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Dimensions of supply risks in the supply of water: A case of Zet district municipality

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Abstract

The purpose of the study is to ascertain water supply risks in a district municipality, in South Africa. It aims to strike a balance between the risk of water supply and demand within the Zet District Municipality's capacity for integrated water service delivery. Inductive thematic analysis and in-depth interviews with district administrators were used to collect qualitative data as part of an exploratory case study design. The findings from the interpretive philosophy reveal that district municipalities lack the capacity to deliver water services due to a variety of supply chain risks and augmenting water demand from the community. Due to the detrimental effects of water shortages on livelihoods, the district's supply risk management capacities need to be strengthened. The supply chain operations should mitigate supply risks not just in water supply, but in service delivery as a whole by striking a balance between water demand and supply to address supply risks. The supply risks that are recognised should take into account data sharing, supplier agility, adaptability, dependability, and infrastructure quality. The force field analysis created a platform to identify the forces that provide a change in the water supply.

Keywords: Force field, Service delivery, Supply chain, Supply risk, Water supply.

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1. Introduction

The social and economic development of any population depends on access to fresh water. This study investigated water supply risks in a district municipality in South Africa. A pseudonym, Zet District Municipality is utilized to protect the identity of the municipality. Although infrastructure has been expanded to supply water to South Africa's rural areas for domestic, industrial, agricultural, and waste removal purposes, the approaches adopted and management of supply and demand have not been adequate to cope with an ever-growing population, climate change, and industrialization, particularly in the country's special economic zones. South Africa's national economic development planning is driven by local economic development (LED), and reindustrialisation. However, the water supply chain is vulnerable to many risks, including variations in demand, natural disasters, and supply disruptions.

Increased population growth and climate change have exacerbated the challenges of water supply in response to escalating demand for household and drinking water and agricultural and corporate water usage. The recent devastating floods in KwaZulu-Natal have been linked to the effects of climate change, leading to geological soil subsidence, a decline in groundwater quality, and seawater intrusion with accumulated debris causing marine pollution. According to the force field theory used in this study, factors driving rising water demand include population growth, the expansion of irrigated agriculture brought on by land reform and appropriation, and economic growth in industrial/special economic zones. Although surface water (in lakes, rivers, and reservoirs) can meet such demand at the global level, there are substantial regional variations, resulting in water stress in certain parts of South Africa [1]. More than two billion people (35% of the world's population) are estimated to be suffering from acute water scarcity [2]. Natural causes (such as rising sea levels and declining precipitation) and human activities (including over-extraction of aquifers due to increasing water needs arising from population growth and industrialization, as well as land-use change and ongoing development) impact demand for and supply of water for social, economic and environmental needs. Surface water resources are generally insufficient to meet the needs of the community, and groundwater is a critical means of attaining freshwater for more than half the world's population [3-5]. Surface water includes any freshwater that is channelled into wetlands, stream systems, and lakes, while groundwater is found in subterranean aquifers [6]. Most groundwater is obtained from snowmelt and rainfall that enters the bedrock via the surrounding soil. Groundwater is the main source of drinking water across South Africa; however, much of it is located very deep underground, making it expensive to pump. The characteristics and level of interaction between ground and surface water impact the success of conjunctive-use projects [7]. Such interaction is receiving increasing attention in Africa due to its importance to ecological systems and sustainability. South Africa's 1998 National Water Act provides water-usage licenses, including those for groundwater, which will only be granted if the reserve, or the amount of water required to provide both basic human requirements and some ecological integrity , has been established Levy and Xu [8].

Bowersox, et al. [9] note that supply chain management (SCM) is an important strategy for public and private enterprises to gain a competitive advantage through cooperation with their partners. "The main causes of problems engulfing government and the general population at large may be an absence of understanding with respect to the concept of supply chain management and its inseparable connectivity to long-term quality service delivery, human capital advancement and related socio-economic growth. " [10]. The attributes of the services along the supply chain provide critical information that informs risk management [11]. Supply chain risk management (SCRM) is defined as "the management of supply chain risk through coordination or collaboration among the supply chain partners, so as to ensure profitability and continuity" [12].

2. Background of the Study

South Africa's Municipal Structures Act describes a municipality as the structure, political office bearers and administration of the municipality, a geographic area, and the community of the municipality. In other words, a municipality consists of a municipal institution (political and administrative structures), and the people who live in the local area. A municipal institution is an organ of the state, and has a separate legal personality. According to the Local Government Municipal Demarcation Act of 1998, a municipality is "a corporate body that has particular ideas and obligation areas, a political structure, political office bearers, a municipal manager and characterised geological zone" Graythorne [13]. Boshoff [14] observe that, South African municipalities are significant players in service delivery. They are also required by law to ensure community participation in their undertakings. The 1996 Constitution's Section 108 requires municipalities to provide basic services to meet the needs of their constituents [15] and water is one such need [16]. It is thus imperative that a balance be struck between supply and demand of water and that the risks that threaten the accomplishment of this goal be identified. Supply chain management risks have a domino effect on both short and long-term operations, planning, sourcing, distribution and financial performance. This study thus investigates the balance between demand for and supply of water services in the district municipality with a view to improve service delivery.

Many portions of South Africa are lacking water as a result of the country's protracted drought. Also, a lot of homes have water cutbacks since their municipalities don't pay the water suppliers. Zet District Municipality is among 30 municipalities that owe money to water utilities. Located in KwaZulu-Natal province, it is home to around 400 000 people. It comprises of five local municipalities that are dominated by remote rural settlements in mountainous areas and they provide costly service deliveries. The district comprises of 1 122 settlements spread across 15 urban areas, 64 dense settlements, 290 villages, 547 scattered settlements and 106 farm settlements, mainly under traditional leadership. The topography, poor roads and poor quality and quantity of local water sources have increased the per capita cost of supplying water to households. For local government purposes, KwaZulu-Natal is divided into one metropolitan municipality (the eThekwini Metropolitan Municipality) and ten district municipalities. The district municipalities are in turn divided into 43 local municipalities. The province has a varied yet verdant climate thanks to diverse, complex topography. In general, the inland areas get progressively cooler whereas the coast is subtropical.

Figure 1 presents the map on the district and metropolitan municipalities that are labelled in capital letters and shaded in various different colours, and the arrow indicates the Zululand district of interest.

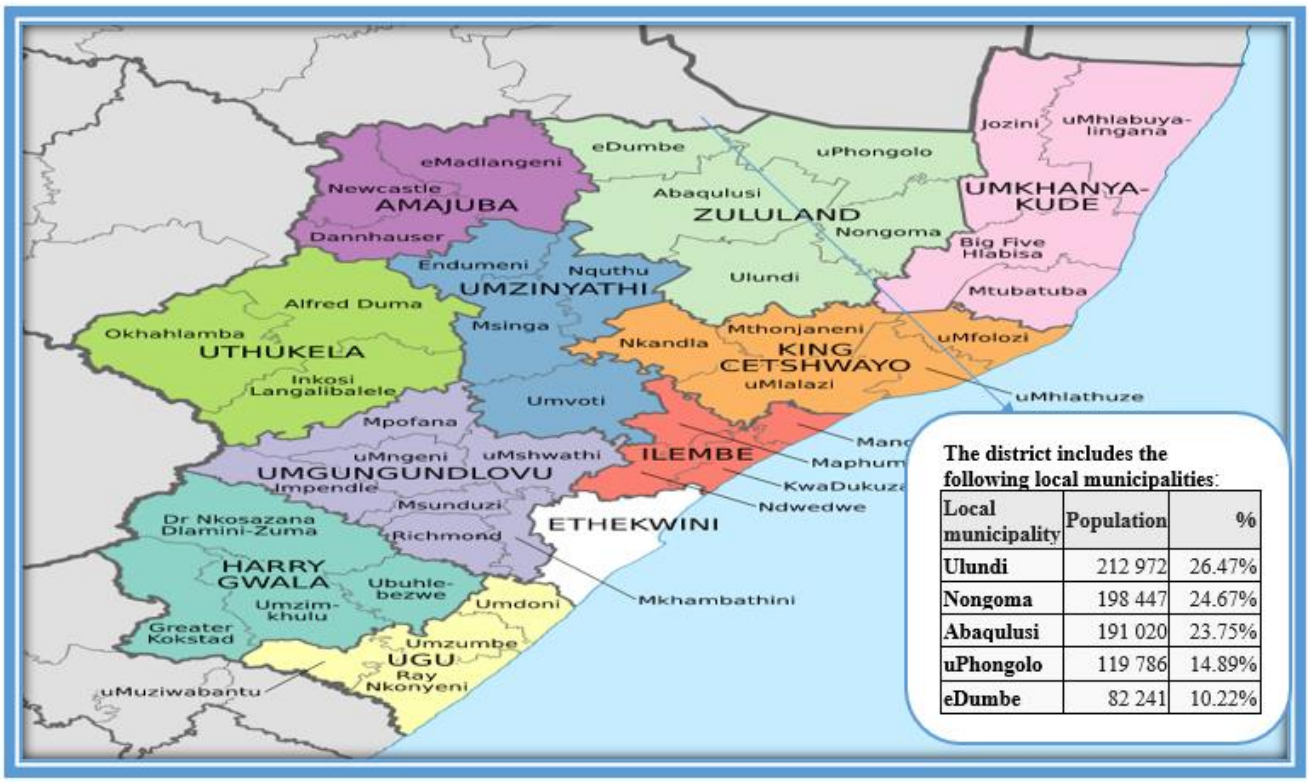

Figure 1.
District map of KwaZulu-Natal province.
Source: South African Tourism [17].
Statistics South Africa Community Survey [18].

Table 1.
District and metropolitan municipalities.

Name	Code	Seat	Area (km²)	Population (2016)	Pop. density (per km²)
Amajuba district municipality	DC25	Newcastle	7 102	531 327	74.8
eThekwini metropolitan municipality	ETH	Durban	2 556	3 702 231	1 448.5
Harry Gwala district municipality	DC43	Ixopo	10 386	510 865	49.2
iLembe district municipality	DC29	KwaDukuza	3 269	657 612	201.2
King Cetshwayo district municipality	DC28	Richards Bay	8 213	971 135	118.2
Ugu district municipality	DC21	Port Shepstone	4 791	753 336	157.2
uMgungundlovu district municipality	DC22	Pietermaritzburg	9 602	1 095 865	114.1
uMkhanyakude district municipality	DC27	Mkuze	13 855	689 090	49.7
uMzinyathi district municipality	DC24	Dundee	8 652	554 882	64.1
uThukela district municipality	DC23	Ladysmith	11 134	706 588	63.5
Zululand district municipality	DC26	Ulundi	14 799	892 310	60.3

Source: Statistics South Africa Community Survey [18]. .

Table 1 indicates the key districts and metropolitan municipalities as per code, towns, kilometres, population and its population density. The table focuses on Zululand as one of the district municipalities ("districts") in KwaZulu-Natal and its seat is Ulundi.

The unique hydrological system and unviable surface water resources mean that community members predominantly rely on groundwater resources for domestic, agricultural, and drinking water [19]. The need to extract groundwater, and its consequent depletion are caused by seasonal fluctuations in water availability, drought-prone conditions, and insufficient

rainfall [20]. Continuous pumping is the primary cause of groundwater depletion, which leads to increase pumping costs, deterioration of water quality, less water in streams and lakes, saline water intrusion in coastal cities, and land subsidence [1]. While these consequences are variable, they ultimately occur to some extent with any groundwater use. The concept of rainwater harvesting (RWH) is not new, and it is widely employed to address water scarcity and urban flooding in many regions [21]. It is a significant source of groundwater recharge that can be used for both drinking and non-drinking applications, such as irrigation and farming [22, 23].

2.1. COVID-19's Impact on Water Risks

The COVID-19 pandemic, which has been described as the first contemporary pandemic [24] and is perhaps the worst crisis of our generation [25] is causing severe a lot of strain on society and has immediate effects on public health and water services. Lockdowns changed social behaviour and, as a result, water usage patterns [26] shifting them from public places and commercial settings to to private residences. As a result, many utilities reported higher peaks than usual [28]. The COVID-19 pandemic, which has been called the first contemporary pandemic [24] and is perhaps the largest problem of our generation [25], is putting a lot of strain on society and has immediate effects on water and public health. Lockdowns changed social behaviour and, as a result, water usage patterns [26], shifting them from public and commercial settings to private residences. As a result, many utilities reported higher peaks than usual [28].

While water consumption increased during the COVID-19 lockdowns, bill payment decreased, possibly due to restricted movement [27, 28]. Customer satisfaction plays a significant role in maintaining a balance between demand and a utility's performance [29]. Furthermore, it is necessary to understand how well a utility is performing to identify and prioritizes some areas for improvement [30]. However, little information is available on service levels, such as supply continuity and supply volume, as well as customer satisfaction with community-managed water supply systems. The unprecedented scale and impact of the COVID-19 pandemic, and the accompanying lockdowns implemented in many countries exacerbated water scarcity and security globally. Furthermore, the pandemic stands to increase water supply inequalities [31]. It is thus critical to analyze COVID-19's impact on water consumption to understand the psychological, social, and financial dynamics in communities [32] to guide water provision in municipal areas.

While strict measures have been put in place worldwide to protect public health and inhibit the spread of the virus, experts have warned that the pandemic is far from over [33]. Water is an essential resource, especially during a pandemic during which hygiene plays a pivotal role in mitigating the spread of the disease [26]. Therefore, it is of paramount importance to secure a safe and reliable water supply while ensuring proper management of the urban and rural water cycle. The COVID-19 pandemic occurred at a critical time for the water sector as it navigates ongoing transformation and infrastructural developments. In recent years, this sector has been transitioning towards the so-called "fourth revolution" [34] which aims to achieve more rational and sustainable management of water resources. Digital revolution [35] combines the power of Big Data analytics and Artificial Intelligence approaches to develop new features in water management, particularly about billing systems, licking/wastewater detection and monitoring and water shedding load.

2.2. Supply Chain Management (SCM) in the Public Sector

In promoting good governance and economic development, each government unit in South Africa is required to adopt an SCM policy that suits its needs [36]. A large size of pool suppliers and service providers are hired by the public sector. Bent [37] SCM in the public sector is described as "an integral part of Financial Management that seeks to introduce globally recognized best practices". It bridges the gap between traditional methods of procuring goods and services and the balance of the supply chain whilst addressing procurement-related matters that are of strategic importance". Effective SCM enables efficient inventory management, improved service delivery and cost containment across the extended supply chain network. However, inefficiency and corruption have plagued supply chains in the South African public sector. Ambe and Badenhorst-Weiss [38] define SCM in the public sector as the "function whereby public sector organizations acquire goods, services and development and construction projects from suppliers. Goods and services should be acquired in line with the general principles of fairness, equitability, transparency, competitiveness and cost-effectiveness enshrined in s217 of the Constitution." The main objective is to purchase goods and services at the best price from appropriate suppliers while maintaining acceptable standards of quality. The Public Finance Management Act of 1999 and preferential procurement regulations require public agencies to administer their funds efficiently. As in the private sector, this calls for effective SCM that starts with customer demand and ends with the delivery of goods and services by internal procedures and the principles of good governance [39].

2.3. Research Problem

The water industry provides water and wastewater administration to private households and the business, and industrial sectors of the economy. It also incorporates manufacturers and suppliers of bottled water. The Water Service Act (108 of 1997) and the National Water Act (36 of 1998) are the basis for the legislative framework within which water supply and sanitation services, water resource management and water usage take place [40]. Section 27 of the Bill of Rights in the Constitution states that "everyone has the right to access the sufficient food and water, and the State must take reasonable legislative measures to achieve the progressive realisation of these rights". Responsibility for providing water services to local communities and businesses has been delegated to the local government. However, many communities confront challenges in accessing water. This is the case in Zet District Municipality where community members are dissatisfied with the services provided, and the municipality seems unable to meet local demand. It is thus an appropriate case to assess the limit of water supply risks and required SCM improvements. The study's objectives were to determine how well water supply

and demand were balanced, how much supply risk was managed within the boundaries of the municipality, how well Zet District Municipality could manage supply risk associated with water delivery, and whether or not integrating service delivery activities would increase water supply.

2.4. The Nature of Water Management

Water is a colourless liquid without taste and smell and it is the main constituent of the earth's streams, lakes, rivers, and oceans. Gato-Trinidad, et al. [41] note that it is commonly used for drinking, washing, watering plants, showering and flushing toilets. Chang [42] adds that it is made up of oxygen and hydrogen. While water is essential to sustain human life and to promote social and economic development, it is becoming a scarce resource in many parts of the world, including South Africa. The amount of drinking water required varies, depending on a person's physical activity, age, health problems as well as natural conditions. As noted previously, in South Africa, municipalities are mandated to provide clean water and local water authorities routinely monitor the quality of drinking water. Wastewater is defined as "any water that has been negatively influenced in terms of its quality by the environmental impact." Surface runoff or stormwater, home, industrial, commercial, or agricultural operations, as well as sewer intake or infiltration, can all contribute to the creation of wastewater. [43]. Municipal wastewater (sometimes known as sewage) is often dumped in a sanitary sewer or combined sewer after being treated at a wastewater treatment plant. To protect human health, other species' health, and the ecosystem's health, wastewater management must be done effectively.

2.5. Theoretical Framework

Theories are formulated to clarify, anticipate, and fathom phenomena as well as to challenge and develop existing knowledge. The theoretical framework is "the structure that can hold or support a theory of a research study, it underpins the research problem of this study" [44]. According to Lewin [45] "a force field theory is broadly utilised as a part of change management and can be utilised to understand most change process in an organization. The author adds that change arises due to an imbalance between driving forces (new personnel, changing markets, new technology) and restraining forces (individual fear of failure, organisational inertia). Lewin also observes that balance is achieved through the connection of two contradictory sets of forces - those looking for advance change (driving forces) and those endeavouring to maintain existing conditions (restraining forces)". Thomas [46] argues that, "even though force field theory has been utilised as a part of different contexts, it is rarely applied to technique". The author highlights that the theory brings new perspectives to the assessment as well as execution of corporate plans. The force field theory suggests that driving forces (external threats of water supply shortages combined with internal benefits) must exceed the resisting forces (culture, structure, perceptions of how things should be done). It was utilised in this study to highlight the supply risks associated with delivering water to the community in response to demand and to assess the balance between water supply and demand.

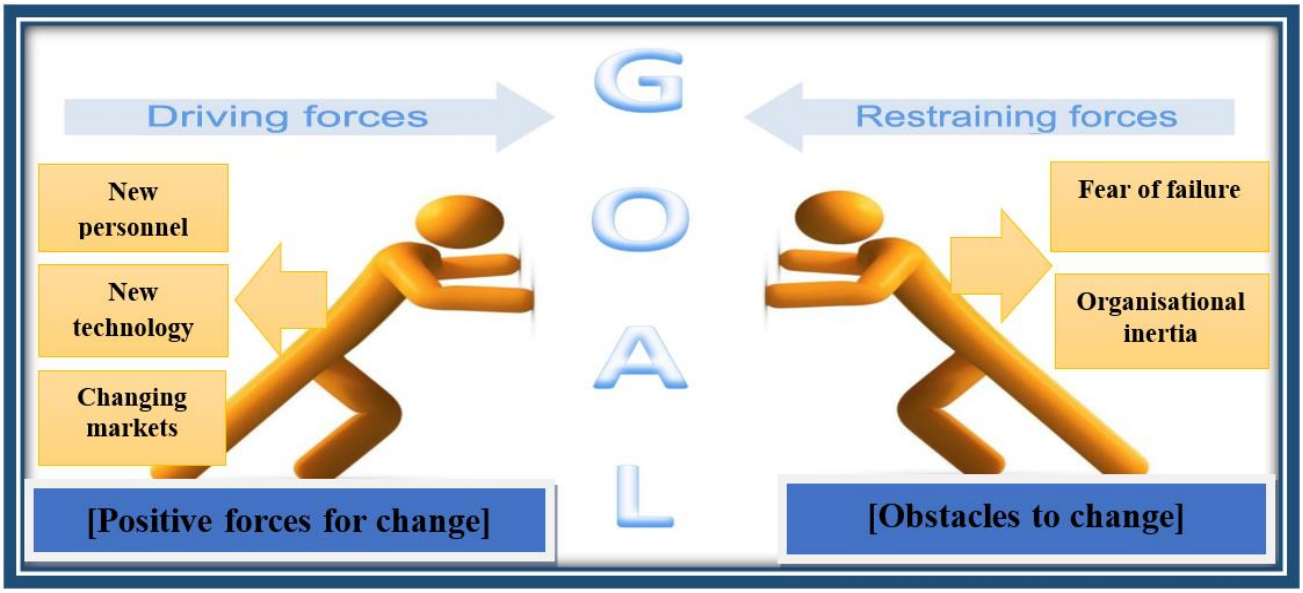

Figure 2.
Example of force field analysis.
Source: Mind Tools [47].

Figure 2 demonstrates that the force field analysis is a method used to identify and assess the forces that cause water scarcity and shortages on the right-hand side as restraining forces (obstacles to change) such as fear to failure and organisational inertia preventing government officials from accomplishing effective service delivery. The left-hand side illustrates driving forces that will propel the municipality forward, such as new employees, new technology, and shifting markets. The force field analysis diagram can be utilised to assess a wide range of circumstances from various perspectives [47]. A municipality operates in a constantly changing environment and should thus consistently adjust to various demands, new technologies, government policies and other developments like lean and agile practices in the supply chain department

and other departments concerned with the supply of water. Bridges [48] states that effectively enacting change necessitates and aids in assisting people to comprehend the challenges to the point where they favourably acknowledge and psychologically own improved approaches. Lewin [45] Insofar as the driving and restraining forces are concerned force field research is especially helpful in generating an all-encompassing perspective on changing circumstances. The aim is to establish the restraining forces which would eventually lead to change. The study further sought to establish the balance between water demand and supply and to promote change management in the municipality. Zet District Municipality has to manage the supply chain risk of water supply to achieve community satisfaction, sustainable costs, higher levels of performance, lean and agile practices and successful adoption of new technology.

3. Literature Review

3.1. Water Delivery Service

Service delivery is a term that does not carry positive connotations in South Africa. The recent wave of community protests focused on various grievances; however, the common denominator was service delivery. It has both monetary and social implications [49]. Section 27(2) of the South African Constitution requires the national government to deliver water to communities and it has delegated this responsibility to municipalities. Independent contractors are part of the equation, with municipalities outsourcing the provision of services to such companies. Kurtz and Clow [50] note that, "The service organization must understand the concept of service quality from the customers' viewpoint, not from the viewpoint of the organization or service provider", while Asmah-Andoh [51] states that, "The 1996 Constitution forces formative obligations on regions with service delivery being key to the role of municipalities". Municipalities are therefore expected to provide essential services that enhance citizens' well-being and security and promote economic development.

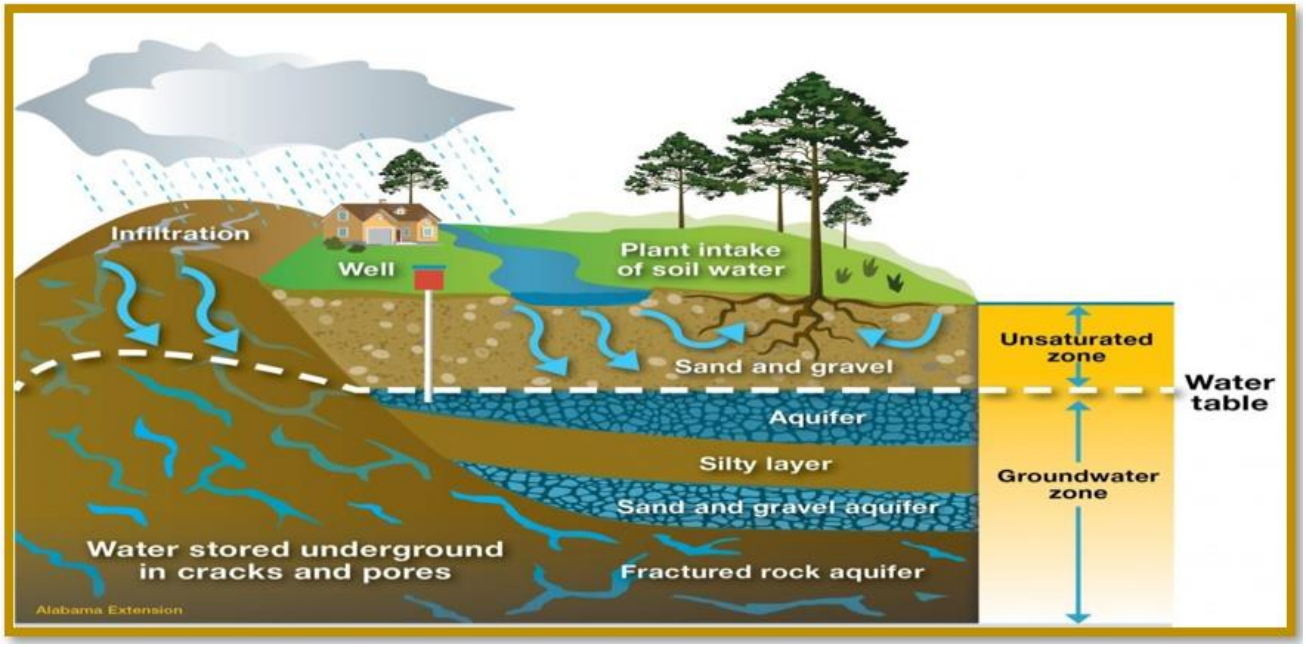

Figure 3.
Water cycle and groundwater.
Source: Curl and Bel [52].

Figure 3 depicts the significant amount of water in the water cycle that is hidden in the ground. It illustrates operable and usable quantities in certain underground places called aquifers from sand and gravel and fractured rocks. The diagram demonstrates the source of groundwater that is filtered and naturally purified through layers of soil, sand, and rocks as it passes through the layers of the Earth into aquifers. The water table shows how naturally occurring water sources are stored underground in cracks and pores, as well as an unsaturated zone and groundwater zone. Curl and Bel [52] describe an unconfined aquifer as one "that is connected to the surface (at atmospheric pressure) and thus the upper surface can rise and fall". Water flows through the surface and downward through small spaces and fractures to fill gaps between rocks and sediment. The authors continue, "'sandwiched' or bounded above and below by impermeable beds or by beds of very low permeability" is how they describe restricted aquifers (confining layers). Groundwater is replenished by rainfall at rates that vary from quick to centuries while precipitation eventually adds water to the aquifer [53] recharging it following environmental changes resulting from climate change to which groundwater resources are vulnerable. The location of the recharge systems is determined by the position of the main channel route, permeability, groundwater depth, and surface features, limiting the options of rural spatial areas [6, 52]. A good permeability rate and suitable groundwater depth create the ideal conditions for the construction of a recharge system [54] to balance the demand for and supply of water in municipalities. However, Mohammad-Hosseinpour and Molina [1] remark that human activities such as excessive aquifer extraction caused by rising water demands that is brought by industrialization and population increase, as well as land-use changes and continued development, impair the performance of natural resources.

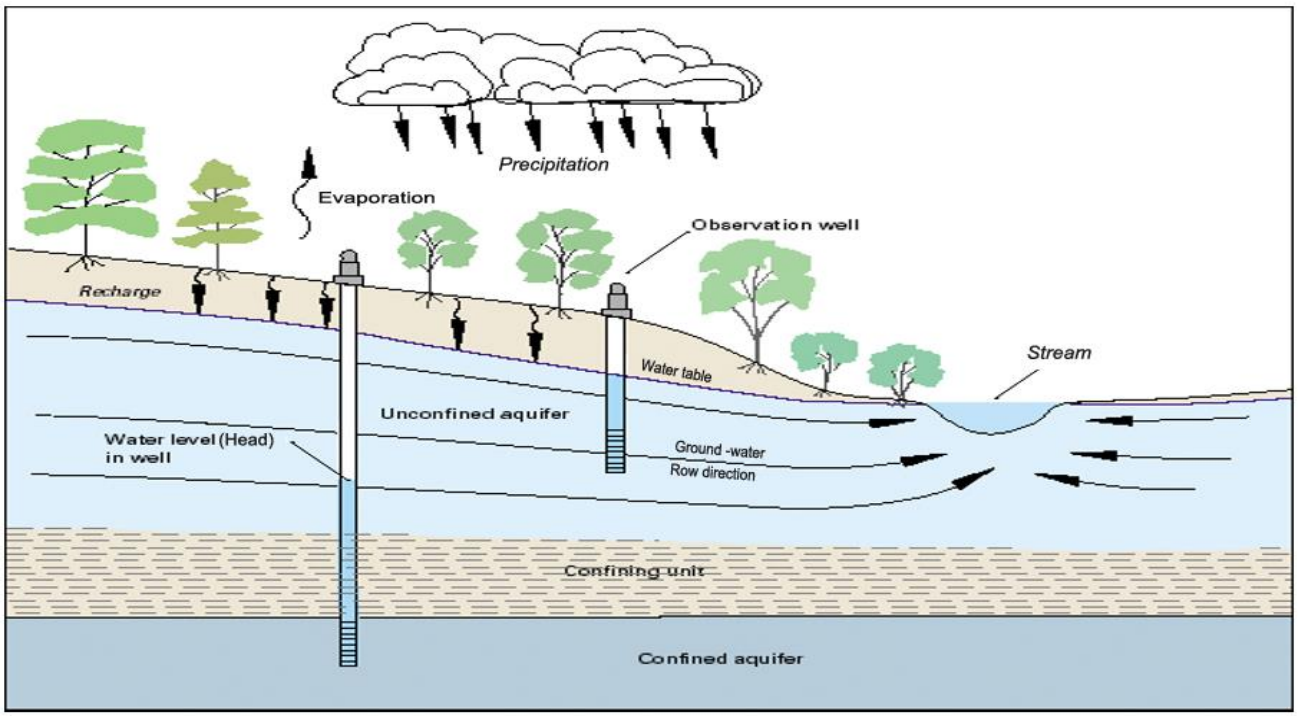

Figure 4.
Groundwater supply.
Source: Alley, et al. [55].

Figure 4 illustrates the effects of pumping from a well in an unconfined aquifer (left) and a confined aquifer (right). When unconfined aquifers are pumped, the water table drops and the pore spaces become unsaturated. Pumping in confined aquifers that decreases water pressure, but the pore space remains fully saturated. Alley, et al. [55] describe ground-water sustainability as the "development and use of groundwater in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences". The focus may be to increase an aquifer's useful life rather than to achieve long-term sustainability. Each groundwater system is unique in that the source and amount of water flowing through the system depend on external factors such as the rate of precipitation, location of streams and other surface-water bodies, and rate of evapotranspiration.

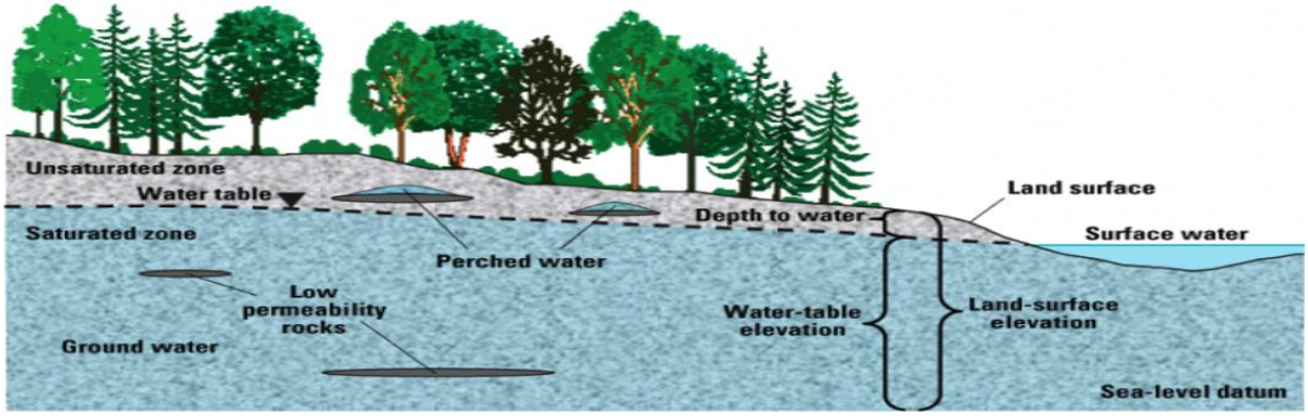

Figure 5.
Schematic cross-section showing perched aquifers above an unconfined aquifer.
Source: Snyder [56] U.S. Geological Survey Scientific Investigations Report 2008–5059, estimated depth to ground water and configuration of the water table in the Portland, Oregon area.

Figure 5 illustrates an estimated depth to groundwater and configuration of the water table in the Portland, Oregon Area and it accentuates practically the significant alternative source of water to mitigate the risk. It shows the groundwater for schematic cross-section water tables perched aquifers atop an unconfined aquifer as well as the unsaturated zone, saturated zone, and groundwater.

3.2. Water Consumption and Scarcity

Water scarcity arises as a result of various factors, including climate change, natural disasters, drought, surface runoff, and evaporation and transpiration. It is arguable that low flow times throughout the summer are connected to a lack of water for home consumption. Food, energy, and water resources are the necessities for human survival and development [57]. They are constrained by water deficits resulting from population growth, community-based cooperatives and agricultural projects,

climate change and a lack of rural water infrastructure. Eriksen, et al. [58] note that Southern Africa is likely to suffer more frequent droughts "due to high temperatures and reduced rainfall". A protracted stretch of abnormally dry weather in a region is referred to as a drought. Little precipitation causes low water levels in aquifers, and the pattern may result in water shortages. Surface runoff is the fifth natural cause of the scarcity of water" [59]. Evaporation is "the key part of the hydrological cycle as seventy-five per cent of the yearly precipitation comes back to the environment because of evaporation and transpiration" [60]. Community leaders and engineers tasked with managing water supplies need to know where the water is and how it moves through the hydrologic cycle [61, 62]. Groundwater recharge and discharge, whose rates and spatial distributions define the relationships between groundwater and the other components of the hydrologic cycle such as precipitation, evapotranspiration, and surface water, are among the least understood pathways.

The Water Cycle—Climate, surface water, and groundwater are linked and recharge/discharge presents the interactions across the interfaces. In South Africa, many rivers have dried up, forcing locals to use boreholes. Dam levels are very low due to the scarcity of rain and it is imperative to reduce water usage. In local water shortages (or climatic deficit), the virtual water trade (VWT) [63, 64] has been increasingly used as a concept to discuss and analyse the water flows embodied in the commercial trade that results in the reallocation of water resources and rebalancing of water budgets [65, 66]. The water scarcity risk transmission in the trade network should be highlighted in policy formulation because local water scarcity could be transferred to distant regions by economic trading activities [67].

Human society faces challenges with food safety, energy security, and protecting water resources as a result of frequent droughts brought on by climate change, high household utilisation as a result of population growth, special economic and industrial zones, crumbling water infrastructure, and the VWT resulting from the urbanisation process [68]. In South Africa, these challenges include water leaks and a lack of water in informal settlements and rural areas. The SCM mechanism and systems involve demand stream processes where food production requires sufficient irrigation; electricity is consumed in the collection, treatment, and transmission of irrigation water, and food processing; and electricity generation requires water for cooling purposes [69]. A sustainable water supply stream system includes integrated water planning, production, distribution, and treatment processes where the optimal planning period for a real-world water supply system is determined [70]. The study aimed to reduce the volume of imported water and increase that of reclaimed water for rural and semi-urban areas. This calls for a focus on rainwater harvesting and water stored in the existing catchment [71] recycling, wastewater management and reuse of water [72] as well as on desalinated seawater with improved hydro-logical technology and imported water [70]. Desalinated seawater has become one of the main alternative water resources. South Africa's use of such alternatives depends on water policy reforms and functional public-private partnerships. KwaZulu-Natal is well placed to embrace this option given its location on the Indian Ocean coast. Additionally, it might provide incentives for both private and public sector organizations to recycle water, encourage rural and urban communities to collect rainwater and invest in infrastructure development to increase aquifers' usable lives and hence support sustainable groundwater use.

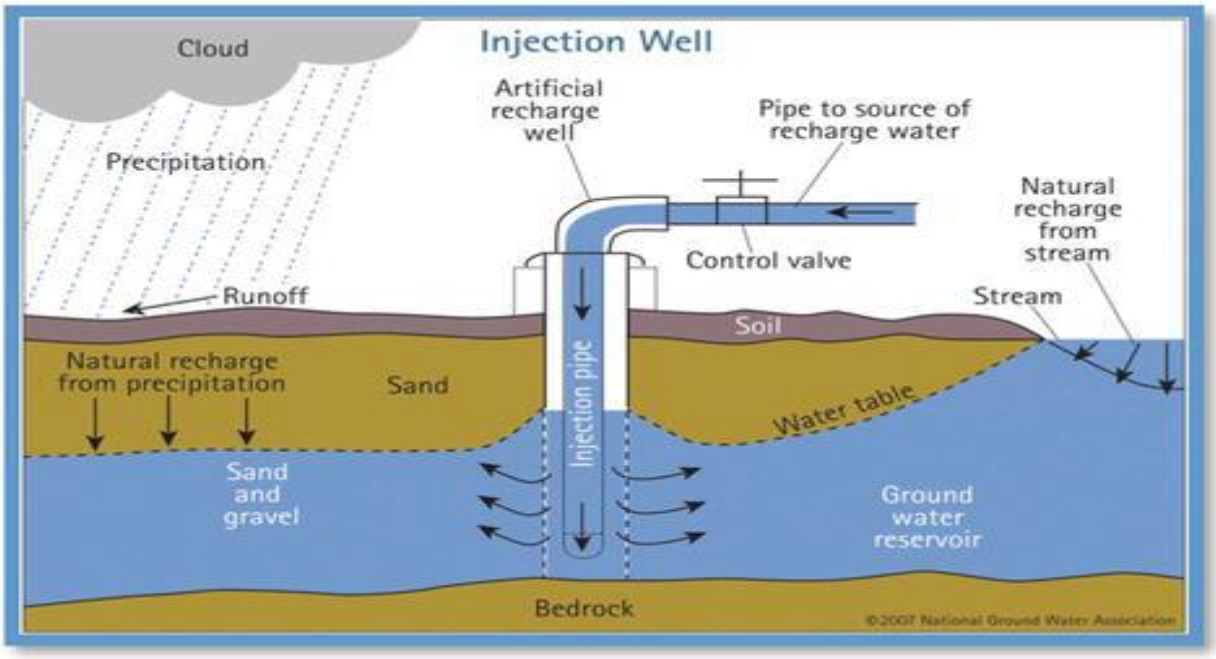

Figure 6.
Injection well for groundwater recharge.

Figure 6 illustrates the injection wells that are used to augment the confined aquifer's groundwater storage by pumping in treated surface water under pressure. The figure depicts recharge as the primary method through which water enters an aquifer and it serves the groundwater reservoir from runoff and streams. It is suitable in coastal regions to capture sea water and also to withstand land subsidence problems in regions where confined aquifers are over-pumped [62]. Groundwater recharge or deep drainage/percolation is a hydrologic process where water moves downward from surface water to groundwater [73, 74].

An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt) [73, 75]. Groundwater from aquifers can be extracted using a water well. Aquifers vary greatly in their characteristics. The study of water flow in aquifers and the characterization of aquifers is called hydrogeology. Groundwater is the foremost supply of freshwater that caters to the household, agricultural and industrial sectors. It has become essential for domestic use, especially for drinking water and food security for billions of people. Artificial recharge of groundwater has emerged as a vital management approach to increase the natural supply of groundwater [62, 76]. An injection well Figure 8 is generally recommended in urban areas. It is used in certain hydrogeological settings for groundwater recharge where aquifers do not receive the natural recharge because of the confining layers of low permeability [74, 77].

3.3. Supply Chain Risk Management (SCRM) on the Stream Sites

To ensure the safety of drinking water in rural areas, water suppliers and service providers require proper water safety plans (WSPs) with a systematic risk assessment methodology [67] that considers all the steps in water treatment systems and water distribution from different sources of water to end consumers [78] followed by implementation and monitoring of risk management control measures. Risk assessment relies on estimates of the likelihood of certain events occurring and the consequences should they occur [79]. The likelihood represents the potential of a hazard or threat, while the consequence is a function of hazard intensity, impact, and system condition [78]. Risk assessment involves quantitative and/or qualitative estimates of risk in a well-defined situation with a recognized threat [80]. Many factors can cause failure in water supply systems in rural areas, including climate change (rainwater shortage) and dilapidated infrastructure. Risk can be defined as exposure to the possibility that the results of a process will not meet expectations [81]. According to Li and Zeng [82], business risk refers to the level of exposure to instability that the enterprise needs to understand and manage adequately. Downstream risks include market instability and fluctuations in demand [83]. Municipalities should thus focus on the demand side of water to manage downstream risks. Upstream risks are "related to procurement and are considered to represent threats to supply affirmation, the probability of poor supplier selection, as well as uncertainty in supply lead time" [84]. The key supply risks relate to the design of the supply system, the location of suppliers and their agility, flexibility, and delivery dependability, and infrastructural quality, coordination and data sharing. This study, therefore, investigated the dimensions and forces driving upstream risks bearing in mind the goal of moderating water supply risks in the future. The SCRM framework is concerned with identifying, exploring, analysing, evaluating, treating, monitoring, reviewing and communicating the supply chain risks associated with the supply of and water demand, in order for it to respond to the demands of the community.

To make the methodology available and accessible to decision-makers in rural/remote areas who may have insufficient experience and knowledge of risk assessment, a cloud-based, online platform employing this methodology has been developed to help them to assess the risks that they may face in their daily roles and to help them to plan and prepare risk mitigation measures [78, 79]. Currently, infrastructure planning and water resources management of almost all projects are based on the assumption of hydrological stationarity [85]. Therefore, a key challenge in water resources management is to determine how to evaluate the reliability and vulnerability of water-related projects within the context of climatic uncertainties [86, 87]. Secondly, decision makers' preferences represent their optimistic/pessimistic attitudes, which should be matched with their information needs [88, 89]. Inertia and myopia in water resource management can be reduced by constructing the model's formulation using multiple objectives and robust decision-making [90, 91]. The WSP approach integrates risk assessment and management practices into a drinking water supply system (DWSS), ensuring water quality from the catchment to the consumer. Water quality refers to physical, chemical, and biological characteristics, with the latter having a more direct impact on people's health [92]. Water safety refers to the availability of quality, affordable drinking water. Water management plans (WMPs) or WSPs, which were first introduced by the World Health Organization (WHO), are aimed at ensuring safety and decreased contamination of the water supply in developing and developed countries Leftwich, et al. [93]. Perez-Vidal, et al. [94] observe that a WSP is an important tool for decision-making that improves administrative, financial, organizational, and operational management. It calls for public-private partnerships between government policy-makers, management and other stakeholders such as service providers and engineers that should be part of the WSP team at each stage of implementation of the drinking water supply system. Ren, et al. [95] indicate that as demand for water increases, the reservoir's storage capacity decreases, and the reliability of the water supply depends on wet encounter situations for different water sources in rural areas. The ability to describe the state of the system varies significantly according to the metrics selected [85] with those of reliability, resilience, and vulnerability best suited to this task [95].

This study constrained the uncertain inputs of the reservoir operation model to improve the credibility of decision-making [87]. The water supply risk in terms of accessibility and availability depends on synchronized public-private collaboration to develop functional, reliable integrated planning, implementation, assessment and monitoring, and improved water supply risk management practices. The other water supply risk stream involves decision-makers exploring alternatives from groundwater to rainwater harvesting, boreholes, seawater desalination, surface dam, river and lake conservation, and a hydrologic water recharge system to prevent water shortages from resulting in soil subsidence, a decline in groundwater quality, and seawater intrusion. The water demand risk is aligned with consumption and the elasticity rate arising from a growing population, expanding irrigated agricultural areas, and special economic and industrial development zones. The water demand risk stream is also influenced by climate change impacts such as a rise in seawater levels and a decline in precipitation, insufficient investment in surface water resources and natural disasters such as the floods in KwaZulu-Natal in April 2022. However, these initiatives are inadequate to meet the demand from rural and urban communities. Rural communities' dependence on groundwater pumping is the primary reason for groundwater depletion which has resulted in

increased pumping costs for municipalities. Coupled with the ongoing drought that has reduced the volume of water in streams and lakes, and land subsidence, there is a shortage of water in the face of increased demand.

4. Research Methodology

4.1. Research Design

The research design sets the direction the research will take after considering the tools to be utilised when designing the data collection instruments [96, 97]. This study was exploratory in nature; therefore, a contextual approach to analysis was adopted [98] that assisted in identifying the supply chain risks about balancing water supply and demand in the areas that make up Zet District Municipality. The study provides a perspective on the scope and notion of SCM, SCRM and the distinctive risks confronted in supplying water. The main philosophical assumptions which influence the research methodology include ontological and epistemological paradigms [99]. Ontology refers to the nature of social reality. It seeks to explain what exists, the basic categories of being and their interactions [99]. Epistemology refers to the nature and arguments about what knowledge is, how it is acquired and how we understand entities. This study adopted interpretivism, also known as the naturalistic or phenomenological paradigm, as its main epistemological research philosophy [100]. A paradigm applies scientific methods through inductive reasoning. Interpretivism contends that reality is not determined by external factors, but is socially and discursively constructed in social interactions [101]. To understand this reality, a researcher needs to engage in in-depth study and sense-making using inductive reasoning.

4.2. Research Approach

Research methods include qualitative, quantitative or mixed methods. Edmonds and Kennedy [102] note that qualitative data collection and analysis seek to understand how individuals characterise, depict and figuratively comprehend experiences. The researcher can tap into the respondents' perceptions [103] and capture what truly matters to them. Qualitative research is thus primarily concerned with obtaining the participants' different points of view on a specific social phenomenon [104]. This study adopted a qualitative approach using a case study. As indicated by Babbie and Mouton [105] "a case study can be typically applied in studies of organizations", in this instance, a municipality. Cooper and Schindler [106] observe that case studies enable in-depth, valuable information to be gathered.

4.3. Sampling Strategy

This study utilised a target population as opposed to a census which includes every component of the population. The target population was 79 staff of Zet District Municipality, which includes five local municipalities. Kvale and Brinkman [107] note that "the number of participants relies upon the motivation behind the study as it decides the approach that the researcher utilises in designing the research". Purposive sampling was employed. According to Ritchie and Lewis [108] "this approach is planned to reflect specific attributes of a chosen population". Edmonds and Kennedy [102] state that purposive sampling involves "the researcher choosing people to take part on a particular need or purpose in light of the research goal, design and targeted population and this is for the most part usually utilised for qualitative methods". According to Brink [109] potential interviewees or participants are selected on account of their comprehension of the phenomenon being referred to or given their encounters in a specific matter or field". Given that this study sought to explore the dimensions of supply risks in the provision of water, it was based at the district level, where the responsible and relevant authorities are located. Table 2 shows the staff profile of Zet District Municipality and the number of participants selected utilizing sampling.

Table 2.
Zet district municipality staff profile.

Department	Staff number	The number selected through purposive sampling
Municipal manager's office	5	1
Corporate services	19	1
Planning and economic development	16	1
Technical services and infrastructure	4	4
Community services	28	1
Finance	7	1
Total	79	9

Purposive sampling was employed to select nine employees for in-depth interviews. These employees were chosen because they were deemed to have appropriate knowledge about the research topic. However, one staff member was not available and eight interviews were conducted. Each of the above-mentioned departments plays a crucial role in the supply of water; the sample thus included representatives of all departments.

4.4. Data Interpretation

Berg [110] notes that primary data are collected to directly address the research issue using techniques that are best suited to a particular study. Primary data was gathered by conducting semi-structured interviews. According to Berg [110] "data analysis is characterized as a procedure of investigating the data that has been received and transforming it into critical pieces of knowledge". The interviews were transcribed and thematic analysis was employed. This involves assigning "codes" to the data [111] to group information of a similar type. The aim was to identify supply risks in the supply of water to improve supply chain operations in the municipality.

4.5. Biographical Information

By the ethical clearance granted for this study, the names of the respondents remain confidential and they are referred to as P1, P2, etc.

Five of the eight participants were male and three were female.

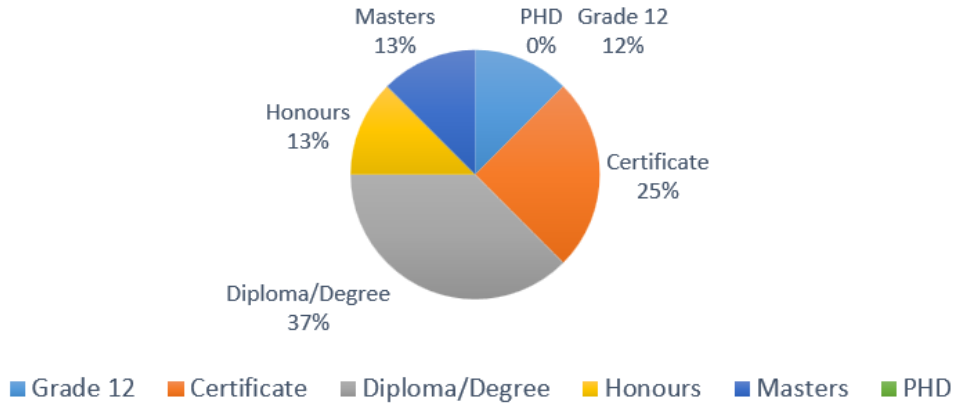

Figure 7.
Educational level.

Figure 7 shows that 37% of the participants had degrees/diplomas as their highest level of education; 25% had certificates; 13% had a Master's degree and 13% had an Honours' degree. Twelve per cent of the respondents had a matric certificate.

4.6. Themes

Thematic analysis is the first qualitative method of analysis that researchers should learn, as it provides core skills that are useful for conducting many other forms of qualitative analysis. It is "a flexible and useful research tool, which can potentially provide a rich and detailed, yet complex account of data" [112]. A thematic map refers to "the graphical presentation of themes, categories, and their relationships, involving a thorough explanation of each theme, their criteria and categories". It helps to outline the objectives that were achieved from the interviews [113]. The Figure 8 presents a thematic map that interrogates the study's objectives.

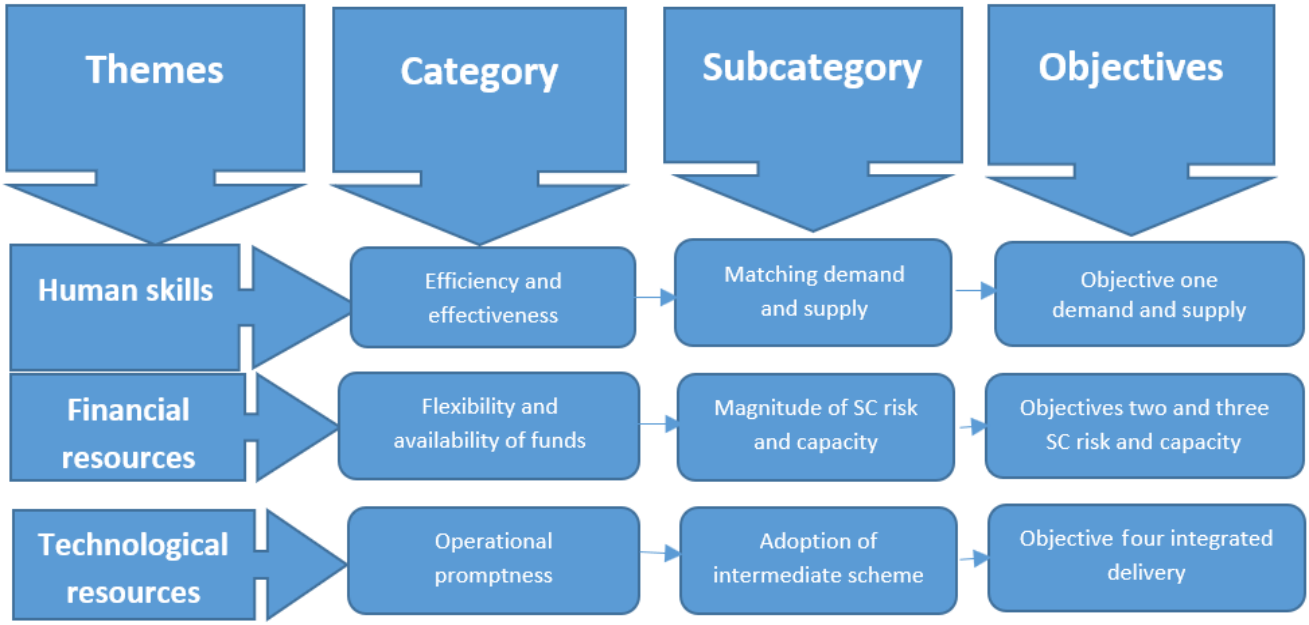

Figure 8.
Thematic map.

4.7. Theme 1: Human Skills

Human skills involve "the ability to work well with other people both individually and in a group" [114]. Referred to as human resources, they are regarded as "a vital resource because people are the driving force behind the achievement of organizational goals; operational functioning, effectiveness and success" [115]. Public sector organisations require a pool of skilled, inspired, competent, and motivated employees that can perform their duties effectively. Furthermore, highly knowledgeable and well-trained managers are required at all levels that are accountable to citizens in the provision of services Auriacombe [116]. Ligami [117] is of the view that to strengthen human skills in Africa, organisations need to achieve the

right skills mix among young people. In a supply chain management context, an organisation requires the ability to harness the power of human resource policies to ensure that the programs are implemented effectively throughout the organization" [118]. The efficiency and effectiveness of responses were a category established for this theme. This is further explained below.

4.8. Efficiency and Effectiveness

Human resources have a major impact on the delivery of water services in Zet District Municipality. P1 observed that *"An important role-player is the people appointed for the provision of the delivery of the service which is water in this case. These are important people who should plan appropriately. If they choose not to do the job efficiently and effectively, it becomes a problem and often leads to delays in service delivery".* P7 concurred and added, *"If political leadership commits to implement a water project within a specific time frame, this information would be communicated to the community members of the Zet district. If the contractor on site decides not to meet the deadlines, it affects everything in the supply chain operations. Sometimes contractors do not meet the requirements of the project in terms of experience, capacity and extensive know-how."* P6 observed that, "*when a person in the field who is required to fit pipes for the supply of water makes a mistake of putting in the wrong pipe, this leads to supply risks associated with human skills and response time in terms of service delivery".* It can thus be concluded that collaboration and information sharing amongst municipal officials is essential for the speed of response in Zet District Municipality's service delivery process. Contractors' capacity, speed of response and experience could improve the supply chain's ability to effectively and efficiently deliver water services.

P5 expressed concern regarding employees' lack of skills: "*The district municipality took over from the local municipalities in meeting the objectives of water provision in the surrounding area. Some of the staff inherited was not skilled, which contributed to delays in the water supply."* Furthermore, P2 noted that, *"service providers do not respond on time."* It is evident from these statements that skills and the speed of response are critical factors in delivering responsive services.

4.9. Matching Demand and Supply

The municipality needs to balance the demand for and supply of water to establish the risks associated with provisionthe of this service. In terms of human skills and time constraints, P2 stated that *"We currently have a challenge but we are trying to make means to train staff to respond timely in meeting the demands of the community and matching the demand and quality supply of water around the Zet district".* P8 argued that, *"the challenge for government is to develop and capacitate the supply side of the supply chain while ensuring the skills necessary to support social improvement and a dynamic and comprehensive economic growth path".* The supply component is most affected by the speed of response in terms of human skills. Although the respondents observed that skills shortages create difficulties in meeting demand, the focus should be on the supply side. To maximise efficiency, heads of departments should focus on peak-time activities to identify skills requirements and inefficiencies. Time as well as speed can determine whether or not the human skills within the municipality are effective.

4.10. Theme 2: Financial Resources

Financial management in the public sector is defined as "all decisions and activities of management, as guided by a chief financial officer, which impact on the control and utilisation of limited financial resources entrusted to achieve specified and agreed on strategic outputs" [119]. The aim is "to manage limited financial resources with the purpose to ensure economy and efficiency in the delivery of outputs required to achieve desired outcomes (effectiveness), which will serve the needs of the community (appropriateness)" [120]. Financial resources are controlled by chief financial officers who are mandated to accomplish set outputs. P1 affirmed that *"The role that the finance division plays in the municipality in the supply of water is to bill for the water that is provided to the community. As a municipality, we are grant reliant. The water that is purified is billed by this division so that we can have some revenue to make the municipality sustainable."* It is thus clear that flexibility and availability of funds have an impact on the dimensions of risks associated with water supply.

4.11. Flexibility and Availability of Funds

Every organisation, whether lean or agile, requires a certain degree of flexibility in its supply chain operations. However, the level of flexibility should make financial sense and should be mutually beneficial to the supplier and its customers. Flexibility and availability of funds are important in a municipality as unexpected events occur that require an immediate response. P7 said that: *"Funds are a challenge in this municipality. The money that we receive from the government is gazetted. The government decides how much money is to be given to each district municipality. However, it does not critically analyse the backlog of water faced by each municipality to allocate funds based on each demand".* P4 concurred and observed that: *"A big challenge is a capital where the municipality could draw up an effective plan of new and improved systems of water supply, but we will always be faced with budget constraints for the provision of water".* P7 stated that, *"In some areas, you would find that there is water but is it not drinkable due to many reasons. There is huge demand and the problem is that grants are not sufficient. The reason for these grants being insufficient is that Zet District Municipality is a rural municipality. People in the surrounding area do not pay for the services provided. Most of these people are unemployed. The municipality is grant dependent and these grants are not enough. This is why it will take a very long time for Zet to supply quality water to the community".*

P2 felt that councillors are not doing their job effectively in terms of finance: *"We need to teach councillors about budget processes. They need to learn how to budget properly to stop them from interfering during the middle of the financial year".* P5 commented that *"there are huge backlogs concerning the provision of water. The groundwater is salty whilst the demand*

increases every single day and the municipality cannot meet this demand with the current level of funding. It will take a long time to eradicate these backlogs". P8 responded: *"New and improved approaches need money as well as change of management. Since the municipality does not bill the community to get more money, grants are never increased whereas, on the other side, water demand persistently increases. If we could come up with a flat rate, maybe there might be a change."*

4.12. The magnitude of Supply Chain Risk and Capacity

Risk management strategies could require a financial injection. P6 stated, *"It is expected that all departments' operations and processes will be subject to risk management strategies to mitigate the risks associated with delivering water to the community. These departments will work together in a consistent and integrated manner, with the overall objective of reducing risk".* P4 was of the view that, *"The supply chain-related risks in the municipality should receive funding support to upgrade the entire supply chain with regards to service delivery".* P1 added that, "*the risk that the finance department faces is limited financial resources in terms of the grants received for implementation as well as for refurbishment".*

4.13. Theme 3: Technological Resources

While there have been remarkable technological advances in past decades, societies have not yet mastered the art of harnessing technology to promote human well-being and prevent undesirable environmental and social impacts. Sound management of technological resources for sustainable development could address the constraints confronting Zet District Municipality in delivering satisfactory water services.

4.14. Operational Promptness

Operational promptness should always be pursued by Zet District Municipality to improve its capability to deliver water services. Sustainable infrastructural capacity is required to provide quality services to the community as well as ensure that the resources at the municipality's disposal are equitably distributed to all areas. P6 commented that: *"The infrastructure that we have in place for water supply is ageing."* P4 observed that "*the municipality is not spending enough on maintenance to prolong the life span of the assets or infrastructure".* P8 noted: *"Water tankers are supplying the community with water at the moment. The municipality installed trackers on these tanker vehicles in order to confirm that the water is delivered to a specific area. The municipality failed to keep up with this system as they did not receive full invoices at the end of the month. The tracker was trying to address the problem and confirm that people received water*". P2 stressed the need for "*the monitoring of water quality using advanced technology*". The major regional schemes are operated by a company called Water and Sanitation Services South Africa (WSSA*).* P3 stated that: *"Another problem with the municipality's infrastructure is that it tends to break most of the time and then they have to shut down every product that needs to take place. Some machines used for water supply are so old that they start creating mud. The mud flows and eventually gets to the seal where the water is meant to come out. It gets stuck, leading to water not getting distributed to the community. The municipality has to find the right person to repair this machine and prepare a requisition. Only then can the order be made. If there's no funding, they must source within their departments".*

4.15. Intermediate Stand-Alone Schemes

The surrounding areas in Zululand do not have access to quality tap water. P5 pointed out that, *"The Zet District Municipality started a comprehensive water master planning exercise to determine the most appropriate methods of providing previously neglected communities with water services. In all cases, the main drivers were to obtain the technical solution that will not necessarily be the lowest in terms of capital requirements but will provide a sustainable service throughout the year at the lowest possible water tariff. The first step was to identify sustainable water sources in the district that could be used to provide water supply even during extreme drought situations and then to determine the most cost-efficient way of supplying communities with these sources".* P7 affirmed that *"Each regional scheme footprint has a sustainable water source from where infrastructure is progressively being rolled out to all households within the supply area".* Human capacity constraints in the public sector can be addressed utilizing technological diffusion and adoption to assist municipalities to fulfil their infrastructure requirements and by engaging in private-public partnerships to improve asset management.

5. Discussion of Results and Recommendations

Municipalities confront many risks in meeting the demand for services. Inadequate responses to such demands have resulted in widespread community protests in South Africa. It is thus important that municipalities identify their dimensions of supply risks to mitigate possible risks that could lead to community dissatisfaction. Most importantly, they need to adopt supply chain risk management strategies to satisfy citizens' need for an adequate water supply.

The first objective of this study was to investigate the balance between water supply and demand in Zet District Municipality. In planning for future needs, it is crucial to establish how much water the municipality can provide (supply), and how much is needed by the community (demand). According to Scully, et al. [121] "today's leadership quality of any organisation needs to be agile – to serve multiple strategic roles across the enterprise while driving a variety of programs and servicing varying levels and/or business units in an autonomous way. Given these complexities, how can human skills capacity achieve the perfect balance between centralizing key functions, while at the same time focusing domain expertise and maintaining just-in-time support across the organization?" The participants highlighted the importance of a skilled workforce. The key supply risks identified include the design of the supply system, location of suppliers, suppliers' agility, flexibility, and dependability, and infrastructural quality, as well as coordination and data sharing. The force field analysis

created a platform to identify the forces that drive change in the water supply. These include community satisfaction, sustainable costs, high-performance goals, lean and agile practices and new technology. The participants noted that the district had experienced water shortages due to drought. This calls for increased efforts on the part of the municipality to better manage the demand side. A range of skills and knowledge is required to address funding constraints as well as management deficiencies in different departments. The participants pointed to the need to bill communities in a manner that assists in meeting the demand for water and mitigates future supply risks. The restraining forces for change derived from the driving forces are inadequate sources of water, a lack of funding, poor planning, organisational inertia and ageing infrastructure. Striking a balance between these forces could facilitate organisational change. Awareness of the driving forces of service delivery could create a pathway for Zet District Municipality to establish the supply operations risks faced in delivering basic services in the region.

The second objective was to determine the degree of supply risk management of water within the restraining forces of the municipality. The participants highlighted the departmental operations and processes that prevent risk management strategies from mitigating the risks associated with delivering water to the community. Financial resources must be devoted to addressing supply chain-related risks about service delivery. Given the increasing demand for water, it is no longer sufficient for the municipality to identify areas that are vulnerable to water shortages. Management of supply risks using restraining forces is important to mitigate risks shortly. The types of risks confronted in supply operations include financial, strategic, operational, technological, and human risks as well as reputation and legal risks. The restraining forces in Zet District Municipality are those faced in water supply operations. Water is an unpredictable resource and to provide this service, risk identification, assessment, response and monitoring and evaluation are essential to meet increased demand.

The third objective was to establish the municipality's (system) capacity to mitigate water supply risk. The findings reflect that it is essential to determine the appropriate response before crafting strategies. Effective collaboration among the different departments could improve capacity to mitigate the supply risks of water delivery. It was noted that risk assessments are conducted for each department to specify the risk they currently face in meeting community demand. Although there is no segregation of duties, the structure does not comply with the regulations about SCM. The lack of effective SCM in the municipality has contributed to delayed responsiveness to increased demand. A corporate water strategy is required that understands the current state of risk at the municipal level. This would facilitate an understanding of the water footprint, both locally and across the value chain.

The fourth objective was to ascertain whether the integration of service delivery activities would enhance the supply component of water provision. Demand can be measured by a population census or community household surveys on the extent, type and quality of services they receive. It has become common knowledge that SCM in the public sector produces unsatisfactory outcomes. Service delivery protests are an indication of citizens' dissatisfaction with service provision. Supply chain management should objectively ensure that services are available of the right quality, at the right time and in the right place. When it comes to water supply and sanitation, the role of the central government is to manage the country's resources to guarantee that every citizen has access to essential services, including water. Monitoring and auditing by the national government is of great importance. Given that Zet District Municipality is a rural municipality, it does not generate sufficient revenue to operate and maintain existing schemes. As a result, it is not spending enough on maintenance. The municipality should strive to ensure effective and efficient governance and management structures to implement its strategies as well as systems to ensure operational competence. The participants clearly stated that water services are part of the municipality's SCM activities. Such services cannot be procured outside of SCM through the bid committee system that oversees the process of specification, evaluation and bid adjudication. It is responsible for the evaluation of bids submitted in response to a public invitation for bids. Furthermore, Integrated Development Planning (IDP) requires community participation in the planning, implementation and management of services. It is an approach to planning that involves the entire municipality and its citizens in finding the best solutions to achieve good long-term development. Integration of service delivery activities would thus enhance water service delivery as it harmonises the relationship between the demand and supply of water.

6. Discussion of Results

Freshwater is a valuable and essential natural resource for several usages such as agricultural, industrial, municipal, and environmental purposes. The frequency of fulfilment of demand for water calls for a proper management system that protects ecosystems and the environment. Rapid progress and development of human societies, including economic (industrial localization and glocalization) and population (invigorated by new young families) growth as well as agricultural and industrial activities (special economic zones), have increased water utilization in South Africa. Rising populations and consumption are increasing the demand for domestic water, negatively impacting water availability Chen, et al. [122]. Liu, et al. [65] note the urgent need to consider trade types and water scarcity when developing water resource allocation and conservation policies in interprovincial trade. The authors found that the water resources flows embodied in interregional trade were an effective method to enable water-scarce regions to shift stress to their trading partners, leading to a redistribution of water resources, and causing more complex imbalances [65, 66]. Based on multiregional input-output and network environment analyses, Liu and Chen [67] highlighted that local water shortages could not only cause local economic losses but also impact distant regions through the national supply chain. Due to agricultural expansion, local hydrological regulation and the supply of fresh water have deteriorated, and the groundwater level has dropped dramatically [123, 124]. The water scarcity risk transmission in the trade network should be highlighted in policy formulation because local water scarcity could be transferred to distant regions by economic trading activities [79].

6.1. Data Quality Control

This section critically analyses the quality of the data collected. This is essential as reliable and valid data is required to draw credible conclusions. The following steps were taken to promote the trustworthiness of the data collected: Credibility: Intensive engagement with the data (recordings, notes and transcripts) was undertaken to demonstrate clear links between the data and the interpretations. The interviews were recorded and extensive notes were taken. The researcher transcribed the interviews verbatim. The background, qualifications and experiences of the participants were clearly stated. The questions were presented in a format that was easily understood by the respondents. Furthermore, highly knowledgeable individuals were purposively selected. Confirmability: To ensure confirmability, the experiences and ideas of the participants were stated, rather than those of the researchers. The methods used to gather and analyse the data were also clearly laid out so that other researchers can evaluate the study's findings. An audit trail was employed to ensure that the data and interpretations were sound and to confirm the findings. Olivia [125] states that "an audit trail is when a qualitative researcher details the process of data collection, data analysis and interpretation of the data".

Dependability: According to Riege [126] dependability is analogous to the notion of reliability in quantitative research. For the clear understanding of reader the processes involved in this study, a detailed description was provided of the research design and how it was implemented. The purpose was to demonstrate stability and consistency in the process of inquiry. Care was taken to ensure that the research process was logical and that the method adopted was appropriate, traceable and documented. Transferability is concerned with whether a study's findings would be replicated by other studies. This is not possible about qualitative studies [127]. However, the conclusions reached in this study could be transferable to other municipalities that face similar water supply risks. Furthermore, the methods used for data collection and analysis are clearly stated, enabling other researchers to evaluate the findings.

6.2. Contributions of the Study

Municipalities are continually looking for more efficient ways to manage their supply chain risks. The conclusions derived from this study could offer feasible solutions to the management and control of supply risks in the provision of water. The study also lays a foundation for further research on municipal service delivery as a whole.

6.3. Managerial Implications

Water supply has long been a sensitive issue in Zet District Municipality. The study's findings will hopefully assist the municipality to address water supply and demand imbalances. This will require a skilled, committed workforce with clearly-defined responsibilities and a comprehensive customer database. Effective responses to water scarcity will require specialised skills. It is therefore important that Zet District Municipality improves its human resources capacity in all departments. Moreover, operational excellence needs to become the municipality's mantra. Activities within the municipality could be improved by focusing on customers' needs and empowering staff. Finally, Zet District Municipality should embrace the concepts of agility, responsiveness and flexibility to meet the demand for water. Lean and agile practices will address organisational inertia and virtual SCM that would establish the dimensions of supply risks faced by the municipality about the supply of water as it would promote flexibility to quickly adapt to changes in supply chain operations.

6.4. Limitations and Delimitations of the Study

Cooper and Schindler [96] note that all research studies have limitations and this study is no exception. In the first instance, it was limited to Zet District Municipality. Therefore, its findings can be linked to the municipalities and rural areas that have been severely affected by the lack of access to quality water. The cross-sectional time frame was another limitation. Secondly, although the target sample was nine officials, only eight were interviewed as one was unavailable. Despite the study's limitations and delimitations, it lays a foundation for future research on this topic.

7. Conclusion

The supply risks experienced in water services in Zet District Municipality have severe consequences, including the loss of lives and illness through using water from contaminated sources like rivers. The findings of this study could inform municipalities' efforts to improve their supply chain operations to ensure that they mitigate supply risks not just in water supply, but in service delivery as a whole. They also demonstrate the importance of striking a balance between water demand and supply to address supply risks.

7.1. Suggestions for Future Research

The study's results suggest that the issue of water supply is one of the factors that contribute to the inadequacy of water provision. The majority of the respondents were of the view that this will take a long time to resolve unless the municipality prioritises this issue. Ever-increasing demand needs to be addressed before it gets out of control. The respondents also indicated that funding constraints hinder the adoption of strategies to remedy the situation. Further research is thus required to understand the dimensions of supply risks in the supply of water to mitigate future risks.

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