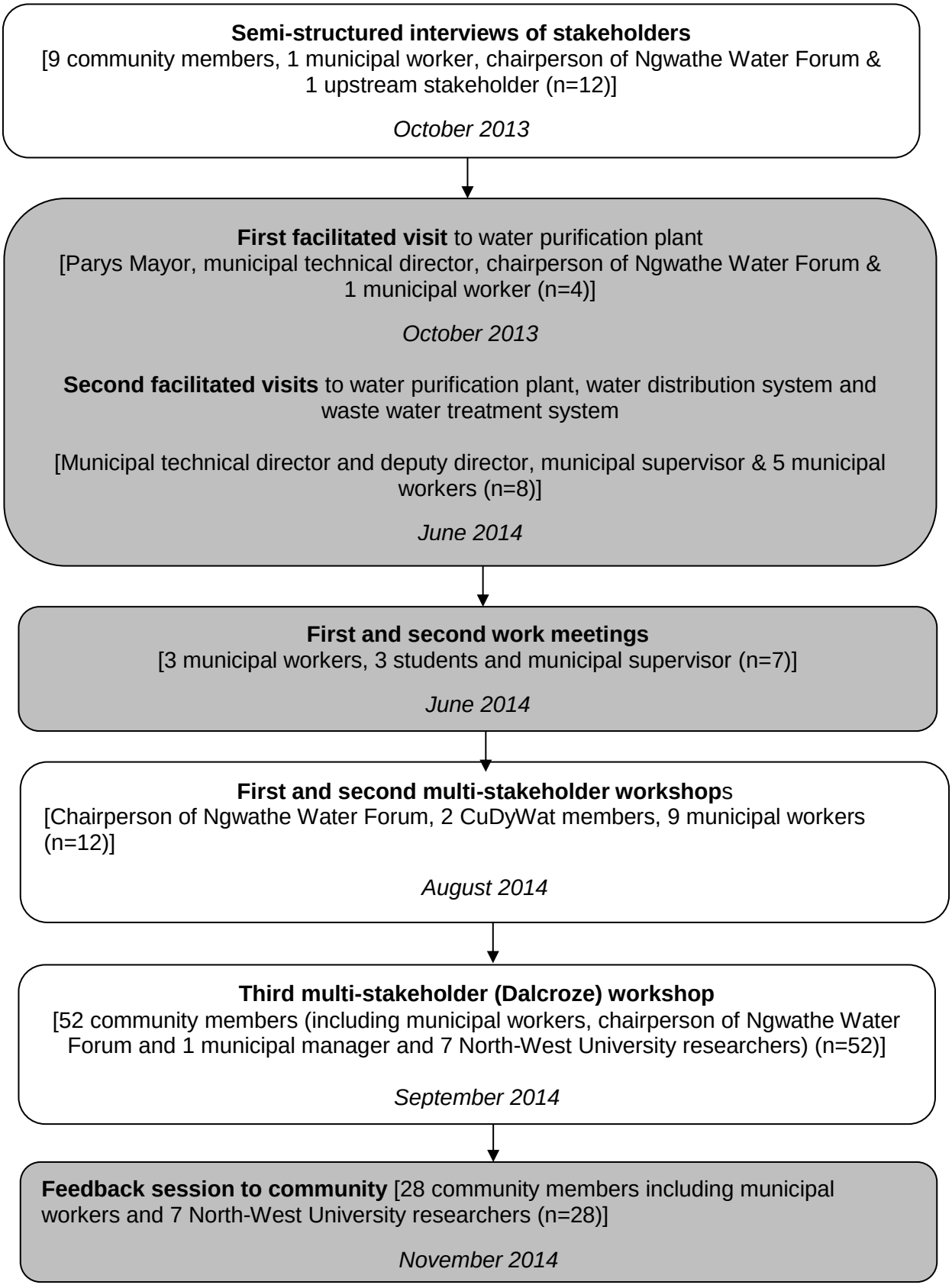


**Figure 10:** The sequence of data-capturing methods

## 3.4 Participation of key stakeholders

Key stakeholders of the Parys WSS were identified as representatives of:

- the Ngwathe Local Municipality, which is the custodian of the Parys WSS
- the Ngwathe Water Forum
- the community of Parys, which consists of residents of the Parys town area, Schonkenville and Tumahole.

### 3.4.1 Community member participation

The Parys community members were willing to participate in the research. This supported the transdisciplinary research approach. Most of the community members whom the researcher approached agreed to be interviewed. Community members also participated in a Dalcroze (movement-to-music) workshop and attended a community feedback meeting. All the events are described and discussed later in this chapter.

#### *3.4.1.1 Semi-structured interviews*

On 5, 10 and 11 October 2013, the researcher travelled to Parys to conduct face-to-face interviews with stakeholders. Twelve semi-structured interviews were conducted. De Vos *et al*. (2011: 358), indicate 12 respondents as a minimum required to create saturation in terms of views. Nine of the 12 interviewees were approached randomly. The other three were interviewed by prior appointment. The interviews were conducted in person and one-on-one. In two cases a friend sat next to the interviewee, and listened and commented (TMR. OA. SSI. P1 & P5. 5 October 2013). In one case the audience consisted of more than one person (TMR. OA. SSI. P4. 5 October 2013).

Signed permission was obtained from each stakeholder prior to the interviews. Community members who were not comfortable with giving personal details required in the informed consent form were not interviewed. The informed consent form is a basic requirement of North-West University (NWU) for field research. It ensures that the research has been approved by the University and that the public is given the right information regarding participation in the research.

The informed consent form provided the name and contact details of the researcher, and the title, purpose, duration and procedures of the research. Implications of participating in the study such as benefits, possible risks, confidentiality and voluntary participation were explained to the stakeholders (see Appendix A). The form used to guide the semi-structured interviews is reproduced in Appendix B. The confidentiality of the participants was ensured in the following manner: the personal details of all the participants were recorded for the purposes of the researcher's archive. However, their details are not disclosed in references, in order to protect their privacy, except in the case of public figures such as the chairperson of the Ngwathe Water Forum and Ngwathe Local Municipality management. References to respondents are coded according to a verifiable system.

Stakeholders who were interviewed included one office-bound Ngwathe municipal worker from Tumahole, a hairdresser from the Parys town area, a Parys restaurant owner, three self-employed persons (one from the Parys town area and two from Tumahole), a student from the Parys town area, one unemployed person from Tumahole, two water entrepreneurs who worked and lived in Tumahole, the

chairperson of the Ngwathe Water Forum in Parys, an art teacher from the Parys town area and an industry employee from Sasolburg (TMR. OA. SSI. P1 to P8. 5 October 2013; TMR. OA. SSI. P9 to P11. 11 October 2013; TMR. OA. SSI. P12. 13 June 2014). The diversity of the interviewed stakeholders afforded the researcher the opportunity to hear stakeholder experiences of the Parys WSS from various points of view. The water and sanitation challenges were captured as described by the stakeholders.

The results of the semi-structured interviews enabled the researcher to confirm the fact that water and sanitation problems were still being experienced in Parys. The research data collected during the semi-structured interviews provided the researcher with some indication of whom to interact with next. After the semi-structured interviews, the data-gathering steps consisted of interactions with the municipality (see Figure 10). The community was invited to participate at a Dalcroze workshop and feedback meeting, which were held as the last data-gathering steps. These measures were introduced as a result of the reluctance of the municipality to include the community in multi-stakeholder workshops as part of the scheduled research programme of the researcher (TMR. OA. FMW. 27 June 2014). The actions of the municipality negatively impacted on the research negatively since all the relevant stakeholders needed to be included throughout the research.

#### *3.4.1.2 The Dalcroze workshop*

The Dalcroze workshop, which took place on 26 September 2014, was the first multi-stakeholder workshop where the community was well represented (see Figure 11). The workshop is discussed in detail in this chapter. Although it was not planned by

the researcher, the workshop was a much-needed opportunity to have a multi-stakeholder workshop representative of the stakeholders of the Parys WSS.

**Figure 11:** Various stakeholders taking part in the third multi-stakeholder (Dalcroze) workshop at Stonehenge on Vaal (Tempelhoff *et al.,* 2014: 21)

The workshop was attended by 52 Parys stakeholders, mainly community members (MG. OA. DW. 26 September 2014; TMR. OA. DW. 26 September 2014). Some community members interviewed at the beginning of the research in 2013 also attended the Dalcroze workshop and the subsequent community feedback meeting in 2014. The community members consented to participate in the Dalcroze music and dance sessions before dealing with the water and sanitation issues.

The stakeholder feedback from the Dalcroze workshop was positive. The stakeholders felt that the event had been invigorating and that it enabled them to engage and collaborate with the researchers, each other and Ngwathe municipal representatives, despite tensions due to water and sanitation issues in the town (TMR. OA. DW. 26 September 2014; Tempelhoff *et al*., 2014: 20).

#### *3.4.1.3 Community feedback meeting*

A total of 28 members of the community also attended a feedback meeting on 10 November 2014, where the researchers reported the results of the Dalcroze workshop. Community members had the opportunity to comment on the draft research report of CuDyWat. This was aligned with the transdisciplinary research approach, where stakeholders form an integral and informed part of the research. The community members welcomed the feedback and engaged further on a way forward to resolve their water and sanitation problems (TMR. OA. CFM. 10 November 2014).

The continued presence of researchers in Parys gave some community members the hope that water and sanitation problems were receiving attention. At the community feedback meeting, one of the community members interviewed in 2013 indicated that he had noticed that the researcher had been working on the Parys WSS for a while which showed commitment to help the community (TMR. OA. CFM. 10 November 2014).

### 3.4.2 Ngwathe Water Forum participation

The Ngwathe Water Forum was formed after the 2008 service delivery protests in Parys as a recommendation from transdisciplinary research conducted at the request of Fezile Dabi District municipality (Van Riet & Tempelhoff, 2009: 31). According to a municipal official, the forum had permission from the Department of Water and Sanitation to operate under the Mooiriver catchment area (TMR. OA. FWM. P1. 13 June 2014).

The Ngwathe Water Forum did not participate as a whole. However, the chairperson of the forum, Mr. Saal de Jager, was willing to participate and take supportive action when there were obstacles in the process of carrying out the research. The researcher interviewed him on 11 October 2013. At the time she indicated that she had been unable to get an appointment with the municipal technical manager for an interview and permission for a possible facilitated visit to the Parys water purification plant. Mr. De Jager offered to take the researcher to the plant. He indicated that there would be municipal workers there who would be willing to give the researcher a facilitated tour of the plant and explain how it functioned (TMR. OA. SSI. P3. 8 October 2013).

The researcher drove to the works with Mr. De Jager who had a remote opener for the gate at the plant. The Mayor, Ms. J Mochela, who was at the works at the time, communicated her discontent with the fact that Mr. De Jager had a remote to the works. Mr. De Jager later said that after the incident his remote was no longer functional as municipality officials had changed the access code. As a result of the apparent conflict and misunderstanding during interactions with the municipal

stakeholders, the research process was severely hampered (TMR. OA. SSI. P3. 8 October 2013; TMR. OA. FV1. 11 October 2013).

Mr. De Jager was also present at the disrupted first multi-stakeholder workshop. On the pavement, after the workshop had been disrupted and the researcher and two NWU CuDyWat team members, had been escorted out of the municipal building, Mr. De Jager phoned the municipal manager. He complained about the disruption of the workshop and stated that the research team was there to assist in finding solutions to Parys's water and sanitation problems. Mr. De Jager attended a subsequent meeting with the municipal manager and was supportive of the research. He participated in the second multi-stakeholder workshop and the subsequent Dalcroze workshop (TMR. OA. SMW. 1 August 2014; TMR. OA. DW. 26 September 2014).

### 3.4.3 Ngwathe municipal management participation

The municipal management played a significant role in enabling the research to be carried out. However, the municipal management refrained from actual participation in the study (see Figure 10). They gave verbal and written permission for the researcher to engage with municipal workers and to view the municipal works (see Appendix C). The municipal management was at times supportive of the research and at others unresponsive and even hostile. This is elaborated below. At the beginning of the research the researcher could not secure an appointment to introduce the study, despite numerous calls to the municipality. The researcher was initially introduced to the municipal water purification workers and the Parys mayor (Ms. J Mochela) by Mr. De Jager. This may have affected the way in which those

stakeholders viewed the researcher in the context of existing relational challenges between the municipality and the community.

The Mayor, Ms. Mochela, was at the water purification plant supervising the water purification process. She gave permission for the researcher to view the plant on that first facilitated visit on 11 October 2013. This was after the municipal technical director at the time (Mr. Henk Coetzer) had appeared and indicated that he had received the researcher's request for municipal assistance, but had been unable to revert back to the researcher due to workload constraints (TMR. OA. FV1. 11 October 2013).

Facilitated visits to the municipal works resumed only in June 2014 due to the deterioration in the researcher's health and a major operation in January 2014. On 26 May 2014 the researcher met with Mr. NE Shabalala, the new municipal technical director, to request permission to conduct research in the municipal area. Due to workload constraints he referred the researcher to Mr. Coetzer.

Mr Coetzer was enthusiastic about assisting the researcher. He had had a positive experience of the study that was conducted previously by Mr. André van Zyl, an official of Fezile Dabi and postgraduate student at NWU. He immediately introduced the researcher to other municipal employees in the building and drove with the researcher to the Fezile Dabi municipal building to do the same. Arrangements were made for subsequent visits to the municipality.

The second facilitated visit to the municipal water and sanitation works took place on the 6 June 2014 as planned. The researcher reported to Mr. Coetzer's office. He instructed the municipal supervisor to take the responsibility of assisting the researcher. The supervisor made arrangements for the researcher to be taken through the water purification plant, the wastewater treatment plant and the potable water distribution system. The municipal management delegated support for the research to the supervisory level and participated minimally in the research. This could be one of the reasons why later in the study the management indicated that they were not comfortable with the community being involved. They were not familiar with the content of the research due to the one-way delegation hierarchy.

#### *3.4.3.1 Multi-stakeholder workshops*

Multi-stakeholders workshops were used to conduct aspects of the resilience assessment as well as to capture the experiences of stakeholders regarding the Parys WSS. The hostility of the municipal management towards the research was experienced at the first multi-stakeholder workshop which was held on 27 June 2014 in Parys in the boardroom on the municipal premises. The workshop was not representative of Ngwathe key stakeholders. It was attended by four municipal water and sanitation workers (including the water purification plant controller who was present at the first facilitated visit), Mr. De Jager and two co-researchers from NWU. The ward councillors, who were expected to represent the community, were not present. The municipality had been explicitly asked by the researcher to invite them to the workshop. The researcher attempted to invite them directly. However, Mr. D Fandisi (ward councillor leader) requested that the municipality invite them.

The atmosphere was relaxed and expectant. The researcher indicated that she would be recording the proceedings of the workshop to enable her to capture all the important details during the interactions. Some 30 minutes into the workshop the municipal technical director came into the boardroom and indicated that he wished to speak to the researcher. Outside the boardroom the technical director and the deputy technical director indicated that the workshop had to cease since members of the public were part of the workshop. The researcher informed them that the study was a transdisciplinary research project which required the involvement of various stakeholders. Furthermore, there was nothing secret about the information that would be used to facilitate the workshop. The researcher also indicated that there were only three members of the public present, i.e. the two co-researchers from NWU and Mr. De Jager from the Ngwathe Water Forum. The technical director insisted that the workshop had to cease because its content had to be ratified by the municipality prior to it being made available to the community (TMR. OA. FMW. 27 June 2014).

The researcher returned to the boardroom to explain that the workshop could not proceed due to a request from the technical director. While the participants enquired about the for reasons for stopping the meeting and expressing their concerns, two employees from the municipality disrupted the meeting and indicated that they had been instructed to evict the attendees from the boardroom (TMR. OA. FMW. 27 June 2014).

After Mr. De Jager made a call from outside the building, the municipal manager intervened. He requested that the researchers and Mr. De Jager come to his office to

resolve the conflict. A meeting subsequently took place with the municipal manager, the technical director, Mr. De Jager, the researcher and the two researchers from NWU. At the meeting a firm foundation was created to identify and address the issues that had led to the disruption of the workshop. The meeting was productive and went a long way towards resolving the conflict. There was consensus that a transdisciplinary study which involved a variety of stakeholders would be effective and beneficial for solving Parys's WSS problems. The municipal manager took a decision to organise another workshop on 11 July 2014.

The municipality postponed the second multi-stakeholder workshop planned for 11 July 2014 to 1 August 2014. The deputy technical director indicated that the municipality was busy preparing for a visit by State President Jacob Zuma. The stumbling blocks experienced impacted on the restricted time granted by the NWU for completion of the research. The workshop was not representative of the key stakeholders. It was attended by eight Ngwathe municipality workers and Mr. De Jager. The mayor, the municipal manager, the technical director and his deputy were not available. The councillors were again absent (TMR. OA. SMW. 1 August 2014). The municipal technical director opened the workshop before excusing himself to attend another meeting. He encouraged the municipal workers to be as open as possible and to answer any questions to the best of their ability.

The lack of community representation at the first and second multi-stakeholder workshops, together with the low participation of the municipal management at all the stakeholder interactions activities, impacted negatively on common group learning dynamics. Reyers *et al.* (2010: 963) indicate that stakeholder engagement

in a transdisciplinary framework is messy, but that once an understanding of each other's contexts and perspectives, basic trust and a common language have been built, co-production of knowledge that transcends disciplines starts to take place. The timeframe of the study and the contact time was too short to arrive at the knowledge creation point particularly, with the Ngwathe municipal management.

### 3.4.4 Municipal worker participation

The Ngwathe municipality workers were eager to participate in the research and attended most of the meetings and workshops. They willingly provided information and their experiences and challenges.

#### *3.4.4.1 Facilitated visits to Parys water and sanitation municipal works*

The facilitated visits involved the researcher being taken through the water purification plant, the water distribution system and the wastewater treatment plant by the relevant municipal workers. During the visits, the researcher observed and extensively photographed different aspects of the municipal works. Notes were taken of the explanations given by the plant operators as progress was made stepwise through the works. Diagrams were drawn of the processes and confirmed for accuracy with the municipal workers on the spot and later in work meetings (see Figures 12, 17 & 20).

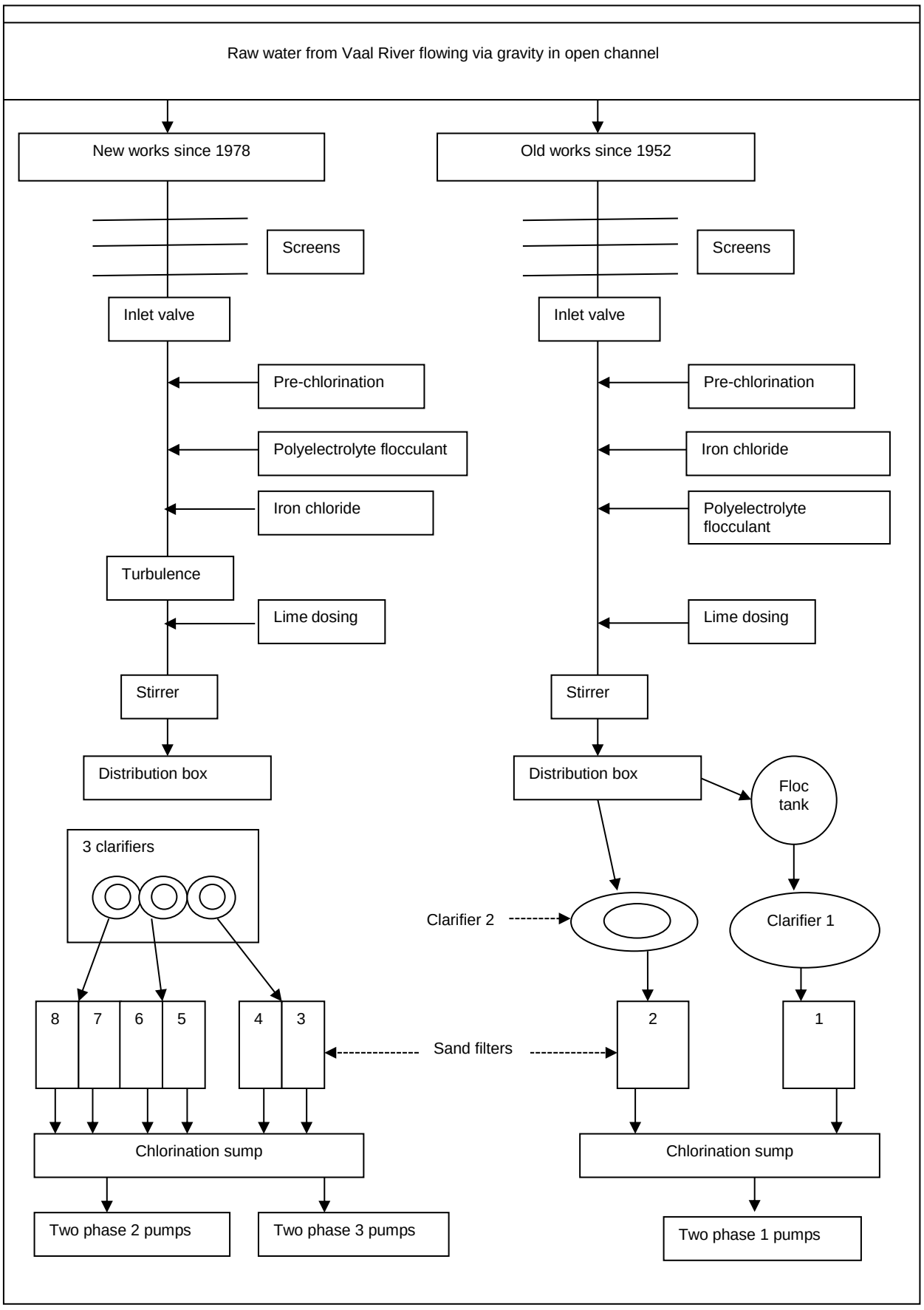


**Figure 12:** Parys water purification process

The Parys water purification process is depicted in Figure 12. According to the water purification plant controllers, the works have an old section which became operational in 1952 and the new section which was added in 1978 (TMR. OA. FV1. Operator 1. 11 October 2013; TMR. OA. FV3. Operator 4. 6 June 2014) (see Figures 13 & 14). Since 1952 the water purification plant has formed a protective barrier between the people of Parys and the deteriorated water quality of the Vaal River.

**Figure 13:** The old water purification works with the second clarifier in view (TMR. OA. Photo 2. 6 June 2014)

**Figure 14:** The new water purification works with the dosing station to the right, the clarifiers in the middle and the control room to the left (TMR. OA. Photo 3. 6 June 2014)

Surface water such as that of the Vaal River contains a variety of suspended solids that cause the water to appear turbid and have a colour. Turbidity is mostly caused by clay particles produced by soil erosion (Schutte & De Villiers, 2002: A9-1). However, bacteria, viruses and microalgae add to turbidity, while colloidal hydroxides of metals, organic substances and complex organic compounds from industrial wastewater add to the turbidity and colour (Schutte & De Villiers, 2002: A9-3). The suspended solids are removed by coagulation followed by clarification, which can be done through sedimentation, dissolved air flotation (DAF) and sand or membrane filtration (Schutte & De Villiers, 2002: B5-1).

The Parys water purification process has not been significantly altered since the plant was commissioned. Raw water flows via gravity in an open channel to the Parys water purification plant (see Figure 15). The initial step in treating the raw water is screening to remove large objects suspended in the water. The inlet valve behind the screens controls the flow of water into the water purification plant. Water samples are taken at this point to measure turbidity, pH and free chlorine. At the time of the facilitated visit, the water purification plant controller indicated that during summer rains the turbidity of the incoming water is high and causes upsets in the purification process. He indicated that they had also discovered free chlorine in the raw water, which was unexpected and was under investigation (TMR. OA. FV1. Operator 1. 11 October 2013; TMR. OA. FV3. Operator 4. 6 June 2014).

**Figure 15:** Parys water purification plant inlet with screens to remove large objects suspended in the raw water (TMR. OA. Photo 1. 6 June 2014)

After screening, chlorine gas is dosed as a disinfectant into the water via a pipe secured to the bottom of the inlet channel. Chlorine dosing is followed by coagulation (TMR. OA. FV1. Operator 1. 11 October 2013; TMR. OA. FV3. Operator 4. 6 June 2014). Chlorine gas is the most commonly used disinfectant in large water purification plants because it is cost effective compared to other disinfectants and can be more accurately controlled (Schutte & De Villiers, 2002: A11-1). Coagulation is a two-step process that involves the destabilisation of suspended particles and mixing to promote collision and aggregation, which is also known as flocculation. Coagulation is a complex process which is affected by coagulant dosage, pH, turbidity, dissolved organic material, anions and cations in solution, mixing effects, zeta potential and temperature (Schutte & De Villiers, 2002: A9-5).

The Parys water treatment process uses a dark brown solution of 37–47% iron chloride as a primary coagulant and a polyelectrolyte as a coagulant aid and lime to control the pH (see Figure 16). After coagulation, the flocs that are formed are separated from the water through clarification and the remaining turbidity is removed via sand filtration. Chlorine gas is again added at the end of the water purification process prior to distribution (TMR. OA. FV1. Operator 1. 11 October 2013; TMR. OA. FV3. Operator 4. 6 June 2014).

**Figure 16:** Chemical dosing pumps enabling coagulation (TMR. OA. Photo 4. 6 June 2014)

Figure 17 shows the Parys water distribution system. There are three pumping stations, with each station consisting of two pumps that pump potable water to different sections of Parys (see Figure 18). The first set of pumps route potable water to the old and new golf course areas. During the second multi-stakeholder workshop it was indicated that a borehole is currently supplying the old and new golf course areas. This was a municipal intervention to increase potable water supply to the Parys community (TMR. OA. FV3. Operator 4. 6 June 2014; TMR. OA. SMW. 1 August 2014).

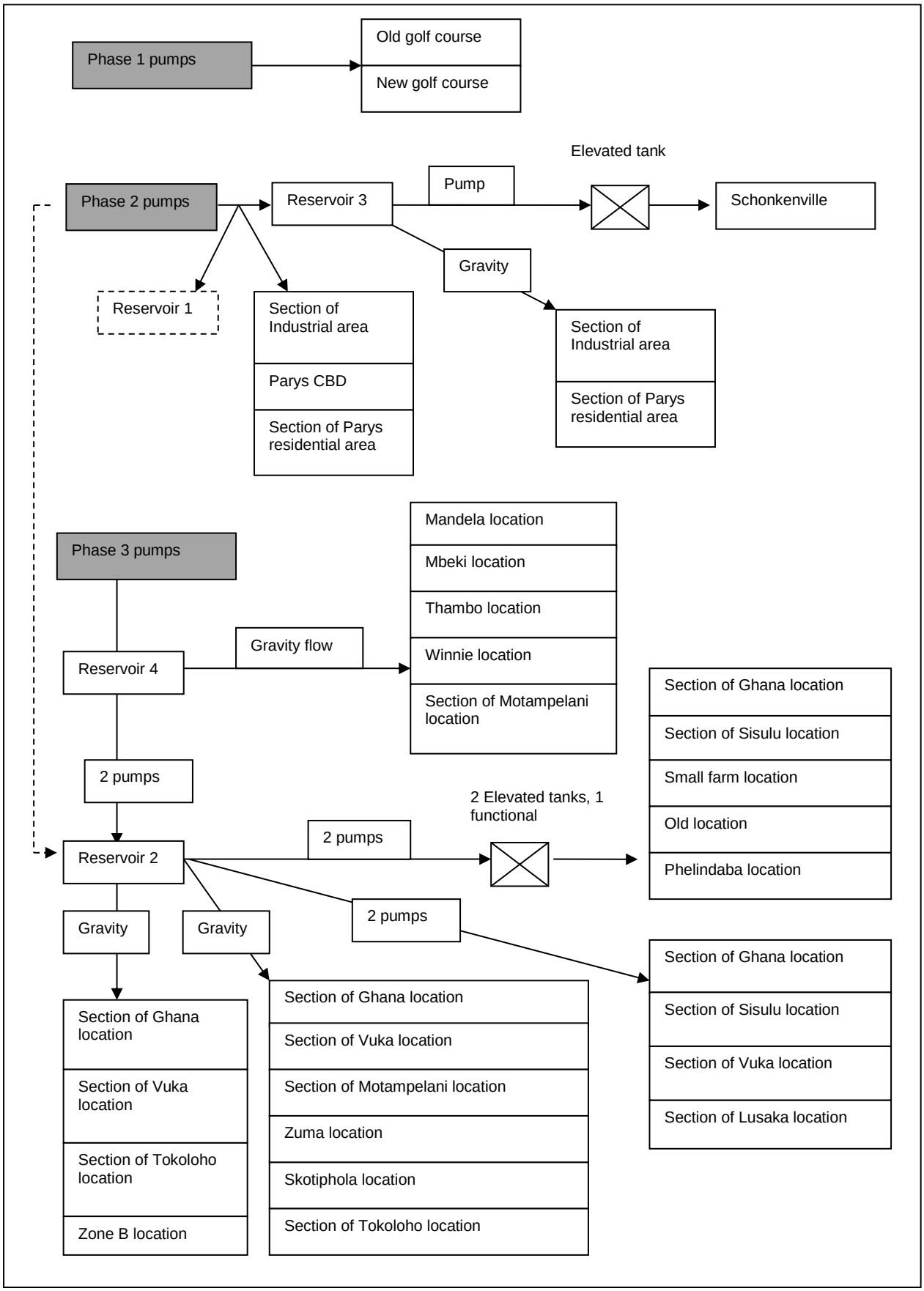


**Figure 17:** Parys water distribution network

**Figure 18:** Potable water pumps at the end of the water purification process (TMR. OA. Photo 5. 6 June 2014)

The second set of pumps route water to Reservoir 3, the Parys central business district (CBD), the Parys residential area, the industrial area and Schonkenville. Apart from this, there is an old discontinued pipeline connecting the second set of pumps to Reservoir 2. There is also a discontinued pipeline connection between the second set of pumps and the non-functioning Reservoir 1 (TMR. OA. FV3. Operator 4. 6 June 2014; TMR. OA. SMW. 1 August 2014). The third set of pumps is connected to Reservoirs 4 and 2. These pumps serve the largest part of the population of Parys. This area is the section that expanded most significantly since 1994. The municipality is currently in the process of drilling boreholes to supplement potable water in Reservoirs 3 and 4 (TMR. OA. FV3. Operator 4. 6 June 2014; TMR. OA. SMW. 1 August 2014). The municipality also provides seasonal untreated Vaal

River water from Rooidam from September to May via furrows situated in the older part of Parys (see Figure 19).


**Figure 19:** Irrigation water channel in Parys town area (TMR. OA. Photo 6. 6 June 2014)

The Parys wastewater treatment works uses a typical biological treatment process (see Figures 20 & 21). According to Schutte & De Villiers *(*2002: B6-1), biologically based processes are good at removing relatively low concentrations of dissolved and colloidal organic compounds. They recommend that chemically based processes be used as pre-treatment in cases of wastewater with high organic carbon content.

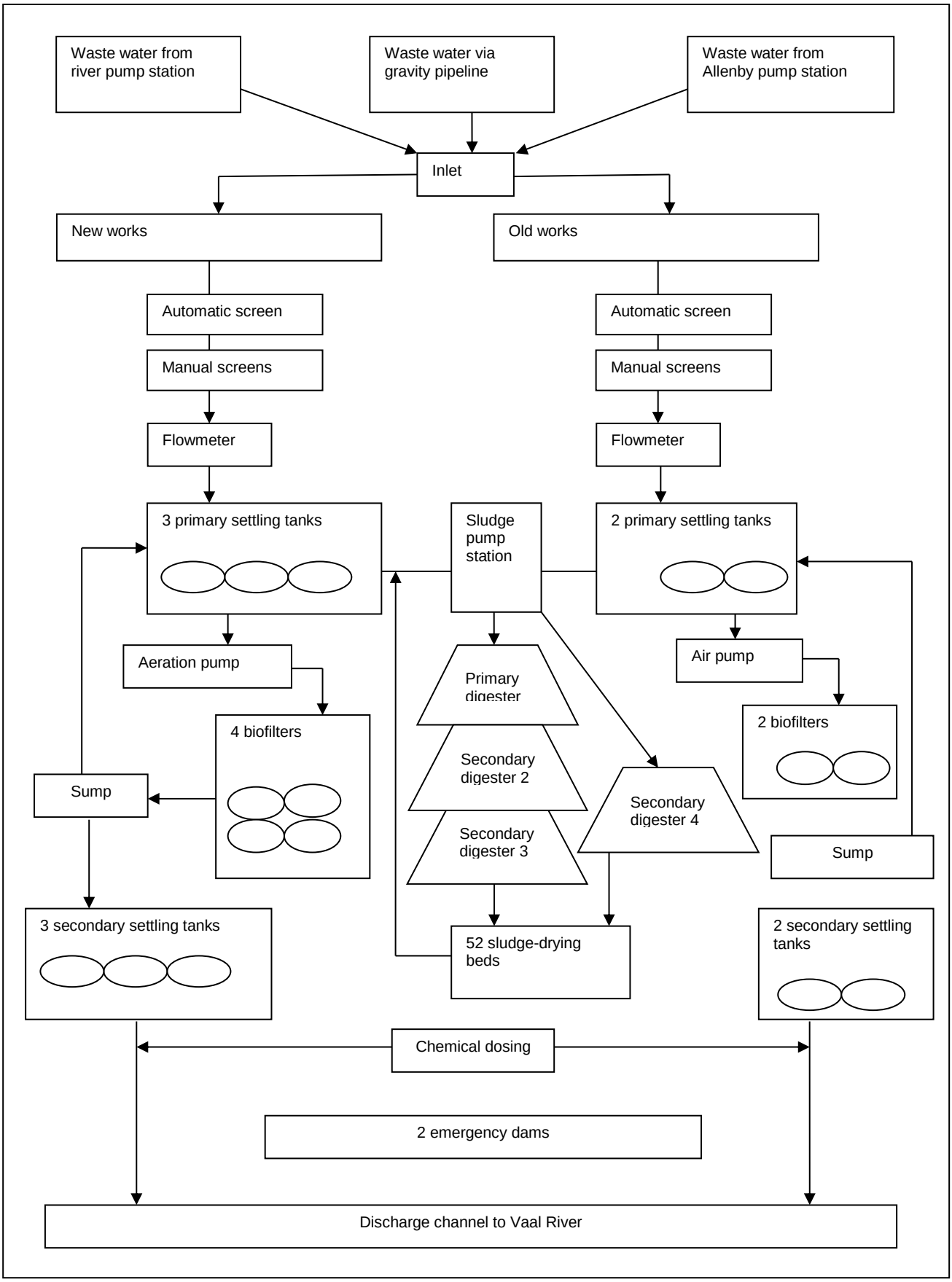


**Figure 20:** Schematic of Parys wastewater treatment works

**Figure 21:** Wastewater treatment plant in Parys (TMR. OA. Photo 9. 6 June 2014)

Figure 22 shows various wastewater streams converging on the Parys wastewater treatment works from the river pump station, the gravity line and the Allenby pump station. The wastewater from the Allenby pump station was red and foaming. An operator at the Parys wastewater treatment plant indicated that this was due to the abattoir wastewater coming through that line. Another operator complained that the water from the abattoir overloaded the wastewater treatment process (TMR. OA. FV2. Operators 2 and 3. 6 June 2014). After the wastewater streams are mixed at the inlet the combined stream is subsequently separated and routed into the new and old works where automatic and manual screens remove large suspended solids. The way in which the screenings are currently managed poses a health hazard to the wastewater treatment plant workers (see Figure 23).

**Figure 22:** Wastewater from the Allenby pump station was red and foaming due to blood from the abattoirs (TMR. OA. Photo 7. 6 June 2014)

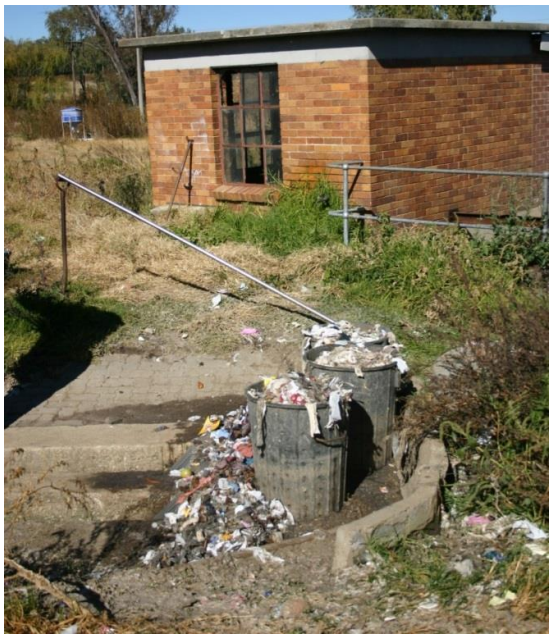

**Figure 23:** Current management of wastewater screenings (TMR. OA. Photo 8. 6 June 2014)

After screening, the flowmeters measure the volumes of wastewater before it goes into primary settling tanks to remove as much of the suspended solids as possible before aeration and biofiltering (TMR. OA. FV2. Operators 2 and 3. 6 June 2014). During biofiltering the dissolved and colloidal organic compounds are utilised as nutrients for a particular group of microorganisms which use atmospheric oxygen to convert dissolved and colloidal organic compounds into more microorganisms, carbon dioxide and water (Schutte & De Villiers, 2002: B6-6).

The biofiltered water flows into a sump where a portion of it is pumped back into the settling tanks to maintain flow to the biofilters and to dilute the untreated wastewater. The remaining portion is pumped into secondary settling tanks, where it is disinfected with HTH chlorine chips prior to discharge. In cases of emergency wastewater is pumped into two emergency dams prior to discharge (TMR. OA. FV2. Operators 2 and 3. 6 June 2014). An official explained that when wastewater of unacceptable quality is released into the environment, it is mostly due to mechanical breakdowns that occur during the nightshift and when high wastewater volumes enter the system (TMR. OA. FV2. Operators 2 and 3. 6 June 2014). An intervention by the municipality, with the help of consultants, has led to an increase in the capacity and capability of the wastewater treatment works (TMR. OA. SMW. P1. 1 August 2014).

Sludge collected from the primary settling tanks, together with the water drained from the sludge drying beds, is pumped by the sludge pump station to four digesters. From the digesters the sludge is sent to the drying beds. The dried sludge is either

disposed of or re-used by local farmers (TMR. OA. FV2. Operators 2 and 3. 6 June 2014).

#### *3.4.4.2 Work meetings with municipal workers*

Work meetings were held to confirm the information collected from facilitated visits to the municipal water and sanitation works and to assess aspects of resilience with the stakeholders. The first work meeting took place on the morning of 13 June 2014 in Parys at the Fezile Dabi district municipal offices. The meeting was attended by the researcher, two Fezile Dabi employees and three students undergoing training from the municipal employees. The meeting was used by the researcher to prepare herself and the possible participants for the subsequent multi-stakeholder workshops. The meeting focused on: describing the Parys WSS and its main issues; exploring alternate regimes and states with their associated thresholds; assessing cycles of change; and exploring adaptability and transformative change. Everyday language was used to enable mutual understanding when performing the resilience assessment activities (TMR. OA. FWM. 13 June 2014).

The second work meeting took place on 13 June 2014 in the afternoon in Parys at the Ngwathe local municipal Commando offices. The meeting was attended by the researcher, the municipal supervisor and the office secretary. The researcher repeated a resilience assessment with the attendees. The municipal supervisor corrected and added to the determination of the focal system boundaries and the descriptions of the water purification works, the portable water distribution system and the wastewater treatment plant (see Figures 1 to 4). He also added to the possible interventions the option of fixing leakages in households, businesses and

industries. He explained that a preliminary study that had been done earlier indicated that the flow of water at night to the wastewater treatment plant pointed to major leakages (TMR. OA. SWM. 1 and 2. 13 June 2014).

### 3.4.5 Participation of co-researchers

The co-researchers who participated in the research were part of NWU's CuDyWat. Two of the CuDyWat members, Dr Claudia Gouws and Mr. Sysman Motloung, played an important role when the first multi-stakeholder workshop went awry. They provided emotional support to the researcher and also participated and supported the research in the subsequent meeting with the municipal manager. They provided notes that they had taken during the workshop and the meeting.

Seven CuDyWat researchers and two Sasol employees collaborated to facilitate the Dalcroze workshop, which was a diagnostic study of the Parys water and sanitation challenges as requested by Sasol on behalf of the Free State Premier (Mr. Ace Magashule) (Tempelhoff *et al.,* 2014: 4) (see Figure 24). The Dalcroze co-researchers were from a variety of disciplines, such as history, political science, environmental science, human resources management, environmental engineering and music studies. The researchers of music studies focused on the impact of music and movement to enhance dialogue and cooperation (see Figure 11). Historical research was used to understand group formations and spatial awareness. Political science research focused on infra-ethics and public sector leadership. Human resources management contemplated human resources and the water sector in urban settings. The engineer in the research group explored alternatives to the

current water and sanitation infrastructure. The author of this study focused on a resilience assessment of the Parys WSS (Tempelhoff *et al.,* 2014: 15).

The co-researchers shared raw and analysed research data in the form of notes, photos and personal insights obtained at the time of the Dalcroze workshop. The co-researchers also collaborated on giving feedback to the community after the workshop. Notes of the feedback meeting were also shared. Phenomenological and case study research strategies were used by the researchers (Tempelhoff *et al.,* 2014: 18).


**Figure 24:** Transdisciplinary researchers involved in the Dalcroze workshop at Stonehenge on Vaal (MG. PA. Photo 1. 26 September 2014)

### 3.5 Data analysis and interpretation

The raw data obtained from all the data collection methods applied was typed, read and arranged in emerging themes (Creswell, 2009: 185). The themed data was subsequently separated into categories of systems and target and transformational knowledge (see Figure 25). Systems knowledge identifies, interprets and structures the problem (Hirsch Hadorn *et al.,* 2008: 4). Target knowledge defines the desired end state, where the problem would be seen as resolved by stakeholders (Hirsch Hadorn *et al.*, 2008: 35). Transformational knowledge provides technical, social, legal, cultural and other possible means of acting that will facilitate movement from a current to a desired situation (Hirsch Hadorn *et al.*, 2008: 35). The research process enabled the researcher to capture the voices of the stakeholders and at the same time use what they were saying to collaboratively carry out a resilience assessment and to develop solutions for the societal problem.

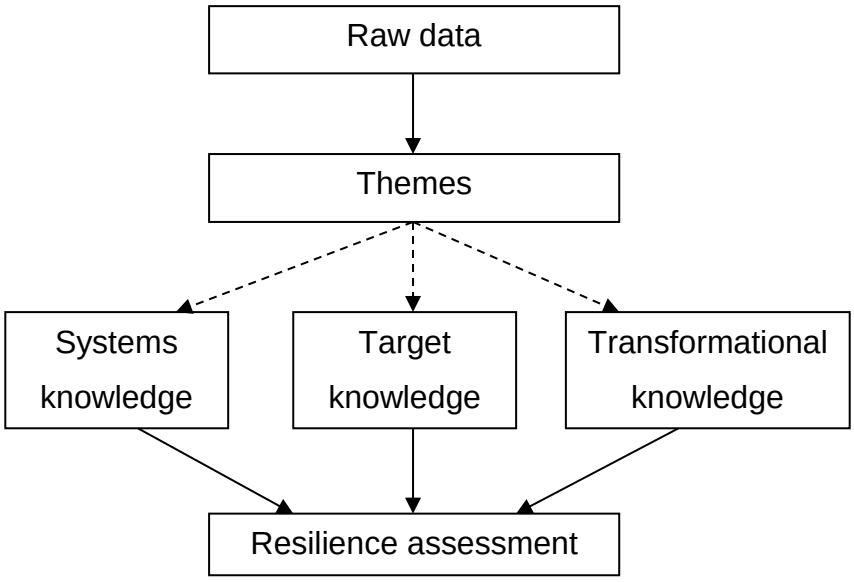


**Figure 25:** Research data analysis

The resilience assessment was carried out iteratively using an increasing amount of information with each iteration as the research data collection methods unfolded in series (see Figure 10).

## 3.6 Chapter summary

A methodological literature review indicated that a transdisciplinary research approach is recommended for exploring social-ecological system challenges. The researcher collaborated with Parys stakeholders and CuDyWat co-researchers to understand the Parys water and sanitation problems from the stakeholder's point of view. The stakeholders participated through semi-structured interviews (12 stakeholders); facilitated visits to the municipal water and sanitation works (12 stakeholders); work meetings with municipal workers (7 stakeholders); multi-stakeholder workshops (64 stakeholders) and feedback meeting (28 stakeholders), which were conducted in series. The stakeholders supplied systems, target and transformational knowledge through the data collection methods. This knowledge was used to collaboratively assess the resilience of the Parys WSS.

There was sound participation of Ngwathe Local Municipality technical staff members, the Ngwathe Water Forum chairperson and Parys community members. The co-researchers from NWU participated in specific activities mainly related to the Dalcroze workshop. The Ngwathe Local Municipality management participated minimally due to lack of time and the lack of trust between the municipality and the community, which impacted the research negatively in the following manner:

- There was low contribution of knowledge required for resilience assessment by the municipal management.
- The management was not familiar with the content of the study and this affected how they interpreted stakeholder participation in the research.
- The benefits of the Dalcroze workshop to harmonise relationships and enhance collaboration in a situation of low trust between the community and the municipality were missed by the municipal management.
- The learning that came with collaboratively assessing the resilience of the Parys WSS was also missed.

# CHAPTER 4

# AN EXPOSITION OF THE RESILIENCE OF THE PARYS WATER AND SANITATION SYSTEM AND POTENTIAL STRATEGIES FOR IMPROVEMENT

Chapter 4 discusses the water and sanitation problems and their causes and consequences as experienced and described by the Parys water and sanitation (WSS) stakeholders. The problems, causes and consequences are part of systems knowledge, which answers questions concerning the start and development of a real-world problem (Hirsch Hadorn *et al.,* 2008: 4). The chapter then indicates how the Nature evolving social-ecological system concepts of resilience, adaptability, transformability, adaptive cycle and panarchy were used to make sense of the systems, target and transformational knowledge provided by the stakeholders. Target knowledge aims to define the desired end state, which is where the Parys water and sanitation problems would be seen as resolved by the stakeholders. Transformational knowledge provides technical, social, legal, cultural and other possible means of acting to facilitate movement from current situation to desired situation (Hirsch Hadorn *et al.,* 2008: 35).

## 4.1 Description of main issues from the stakeholders' perspective

The water and sanitation problems experienced by the stakeholders were solicited through the following data collection methods: semi-structured interviews, facilitated visits to the municipal water and sanitation works, work meetings with municipal workers and multi-stakeholder workshops. The water and sanitation problems are summarised in Table 3, located spatially on a Parys WSS map (see Figure 26) and are then discussed in detail. Additionally, the stakeholders provided the causes (also

referred to as disturbances, shocks or drivers) and the consequences associated with the identified problems.

**Table 3:** Water and sanitation problems according to stakeholders

| **Problems relating to the *ecological and infrastructural aspects* of the Parys WSS** | | **Geographic boundary** (see Figure 26) |
|---|---|---|
| Problem 1 | Deteriorating quality of raw water | Upstream of Parys WSS |
| Problem 2 | Lack of potable water | From Parys water purification plant to household, industry and business taps |
| Problem 3 | Potable water distribution problem | |
| Problem 4 | Unacceptable quality of potable water | |
| Problem 5 | Wastewater governance and management problem | From households, industry and business to wastewater treatment plant |
| **Problems relating to the *social aspects* of the focal system** | | |
| Problem 6 | Municipal management impacting negatively on the system | Entire Parys WSS |
| Problem 7 | Municipal technicians impacting negatively on the system | Entire Parys WSS |
| Problem 8 | The community impacting negatively on the system | Entire Parys WSS |

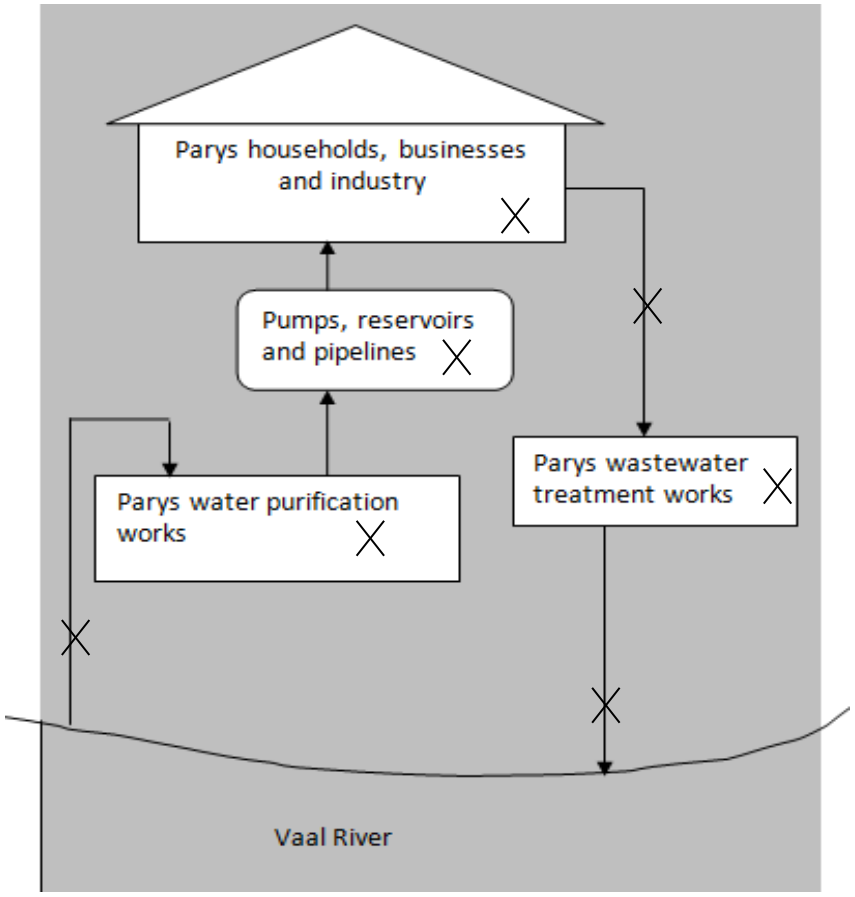


**Figure 26:** Spatial location of some of the problems of the Parys water and sanitation system (marked with an X)

Van Donk and Gaidien (2014: 11) indicate that the disturbances (causes), problems and consequences referred to when discussing resilience are seen as abnormal, alarming and unexpected, which is not always the case. In respect of the Parys WSS, the problems, together with their associated causes and consequences, have been recurring over a prolonged period of time. For local residents, and even officials responsible for the operations, some of the issues have literally become 'normal' and stakeholders now appear to have become 'accustomed' to them.

The collected systems knowledge confirmed the complexity of the Parys WSS. The eight identified problems, together with their multiple causes and consequences, are interconnected and emanate from the human (individuals, society and government), ecological (environment and resources) and support (economy and infrastructure) subsystems of the Parys WSS, as well as from larger social-ecological systems within its panarchy. The complexity of the problems explains why one-dimensional interventions would not be adequate to bring about the required changes.

### 4.1.1 Deteriorating quality of raw water

During semi-structured interviews and the second multi-stakeholder workshop, respondents pointed out the deteriorating quality of the raw water feeding the Parys water purification plant as a problem (TMR. OA. SSI. P11. 10 October 2013; TMR. OA. SMW. P2. 1 August 2014). This problem is aligned with the findings of the empirical literature review given in Chapter 1. Stakeholders identified several causes of this problem. An upstream environmental specialist indicated that effluents from the Klip River, Rietspruit, and Emfuleni wastewater treatment works, as well as from industries upstream of Parys, were resulting in salination, nutrients and bacteriological contaminants in the Vaal River Barrage (TMR. OA. SSI. P11. 10 October 2013).

A municipal technician and a community member commented that Parys was surrounded by farms, and that on rainy days during spring farmers started to plough and plant. The chemicals used by the farmers entered the Vaal River and went directly into the Parys water purification plant, which was not designed to deal with the chemical contaminants. It could only deal with limited amounts of turbidity and

microorganisms (TMR. OA. SMW. P2. 1 August 2014; TMR. OA. SMW. P1. 1 August 2014). A municipal technician working at the Parys water purification plant said that the turbidity of the raw water usually increased significantly during the rainy summer months due to larger volumes of Vaal River water causing turbulence and erosion upstream of Parys (TMR. OA. FV3. Operator 4. 6 June 2014).

Stakeholders also identified consequences of the deteriorating raw water quality. A water entrepreneur operating in Parys and a municipal technician indicated that the raw water had become incompatible with the Parys water purification process (linked to Problem 4: unacceptable quality of potable water) (TMR. OA. SSI. P9. 11 October 2013; TMR. OA. FV3. Operator 4. 6 June 2014; TMR. OA. SMW. P2. 1 August 2014). Another municipal technician indicated that there were significant losses of potable water due to frequent sand filter backwashes caused by the deterioration of the quality of Vaal River water (linked to Problem 2: lack of potable water) (TMR. OA. SMW. P1. 1 August 2014). A community leader commented that the algal growth due to upstream pollution had turned the Vaal River into the ‘Green River’ in the past few years. He explained that nature was looking after the water, and that the algae were eating all the contaminants (TMR. OA. SMW. P1. 1 August 2014). However, the residue excreted by the algae caused the bad taste and smell which the current water purification process could not address (linked to Problem 4: unacceptable quality of potable water) (TMR. OA. SMW. P1. 1 August 2014; TMR. OA. SSI. P1. 05 October 2013).

The consequence of fish kills and the loss of biodiversity in the Vaal River in the vicinity of Parys was not mentioned during all the interactions with the stakeholders.

The stakeholders were more aware of the human and support systems than of the natural system of the Vaal River and its flora and fauna.

### 4.1.2 Lack of potable water

Problem 2 (lack of potable water) was caused by other problems within the system. Stakeholders identified Problem 1 (deteriorating raw water quality), Problem 3 (potable water distribution problem), Problem 6 (the municipal management impacting negatively on the system), Problem 7 (the municipal technicians impacting negatively on the system) and Problem 8 (the community impacting negatively on the system) together with their causes and consequences as the causes of the lack of potable water. This means that unless Problems 1, 3, 6, 7 and 8 are addressed, Problem 2 cannot be fully resolved. The interconnectedness of the causes, problems and consequences need to be considered in the development of interventions.

Stakeholders also described the consequences of the lack of potable water. Firstly, the municipal technicians have to increasingly push the water purification plant production capacity from 15 ML/day to 19 ML/day to meet consumer demands (TMR. OA. SSI. P10. 11 October 2013; TMR. OA. DW. P12. 26 September 2014; GM. OA. DW. P12. 26 September 2014; Ngwathe Local Municipality, 2010: 5; Ngwathe Local Municipality, 2011: 16; Ngwathe Local Municipality, 2012: 28). Operating the plant above capacity causes equipment failure and prevents ongoing maintenance work from being done (TMR. OA. SMW. P1. 1 August 2014).

Secondly, the residents of Parys experienced low water pressure daily, especially during the day (TMR. OA. SSI. P1 to P8. 05 October 2013; TMR. OA. SSI. P9 & P10. 11 October 2013; TMR. OA. DW. P19 and P25. 26 September 2014; GM. OA.

DW. P19 and P25. 26 September 2014). They also spoke about the water supply being absent or practically non-existent over extended periods, ranging from part of a day, to one day, to days on end, in some cases for months and even years (TMR. OA. DW. P27. 26 September 2014; GM. OA. DW. P27. 26 September 2014; TMR. OA. SSI. P5. 05 October 2013; TMR. OA. SSI. P9. 11 October 2013; TMR. OA. DW. P34. 26 September 2014; GM. OA. DW. P34. 26 September 2014; TMR. OA. SSI. P3. 05 October 2013).

Thirdly, the residents have to buy drinking water because they cannot drink the potable water supplied by the municipality (see Figure 27). Alternative water sources were being explored by residents and the municipality, e.g. rain water harvesting and borehole water (TMR. OA. SSI. P12. 13 June 2014). Municipal tractors with water containers drove around the community supplying people with water (TMR. OA. SMW. P5. 1 August 2014). The residents who could afford to purchase Jojo tanks used them to cushion the negative impacts of water shortages, which included geyser damage (TMR. OA. DW. P17, P22 and P23. 26 September 2014; GM. OA. DW P17, P22 and P23. 26 September 2014).

One respondent's experience of access to potable water was different from that of all the other stakeholders. She was from Old Location, the first township extension of Tumahole. She said that she did not experience water shortages and there was abundance of water in her part of town (TMR. OA. SSI. P12. 13 June 2014).

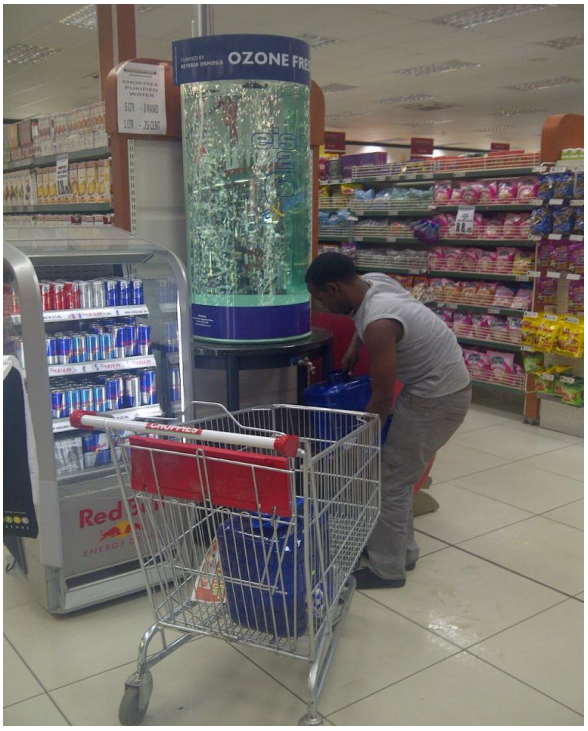


**Figure 27:** Parys resident buying water from a local supermarket (TMR. OA. Photo 1. 25 September 2014)

### 4.1.3 Water distribution problem

The first disturbance to potable water distribution was power outages, which prevented potable water from being pumped to the reservoirs (linked to Problem 8: community impacting negatively on the system). There were no generators on standby to kick in when there was a power outage (linked to Problem 6: municipal management negatively impacting on the system). Therefore, this disturbance, combined with potable water demand outstripping the capacity of the plant (linked to Problem 8), had the consequence of reservoirs being almost empty most of the time (TMR. OA. FV4. Operator 5. 6 June 2014). According to a municipal technician, Reservoir 1 used to work – it used to be connected to Reservoir 3, but it had become non-functional because it no longer received water due to the low water level in

Reservoir 3. The low water levels in the reservoirs affected the water being supplied via gravity to households (linked to Problem 2: lack of potable water) (TMR. OA. SMW. P5. 1 August 2014). The low levels also led to a situation where the sludge that had accumulated at the bottom of the reservoirs was being routed to the community (linked to Problem 4: unacceptable quality of potable water) (TMR. OA. SMW. P1. 1 August 2014).

The second water distribution disturbance was the old, worn-out potable water distribution pipes which required refurbishment (linked to Problem 6: municipal management impacting negatively on the system). The state of the pipes resulted in frequent pipe bursts (TMR. OA. DW. P12. 26 September 2014; GM. OA. DW. P12. 26 September 2014). The municipality cut the water supply when there were pipe bursts (linked to Problem 2: lack of potable water) (TMR. OA. SSI. P12. 13 June 2014). The third water distribution disturbance occurred when the plumbers who repaired the potable water distribution pipes did not flush them properly, which sporadically impacted on the potable water quality (linked to Problem 7: municipal technicians negatively impacting on the system). This was mentioned by two different municipal technicians on separate facilitated visits to municipal works (TMR. OA. FV1. Operator 1. 11 October 2013; TMR. OA. FV3. Operator 4. 6 June 2014).

The fourth water distribution disturbance was leaks in households, industries and businesses which channelled potable water into the environment and the wastewater collection system (linked to Problem 8: community impacting negatively on the system). A municipal technical supervisor indicated that this was one of the reasons for the high potable water demand. He said a recent preliminary study had been

done where the day and night flows to the wastewater treatment plant were compared, which confirmed this fact (TMR. OA. SWM. P1. 13 June 2014).

### 4.1.4 Unacceptable quality of potable water

According to one respondent, before 1992 the problem experienced in Parys was water shortages, not water quality (TMR. OA. SSI. P9. 11 October 2013). Another said the water quality deteriorated in 2008 and 2009. During this period, potable water looked like tea – it was brown and rusty. However, after Rand Water intervened, the quality of potable water became good. Her household could refrigerate and drink the water as well as cook with it (TMR. OA. SSI. P12. 13 June 2014).

At the Dalcroze workshop a community member said he had seen an improvement in potable water quality. He said in 2009 and 2010 the water was not clean (TMR. OA. DW. P25. 26 September 2014; GM. OA. DW. P25. 26 September 2014). Another said the quality of the water leaving the Parys water purification plant was acceptable (TMR. OA. DW. P22. 26 September 2014; GM. OA. DW. P22. 26 September 2014). At the second multi-stakeholder workshop a participant said the high chlorine concentration at the plant may be masking the problems before the water entered the distribution system (TMR. OA. SMW. P1. 1 August 2014).

Despite the improvements seen by some, most Parys residents indicated that they had negative experiences of Parys's potable water quality. They complained that the water was still not clean because it smelled, tasted and looked bad (linked to Problem 1: deteriorating raw water quality) (TMR. OA. SSI. P1 to P8. 05 October

2013; TMR. OA. SSI. P9 to 10. 11 October 2013; TMR. OA. DW. P4, P10, P29 and P34. 26 September 2014; GM. OA. DW.P4, P10, P29 and P34. 26 September 2014). A resident from the Parys town area said that her potable water had a chlorine taste (TMR. OA. SSI. P6. 05 October 2013). Others said that the potable water looked brown and at times contained algae, sand, rust or mud (TMR. OA. SSI. P1. 5 October 2013; TMR. OA. SSI. 9. 11 October 2013; TMR. OA. SSI. 5 & 7. 05 October 2013; TMR. OA. SSI. 9. 11 October 2013).

A community member identified one of the causes of unacceptable potable water quality as the presence of ferric chloride that was used in the water purification process. He said that it gave potable water a yellow colour which was unacceptable to the community (TMR. OA. DW. P16. 26 September 2014; GM. OA. DW. P16. 26 September 2014). Other causes of unacceptable potable water quality were identified as: Problem 1 (deteriorating raw water quality); Problem 2 (lack of potable water); Problem 3 (potable water distribution problem); Problem 7 (the municipal technicians impacting negatively on the system) and Problem 8 (the community impacting negatively on the system), together with their respective causes and consequences.

The consequences of poor-quality potable water were identified as follows by the stakeholders:

- The municipality cut the water supply when potable water was unfit for domestic use (linked to Problem 2: lack of potable water).
- For years, the people of Parys have not been able to drink the potable water supplied by the municipality (TMR. OA. SSI. P1 & P3. 05 October 2013; TMR.

OA. SSI. P3. 05 October 2013; TMR. OA. DW. P34. 26 September 2014; GM. OA. DW. P34. 26 September 2014). A stakeholder said “One sip of Parys water and you will not want to drink it” (linked to Problem 2: lack of potable water) (TMR. OA. SMW. P1. 1 August 2014). A municipal official explained that the community assumed that the yellow to brown colour of the water meant that the water was not suitable for drinking. This assumption had gone on for years, therefore, when people were told that the brown water had been tested and that it was suitable for drinking they still would not drink it (TMR. OA. FWM. P1. 13 June 2014).

- The water negatively affected the community’s health (TMR. OA. SSI. P4. 05 October 2013; TMR. OA. SSI. P9. 11 October 2013; TMR. OA. DW. P1. 26 September 2014; GM. OA. DW. P1. 26 September 2014). For instance, it gave children diarrhoea (TMR. OA. SSI. P5. 05 October 2013). A community member said “The water will not kill you immediately if you drink it, but it gives you a slow puncture. The heavy metals accumulate in your body” (TMR. OA. SMW. P1. 1 August 2014).
- Some of the residents could not use the water for washing themselves due to its bad quality (linked to Problem 2: lack of potable water) (TMR. OA. SSI. P3. 05 October 2013).
- Some residents used domestic membrane water purification systems (TMR. OA. SMW. P1. 1 August 2014). Reverse osmosis required frequent filter changes due to the bad quality of the municipal potable water that was being purified. The cost of filter changes was high for the stakeholders. The membrane filtration process increased water demand since some potable

water was discarded during the process (linked to Problem 2: lack of potable water) (TMR. OA. SSI. P2. 05 October 2013).

- Some residents purchased water for drinking purposes (TMR. OA. SSI. P1 to 6. 05 October 2013).
- Those who could not afford to buy water chemically treated the municipal potable water before drinking it. A community member indicated that he boiled the water and added bleach when he could not afford to buy bottled water (TMR. OA. SSI. P5. 05 October 2013).

### 4.1.5 Wastewater governance and management problem

Seven causes leading to the wastewater governance and management problem were identified by the stakeholders. The first cause was also a cause of Problem 3 (potable water distribution problem), i.e. leaks in households, industries and businesses which channelled potable water to the wastewater collection system. The second cause, rain water, like the first cause, added to the increase of wastewater volumes above the plant capacity (TMR. OA. FV2. Operator 2 and 3. 6 June 2014).

The third cause was that wastewater pipes burst due to and aging infrastructure (linked to Problem 6: municipal management impacting negatively on the system) (Ngwathe Local Municipality, 2006: 28). The fourth cause was breakdowns of wastewater treatment works equipment, especially during night shifts (linked to Problem 7: municipal technicians impacting negatively on the system) (TMR. OA. FV2. Operators 2 and 3. 6 June 2014). Two other causes were linked to a cause of Problem 6 (municipal management negatively impacting on the system), i.e. refusal to develop and enforce local rules. There were no rules with regard to what abattoirs

could dispose into the wastewater collection system. A community leader and a municipal official said that the municipality kept complaining about the abattoirs but there was no chemical oxygen demand (COD) limit for abattoir wastewater. The health practitioners could not hold the abattoirs to any limit. The blood from the abattoirs put an unacceptably high COD load on the biofilters (TMR. OA. FWM. P1. 13 June 2014; TMR. OA. SMW. P1. 1 August 2014).

The cause above also manifested in the following manner. Parys is surrounded by various tourist destinations along the Vaal River, some of which transport their wastewater to the Parys wastewater treatment plant. However, the municipality did not keep a proper record so that they could invoice them correctly and be paid for services rendered (TMR. OA. FWM. P1. 13 June 2014). The seventh cause was those tourist destinations dumping their wastewater directly into the Vaal River (linked to Problem 8: the community impacting negatively on the system) (TMR. OA. SMW. P4. 1 August 2014).

The consequences of the problem of wastewater governance and management were negative impacts on: the Vaal River water quality and ecosystem; the health of residents; community livelihoods connected to the river; and the ability of the Ngwathe Local Municipality to prepare potable water for the downstream town of Vredefort (TMR. OA. SMW. P1. 1 August 2014).

### 4.1.6 Municipal management impacting negatively on the system

The stakeholders identified causes leading to the municipal management impacting negatively on the Parys WSS. Firstly, the commitment of the national government to

provide potable water to all South Africans and to eradicate the bucket sanitation system had put an enormous responsibility on the Ngwathe Local Municipality to supply water to the increasing population of Parys and to replace Tumahole's bucket toilets with a waterborne system (TMR. OA. DW. P12 and P16. 26 September 2014; GM. OA. DW. P12 and P16. 26 September 2014; Ngwathe Local Municipality, 2011: 18). The associated use of wrong population data by national government and the Ngwathe Local Municipality to develop and fund water and sanitation infrastructural project interventions had hamstrung the municipality (TMR. OA. SMW. P1. 1 August 2014).

Secondly, the stakeholders said that municipal management lacked the required skills in planning ahead and developing a vision for the Parys WSS (TMR. OA. SSI. P2. 5 October 2013; TMR. OA. SSI. 10 and 11. 11 October 2013). A community leader stated that the municipality was merely trying to stamp out fires. As a fire occurred the municipality tried to kill it. He recommended a preventive approach rather than waiting for something to go wrong (TMR. OA. SMW. P1. 1 August 2014). One resident stated that the municipal management was incompetent because those who had fought for freedom from apartheid were rewarded with jobs that they could not undertake (TMR. OA. SSI. P9. 11 October 2013).

Thirdly, the stakeholders said that the municipality had limited funds (TMR. OA. SSI. P10. 11 October 2013; TMR. OA. SMW. P7. 1 August 2014). At the second multi-stakeholder workshop, there was lack of consensus as to whether the lack of funds was due to bad financial management (TMR. OA. SSI. P2 & P3. 5 October 2013). A restaurant owner in Parys gave an example of management having received

bonuses and driving around in large cars while the municipal workers had not been paid (TMR. OA. SSI. P2. 5 October 2013). A community leader said that the municipality spent the limited funds that it had badly. Costly projects with limited impact were embarked upon. However, the improvements that were seen were not related to the amount of money that was spent. The consultants assisting the municipality were making more work for themselves and overcharging the municipality (TMR. OA. SMW. P1. 1 August 2014). A self-employed resident said that there was corruption on the part of a clique of municipality employees who had teamed up to award tenders to friends and relatives (TMR. OA. SSI. P5. 5 October 2013).

Fourthly, the stakeholders said that the municipal management was not accountable to anyone, therefore, it did not communicate with the community (TMR. OA. DW. 26 September 2014; GM. OA. DW. 26 September 2014). The residents wanted to be kept up to date on the actions were being taken to resolve the water and sanitation problems. A stakeholder indicated that the government had committed to the people first (Batho Pele) principle. Therefore, the municipality had to consult the community and follow up on things (TMR. OA. DW. P22. 26 September 2014; GM. OA. DW. P22. 26 September 2014).

Fifthly, a community leader indicated that the municipal management refused to develop and enforce crucial by-laws. For instance, it refused a proposal from some community members to introduce water restrictions for people in the lower regions who waste water, while people in the higher elevations of the town had no water supply (TMR. OA. DW. P22. 26 September 2014; GM. OA. DW. P22. 26 September

2014; TMR. OA. SSI. P10. 11 October 2013; TMR. OA. SMW. P1. 1 August 2014). A municipal official and a community leader said that the municipal management had also rejected a proposal to set standards for the quality of wastewater from local abattoirs (TMR. OA. FWM. P1. 13 June 2014; TMR. OA. SMW. P1. 1 August 2014).

The sixth cause was identified as the municipal management not wanting to admit that there was a complex water and sanitation problem in Parys (TMR. OA. SSI. P2. 5 October 2013). A community member said that the municipal management had refused to cooperate with people who were attempting to assist (TMR. OA. SSI. P2. 5 October 2013). A municipal official indicated that the municipal management did not want to discourage tax payers by communicating the fact that there may be no quick solution to the Parys WSS problems due to the complexity of the problems and the lack of funds (TMR. OA. SMW. P4. 1 August 2014). They rather gave the community false hope by communicating small positive changes that had no impact on the problems that the community was experiencing. Another municipal official said, “When you listen to the radio, you hear the municipality talk about changing the media at the water purification plant. Afterwards, the problem remains” (TMR. OA. SMW. P5. 1 August 2014).

The consequences of the negative impact on the system by the municipal management were as follows:

- Complaints from the community were not adequately addressed. A community member had been lodging complaints with the municipality for the past two years without getting help (TMR. OA. DW. P28. 26 September 2014; GM. OA. DW. P28. 26 September 2014).

- Lack of planning resulted in the lack of water purification chemicals (TMR. OA. SSI. P12. 13 June 2014).
- The community received no warning before water and sanitation disturbances occurred (TMR. OA. SSI. P5. 5 October 2013). According to a municipal official, the municipality was responding to this complaint by giving the residents notice via pamphlets indicating the specific streets and times when water would be cut off (TMR. OA. SSI. P12. 13 June 2014).
- The community members said they did not know who their leaders were. One lamented the fact that he did not know who the mayor of Parys was because he had never seen her in his community (TMR. OA. DW. P36. 26 September 2014; GM. OA. DW. P36. 26 September 2014).
- Community members felt estranged from the WSS. One member complained that he used to visit the water purification plant but he had since been banned from the works (TMR. OA. DW. P22. 26 September 2014; GM. OA. DW. P22. 26 September 2014).
- The community elected new councillors hoping for solutions, but the problems persisted (TMR. OA. DW. P28. 26 September 2014; GM. OA. DW. P28. 26 September 2014).

### 4.1.7 Municipal technicians impacting negatively on the system

The stakeholders indicated that one of the reasons that municipal technicians were negatively impacting on the system was because the supervisors were selected by the workers and could therefore, not reprimand them when they did not perform properly (TMR. OA. SSI. P10. 11 October 2013). The technicians were described as unreliable because at times they came out when called to help and at other times

they did not respond (TMR. OA. SSI. P9. 11 October 2013). The stakeholders said that the technicians were too lazy to do the required work and that they lacked knowledge, competence and training (TMR. OA. SSI. P2. 5 October 2013; TMR. OA. SSI. P10. 11 October 2013). A community member said that the technicians did not have appropriate procedures to guide them in their work (TMR. OA. SSI. P10. 11 October 2013). They also lacked the right tools to fix the problems (TMR. OA. SMW. P1. 1 August 2014).

The consequences of the negative impact on the system by the municipal technicians (Problem 7) were identified as Problem 2 (lack of portable water), Problem 3 (potable water distribution) and Problem 4 (unacceptable quality of potable water). The link between Problem 7 and Problem 4 was demonstrated in a situation where the Parys water purification plant could only pass the Blue Drop assessments after an intervention by Rand Water to help the Ngwathe Local Municipality technicians (TMR. OA. SSI. P12. 13 June 2014). Another consequence of the negative impact on the WSS by municipal technicians was unnecessary interruptions to service delivery due to the manner in which they fixed problems (TMR. OA. SSI. P4. 05 October 2013).

### 4.1.8 The community's negative impact on the system

The first manner in which the community negatively impacts on the WSS is by increasing potable water demand (link to Problem 2). Parys is situated on the border of three provinces, which has resulted in an ongoing influx of people into the town (TMR. OA. FWM. P2. 13 June 2014). The influx was linked to urbanisation. Municipal officials indicated that when they visited farms, they found a situation

where farmers no longer had big communities on their farms. Men worked on the farms but the wives and children lived in Parys. (TMR. OA. FWM. P1. 13 June 2014). Some of the people who moved to Parys went to live in informal settlements and then demanded services which the municipality had not planned to supply (TMR. OA. FWM. P1. 13 June 2014; TMR. OA. DW. P16 & P12. 26 September 2014; GM. OA. DW. P16 & P12). Other ways in which the community increased potable water demand were:

- Adopting water-intensive lifestyles (TMR. OA. DW. P35. 26 September 2014; GM. OA. DW. P35. 26 September 2014).
- Not reporting water leakages. It was common to see children playing with water from leaks, especially in informal settlements which have communal taps (TMR. OA. FWM. P1. 13 June 2014).
- Residents with Jojo tanks took more than their share when water was available to the detriment of other consumers (TMR. OA. SMW. P1. 1 August 2014).

Secondly, the community vandalised the water and sanitation infrastructure. Community members stole taps from people's homes (linked to Problem 2: lack of potable water) (TMR. OA. DW. P14. 26 September 2014; GM. OA. DW. P14. 26 September 2014; TMR. OA. FV4. Operators 5 and 6. 6 June 2014). They also stole electricity cables, thereby preventing the municipality from pumping water to the reservoirs (linked to Problem 3: potable water distribution problem) (TMR. OA. FV4. Operators 5 and 6. 6 June 2014). Thirdly, the community contaminated water supplied by the municipality in Jojo tanks by throwing foreign objects into the tanks (linked to Problem 4: unacceptable quality of potable water and Problem 2: lack of

potable water) (TMR. OA. DW 3 and 34. 26 September 2014; GM. OA. DW 3 and 34. 26 September 2014). A community member recounted the story of a person who swallowed a used condom while drinking water from a municipal Jojo tank (TMR. OA. DW. P36. 26 September 2014; GM. OA. DW. P36. 26 September 2014).

Fourthly, the community was described as ignorant with regard to how the WSS worked (TMR. OA. DW. P48. 26 September 2014; GM. OA. DW. P48. 26 September 2014). Stakeholders said that the community focused on blaming the municipality, and pointed mainly at the negative impacts the municipality was having on the WSS (TMR. OA. DW. P48. 26 September 2014; GM. OA. DW. P48. 26 September 2014). A community member encouraged the community to support the municipality and appreciate their efforts (TMR. OA. DW. P26. 26 September 2014; GM. OA. DW. P26. 26 September 2014). Fifthly, the community offered help to the municipality; however, the help had political undertones (TMR. OA. SSI. P9. 11 October 2013).

The result of the negative impacts the community has on the WSS is the municipality having to work without community support to address the Parys WSS challenges. As discussed later on in the chapter, the lack of cooperation between the stakeholders impacted on the adaptability and transformability of the system, which added to the movement of the system to an unsustainable state and its resilience in it.

## 4.2 Resilience assessment of the Parys water and sanitation system

### 4.2.1 Stakeholders' views of the water and sanitation system

The problems and their associated causes and consequences described by the Parys WSS stakeholders indicated that the stakeholders mostly saw the system from

a Nature flat point of view. This was also confirmed when applying the concepts of adaptability, transformability, resilience, the adaptive cycle and panarchy to the WSS. A Nature flat view is one of the five different views of social-ecological systems as explained by Gunderson & Holling (2002: 11), i.e. Nature flat, Nature balanced, Nature anarchic, Nature resilient and Nature evolving. A Nature flat view of social-ecological systems does not adequately link actions from the human system (encompassing individuals, the social and government systems) with their associated consequences in the human system, the support system (encompassing the economic and infrastructure systems) and the natural system (encompassing the environment and the resource system). This can be seen by the fact that the Parys water and sanitation problems and their causes stem from actions in the human system. However; these human actions are not being used as cues to anticipate the associated consequences in the human, support and natural systems.

Typical of a Nature flat point of view, the Parys stakeholders relied mostly on reactive human action to remedy social-ecological system problems through community activism without fully acknowledging the role played by the limits of the support and the ecological systems. A Nature flat view of the Parys WSS is an unhelpful foundation on which the stakeholders are seeking to achieve sustainable development of the system. It is unhelpful because the complexity and the dynamics of the system are not well considered through that point of view.

The research was thus introducing a new point of view (Nature evolving) in a predominantly Nature flat culture. This enabled the stakeholders who participated in the resilience assessment to work within a framework that looked at the social,

support and ecological aspects of the system as well as its complexity and dynamics. The reach of the Nature evolving approach within the Parys WSS was, however, limited by the lack of participation by the municipal management in the resilience assessment activities.

### 4.2.2 Alternate regimes, states and thresholds of the Parys water and sanitation system

A Nature evolving approach views social-ecological systems as existing in a stability landscape with dynamic multi-stable regimes separated by thresholds (Gunderson & Holling, 2002: 14). A regime is made up of a set of states within which a socio-ecological system has specific essential structure, function, feedbacks and identity (Resilience Alliance, 2007b: 15). As a social-ecological system, a WSS can be moved from one regime to another by changes in the stability landscape, disturbances or by the dynamics associated with the development of the system through the adaptive cycle phases. This is defined as regime shift and can occur towards a desirable or undesirable regime (Resilience Alliance, 2007a: 5).

Three regimes were identified for the Parys WSS: Regime 1 (a household-based WSS); Regime 2 (a combination of the household-based and the community-based WSS); and Regime 3 (a community-based WSS). Within each of the regimes two states were identified: the sustainable and unsustainable state (see Figure 28). The regimes were identified from the Parys WSS historical trajectory discussed in Chapter 1 and from the information supplied by the stakeholders on the causes, problems and consequences.

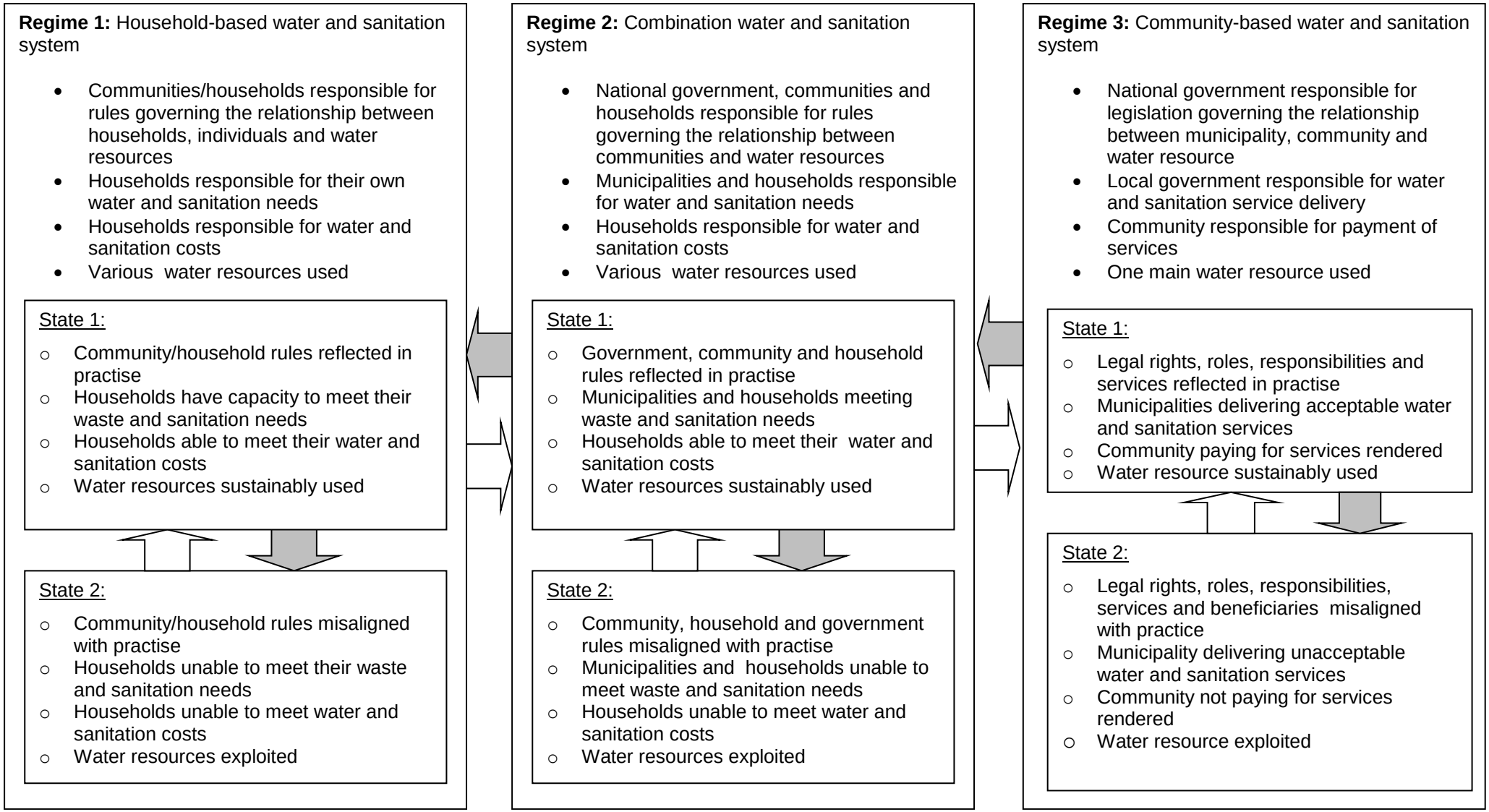


**Figure 28:** Alternative regimes and states of the Parys water and sanitation system

The thresholds between the regimes and the states within the regimes are linked to the problems that were identified by the stakeholders. The causes of the Parys WSS problems are driving the system towards the thresholds. The consequences give an indication of the regime and state within which the WSS exists and its current trajectory. The following thresholds were identified:

1. Raw water quality in the Vaal River Barrage in relation to the ability of the river to sustain ecological diversity within the WSS boundaries;
2. Raw water quality from the Vaal River in relation to the Parys water purification process capability;
3. The community's potable water demand in relation to the capacity of the Parys water purification works;
4. The condition of the potable water distribution system in relation to its ability to maintain the quality and quantity of water during transportation;
5. The quality of the wastewater in relation to the wastewater treatment process capability;
6. The capacity of the Parys wastewater treatment works in relation to the wastewater volumes from the town;
7. The management skills of the Ngwathe Local Municipality management in relation to the complexity of the system under management;
8. The technical skills of the Ngwathe Local Municipality technicians in relation to the complexity of technical tasks; and
9. Water and sanitation rights of the individuals in relation to the capacity of households to fund and maintain them.

The movement from one regime to the next is reliant mostly on the ability of households to meet their own water and sanitation needs in relation to provision of the same services in a centralised form. In the case of the Parys WSS, the ability of the community to provide its own water and sanitation needs on a household basis was found to be low when adaptability and transformability were considered. The WSS is in Regime 3 (community-based WSS), where: national government is responsible for legislation governing the relationship between the municipality, the community and the water resource; the local government is responsible for water and sanitation service delivery; the community is responsible for payment for the services; and one main water resource is used.

Movement from the sustainable state to the unsustainable states in all three regimes relies on the performance of all WSS components within a regime. The Parys community's Nature flat view of social-ecological systems places emphasis on Threshold 7 (the management skills of the Ngwathe Local Municipality management in relation to the complexity of the system under management) and Threshold 8 (the technical skills of the Ngwathe Local Municipality technicians in relation to the complexity of technical tasks). This view does not adequately acknowledge the other remaining seven thresholds. It results in the performance of the Parys WSS within Regime 3 (community-based WSS) being poor, meaning the system tends to move towards and be resilient in the unsustainable State 2. This state is where: the legal rights, roles, responsibilities, services and beneficiaries are misaligned with what is taking place in practice; the municipality is delivering unacceptable water and sanitation services; the community is not paying sufficiently for services rendered; and the water resource is being exploited.

According to the causes, problems and consequences supplied by the stakeholders, Regime 3 (community-based WSS) is desirable to them. This was confirmed during the work meetings and multi-stakeholder workshops. The stakeholders wished for the system to move from Regime 3 (community-based WSS) State 2 (unsustainable state) to Regime 3 (community-based WSS) State 1 (sustainable state). This requires sufficient adaptability, which is the capacity of stakeholders in a social-ecological system to build resilience away from undesirable regimes and within desirable regimes through appropriate and intentional collective action.

Some stakeholders were considering Regime 2 (combination of household-based and community-based WSS) State 1 (sustainable state). There were already indications that members of the community were partially taking the responsibility to provide their own household-based water services due to the persistence of water and sanitation problems in the town. Movement from Regime 3 to 2 would require sufficient transformability, which is the capacity of stakeholders to create a fundamentally new social-ecological system when ecological, political, social or economic conditions make the existing system unsustainable (Walker *et al.*, 2004: 3; Folke, 2006: 262).

### 4.2.3 Adaptability and transformability

#### *4.2.3.1 The adaptability of the Parys water and sanitation system*

Adaptability is linked to the state of natural, financial, infrastructural and human capital as well as social capacity (Resilience Alliance, 2007a: 38). Firstly, the applicable natural capital within the system refers to the capacity of the Vaal River to supply raw water of an appropriate quantity and quality to the Parys water

purification works, as well as the capacity of the Vaal River to transport, dilute and treat effluent exiting the Parys waste water treatment system.

The Vaal River‘s capacity to supply the right quantity of water to the Parys WSS has improved due to the Lesotho Highlands Water Project (LHWP). However, its ability to supply the appropriate quality of water has been significantly compromised because of the increase in turbidity during the rainy season and the escalating discharge of industrial and municipal effluents upstream of Parys. The quality of the effluent exiting the Parys wastewater treatment works was at times beyond the river’s capacity to effectively dilute and treat before the next downstream abstraction point for the town of Vredefort. Therefore, the natural capital is at present low in comparison to the Parys WSS demands.

Secondly, the financial capital of the Parys WSS is low as explained below. According to the stakeholders, the community is not paying for services received (TMR. OA. DW. P26. 26 September 2014; GM. OA. DW 26. 26 September 2014; TMR. OA. SMW. P 7. 01 August 2014). A participant in the first work meeting pointed out that the community was asking itself the following question “What is the use of paying for dirty water?” (TMR. OA. FWM. P1. 13 June 2014). A stakeholder attending the second multi-stakeholder workshop indicated that non-payment was a big issue, which needed to be addressed (TMR. OA. SMW. P1. 01 August 2014). A municipality official in the same workshop said that non-payment for services by the community was the reason for the system’s heavy reliance on funds from national government. She emphasised that funds from national government could not be the only source of money for the WSS (TMR. OA. SMW. P7. 01 August 2014).

The funds from national government are received in the form of a Municipal Infrastructure Grant (MiG) established in 2003. The Department of Provincial and Local Government (DPLG) manages the grant. The vision of the MiG programme was to provide all South Africans with a basic level of service by 2013 through the provision of grant finance aimed at covering the capital cost of basic infrastructure for the poor (DPLG, 2004: 1). According to a stakeholder in the second multi-stakeholder workshop, the municipality spends limited funds on expensive projects with limited impact (TMR. OA. SMW. P1. 01 August 2014). Another participant was reluctant to scrutinise municipal spending because he felt that by discussing how the municipality was spending the limited funds, the workshop was finding fault with the municipality. According to him, the workshop was insinuating that the municipal funds were not being properly monitored. He said he felt afraid and advised the workshop to stop discussing the point because it was a deep issue (TMR. OA. SMW. P4. 01 August 2014).

The municipality used a debt coverage ratio as an indicator of the municipality's ability to generate sufficient revenue to pay interest and redeem its long-term debt. This indicator declined between the 2008 to 2009 and 2009 to 2010 financial years, suggesting that the municipality was receiving less revenue from services rendered to meet its financial obligations (Ngwathe Local Municipality, 2010: 30). As of 2010, the Ngwathe Local Municipality had plans to increase its debt collection. The interventions proposed and implemented included: the proclamation of a credit control by-law; appointment of staff to improve information reporting; appointment of debt collectors; and increasing debt collection methods (Ngwathe Local Municipality,

2011: 52). Sinwell *et al.* (2009: 1) found a correlation between service delivery protests and communities' inability to pay for water and sanitation services due to poverty and unemployment. Ngwathe Local Municipality had local economic development (LED) projects, but these only contributed to a limited extent towards addressing the significant poverty and unemployment needs in the town (Ngwathe Local Municipality, 2010: 5, 25).

Thirdly, the infrastructural capital of the Parys WSS is low due to the fact that the water and sanitation infrastructure is old and requires substantial capital investment to be renewed. It is also inadequate for the current and future community needs and requires up-scaling. According to the Ngwathe Local Municipality annual reports (2005 to 2006; 2009 to 2010; 2010 to 2011) and the integrated development plans (2011 to 2012 and 2012 to 2017), the municipality is planning and executing infrastructure projects in line with Scenario 2 (where the Parys WSS remains at current thresholds levels) by using Response A. a. ii. a. i. a. i (which refers to limited action and small interventions) (see Tables 5 and 6). The response is conservative and has limited potential to address the current situation and does not take into consideration the plausible Scenario 1 (where the Parys WSS breaches all thresholds levels) (Ngwathe Local Municipality, 2006: 28; Tempelhoff, 2008: 17; Ngwathe Local Municipality, 2010: 5; Ngwathe Local Municipality, 2011: 16).

Fourthly, human capital, which encompasses diversity, levels of education, professions and health, is moderate to low in the Parys WSS. The town is racially diverse; however, settlement patterns are still based on apartheid-era town planning, with previously advantaged people living predominantly in the Parys town area and

the previously disadvantaged living in Schonkenville and Tumahole. There has been a rise in education levels, with people who had no form of schooling dropping to 8.5% (StatsSA, 2011: 1- 38; Municipal Demarcation Board, 2013: 9).

The Ngwathe Local Municipality annual report for the period 2005 to 2006 indicated that the Parys district had a gross geographical product of R231 968 000. The contributions per sector to the gross geographical product were as follows: trade and catering 22.9%, agriculture, fishing and forestry 13.2%, manufacturing 17%, finance and real estate 19.3%, and transport and communication 4.7%. These figures indicate the diversity of professions within the system. However, it must be highlighted that the unemployment rate is high, indicating that only a minority of the people participate in the town's economic activities.

The health of the community is affected negatively by the lack of proper water and sanitation. CRS (2003: 4) equates water with life and sanitation with health. They link the lack of proper water and sanitation to diseases such as diarrhoea, dysentery, typhoid, dengue and cholera, and health conditions such as helminths (tapeworms). According to a municipal official, those with compromised immune systems such as the elderly, children and HIV/Aids sufferers are strongly affected by the lack of water and bad quality water. The official further said: "How do you drink your medication with dirty water? The medication is there to help you and the water harms you" (TMR. OA. FWM. P1. 13 June 2014). Another official at the same meeting pointed out that when you are sick you still may have to walk long distances to fetch water (TMR. OA. FWM. P2. 13 June 2014).

According to a community participant at the Dalcroze workshop, water plays a big role in people's health and spiritual and economic activities. She said "Water is life" (TMR. OA. DW. P36. 26 September 2014). A resident of Tumahole said she needed water because without it she could do nothing (TMR. OA. DW. P2. 26 September 2014). Another said: "I cannot survive without water" (TMR. OA. DW. P11. 26 September 2014). The community uses water for normal domestic uses, i.e. drinking, cooking, washing dishes, clothes, themselves, and to transport sewage from their houses to the wastewater treatment plant.

These domestic uses are applicable both in home settings as well as in public settings such as schools. A teacher from a local school indicated that running a school without water was a big problem (TMR. OA. DW. P18. 11. 26 September 2014). Someone else elaborated by saying that high population areas such as schools and churches created a health hazard if they had no water for a period of eight hours (TMR. OA. DW. P25. 26 September 2014). A stakeholder said children cannot go to school because they cannot bath without water (TMR. OA. DW. P36. 26 September 2014). Another teacher said she was embarrassed to have to carry a bucket to the toilet at school. She also said the children were too scared to go to the toilets because of maggots in the toilets due to the lack of water (TMR. OA. DW. P42. 26 September 2014).

The fifth point is that the social capacity of the Parys WSS is low. It depends largely on four pillars: leadership, trust, communication networks and learning (Pollard *et al.* 2008: 10; Resilience Alliance, 2007a: 37). With regard to leadership, the Ngwathe Local Municipality is the highest leadership structure with regard to the Parys WSS.

From 2005 to 2015 four different municipal managers were mentioned in the annual reports: S Msibi, NN Selai, T Mokoena and LD Kamolane. In the same period three different mayors were mentioned; BV Mangwana, MP Moshodi and J Mochela. The changes in leadership could be negatively impacting the overall quality of leadership at the Parys WSS (Ngwathe Local Municipality, 2006: 1; Ngwathe Local Municipality, 2006: 2; Ngwathe Local Municipality, 2010: 4; Ngwathe Local Municipality, 2011: 2; Ngwathe Local Municipality, 2011: 3) (see Appendix C, Figure 1).

Community leaders in, for example, the Ngwathe Water Forum should be supporting the municipality in terms of leadership on water and sanitation. The forum was established after the 2008 crisis for the purpose of enhancing communication between the municipality and the community. The municipality and community leadership were expected to be part of the forum and to work together to find solutions to the Parys WSS problems (Van Riet & Tempelhoff, 2009: 31). The minutes of the Ngwathe Water Forum meetings held in January, February, March, June, July, August and November of 2010; February and September of 2011; and March of 2012, suggest that the Ngwathe Local Municipality was frequently not present. This had a negative impact on the leadership within the forum and the Parys WSS as a whole (CG. OA. MNWFM. 24 October 2013).

The Ngwathe Water Forum and the municipality do not appear to be united and in a mode of collaboration, according to some members of the community. One member indicated that she did not look to the municipality when she experienced water and sanitation problems, but rather sought help from the Democratic Alliance leadership, particularly from Mr. S De Jager, Mr. A Schoonwinkel and Mr. J La Cock (TMR. OA.

SSI. P2. 05 October 2013). Another said that the help offered by some members of the Democratic Alliance had political undertones (TMR. OA. SSI. P9. 11 October 2013).

The trust levels which form part of the social capacity of the system are low between the municipality and the community. A municipal official indicated that community members in the township had the perception that the municipality provided the township with brown water and the Parys town area with better quality water (TMR. OA. FWM. P1. 13 June 2014). A person from the Parys town area indicated that she had observed that there were water trucks going to Tumahole but not to the Parys town area (TMR. OA. SSI. P6. 05 October 2013) (see Figure 29). A municipal official also advised that although the chairperson of the Ngwathe Water Forum had offered a venue for the subsequent multi-stakeholder workshop, the researcher should decline, because the municipality representatives would not attend. The researcher was advised to ask the municipality to provide the venue so that they could be convinced that the researcher was neutral and was not part of the media (TMR. OA. FWM. P1. 13 June 2014). From the views expressed by stakeholders, it is apparent that there are diverse views and key role players and their activities are interrogated from numerous perspectives.


**Figure 29:** Water being delivered to Tumahole households by Ngwathe municipal workers (TMR. PA. Photo 10. 6 June 2014)

The interruption of the first multi-stakeholder workshop by the municipality management, due to the presence of the public, also indicated low trust levels between the two key stakeholders. One of the attendees at the multi-stakeholder workshop indicated that the lack of trust could be due to the fact that a court case was under way against the municipality (TMR. OA. FMW. 27 June 2014).

An environmental NGO, which aims to protect and maintain the environmental integrity of the Vaal River and its environs in the area between the Vaal Dam and Parys by the name of Save the Vaal Environment (SAVE), is active in Parys. According to a meeting of the Ngwathe Water Forum, held on 21 July and 25 August 2010, it responds to water and sanitation disturbances in town by alerting residents

through local media and taking water problems to court (CG. OA. MNWFM. 24 October 2013). According to forum meetings of 24 November 2010 and 16 February 2011, in most cases the blame for the water and sanitation pollution problems were placed on the municipality (CG. OA. MNWFM. 24 October 2013). Therefore, the municipality was operating under a cloud of suspicion and legal actions in the form of court orders and injunctions that did not foster trust (CG. OA. MNWFM. 24 October 2013).

Communication, which is another aspect of social capacity, is lacking. The lack of appropriate communication on the part of the municipality was highlighted by the community as a problem. Poor communication has persisted, despite the water forum being created for the purpose of facilitating communication between the municipality and the community. Sinwell *et al.* (2009:1, 9) linked service delivery protests to unsuccessful attempts by community members to engage with local authorities over issues of failed service delivery and frustration with ward councillors and other representatives of local government, who are perceived by local township residents as incompetent and unresponsive to their needs.

A participant at the Dalcroze Workshop said that if she were the municipal manager she would listen to what the community was saying (TMR. OA. DW. P2. 26 September 2014). Another participant said the solution to the Parys WSS lay in people being informed, because an informed community would stand together with the municipality to solve problems (TMR. OA. DW. P21. 26 September 2014). The need for the councillors to take the people's grievances to the right place to be addressed was highlighted (TMR. OA. DW. P27. 26 September 2014). At a meeting

of the Ngwathe Water Forum held on 13 January 2010, there was recognition by community leaders for a concerted effort not to focus on complaining, but instead to seek solutions. However, the minutes of that meeting indicated that the community persisted in responding to Parys WSS problems by blaming the municipality (CG. OA. MNWFM. 24 October 2013).

One of the stakeholders interviewed mentioned the Water forum tag system as a current coping mechanism to deal with water and sanitation problems (TMR. PA. SSI. P10. 11 October 2013). Another said that to their credit, the municipality announced via radio, Facebook or loudspeakers if water and sanitation disturbances were anticipated (TMR. OA. SSI. P9. 11 October 2013).

Lastly, the need to learn about water and sanitation was highlighted by the stakeholders. At the Dalcroze workshop two community members encouraged the community of Parys to take care of its water by starting to educate their children and themselves about water (TMR. OA. DW. P10 & P26. 26 September 2014). The need to develop and implement a workplace skills plan to address the skills training gaps of the Ngwathe Local Municipality workforce was mentioned in the Ngwathe Local Municipality annual report of 2009 to 2010 (Ngwathe Local Municipality, 2010: 36). A municipal official said that having funds would enable operational interventions such as training personnel to do proper maintenance (TMR. OA. DW. P7. 26 September 2014). Additional expertise is available to the Parys WSS in the form of provincial and national departments, consultants, community members and academia. Current academic studies on Parys are being increasingly conducted in a transdisciplinary mode, which involves mutual learning among stakeholders.

Overall, the adaptability of the Parys WSS is moderate to low as discussed above. This means the capacity of the stakeholders to move the system from Regime 3 (community-based WSS) State 2 (unsustainable state) to Regime 3 (community-based WSS) State 1 (sustainable state) is low. In some cases community members did not realise that they should participate in mobilising the system towards a desirable regime. There was an expectation by some members of the community that once the municipality had heard their needs, it would steer the Parys WSS to Regime 3 (community-based WSS) State 1 (sustainable state).

An interviewee said that the Free State premier, Ace Magashule, was living in Tumahole and that he cleaned his own water with a reverse osmosis system. This meant that everyone was aware of the Parys water and sanitation problems. He just could not understand why, when they knew of the problem, they did not solve it for everyone (TMR. OA. SSI. 5. 5 October 2013). Others did not see how they could provide solutions to the problem (TMR. OA. SSI. 1 and 7. 5 October 2013). One stakeholder indicated that it was not her responsibility to find possible solutions to the water and sanitation problems in Parys, it was time for Ngwathe municipality to take responsibility. She indicated that patience was her coping mechanism for waiting for the municipalities to solve the problems (TMR. OA. SSI. 8. 05 October 2013). Another stakeholder said that there was no time for excuses any longer as the municipality had received the message from the people and they now knew what the problems were that they were expected to solve (TMR. OA. DW 37. 26 September 2014).

#### *4.2.3.2 The transformability of the Parys water and sanitation system*

The fundamental transformation of the Parys WSS is limited by the fact that water and sanitation are basic human needs. The people of Parys rely heavily on the Vaal River in all three Parys WSS regimes. However, the structure and the feedback of the WSS can be altered by moving to Regime 2 (combination of household-based and community-based WSS) State 1 (sustainable state) and Regime 1 (household-based WSS) State 1 (sustainable state) by significantly reducing the quantity of water used by households. This would imply the application of new greener technologies and transforming the views of the community on water and sanitation.

The low natural, financial, infrastructural and human capitals, as well as the social capacity of the Parys WSS, which are applicable to its adaptability, are also relevant to transformability. The low capitals are linked to the stakeholders' Nature flat view of the WSS. This view restricts the stakeholders from realising that the performance of their system does not only rely on Thresholds 7 and 8. The stakeholders lack the capital to maintain the system in Regime 3 (community-based WSS) State 1 (sustainable state), or to transform the system into sustainable states in the other two regimes.

The stakeholders' Nature flat view of the WSS and the low capitals suggest that the community of Parys is not prepared to transform the system to Regime 2 (combination of household-based and community-based WSS) State 1 (sustainable state) or Regime 1 (household-based WSS) State 1 (sustainable state). Most stakeholders were not aware of the importance of Threshold 9 (water and sanitation rights of the individuals in relation to the capacity of households to fund and maintain

them) to the performance of their system. Even in the time of crisis there was evidence of wastage of potable water in town. One participant said that white people in Parys liked gardening. They would use the limited potable water to water their plants if the municipality did not make irrigation water available as early as possible in September (TMR. OA. SMW. P1 to 8. 1 August 2014). Another said it was normal to see leaking taps in Tumahole (TMR. OA. DW. P10. 26 September 2014).

The inability of the Ngwathe Local Municipality to meet the water and sanitation needs of the community for a long period of time has resulted in stakeholders who have the ability to meet their own water and sanitation needs taking more of that responsibility. Although the responsibility is taken reluctantly, it has resulted in the system showing signs of moving towards Regime 2 (combination of household-based and community-based WSS).

### 4.2.4 Adaptive cycle and panarchy

#### *4.2.4.1 The adaptive cycle of the Parys water and sanitation system*

The four phases of the adaptive cycle of the Parys WSS are shown in Table 4. The growth phase (r-phase) involves the development of the Vaal River as the main water resource alongside the development of the town. As indicated by the empirical literature review in Chapter 1, even when the town was founded in 1876 inherent water shortages and water quality issues were being experienced by the Parys community with regard to the Vaal River. These were overcome by the use of diverse water sources until the construction of the Parys water and sanitation works in 1952 (TMR. OA. FV1. Operator 1. 1. 11 October 2013; TMR. OA. FV3. Operator 4. 6 June 2014).

**Table 4:** The adaptive cycle of the Parys water and sanitation system

| **Reorganisation stage (α):** | **Conservation stage (K):** |
|---|---|
| **Ecological:**<br>• Refocus on addressing Vaal River water pollution upstream and downstream of Parys<br>• Municipality investigating alternative water resource options<br><br>**Social:**<br>• Interventions from national and provincial departments, Rand Water, industry, water forums, NGOs and academia<br>• Movement towards Regime 2 (combination of household-based and community-based WSS) due to persistence of problems | **Ecological:**<br>• Ecological service capacity to dilute effluents is approached upstream and downstream of Parys<br><br>**Social:**<br>• The significant demand for water, sanitation and effluent discharge results in the capacities of the municipal works being approached<br>• No substantial upgrades to meet new demands<br>• Upgrades to address further deterioration in raw water hamstrung by high water demand |
| **Growth stage (r):** | **Release stage (Ω):** |
| **Ecological:**<br>• The Vaal River in the focal system is developed as a water resource to meet increases in demand for water, sanitation and effluent discharge<br><br>**Social:**<br>• The demand for water, sanitation and effluent discharge increases upstream and within the Parys WSS<br>• The water purification system is commissioned to addressed deteriorating quality of Vaal River water<br>• Upgrades to municipal works are done to meet increasing water and sanitation demands | **Ecological:**<br>• Eutrophication and fish kill events occur in the Vaal River within the focal system<br><br>**Social:**<br>• The Parys water treatment system unable to deliver water of appropriate quantity and quality. The Parys effluent treatment works unable to sufficiently treat effluent prior to discharge<br>• Service delivery protests |

Gunderson & Holling (2002: 47) indicate that the front loop stage, which encompasses the r-phase and the K-phase, is usually slow, and undergoes incremental growth and accumulation. The management objectives in the front loop are focused on maximising production and accumulation. The dynamics of the system in the front loop are predictable and there is a higher degree of certainty when compared with the dynamics of the back loop.

In the 1940s the community of Parys started to experience water quality problems from the Vaal River due to pollution (Van Riet & Tempelhoff, 2009: 34). The ecological capacity of the Vaal River to dilute and treat effluent upstream of Parys

was breached. However, to allow upstream development despite the negative impact on the environment, the Parys water purification plant was used to treat the Vaal River water to provide potable water for the community.

The water purification and the wastewater treatment works underwent major upgrades in the 1970s, hence the existence of the old and the new works (see Figures 15 and 22). The system's carrying capacity was increased, which enabled further growth in the r-phase. Post-1994, the demand for water and sanitation in Parys grew significantly as the right to water and sanitation was afforded to all South Africans, which had not previously been the case. A participant at the second multi-stakeholder workshop indicated that under apartheid there were cases where 10 households in Tumahole shared one toilet. He said that this has been addressed by the democratic dispensation. He indicated that some reservoirs had been built in Parys post-1994 (TMR. OA. SMW. P2. 1 August 2014). The capacities of the water purification and waste water treatment plants were also slightly increased via optimisation projects (TMR. OA. FV1. Operator 1. 11 October 2013; TMR. OA. FV3. Operator 4. 6 June 2014).

Pollard *et al.* (2008: 10), describe a social-ecological system that is resilient in a sustainable regime as having policies that focus on slow controlling variables (such as the Vaal River water quality) associated with thresholds that may result in slow, creeping changes which often go undetected. This is not the case with the Parys WSS. The capacity of the Parys water purification plant to treat the Vaal River water was breached from around 2005. According to a municipal official, a technical capital project was undertaken in 2008 in the form of an activated carbon filter to address

the taste and smell of potable water. The project cost in the region of R4 million. The downside of the project was that the new plant would reduce the available potable water because it required potable water for backwashing. The high demand for potable water by the community had the effect of delaying the commissioning of the plant to address potable water quality (TMR. OA. SMW. P1. 01 August 2014). Another municipal official indicated that the municipality did not have the right population figures and an understanding of the water demand of the town when the project was started (TMR. OA. SMW. P5. 01 August 2014).

At that stage the community was exclusively reliant on the municipal works to deliver water and sanitation services. The Resilience Alliance (2007a: 50) states that as a system matures its structure increases and energy goes into maintaining the system. The system loses its flexibility and capacity to adapt and respond to change. As the system approaches a steady state or its carrying capacity, it enters the K-phase or the conservation phase.

Post 1994, the municipality increased access to water and sanitation for the growing population. However, no corresponding upgrades were made to the water purification plant and the wastewater treatment plant. This led to the system's capacity to provide enough potable water and to treat resulting wastewater being breached. Subsequently the service delivery protest of 2008 took place. It is at this point that the Parys WSS entered the release (Ω) phase, also called creative destruction. However, a regime change did not occur at that stage due the fact that Regime 3 (community-based WSS) has broad latitude and deep resistance, and the Parys WSS trajectory was not close to the thresholds between Regime 3

(community-based WSS) and the other regimes (precariousness). The system became more resilient in State 2 (unsustainable state) in the same regime.

The latitude of a regime is the maximum amount the system can change before losing its ability to recover. It is broad for Regime 3 because the WSS can occur in the sustainable and the unsustainable states before a regime shift occurs. Resistance is the ease or difficulty of changing the system. It is deep for Regime 3 because a community-based WSS fits within the current water and sanitation legislation at the local, provincial and national levels. It is also subsidised by the larger scales. Additionally, it is difficult for each household to take charge of its own water and sanitation needs due to the cost and technical skill required. Precariousness relates to how close the system is to a threshold in its current trajectory. The thresholds that the system was close to were those between Regime 3 (community-based WSS) State 1 (sustainable state) and Regime 3 (community-based WSS) State 2 (unsustainable state) (Walker *et al.,* 2004: 2).

Following the collapse (Ω) phase, the system reorganises (α-phase), based on the various forms of capital that had accumulated during the growth and conservation phases. The capital determines the system's ability to adapt and continue development in the same regime or to transform into a new regime (Resilience Alliance, 2007a: 51). As indicated, Parys's WSS adaptability and transformability are low. The stakeholders do not consciously direct the movement of the system from one regime to another. The system is now predominantly in Regime 3 (community-based WSS) State 2 (unsustainable state) and is also showing movement towards

Regime 2 (combination of household-based and community-based WSS) State 2 (unsustainable state).

#### *4.2.4.2 Parys water and sanitation system panarchy*

An important factor that is affecting the Parys WSS's adaptability and transformability is the panarchy within which its exits, i.e. the smaller and larger systems with which it interacts. The Parys WSS is in the reorganisation phase (α-phase) where it is preparing to enter a new growth phase. The social-ecological systems larger than the Parys WSS are in the fore-loop at the K-phase. The Vaal River continues to be developed to support further economic growth in the country on provincial and national levels. Its limits are being increased to accommodate further growth through significant technical capital projects, e.g. the LHWP. There is population growth, urbanisation and migration at these larger scales which keep increasing the demand for water and dilution of effluents from wastewater treatment plants and the industry, mining and agricultural sectors. The protection of the Vaal River should be enforced at national level. However, due to the focus on growth at that level, enforcement is not emphasised. The deteriorating quality of the Vaal River disables the Parys WSS to meet the water and sanitation needs of the community.

The change from apartheid to a democratic dispensation in South Africa happened on a national scale, but that change impacted on the character and dynamics of the Parys WSS on a local scale. Under the new multiracial democratic dispensation, all people have equal rights before the law. The right to live in a protected and healthy environment and have access to adequate housing, food and water applies to all people living in South Africa according to the Bill of Rights in Chapter 2 section 24 of

the South African Constitution. This right is supposed to be brought to fruition at the municipal level through the Water Services Act (108 of 1997) and the Local Government Municipal Systems Act (32 of 2000).

The commitment at the national level to eradicate the bucket system and extend water and sanitation services to the previously disadvantaged is not properly funded by national government in the Parys WSS. This restricts the municipality to small technical projects that are not effective in significantly increasing the capacity of the water and sanitation works. Therefore, the manner in which the Parys WSS connects with the larger social-ecological system is a Remember connection. The Parys WSS's ability to adapt or transform is constrained by the larger social-ecological systems. The inability of the Parys WSS to make the required changes makes it more reliant on the larger systems for its survival. Gunderson & Holling (2002: 6) indicate that policies based on unsustainable principles may initially succeed; however, they result in rigid institutions, fragile ecosystems and a disillusioned public with no trust in governance.

The social systems smaller than the focal system are in the growth phase (r-phase). They consist of the previously disadvantaged and the previously advantaged. The previously disadvantaged households and individuals in the community are exploring the new rights granted to them by the change from apartheid to democracy. However, their development is slowed down by the lack of accumulated capital and limited new job opportunities. From 2005, the Ngwathe Local Municipality annual reports have been highlighting the fact that a large section of the Parys population receives a low income or no income at all (Ngwathe Local Municipality, 2006: 9).

This results in non-payment for water and sanitation services which hampers the ability of the municipality to provide the much-needed services to the previously disadvantaged and the previously advantaged. The previously advantaged are utilising previously accumulated capital to develop and grow tourism as a new economic pillar of the town (Ngwathe Local Municipality, 2006: 7). At the same time they have to explore alternative methods to provide the water and sanitation required by their businesses.

The development in the smaller systems is restricted by the focal system being in the back-loop. The water and sanitation services needed to support growth at individual and household levels are not forthcoming. However, the fact that the focal system is in the α-phase opens up opportunities for innovation that could support the growth of the smaller systems in new ways.

### 4.3 Exploration of interventions

Walker *et al*. (2002: 1), explain that social-ecological systems are constantly changing and at times change faster than the forecasting models can be calibrated. The Resilience Alliance (2007b: 33) recommends developing possible future scenarios and associated indicators indicating that the system is moving along a trajectory towards a specific scenario. A scenario is not a prediction of the future. It is a possible, plausible future that might arise under certain circumstances. A set of scenarios that bracket the range of possible futures is a useful tool for examining the kinds of processes and dynamics that could lead to a social-ecological system developing along particular trajectories (Resilience Alliance, 2007b: 5). The possible

scenarios for the Parys WSS were developed based on the system thresholds (see Table 5).

**Table 5:** Possible system scenarios based on Thresholds 1 to 9

| **Scenario 1** | **Scenario 2** | **Scenario 3** |
|---|---|---|
| Vaal River water quality deteriorates to a point where the fauna and flora diversity cannot be supported | Vaal River water quality keeps supporting current fauna and flora diversity | Vaal River water quality improves. Lost fauna and flora diversity is recovered to some extent |
| Raw water deteriorates to a point where it cannot be treated without membrane technology | Raw water quality stabilises at current quality | Raw water quality improves |
| Demand for potable water increases | Demand for potable water stabilises | Demand for potable water declines |
| The water distribution system enters a state where it cannot maintain the water quality and quantity between works and community | Water distribution system issues stabilise | Water distribution system issues decline |
| Wastewater quality deteriorates to a point that it is not compatible with the wastewater treatment process | Wastewater quality stabilises | Wastewater quality improves |
| Volume of wastewater increases significantly | Volume of wastewater stabilises | Volume of wastewater decreases |
| Management skills of the Ngwathe Local Municipality management decrease in relation to the complexity of the system under management | Management skills equal the complexity of system | Management skills increase in relation to the complexity of system |
| Technical skills of the Ngwathe Local Municipality technicians decrease in relation to the complexity of technical tasks | Technical skills equal the complexity of technical tasks | Technical skills increase in relation to the complexity of technical tasks |
| Water and sanitation rights of individuals remain above the capacity of households to fund and maintain them | Rights equal capacity to fund and maintain them | Rights less than the capacity to fund and maintain them |

They scenarios were developed and discussed during the first and second work meetings and the second multi-stakeholder workshop. There was consensus that Scenario 1 (where the Parys WSS breaches all thresholds levels) is the most likely future scenario for the system (see Table 5). (TMR. OA. FWM. P1 & P2. 13 June 2014; TMR. OA. SWM. P1 and P2. 13 June 2014; TMR. OA. SMW. 1 August 2014). The scenarios were used to investigate interventions to keep the Parys WSS within the desirable Regime 3 (community-based WSS) State 1 (sustainable state).

### 4.3.1 Interventions linked to Threshold 1

Threshold 1 refers to the raw water quality in the Vaal River Barrage in relation to the ability of the river to sustain ecological diversity within the Parys WSS. The National Water Act of 1998 acknowledges that national government has an overall responsibility for and authority over the nation's water resources (RSA, 1998: 32). The Vaal River in the vicinity of Parys requires national government to exercise its responsibility of protecting the quality of water in the Vaal River. A municipal official indicated that there was a need for communication between the upstream municipalities and the Ngwathe Local Municipality. She also said that on the catchment level, the Department of Water and Sanitation (DWS) must make sure that all the discharges are compliant; they had to be strict so that the quality of water resources could be improved (TMR. OA. FWM. P1. 13 June 2014).

Chapter 3 Part 4 of the National Water Act (32 of 1998) empowers a person conducting an activity that leads to water resource pollution to take measures to prevent that pollution. In the case of the Vaal River in the vicinity of Parys the polluters of the natural resource are upstream mining, industry, municipalities and

farming entities (Tempelhoff *et al*., 2007: 110). The Act further stipulates that if measures are not taken by the polluters, the catchment management agency should step in to prevent pollution and to recover all reasonable costs from the persons responsible for the pollution. There is also an opportunity according to Chapter 5 Part 1 of the National Water Act (32 of 1998) for the projects to be funded through the establishment of water use charges, which would enable the polluter-pays principle.

The Ngwathe Local Municipality annual reports recognise the Vaal River and its structure in the town (i.e. several islands) as unique in nature and an environmental asset. This recognition must translate into action to protect the river from polluters upstream and within Parys (Ngwathe Local Municipality, 2006: 28; Ngwathe Local Municipality, 2010: 5; Ngwathe Local Municipality, 2011: 16; Ngwathe Local Municipality, 2012: 4). The tourist destinations along the Vaal River in the vicinity of Parys that are caught disposing of wastewater directly into the river should be fined as well as named and shamed for unacceptable behaviour that harms the river.

### 4.3.2 Interventions linked to Threshold 2

Threshold 2 refers to the raw water quality from the Vaal River in relation to water purification process capability. The protection of the Vaal River in the vicinity of Parys will enable the Ngwathe Local Municipality to prepare potable water of acceptable quality for the community of Parys. The quality of the Vaal River water at the point of abstraction for the Parys water purification plant has deteriorated to a point where it is no longer suitable for the water purification technology used by the plant. National government is responsible for the sustainable use of the water for the

benefit of all users and has to equitably allocate water for beneficial use according to the preamble of the National Water Act (32 of 1998).

The participants in the second multi-stakeholder workshop agreed that the municipality was in the process of implementing Technical Response A (which refers to limited action and small changes to address the impact of the deterioration of the Vaal River water quality on the ability to produce potable water for Parys) (see Table 6) to address the raw water quality problem. The municipality is focusing on an activated carbon filter to address the smell, taste and appearance of the potable waste. It was pointed out that this treatment would not address the problem of present chemical contaminants (TMR. OA. SMW. P1. 1 August 2014).

Technical Responses B and C (which respectively refer to membrane technology and a pipeline to Rand Water in Vereeniging to address the impact of the deterioration of the Vaal River water quality on the ability to produce potable water for Parys) would be more appropriately based on the most likely scenario for the system, i.e. Scenario 1 (where the system breaches all thresholds levels) (see Table 6). Response B refers to membrane-based water purification technology to remove chemical contaminants in the water. This technology requires significant capital investment and running costs. It is also more complex than the current treatment process. It would impact on Thresholds 7 and 8 by requiring more technical and managerial skills within the municipality to keep the system in the current regime. Technical Response C has a high capital investment requirement. It also has the potential to impact on Threshold 1, where upstream pollution may increase due to the health risk to the community of Parys being removed. The capital required for

Response B or C could be sourced via the MiG funding from national government or be raised through water use charges.

**Table 6:** Summary of technical capital projects

| **Technical Response A** | **Technical Response B** | **Technical Response C** |
|---|---|---|
| Municipality does not upgrade the Parys water purification process to cater for possible future severe deterioration in Vaal River water quality at its raw water abstraction point | Municipality upgrades the Parys water purification process to cater for possible future severe deterioration in Vaal River water quality at its raw water abstraction point | Rand Water may take responsibility of supplying potable water to Parys to avoid the impact of effluent discharge upstream of Parys. Parys water purification plant becomes obsolete |
| a. Municipality slightly increases the capacity of water purification plant<br>Or<br>b. Municipality significantly increases the capacity of the Parys water purification plant to produce surplus potable water to allow for growth | | |
| i. Municipality keeps relying only on electric pumps without back-up generator<br>Or<br>ii.. Municipality purchases back-up generator to enable pumping of water during electricity supply disruptions | | |
| a. Municipality replaces water distribution pipes as they burst and does not clean out reservoirs<br>Or<br>b. Municipality overhauls and refurbishes water distribution pipes and removes sludge from reservoirs | | |
| i. Municipality and community fix leaks in homes, businesses and industries<br>Or<br>ii. Municipality and community do not fix leaks in homes, businesses and industries | | |
| a. Municipality replaces wastewater collection pipes as they burst<br>Or<br>b. Municipality overhauls and refurbishes wastewater collection pipes | | |
| i. Municipality slightly increases capacity of the wastewater treatment plant<br>Or<br>ii. Municipality significantly increases the capacity of the wastewater treatment plant to accommodate increase in effluent linked to increase in potable water supply as well as in rainy seasons | | |

A municipal official said that the municipality was aware that the water and sanitation problem was big. The municipality had big plans, but it could only implement small

plans because they did not have funds. It required funding to do bulk infrastructure refurbishment (TMR. OA. SMW. P6. 1 August 2014). The grants received from national government were limited by inaccurate population size estimates (TMR. OA. SMW. P3. 1 August 2014; TMR. OA. SMW. P1. 1 August 2014).

### 4.3.3 Interventions linked to Threshold 3

Threshold 3 refers to the community's potable water demand in relation to the capacity of the Parys water purification works. In order to address water shortages, the municipality is sinking boreholes as an alternative water source. The quality of borehole water has to be monitored to ensure that it is consistently suitable for human consumption. There are also plans to increase the current capacity from 15 ML by 6 ML .The one clarifier associated with the capacity will not be sufficient (TMR. OA. SMW. P5. 1 August 2014). Elevated tanks have been erected at Schonkenville and Tumahole to assist with water pressure issues and to prevent water shortages (TMR. OA. SSI. P12. 13 June 2014; TMR. OA. FV4. Operators 5 and 6. 6 June 2014). The elevated tanks have greatly assisted people who had no water three days a week to have constant access to water (TMR. OA. SSI. P12. 13 June 2014).

The workshop participants pointed out that slightly increasing the water purification plant capacity would be inadequate to enable growth in the current situation as well as for the plausible future Scenario 1 (where the system breaches all thresholds levels) (TMR. OA. SMW. 1 August 2014). This implies that after implementing the response, the current problems could continue, and that should Scenario 1 occur, the problems will escalate. A stakeholder mentioned that the increase in the water

purification system's capacity should take into consideration the opportunity to provide potable water to the people of Vredefort, which is 50 km downstream of Parys. He said that there was already a pipeline between Parys and Vredefort (TMR. OA. SMW. P1. 01 August 2014).

### 4.3.4 Interventions linked to Thresholds 4 and 6

Threshold 4 refers to the condition of the potable water distribution system in relation to its ability to maintain the quality and quantity of water during transportation. Threshold 6 refers to the capacity of the Parys wastewater treatment works in relation to the wastewater volumes from the town. The only part of the response that was bold was a comprehensive plan to fix leaks through the EPWP (Expanded Public Works Programme) from a national grant. It was scheduled to start in August 2014. Private and municipal plumbers would collaborate in fixing leaks in the potable water distribution system, in households and in the wastewater collection system (TMR. OA. SMW. P7. 01 August 2014). There is proof that clean water is flowing into the sewerage works at night, so the focus on the leaks may be very helpful (TMR. OA. SMW. P1. 01 August 2014).

The municipality could also explore public-private partnerships in addition to the current EPWP to fix leaks in the system. In April 2013, DWS supported a public-private partnership between Sasol and Emfuleni local municipality to reduce water losses through leakages, and to educate people and create awareness of leaks (Mabudafhasi, 2013: 1). The attention that the municipality is currently giving water leaks through the EPWP has the potential to reduce the volume of wastewater entering the wastewater treatment plant. Diverting storm water from the wastewater

treatment plant could also address the issue of increased volumes during the rainy season.

### 4.3.5 Interventions linked to Threshold 5

Threshold 5 refers to the quality of the wastewater in relation to the wastewater treatment process capability. The municipality should use its authority to establish by-laws through a consultative process to provide a clear guideline with regard to the disposal of blood into the wastewater collection system by abattoirs. There is a technical opportunity to use abattoir waste in fly farming. This business concept has been researched and is currently being explored on a pilot scale in Stellenbosch by environmental entrepreneur Jason Drew. This would alleviate the negative impact of the abattoir-blood-containing stream on the wastewater treatment plant. It also has the potential to create a viable protein business and provide some jobs in the town (Drew & Joseph, 2012: 150).

### 4.3.6 Interventions linked to Threshold 7

Threshold 7 refers to the management skills of the Ngwathe Local Municipality management in relation to the complexity of the system under management. The Ngwathe Local Municipality management has the responsibility to provide appropriate leadership to the Parys WSS to increase its current low adaptability and transformability. These qualities are based on stakeholders having a common framework from which to make sense of the WSS and to take collective action to shift the system to the desired regime and state and to maintain it within them.

The Nature evolving framework with its associated concepts has the potential to address the complexity and dynamics of the Parys WSS. It can be applied through an adaptive management approach which is required for complex adaptive systems such as the Parys WSS. This approach involves probing the system in an experimental way to gain an understanding of its dynamics, i.e. resilience assessment. The system dynamics are crucial for deciding which interventions to embark upon and when to implement them to keep the system in a sustainable regime. (Resilience Alliance, 2007a: 73).

The use of the resilience assessment framework as applied in this research would be an effective adaptive management tool for the Ngwathe municipal management and the Ngwathe Water Forum. Fabricius and Cundill (2014: 1) say adaptive management involves the accumulation of knowledge through a process that aims to ensure tight feedback between changes in the ecosystem and responses from decision makers. They do not, however, recommend adaptive management when there is high organisational resistance, system boundaries are unclear, and there are numerous issues, scales and stakeholders (Fabricius & Cundill, 2014: 5). This is not the case with the Parys WSS.

### 4.3.7 Interventions linked to Threshold 8

Threshold 8 refers to the technical skills of the Ngwathe Local Municipality technicians in relation to the complexity of technical tasks. A municipal official indicated that the municipality had a master plan that looks at holistic solutions to the Parys water and sanitation problems. Most of the solutions in the master plan deal with the capacity of the municipal workforce. An official said that having funds would

enable operational interventions such as training personnel to do proper maintenance (TMR. OA. MSW. P5 and P7. 1 August 2014). Past technical assistance by Rand Water was affirmed as having enabled the municipality to achieve better technical results. Skills transfer between Rand Water and municipal technicians should be intensified (TMR. OA. SSI. P12. 13 June 2014).

### 4.3.8 Interventions linked to Threshold 9

Threshold 9 refers to the water and sanitation rights of individuals in relation to the capacity of households to fund and maintain them. According to Chapter 3 section 21 of the Water Services Act (108 of 1997); the Parys community is liable to pay for water and sanitation services rendered. The community should be made aware of the cost of potable water and be given the chance to re-evaluate how it should be used in their households. The amount charged for water and sanitation services must reflect the actual cost of those services. People waste water because they do not know that the water treatment chemicals are so expensive (TMR. OA. SSI. P12. 13 June 2014). Prepaid water meters could be installed to enable the municipality to recover payments for services rendered and to assist the community to regulate their own water usage.

Households that cannot afford to pay for water and sanitation services should also have prepaid water meters. The municipality would have to give them vouchers to purchase water. This would help the households to become aware of the cost of the water that they are receiving. A municipal official said that some people paid for water services, but there are many indigent households in the Parys. She insisted that the indigents must give back by respecting what they receive free of charge.

She stressed that some people who pay for water suffer more than the indigent households. The source of funds to cover services to indigent households should be aligned with the cost that the municipality incurs to supply those services (TMR. OA. SSI. P12. 13 June 2014).

## 4.4 Chapter summary

The systems knowledge for the study was the Parys WSS problems and their causes and consequences as experienced and described by the community. It indicated that the stakeholders viewed the Parys WSS from a Nature flat point of view which hampered their comprehension of the system's complexity and dynamics. The systems knowledge was utilised to identify possible regimes and states of the system and the thresholds between them. The assessment of the resilience of the Parys WSS indicated that the system can operate in three different regimes, each with a sustainable and an unsustainable state. The Parys WSS is currently operating in a community-based regime (Regime 3) where the national government is responsible for legislation governing the relationship between municipality, community and water resource; the local government is responsible for water and sanitation service delivery; the community is responsible for payment for services; and one main water resource is used. In this regime, the Parys WSS is in the unsustainable State 1 where legal rights, roles, responsibilities, services and beneficiaries are misaligned with practice; the municipality is delivering unacceptable water and sanitation services; the community is not paying for services rendered; and the water resource is being exploited.

The capacity of the stakeholders to move the system to a sustainable state within Regime 3 (adaptability) is low. The capacity of the stakeholders to move the system to other regimes (transformability) is also low. The system is in the reorganising phase (α-phase). The low system capitals are only sufficient to support the subsequent growth phase in an unsustainable Regime 3 (a community-based WSS) State 2 (unsustainable state). The reasons for low adaptability and transformability are: 1) low capitals [natural, financial, infrastructural, human capital and social capacity (leadership, trust, communication networks and learning)], 2) the stakeholders' Nature flat view of the WSS and 3) the remember-connection with larger-scale systems. The remember-connection with the larger systems restricts the Parys WSS stakeholders from making appropriate changes to address the water and sanitation disturbances at the focal level.

Possible future scenarios for the Parys WSS were developed with stakeholders. The most plausible scenario was where the system breaches all the nine identified thresholds and remains in the undesirable Regime 3 State 2 or moves to other unsustainable states in Regimes 1 (a household-based WSS) and Regime 2 (a combination of the household-based and the community-based WSS). The stakeholders identified Regime 3 State 1 as desirable for them (target knowledge). The plausible scenario and the target knowledge were utilized to develop interventions (transformational knowledge) to shift the system from the current Regime 3 State 2 to Regime 3 State 1. The interventions focus on stakeholder comprehension of the complexity of the WSS and management of the system through managing its resilience.

# CHAPTER 5

# CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

The Ngwathe Local Municipality is currently experiencing persistent problems with regard to supplying water and sanitation services to the community of Parys. An empirical literature review indicated that the water and sanitation problems stem from the social and ecological aspects of the Parys WSS within a bigger South African and global context. The problems are linked to an ongoing ecological challenge of deteriorating raw water quality in the Vaal River Barrage which was already identified in the 1930s. They are also associated with the social challenge of political changes which influence legislation pertaining to the rights of South Africans, for example; economic participation, land ownership, mobility, access to water resources as well as water and sanitation services.

The persistence of the Parys water and sanitation problems despite various interventions to address them provided an opportunity to explore emerging innovative concepts to provide solutions. A theoretical literature review indicated that problems stemming from social and ecological systems require an integrative approach of the systems into what is referred to as a social-ecological system. The concept of social-ecological systems emerges within the context of sustainable development, which seeks to balance social, environmental and economic aspects. The manner in which stakeholders view social-ecological systems is highlighted as the reason behind the failure to solve sustainable development challenges such as water and sanitation system problems. Five different views of social-ecological

systems were indicated as Nature flat, Nature balanced, Nature anarchic, Nature resilient and Nature evolving in order of fit to observed social-ecological system dynamics. The Nature evolving view of social-ecological systems has associated concepts to address the complexity and dynamics of an evolving system, i.e. adaptability, transformability, resilience, the adaptive cycle and panarchy. These concepts were used to explore the WSS problems and to propose interventions.

A methodological literature review indicated that a transdisciplinary research approach was suitable for exploring social-ecological system challenges. It is able to integrate knowledge from various disciplines and stakeholders as well as across problem fields. A transdisciplinary research approach was used to explore the loss, creation and maintenance of resilience of the Parys WSS in a collaborative manner with relevant stakeholders. It was supported by the selected research paradigm (constructivism), design (qualitative), strategies (phenomenological and case study) and data-capturing methods. The methods involved stakeholders' participation through semi-structured interviews (12 stakeholders); facilitated visits to the municipal water and sanitation works (12 stakeholders); work meetings with municipal workers (7 stakeholders); multi-stakeholder workshops (64 stakeholders) and feedback meeting (28 stakeholders).

The stakeholders comprised of the Ngwathe Local Municipality, Ngwathe Water Forum members as well as the community of Parys, which encompasses the Parys town area, Schonkenville and Tumahole. There was sound participation in the research by Ngwathe Local Municipality technical staff members, the Ngwathe Water Forum chairperson and community members. The co-researchers from NWU

participated in specific activities mainly related to the Dalcroze workshop. The Ngwathe Local Municipality management participated minimally due to lack of time as well as a lack of trust between the municipality and the community. This impacted the research negatively in the following ways:

- There was low contribution of knowledge required for resilience assessment by the municipal management.
- The management was not familiar with the content of the study and this affected how they interpreted stakeholder participation in the research.
- The benefits of the Dalcroze workshop to harmonise relationships and enhance collaboration in a situation of low trust between the community and the municipality were missed by the municipal management.
- The learning that came with collaboratively assessing the resilience of the Parys WSS was also missed. This was a great loss because the concept of resilience and its associated framework is ideal for adaptive management of complex adaptive systems such as the Parys WSS.

The collaborative assessment of the resilience of the Parys WSS afforded the stakeholders who participated the opportunity not only to voice their experiences of the WSS, but to understand its dynamics and complexity. The stakeholders contributed the systems, target and transformational knowledge required to collaboratively assess the resilience of the Parys WSS. Systems knowledge answers questions about the start and development of a real-world problem. The systems knowledge for the study was in the form of the problems of the Parys WSS and their causes and consequences as experienced and described by the community.

The research findings indicated that the Parys water and sanitation problems are interconnected and confirmed that they emanate simultaneously from the human (individual, social and government) system, the support (economic and infrastructure) system and the natural (environment and resource) system. This supported the need to approach the WSS as a social-ecological system.

The systems knowledge was used to identify possible regimes and states of the system and the thresholds between them. It also indicated that the stakeholders' view of the social-ecological system was Nature flat, where the response of the ecological part of the system to human action is not appropriately acknowledged. This view was affecting the ability of the stakeholders to comprehend the WSS complexity and dynamics.

The assessment of the resilience of the Parys WSS indicated that the system can operate in three different regimes, each with a sustainable and an unsustainable state. The Parys WSS is currently operating in a community-based regime (Regime 3) where the national government is responsible for legislation governing the relationship between municipality, community and water resource; the local government is responsible for water and sanitation service delivery; the community is responsible for payment for services; and one main water resource is used. In this regime, the Parys WSS is in the unsustainable state where legal rights, roles, responsibilities, services and beneficiaries are misaligned with practice; the municipality is delivering unacceptable water and sanitation services; the community is not paying for services rendered; and the water resource is being exploited.

The capacity of the stakeholders to move the system to a sustainable state within Regime 3 (adaptability) is low. The capacity of the stakeholders to move the system to other regimes (transformability) is also low. The system is in the reorganising phase (α-phase). The low system capitals are only sufficient to support the subsequent growth phase in the undesirable Regime 3 (a community-based WSS) State 2 (unsustainable state). The reasons for low adaptability and transformability are: 1) low capitals [natural, financial, infrastructural, human capital and social capacity (leadership, trust, communication networks and learning)], 2) the stakeholders' Nature flat view of the WSS, and 3) the remember-connection with larger-scale systems. The remember-connection with the larger systems restricts the Parys WSS stakeholders from making appropriate changes to address the water and sanitation disturbances at the focal level.

Possible future scenarios for the Parys WSS were developed with stakeholders. The most plausible scenario was where the system breaches all the nine identified thresholds and remains in the undesirable Regime 3 (a community-based WSS) State 2 (unsustainable state) or moves to other unsustainable states in Regimes 1 (a household-based WSS) and Regime 2 (a combination of the household-based and the community-based WSS). The stakeholders identified Regime 3 (a community-based WSS) State 1 as desirable for them (target knowledge). The plausible scenario and the target knowledge were utilized to develop interventions (transformational knowledge) to shift the system from the current Regime 3 (a community-based WSS) State 2 (unsustainable state) to Regime 3 (a community-based WSS) State 1 (sustainable state). The interventions focus on stakeholder

comprehension of the complexity of the WSS and management of the system through managing its resilience.

## 5.2 Recommendations

The following recommendations are proposed with regard to the application of a transdisciplinary research approach to assess the resilience of the social-ecological system:

- The existing condition of stakeholder relationships within the community should be considered when selecting data collection methods. It affects the stakeholders' willingness to participate in collaborative activities which are fundamental to transdisciplinary research. Different data collection methods are recommended to get stakeholders to participate. They reveal different perspectives of the social-ecological system. The facilitated visits to the municipal works provided an understanding of the ecological system and the infrastructure connecting it to the social system. The interviews provided personal experiences of stakeholders. The workshops enabled the confirmation and merging of information, collaborative thinking and identification of commonalities.
- The perceptions that stakeholders have about the researcher can affect their cooperation in the study. It is important to address the perceptions as much as possible to ensure that the research is not negatively impacted.
- The assessment of resilience provides a neutral platform on which the stakeholders can focus and collaborate. Therefore, it is an effective tool even where there are relationship problems between stakeholders.

- The knowledge that the stakeholders supply when talking about their normal day-to-day experiences can be used successfully for the purpose of resilience assessment. The stakeholders can therefore, participate in the assessment process at a different level of consciousness of the process.
- When consciously carrying out the resilience assessment with the stakeholders, the use of everyday examples to explain the concepts of the adaptive cycle and the regime shifts and panarchy enabled the stakeholders to grasp the concepts and to visualise the dynamics and complexity of the WSS.

The following recommendations are put forward from the resilience assessment of the Parys WSS:

- Firstly, it is recommended that the Parys WSS be approached by stakeholders as a social-ecological system. This means that the complexity of the Parys WSS which is due the interconnectedness of its human, support and natural systems as well as its panarchy with smaller and larger systems should be seriously considered when developing and implementing interventions.
- Secondly, the adoption of an adaptive management approach based on a Nature evolving view of the Parys WSS as a framework from which stakeholders can collectively address water and sanitation problems is recommended. The Ngwathe Water Forum is an ideal platform where the proposed approach to the Parys WSS can be presented, discussed and explored through transdisciplinary interactions. The intervention has the potential to provide a common and helpful language from which to increase

the WSS adaptability, i.e. the ability of stakeholders to act as a unit to direct the movement of the WSS towards desirable regimes and states.

- Thirdly, it is recommended that the stakeholder focus be spread from the current emphasis on two of the nine thresholds (Threshold 7: the management skills of the Ngwathe Local Municipality management in relation to the complexity of the system under management and Threshold 8: the technical skills of the Ngwathe Local Municipality technicians in relation to the complexity of technical tasks) to include seven other critical system thresholds namely: Threshold 1) raw water quality in the Vaal River Barrage in relation to the ability of the river to sustain ecological diversity within the WSS boundaries; Threshold 2) raw water quality from the Vaal River in relation to the Parys water purification process capability; Threshold 3) the community's potable water demand in relation to the capacity of the Parys water purification works; Threshold 4) the condition of the potable water distribution system in relation to its ability to maintain the quality and quantity of water during transportation: Threshold 5) the quality of the wastewater in relation to the wastewater treatment process capability; Threshold 6) the capacity of the Parys wastewater treatment works in relation to the wastewater volumes from the town; and Threshold 9) water and sanitation rights of the individuals in relation to the capacity of households to fund and maintain them. The multi-focus is important because the system cannot be maintained in the desirable regime and state by focusing on one or two thresholds at a time. Interventions to address the causes moving the system towards the nine thresholds have been proposed in this study. It is recommended that they be considered within an adaptive management framework.

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## APPENDICES

### Appendix A: Informed consent form for interviews

| | |
|---|---|
| **Researcher**: | Researcher's name and surname |
| **Title of research project**: | Assessing social ecological system resilience through a transdisciplinary approach: Parys water supply and sanitation system |
| **Purpose of the research :** | To assess the resilience of the Parys water and sanitation system. The assessment will indicate the regime in which the system is operating and identify the regime in which the stakeholders would like it to operate. This will support the identification and implementation of appropriate interventions. The assessment will be done in a transdisciplinary manner, by involving various stakeholders in the research. |
| **Duration**: | One month |
| **Procedures**: | Answer interview questions. The interviews will be recorded and transcribed. |
| **Possible risks**: | Victimisation for airing views. The information from the intervieiws will be referred to without connecting it to the person's name. |
| **Benefits**: | The benefits would be to identify issues with the participants' water and sanitation system and to propose solutions which could result in a better system for the participants. |
| **Voluntary participation**: | It will be clearly explained to the participants that they DO NOT NEED to participate in the study. The participants must be made aware that their participation is VOLUNTARY. |
| **Confidentiality**: | The recorded versions of the interview will not identify the participants by name. The transcribed interviews will be photocopied, scanned and stored electronically by the researcher in a format that excludes the names of the participants. This information will be made available. The original hardcopies will be shredded. The names of the people who gave the specific interviews will be archived separately and not made publicaly |

| | |
|---|---|
| | available. |
| **Dissemination of information:** | Information gathered in the project will be disseminated as part of a mini-dissertation, reported at conferences, published in articles and presented to stakeholders. |
| **Contact details**: | Contact details of researcher |
| **Permission for identification for follow-up evaluations:** | The study includes follow-up workshops. The workshops will give you the opportunity to participate with other stakeholders in assessing the resilience of the Parys water and sanitation system. The workshops will be about four hours long. Participation in the workshops is voluntary. We will go through a five-step process, answering questions and debating issues and consolidating positions. The information will be incorporated into a mini-dissertation and communicated to stakeholders via a subsequent feedback workshop. |
| **University endorsement:** | This research project was approved by the North-West University's Ethics Sub-committee for Social and Behavioural Sciences on 30/09/2013. The ethics approval number is: FH-SB-2012-0031. |
| **Informed consent**: | I …… (initials and surname of participant) have read and understand the nature of my participation in this research project and agree to participate.<br>Signature _____<br>Date: _____<br>Researcher: _____ |
| **Informed consent and permission to be identified for follow-up evaluations:** | I …… (initials and surname of participant) have read and understand the nature of my participation in this research project and agree to be identified and invited to participate in follow-up evaluations.<br>Signature _____<br>Date: _____<br>Researcher: _____ |

**Appendix B: Form used to facilitate the interviews**

| **Details of the person being interviewed** |
|---|
| Name of person conducting interview:<br>Name of person being interviewed:<br>ID number:<br>Contact phone number:<br>Address:<br>Race:<br>Employment:<br>Education (matric, degree/diploma, etc.):<br>Date and time: |
| **Question 1: Identifying main issues of concern**<br>a. What problems do you experience with regard to water at home/in your business/ place of work/school etc. in Parys?<br>b. What do you think are the causes of these problems?<br>c. What can be done to solve these problems?<br>d. Whom do you usually contact to help you solve the problem and do you get help?<br>e. How do you cope when the problem persist? |
| **Question 2: Direct and indirect uses of natural resources**<br>What do you use water for at home/in your business/place of work/school etc. in Parys? |
| **Question 3: Opportunity for questions by person being interviewed and free-flow information** |

## Appendix C: Letter granting the researcher permission to conduct research in Ngwathe Local Municipality

Postal address : PO Box 359
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**PARYS**
9585
Tel: +27 (0) 56 816 2700
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Ngwathe MUNICIPALITY
The home of harmony, prosperity and growth

**OFFICE OF THE**
**MUNICIPAL MANAGER**

27 June 2014

**TO WHOM IT MAY CONCERN**

Ms R Terblanché is a Master's Degree Student at North West University, doing research on Cultural Dynamics of water in Ngwathe Local Municipality.

Permission has been granted to Me Terblanché to interview staff and enter relevant premises in pursuance of her research.

It is anticipated that you would find the above in order.

Yours faithfully

**LD KAMOLANE**
**ACTING MUNICIPAL MANAGER**

**/rj**