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IDENTIFYING TRENDS AND RELATIONSHIPS BETWEEN KEY
PERFORMANCE INDICATORS TO AID MUNICIPAL
MANAGEMENT AND DECISION MAKING

by

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Declaration

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Synopsis

South African municipalities are under pressure to improve the current state of the water and wastewater service delivery industry. Knowing that there exists a need for improvement within the municipal water and wastewater industry, the Department of Water Affairs (DWA) launched a municipal strategic self-assessment (MuSSA) initiative to evaluate the business health of the industry. MuSSA asks high level technical management staff five key questions about sixteen key business attribute areas. This study seeks to determine if the MuSSA data can be used to aid municipal decision making, by way of drawing correlations between key performance indicators contained in the MuSSA questions. The correlations are to bring forth areas that must be focussed on to improve selected attribute areas requiring attention within municipalities. Three areas have been chosen from the MuSSA data to be investigated in this research project namely; (i) staff skill levels and capacity, (ii) non-revenue water and (iii) the execution of planned water services activities.

In the MuSSA questionnaire there are questions addressing each of (i), (ii) and (iii) to determine the municipality's performance in each of the three areas. Non-parametric statistics are used to determine with which of the MuSSA questions' answers the relevant questions' answers significantly correlate for (i), (ii) and (iii). Engineering judgement and expert opinion are used to determine if the questions correlating with the relevant questions for (i), (ii) and (iii) either affect, are affected by or have no relation with the question. These results are then organized using a flow diagram and are discussed in detail by way of a bivariate histogram of each correlation.

The investigation revealed that municipalities not having sufficient technical management capacity are not performing well on at least one of the five questions asked on eleven of the sixteen MuSSA business attributes. The skill level of water and wastewater treatment works staff were found to be strongly affected by technical management capacity and skill, water services planning and financial sustainability of the organization. Municipalities training technical management and operational staff showed a high percentage of skilled operational staff employed at treatment works. Water and wastewater treatment works staff capacity are very dependent of the level of skill and capacity of technical management employed by the municipality. Municipalities having appropriate budgets and funding to appoint and train staff showed a tendency to be better at operational staff capacity building than those lacking funding.

The reduction of non-revenue water (NRW) showed strong correlations with technical management and network operational repair staff skills and development. Municipalities employing staff with correct skills and experience combined, with commitment from management to reduce NRW

by way of monitoring and practicing of pressure management programs, significantly reduced NRW percentages. Equally crucial to the reduction of NRW, as revealed from the investigation, is the practicing of infrastructure asset management within the municipality. It was concluded that municipalities should strive to reach a NRW percentage of 30% or less to become financially stable, due to correlation between funding of routine operations and building up of cash reserve versus NRW percentages.

Municipalities wanting to improve the execution rate of planned water services activities are recommended to address, among other factors, technical management skill levels and capacity. Municipalities lacking technical management skill and capacity reported a low percentages of planned activities being executed. Also of high significance, is the technical operational staff skill levels and capacity, due to their involvement in the execution of planned activities. The involvement of council members in water and wastewater planning and the reporting of data and issues to council greatly enhances municipalities' abilities to execute planned activities. This can mainly be contributed to increased funding in situations where council members support planned projects. The lack of funding was found to be a major inhibitor of the execution of planned activities. Even though a great deal of municipalities indicated that they are effectively spending allocated budgets, this positive indication is not seen in the percentage municipalities executing planned activities and leads to the conclusion that there is a lack of funding. Municipalities taking actions in other areas of their business such as infrastructure asset management and planning were more effective at executing planned activities.

In all, it was concluded that technical management and operational staff skill levels and capacity need to be present for a municipality to function properly. Municipalities also are in need of funding to execute planned activities and need to become financially self sustainable. One way of working towards the goal of financial self sustainability is the reduction of NRW percentages. The data from this investigation shows great similarity with the literature consulted on the current state and functioning of South African municipalities. The statistical analysis of the MuSSA data accurately revealed correlations among key performance indicators in municipalities. The conclusion can be drawn that investigation of correlations among MuSSA questions can be used to help aid municipal decision making.

Sinopsis

Suid-Afrikaanse munisipaliteite is onder druk om die huidige toestand van die water en afvalwater dienslewering te verbeter. Met die wete dat daar 'n behoefte vir verbetering in die munisipale water en afvalwater bedryf is het die Departement van Waterwese 'n munisipale strategiese self-assessering (MuSSA) projekte geïnisieer om die welstand van die bedryf te evalueer. MuSSA vra hoë vlak tegniese bestuurs personeel vyf kern vrae oor sestiensleutelbesigheidsaspekte. Hierdie studie poog om vas te stel of die MuSSA data gebruik kan word om munisipale besluitneming te help verbeter, deur middel van die evaluering van korrelasies tussen die sleutelprestasieaanwysers soos vervat in MuSSA vrae. Die korrelasies bring na vore gebiede waar op gefokus moet word om geselekteerde kenmerkareas binne munisipaliteite, wat aandag vereis, te verbeter. Drie areas uit die MuSSA-data is ondersoek in hierdie navorsingsprojek naamlik; (i) personeelvaardigheidsvlakke en kapasiteit, (ii) nie-inkomstewater en (iii) die uitvoering van die beplande waterdiensaktiwiteite.

In die MuSSA vraelys is daar vrae wat elk van (i), (ii) en (iii) aanspreek om die munisipaliteit se prestasie op die drie gebiede te monitor. Nie-parametriese statistiek word gebruik om die oorblywende MuSSA vrae wat se antwoorde met die relevante vrae se antwoorde korreleer vir (i), (ii) en (iii) vas te stel. Kundigheid en oordeel van ingenieurs word gebruik om te bepaal of die vrae wat korreleer met die relevante vrae vir (i), (ii) en (iii) die relevante vraag beïnvloed, beïnvloed word deur die relevante vraag of geen verhouding het met die relevante vraag nie. Hierdie resultate word dan georganiseer met behulp van 'n vloeiagram en word in detail bespreek deur middel van 'n tweeveranderlike histogram van elke korrelasie.

Die ondersoek het aan die lig gebring dat munisipaliteite wat nie genoegsame tegniese bestuurskapasiteit het nie swak presteer op ten minste een van die vyf vrae van elf van die sestiensleutelbesigheidsaspekte. Die personeelvaardigheidsvlakke van water en afvalwaterbehandelingswerke word sterk beïnvloed deur die tegniese bestuurskapasiteit en -vaardigheid, waterdiensbeplanning en die finansiële volhoubaarheid van die organisasie. Munisipaliteite wat opleiding van tegniese bestuur en operasionele personeel uitvoer het 'n hoë persentasie van opgeleide operasionele personeel werksaam by suiweringswerke. Water en afvalwaterbehandelingswerke se personeelkapasiteit is baie afhanklik van die vlak van vaardigheid en kapasiteit van tegniese bestuur in diens van die munisipaliteit. Munisipaliteite met toepaslike begrotings en befondsing om personeel aan te stel en op te lei het 'n neiging om beter te presteer met kapasiteitsbou van operasionele personeel as die wat aan 'n gebrek ly van befondsing.

Die vermindering van nie-inkomstewater (NRW) het sterk korrelasies met tegniese bestuur en

netwerkherstel personeelvaardighede en ontwikkeling. Munisipaliteite wat personeel met die korrekte vaardighede en ervaring in diens het, gekombineer met bestuur wat dit nastreef om NRW te verminder by wyse van monitering en uitvoering van druk beheer in water netwerke het aansienlik kleiner NRW persentasies. Ewe noodsaaklik vir die vermindering van NRW, soos geopenbaar deur die ondersoek is die beoefening van interne infrastruktuur batebestuur deur die munisipaliteit. Daar is tot die gevolgtrekking gekom dat munisipaliteite daarna moet streef om 'n NRW persentasie van 30% of minder te bereik om finansiële stabiel te word, as gevolg van die korrelasie tussen befondsing van roetine bedrywighede en die opbou van kontant reserwe teenoor NRW persentasies.

Munisipaliteite wat die uitvoeringskoers van beplande waterdienste aktiwiteite wil verbeter, word aanbeveel om onder andere, tegniese bestuurs vaardigheids vlakke en kapasiteit aan te spreek. Munisipaliteite wat nie tegniese bestuursvaardigheid en -kapasiteit het nie, berig dat 'n lae persentasie van beplande aktiwiteite uitgevoer word. Die tegniese operasionele personeel vaardigheidsvlakke en kapasiteit, as gevolg van hul betrokkenheid in die uitvoering van beplande aktiwiteite is ook van groot belang. Die betrokkenheid van lede van die raad by water en afvalwater beplanning en die rapportering van data en kwessies aan die raad verhoog baie munisipaliteite se vermoëns om beplande aktiwiteite uit te voer. Dit kan hoofsaaklik toegeskryf word aan verhoogde befondsing in situasies waar raadslede beplande projekte ondersteun. Dit is gevind dat die gebrek aan befondsing 'n groot inhibeerder van die uitvoering van beplande aktiwiteite is. Alhoewel 'n meerderheid van die munisipaliteite aangedui het dat hulle begrotings effektief spandeer, word dit egter nie weerspieël in die persentasie munisipaliteite wat beplande aktiwiteite uitvoer nie en lei dit tot die gevolgtrekking dat daar 'n gebrek aan befondsing is. Munisipaliteite wat klem lê op ander gebiede van hul besigheid soos, infrastruktuur batebestuur en beplanning was meer effektief met die uitvoering van die beplande aktiwiteite.

Daar is tot die gevolgtrekking gekom dat tegniese bestuur en operasionele personeel vaardigheidsvlakke en kapasiteit noodsaaklik is vir 'n munisipaliteit om behoorlik te funksioneer. Daar is ook 'n behoefte aan befondsing by munisipaliteite om beplande aktiwiteite uit te voer en munisipaliteite moet finansiële onafhanklik en lewensvatbaar word. Een manier om te werk te gaan om finansiële self volhoubaarheid te bereik, is die vermindering van NRW persentasies. Die data van hierdie ondersoek toon groot ooreenkomste met die literatuur wat geraadpleeg is oor die huidige stand en funksionering van Suid-Afrikaanse munisipaliteite. Die statistiese analise van die MuSSA data het akkurate korrelasies geopenbaar tussen die sleutel prestasie-aanwysers in munisipaliteite. Die gevolgtrekking kan gemaak word dat die ondersoek in terme van die korrelasie tussen MuSSA vrae gebruik kan word om munisipale besluitneming te help verbeter.

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List of Abbreviations

Acronyms

CSIR - Council for Scientific and Industrial Research

DMA - District management area

DWA - Department of Water Affairs

LGWSETA - Local Government Water Sector Education and Training Authority

IAM - Infrastructure Asset Management

IBNET-International Benchmarking Network for Water and Sanitation Utilities

IMESA - Institute for Municipal Engineers South Africa

IDP - Integrated Development Plan

IWA - International Water Association

MIG - Municipal Infrastructure Grant

MuSSA - Municipal Strategic Self Assessment

MM - Municipal Manager

NRW - Non-Revenue Water

O&M - Operations and Maintenance

PMU - Project management unit

SALGA - South African Local Government Association

SAICE - South African Institution of Civil Engineering

WCDM - Water Conservation & Demand Management

WRM - Water Resource Management

WSA - Water Service Authority

WSP - Water Safety Plan

WSPs - Workplace skills plan

WTW - Water Treatment Work

WWTW - Wastewater Treatment Work

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Chapter 1

Introduction

"Municipalities inadequate - official" - Engineering News (July 2012)[9]

"Municipalities spend on parties, not toilets" - News24 (July 2012)[10]

"Water shortages to hinder economic growth" - Infrastructure News (June 2012)[11]

Such are the news headings seen daily by the South African public, regarding their municipal water and wastewater services. These articles mention the lack of technical capacity, funding gaps, ill technical management capabilities and poor revenue management, resulting in outright disastrous situations at many of the South African municipalities. South Africa is a water scarce country and cannot afford to mismanagement its resources, including human, financial, infrastructure and natural resources. There is a need to optimize the use of these available resources, maximizing service delivery especially in the water and wastewater services delivery sector.

Local Government, since its transition in 2000, continues to face a range of service delivery challenges. A growing economy and increased urbanization have resulted in a substantially increased demand for water infrastructure, against a backdrop of poor municipal service quality due to ageing infrastructure, deteriorating operations and maintenance levels, a severe lack of skilled personnel, inappropriate use of available funds and political interference. A recent government assessment confirmed that many South African municipalities remain in trouble, with many in a critical state or at high risk (see Figure 1.1). Continued service delivery weaknesses are tipping many municipalities into outright service emergencies, leading to a growing number of water related service delivery protests [12]. Under these challenging circumstances, optimizing the implementation and allocation of municipal resources holds great significance.

In order to both better understand the status of municipal water services delivery and to assist and ensure effective and sustainable water services provision, the Department of Water Affairs (DWA) undertakes an annual national Municipal Strategic Self-Assessment (MuSSA). The purpose of the MuSSA is to assess the overall water service business health or vulnerability of municipalities, by measuring the vulnerability levels of sixteen key business attribute areas. The MuSSA asks senior municipal technical managers five clear and relatively simple "essence" questions per business attribute, thereby capturing the performance of the municipality against a range of performance, gov-

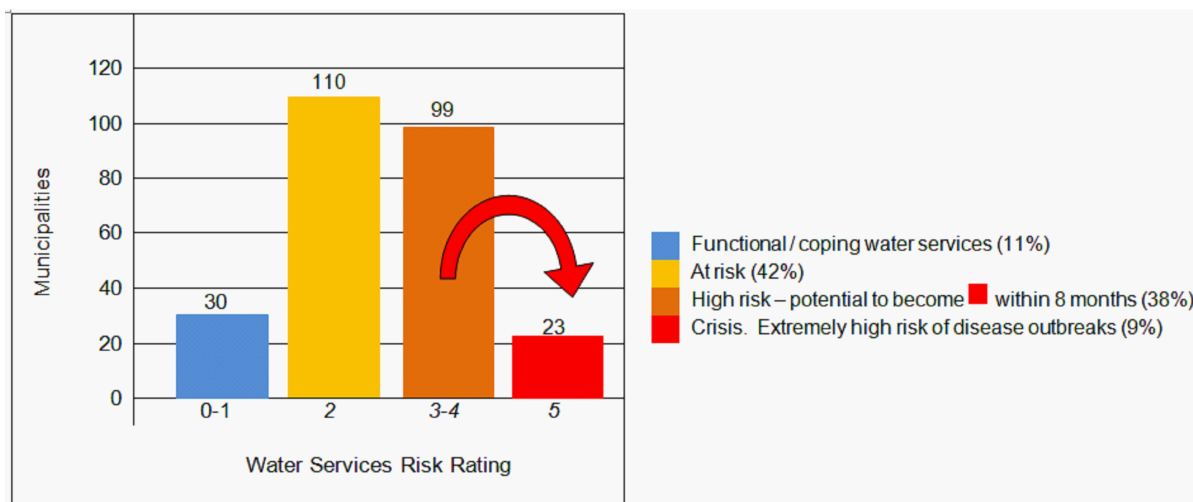


Figure 1.1: Risk rating of water services provision by local government [1]

ernance and development indicators. The MuSSA outputs were used as input into the high priority "Local Government Turnaround Strategy" in terms of (i) confirming highly vulnerable municipalities and (ii) providing detail on areas of high vulnerability within weak municipalities. 97% of Water Service Authorities (WSA) participated in the 2011 MuSSA.

MuSSA's basic graphical outputs are a useful tool for municipalities to quickly determine in which areas they are most vulnerable. However, these simple outputs do not indicate the relationships and trends amongst Vulnerability Indicators (VI). In this study, statistical analysis is used to generate information on the relationships (correlations) between the VI's which aims at facilitating municipalities in assigning their resources (financial and human) to address those areas which are most critical in order to reduce areas of vulnerability. In brief, a detailed non-parametric statistical analysis is to be conducted to determine the correlations existing between several chosen relevant questions and each of the remaining 79 MuSSA questions. While the analysis establishes a correlation coefficient (i.e. indicate the existence of a relationship between two aspects), it does not distinguish which one of the two aspects is the 'cause' or which is the 'effect'. This is left to engineering judgment. The factors with high correlations with other factors from the analysis can be seen as critically contributing or influenced factors. Those judged to be contributing can be addressed to improve the relevant attribute area. This information may assist municipal managers to assign their limited resources more effectively and improve municipal water services business efficiency. This study will focus on identifying such factors within the following key areas: staff skill levels and capacity, non-revenue water and execution of planned water services activities.

The general research hypothesis to be answered by this investigation is;

Can the Municipal Strategic Self-Assessments data be used to identify relationships between key business attributes, which may aid municipal water services decision making and improve the current state of (i) technical staff skill levels and capacity, (ii) Non-Revenue Water (NRW) percentages and (iii)

execution of planned water services activities.

Correlation analyses are either done using parametric or non-parametric statistical tests. A parametric test makes numerous assumptions about numerical values assigned to observations and the distribution which the samples are drawn from. In the case of the MuSSA data very little is known about the distribution of the data samples. For this reason a non-parametric test, which allows for the analysis of data even though very little is known about its distribution is to be used in this study, due to the fact that it makes no assumptions about the data sample's statistical distribution. This method uses rank tests or order tests, and the measurement scale applied to the data puts certain constraints on the statistical interpretations and operations that can be executed on the data [13]. By using Spearman's R and Mann-Whitney U-Test, the significance of the relationships among the answered MuSSA questions will be determined together with the strength of the relationship. Each MuSSA question has a set of possible answers to the question. These possible answers contain some kind of rank or order in preference, to which a value is assigned. The values of the ranks assigned to questions are not important, as long as the ranks of the preference in the answers are preserved. Thus, higher ranks (i.e. higher meaning a larger number) are assigned to more preferred answers, and lower ranks are assigned to less preferred answers (in each scale), while preserving the order of preference. The output from each analysis is a significance level (probability of a correlation's existence) and a correlation coefficient (which indicates that a change in one factor is due to change in the other).

The results from the analysis will be sorted into two categories using engineering judgement, with respect to their relationship to the particular MuSSA question being investigated, as being either (a) the influencing factor or (b) the factor effected. To help visualize the interaction between the relevant questions and their correlations amongst each other, a flow chart of the correlations will be constructed for each question investigated. The correlations are reported and discussed in order to reach conclusions on of their usefulness in improving water services delivery, within the attribute areas (i), (ii) and (iii) as mentioned in the research hypothesis.

The outline of this research is as follows;

Chapter 2 - Review of the relevant literature in the three focus areas.

Chapter 3 - Research methodology stating the research hypothesis and how it will be investigated, including statistical methods and procedures.

Chapter 4 - Investigates the output from the analysis on the MuSSA data relating to the significance and improvement of staff skill level and capacity building.

Chapter 5 - Investigates the output from the analysis on the MuSSA data highlighting the critical areas relating to non-revenue water.

Chapter 6 - Investigates the output from the analysis on the MuSSA data revealing the factors contributing to the execution of planned water services activities.

Chapter 7 - Sets forth the conclusions drawn from the study and makes recommendations including recommendations for future studies in the particular field.

Chapter 2

Literature review

2.1 Introduction

This chapter seeks to inform the reader about the current state of (i) staff skill levels and capacity, (ii) non-revenue water and (iii) water services planning in South African municipalities.

2.2 Technical staff skill level and capacity

2.2.1 An overview of shortages

In the past the public sector was known for employing large numbers of civil professionals, which allowed them to carry out maintenance and construction of all small projects and many large projects [6, p.61]. A major shift has occurred, the result being that the public sector's technical departments have now become strategic only initiating projects to be tendered for by the private sector. This shift has resulted in the public sector accounting for 70% of the work carried out by the private sector's civil engineering contractors. Together with this shift, there has been a major reduction in the number of civil engineering staff in technical departments. As a result, the ability of the public sectors' technical departments to carry out proper maintenance and service delivery has been greatly handicapped [6]. A net loss of 70 to 90 civil engineering staff per annum has occurred since the late eighties in local government based on the number of staff employed in mid-2007, which was estimated to be 1 300 to 1 400 [2, p.14].

In 2008, Dawie Botha, the then executive director of SAICE, estimated that there were around 2 000 vacancies in South African municipalities for civil engineers [14]. The Department of Public Works recently addressed the Construction Industry Development Board and called upon them to invest skills in the public sector, adding that the private sector will offer competitive salaries. Thulsa Nxesi, Public Works Minister, argued that the lack of skill and proper management in the Public Works Departments are contributing to the decline of the infrastructure development sector due to the large amounts of works contracted by the public sector to the private sector [15]. It has been reported that some municipalities have vacancy rates from 40% to 60% in their technical departments [16].

With the decline in civil professionals employed in the municipal environment, there has been an increase in the number of appointments of non-technical staff in senior technical management positions, leading to the loss of the understanding of the importance of technical professionals to the functioning of municipalities [6, p.61]. Unqualified staff working as engineering technicians in South Africa was reported to be 58 140 people over the period of 1996 to 2005 [17, p.76]. These people typically had a NQF4 or less. The Department of Public Works found that in many cases where there are appropriate numbers employed, that many of the staff simply did not have the critical skills to effectively manage and ensure delivery of infrastructure projects [18, p.4]. They also found that 40% of senior officials and managers have less than five years experience in the public sector, which is of great concern and shows the shortage of mid-career professionals. Extensive vacancies in senior professional staff levels have also been created by the offering of early retirement packages and the leaving of senior members due to extreme frustration caused by non-technical decision makers.

Table 2.1: Percentage vacancies in local government reported from workplace skills plans submissions [6, p.62]

Occupation	Skill shortage	Employment equity requirement	Other, including budget constraints	Total (%)
Leadership & governance	0.00%	0.00%	0.13%	0.13%
Senior officials & managers	1.01%	0.09%	2.37%	3.47%
Professionals	3.99%	0.13%	1.67%	5.79%
Technicians/associated professionals	12.76%	0.22%	1.27%	14.25%
Skilled agricultural & fishery workers	0.00%	0.00%	0.00%	0.00%
Clerks	11.79%	1.05%	6.62%	19.46%
Service workers	8.11%	0.26%	4.25%	12.62%
Craft & related workers	1.67%	0.04%	1.27%	2.98%
Plant, machine operators	5.61%	0.26%	5.09%	10.96%
Elementary occupations	21.96%	0.18%	8.20%	30.34%
Total (%)	66.90%	2.24%	30.86%	100.00%

A vastly underestimated number of the vacancies are shown in Table 2.1, as prepared by the Local Government Water Sector Education and Training Authority (LGWSETA) from the workplace skills plans¹ submitted by municipal councils. Only the councils that do have adequate capacity are able to accurately report on the professional and technical vacancies by filling in their workplace skills plan, leading to the belief that the data in Table 2.1 greatly underestimates the extent of the vacancies [6, p.62]. Further research conducted by Ms. Lawless and her team, which included a full census of the 284 local and district municipalities and metros and visits to two councils per province, yielded

¹A plan developed every year at enterprise level that describes an organization's training and skills development strategy that will help it to meet its overall business objectives and targets, a key source of information about the sector in terms of demographics, existing qualifications, and training and development priorities for the forthcoming year and a document that will inform the LGWSETA's strategic priorities in the development of its Sector Skills Plan. Required by the Skills Development Act

much greater vacancy numbers. The statistics for the civil engineering professionals are as follows [6, p.62]:

No civil professionals

- 79 of the 231 local municipalities have no civil engineers, technologists or technicians
- 4 of the 47 district municipalities have no civil engineers, technologists or technicians

Only one civil technician

- 42 of the 231 local municipalities have only one civil technician
- 4 of the 47 district municipalities have only one civil technician

Only young staff

- 38 of the 231 local municipalities employ only technologists and technicians under the age of 35
- 6 of the 47 district municipalities employ only technologists and technicians under the age of 35

Only 70 with civil engineers

- Only 45 of the 231 local municipalities have civil engineers
- Only 25 of the 47 district municipalities have civil engineers

SAICE conducted a study of local government in March and April 2005 which confirms the results from Allyson Lawless' investigation with the following facts [2, p.79];

- There has been a great migration of staff to the private sector
- 83 municipalities had no civil engineering staff and 49 had only one, or perhaps one or two very young inexperienced civil engineering staff which shows that there is a great need for staff
- After graduation there were many student technicians who could not obtain training or permanent employment positions
- A lack of experienced staff exists that is capable and has time to offer advice, in the form of mentors

Figure 2.1 shows the distributions of civil engineering staff as employed in local municipalities and metros. It is estimated that the vacancies in local and district municipalities and metros are around 40% on average [6, p.63].

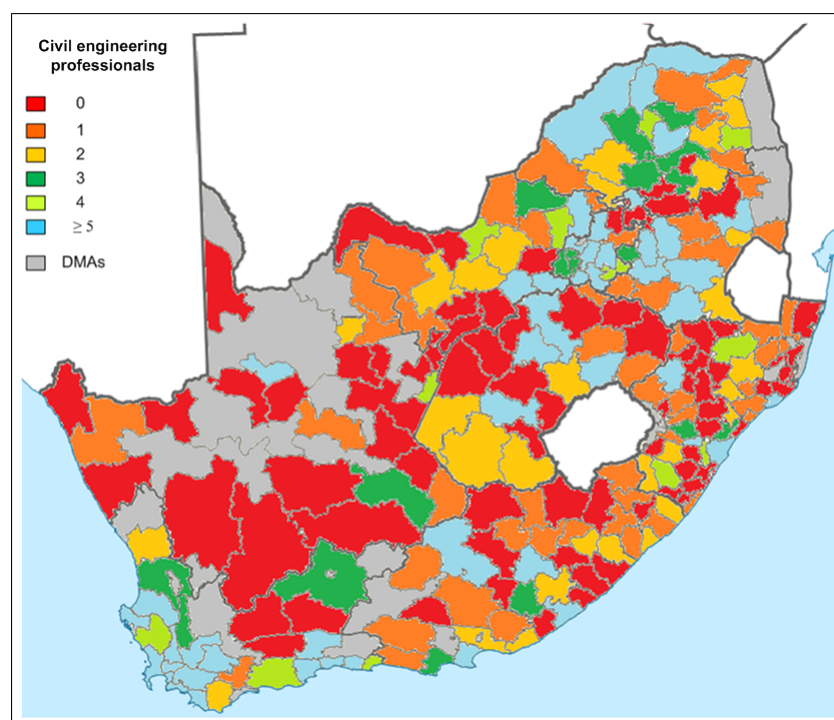


Figure 2.1: Civil engineering professionals employed in local municipalities and the metros, April 2005 [2, p.80]

2.2.2 Suggested number of civil professionals required

An appropriate measure of determining the number of civil engineering staff required has been formulated by Ms. Lawless and is an idea that could be implemented in the future. Ms. Lawless recognized that the number of civil engineers required is directly related to the number of households and not so much the number of inhabitants. The end user in terms of services provided by the engineer is the households. Realizing this, she set out to develop an equation to determine the number of civil engineers needed per household. It might seem that population or number of inhabitants would be an accurate parameter for the determination of engineering staff required, but Ms. Lawless justifies the use of households served by the institution. The number of people living in a household will not directly affect the number of staff required but rather the type of infrastructure required [2, p.163]. It is also more accurate to use households from the fact that the population increased by 10% from 1996 to 2001 while the number of households increased with 24% in the same time period [2, p.163], resulting in a greater demand for services. The significant difference in increase of household to population shows that the number of households would result in a higher number of technical staff required, which correlates with the increase in services required for the households increase. More than 50% of the municipalities in South Africa service at least 25 000 households [2, p.163], as seen in Figure 2.2 and amounts to a significant responsibility for the institution.

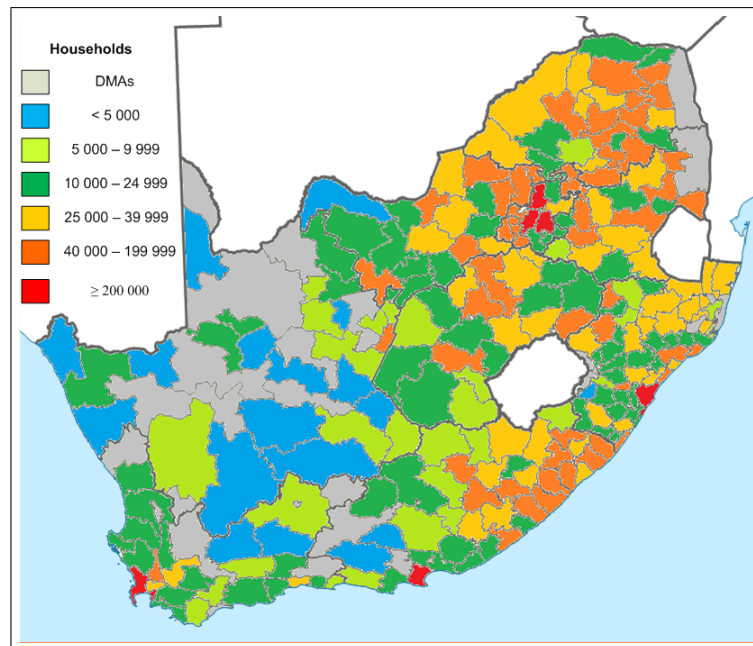


Figure 2.2: Number of households per local municipality and in the metros [2, p.164]

2.2.2.1 Formula for calculating number of civil engineering staff required

The development of the formula was done after careful observation of the performance, or rather the lack thereof in a large sample of South African municipalities and metros. The results from the formula are to serve as a guide only, giving a good indication of the number civil engineering staff (N_H) required by the institution to properly perform the functions assigned to them.

The basic formula as derived by Allyson Lawless is given in Equation 2.2.1 [2, p.164]. The number of civil professionals required based on households is N_H and is calculated as follows:

$$N_H = 1 + \text{ROUND}(N/5 * \sum_{CEF} /9) \quad (2.2.1)$$

Given the following:

ROUND - refers to the rounded value in the brackets to the nearest integer.

N = Number of households

$\sum_{CEF} = a + b + c + d + e + f + g + h + i$ (Representing the sum of the civil engineering functions performed in a municipality)

Score 1 for each of the following functions that is performed and 0 for the functions not performed by the municipality.

a = Planning

b = Road service provision

c = Storm water service provision

d = Sanitation service provision (For municipalities that predominantly supply dry sanitation and limited water-borne networks set $d = 0.5$)

e = Solid waste service provision

f = Traffic engineering and transport planning

g = Water service authority

h = Water service provision

i = Has a PMU (Project management unit)

Ms. Lawless continues to make further suggestions on factors that should be considered when using Equation 2.2.1 to determine the number of civil engineering professionals required to service a given area, which can be further investigated by the reader if necessary. It is once again stressed that the number of civil engineering professionals required as calculated from the formulas above is a guideline only, but should give a good indication of what the benchmark should be.

In the past, fifteen to twenty civil engineering staff serviced every 100 000 inhabitants in South Africa, which is significantly higher than the five to seven suggested by the formula[2, p.171]. It is however a radical improvement on the one or two currently employed to service the same 100 000 members of the population. Using the basic equation (Equation 2.2.1), Ms. Lawless obtained the results as shown in Figure 2.3, where it can be seen that almost 60% of the local municipalities and metros have less than 50% of the civil engineering staff required[2, p.171]. The results shown in Figure 2.3 are without localized adjustments for urbanization, land use, size and the other various factors that each municipality should incorporate in their calculations, implying that even more than 60% of the municipalities employ less than 50% of the civil engineering staff required[2, p.171].

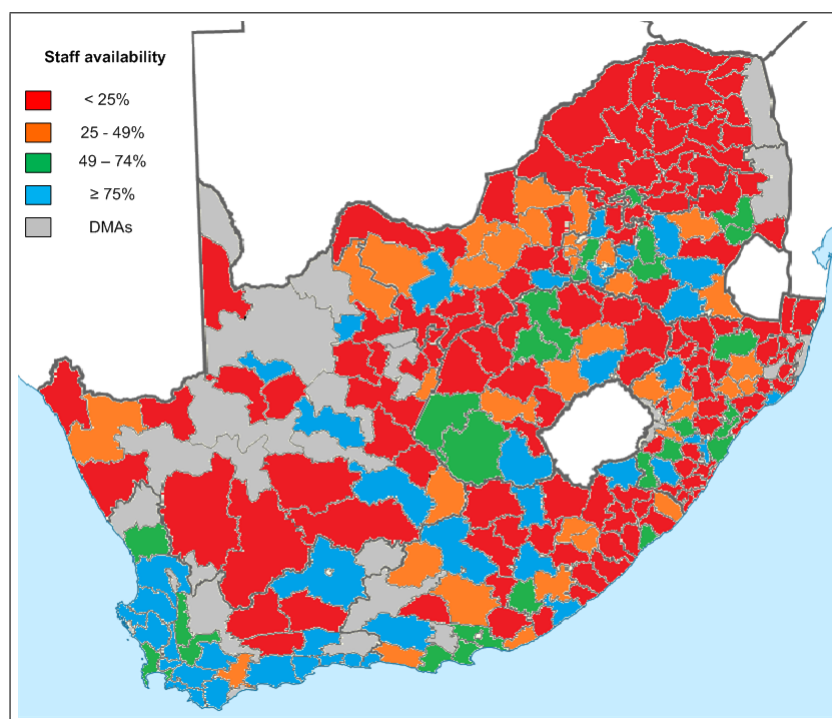


Figure 2.3: Percentages of the calculated values from the basic formula of civil engineering staff employed in 2005 [2, p.172]

2.2.3 The impact of lacking technical skills and capacity

The impact of the loss of skilled technical staff in the South African municipal environment has been drastic and is reflected in the current state of our infrastructure and service delivery capabilities. The 2011 SAICE infrastructure report card awarded a C- to the country's infrastructure. This indicates that the state of infrastructure is acceptable for now, however it is being stressed and weak at periods and it will require serious investment to improve in the near future [19].

The National Planning Commission (NPC) has pointed out in its 2011 diagnostic overview that transformation in the post-apartheid state required that the racial monopoly over skill be challenged and dismantled[20]. The reasoning behind this statement made by the NPC is that they recognized that *"the result has been a reduction in the number of professionals available to the state and a looming crisis in the generational reproduction of professional expertise as the ageing cohorts continue to leave the system"* and that *"this skills deficit has an adverse impact not only on frontline service delivery...but also on the ability of government to engage in long term planning, coordination across institutions, run efficient operations, ensure adequate maintenance of infrastructure, establish organizational systems and routines, and manage personnel and industrial relations"* [20].

Allyson Lawless identified the issue of racial equity appointments over skilled and experienced candidates especially in management positions. She noticed that political appointees have taken over the roles of technical and assistant technical managers, based on the belief that anyone with management qualifications or experience can manage anything. This has led to major problems as civil engineering infrastructure management is a complex process and requires thorough understanding of financial, social and technical issues before decisions can be taken. The result is that these political appointees are failing miserably in making the correct technical decisions[6, p.199]. Table 2.2 shows the principle factors causing failure or problems in the operations of South African municipalities, as found by Allyson Lawless. Lacking skills have especially caused frequent failures of South African water and wastewater treatment plants, an occurrence we as a water scarce country can not afford.

Table 2.2: Principle causes of operational problems in South African municipalities[6, p.206]

Reasons for failing operations	%
Shortage of skilled and experienced operational and technical staff	33
Ageing/unmaintained infrastructure/poor preventative maintenance programs	26
Budget constraints	18
Lack of commitment/understanding by officials	18
Vandalism and end-user abuse of infrastructure	5

To help with the monitoring of the skills employed at water and wastewater treatment works, government has introduced Regulation No. 2834. The regulation classifies treatment works according to size and complexity, and in accordance, prescribes the staff skill levels and numbers to be employed at the relevant plants[21]. It requires continuous mandatory training of process controllers and the certification of supervisors and technical managers at municipalities.

2.3 Non-revenue water in South African municipalities

A municipality is a publicly owned business, which delivers services to the general population and industries in its region. One of the most valuable resources provided by municipalities in South Africa is water. South Africa is among the world's thirty most water scarce countries. As a result of the rapid growth of the South African economy, water use has also drastically increased, and the economic growth and well being of South Africa is in danger if the failure to effectively manage the water resources continues [11]. To make matters worse, investment towards the improvement of water and sanitation provision systems have actually declined according to Douglas Flint [11]. Municipalities need to become financially sustainable to fund routine operations and new developments. One way in which this can be achieved is the minimizing of non-revenue water (NRW), and by the improvement of metering and billing of water connections.

2.3.1 The definition of non-revenue water

Non-revenue water (NRW) is defined by the International Water Association (IWA) as per Figure 2.4. Municipal water systems have an input volume, which is known. This known value is what enters the network and has the potential to generate revenue. In an ideal world "Authorized consumption" would represent all the water provided by the municipality, however the system input volume is classified as either "Authorized consumption" or "Water losses". Water losses are what in essence would be the major contributing factor to NRW, however, there are two areas of NRW under authorized consumption which are also of interest namely;

- Unbilled metered consumption
- Unbilled unmetered consumption

In the case where a municipal organization has a functioning metering system but a lacking financial system, the water lost due to the lack of customer billing would fall in the "Unbilled metered consumption" category. Such a case can be considered as a system failure and is of particular interest to this study. Unbilled metered consumption also includes cases such as when the fire brigade extinguishes a fire using municipal water, since billing in such case is not applicable. In the South African context unbilled metered consumption includes the 6000l/household, forming part of the basic human rights to basic water services.

Apparent losses, as indicated in Figure 2.4, refers to unauthorized consumption and customer meter inaccuracies. Illegal connections and water theft are the main contributors to unauthorized consumption and are a significant issue in the South African context of NRW. Infrastructure News and Service Delivery reported in an article on 03 July 2012 that eThekweni Municipality had 40 000 illegal domestic water connections, representing the majority of unauthorized water use in the municipality [22]. Almost all literature consulted has shown that South African municipalities have aging infrastructure, and this includes water meters. As water meters age, they tend to under measure and this results in major revenue losses for the WSA [23]. Such a case is an apparent loss as indicated in Figure 2.4.

System Input Volume	Authorized consumption	Billed Authorized Consumption	Billed Metered Consumption	Revenue Water	
			Billed Unmetered Consumption		
		Unbilled Authorized Consumption	Unbilled Metered Consumption		Non-Revenue Water
			Unbilled Unmetered Consumption		
	Water Losses	Apparent Losses	Unauthorized Consumption		
			Customer Meter Inaccuracies		
		Real Losses	Leakage on Distribution Network		
			Leakage at Storage Units		
		Leakage on Service Connections to Customer Meter			

Figure 2.4: National NRW assessment based on the standard IWA Water Balance [3, p.128] *Figure not to scale

One of the contributors to NRW in the South African context are real losses. Real losses are caused by infrastructure failures and include;

- Leakage on transition and distribution mains
- Leakage and overflows at storage tanks
- Leakage on service connections up to the point of the customer meter

In 2008 the Water Research Commission (WRC) did a study on 182 randomly selected Johannesburg properties and found that 59% of the properties had on site leaks with average leak flow of 40.7l/h [24]. This implies that almost a third of municipal water consumption is made up of on-site leaks.

2.3.2 The impact of non-revenue water in South Africa

In order for an organization to provide services, one of the key requirements is funding. With the change to democracy in 1994, South Africa has taken the task upon itself to provide basic water and sanitation services to its people. As a result, vast growth has taken place in the number of households served by municipalities. A large portion of the South African population are unemployed and lacking in proper education, and their average monthly incomes do not allow them to pay for basic water services. The provision of free basic services in itself is a step in the right direction for South Africa as a country. However, it has become a heavy burden for the municipalities to carry. Municipalities

must now provide services to clients whom do not render any income towards their organization. Government grants are provided, but are not sustainable. Minimizing revenue lost due to (i) unaccounted for water and (ii) unmetered and unbilled billed water, will help maximize the effectiveness of the available resources to deliver proper service to an even greater number of deserving South Africans.

Table 2.3 is from the International Benchmarking Network for Water and Sanitation Utilities (IB-NET) and it indicates that 37% of South African municipalities' water in 2009 was non-revenue water (NRW). From Table 2.3, the steady rise in NRW percentages in South Africa is evident and is an indication of the deteriorating situation. 37% NRW is relatively average if compared to the world average of 36.2% NRW [25], but is very high if compared to developed countries and leaves room for improvement. An estimate made from a study conducted by DWA, shows that South Africa's NRW has a monetary stock value of R6 billion per annum [25].

Table 2.3: The International Benchmarking Network for water and sanitation utilities country report: South Africa [7]

Indicator	2005	2006	2007	2008	2009
1.1 Water coverage (%)	-	-	78	78	78
2.1 Sewerage coverage (%)	75	73	49	50	53
4.1 Total water consumption (l/person/day)	188	185	207	244	242
4.7 Residential consumption (l/person/day)	146	144	132	191	190
6.1 Non-revenue water (%)	30	28	32	37	37
6.2 Non-revenue water (m ³ /km/day)	21.6	19.5	26.6	34.9	35.3
8.1 % Sold that is metered (%)	100	100	99	100	100
11.1 Operational cost W&WW (US\$/m ³ water sold)	1.22	1.18	1.28	1.27	1.41
12.3 Staff W/1000 W pop served (W/1000 W pop served)	0.4	0.4	0.3	0.1	0.3
18.1 Average revenue W&WW (US\$/m ³ water sold)	1.09	1.06	1.15	1.21	1.26
23.1 Collection period (Days)	197	175	314	368	284
23.2 Collection ratio (%)	74	79	97	98	100
24.1 Operating cost coverage (ratio)	0.89	0.9	0.99	0.95	0.89

It is therefore important that South African municipalities manage the water sources and operate the delivery systems in such a manner that will significantly reduce the amount of NRW, by addressing the factors having the greatest contribution towards the increases in NRW. Experts believe that if South Africa's water resources are not effectively managed, critical water shortages can become reality as early as 2020 [26]. Large reductions in NRW will result in massive savings in the long term, which will be needed as it is reported that South Africa's infrastructure deficit is R58 billion/year and only 44%-50% of these funds are available[27].

2.4 Municipal water services planning

Planning for needs in a municipality is a complex procedure and is done by way of several processes. In particular the water services planning is conducted by way of the Water Safety Plan, Water, Sewage and Storm Water Master Plan, Water Service Development Plan and the Integrated Development Plan.

The Water Safety Plan (WSP) arises from the systematic process called Water Safety Planning. Water Safety Planning is a process that works towards the provision of delivering safe, uninterrupted and sustainable drinking water that meets the numerical limits in SANS 241.

The standard has been separated into two parts namely: SANS 241-1:2011 Ed.1 Drinking water Part 1: Microbiological, physical, aesthetic and chemical determinants and SANS 241-2:2011 Ed.1 Drinking water Part 2: Application of SANS 241-1. Part 1, as the name suggests, deals with the actual requirements of drinking water. There are definitions for each of the determinants and terms used in the standard. This is followed by the microbiological determinants. The standard has taken a risk based approach to expressing the requirements which is in line with the current industry trend of risk based assessments. Part 2 Outlines the interpretation of results obtained, and includes an in depth sampling guideline[28]. The process implements an integrated water quality management plan, which includes a risk assessment approach from catchment to the point of delivery. The WSP is developed using the Water Safety Planning process and is a guiding plan with respect to managing, avoiding, minimizing chances of water contamination in the water supply systems of the Water Service Authority (WSA). The contents of the WSP include management plans describing actions taken during normal operations or incident conditions, documenting the system assessment (including upgrade and improvement), monitoring and communication plans and supporting programs. The WSP also requires the development of the plan, implementation of the plan, review of the performances and amendments or modifications to the plan to ensure that it remains relevant to the current situation[29].

The Water and wastewater Master Plans provide detail information of the current needs of the municipality, long and short term. It especially focuses on assets namely infrastructure needs and has detailed information, such as remaining useful lives. It is an in depth detail plan of the needs versus the available resources of the municipality.

Section 12 of the Water Services Act of 1997 requires that all WSA develop a Water Services Development Plan (WSDP), as part of preparing the Integrated Development Plan(IDP) [30]. Section 13 of the Water Services Act of 1997 describes the content of the WSDP and each WSDP must include details of the following[30];

- (a) the physical attributes of the area to which it applies (from the Master Plan)
- (b) population size and distribution of the area
- (c) time frame of the plan, which includes the five year implementation program
- (d) existing water services (from the Master Plan)

- (e) use of water for industrial purposes in the WSA
- (f) effluent from industrial water use within the WSA (risks in Water Safety Plan)
- (g) the number and location of persons who are currently not provided with water services
- (h) plans for the future provision of water services and water for industrial use, including the operation, maintenance, repair and replacement of existing and future infrastructure (many of the details from Master Plan)
- (i) the number and location of persons to whom water services cannot be provided to in the next five years
- (j) existing and proposed water conservation, recycling and environmental protection measures (possibly in the WSP)

The WSDP is the primary instrument of planning in the water services sector and is a tool to assist the WSA to carry out its mandate effectively. It is also essential for the development of a long term realistic investment plan which prioritizes the provision of basic water service and promotes economic development[4].

Each municipality must, according to Section 25 of the Municipal Systems Act of 2000, adopt a single, inclusive and strategic plan for the development of the municipality called the Integrated Development Plan (IDP) [31]. This integrated development plan must do the following [31];

1. link, integrate and co-ordinate plans and take into account proposals for the development of the municipality
2. align the resources and capacity of the municipality with the implementation of the *plan*
3. form the general framework for the basis of the general annual budget

The Municipal Systems Act also sets forth what the IDP must reflect in Section 26 of the Act and they include among other the following;

- (a) reflect the council's vision for long term development in the municipality
- (b) assess the existing level of development including the identification of communities that require access to basic municipal service
- (c) the council's development priorities
- (d) the council's development strategies
- (e) a spatial development framework
- (f) the council's operational strategies
- (g) disaster management plan

- (h) a financial plan, including a budget projection plan for at least the next three years
- (i) key performance targets and indicators

The persons responsible for the drafting of the IDP are the executive committee or executive mayor of the municipality. Due to this the IDP has become a political document, or in other words an impractical wish list especially in cases where lacking experienced and technical management staff assist the process [2, p.88].

Figure 2.5 shows the interaction among the different planning processes in municipalities. The WSP and the Master Plans are planning processes that feed into the WSDP. The WSDP in turn forms a section within the IDP. By law, municipalities are required to have an IDP, part of which is the WSDP. The WSDP can however not be done without having a (i) WSP and (ii) Master Plans, as the data in (i) and (ii) are needed to construct a WSDP [4; 32]. It can therefore be concluded that all these planning processes are required by law, directly or indirectly, and that all municipalities should have them in place or at least to some extent.

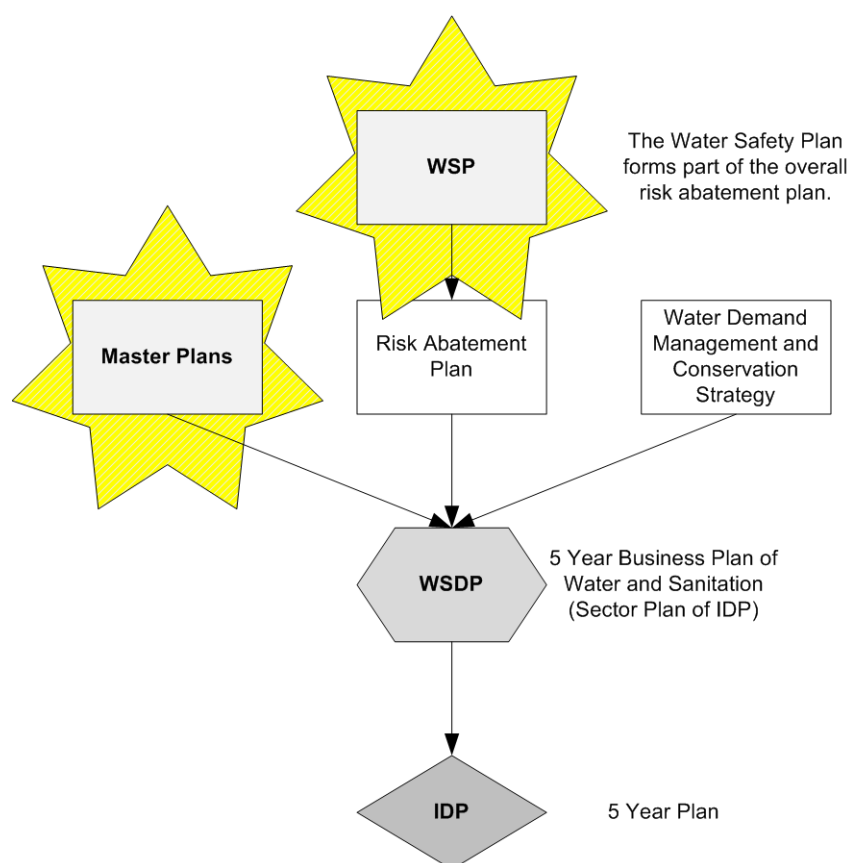


Figure 2.5: Water services planning in municipalities [4]

2.5 Municipal strategic self-assessment (MuSSA)

The Department of Water Affairs (DWA) is aware of the difficult situation in the South African municipal environment with regards to water service delivery. In house surveys conducted in 2009 by

DWA classified 38% of municipalities' water services delivery as being at high risk, with potential to deteriorate[1]. In order to help municipalities assess the overall business health of their water service sectors, DWA has launched the Municipal Strategic Self-Assessment (MuSSA). Municipal self-assessment tools are used for planning purposes due to their ability to indicate the health of the business in real time, by way of an easy and fast questionnaire. Professionals describe self-assessments as reports that provide a comprehensive overview of a municipality in terms of demographics and infrastructure, as well as a review of existing planning studies in relation to the national plan [1]. Since 2005, South Africa has been using MuSSA's to help assist Water Service Authorities (WSA) in understanding, supporting and guiding the status of municipal water quality management and related water services quality [1]. MuSSA has also been conducted in support with the Blue and Green Drop incentive based regulatory assessments, to help promote and develop sustainable water services provision. The fact that a municipality can assess itself, and then gauge its performance against that of peers, makes MuSSA a unique and useful tool.

2.5.1 The MuSSA data used for this research project

The Municipal Strategic Self-Assessment on which the data for this study is based, is a revised MuSSA from the one first launched in 2005. It focuses on the overall business status, but in particular the business health. This helps the MuSSA to easily identify areas of vulnerability that threaten the sustainability of the municipality's water services provision.

The MuSSA asks high level technical management five essence questions about sixteen key business attribute areas namely; (1)Water services planning, (2)Management skill level (Technical), (3)Staff skill level (Technical), (4)Technical staff capacity, (5)Water resource management, (6)Water conservation and demand management, (7)Drinking water safety and Blue Drop status, (8)Wastewater/ environmental safety and Green Drop status, (9)Infrastructure asset management, (10)Operations and maintenance of assets, (11)Financial management, (12)Revenue collection, (13)Information management, (14) Organizational performance, (15)Water service quality and (16)Customer care. Refer to Appendix A.1 for the complete questionnaire with detailed questions. As seen in Appendix A.1, each question has a set of possible answers reflecting the municipality's performance to the relevant question.

MuSSA is first and foremost a municipal management tool supporting water services delivery management. The primary objectives of MuSSA is to provide a common language and educational tool between technical and non-technical officials. It also helps support interdepartmental collaboration in local government turn around strategies. MuSSA's ability to point out key vulnerability areas allows it to serve as a benchmark tool, that helps local government flag and track key vulnerabilities. National planning and regulatory needs are also easily identified and reported on to policy makers together with the overall water service business health. One of MuSSA's strongest contributions towards water service delivery improvement is the ability to prioritize action needs in planning activities by way of the vulnerability indicator[8]. MuSSA currently has two outputs namely a spider diagram and a vulnerability index (VI).

The vulnerability index takes each business attribute and weights the vulnerability thereof in such a manner that both the number and actual score of service area vulnerabilities are factored into the ranking of the municipality. Thus the municipality is assigned a level of vulnerability on each of the sixteen key business attribute areas and then a combined vulnerability index. The VI is an important tool used to prioritize support to Water Service Authorities (WSA) for follow up action on indicated areas of vulnerability or risk. Figure 2.6 shows the vulnerability of the South African municipalities with regards to technical staff skill levels from the 2011 MuSSA data. Compared to the findings of Allyson Lawless on technical staff shortages in Figure 2.3, both the MuSSA data and Ms. Lawless' research show vulnerability on skill and capacity shortages in generally the same regions.

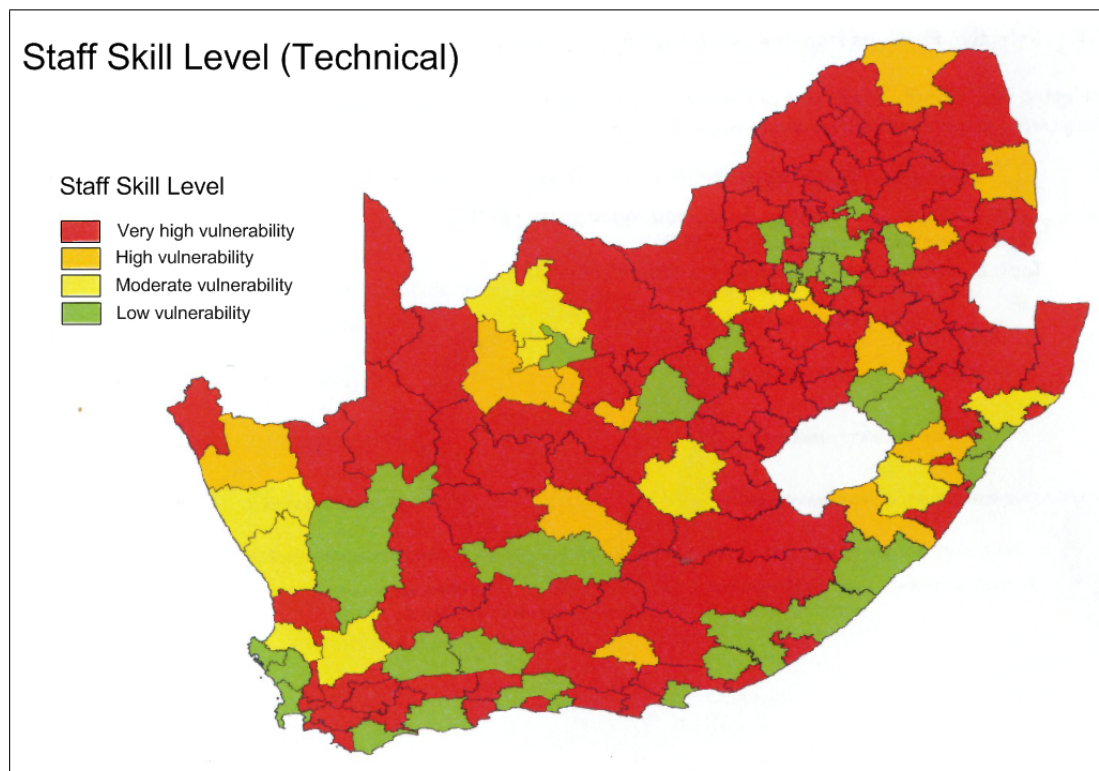


Figure 2.6: Technical staff skill level vulnerability: MuSSA[5]

The spider diagram, as shown in Figure 2.7, provides an easy to understand visual output that clearly indicates the business health of the municipality in the sixteen key business attribute areas, and has significant power to indicate performance in a non-technical and technical business environment.

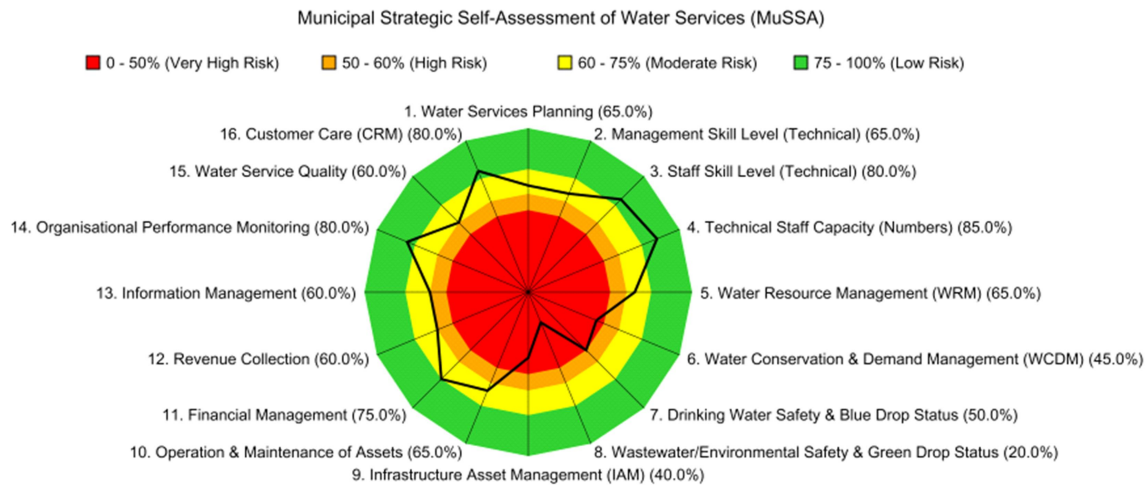


Figure 2.7: Typical MuSSA spider diagram output[1]

Due to the high level of support from the Department of Water Affairs (DWA), South African Local Government Association(SALGA), Institute for Municipal Engineers South Africa(IMESA) and the Water Research Commission(WRC) MuSSA has been exceptionally successful in achieving high participation percentages by municipalities, as shown in Table2.4.

Table 2.4: National participation in the 2011 MuSSA[8]

National MuSSA Survey Participation			
Province	Total WSAs	Actual returns	Actual % returns
Eastern Cape	17	15	95.0%
Free State	20	19	94.1%
Gauteng	13	13	100.0%
KZN	14	14	100.0%
Limpopo	11	11	100.0%
Mpumalanga	18	18	100.0%
Northern Cape	32	31	96.9%
North West	11	10	90.9%
Western Cape	30	27	96.7%
National	166	161	97.0%

As shown in Table 2.4, 161 of the 166 Water Service Authorities participated and completed the MuSSA survey by September 2011[8]. In an environment where it is often hard to come by quality and reliable data, this high percentage of participation is very positive. The questionnaire is mostly completed either by the municipal technical manager and/or water services manager. Feedback to the managers on the performance of their water services have been complimented by statements such as "*MuSSA immediately helps me focus on where my key issues of concern are.*", "*MuSSA correctly confirmed my municipality's greatest areas of technical vulnerability.*" and "*vulnerabilities are immediately evident and can be addressed in a prioritized manner*" [1]. These statements along with many

others have confirmed the effectiveness and contribution made by MuSSA as a self-assessment, management and development tool, helping WSA to identify business development gaps and vulnerabilities.

2.5.2 The future of MuSSA

MuSSA is a continuous process that requires continuous development to keep it relevant to the current status of municipalities. Knowing this, DWA is continuously working on regularly improving the format of the questionnaire and how the questions are to be answered, ensuring that the data and assessment remains accurate. The newer version of MuSSA contains more detailed answer options to enhance the quality of the data obtained from the assessment. Several of the questions have also been revised to ensure that they are interpreted correctly.

Chapter 3

Research methodology

This chapter documents the design, methodology and logical thinking practiced during the course of this research project.

3.1 Scope of study

Municipalities consist of several functioning bodies. Although each of these functioning bodies have a unique set of tasks to execute, they do not operate in isolation and consequently there exists relationships among these functioning bodies. It would be safe to say that for instance the skill level of technical management staff will influence the ability of the municipality to perform infrastructure asset management. In turn other attributes such as financial self sustainability of the municipality will influence its ability to employ staff with the correct skill levels. This investigation will seek to investigate how functions or attributes of selected aspects within these functioning bodies of municipalities influence or are influenced by other functions or attributes. The results from the investigation will possibly confirm expected relationships, but also reveal unexpected relationships among municipal functions and attribute areas. These results will help municipal managers to better understand the interaction among departments and reveal aspects requiring the allocation of resources to improve critical business attribute areas.

As mentioned in the literature review section covering the Municipal Strategic Self- Assessments (MuSSA) launched by the Department of Water Affairs (DWA), MuSSA covers sixteen key business attribute areas regarding the functioning of South African municipalities. Three aspects covered in MuSSA have been chosen to be investigated in detail namely; technical staff skill levels, non-revenue water (NRW) and the execution of planned water service activities. The relevant questions investigating the state of each of the three aspects mentioned have been identified in the MuSSA questionnaire. Correlations are calculated between the answers of these questions to all the answers of the remaining 79 questions, with the aim to identify (a) factors that influence the state of the aspect under consideration and (b) aspects that are influenced by the state of the aspect under consideration.

Take for instance the state of technical management skill levels versus the state of infrastructure asset management. Suppose the possible responses to the state of technical management skill levels are good, average and bad, and the response for infrastructure asset management is complete,

somewhat complete and non-existent. The aim here would be to investigate the correlation of the state of infrastructure asset management with regards to the state of technical management skill level, in other words do technical management skill levels influence the way in which infrastructure asset management is answered, or does a more preferred answer to technical management skill levels lead to a more preferred answer for infrastructure asset management. This research project will investigate the existence of such expected correlations but also explore and possibly discover attribute areas that influence or are influenced by the questions chosen to be investigated in detail.

The general question to be answered during the course of this research project is;

Can the Municipal Strategic Self-Assessments data be used to identify relationships between key business attributes, which may aid municipal water services decision making and improve the current state of (i) technical staff skill levels and capacity, (ii) Non-Revenue Water (NRW) percentages and (iii) execution of planned water services activities.

Each of the three aspects chosen to be investigated is in some way or another of significance to the South African municipal environment. The significance of each will be set forth in this section.

Technical staff skill level and capacity

South Africa faces a unique challenge in terms of staff skill levels and capacity, due mostly to its political history. Section 2.2 of the literature study highlights the shortage of skilled, professional and experienced technical staff in South African municipalities, fueled by the ever presence of appointments of staff based on equity and politics rather than skill and experience.

In order to show the significant impact of technical management staff capacity, question 2.1 of the MuSSA analysis will be investigated to determine which other aspects it strongly correlates with. Question 2.1 investigates the number of technical organogram posts filled within the municipality. Technical management is the highest level of staff capacity or skill covered by the MuSSA data in terms of ranking positions within a business, and the data is for this reason not expected to reveal many factors influencing technical management capacity levels.

Municipalities are struggling to deliver quality and sustainable water services to the country, and as highlighted in Section 2.2, one of the root causes to failure of water and wastewater treatment works is the skill level of technical staff employed. MuSSA includes two questions investigating the skill level of staff employed at water and wastewater treatment works namely question 3.1 and 3.2. Questions with answers strongly correlating with answers to questions 3.1 and 3.2 will be identified to determine factors significantly contributing to, or influenced by the level of staff employed at treatment works.

Capacity building in the South African municipal environment is of great concern. Question 4.2 and 4.3 of the MuSSA ask municipalities if the appropriate number of technical staff are employed at water and wastewater works. Questions with answers strongly correlating with answers to questions 4.2 and 4.3 will be identified to determine factors significantly contributing to, or influenced by the number of staff employed at treatment works.

Non-revenue water

Non-revenue water (NRW) is resulting in major financial losses for the South African water industry, as highlighted in Section 2.3.2. The reduction of NRW in South African municipalities will not

only result in financial gain for the institutions from increased revenue but will also decrease water demands, delaying capital investment needed to continually ensure the sustainable water service delivery to the growing South African population.

The investigation of factors contributing towards NRW will help gain insight as to what must be addressed to reduce NRW within municipalities. The MuSSA question investigating the percentage NRW is question 6.2, asking municipalities what their percentage unaccounted for water (also known as NRW) is. The correlations gained from the analysis with relation to question 6.2 will be investigated to determine the factors influencing the percentage NRW and the factors being influenced by the percentage NRW.

Execution of planned water service activities

Section 2.4 shows the interaction of the different water service planning processes and the overall municipal planning processes. MuSSA investigates four planning processes with relation to water namely (i) Water safety planning (WSP), (ii) Water and wastewater Master Planning, (iii) Water Services Development Planning (WSDP) and (iv) Integrated Development Planning (IDP). (i) to (iii) are required to construct the Integrated Development Plan (IDP), which is required by law. It is the duty of the Minister of Water Affairs to prosecute municipalities not performing proper planning, according to Chapter VIII of the Water Services Act of 1997. Thus, planning is a legal obligation that requires the submitting of planning documents, as requested by the Minister of Water Affairs. This investigation will focus on improving the execution rate of these planned activities, that require extensive man hours to conduct. MuSSA asks, in question 1.4, whether municipalities are implementing and executing the activities planned and set forth in the four planning processes. To identify factors that significantly contribute to successful execution of planned activities, with the aim to help enhance the number of planned activities executed, the correlations revealed from the analysis correlating with question 1.4 will be investigated.

3.2 Calculation of correlations

When performing correlation calculations there are typically two groups of statistical methods to choose from. The most commonly used methods are parametric statistical methods, which are easy to use and can be very precise when used in the correct manner. The second type of statistical methods used are non-parametric statistical methods. Non-parametric methods are more robust than parametric methods in terms of the problems which they can be applied to, and are useful in situations where little or nothing is known about the distributions from which the data was drawn. A more detailed investigation of the models follow in order to determine which one is suitable for the analysis of the MuSSA data.

Parametric statistics is a modern statistical method that makes certain assumptions about the samples drawn from a population. These assumptions regarding the samples are as follows [33, p.2]:

- they are randomly drawn from a normally distributed population
- samples consist of independent observations, excluding the case of paired values

- the values drawn fit an interval or ratio measurement scale
- samples have respective populations with approximately equal variances
- adequately large samples sizes are drawn
- each sample approximately resembles a normal distribution

In the case that the above mentioned are not known with regards to the sample drawn, there are several options to manipulate the samples in order to comply with the assumptions of a parametric sample. Firstly, in the case where there exists extreme outliers, they can be removed if considered irrelevant to the population [33, p.2]. The removal is however very rarely as easy as it sounds and requires a great deal of justification. The second option is to mathematically adjust the sample values, which will force them to comply with the requirements of a parametric test [33, p.2]. Thirdly, there exists complicated methods which require extensive statistical knowledge and also a very comprehensive understanding of the data samples being used and a statistician should be consulted in such a case.

Fortunately, techniques have been developed for the cases where there is little known about the samples drawn from populations and they do not require numerous and extensive assumptions about the population [13, p.3]. Non-parametric or distribution-free techniques have less requirements that must be met by the populations and also by the samples which are drawn from the populations. Non-parametric statistics allows analysis of data to be executed even though very little is known about the distribution of the data. The type of non-parametric statistics which will be used in this study will make use of rank test or order tests. A parametric statistical test makes assumptions about numerical values assigned to observations. The measurement scale that is implemented puts certain constraints on the statistical interpretations and operations that can be executed on the data [13, p.3]. Very little is known about the distribution of the data from the MuSSA analysis and the values drawn do not all fit an interval or ratio scale, therefore non-parametric statistics will be applied to the data. This study will make use of non-parametric tests that will focus on the order, or ranking, of scores and not the numerical value as in the case of most parametric tests. Correlations and relationships among questions will be investigated at a certain level of significance. Significance is indicated by a P-value, being the smallest level of significance that would lead to rejection of the null hypothesis with the given data [34].

Let A and B be two questions with a set of possible answers. The null hypothesis H_0 would be: there is no correlation between the answers of question A and B. The research hypothesis H_A would be: there is a correlation between the answers of question A and B. The calculation of each correlation is associated with a level of risk or level of significance, the smaller the P-value the more significant the relationship. Before performing calculations, a level of significance must be chosen at which the null hypothesis will be rejected. This research project uses a level of 99% significance. In other words, there is a 99% chance that any observed statistical difference will be due to the nature of the data and not due to chance. Thus if, after performing the correlation between question A and B, it

was found that a correlation exists with a level of significance higher than 99% (P-value <0.01), the research hypothesis will be accepted.

3.2.1 Measurement scales

In order to perform statistical tests on the MuSSA data a measurement scale must be applied to the data. Four main measurement scales exist when doing non-parametric tests on data that focuses on the rank, or order of the results obtained. Each measurement scale achieves a level or accuracy of measurement, and the appropriate scale must be selected by the user for the purpose of the analysis of the data at hand.

Nominal or categorical scale

Definition - This scale is chosen when numbers are used solely for the purpose to classify an object, person, or characteristic. The nominal or categorical scale is measurement at its weakest level and uses numerical values to identify groups [13, p.23]. A *dichotomous variable* is a special classification of nominal data that is a measure of two conditions such as yes and no. A continuous dichotomous variable has some type of order to the two conditions, such as true or false and pass or fail [33, p.3].

The ordinal or ranking scale

Definition - This scale is applied to data in the case where the objects in the different categories of the measurement scale differ but also stand in some kind of relation. Typical relations that may exist are: higher, better, more preferred, more mature etc. These relations can be defined by the "greater than" symbol $>$. If the relation $>$ holds between all pairs of classes enabling a complete rank ordering of classes, it may be called an ordinal scale [13, p.25].

The interval scale

Definition - This measurement scale is significantly stronger than the ordinal scale, in the sense that it holds all the characteristics of the ordinal scale but in addition, the distances or differences between any two numbers on the scale have meaning [13, p.28]. A unique characteristic of an interval scale is that a common and constant unit of measurement exists. The ratio of any two intervals is also independent of the measurement ratio and the zero point [13, p.28].

The ratio scale

Definition - When a true zero point exists and all the characteristics of the interval scale are met, the measurement scale can be defined as ratio scale. The unit of measurement in the ratio scale is independent of the ratio between any two points on the scale [13, p.30].

Due to the fact that the data to be analyzed in this study meets the requirements of the ordinal scale and nominal scale, a more in depth literature study will be conducted on these scales in Sections 3.2.1.1 and 3.2.1.2.

3.2.1.1 The nominal scale

The form of the nominal measurement scale of particular interest to this study is when the variables are in the continuous dichotomous format. Several questions in the MuSSA to be analyzed have answers in this form namely true and false or yes and no. They indicate a preference in order, in other words answering true or yes is generally a more preferred response than false or no. Lets take the case where a teacher assigns pass or fail to a student for an assignment. Let P = Pass and F = Fail. P and F now represent an order of performance at the lowest level, and can only distinguish between pass or fail and give no other indication of performance. Using the nominal scale to assign values we would assign P = 1 and F = 0. The values assigned do not matter, as long as they preserve the order of preference in response to the question.

Formal properties

The nominal scale is a scaling operation that partitions a given class into a set of mutually exclusive subclasses. The only relation involved is that of equivalence, meaning the members of any one subclass must be equivalent in property being scaled. Mathematically the equivalence relation is reflexive, symmetrical and transitive¹. Let x_1, x_2, \dots, x_n be a set of objects, in the case of this research project, x_i are all the data points of municipalities' answers to a specific question with a nominal scale of measure. Suppose x_i has some *true* attribute $A(x_i)$, in the context of the research data $A(x_i)$ are all the valid responses to the specific question, then for any pair of attributes in the set the following are valid [13, p.24];

- $A(x_i) = A(x_j)$
if x_i and x_j are in the same classes (all municipalities responding the same to the specific question are categorized into the same class)
- $A(x_i) \neq A(x_j)$
if x_i and x_j are in different classes

The resulting labeling of the systems objects, $L(x)$, by way of a nominal scale, will be done such that;

$$L(x_i) = L(x_j) \text{ - if and only if } A(x_i) = A(x_j)$$

and

$$L(x_i) \neq L(x_j) \text{ - if and only if } A(x_i) \neq A(x_j)$$

Thus the objects are labeled as to preserve the order in preference.

¹ *Reflexive*: $x = x$ for all values of x . *Symmetrical*: if $x = y$, then $y = x$. *Transitive*: if $x = y$ and $y = z$

3.2.1.2 The ordinal scale

Data to be analyzed in this study records the ability or aptitude of organizations to perform certain functions and meet set requirements. The data is in a form that holds strength of ranks, and may appear to be more precise but do not meet the requirements of a higher standard of measure than that of the ordinal scale.

A simple example of an ordinal scale would be the grades assigned to students in a course. Lets take the letter grades as A,B,C,D and F. These letter grades represent an order of performance where $A > B > C > D > F$. Let the following ordinal scale be assigned to the letter grades: $A = 4, B = 3, C = 2, D = 1, F = 0$. The values assigned are arbitrary and any other values can be assigned, permitted they preserve the intended order [13, p.26].

Formal properties of the ordinal scale

Compared to the nominal scale, the only fundamental difference in the ordinal scale is that it incorporates both the "=" and ">" relations. The latter relation is irreflexive, asymmetrical and transitive¹. Let x_1, x_2, \dots, x_n be a set of objects, in the case of this research project, x_i are all the data points of municipalities' answers to a specific question with an ordinal scale of measure. Suppose the *true* attributes, $A(x_i)$ ², of x_i exist in some relation to each other additional to the equivalence relation as shown here [13, p.26];

- $A(x_i) = A(x_j)$
if x_i and x_j are in the same classes
- $A(x_i) \neq A(x_j)$
if x_i and x_j are in different classes
- $A(x_i) > A(x_j)$
if x_i exceeds x_j in the "amount" of the attribute that it has

The resulting labeling of the systems objects, $L(x)$, by way of an ordinal scale will be done such that;

$$L(x_i) = L(x_j) \text{ - if and only if } A(x_i) = A(x_j)$$

and

$$L(x_i) \neq L(x_j) \text{ - if and only if } A(x_i) \neq A(x_j)$$

In addition the ordinal scale also has the greater than function.

$$L(x_i) > L(x_j) \text{ - if and only if } A(x_i) > A(x_j)$$

¹*Irreflexive*: it is not true for any x that $x > x$. *Asymmetrical*: if $x > y$, then $y \not> x$. *Transitive*: if $x > y$ and $y > z$, then $x > z$

²all the possible responses to the particular question

The result being that the objects are ordered in the same manners as which the attributes are ordered.

Admissible operations

Due to the fact that the ordinal scale is monotonic¹ in nature, it does not matter what numerical values are assigned to a pair of classes or to the members of those classes. The only requirement is that higher numbers are assigned to the members of the classes which are "greater" or "more preferred" [13, p.26]. It is obvious that lower numbers for the more preferred classes may also be used, as long as the convention is kept constant throughout the analysis by the user. In other words any monotonic transformation may be executed on an ordinal scale and the properties of the scale will be preserved.

3.2.2 Statistical methods used

Due to the nature of the measurements scales applied to the MuSSA data two types of statistical procedures are needed to analyze the questions of interest, namely the Spearman Rank-Order Test and the Mann-Whitney U-Test. Each will be described in detail in the following sections.

3.2.2.1 Spearman rank-order correlation

When two variables are of the ordinal scale of measurement and the sample size N is greater than four ($N \geq 4$), then the Spearman rank-order correlation statistical procedure can be used [33, p.124]. When no ties² exist, Equation 3.2.1 can be used to calculate the Spearman rank-order correlation coefficient, r_s [33, p.124].

$$r_s = 1 - \frac{6 \sum D_i^2}{n(n^2 - 1)} \quad (3.2.1)$$

Where n is the number of rank pairs and D_i is the difference in the ranks between a ranked pair. When ties are present in the data set, Equation 3.2.1 must be adapted to Equation 3.2.2 to determine r_s . With r_s indicating the strength of the correlation, where the relationship between r_s and the P-value is a direct relationship. The higher the r_s value the lower the P-value, and the more significant the correlation and vice versa.

$$r_s = \frac{(n^3 - n) - 6 \sum D_i^2 - (T_x + T_y)/2}{\sqrt{(n^3 - n)^2 - (T_x + T_y)(n^3 - n) + T_x T_y}} \quad (3.2.2)$$

where

$$T_x = \sum_{i=1}^g (t_i^3 - t) \quad (3.2.3)$$

and

$$T_y = \sum_{i=1}^g (t_i^3 - t) \quad (3.2.4)$$

¹A monotonic transformation is one which preserves the ordering of objects

²Tie meaning a repeating rank in the data set for a particular observation

With g being the number of tied groups in that variable, and t_i the number of tied values in the group. Consequently it can be seen that if there are no ties in a variable, then $T = 0$. To determine whether the correlation is significant or not, tables exist for small sample sizes. It can however also be done by computing a z -score and then using tables with normal distributions to determine the level of significance [33, p.124]. Equation 3.2.5 illustrates this calculation, with n being the number of paired values and r the correlation coefficient.

$$z = r[\sqrt{n-1}] \quad (3.2.5)$$

3.2.2.2 Mann-Whitney U-test

The Mann-Whitney U-test is a statistical procedure for comparing two samples that are independent, or not related [33; 13]. The general strategy of the procedure is to determine if the values from two samples are randomly mixed in the ranking order, or if they are clustered at opposite ends when combined. This test procedure will be used to determine the relationship between ordinal and dichotomous variables [33, p.58]. In other words, the procedure determines if there is a correlation between how two variables were answered during the MuSSA questionnaire. The calculation of the Mann-Whitney U-test statistic is done by way of Equation 3.2.6.

$$U_i = n_1 n_2 + \frac{n_i(n_i + 1)}{2} - \sum R_i \quad (3.2.6)$$

The smaller of the obtained U statistics is the obtained value. Where U_i is the test statistic for the sample of interest, n_i the number of values from the sample of interest, n_1 is the number of values from the first sample, n_2 is the number of values from the second sample and $\sum R_i$ is the sum of the ranks from the sample of interest.

In order to test the U statistic for significance, a z -score is computed and a table with normal distribution is used to obtain a critical region of z -scores.

$$\bar{x}_U = \frac{n_1 n_2}{2} \quad (3.2.7)$$

Where \bar{x}_U is the mean, n_1 is the number of values from the first sample, n_2 is the number of values from the second sample.

$$s_U = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}} \quad (3.2.8)$$

Where s_U is the standard deviation.

$$z = \frac{U_i - \bar{x}_U}{s_U} \quad (3.2.9)$$

The z -score is used to determine a P-value or the level of significance between the answers of the questions.

3.2.2.3 Calculation procedures

When doing the correlation statistics calculations, eight simple steps are followed for both statistical procedures [33].

1. State the null and research hypotheses

Spearman Rank-Order Correlation

The null hypotheses

H_0 : There is no correlation between the answers of the two questions

The research hypotheses

H_A : There is a correlation between the answers of the two questions

Mann-Whitney U-test

The null hypotheses

H_0 : There is no tendency for ranks of one question to be significantly higher (or lower) than the other.

The research hypotheses

H_A : The ranks of one question is systematically higher (or lower) than that of the other.

2. Set the level of risk (or the level of significance) associated with the null hypotheses.

The level of risk chosen for this research project is 0.01. In other words, there is a 99% chance that the observed statistical difference will be real.

3. Choose the appropriate test statistic.

This choice is influenced by the quality of the data or measurement scale. The choices for this study are Spearman's rank-order correlation when comparing to variables with ordinal measurement scales and the Mann-Whitney U-test when comparing one variable with ordinal scale of measurement and one with the nominal scale of measurement.

4. Compute the test statistic.

Using the two methods described.

5. Determine the value needed for the rejection of the null hypotheses, the critical value.

6. Compare the critical value to the obtained value.

7. Reject or accept the null hypotheses.

8. Report the results.

3.3 Analysis of the MuSSA data

This section aims to inform the reader of how the statistical methods were applied to analyze the MuSSA data. Throughout the process of analyzing the MuSSA data Justin Harvey, a statistical consultant from the University of Stellenbosch, was consulted to offer guidance in the application of the statistical methods to the data at hand.

3.3.1 Raw data

The data capturing was led by DWA and facilitated by Emanti Management (Pty) Ltd, a private water management company based in TEGNO Park, Stellenbosch. The data received for the analysis consisted of a sample size of 158 municipalities across South Africa.

Each of the 80 MuSSA questions have a fixed set of possible answers, determined during the development stage of the questionnaire. In total there were thirteen typical answer sets for the MuSSA questions capturing the data in a qualitative format. Table 3.1 shows an example of three of the answer sets.

Table 3.1: Example of possible answers sets to the MuSSA questions

Answer set 1	Answer set 3	Answer set 11
Yes, strongly agree	Yes, strongly agree	Yes, All (i.e. 100%)
In development	No, disagree/Don't know	Most (i.e. >75%)
No, disagree/Don't know		Some (i.e. > 50%)
		< 50%/None/Don't know
		Not applicable

Each of the answer sets contain some kind of hierarchy or ranking. Answer set 11 in Table 3.1 contains the possible answer "Not applicable". Municipalities responding not applicable either (i) answered the questionnaire wrongly or (ii) the question did not apply to their system. In case (i) the data was removed due to it being inaccurate data. In case (ii) the municipalities could not be penalized for their response, and it was considered to assign a rank equal to the most preferred response for that particular question for a not applicable response. However, this also incorrectly skewed the data. Therefore, in the event of a municipality responding "Not applicable" to a particular answer, that data point was removed from the analysis, and they were not used as data points during this research project. The reader will notice that when the data is discussed, a *B* is used to distinguish the "Not applicable" response. This was only done to easily identify the data points within the sample having this response, and delete them from the data set. It is once again stressed that municipalities responding "Not applicable" to any question were removed from the analysis for that particular question. This can be seen in the analysis output where not all the calculations have the same sample sizes.

3.3.2 Converting qualitative data to quantitative data

In order to perform a statistical analysis on the MuSSA data, quantitative values are assigned to the qualitative data. Ranks are assigned to the possible responses of answers to a question. Table 3.2 indicates the assignment of ranks for questions 6.2 and 1.1. As the level of preference to a response increases, so does the score or rank assigned to the response.

Table 3.2: Response scale: Q.6.2 & Q.1.1

Q. (6.2)		Q (1.1)	
Score	Response	Score	Response
5	Less than 20%	3	Yes, strongly agree
4	Less than 30%	2	In development
3	Less than 40%	1	No, disagree/Don't know
2	Don't know		

This method of assigning ranks to possible responses was done for each of the 13 possible answer sets of the 80 MuSSA questions.

3.3.3 Performing the statistical procedures

The computer software Statistica was used to statistically analyze the relationship of each of the relevant questions with all the other questions. The data was prepared using Excel and then exported to Statistica.

3.3.4 Interpreting the results

The results from the statistical procedures only indicate the existence of a relationship between the two variables and the level of significance of the relationship. The purpose of this research project is to identify factors that influence several selected variables, and also to determine the factors that these selected variables influence, or in other words, to identify the cause and effect relationship between two variables. The knowledge of experts in the field of municipal engineering together with logical thinking is required to interpret the data yielded from the statistical analysis of the MuSSA data. Knowing this a panel of experts in the field of municipal engineering have been consulted to interpret the results from the statistical analysis. A short description of each expert's relevant education and experiences follows.

Panel of water experts consulted:

Grant Mackintosh, Managing Director

Emanti Management (Pty) Ltd.

Grant's more than twenty year career in the water industry has been characterized by the development and implementation of innovative and cost effective processes, methodologies and services in the water services sector. Special areas of contribution include the drinking water treatment field (where he is the co-inventor of two international patents); the drinking-water quality management arena (where he oversaw the national roll-out of a municipal water quality management system, for which Emanti won South African and international awards); and management methods for assessing and guiding sustainable municipal water services performance improvement. Grant is a Fellow of WISA and in addition to Engineering Degrees from UCT, has an MBA (Cum Laude). His present career focus is the roll-out of appropriate IT supported local government Water Services Management tools, to meet both the private and public sector market needs for improved service delivery

and governance in the water and wastewater sector.

Allestair Wensley, Chief Engineer: Water Services Planning & Information

Department of Water Affairs, South Africa

Allestair's current core responsibilities include the provision of strategic interpretation of water service information; the provision of specialist advice on specific water service related issues; managing the development of the water service information system and the deployment of appropriate water service IT solutions. Some of his current achievements include the successful national deployment of an electronic municipal water quality management system within all water service authorities in 2006. He is also a sought after speaker at national and international conferences on the topic municipal water planning and development. Allestair holds a degree in Civil Engineering from the University of the Witwatersrand and a Post Graduate Diploma in Strategic Marketing from the University of South Africa. He is a registered Professional Engineer in South Africa and a Chartered Civil Engineer with the Institution of Civil Engineers in the UK.

Philip de Souza, Director

Emanti Management (Pty) Ltd

Philip's career in the water industry has included the development and implementation of an electronic drinking water quality management system which has entailed the development of a number of water sector tools, one of them being the WRC water safety planning tools. In addition, Philip has significant experience with water treatment process engineering (desktop studies and fieldwork), especially stabilization and aggression mitigation, municipal water quality management, water safety planning, wastewater risk abatement planning, liquid waste management, wastewater recovery and reuse, specialist studies for environmental impact assessments, the implementation of ISO14001 environmental management systems, data analysis and associated business intelligence, training of municipal officials and municipal benchmarking. Philip has a BSc in Chemical Engineering from UCT and Honors in Water Utilization Engineering from Pretoria University.

Shawn Moorgas, Director

Emanti Management (Pty) Ltd

Shawn has extensive technical municipal skills, having operated as a chief engineer within local government for eleven years. Shawn's municipal background has equipped him with the necessary knowledge and experience for effective management of water, wastewater and solid waste operations. His unique understanding of the municipal environment has enabled him to provide technical support and appropriate turnaround interventions to municipalities in their efforts to achieve effective and sustainable water services management. Shawn obtained his National Higher Diploma from Peninsula Technikon in 1993 with distinction.

Unathi Jack, Chemical Engineering Technologist

Emanti Management (Pty) Ltd

Unathi is a specialist wastewater and drinking water treatment process engineer with more than five years of experience in non-metro water quality management. She is an assessor for Blue and Green Drop Certification of water services authorities on behalf of DWA and has extensive knowledge and practical experience in wastewater and drinking water treatment process engineering. Unathi ob-

tained her M Tech in Chemical Engineering from Peninsula Technikon.

The expertise of these individuals in particular were used extensively to interpret the result from the analysis, along with expert input from several other individuals from the municipal environment.

3.3.5 Possible data and analysis shortcomings

When applying statistics to data, the user should be careful when interpreting the data yielded from the analysis. Interpretation of the results is more often that not, not as straight forward as it seems and experts in the field of statistics and the relevant data should be consulted, as done in the case of this study. One of the factors that was determined as possibly being an issue in this study is that the yielded data could have correlations by pure chance due to the nature of the data sampel[13]. This is not eliminated by the significance level because the analysis can not apply logic to the data. The significance level only indicates the level of significance of the relationship between the data used in the analysis. It is up to the user to identify correlations occurring purely by chance and as a results of the nature of the data and then interpret the results correctly.

There also exists the possibility of partial correlations within the data. Let X, Y and Z be three variables which each of N subjects are rated on, with X and Y strongly correlating. There exists a possibility that Z can influence the correlation between X and Y as shown in Figure 3.1. This is called a partial correlation [35].

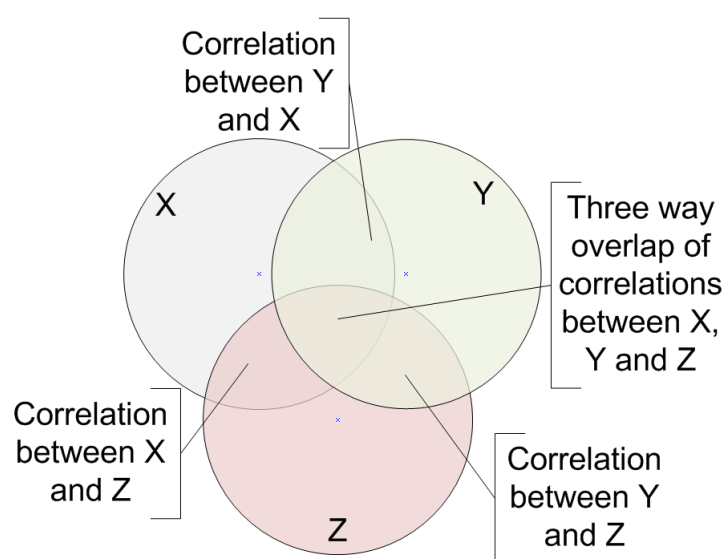


Figure 3.1: Partial correlation between three variables

This partial correlation can (i) not exist, (ii) enhance the correlation between X and Y or (iii) suppress the correlation between X and Y. To obtain the true correlation between X and Y, the effect of Z must be removed. The rationale for analyzing the effect of the third variable should only be based on *a priori* notions. Considerable risks are involved in a strategy of simply calculating all possible partial correlations and testing their significance because (a) the sample size at hand is not sufficient

[36] and (b) as the number of variables increase the possibility of obtaining spurious differences increases with increasing tests conducted [13, p.261]. Both (a) and (b) will impact partial correlation calculation on the MuSSA data. (a) and (b) will impact the analysis because MuSSA has 80 variables, which implies that partial correlation between all 80 variables would have to be calculated. It is recommended to have at least twenty samples per correlation calculation [36]. The MuSSA data at hand only has 110 samples or less. During the course of the interpretation of the results, this fact has been considered and its possible influence on the outcome of the results is noted and understood.

Due to the fact that MuSSA is a self assessment, the possibility of some sort of bias always exist. Holden (2009) reports in his publication that internet based self-reporting may lessen the effects of the response biases due to the anonymous factor [37]. This anonymous factor has been eliminated by MuSSA by targeting specific persons within the municipality to complete the assessment. MuSSA is also completed each year and thus minimizes the factor of bias caused by time elapsed before the questionnaire takes place. To help guide the process of developing MuSSA and continually update it, Emanti has developed a set of self-assessment survey guidelines, as seen in Appendix A.2. The guidelines focusses in detail how questions are asked to avoid bias and minimize inaccurate results.

One of the major concerns, is the accuracy of the MuSSA answers to the questions. To test the accuracy of the data, the Blue and Green Drop scores published by DWA and those reported by MuSSA were compared. The true scores do not have the response "Don't know". The scale for the comparison of the MuSSA Blue and Green drop scores are as shown in Table 3.3. Figure 3.2a and 3.2b are histogram plots of the MuSSA Blue and Green drop versus the true Blue and Green drop as reported by DWA. The MuSSA data tends to slightly overestimate at the higher end of Blue and Green drop performance, but to a relatively low percentage. The outliers seen at the lowest score for the true Blue and Green Drop is due to the fact that, in most of the municipalities with such low scores, they most probably responded "Don't know" to the MuSSA question. When the "Don't know" column from the MuSSA results are added to the lowest possible response (<33%), it adds up to approximately the same number as municipalities that actually scored less than 33% as reported by DWA. So it can be concluded from this that in general, the MuSSA values tend to slightly overestimate the true values at the high end of performance and underestimate at the low end of performance, but gives a good representation of the real situation.

Table 3.3: Response scale: MuSSA Blue and Green drop vs DWA reported Blue and Green drop scores

MuSSA Blue and Green drop		True Blue and Green drop	
Score	Response	Score	Response
6	>90% (Excellent)	6	>90% (Excellent)
5	75% - 90% (Very Good)	5	75% - 90% (Very Good)
4	50% - 75% (Good)	4	50% - 75% (Good)
3	33% - 50% (Needs Attention)	3	33% - 50% (Needs Attention)
2	<33% (Needs Urgent Attention)	2	<33% (Needs Urgent Attention)
1	Don't know		

The possible presence of partial correlation are also noted. The input of expert opinions will be

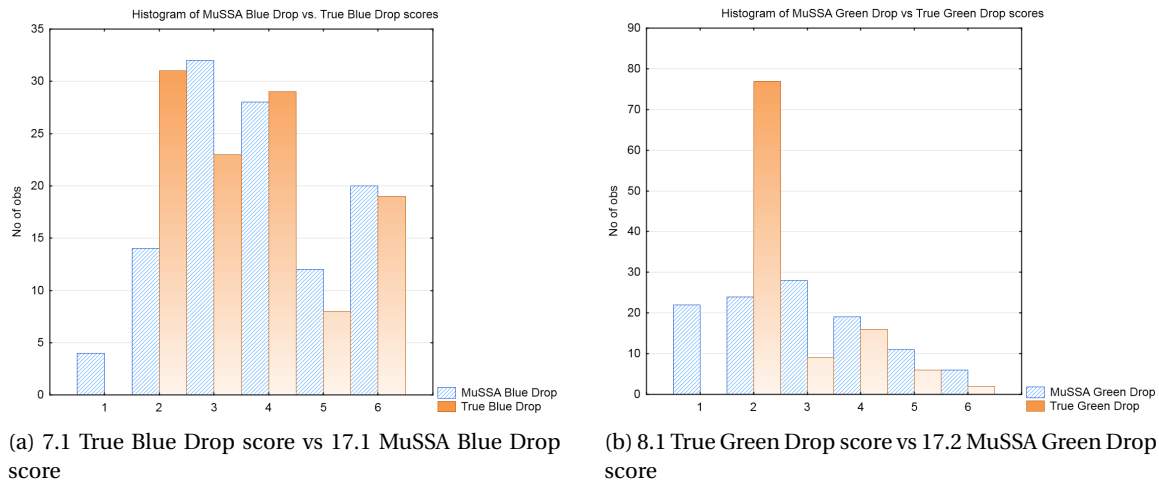


Figure 3.2: Comparison of True Blue and Green Drop scores to MuSSA declared Blue and Green Drop

used to eliminate any enhanced correlations due to partial correlations. This will be achieved by reviewing the results from the analysis with experts and classifying the factors. Correlations possibly hidden due to this effect will not be investigated in this research project. In such a case, the significance level will be artificially low, so we would not have picked up the correlation. Thus, it would not have been considered in this study. However, when reviewing the results with the panel of experts, they were asked to mention any expected correlations which did not result from the analysis. In spite of these shortcomings, it is believed that the correlations obtained from this study will give insight into the South African municipal environment.

3.3.6 Reporting the results

The correlations obtained from the analysis with a level of significance of 99% or higher were investigated. Each of the correlations are classified into one of three categories (i) factors contributing to the relevant question, (ii) factors influenced by the relevant question and (iii) uncertain. The questions in (iii) are the questions of which the correlations to the relevant questions are judged to be due to pure chance, resulting from the nature of the data or enhancement by partial correlations, as previously described. The results are then converted to a flow diagram, for example as seen in Figure 4.1.

Further discussion of each individual correlation then takes place by way of discussing the bivariate histogram, plotting the observation of the questions under consideration. The significance of the relationship between the two questions is discussed as to how it is unique to the South African municipal environment.

Chapter 4

Staff skill levels and numbers in the South African municipal environment: MuSSA output

Municipalities in SA have to overcome one of the greatest challenges regarding operational capability, namely shortages of skilled technical staff. The lack of skilled personnel in the public sector is a common occurrence in developing countries where the private sectors are more attractive to professionals. The MuSSA questionnaire covers three attribute areas regarding technical staff skill levels and numbers (i) Technical management skill levels, (ii) Technical staff skill levels and (iii) Technical staff capacity. The three attribute areas stated in (i) to (iii) will specifically be investigated in Sections 4.1 to 4.3 respectively.

Essentially management skill levels affect the performance of staff employed under their supervision in terms of productivity, effectiveness, skill level employed etc., as is the case in many top down business structures. The attribute areas correlating with that of the technical management staff from the MuSSA statistical analysis are investigated in this chapter to determine the areas effected by management staff skill level and conversely the areas effecting management skill level, in the South African municipal environment.

The MuSSA also assessed two sectors in the municipal environment with regards to the technical staff skill levels and numbers in each of the two sectors, wastewater treatment works (WWTW) and water treatment works (WTW). The development of skills and capacity building in WTW and WWTW are investigated by way of the statistical analysis of MuSSA. Firstly, for skills development and capacity building in WTW and WWTW combined and then in the sector specific areas. As WWTW and WTW face unique challenges specific to each sector, it is important to distinguish the attribute areas that are specific to each sector. The interpretation of the results from the analysis was done as described in Section 3.3, leading to the layout of the flowcharts. In the following sections, each question's answers correlating with the relevant question's answers are presented in a 3D histogram. The histogram is a summary of the number of observations for each combination of answers from the sample of municipalities. Each histogram is accompanied by a table indicating the possible re-

sponses to each of the questions involved and the statistical data of the correlation.

4.1 Management capacity level: Filling of key posts in technical organograms

Technical decision makers in the South African municipal environment have in the recent past been replaced by non-technical decision makers, or have been offered early retirement. As a result there exists extensive vacancies in the technical management area within South African municipalities [6, p.62], as discussed in Chapter 2.2.1. The contribution of skilled and experienced technical management staff in the municipal environment is very significant in terms of their decision making and planning capabilities. In many cases municipalities are unable to fill vacant posts in their organograms due to the shortages of technical managers and decision makers attracted to the South African municipal environment. This section will highlight the importance of technical management staff capacity by discussing the areas influencing technical management capacity and the areas being influenced by technical management capacity. To determine whether key posts within municipal technical management organizational organograms have been filled, the 2011 MuSSA asked the following question;

Q. 2.1 Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Service Manager, Superintendent of Water Works)?

It is suggested that not less than five civil engineers should be employed per 100 000 members of the population [2, p.171]. In the event where a municipality has filled key posts within its technical management organogram, the chances of the minimum suggested requirement of five civil engineers per 100 000 drastically increases as will be seen in Section 4.1.2.

To help the reader visualize the output from the statistical analysis, a flow chart indicating the significant correlations has been constructed. The flow chart has been laid out with the help of experts as described in Sections 3.3.4 and 3.3.6. The factors deemed to contribute towards the filling of technical management organogram posts are separated from those being influenced by the number of technical management organogram posts filled. The result is as shown in Figure 4.1. As the focus of this research project is to improve decision making and resource allocation with regards to the chosen attribute areas, the factors influenced by technical management capacity will only be briefly discussed, highlighting its importance and holistic influence on the South African municipal environment.

Question 2.1 is targeting high level technical management, thus there are very few factors influencing technical management posts filled in terms of the MuSSA as shown in Figure 4.1. The areas deemed to respectively influence Q. 2.1 and to be affected by Q. 2.1 are investigated in the following sections, with a greater focus on the areas influencing Q. 2.1.

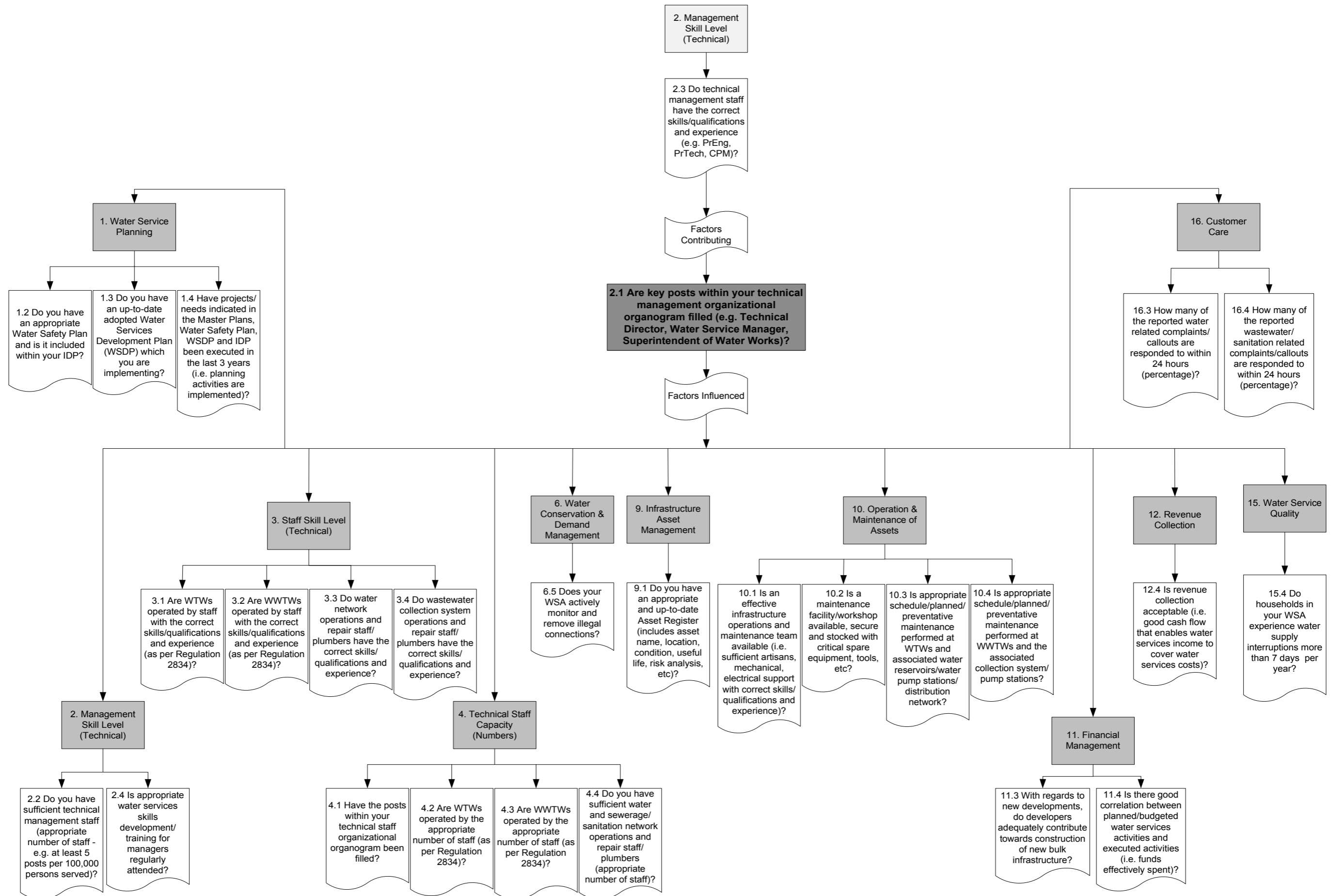


Figure 4.1: Key post within technical management organizational organogram: MuSSA Output

4.1.1 Areas influencing the filling of key posts in technical management organograms

Only one of the sixteen MuSSA business attribute areas that strongly correlated with the percentage of technical management organogram posts filled is considered to be an influencing factor. This attribute area is the management skill level as assessed by question 2.3 in the MuSSA questionnaire, as shown in Figure 4.1.

Question 2.1 Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)?

vs.

Question 2.3 Do technical management staff have the correct skills/qualifications and experience (e.g. PrEng, PrTech, CPM)?

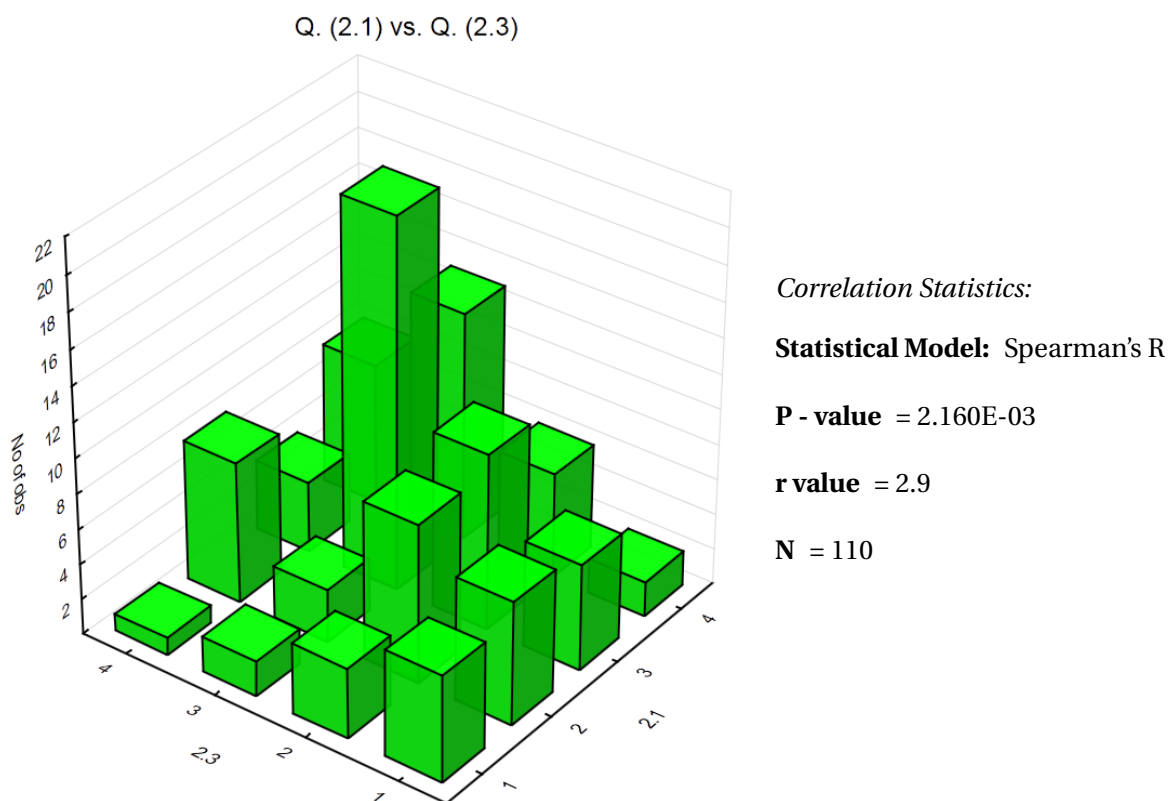


Figure 4.2: Bivariate histogram of Q.(2.1) vs. Q. (2.3)

Table 4.1: Response scale: Q.2.1 & Q.2.3

Q. (2.1)		Q. (2.3)	
Score	Response	Score	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

Discussion of Figure 4.2:

Figure 4.2 shows that of the municipalities where technical management staff did not have the correct skills, scoring 1 for question 2.3, only 9.5% were able to fill all the positions on their technical management organograms. The percentage municipalities having all their technical management posts filled increased from 20.7% to 33% to 38.1% as the percentage of technical management staff with proper skills increased from "Some(>50%)" to "Most(>75%)" to "All(100%)" respectively.

Significance of relationship:

The skill and culture of the existing technical management staff at a municipality seems to have a strong affect on the appointment of additional staff to fill vacant posts. When staff with proper skills are present, they tend to have the capacity to appoint additional technical management staff to fill vacant posts within the technical management organizational organogram, which leads to capacity building in the municipality.

4.1.2 Areas affected by key posts in technical management organograms being filled

The presence of proper technical management capacity has a significant impact on a municipalities' ability to operate. Allyson Lawless found that where no civil engineers are present, non-technical staff are not confident to make decisions and consequently little is spent on operations and maintenance (O&M). In the case where only one civil engineer is employed by a municipality, there is no capacity to deal with the growing number of problems [2, p.79]. This together with the literature covered in Chapter 2 highlights the importance of technical management capacity, and it is expected that technical management capacity will strongly influence a majority of the attribute areas covered in MuSSA. The statistical analysis of the MuSSA data revealed that eleven business attribute areas strongly correlate with the filling of technical management organogram posts, by way of at least one of the five questions investigating the attribute area. These business attribute areas which were classified as areas effected by technical management capacity are as shown in Figure 4.1. Each of the questions falling under the influenced attribute areas will briefly be discussed in this section, as it is not the purpose of this study to highlight the areas effected by technical management capacity but rather on the areas influencing technical management capacity. The histograms and statistical information for these questions are given in Appendix B.

1. Water service planning**a) Water safety planning, Figure B.1**

The WSP process is steered by a group of people that includes the technical, financial and management staff of the municipality" [38]. Without technical management staff capacity a municipality will be severely hampered in its quest to develop a proper WSP, which is essentially a planning process to manage all the risks faced by the municipality in terms of water safety. Figure B.1 shows that, of the municipality in the sample with "<50%/None" of the posts in the technical management organogram filled, not a single one has a fully developed Water Safety Plan (WSP). Of municipalities with all the techni-

cal organogram posts filled, 55.2% have a WSP in development, while 41.4% have a fully developed and implemented WSP. This is a vast improvement in the development of a WSP from municipalities lacking technical management capacity. It is therefore important that all the vacant posts in a municipality's technical management organogram are filled by competent staff.

b) Water service development planning, Figure B.2

A Water Service Development Plan (WSDP) is a complex plan that makes provisions for the short and long term needs of the municipality to meet the set goals with regards to planning for all the resources required. Typical areas covered in a WSDP are water resources, water infrastructure, environmental issues, customer care and involvement, water service management, institutional arrangements, and financial management. See Section 2.4 for more details on the WSDP. All the areas mentioned here require technical management expertise to be properly managed and planned for in terms of future and current needs. From the analysis of Figure B.2, the importance of technical management capacity to the WSDP process can clearly be seen. As the percentage of posts filled in the technical management organograms increased from >50%, >75% to fully filled, the percentage of municipalities with a fully developed and implemented WSDP went from 48%, 56% to 80% respectively, as shown in Figure B.2. This indicates a general increase in fully developed WSDP with an increase in technical management capacity. It is positive to note that 56% of municipalities have a fully developed and implemented WSDP, and a further 39% have a WSDP in development.

c) Execution of planned water services activities, Figure B.3

When technical management staff in a municipality are lacking, then there exists a severe lack of decision making capabilities and project needs are not executed [6; 2]. Technical management plays a very significant role in the execution of project needs within a municipality, and officials must realize the importance of having educated and experienced technical management staff to the sustainability of the organization. Figure B.3 shows that municipalities with all the organogram posts filled have a much higher success rate in achieving the project needs. Municipalities must strive to have all the technical management organogram posts filled. This greatly enhances the capability to execute more than 75% of the planned water service needs. Having all the posts in your organogram filled does not mean that sufficient technical management staff is employed, but it is a good start to building sufficient technical management capacity.

2. Management skill level technical

a) Sufficient technical management staff (e.g. 5 per 100 000 persons served)

It is obvious that if all the posts in the technical management organogram have been filled, that the response to question 2.2 will also be more favorable. This correlation is an indication of good practice. It must be noted that just because all the posts in a technical

management organogram have been filled it is not necessarily true that sufficient technical management staff will be employed by the municipality, as there most likely is a need for more posts in the organogram. The suggestion of 5 professionals per 100 000 persons served falls in line with suggested numbers of staff needed by Allyson Lawless. The MuSSA data revealed that 60 of the 110 municipalities in the sample have "Some(>50%)" sufficient technical management staff as stated in question 2.2., which means they have in the order of two and a half to three technical management staff per 100 000 persons served. Allyson Lawless found that on average two to three civil engineering professionals were being employed per 100 000 persons served.

b) Water service development training of managers

In order to send managers on training, they must first be employed at the municipality, thus this correlation is expected. It is also logical that only municipalities with proper technical management capacity will be able to function with several staff members away on training. It is worrying that the data indicates that only 38.2% of municipalities are performing water service development training on managers.

3. Staff skill level technical

a) Water and wastewater operational staff, Figure B.4

Having sufficient technical management staff allows for managers to focus on non-technical areas, such as staff requirements. This effect can be seen in Figure B.4 where municipalities with only "<50%/None" and "Some(>50%)" of the technical management posts filled are not able to ensure that staff with proper skills and qualifications operate WTW and WWTW. Somewhat of a turnaround point is reached when municipalities start to fill >75% of the technical management posts. This seems to allow managers some time to focus on staff requirements. It can be seen from Figure B.4, that even though a municipality has all its technical management posts filled, there is still a possibility that its WTW and WWTW will not be operated by 100% of staff with the correct skills and qualifications. This is due to the fact that WTW and WWTW skilled staff is a scarce skill on a global scale and not just in South Africa [39]. The ability of an organization to appoint properly skilled staff to operate the WTW and WWTW is heavily influenced by the technical management capacity. Municipalities lacking proper technical management staff do not have the capacity to make educated technical decisions, including the recruitment and appointment of technical staff to operate treatment works. When technical staff are lacking, it has been found that council takes over the role of technical decision makers, such as that of the Municipal Manager (MM), which includes staff appointments. This results in delays and inappropriate decisions [2, p.101].

b) Water and wastewater network repair staff, Figure B.5

Technical management staff are the driving force behind the operations and maintenance of water and wastewater networks. If they are educated and skilled they will be

more likely to strive to improve the skills and qualifications of the operational staff, allowing that they have the capacity to do so. Figure B.5 shows that the increase in skilled operations staff is strongly related to the percentage technical management posts filled. The lack of this trend at the 100% technical management posts filled is mainly due to the fact that water and wastewater network operations staff are scarce skills in South Africa and globally, and municipalities are understaffed and can not afford to spend time training additional staff.

4. Technical staff capacity

a) The filling of technical organogram posts, Figure B.6

There exists a very strong correlation between the number of technical management staff and the technical staff posts filled in a municipality. This was one of the strongest or most significant relationships from the analysis. The percentage of municipalities with "Most(>75%)" of the technical management organogram posts filled and that have "Most(>75%)" of the technical organogram posts filled is 68.3%. In the case where all the technical management posts are filled, it can be seen that the majority of municipalities were not able to fill all the technical posts (only 35%), 45% of these filled "Most(>75%)" of the technical organogram posts. Management posts do seem to be filled before technical posts are filled from the fact that the graph is heavier above the diagonal on the management side. The lack of technical staff despite the presence of management may be due to the lack of technical staff in South Africa. Municipalities with technical management staff capacity have the ability to spend time on the appointment of vacant technical posts, but they also understand the importance of filling these posts with regards to the proper operation of the municipality. This understanding results in them making effort to have these posts filled, allowing they have the capacity and time to do so.

b) Water and wastewater operational staff number, Figure B.7

Technical management capacity strongly influences the technical staff capacity of both WTW and WWTW in South African municipalities. The percentage of the municipalities with "<50%/None" of the technical management staff posts filled and that have "<50%/None" of the water and wastewater treatment works operated by the correct number of staff as per Regulation 2834, is 60% or more. This percentage is an indication of the strong relation between management and technical staff numbers. Lacking management capacity creates work overloads on those individuals who are present and in some cases nobody is present. Technical management needs to become the organizational champions and take responsibility for the growth of the municipalities. They can however only devote effort towards this cause if they have available time to focus on non-technical matters such as staff capacity building. Municipal managers and other non-technical decision makers mostly do not understand the importance of technical staff capacity and would rather spend money on issues that will attract votes. Municipalities need at least

75% of the technical management organogram posts filled to start functioning properly with regards to the appointment of WTW and WWTW operational staff.

c) Water and sanitation network operations and repair staff, Figure B.8

Management plays a key role in the O&M of water and sewerage networks, especially in terms of planning and decision making. Decisions which include the appointment of staff and planning future needs in terms of human resources by way of the WSP, WSDP, Master Plans and the IDP. It is shown in Figure B.8 that increasing technical management numbers positively influence water and sewerage operations and maintenance staff numbers. It is seen here that in order to ensure enough technical management capacity for the management of network O&M staff, a municipality ideally needs to have all its technical management organogram posts filled.

5. Water conservation & demand management, Figure B.9

Illegal connections pose a major threat to South African municipalities in terms on revenue collection and future water demands, and is in dire need of attention. The first step towards enabling a municipality to properly perform its duties with long term goals in mind should be capacity and skills development of the staff employed. Having technical management staff allows a municipality to address technical issues at ground level before they become business issues, such as the removal of illegal connections. Sufficient technical management capacity is however needed to allow them to commit time to the relevant issue. The data indicates that the municipalities with more than 75% of the technical management organogram posts filled show significant improvement towards the removal and monitoring of illegal connections.

6. Infrastructure asset management, Figure B.10

Asset management requires an organizational champion, especially in the South African environment [40]. Components of the asset register require technical input and cannot be done by non-technical staff. Of the municipalities responding "<50%/None" to the percentage technical management posts filled, 53.8% did not have an asset register. A drastic increase occurs in the development of asset registers for the municipalities that have "Most(>75%)" and 100% of the technical management posts filled, with 63.4% and 72.4% of them respectively with a fully developed Asset Registers. 33 Municipalities of the sample do not have Asset Registers. Technical managers are key in the process of developing an asset register that is complete and accurate. The low percentage (10%) of municipalities that responded that asset registers are in development shows that the keeping of an asset register is either completely being done or not being done at all in most cases. Many municipalities have large numbers of assets, and in the municipalities where technical management staff are lacking, they simply do not have the capacity to develop and keep the asset register up to date.

7. Operation & maintenance of assets

a) Infrastructure operations and maintenance team, Figure B.11

Infrastructure asset management (IAM) is key to the long term service delivery success

of municipalities, but is being neglected in many cases in South African. A direct link has been drawn between failing infrastructure and increased health risks within municipalities [2]. The severity of the situation is reflected in the data showing that; of the municipalities with "<50%/None" and "Some(>50%)" of the technical management organogram posts filled, 84.6% and 62.9% respectively do not have an infrastructure operations and maintenance team available. A majority shift occurs, in terms of municipalities with infrastructure asset management teams available and technical management posts filled, when municipalities fill more than 75% of the posts in the technical management organogram. The percentages of the municipalities with "Most(>75%)" and 100% of the management posts filled and with effective infrastructure O&M teams available are 61% and 82.7% respectively. Technical management capacity allows municipalities to plan ahead and to perform IAM. Technical managers are in charge of the technical planning process, which includes predicting future skilled staff demands and requesting HR to hire staff when required. Technical management must become the organizational champions to ensure success, but this can only occur if technical management capacity exists.

b) Management of the maintenance workshop

The ordering and stocking of maintenance equipment and tools are not necessarily in the job description of a technical manager, but they are ultimately responsible for it. A municipality with sufficient technical management capacity will have the ability to devote attention to smaller details such as the stocking and maintenance of an asset maintenance workshop. Therefore, this correlation is expected and is an indication of good practice within the organization.

c) Preventative maintenance on water and wastewater distribution networks, Figure B.12

It can not be stressed enough that technical managers must become the organizational champions in promoting good practice, which includes preventative maintenance on all municipal assets. From the data it is visible that once a municipality is able to fill more than 75% of its technical management organogram posts, the organization starts to become competent in preventative maintenance of its WTW and WWTW assets.

8. Financial management

a) Contribution by developers towards new infrastructure, Figure B.13

Municipal departments either work from a bulk pool of funds with no concrete allocation of funds to departments, or they are ring-fenced. "Ring-fencing often denotes that funds set aside for an activity are not spent on anything else, and revenues generated by those activities are invested back into the same sector" [41]. In both cases, but more so in the ring-fenced case, the technical manager will have input on the funds allocated to his department. Adequate technical management capacity will allow technical managers to attend to non-technical issues, such as contributions from developers. From Figure B.13

it should be noticed that when municipalities start to have more than 75% of the technical management posts filled, there is a major increase in the percentage of municipalities receiving adequate funds from new developers.

b) Budgeted water service activities versus executed activities, Figure B.14

According to Allyson Lawless, little or no spending on operations and maintenance takes place where there are no civil engineering professionals [2, p.79], because non-technical staff assigned with technical responsibilities are not confident to make technical decisions. This is also true for cases where inadequate technical capacity is present in municipalities. Where inadequate technical staff capacity exists, non-technical staff are often expected to fulfil many technical roles and are unable to spend the municipal infrastructure grants (MIG), not to mention the lack of planning that occurs for the spending of funds. However, the data shows that of the municipalities responding "Most(>75%)" and "All(100%)" to the percentage technical management posts filled, respectively 82.9% and 89.6% of them have a good correlation between planned water service activities and those executed. This is a vast improvement on those with less than 75% of organogram posts filled, that generally execute less than 50% of budgeted activities. It is positive to note that, despite the shortage of skills, only 27 of the municipalities in the sample feel that they are not performing planned water services activities. Municipalities with more than 75% of technical management posts filled show a significant increase in the correlation between budgeted and executed activities.

9. Revenue collection, Figure B.15

A technical manager who becomes an organizational champion will fight for his financial department to perform revenue collection, especially in a ring fenced organization. This will help ensure that more funds are available to drive operations of projects. It is worrying to see that 57 of the 110 municipalities in the sample feel that revenue collection is not acceptable. The data does show that by filling more than 75% of technical management posts, the ability of a municipality to perform proper revenue collection drastically increases. Of the municipalities that have "Most(>75%)" and 100% of the technical management staff posts filled respectively, 51% and 69% have acceptable revenue collection. Without revenue collection the municipality will become unsustainable.

10. Water service quality, Figure B.16

Technical management is the key factor to successful planning to meet consumer needs. Without input from technical management experts, planning for service provision needs becomes extremely difficult for the person involved and more often than not fails to reach set standards, hence the interruptions in service. Common causes of interruptions are water network breaks due to aged and ill maintained networks, which is indirectly influenced by technical management capacity through management influence on the maintenance of water networks staff and planning as discussed in this chapter. Consider the municipalities that have "<50%/None", "Some(>50%)", "Most>75%" and 100% of the technical management posts filled respectively;

for each case the percentage municipalities with 0% households experiencing interruptions as stated by Q.(15.4) is 23%, 37%, 54% and 72% respectively. This shows the reduction in water supply interruptions for municipalities with higher percentages of technical management posts filled. Having more than 75% of the technical management organogram filled, as shown in Figure B.16, creates a major increase in the number of households experiencing no water supply interruptions.

11. Response to water and sanitation related complaints, Figure B.17

The majority percentage of municipalities that have "Most(>75%)" of complaints responded to even though "<50%/None" technical management posts are filled, in most cases will be due to lack of information and can be considered an educated guess made by the person completing the questionnaire. Management of call outs to technical problems is positively influenced by the filling of technical organogram posts. The slight decrease in call outs responded to at the 100% technical management posts filled can be explained by the fact that in such a case management will most likely be well informed and know the real percentages of the call outs responded to within 24 hours. Having "Most(>75%)" of technical management posts filled seems to bring about a positive change in the number of call outs responded to within 24 hours.

4.1.3 Summary of significant technical management correlations

The importance of technical management capacity has in many cases been underestimated. The only factor from the analysis that was classified as influencing the filling of technical management organogram posts, is the skills and experience of existing management staff. What the MuSSA analysis results have proven is that technical management capacity has a very significant impact on several important organizational business attributes namely;

1. Water service planning
2. Management skill level (Technical)
3. Staff skill level (Technical)
4. Technical staff capacity
5. Water conservation and demand management
6. Infrastructure asset management
7. Operations and maintenance of assets
8. Financial management
9. Revenue collection
10. Water service quality

11. Customer care

Each of the 11 key business attribute areas mentioned here have one of many things in common, namely that they require the skills of technical management within a municipal organization to be executed efficiently. In many of South African municipalities young and unexperienced staff are being appointed in areas that require not only skills, but also experience that can only be gained with time. In other cases non-technical staff are being appointed in technical management positions. Allyson Lawless has reported in both her books that in such cases it has been found that poor and ill decision making takes place with regards to technical decisions and that funds are not being spent on allocated problems. In other words, the work is not being done. This study revealed similar results.

The MuSSA results have indicated that a municipality needs to fill at least 75% of its technical management organogram posts to see significant improvement in the performance of the above mentioned 11 business attribute areas.

4.2 Operational staff skill levels and qualifications, as per Regulation 2834

"Experience has indicated that a large proportion of the operating staff at water care works are not competent to perform the tasks expected of them, to ensure that plant effluents comply with water quality standards. In December 1985 regulation No. 2834, in terms of the Water Act, 1956 (Act 54 of 1956) for the erection, enlargement, operation and registration of water care works, was promulgated in an attempt to alleviate this problem." [42].

The functioning and proper operation of (i) water treatment works (WTW) and (ii) wastewater treatment works (WWTW) are important to the livelihood of South Africa. Both (i) and (ii) are fundamental building blocks for economic growth and healthy communities.

The state of water and especially wastewater treatment is of great concern to the government [43, p.26]. One of the root causes identified as contributing to the poor condition of water and wastewater infrastructure is inadequate skills, especially technical skills [43]. Although the bulk of the planning and management is coordinated by higher level technical management staff, the execution and management of work at ground level is left to a handful of skilled staff. Their contribution to the process must not be underestimated. The importance of their skill levels and qualifications is emphasized in nearly every piece of relevant literature consulted. In the following sections the correlations influencing the skill levels and qualifications of (i) and (ii) according to the MuSSA analysis are investigated.

As was done in Section 4.1, the output from the statistical analysis is given in the form of flow charts showing the correlations identified by the analysis between different factors and operational staff skill levels at water and wastewater treatment works respectively in Figures 4.3 and 4.4. The flow charts have been laid out with the help of experts as described in Sections 3.3.4 and 3.3.6. The factors deemed to affect the operational staff skill levels and experience are separated from those being effected by the staff skill levels and experiences. The factors judged to be the result of correlations due

to the nature of the data or from partial correlations are classified as uncertain in the flow charts, see Section 3.3 for more details. The final flow charts are shown in Figures 4.3 and 4.4.

The significant factors from the analysis common to both the WTW and WWTW staff skill levels will first be discussed simultaneously, then the factors unique to WWTW staff skill levels and experience.

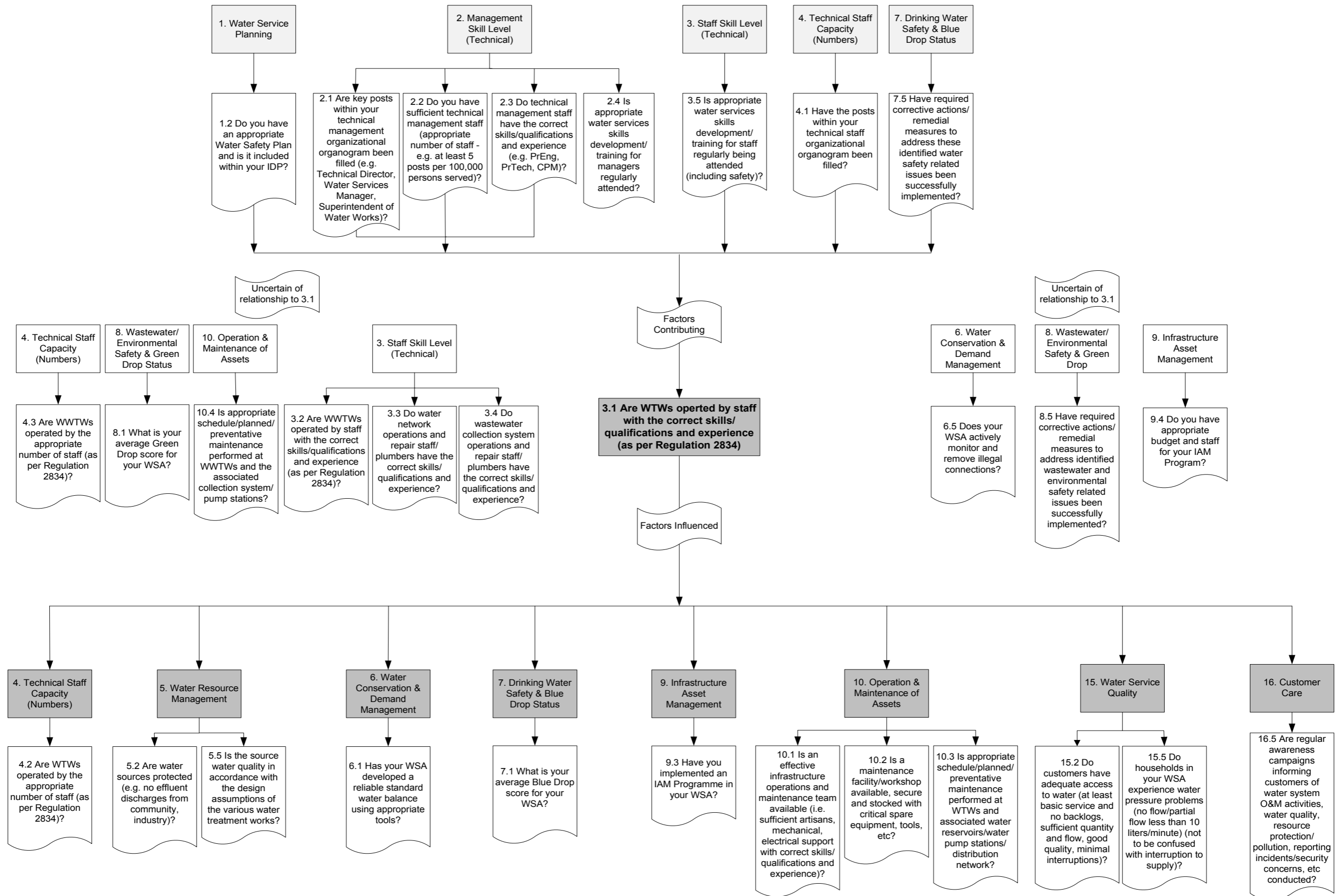


Figure 4.3: Are WTWs operated by staff with correct skill levels and qualifications?: MuSSA Model.

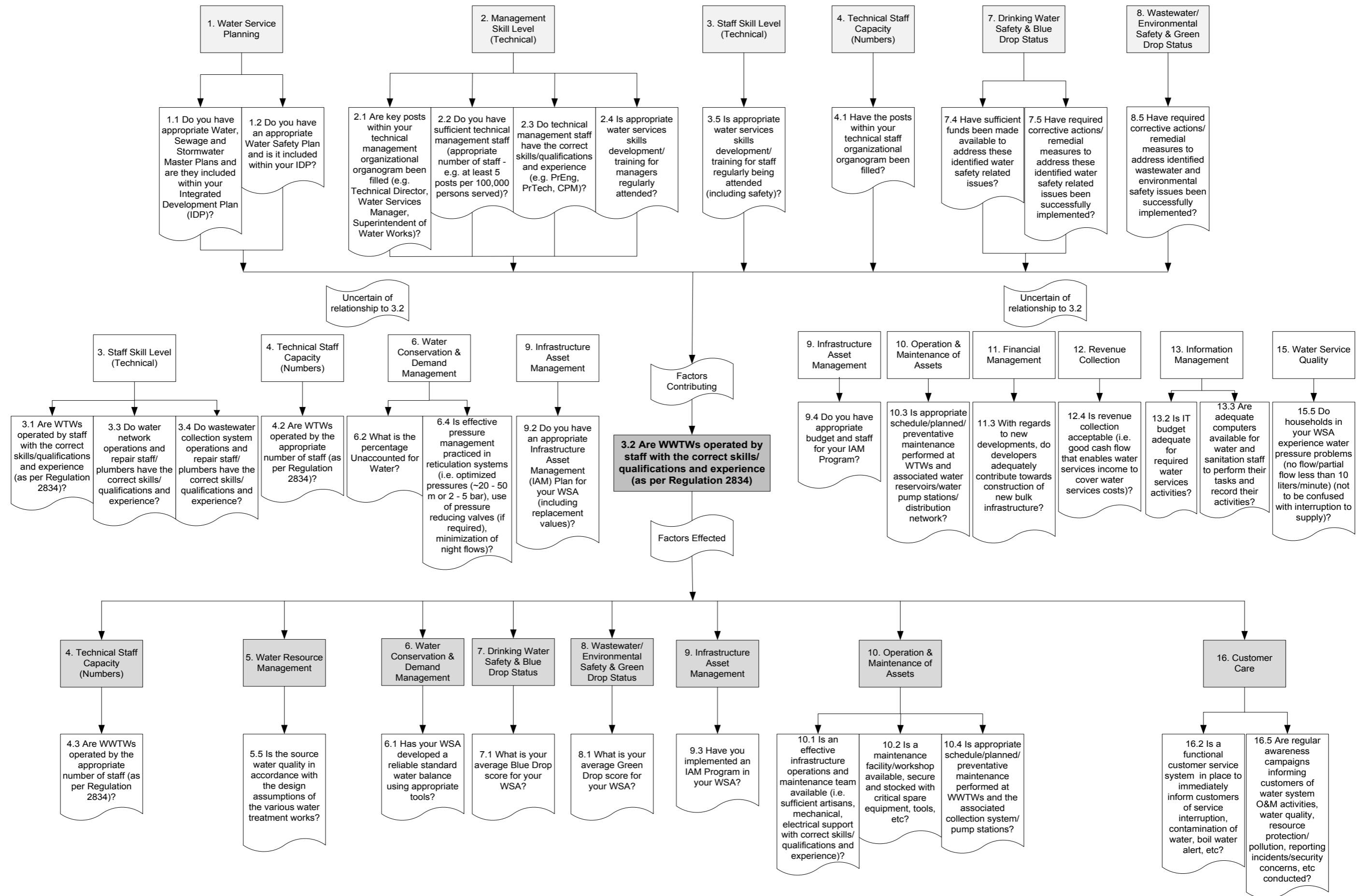


Figure 4.4: Are WWTWs operated by staff with correct skill levels and qualifications? : MuSSA Model.

4.2.1 Areas influencing water and wastewater treatment works operational staff skill levels and qualifications

In this section MuSSA questions that have a significant relationships with technical staff skill levels at both WTW and WWTW are investigated. MuSSA includes two separate questions to investigate the staff skill levels at WTW and WWTW namely;

Q. 3.1 Are WTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

&

Q. 3.2 Are WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

The questions will be discussed as to how they relate and are significant to staff skill levels at WTW and WWTW. Figures 4.3 and 4.4 show the results of the statistical analysis of the MuSSA data after engineering judgement has been applied. It is clear from Figures 4.3 and 4.4, that wastewater treatment works (WWTW) staff skill levels significantly correlates with more MuSSA questions than water treatment works (WTW) does. This is mainly due to the complex nature of the wastewater treatment processes that requires the involvement of more municipal resources. WTW and WWTW staff skill levels also have a significant number of "by chance" correlations after engineering judgement has been applied and are shown under the "uncertain" group in the flow charts. Questions 3.1 and 3.2 have a "Not Applicable" option to their answer sets, and have been processed as explained in the research methodology and statistics chapters. The factors shown in Figures 4.3 and 4.4 are discussed below;

Question 3.1 & 3.2 Are WTW and WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

vs.

Question 1.2 Do you have an appropriate Water Safety Plan(WSP) and is it included within you IDP?

Correlation Statistics: 1.2 vs 3.1

Statistical Model: Spearman's R

P - value = 3.369E-03

r value = 2.9

N = 98

Correlation Statistics: 1.2 vs 3.2

Statistical Model: Spearman's R

P - value = 1.579E-04

r value = 3.6

N = 107

Discussion of Figure 4.5:

Water treatment

The percentage of municipalities responding "No, disagree" to their WSP and having "<50% /None"

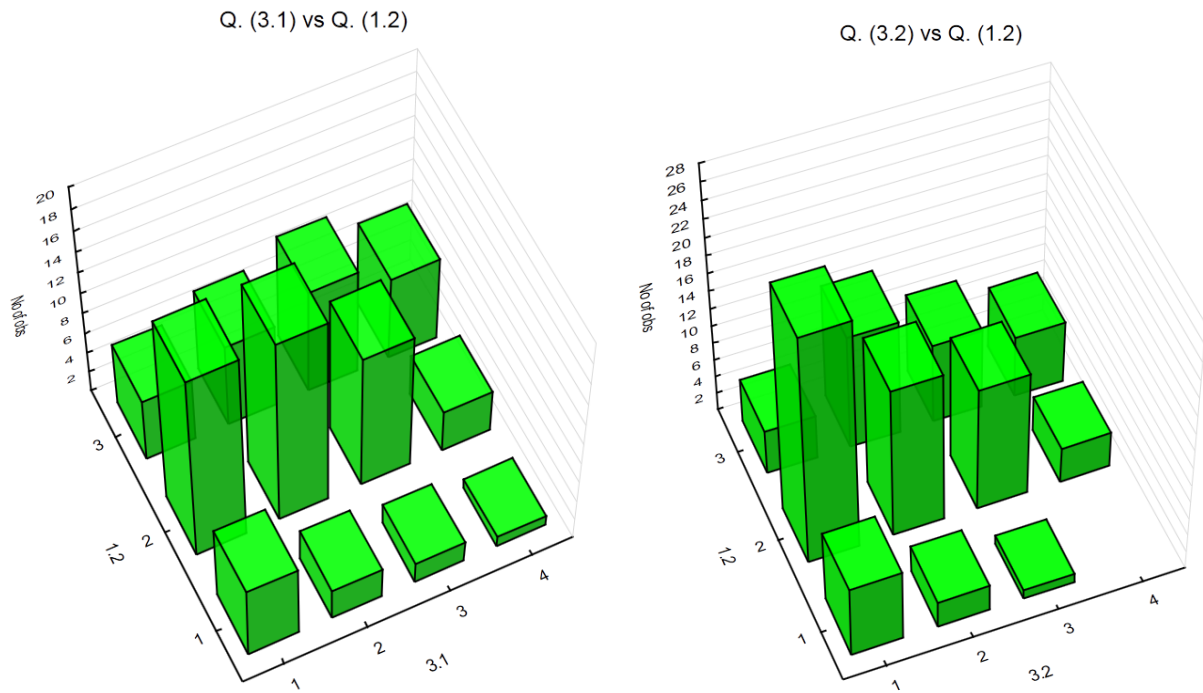


Figure 4.5: Bivariate histogram of Q.(3.1) & Q.(3.2) vs. Q.(1.2)

Table 4.2: Response scale: Q.3.1 & Q.3.2 & Q.1.2

Q. (3.1) & (3.2)		Q. (1.2)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In development
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		
B	Not applicable		

of their WTW staff at the correct skill levels and qualifications is 53.8%. Consider the municipalities having a WSP in development, of them 33.9% have "<50%/None", 33.9% have "Some(>50%)", 24.5% have "Most(>75%)" and 7.5% have all their WTW operated by staff with the correct skills and experience. This indicates that those in the development stage still perform at the lower end of question 3.1, but better than those with no WSP. Of the municipalities with a fully developed and integrated WSP, a total of them 56% have either "Some(>50%) and "Most(>75%) combined of WTW operated by skilled and experienced staff. Even with a fully developed WSP, the majority of municipalities could not have all the staff skilled and qualified.

Wastewater treatment

Of the municipalities responding "No, disagree" to the WSP, 66.6% have "<50%/None" of their WWTW staff at the correct skill levels and qualifications. Not a single municipality in the sample size has all its WWTW operated by staff with the correct skills and experience. The percentage of municipalities with a WSP in development and "<50%/None" of WWTW operated by skilled and experienced staff is 42.6%. This is a slight improvement from those with no WSP. The municipalities with a WSP in devel-

opment show from the data that 27.8% of them have "Some(>50%)" and 22.9% have "Most(>75%)" of the WWTW operated by skilled and experienced staff. Of the municipalities with a fully developed and integrated WSP; 38.2% of them have "Some(>50%)", 26.4% have "Most(>75%)" and 20.5% have all the WWTW operated by skilled and experienced staff. This shows that those with a fully developed and integrated WSP have the most success in employing skilled operational staff.

Significance of relationship:

Water Safety Planning focusses on risk identification, ensuring that the quality of water delivered by the municipality is safe and meets set standards. Operational staff not meeting set skill and qualifications is a risk to water quality. When the WSP is being planned, the risk of lacking staff skill levels will be identified and hopefully be addressed in the IDP. A WSP in the development phase slightly helps municipalities in the right direction with regards to skills employed. The reason why the majority of municipalities do not have all WTW and WWTW staff skilled and qualified, even though they have a fully developed WSP is due to the fact that water treatment personnel is a globally scarce skill [17].

Question 3.1 & 3.2 Are WTW and WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

vs.

Question 2.1 Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)?

These correlations have been discussed in Section 4.1.2. It was seen that municipalities with at least 75% of their technical management organogram posts filled showed better performance in terms of employing WTW and WWTW operational staff that meet staff skill level requirements. Where no technical management capacity exists, management can not devote time to non-technical issues such as staff appointments and municipalities struggle to employ staff with the correct skills, never mind train them.

Question 3.1 & 3.2 Are WTW and WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

vs.

Question 2.2 Do you have sufficient technical management staff (appropriate number of staff- e.g. at least 5 posts per 100 000 persons served)?

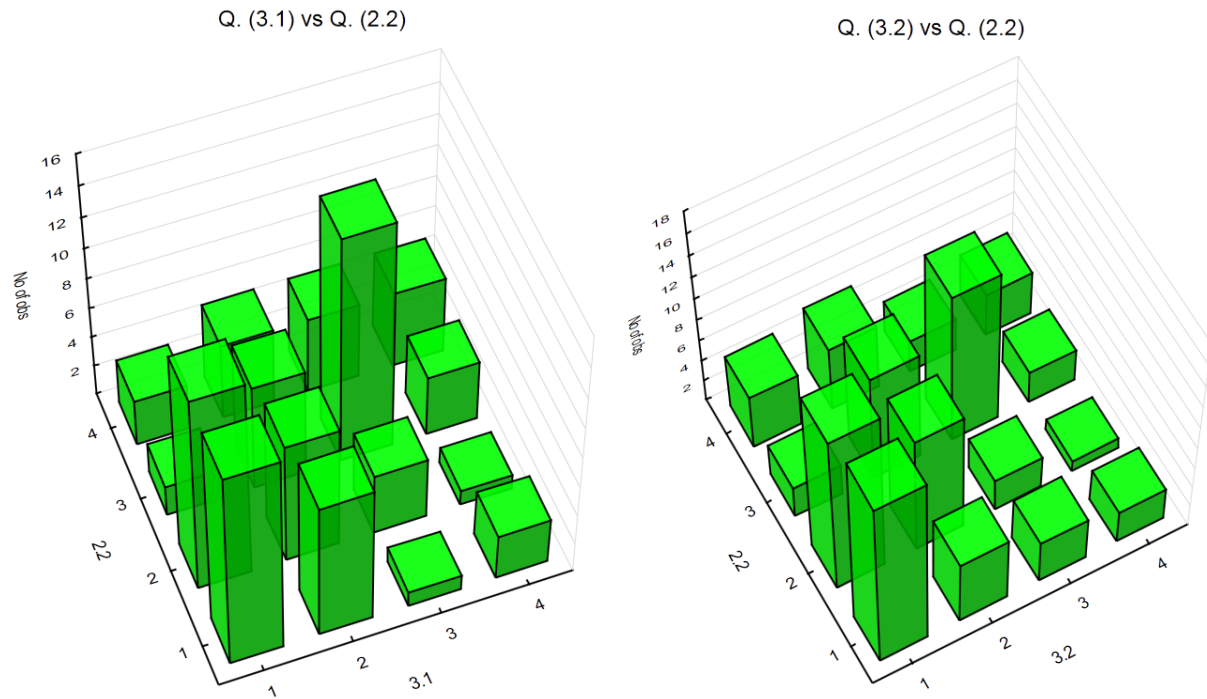


Figure 4.6: Bivariate histogram of Q. (3.1) & Q. (3.2) vs. Q.(2.2)

Correlation Statistics: 2.2 vs 3.1

Statistical Model: Spearman's R

P - value = 1.823E-05

r value = 4.2

N = 98

Correlation Statistics: 2.2 vs 3.2

Statistical Model: Spearman's R

P - value = 1.081E-03

r value = 3.1

N = 107

Table 4.3: Response scale: Q.3.1 & Q.3.2 & Q.2.2

Q. (3.1) & (3.2)		Q. (2.2)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know
B	Not applicable		

Discussion of Figure 4.6:

Water treatment

Of the municipalities having "<50%/None" sufficient technical management staff; 50% of them have "<50%/None" and 34% have "Some(>50%)" of the WTW staff skilled and experienced. The same trend is true for municipalities with "Some(>50%)" technical management capacity. Consider the

municipalities with "Most(>75%)" technical management staff capacity; of them 53.5% have "Most(>75%)" and 14.2% have all WTW operated by staff with correct skills and experience, which is a good improvement from those with less than 75% capacity. Municipalities having 100% sufficient technical management staff capacity responded the following to their WTW operational staff skills an experience; 16.6% of them have "<50%/None)", 27.8% have "Some(50%)", 27.8% have "Most(>75%)" and 27.8% have all their WTW staff skilled and experienced.

Wastewater treatment

The percentages of municipalities with "<50%/None" technical management staff capacity, with "<50%/None" and "Some(>50%)" of WWTW operated by staff with correct skill level and experience are 58.3% and 25% respectively. There is no improvement in the staff skill levels and experiences for municipalities with "Some(>50%)" technical management staff capacity, with 61.5% of them having "<50%/None" and 26.9% of them having "Some(>50%)" of WWTW operated by staff with correct skill levels and experience. Consider the municipalities with "Most(>75%)" technical management capacity; of them 26.8% have "Some>50)" and 34.15% have "Most(>75%)" of the WWTW operated by staff with the correct skill levels and experience. Municipalities having 100% sufficient technical management staff capacity responded the following to WWTW operational staff skills an experience; 21.4% of them have "<50%/None)", 42.8% have "Some(50%)", 25% have "Most(>75%)" and 10.7% have all their WWTW staff skilled and experienced. A general improvement in performance for question 3.2 is seen for municipalities with more than 75% sufficient technical management staff.

Significance of relationship:

Question 2.1 asked if all technical management organogram posts were filled, versus question 2.2 which asks if sufficient technical management staff is available. Recommended numbers coincide with that of Allyson Lawless of 5 professionals per 100 000 persons served[2]. It is once again true that without sufficient technical management staff, management is not able to devote time and energy towards non-technical issues, such as staff requirements and qualifications. Having more than 75% sufficient technical management staff, allows municipalities to start devoting time towards staff skill levels and qualifications in both WTW and WWTW. Municipalities with 100% of their technical management posts filled are unable to fill 100% of their WTW and WWTW with skilled and qualified staff due to skill shortages. The spike seen for both WTW and WWTW of municipalities having "Most(>75%)" sufficient technical management staff and "Most(>75%)" skilled staff can be attributed to both management capacity and skilled labor capacity problems, even with good management skills it would be hard to employ 100% skilled and qualified staff in South Africa.

Question 3.1 & 3.2 Are WTW and WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

vs.

Question 2.3 Do technical management staff have the correct skills/qualifications and experience (e.g. PrEng, PrTech, CPM)?

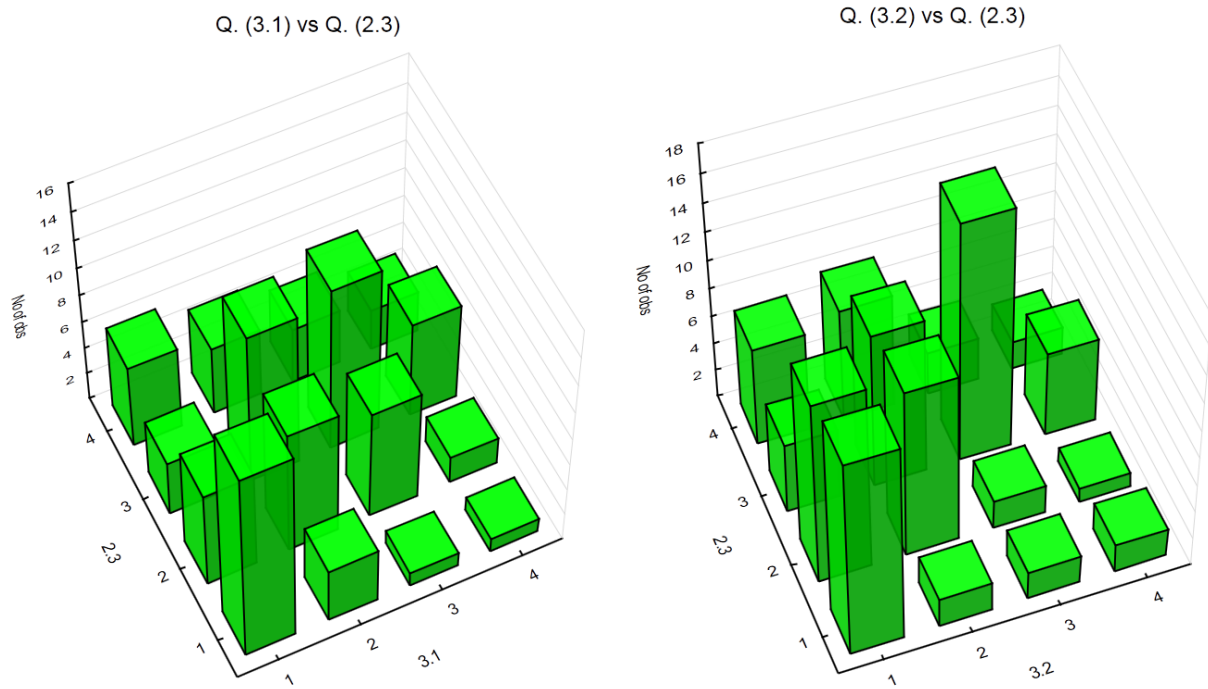


Figure 4.7: Bivariate histogram of Q. (3.1) & Q. (3.2) vs Q.(2.3)

Correlation Statistics: 2.3 vs 3.1

Correlation Statistics: 2.3 vs 3.2

Statistical Model: Spearman's R

Statistical Model: Spearman's R

P - value = 2.417E-03

P - value = 2.133E-03

r value = 3.0

r value = 2.9

N = 98

N = 107

Table 4.4: Response scale: Q.3.1 & Q.3.2 & Q.2.3

Q. (3.1) & (3.2)		Q. (2.3)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know
B	Not applicable		

Discussion of Figure 4.7:

Water treatment

The percentage of municipalities with "<50%/None" of their technical management staff with correct skills and experience and "<50%/None" of their WTW staff skilled and experienced is 70%. Of

the municipalities with "Some(>50%)" of their technical management staff with the correct skill levels and experience; 34.6% have "Some(>50%)", 30.7% have "Most(>75%)" and 7.6% have all the WTW operated by staff with the correct skills and experience. This is an improvement on from those with less than 50% staff with the correct skills, but those with more than 75% of staff skilled perform the best as reported next. Consider the municipalities with "Most(>75%)" of their technical management skilled; of them 32.3% have "Some(>50%)", 35.2% have "Most(>75%)" and 20.9% have all the WTW operated by skilled and experienced staff. Of the municipalities with all their technical management staff skilled and experienced; 33.3% have "<50%/None", 27.7% have "Some(>50%)", 22.2% have "Most(>75%)" and 16.6% have all the WTW operated by skilled and experienced staff.

Wastewater treatment

Of the municipalities with "<50%/None" of their technical management staff skilled and experienced, 70% have "<50%/None" of their WWTW staff skilled and experienced. Of the municipalities with "Some(>50%)" of their technical management staff with the correct skill levels and experience; 46.4% have "<50%/None", 42.8% have "Some(>50%)" and 3.5% have all of their WWTW operated by staff with the correct skills and experience. These municipalities already show a good improvement in the ability to employ skilled staff. The percentages of the municipalities with "Most(>75%)" of their technical management staff skilled and experienced with "Most(>75%)" and all their WWTW operated by staff with the correct skills and qualifications are 43.5% and 15.3% respectively. A slight reduction in the performance of question 3.2 is visible for municipalities reporting to have all their management staff skilled and experienced. Of the municipalities with all their technical management staff skilled and experienced 35% have "<50%/None", 40% have "Some(>50%)", 15% have "Most(>75%)" and 10% have all their WWTW operated by skilled and experienced staff.

Significance of relationship:

Technical management staff skills and qualifications was thought to have an impact on lower level staff skills and experience in the initial stages of the research, and it has been proven by the data shown in Figure 4.7. Municipalities with less than 75% of their technical management staff skilled and qualified have a very slim chance of being able to hire WTW and WWTW staff with the correct skills and qualifications, as they do not have the knowledge to know what is required. The reduction in increased skilled WTW and WWTW skilled staff for municipalities having all their technical management staff skilled can be attributed to the fact that they actually know what the situation is in their municipality, or due to a lack of commitment to change. The country is in a skills shortage crisis and it is very unlikely that the majority (more than 75%), or as a matter of fact in the South African context more than 60% would be considered good, of municipalities will have all their WTW and WWTW staff meeting regulation requirements.

Question 3.1 & 3.2 Are WTW and WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

vs.

Question 2.4 Is appropriate water service skills development/training for managers regularly attended (including safety)?

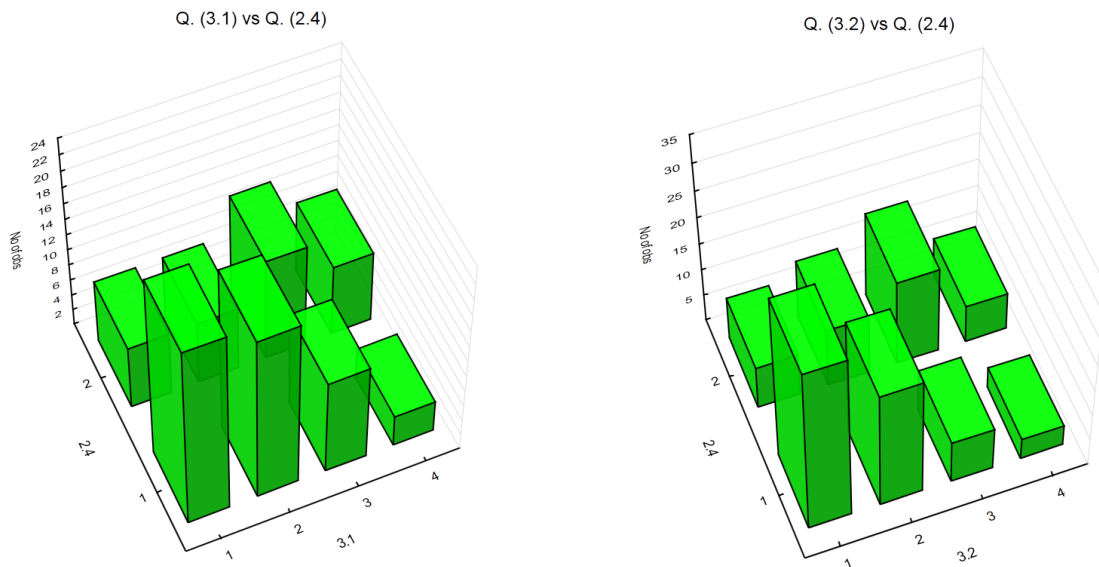


Figure 4.8: Bivariate histogram of Q.(3.1) & Q.(3.2) vs. Q.(2.4)

Correlation Statistics: 2.4 vs 3.1

Statistical Model: Mann Whit

P - value = 4.310E-03

Absolute z value = 2.9

N = 98

Correlation Statistics: 2.4 vs 3.2

Statistical Model: Mann Whit

P - value = 2.535E-04

Absolute z value = 3.7

N = 107

Table 4.5: Response scale: Q.3.1 & Q.3.2 & Q.2.4

Q. (3.1) & (3.2)		Q. (2.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		
B	Not applicable		

Discussion of Figure 4.8:

Water treatment

The percentages of the municipalities not doing water service skills development on technical managers, that have "Some(<50%)" and "Most(>50%)" of their WTW operational staff skilled and experienced are 38.3% and 35% respectively. The percentage of municipalities with more than 75% of

WTW staff skilled drastically increases when training of managers occurs. Of the municipalities performing water service skill development training on managers; 34.2% have "Most(>75%)" and 23.6% have all their WTW operated by staff with the correct skill levels and experience. Only 38 of the 98 municipalities indicated that they are doing water service training on their technical managers.

Wastewater treatment

Of the municipalities not doing water service skills development on technical managers; 47.6% have "Some(<50%)" and 33.8% have "Most(>50%)" of their WWTW operational staff skilled and experienced. Of the municipalities performing water service skill development training on managers; 38.1% have "Most(>75%)" and 16.6% have all their WWTW operated by staff with the correct skill levels and experience. Only 42 of the 107 municipalities indicated that they are doing water service training on their technical managers.

Significance of relationship:

Technical managers with knowledge about water services will understand and comprehend the impact of skilled operators at WTW and WWTW. This can clearly be seen in that a significant percentage of municipalities that do perform training have more than 75% of their WTW and WWTW staff skilled. The reason for the majority not reaching 100% skilled employees is due to the skills shortage of technical operational staff in South Africa.

Question 3.1 & 3.2 Are WTW and WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

vs.

Question 3.5 Is appropriate water service skills development/training for staff regularly being attended (including safety)?

Correlation Statistics: 3.5 vs 3.1

Statistical Model: Mann Whit

P - value = 3.297E-05

Absolute z value = 4.2

N = 98

Correlation Statistics: 3.5 vs 3.2

Statistical Model: Mann Whit

P - value = 4.340E-06

Absolute z value = 4.6

N = 107

Discussion of Figure 4.9:

Water treatment

Of the municipalities not performing water service training on the staff; 42.8% of them have "<50% /None" of the operational staff skilled and experienced. The percentages of municipalities performing training on the staff and with "Most(>75%)" and all of the operational staff skilled and experienced are 31.4% and 31.4% respectively. This is a good improvement on those not performing training.

Wastewater treatment

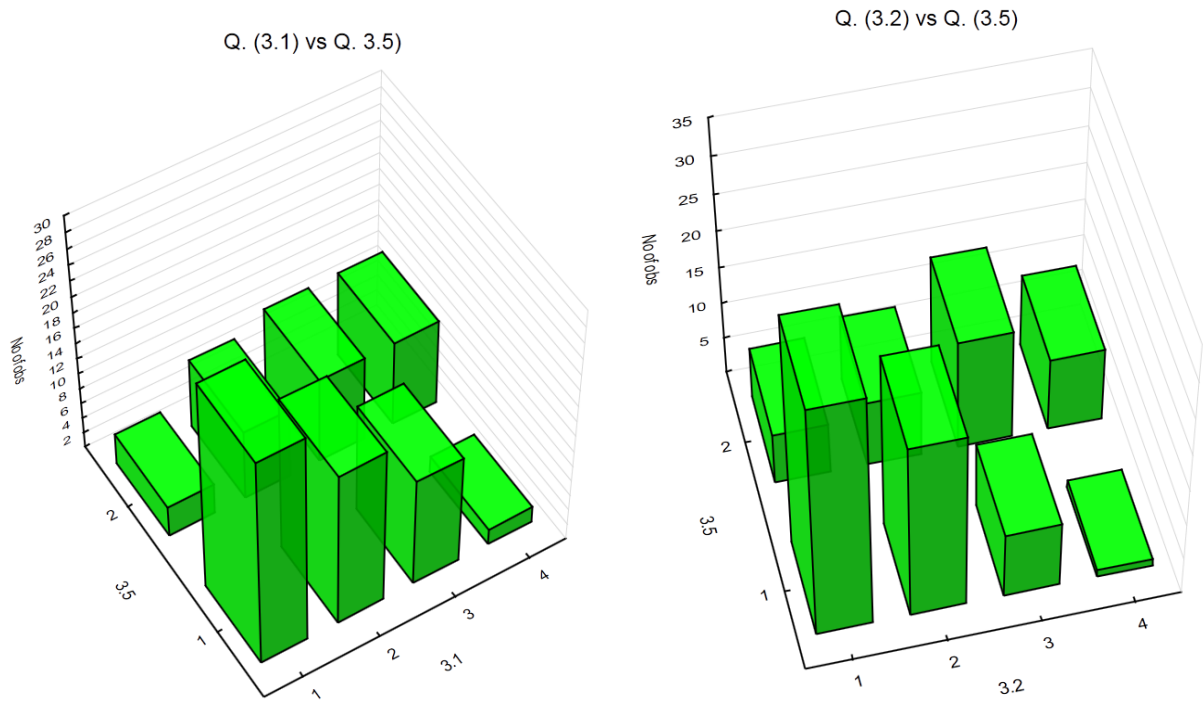


Figure 4.9: Bivariate histogram of Q.(3.1) & Q.(3.2) vs. Q.(3.5)

Table 4.6: Response scale: Q.3.1 & Q.3.2 & Q.3.5

Q. (3.1) & (3.2)		Q. (3.5)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		
B	Not applicable		

Of the municipalities not performing water service training on the staff; 48.4% of them have "<50% /None" and 36.3% have "Some(>50%)" of the operational staff skilled and experienced. This reveals that, the municipalities not performing training generally do not have skilled staff employed. The percentages of municipalities performing training on the staff and with "Most(>75%)" and all of the operational staff skilled and experienced are 36.5% and 24.3% respectively.

Significance of relationship:

The contribution of training to staff is expected to increase the number of staff with correct skills and qualifications. It is important for municipalities to develop the skills of their in house staff, due to the lack of skilled staff in South Africa. It is also noticeable that the majority of municipalities that do perform training reported to have more than 75% of staff skilled. This correlation shows the importance of performing training on staff.

Question 3.1 & 3.2 Are WTW and WWTW operated by staff with the correct skills/qualifications and

experience (as per Regulation 2834)?

vs.

Question 4.1 Have the posts within your technical staff organizational organogram been filled?

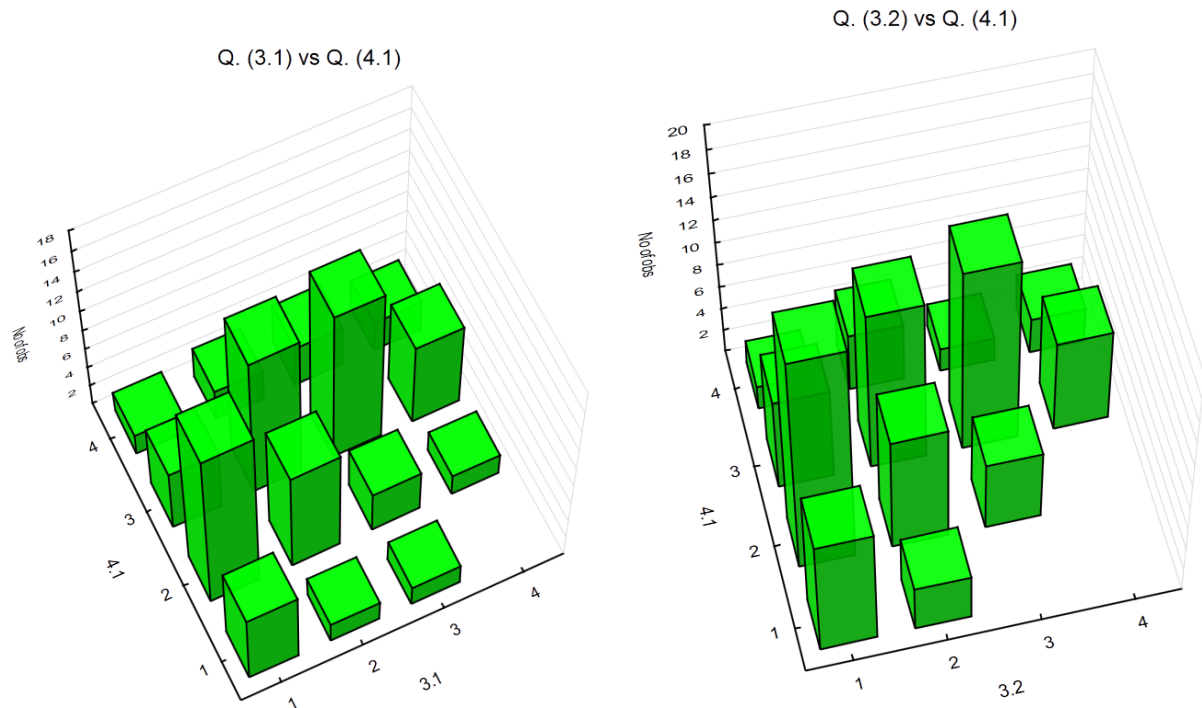


Figure 4.10: Bivariate histogram of Q.(3.1) & Q.(3.2) vs. Q.(4.1)

Correlation Statistics: 4.1 vs 3.1

Statistical Model: Spearman's R

P - value = 1.172E-05

r value = 4.6

N = 98

Correlation Statistics: 4.1 vs 3.2

Statistical Model: Spearman's R

P - value = 1.822E-07

r value = 4.8

N = 107

Table 4.7: Response scale: Q.3.1 & Q.3.2 & Q.4.1

Q. (3.1) & (3.2)		Q. (4.1)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know
B	Not applicable		

Discussion of Figure 4.10:

Water treatment

Not a single municipality with "<50%/None" of its technical staff posts filled was able to have 100% of its WTW staff skilled and experienced. Consider the municipalities with "<50%/None" of their technical staff posts filled; 50% of them have "<50%/None", 31.2% have "Some(>50%)", 12.5% have "Most(>75%)" and 6.2% have all of their operational staff skilled and experienced. Of the municipalities having "Most(>75%)" of their technical organogram posts filled; 32.5% have "Some(>50%)" and 34.8% have "Most(>75%)" of their treatment works staff skilled and experienced. This is a major improvement on those with less than 50% technical posts filled, with the majority having more than 75% of WTW staff skilled. The percentages of municipalities with all their technical posts filled and with "Most(>75%)" and all their operational staff skilled and experienced are 33.3% and 25% respectively.

Wastewater treatment

Of the municipalities with "<50%/None" of their technical posts filled, 71.4% only have "<50%/None" of their operational staff skilled and experienced. These municipalities are the weakest performers in terms of employing skilled staff. The percentages of the municipalities with "Some(>50%)" of technical posts filled and with "<50%/None" and "Some (>50%)" of their operational staff skilled and experienced are 54.2% and 28.5% respectively. They show no real improvement on those with less than 50% technical posts filled. A good improvement occurs for those with more than 75% of posts filled. Consider the municipalities with "Most(>75%)" of their technical posts filled; of them 30.3% have "Some(>50%)", 34.7% have "Most(>75%)" and 17.3% have all their operational staff skilled and experienced. Of the municipalities with all their technical posts filled; 41.6% have "Some(>50%)", 16.6% have "Most(>75%)" and 25% have all their operational staff skilled and experienced.

Significance of relationship:

WTW and WWTW operational staff are technical staff and should be included in the technical organogram. If these posts are not filled or do not exist, then it is impossible for them to be skilled or unskilled. Technical staff posts must first be filled in order to ensure that there are operational staff at WTW and WWTW. Therefore, the first step towards improving skill levels at WTW and WWTW is to at least appoint some kind of technical staff. It is very unlikely, as shown in Figure 4.10, that the majority of South African municipalities will have all their WTW and WWTW staff skilled and experienced, even though all posts are filled. This is mainly due to the skill shortage.

Question 3.1 & 3.2 Are WTW and WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

vs.

Question 7.5 Have required corrective actions/remedial measures to address identified water safety related issues been successfully implemented?

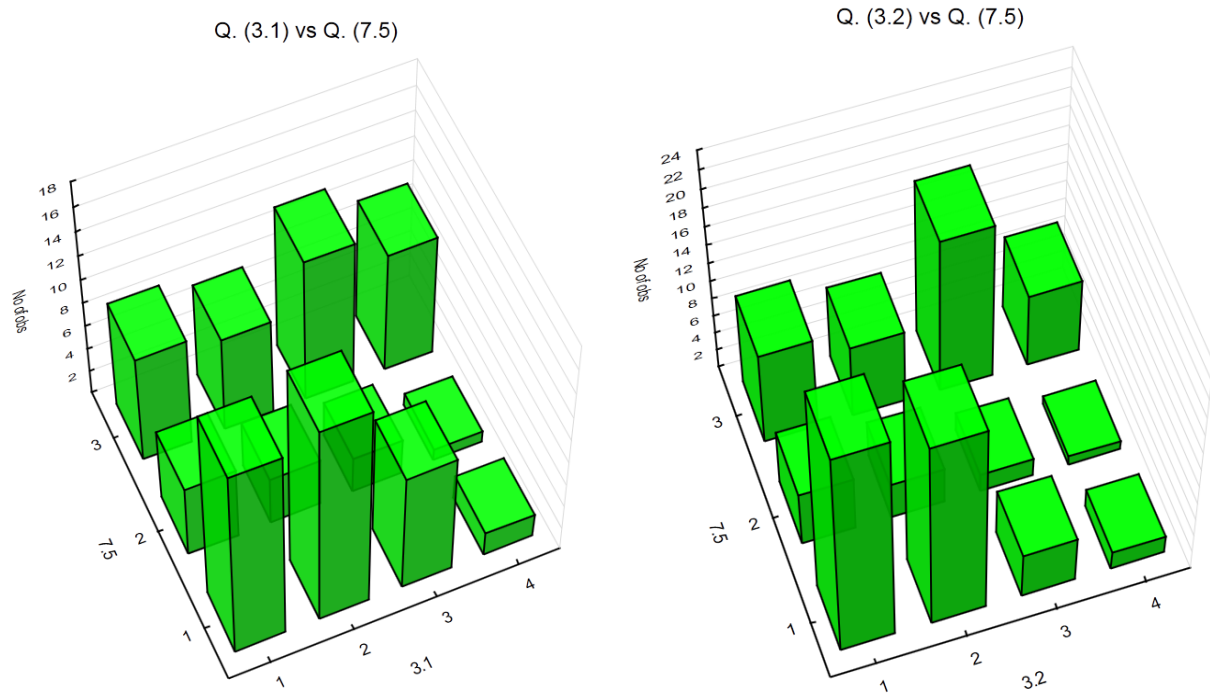


Figure 4.11: Bivariate histogram of Q.(3.1) & Q.(3.2) vs. Q.(7.5)

Correlation Statistics: 7.5 vs 3.1

Statistical Model: Spearman's R

P - value = 8.915E-03

r value = 2.6

N = 98

Correlation Statistics: 7.5 vs 3.1

Statistical Model: Spearman's R

P - value = 2.851E-05

r value = 3.9

N = 107

Table 4.8: Response scale: Q.3.1 & Q.3.2 & Q.7.5

Q. (3.1) & (3.2)		Q. (7.5)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In Process
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		
B	Not applicable		

Discussion of Figure 4.11:

Water treatment

The percentages of the municipalities not implementing the required actions to address water safety related issues with "<50%/None" and "Some(>50%)" of operational staff skilled and experienced are 35.5% and 37.7% respectively. Of the municipalities in the development stage of addressing water

safety related issues; 42.8% have "<50%/None" and 28.5% have "Some(>50%)" of their operational staff skilled and experienced, which is no real improvement on those not implementing required the actions. Consider the municipalities fully addressing identified water safety related issues; of them 30.7% have "Most(>75%)" and 25.6% have all operational staff skilled and experienced.

Wastewater treatment

Of the municipalities not implementing the required actions to address water safety related issues; 45.1% have "<50%/None" and 41.1% have "Some(>50%)" of operational staff skilled and experienced. Of the municipalities in the process of addressing water safety related issues; 46.1% have "<50%/None" and 30.7% have "Some(>50%)" of operational staff skilled and experienced. The percentages of municipalities addressing water safety related issues with "Most(>75%)" or all operational staff skilled and experienced are 39.5% and 18.6% respectively. Those implementing required actions show a good tendency towards employing skilled staff at WWTW.

Significance of relationship:

Pollution of South African water sources is of great concern and is confirmed in the low score achieved by wastewater systems on the current SAICE Report Card. Having properly skilled operational staff at WWTW will help to reduce the pollution of water sources, thus reducing water safety related issues. Lacking staff skill at WTW will most likely lead to water safety related risks, if not addressed. Figure 4.11 shows that municipalities implementing the required remedial actions have more skilled WTW and WWTW personnel employed. Water safety related issues should not just be limited to water, but it is suggested that the broader picture of pollution is also considered.

4.2.2 Areas influencing wastewater treatment works operational staff skill levels and qualifications

In addition to the factors discussed so far in Section 4.2.1, WWTW have additional factors significantly correlating with staff skill levels. The following MuSSA questions investigated have a significant influence on staff skill levels at wastewater treatment works (WWTW). The questions will be discussed as to how they relate, and are significant to the staff skill levels at WWTW. MuSSA includes a questions to investigate the staff skill levels at WWTW namely;

Q. 3.2 Are WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

Figure 4.4 shows the results from the statistical analysis of the MuSSA data after engineering judgement has been applied. It is clear from Figures 4.3 and 4.4 that wastewater treatment staff skill levels significantly correlate with more MuSSA questions than does water treatment, this is mainly due to the complex nature of wastewater treatment processes that requires a more complex set of resources. Wastewater treatment is a more an extensive process than normal water treatment, requiring more attention from staff and allocation of resources.

Q. 3.2 Are WWTW operated by staff with the correct skills/qualifications and experience (as per Reg-

ulation 2834)?

vs.

Question 1.1 Do you have appropriate Water, Sewage and Storm Water Master Plans and are they included within your Integrated Development Plan (IDP)?

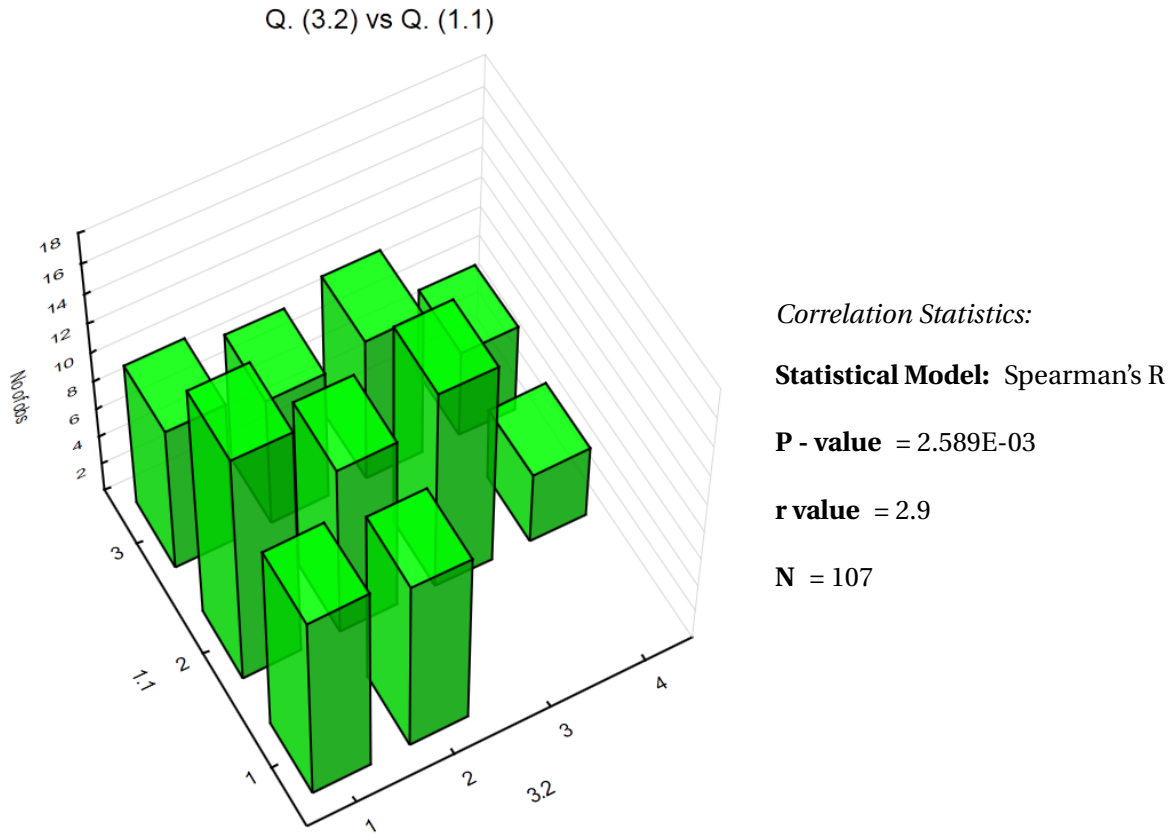


Figure 4.12: Bivariate histogram of Q.(3.2) vs. Q.(1.1)

Table 4.9: Response scale: Q.3.2 & Q.1.1

Q. (3.2)		Q. (1.1)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In development
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		
B	Not applicable		

Discussion of Figure 4.12:

Not a single municipality with no appropriate Master Plans has more than 75% of WWTW staff skilled and experienced. Of the municipalities with Master Plans in development; 34% have "<50%/None" of the staff skilled and experienced, 25.5% have "Some(>50%)" and 29.7% have "Most(>75%) of the staff skilled and experienced. Those in the development stage show a great deal of improvement from

those with no Master Plans. The percentages of municipalities with Master Plans fully implemented, and with "<50%/None", "Some(>50%)" and "Most(>75%)" of the staff skilled and experienced are 28.5%, 25.7% and 28.5% respectively. Those with fully developed and implemented Master Plans are most likely to have all operations staff skilled. Of the municipalities with fully developed and implemented Master Plans, only 17.1% have all their staff skilled and experienced.

Significance of relationship:

Master Planning is a holistic process that looks at all the needs and requirements that a municipality has (long and short term). Due to the lack of skills in South Africa it is evident from Figure 4.12, that a municipality not performing Master Planning will not have proper skilled staff capacity to operate its WWTW. This is caused by a lack of planning for the long term need of skilled operational staff. The appointment of staff in the municipal environment is not a rapid process and requires time and immense amounts of paperwork, thus planning for future staff needs is crucial. Performing Master Planning does not ensure the employment of 100% skilled WWTW personnel but it greatly enhances the municipalities chances to have more skilled personnel. It must be noted here that question 1.1 also has a strong relationship with WTW staff skill level and experience, question 3.1, but at a lower level of significance ($P = 0.045$).

Q. 3.2 Are WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

vs.

Question 7.4 Have sufficient funds been made available to address these identified water safety related issues?

Table 4.10: Response scale: Q.3.2 & Q.7.4

Q. (3.2)		Q. (7.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		
B	Not applicable		

Discussion of Figure 4.13:

Consider the municipalities not having sufficient funds to address water safety related issues; of them 43% have "<50%/None" and 37.5% have "Some(>50%)" of WWTW staff skilled and experienced. Of those not having sufficient funds only 5.5% have 100% of their WWTW staff skilled and experienced. Those not having sufficient funds to address water safety related issues tend to perform on the lower end for question 3.2. Of the municipalities having sufficient funds allocated for water safety related issues; 40% have "Most(>75%)" of WWTW staff skilled and experience, and 20% have all the staff skilled and experienced. This is a great improvement on those not having funds

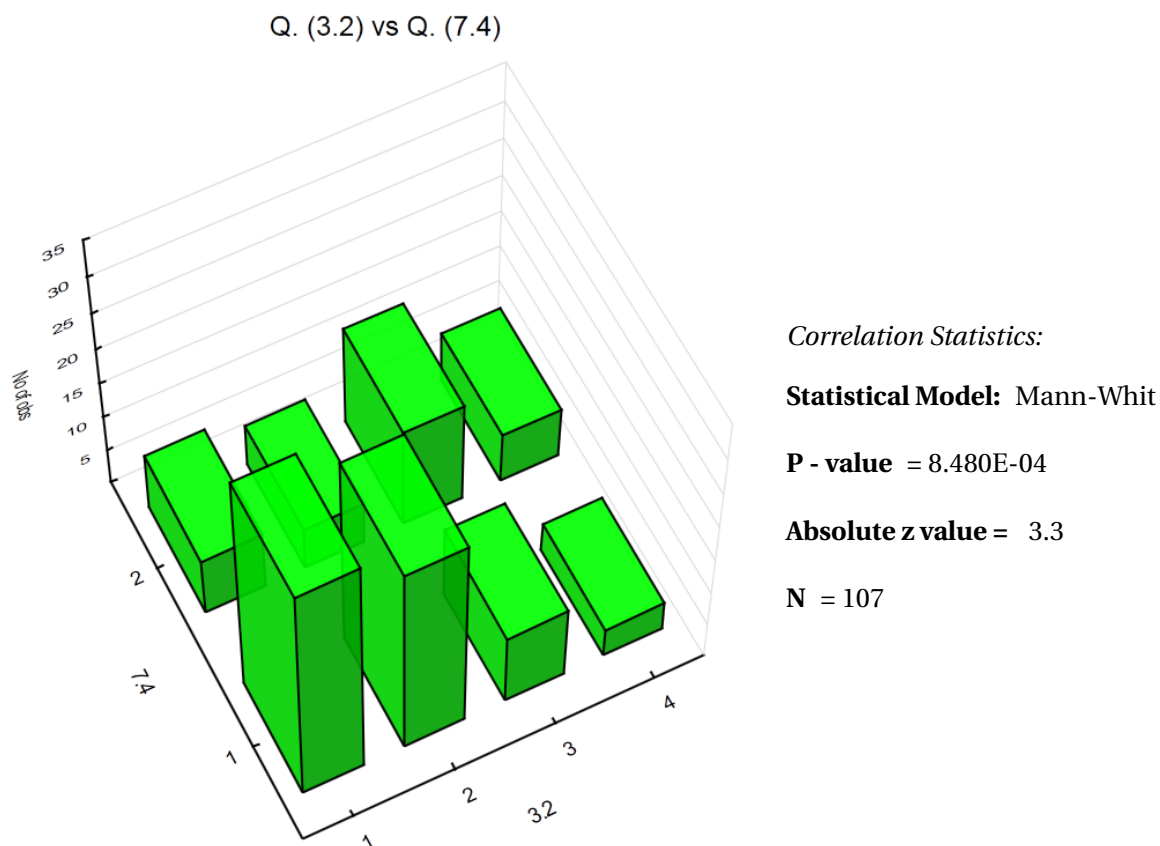


Figure 4.13: Bivariate histogram of Q.(3.2) vs. Q.(7.4)

available. It must be noted that 67% of municipalities (72 out of 107) indicated that they do not have sufficient funds allocated to address water safety related issues.

Significance of relationship:

Water safety related risks include pollution of water sources, which is a major problem in the South African context as we are a water scarce country. Not having properly qualified and experienced WWTW operators will greatly enhance the chances of pollution due to unacceptable effluent quality. In a ring fenced municipality, where financial resources are allocated to the areas they were intended to go, the resources can be committed towards staff skill level improvement. It must be noted that Q. 7.4 had a relatively strong correlation with Q. 3.1 also at $P = 0.019$.

Q. 3.2 Are WWTW operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

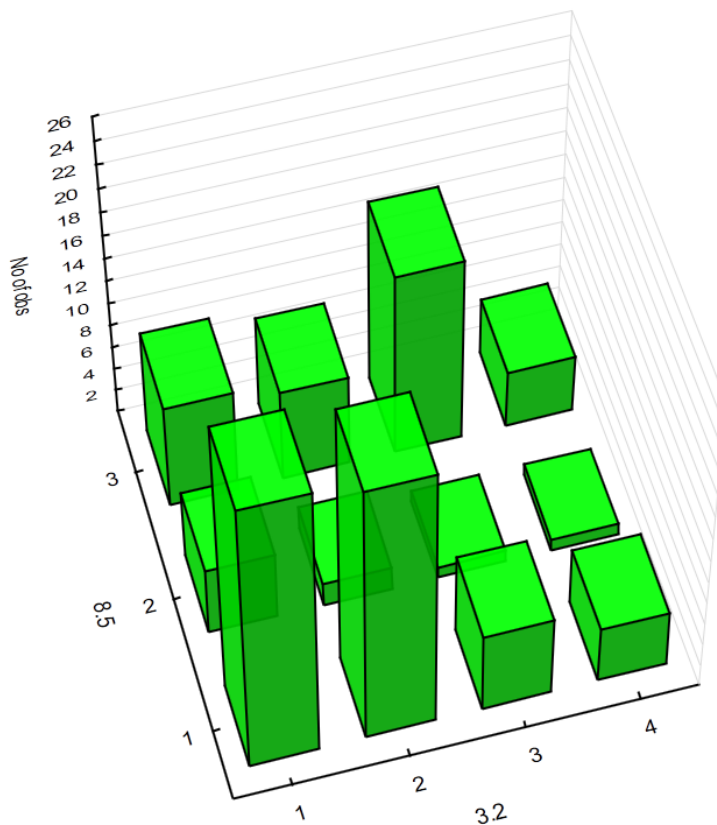
vs.

Question 8.5 Have required corrective actions/remedial measures to address these identified wastewater and environmental safety related issues been successfully implemented?

Discussion of Figure 4.14:

The percentages of the municipalities not performing the required remedial actions with "<50%/None" and "Some(>50%)" of their WWTW staff skilled and experienced are 40.6% and 38.9% respectively. These municipalities show very little tendency to have more than 75% of staff skilled. Of those mu-

Q. (3.2) vs Q. (8.5)



Correlation Statistics:

Statistical Model: Spearman's R

P - value = 9.969E-03

r value = 2.6

N = 107

Figure 4.14: Bivariate histogram of Q.(3.2) vs. Q.(8.5)

Table 4.11: Response scale: Q.3.2 & Q.8.5

Q. (3.2)		Q. (8.5)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In Process
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		
B	Not applicable		

municipalities with the remedial actions required in process; 60% have "<50%/None" of WWTW staff skilled and qualified. Of the municipalities taking the required actions to address wastewater and environmental safety issues; 42% have "Most(>75%)" of their WWTW staff skilled and experienced. These municipalities are more capable of employing staff with the correct skills and experience at WWTW. 55% of municipalities (59 out of 107) reported that they were not taking the required actions to address wastewater and environmental related safety issues.

Significance of relationship:

Wastewater and environmental safety related issues include pollution of water sources, which can occur from effluent not meeting the required standards. Two factors can cause this namely failing infrastructure and human error at the operational level or both. Having skilled and experienced

staff will eliminate the latter risk, which is a regular occurrence in the South African context. It does not help to have these remedial actions in process, it actually needs to be implemented before any change will be seen in operational staff skill levels.

4.2.3 A summary of significant influencing water and wastewater operational staff skill level correlations

A study launched by the CSIR found that one of the major underlying issues causing water treatment plant failures is operator error, which highlights the reason for the in depth look at factors influencing WTW and WWTW operator skill levels [39, p.5]. A summary of the attribute areas that have a significant impact on both WTW and WWTW staff is given below. Each of the attribute areas are listed, and then the questions with a significant impact on both WTW and WWTW falling under each attribute area is summarized. The questions found to have a significant impact on both WTW and WWTW staff skill levels and experience are as follows, each summarized under its relevant attribute area;

1. Water service planning

In particular, the execution of a Water Safety Plan (WSP) has a major impact on the percentage of skilled operational staff a municipality employs at its treatment works. It was found from the data that not having a WSP or having it in development does not help improve the staff skill levels, as it does not lead to action being taken towards correcting the problem. Municipalities must go through the entire WSP process where they will identify the risk of operator skill levels at both WTW and WWTW to water quality, which will lead to improvement. It is worrying to note that only approximately 30% of municipalities in the sample had a fully developed and implemented WSP.

2. Management skill level technical

Technical management staff play a very critical role in the skills and experience of operational staff employed at WTW and WWTW. It was found that municipalities need to have at least 75% of their technical management organogram posts filled to have sufficient management capacity to devote time towards the matter of appropriate staff appointments. Municipalities with less than 75% of technical management staff skilled and experienced also reflected lacking skill levels in the operational staff, due to the lack of understanding by management of the importance of technical skills. The training of in house staff, both management and operational staff, is key to the success of a municipality. South Africa does not have enough skilled technical staff and municipalities must make effort to develop and retain their own skilled personnel by succession planning, acceptable salaries and packages and provision of a supporting mentor structure.

3. Technical staff skill level

Municipalities not performing training of technical operational staff reported that they generally do not have skilled personnel capacity. Municipalities must start to develop the staff at

hand to move forward, as South Africa simply just does not have enough skilled technical personnel to operate its treatment works. It is worrying to see that less than 40% of municipalities in the sample are performing skills development of technical staff at operational level.

4. Technical staff capacity

The filling of technical organogram posts is an indication of good practice in the organization, and a good starting point for a municipality in terms of skill and capacity building. From the data is seen that municipalities with at least 75% of their technical management organogram posts filled, the majority also have more skilled technical staff. This can mainly be attributed to good practice within the organization and to the fact that staff must first be employed before their skills can be developed or assessed.

5. Drinking water safety & Blue Drop status

Many of South Africa's water and wastewater treatment plants are failing due to operator error, an indication of unskilled staff being employed. This must be identified as a water safety related issue. Wastewater treatment plants cause pollution of our water sources leading to a water safety related risk. Water treatment plant failures cause a failure of drinking water quality. Thus, taking action to correct water safety related issues should first and foremost be done through the employment of skilled personnel at both water and wastewater treatment plants.

Three key business attribute areas from MuSSA that were identified as being significant (P-value less than 0.01) contributors to the skills and experiences of WWTW staff are summarized below. It must be mentioned that all three these areas also showed relatively strong correlations for WTW staffs skills and experiences, but fell short of the 99% significance as chosen for this study. The questions found to have a significant impact on WWTW staffs skill levels and experiences are as follows, each summarized under its relevant attribute area; it must be mentioned that all three these areas also showed relatively strong correlations for WTW staff;

1. Water service planning

The MuSSA data revealed that not a single municipality not having a Master Plan had more than 75% of its WWTW staff skilled and experienced. Those that do have Master Plans in development are moving in the right direction with regards to employing more technical operational staff with the correct skills and experience. Municipalities with fully developed and integrated Master Plans are more likely to employ staff with correct skill levels at WWTW, it is also an indication of good practice. WTW's staff skill levels correlated at a 95.5% significance with Master Planning.

2. Drinking water safety & Blue Drop status

The availability of funds to address water safety related issues strongly influences the level of skills employed at WWTW (correlation with WTW was also strong at P-value of 0.019). The lack of funds to attract skilled personnel was identified by the CSIR as an underlying issue to the state of South Africa's water and wastewater treatment plants [39]. It is a worrying factor to see

that only 32.7% of the municipalities in the sample reported to have sufficient funds to address water safety related issues.

3. Wastewater/environmental safety & Green Drop status

One of the major threats to the South African environment is the quality of effluent flowing from wastewater treatment plants. A cause associated with the failure of effluent to meet standards is the lack of commitment by officials to carry out the required actions [39, p.7], as highlighted in question 8.5 the execution of the necessary actions is crucial to success. Municipalities that do not perform the required actions to rectify identified issues are almost certain to also not be employing skilled personnel at WWTW. The contribution of skilled technical staff must not be underestimated in solving wastewater related issues such as effluent failing to meet standards.

This then summarizes the factors from the analysis of the MuSSA data determined to influence the state of water and wastewater operational staff skill levels. Municipalities are encouraged to strongly consider the above mentioned points when seeking to improve the skills of the operational staff at water and wastewater treatment plants as areas to focus the allocation of resources and man hours to.

4.3 Operational technical staff capacity, as per Regulation 2834

Staff capacity at water and wastewater treatment plants in South African municipalities are a worrying issues [39; 2]. The CSIR identified lacking staff capacity and skill as one of the major underlying causes of WTW and WWTW breakdowns in the 2007 report on the municipal infrastructure [39]. As the technical staff capacity at water and wastewater treatment plants is a clear threat to the well being of South Africans, the next section seeks to investigate the factors contributing towards the problem using the data gained from the statistical analysis on the MuSSA data. MuSSA contains two questions about the technical staff capacity at water and wastewater treatment plants namely;

Q. 4.2 Are WTW operated by the appropriate number of staff (as per Regulation 2834)?

&

Q. 4.3 Are WWTW operated by the appropriate number of staff (as per Regulation 2834)?

In order to improve the technical staff capacity, municipalities must apply the limited resources to the areas that will have the greatest impact towards improvement. The significant correlations from the analysis were sorted into those contributing and those influenced by WTW and WWTW staff capacity. The correlations judged to be a result of partial correlations or by pure chance due to the nature of the data, by way of experts' opinions, were classified as uncertain, for more detail on the interpretation of the analysis data see Section 3.3. Figures 4.15 and 4.16 show the layout of the interaction between the correlations gained from the analysis with WTW and WWTW staff capacity. The analysis of the MuSSA data revealed that three of the 16 key business attributes have a significant correlation influencing the WTW and WWTW staff capacities, by way of at least one of the five

essence questions, as shown in Figures 4.15 and 4.16. The correlations influencing both WTW and WWTW staff capacity will first be discussed, followed by those specific to WWTW staff capacity.

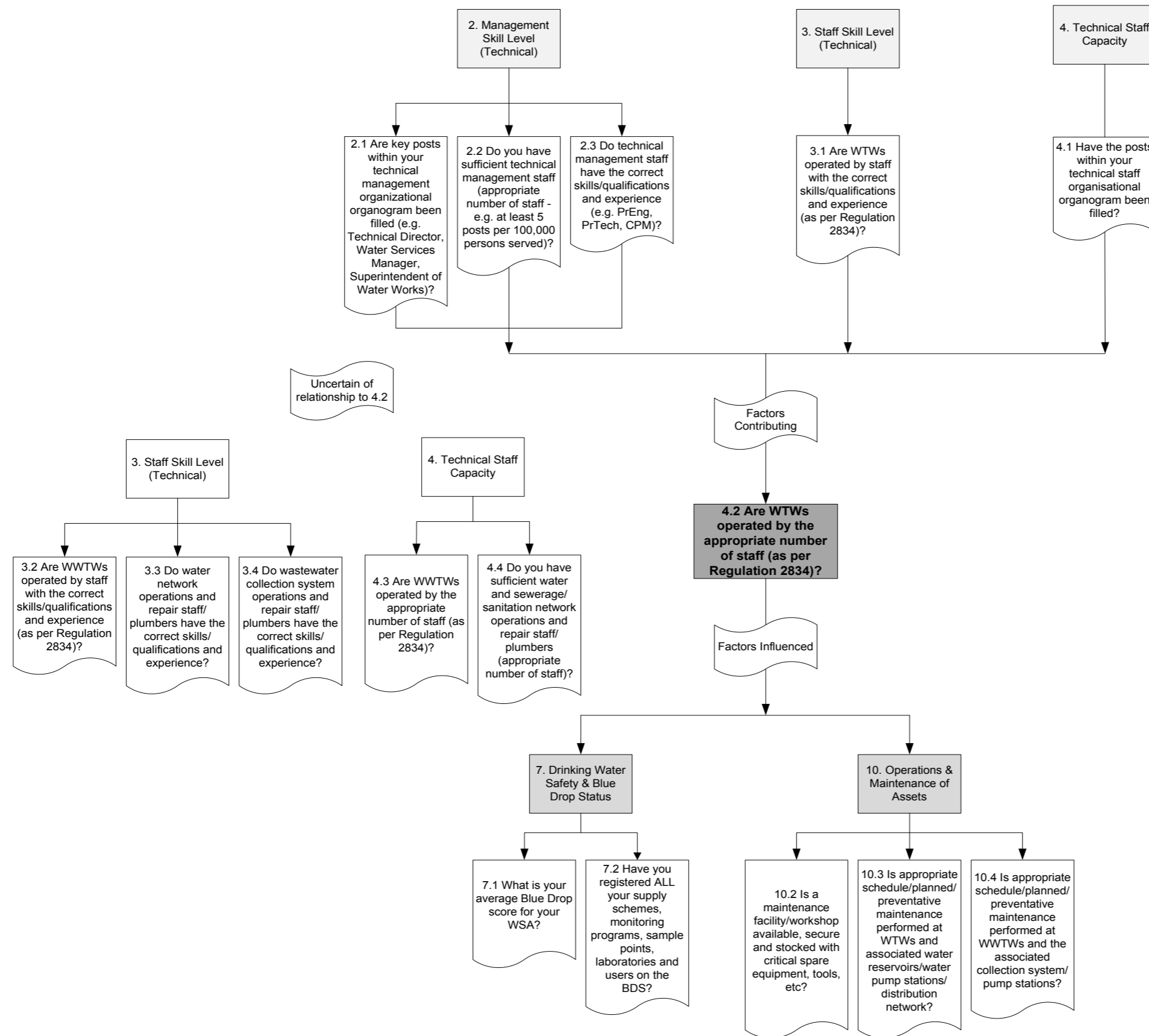


Figure 4.15: WTWs Staff Capacity: MuSSA

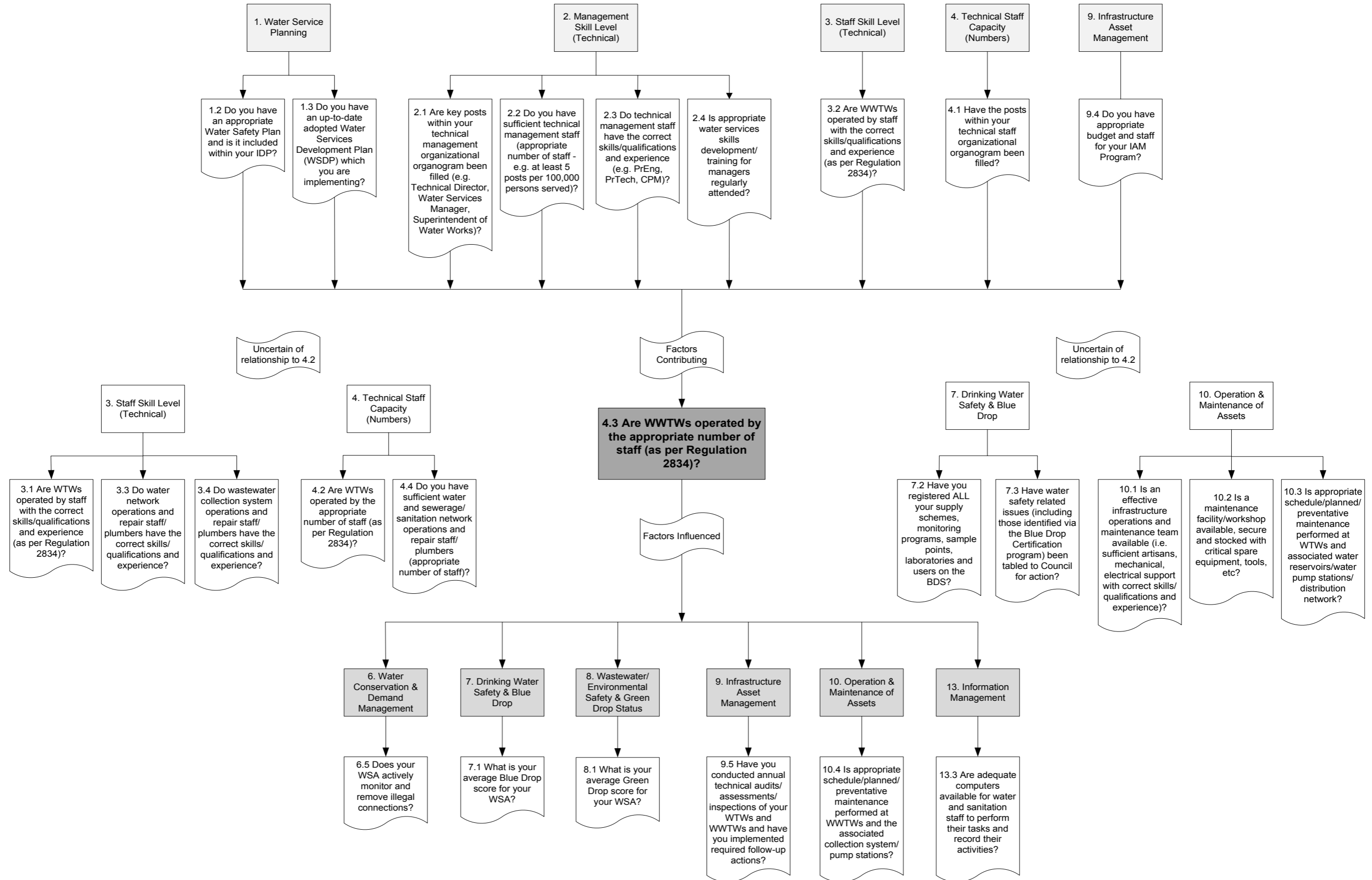


Figure 4.16: WWTWs Staff Capacity: MuSSA

4.3.1 Areas influencing water and wastewater treatment works operational staff capacity

Figures 4.15 and 4.16 show the results of the statistical analysis of the MuSSA data after engineering judgement has been applied. From the figures it can be seen that both WTW and WWTW staff capacity have a strong relationship with management staff skill level, this relationship and those indicated as influencing factors in both Figures 4.15 and 4.16, will be discussed in this section as areas contributing to both WTW and WWTW staff capacity.

Q. 4.2 & 4.3 Are WTW and WWTW respectively operated by the appropriate number of staff (as per Regulation 2834)?

vs.

Question 2.1 Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)?

This correlation has been discussed in detail in Section 4.1.2. The importance of technical management capacity is seen here. Technical managers are often overloaded with work and do not have time to devote towards staff appointment, leaving it to non-technical decision makers. They often do not understand the importance of technical staff capacity. The filling of at least 75% of technical management organogram post is crucial to the functionality of the municipality.

Q. 4.2 & 4.3 Are WTW and WWTW respectively operated by the appropriate number of staff (as per Regulation 2834)?

vs.

Question: 2.2 Do you have sufficient technical management staff (appropriate number of staff - e.g. at least 5 posts per 100 000 persons served)?

Correlation Statistics: 2.2 vs 4.2

Statistical Model: Spearman's R

P - value = 3.039E-03

r value = 2.9

N = 98

Correlation Statistics: 2.2 vs 4.3

Statistical Model: Spearman's R

P - value = 3.794E-04

r value = 3.4

N = 107

Discussion of Figure 4.17:

Water treatment

The percentages of municipalities with "<50%/None" technical management staff and with "<50%/None" or "Some(>50%)" of WTW operated by the appropriate number of staff are 46.1% and 30.7% respectively. Of the municipalities having "Some(>50%)" technical management staff capacity, 38.4% have "Some(>50%)" operational staff capacity. This can be seen as a slight improvement, but the munic-

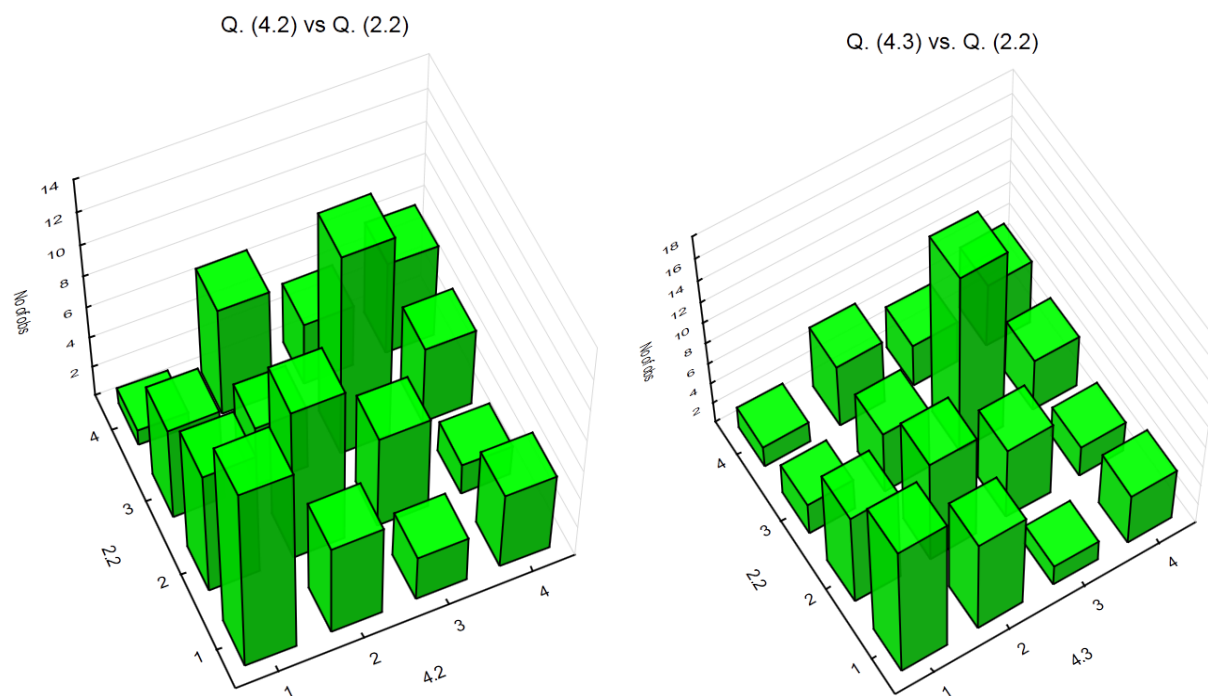


Figure 4.17: Bivariate histogram of Q.(4.2) & Q.(4.3) vs. Q.(2.2)

Table 4.12: Response scale: Q.4.2 & Q.4.3 & Q.2.2

Q. (4.2) & (4.3)		Q. (2.2)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know
B	Not applicable		

palities having more than 75% sufficient technical management capacity show a great improvement towards capacity building. Of the municipalities with "Most(>75%)" technical management capacity; 46.4% have "Most(>75%)" and 22.2% have 100% of the WTW operated by the correct number of staff. Consider the municipalities with 100% sufficient technical management capacity; of them 17.8% have "Most(>75%)" and 33.3% have all the WTW operated by the correct number of staff, this a noticeable improvement in the percentage of municipalities with 100% operational staff..

Wastewater treatment

The percentages of municipalities with "<50%/None" technical management staff and with "<50%/None" or "Some(>50%)" WWTW operational staff capacity are 44.8% and 34.4% respectively. Of the municipalities with "Some(>50%)" technical management staff capacity, 34.4% have "Some(>50%)" WWTW operational staff capacity. A high presence of observations are visible on the diagonal of the histogram, clearly showing that with increased management capacity there is a equal increase in operational staff capacity. Of the municipalities with "Most(>75%)" technical management capacity; of them 54.4% have "Most(>75%)" and 22.2% have 100% of the WWTW operated by the correct number

of staff. Consider the municipalities with 100% sufficient technical management capacity; of them 16.1% have "Most(>75%)" and 33.3% have all the WWTW operated by the correct number of staff.

Significance of relationship:

Question 2.2 once again shows the importance of technical management staff capacity towards lower level staff development and capacity building. The percentage of municipalities having water works with sufficient technical management staff directly correlates with those having sufficient technical management capacity. Technical management staff are in many cases over worked in municipalities, and do not have the energy to devote time towards non-technical issues such as technical staff capacity building[2; 44]. It is worrying to see that only 18% of municipalities have sufficient technical management capacity as reported in the data.

Q. 4.2 & 4.3 Are WTW and WWTW respectively operated by the appropriate number of staff (as per Regulation 2834)?

vs.

Question 2.3 Do technical management staff have the correct skill/qualifications and experience (e.g. PrEng, PrTech, CPM)?

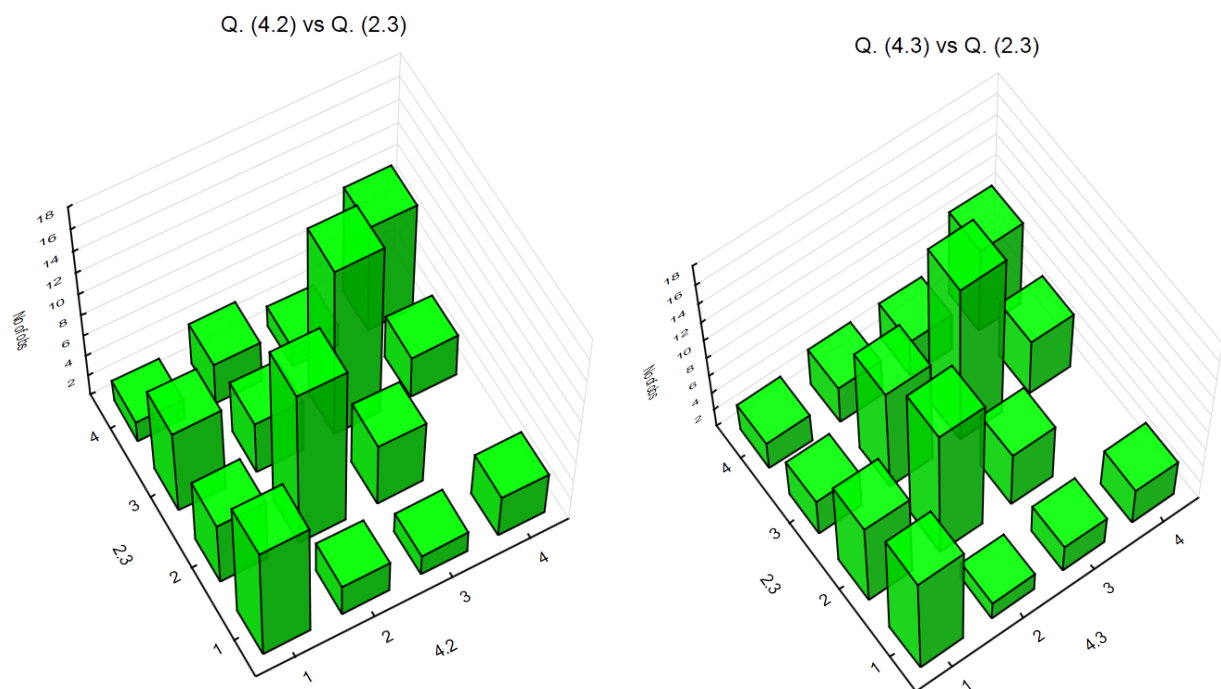


Figure 4.18: Bivariate histogram of Q.(4.2) & Q.(4.3) vs. Q. (2.3)

<p><i>Correlation Statistics: 2.3 vs 4.2</i></p> <p>Statistical Model: Spearman's R</p> <p>P - value = 1.566E-04</p> <p>r value = 3.7</p> <p>N = 98</p>	<p><i>Correlation Statistics: 2.3 vs 4.3</i></p> <p>Statistical Model: Spearman's R</p> <p>P - value = 6.925E-05</p> <p>r value = 3.7</p> <p>N = 107</p>
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Table 4.13: Response scale: Q.4.2 & Q.4.3 & Q.2.3

Q. (4.2) & (4.3)		Q. (2.3)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know
B	Not applicable		

Discussion of Figure 4.18:

This is one of the strongest correlations yielded from the data and can be identified by the high presence of data points on the diagonals of Figure 4.18.

Water treatment

Of the municipalities with "<50%/None" technical management staff skilled and experienced, 55% have "<50%/None" of the WTW operated by the correct number of staff. The percentage of municipalities with "Some(>50%)" of the technical management staff skilled and experienced and with "Some(>50%)" of the WTW operated by the correct number of staff is 55.5%. This prominent increase of technical staff capacity continues as the percentage of management staff with the correct skills and experience increase. Of the municipalities with all the technical management staff skilled and experienced, 55.5% have all the WTW operated by the appropriate number of staff.

Wastewater treatment

The percentage of municipalities with "<50%/None" of their technical management staff skilled and experienced and with "<50%/None" of WWTW operated by the appropriate number of staff is 55%. Of the municipalities with "Most(>75%)" of the technical management staff skilled and experienced, of them 44.7% have "Most(>75%)" of the WWTW operated by the correct number of staff. The municipalities with all the technical management staff skilled and experienced perform the best, with 45% of them having all the WWTW operated by the appropriate number of staff.

Significance of relationship:

The correlation between technical management staff skills and the technical staff capacity at ground level is one of the strongest yielded from the data. It shows the importance of having technical managers in a municipality taking technical decisions and managing technical staff. Unskilled technical

managers or non-technical managers appointed in technical positions are unable to make accurate and good decisions, and at times do not make decisions at all [2, p.84]. Municipalities need to stop appointing staff based solely on an equity and cost criteria and rather focus on skills and experience of the applicants.

Q. 4.2 & 4.3 Are WTW and WWTW respectively operated by the appropriate number of staff (as per Regulation 2834)?

vs.

Question 3.1 & 3.2 Are WTW and WWTW respectively operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?

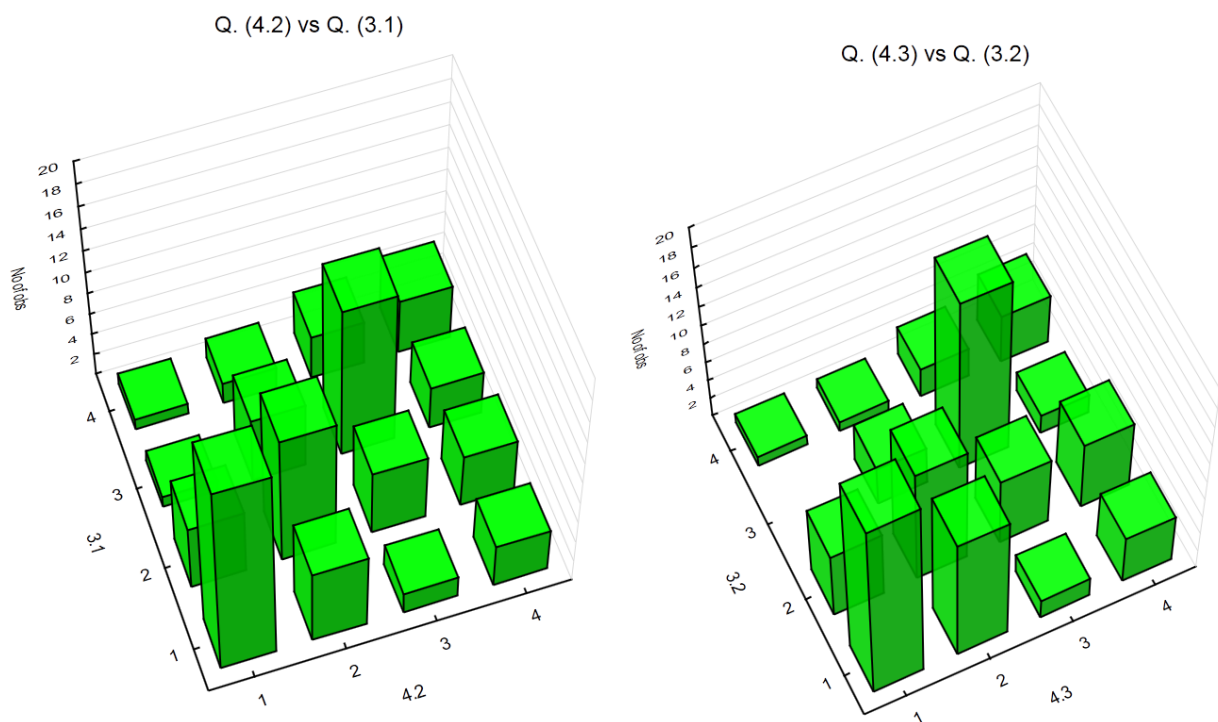


Figure 4.19: Bivariate histogram of Q.(4.2) & Q.(4.3) vs. Q.(3.1) & Q.(3.2)

Correlation Statistics: 3.1 vs 4.2

Statistical Model: Spearman's R

P - value = 1.000E-06

r value = 4.7

N = 97

Correlation Statistics: 3.2 vs 4.3

Statistical Model: Spearman's R

P - value = 1.533E-07

r value = 4.8

N = 106

Discussion of Figure 4.19:

Water treatment

Table 4.14: Response scale: Q.4.2 & Q.4.3 & Q.3.1 & Q. 3.2

Q. (4.2) & (4.3)		Q. (3.1) & (3.2)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know
B	Not applicable	B	Not applicable

The percentage of municipalities with "<50%/None" of the operational staff skilled and experienced and with "<50%/None" of the WTW operated by the appropriate number of staff is 58.0%. Of the municipalities with "Most(>75%)" of the operational staff skilled and experienced; 56% have "Most(>75%)" and 33.3% have all the treatment works operated by the appropriate number of staff, a positive improvement on those with less than 75% skilled operational staff. Consider the municipalities with all the operational staff skilled and experienced; of them 16% have "Most(>75%)" and 41.6% have all the treatment works operated by the correct number of staff. These municipalities achieved the highest rate of success in employing the correct number of staff at all treatment works.

Wastewater treatment

Of the municipalities with "<50%/None" of the operational staff skilled and experienced, 48.7% of have "<50%/None" of the WWTW operated by the appropriate number. The percentage of municipalities with "Most(>75%)" of operational staff skilled and experienced and having "Most(>75%)" of WWTW operated by the appropriate number of staff is 75%. A very strong increase in the number of municipalities employing more than 75% of the required number of staff at WWTW occurs as soon as more than 75% of staff employed have the required skills and experience. Of the municipalities with all the operational staff skilled and experienced, 50% have all the WWTW operated by the correct number of staff.

Significance of relationship:

Skilled operational staff do not have a direct influence on the number of staff appointed at a municipality, however a skilled operator will be able to identify staff shortages and inform his or her manager of the shortages. It is not being suggested here that employing skilled operational staff will enhance capacity building, this correlation rather shows that when the management capacity (i.t.o. skill and capacity) is capable of employing skilled operational staff they will most likely also be employing the correct number of staff and vice versa. This correlation gives an indication of good or bad practice occurring within the organization.

Q. 4.2 & 4.3 Are WTW and WWTW respectively operated by the appropriate number of staff (as per Regulation 2834)?

vs.

Question 4.1 Have posts within you technical staff organizational organogram been filled?

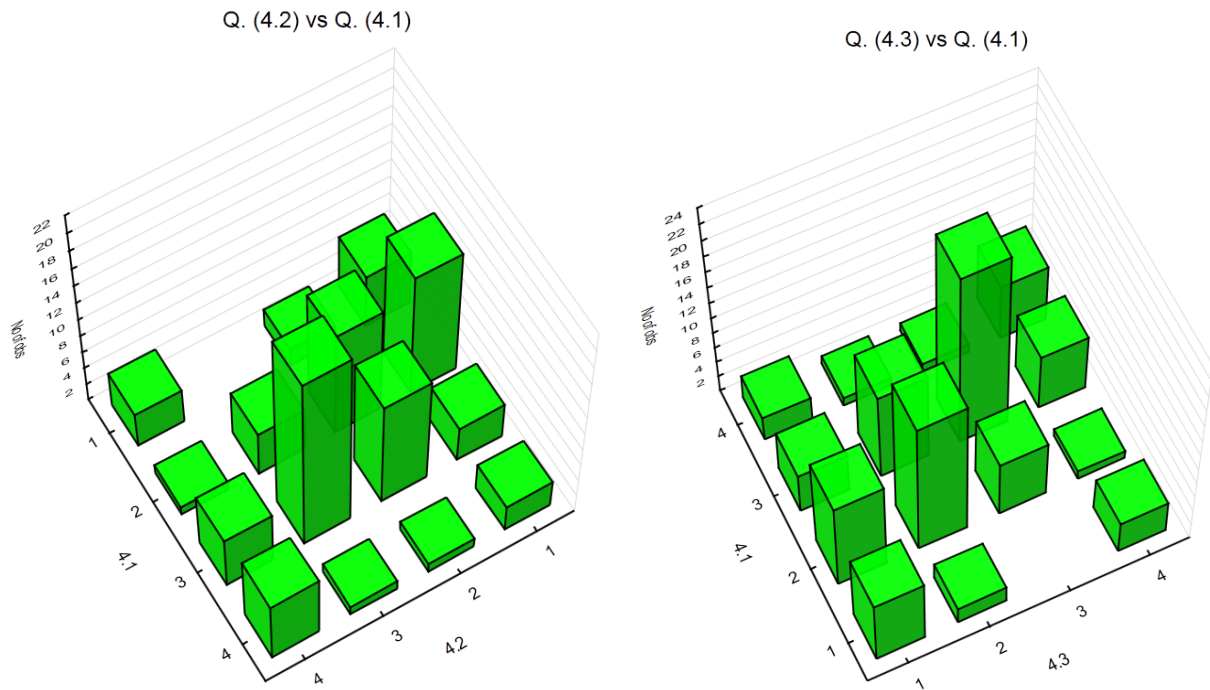


Figure 4.20: Bivariate histogram of Q.(4.2) & Q.(4.3) vs. Q.(4.1)

Correlation Statistics: 4.1 vs 4.2

Statistical Model: Spearman's R

P - value = 1.682E-04

r value = 3.7

N = 98

Correlation Statistics: 4.1 vs 4.3

Statistical Model: Spearman's R

P - value = 7.611E-05

r value = 3.7

N = 107

Table 4.15: Response scale: Q.4.2 & Q.4.3 & Q.4.1

Q. (4.2) & (4.3)		Q. (4.1)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know
B	Not applicable		

Discussion of Figure 4.20:

Water treatment

Of the municipalities with "<50%/None" of the technical staff posts filled, 50% have "<50%/None" of the WTW operated by the appropriate number of staff. The percentages of the municipalities that have "Some(>50%)" of the technical posts filled and "<50%/None" or "Some(>50%)" of the treatment

works operated by appropriate number of staff are 43.7% and 37.5% respectively. This is already a good improvement and shows the municipality is moving in the right direction. Of the municipalities with "Most(>75%)" of the technical staff posts filled; 28.5% have "Some(>50%)" and 47.6% have "Most(>75%)" of the WTW operated by the appropriate number of staff. Consider the municipalities with all their organogram posts filled. They are the best at employing the required number of staff at all WTW, with 58.3% of them having all the WTW operated by the appropriate number of staff.

Wastewater treatment

The percentage of the municipalities with "<50%/None" of the technical staff posts filled and "<50%/None" of the WWTW operated by the appropriate number of staff is 57.1%. Consider the municipalities with "Some(>50%)" of the technical organogram posts filled; of them 30.5% have "<50%/None" and 47.2% have "Some(>50%)" of the WWTW operated by the appropriate number of staff. The performance of the municipalities continues to increase for appropriate number of staff employed as the percentage of technical organogram posts filled increases. Of the municipalities with all the technical organogram posts filled, 58.3% have all the WWTW operated by the correct number of staff.

Significance of relationship:

This correlation is expected due to operational staff being posts that should be included in the technical organogram. If posts in the technical staff organogram is not filled then it should be noticed in the technical staff capacity, as seen in the results from Figure 4.20. The filling of vacant organogram posts is a good place for a municipality to start with capacity building. It is worrying to see that so few municipalities have all the technical organogram posts filled, only 12%.

4.3.2 Areas influencing wastewater treatment works operational staff capacity

The following MuSSA questions investigated have significant impact on the staff capacity at WWTW. The questions will be discussed as to how they relate, and are significant to staff capacity at WWTW. MuSSA includes a question to investigate the staff skill levels at WWTW namely;

Q. 4.3 Are WWTW operated by the appropriate number of staff (as per Regulation 2834)?

Figure 4.16 shows the results of the statistical analysis of the MuSSA data, after engineering judgement has been applied. It is clear from Figures 4.15 and 4.16 that wastewater treatment staff capacity significantly correlates with more MuSSA questions than does water treatment, these areas unique to WWTW staff capacity will be discussed in this section. Question 4.3 had a "Not Applicable" option to its answers, and has been processed as explained in the research methodology and statistics chapters.

Q. 4.3 Are WWTW operated by the appropriate number of staff (as per Regulation 2834)?

vs.

Question 1.2 Do you have an appropriate Water Safety Plan and is it included within your IDP?

Discussion of Figure 4.21:

The percentage of municipalities that do not have a Water Safety Plan (WSP) and have "<50%/None" of WWTW operated by the appropriate number of staff is 46%. Those with a WSP in development show a tendency to have less than 75% of the WWTW operated by appropriate numbers of staff,

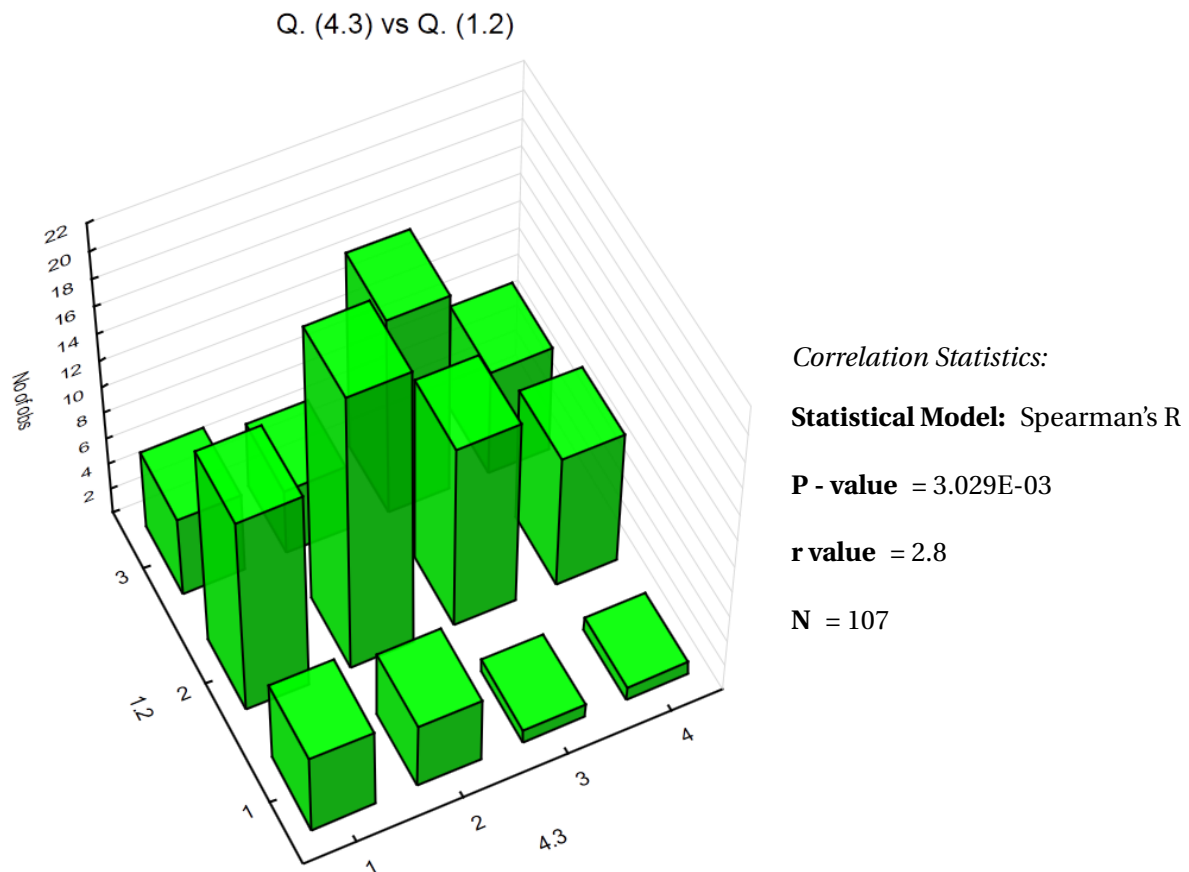


Figure 4.21: Bivariate histogram of Q.(4.3) vs. Q.(1.2)

Table 4.16: Response scale: Q.4.3 & Q.1.2

Q. (4.3)		Q. (1.2)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In development
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		
B	Not applicable		

35% of these municipalities indicated that they have "Some(>50%)" of the works operated by the appropriate number of staff. Of the municipalities with a fully developed and implemented WSP; 44.1% have "Most(>75%)" and 23.5% have all the WWTW operated by the appropriate number of staff. Those with a complete WSP implemented in the IDP show that they tend towards employing 75% of more sufficient operational staff. Water Safety Planning also showed a relatively strong relationship with WTW staff capacity at a P - value of 0.013.

Significance of relationship:

Water Safety Planning is a process which the municipality develops to ensure that the quality of water delivered will meet standards. A large portion of the WSP planning process is the identification of risks to the quality of the water sources. A risk faced by many South African municipalities is the

pollution of water sources due to wastewater treatment plants not operating at standards. Some of the reasons include infrastructure failure, but operator error has also been identified as one of the main reasons for failure [39; 2; 6]. Having a fully developed WSP and implementing it within the IDP will help to identify risks, such as pollution of water sources. This will draw attention to the need for adequate technical staff capacity. It is worrying to see that only 31.8% of the municipalities have a fully developed and integrated WSP, but encouraging to see that 56% have a WSP in development. It must be noted that question 1.2 also had a strong correlation with WTW operator staff capacity.

Q. 4.3 Are WWTW operated by the appropriate number of staff (as per Regulation 2834)?

vs.

Question 1.3 Do you have and up to date adopted Water Services Development Plan (WSDP) which you are implementing?

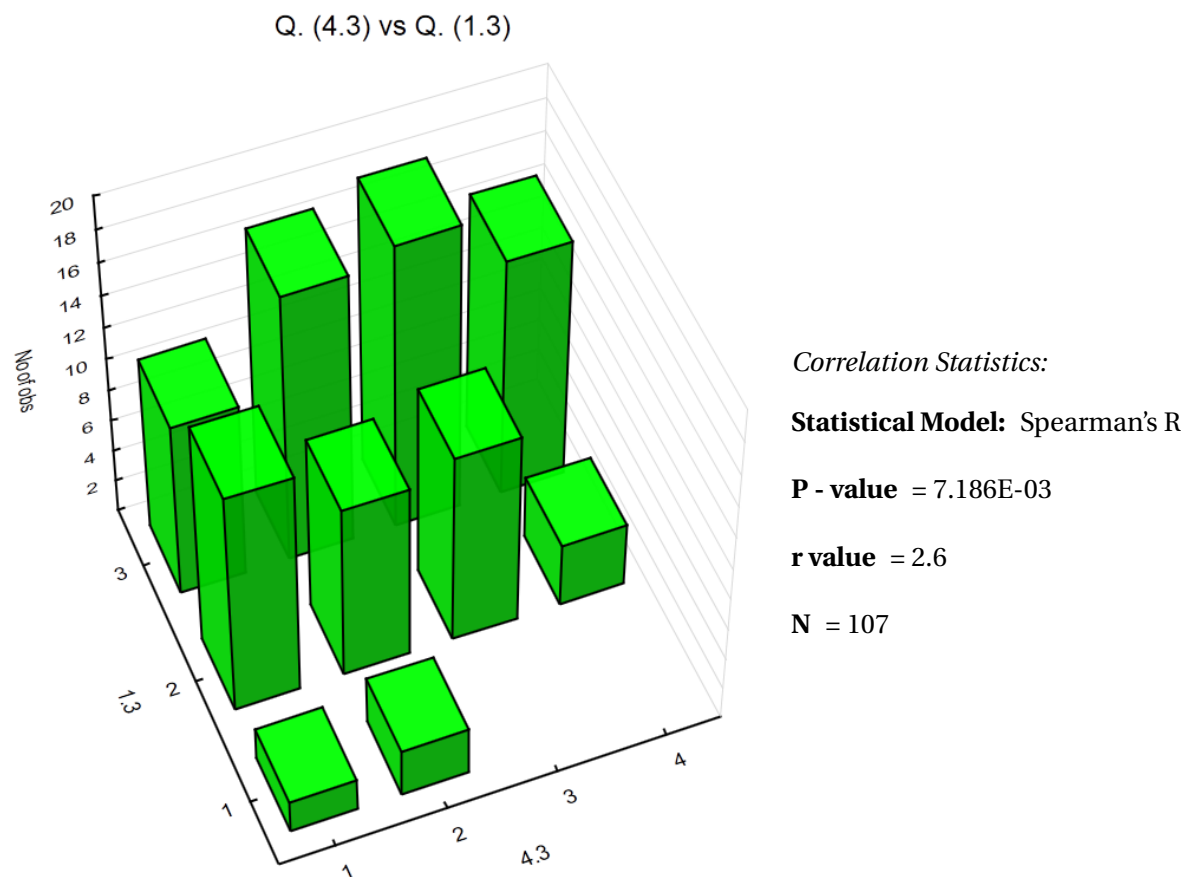


Figure 4.22: Bivariate histogram of Q.(4.3) vs. Q.(1.3)

Discussion of Figure 4.22:

Only 5 municipalities do not have a WSDP, and of these none were able to have 75% or more of WWTW operated by appropriate numbers of staff. Of the municipalities with a WSDP in development; 34.2% have "<50%/None" and 26.% have "Some(>50%)" of WWTW operated by appropriate

Table 4.17: Response scale: Q.4.3 & Q.1.3

Q. (4.3)		Q. (1.3)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In development
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		
B	Not applicable		

number of technical staff, while only 9.7% have all the treatment plants operated by appropriate numbers. The improvement from those with no WSDP, to those with a WSDP in development is noticeable in the increased number of municipalities that are able to have 75% or more of WWTW operated by the appropriate number of staff. Consider the municipalities with a fully developed WSDP; of them 27.8% have "Some(>50%)", 29.5% have "Most(>75%)" and 24.5% have all of the WWTW operated by the appropriate numbers of staff, they are even more capable than those in the development stage to employ more operational staff.

Significance of relationship:

WSDP is the planning process through which a municipal organization plans for future developments in its water and sanitation departments. During this planning process the organization set goals that it wishes to meet, and plans for resources that will be needed for the development of these goals. It is positive to see that only five municipalities have no WSDP and that a 57% majority have a fully updated WSDP, which they are implementing. Figure 4.22 shows that being in the development stage helps municipalities to realize the need for capacity building at WWTW, but they do not yet comprehend the urgency of the matter, as the majority are not yet employing sufficient staff. Municipalities that do have a fully developed WSDP do seem to realize that WWTW technical staff capacity building is an important issue, in terms of sanitation development, and tend to have at least more than 50% of their WWTW operated by the appropriate number of staff. Appointment of staff in the municipal environment is a timely tedious process and requires planning for future needs.

Q. 4.3 Are WWTW operated by the appropriate number of staff (as per Regulation 2834)?

vs.

Question 2.4 Is appropriate water services skill development/training for managers regularly attended?

Discussion of Figure 4.23:

The percentages of the municipalities not doing service development training on managers and with "<50%/None" or "Some(>50%)" of the WWTW operated by the appropriate number of staff are 34.8% and 34.8% respectively. 61.7% of municipalities reported that they were not doing in service development training on managers, and they struggle to have more than 75% of WWTW operated by the appropriate number of staff. Of the municipalities doing service development training on managers,

Q. (4.3) vs Q. (2.4)

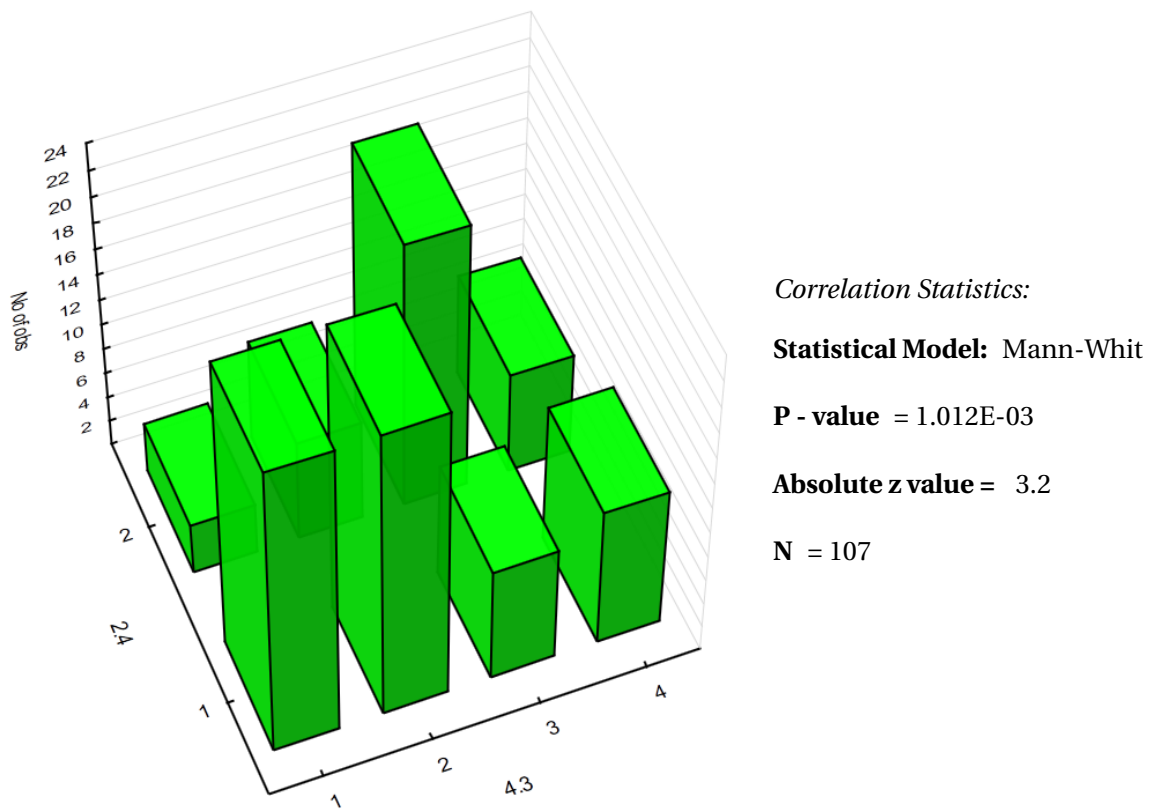


Figure 4.23: Bivariate histogram of Q.(4.3) vs. Q.(2.4)

Table 4.18: Response scale: Q.4.3 & Q.2.4

Q. (4.3)		Q. (2.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		
B	Not applicable		

51.2% have "Most(>75%)" of the WWTW operated by the appropriate number of technical staff. Water service development training of managers also strongly correlated with the WTW technical staff capacity at a P - value of 0.0102, which is just outside the range for discussion for the purpose of this paper.

Significance of relationship:

It has already been proven in the previous sections that technical management skill level has a significant affect, not only on lower level technical capacity building, but also skills development of operational staff. Development of technical managements skills in the area of water service development educates them about the importance of technical skills capacity building and, as seen from Figure 4.23, will help them to encourage good practice within the organization. It is very encourag-

ing to note that those municipalities who are performing skills development on managers are able to better manage the development technical skills.

Q. 4.3 Are WWTW operated by the appropriate number of staff (as per Regulation 2834)?

vs.

Question 9.4 Do you have appropriate budget and staff for you IAM Program?

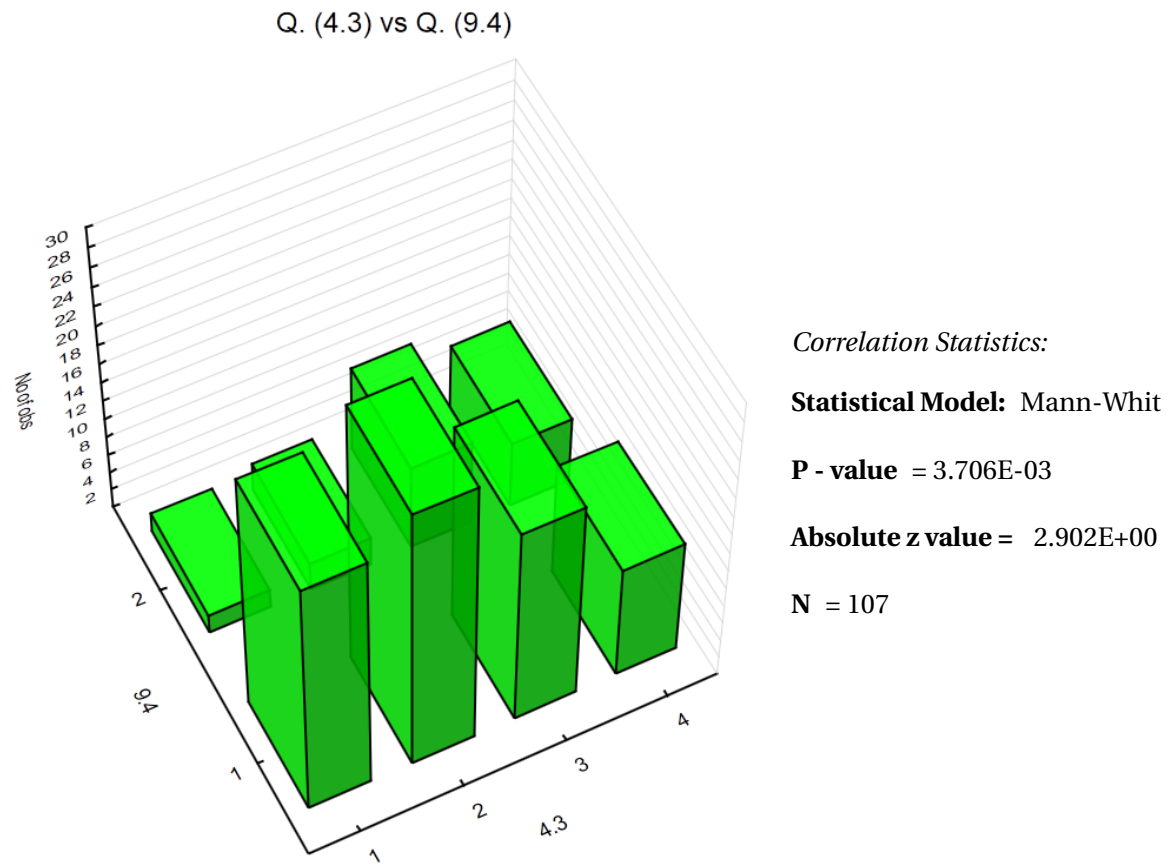


Figure 4.24: Bivariate histogram of Q.(4.3) vs. Q.(9.4)

Table 4.19: Response scale: Q.4.3 & Q.9.4

Q. (4.3)		Q. (9.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		
B	Not applicable		

Discussion of Figure 4.24:

Of the municipalities with insufficient IAM budgets; 29% have "<50%/None", 32.5% have "Some(>50%)" and 24.4% have "Most(>75%)" of WWTW operated by the appropriate number of staff. 80.3% of the municipalities indicated that they do not have appropriate budgets and staff for IAM, and they generally perform on the lower end in terms of employing sufficient operational staff at WWTW. Of the municipalities with sufficient IAM budgets; 42.9% have "Most(>75%)" and 33.3% have "All(100%)" of the WWTW operated by the correct number of staff.

Significance of relationship:

Having staff to do in-house day to day maintenance on equipment and infrastructure at treatment plants is an IAM necessity. The appointment of such staff is reliant on the budgeting for such posts in the technical organogram. Proper IAM budgeting is essential to ensure the appointment of sufficient technical staff to perform day to day operations on treatment plants. The out sourcing of maintenance work is an option, but there still remains a need for maintenance staff employed at treatment works to perform every day maintenance tasks.

4.3.3 A summary of significant influencing water and wastewater treatment works staff capacity levels

Vast growth has taken place in the provision of basic water and sanitation service in South Africa, and we should be proud of the progress made. The restructuring of municipalities has however created capacity problems, not only at higher level management, but also at ground level operations[2, p.10]. With huge reductions in staff numbers over the last ten to fifteen years, and growth in the areas and number of persons served by municipalities, capacity building must take priority in municipalities. The MuSSA data analysis revealed three business attribute areas that have a significant influence on both water and wastewater treatment operational staff, and the relevant questions under each of the attribute areas are summarized as follows;

1. Management skill level technical

In many cases political appointees have taken over the roles of technical managers, believing that anyone with management qualifications or experience can manage a municipality. This belief is wrong[6, p.199]. The importance of technical management staff skill and experience in the field of municipal management is of utter importance, and has been proven by the data. The percentage skilled and experience technical management staff strongly influences the percentage of treatment works operated by the appropriate number of technical staff. It is evident that municipalities not having at least 75% of their technical management organogram posts filled have a very slim chance at having the management capacity to devote time and energy towards technical operations staff capacity building. The few remaining technical managers just simply can not handle the enormous workload that they face[2]. The result being the miserable failure of municipalities in the area of basic services [2].

2. Staff skill level technical

The MuSSA data has shown that water and wastewater treatment works operated by skilled and experienced staff will most likely also be operated by the appropriate number of technical staff. This can be attributed to two things (i) skilled and experienced staff will be able to identify staff shortages and will notify superiors of the situation to be addressed, (ii) a municipality with the technical management skill and capacity able to appoint skilled operators will also be able to appoint the appropriate number of technical staff, in other words the presence of good or bad practice through out the organization.

3. Technical staff capacity

The first place that a municipality should start in terms of capacity building of its technical operational staff is the filling of vacant organogram posts. The results showed a significant increase in the number of treatment works operated by the appropriate number, or at least increasing number of technical staff, as the number of technical staff posts in the organizational organogram filled reached 75% or more.

From Figure 4.16 it can be seen that WWTW staff capacity correlates strongly with four extra MuSSA questions compared to WTW staff capacity. These four questions fall under three business attribute areas, and have been summarized below. These questions also have relatively strong correlations with WTW staff capacity, even though the statistical level of significance was not above the research threshold value. They should therefore also be considered in the capacity building process of WTW operational staff.

1. Water service planning

Municipalities not having a WSP are failing miserably to plan for future needs, in terms of WWTW technical operational staff, and it shows in the current state that they are in, as reported by the 2011 SAICE Infrastructure Report Card for South Africa. The data also revealed that, even though the majority of municipalities only have a WSP in development, there is a need to have a fully developed WSP and implemented in the IDP to work towards success. The final step of the planning takes place in the IDP, and is essential to addressing identified issues. Municipalities with a fully developed and implemented WSP are performing much better in terms of technical staff capacity building. The exact same observation was made for the Water Service Development Planning (WSDP). Municipalities need to move beyond the development stage of the planning process and implement the strategies in order for them to move forward, especially speaking in terms of capacity building.

2. Management skill level technical

It has been mentioned that the skill of technical management staff plays an important role in the functionality of a municipality. Due to the fact that South Africa has limited resources of skilled technical personnel, municipalities need to develop the skills of the individuals at hand. This not only shows good practice, but will also allow them to make better technical decisions in the future and help develop the understanding of the importance of technical operational staff capacity.

3. Infrastructure asset management

In house infrastructure maintenance is essential to ensure the well being of treatment plants. A component of the WWTW and WTW staff must be maintenance staff. Lacking staff budgets and skilled personnel has resulted in municipalities outsourcing day to day maintenance activities. This has led to an administrative nightmare. Proper IAM staff is crucial to the sustainability of the water and wastewater service delivery sector.

Chapter 5

Non-revenue water (NRW)

Revenue is essential to the operation and sustainability of any organization or business, and municipalities are no exception. Industry and experts are concerned with the current trend of municipalities not collecting sufficient revenue for the services delivered. This has led to the majority of municipalities becoming reliant on government grants, which is not a sustainable or healthy business indication.

In the following section it will be attempted to determine the contribution of each of the 16 key business attribute areas to non-revenue water (NRW) in the South African context. In order to help minimize revenue lost, non-revenue water must be minimized within municipalities. To achieve this it must first be known what influences NRW in the South African municipal context. The MuSSA questions address two aspects with relevance to non-revenue water namely: (i) unaccounted for water and (ii) percentage metered and billed connections. Results from statistical analysis of the data indicate that both (i) and (ii) have a significant relationship with "acceptable" revenue collection in municipalities, as shown in Figure C.1. Figure C.1 was constructed by way of expert opinion and engineering logic as described in the research methodology chapter. The key MuSSA business attribute area investigated in depth in this chapter is water conservation & demand management. The questions with significant influencing correlations to the two questions falling under water conservation and demand management investigating NRW are the focus of this chapter.

5.1 Non-revenue water (NRW): MuSSA output

The 2011 MuSSA analysis as described in Chapter 2.5 was extensive and covered 16 business attributes regarding the South African municipal environment and its functionality. One of the business attributes covered is water conservation & demand management (WCDM). Two questions are of interest in the MuSSA analysis under WCDM.

1. Q.(6.2) What is the percentage Unaccounted for Water?
This question refers to the area defined as non-revenue water in Figure 2.4.
2. Q.(6.3) What percentage of connections are metered and billed (residential and non-residential (commercial, industrial, etc.)?)

A municipality's response to question 6.3 reveals insight into billed and unbilled metered consumption as defined in Figure 2.4.

These questions relate to (1)NRW and (2)billed and unbilled authorized consumption as defined by the IWA Water Balance in Figure 2.4. Question 6.2 from the MuSSA data reveals the percentage NRW and takes into account all the areas of NRW as indicated in Figure 2.4. Subsection 5.1.1 discusses all the areas that have a significant influence on question 6.2. It is desirable to have the majority of authorized consumption as metered and billed as billed consumption, as this would create a healthy business environment. Unmetered billing of clients is a way of operating but in many cases it is the root cause of conflict between clients and service providers. Unmetered billing has the potential to create a negative image towards the organization and can cultivate a culture of reluctance to pay debts. Key words in question 6.3 of the MuSSA data are metered *and* billed. Metering of water delivered, lacking the billing for services delivered yields no revenue. Subsection 5.1.2 will briefly discuss the contribution of metering and billing to NRW, and what areas must be addressed according to the MuSSA data to enhance metering and billing. It is believed that with a good knowledge of the overall functioning, and influencing factors of questions 6.2 and 6.3 of the MuSSA data, a municipal organization's ability to improve its NRW status and revenue collection will drastically increase, as explored in the following sections of this chapter.

5.1.1 The percentage unaccounted for water

Question 6.2, as previously mentioned in Section 5.1, refers to the percentage NRW the municipality is operating at. The statistical analysis of the MuSSA data has yielded several correlations with question 6.2. Figure 5.1 illustrates these correlations and their interactions. Each correlation has been carefully considered to classify its relationship with 6.2 as being a contributing or influencing factor or having an uncertain relationship, hence the structure and flow of Figure 5.1. For more detail on the classification of analysis results refer to Section 3.3.4. The significant correlating questions that were classified as uncertain in Figure 5.1 are either due to partial correlation or circumstantial correlations resulting from the nature of the data, as explained in Chapter 3.

In the following section, each question significantly correlating and influencing question 6.2 will be presented in a bivariate histogram. The histogram is a summary of the number of observations for each combination of answers from the sample of municipalities. Each histogram is accompanied by a table indicating the possible responses to each of the questions involved and statistical information.

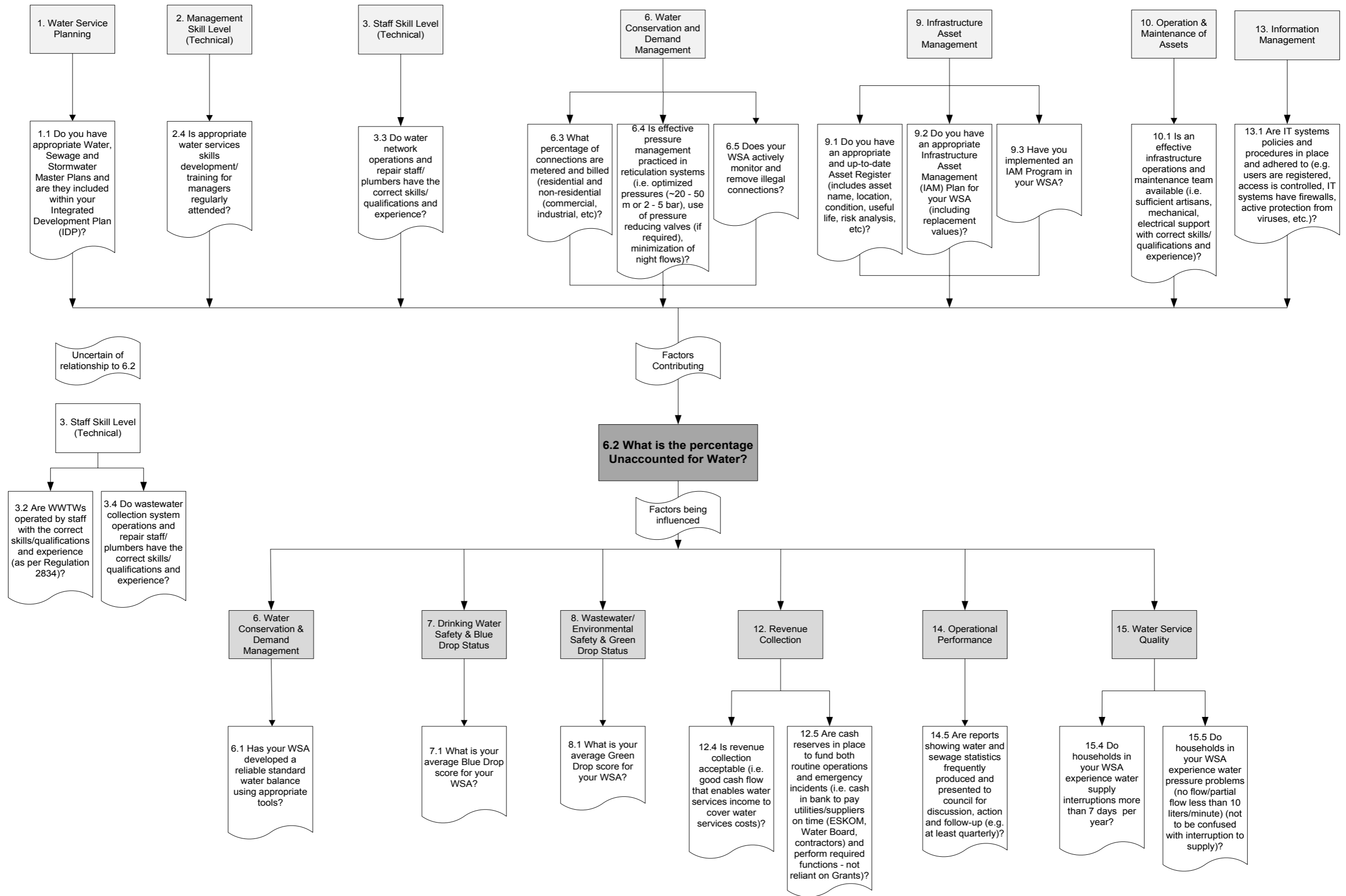


Figure 5.1: What is the percentage unaccounted for water?: MuSSA Model.

5.1.1.1 Areas influencing the percentage unaccounted for water

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 1.1 Do you have appropriate Water, Sewage and Storm water Master Plans and are they included in your Integrated Development Plan (IDP)?

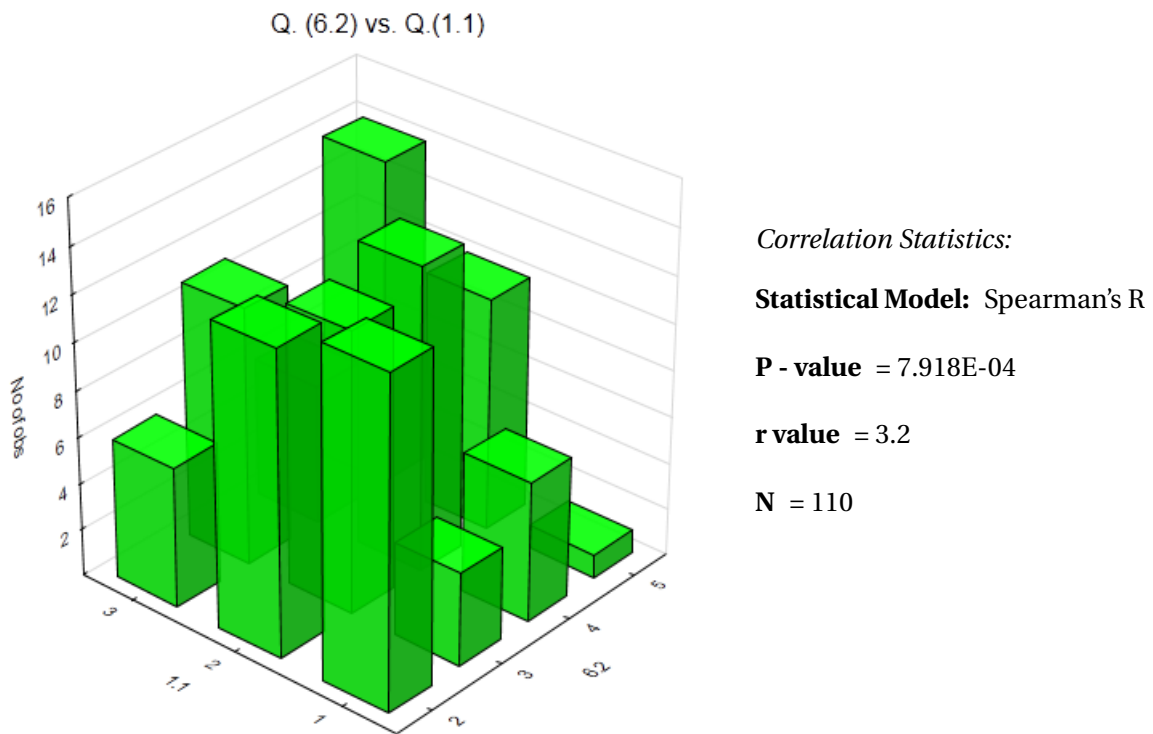


Figure 5.2: Bivariate histogram of Q.(6.2) vs. Q.(1.1)

Table 5.1: Response scale: Q.6.2 & Q.1.1

Q. (6.2)		Q (1.1)	
Score	Response	Score	Response
5	Less than 20%	3	Yes, strongly agree
4	Less than 30%	2	In development
3	Less than 40%	1	No, disagree/Don't know
2	Don't know		

Discussion of Figure 5.2:

Municipalities that responded "No,disagree" with regards to Master Plans scored "1" for Q. 1.1. Of those scoring "1" for the Master Plans, 56% responded "Don't Know" when asked what is their percentage unaccounted for water, as shown in Figure 5.2. Of the municipalities who did have Master Plans and implemented them in their IDP's, 40% of them kept NRW below 20%, while a further 45% have a NRW percentage below 40%. Municipalities with Master Plans in the development stage

showed no tendency towards the reduction or increase of NRW percentages, as seen from Figure 5.2 by the small variations in NRW percentage.

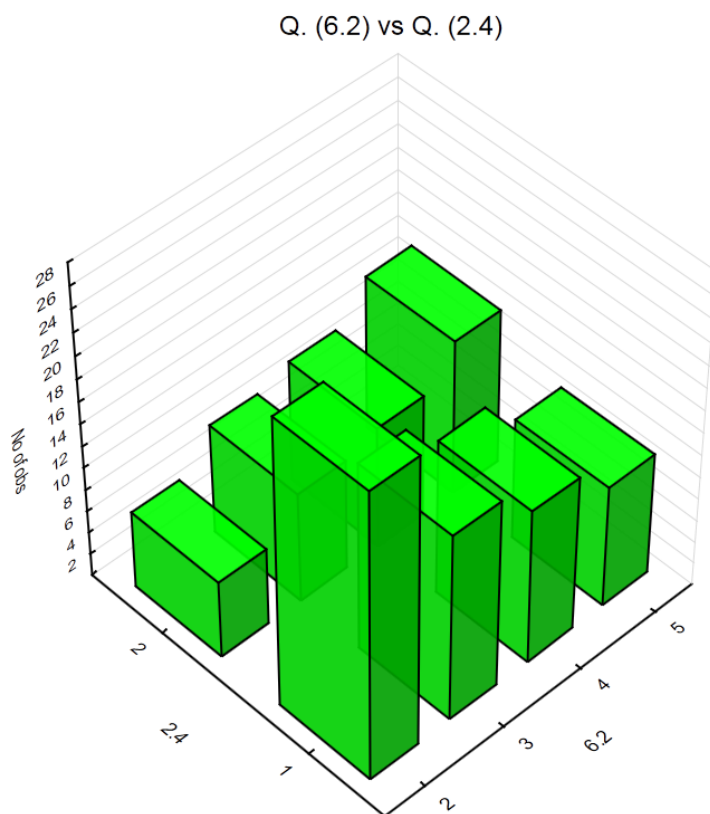
Significance of relationship:

The results show that after completing and implementing Master Plans municipalities will be more capable of reducing NRW. On the contrary, the cases that don't have Master Plans will most likely not know what the amount of revenue lost is resulting from NRW. The development but also completion and implementation of Master Plans are critical in reducing NRW in South Africa. It is important that the Master Plans do not become stagnant at the development stage, as this will not enhance the municipalities capability to reduce NRW. It must be mentioned that 48 of the 110 municipalities were in the development stage.

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 2.4 Is appropriate water services skills development/training for managers regular attended?



Correlation Statistics:

Statistical Model: Mann-Whit

P - value = 7.793E-03

Absolute z value = 2.7

N = 110

Figure 5.3: Bivariate histogram of Q.(2.4) vs. Q.(6.2)

Discussion of Figure 5.3:

Management skill levels and development training seems to have a significant impact on NRW. Of the municipalities who don't perform skills development training on managers, 40% don't know the

Table 5.2: Response scale: Q.6.2 & Q.2.4

Q. (6.2)		Q. (2.4)	
Score	Response	Score	Response
5	Less than 20%	2	Yes, strongly agree
4	Less than 30%	1	No, disagree/Don't know
3	Less than 40%		
2	Don't know		

percentage NRW. Figure 5.3 indicates that of the municipalities who do perform training and development on managers, 59.5% have a NRW percentage below 30%. While of those not performing training only 37% have a NRW percentage below 30%, this is half the percentage of those performing training.

Significance of relationship:

Water service skills development of managers has a direct affect on NRW performance, and can be seen as an essential requirement to help improve the NRW status of municipalities. It is believed that in most cases the skills and development of higher management staff are reflected in operational staff. Therefore, if management staff are well trained they will be capable of taking responsibility for assigning tasks and the appointment of appropriate personnel.

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 3.3 Do water network operations and repair staff/plumbers have the correct skills/qualifications and experience?

Table 5.3: Response scale: Q.6.2 & Q.3.3

Q. (6.2)		Q. (3.3)	
Score	Response	Score	Response
5	Less than 20%	4	Yes, All (i.e. 100%)
4	Less than 30%	3	Most (i.e. >75%)
3	Less than 40%	2	Some (i.e. > 50%)
2	Don't know	1	< 50%/None/Don't know

Discussion of Figure 5.4:

Figure 5.4 shows the contribution of quality craftsmanship to the reduction of NRW percentages in the form of repair staff to water networks. Of the municipalities with "<50%/None" of the network staff having the correct skills and experience, 52.1% could not report on the percentage NRW and only 4.3% could achieve a NRW status of less than 20%. Municipalities that have "Most(>75%) or all of the staff experienced and skilled have a 65% success rate in achieving a NRW status of less than 30%, a vast improvement on those with only "Some(>50%)" operational staff skilled.

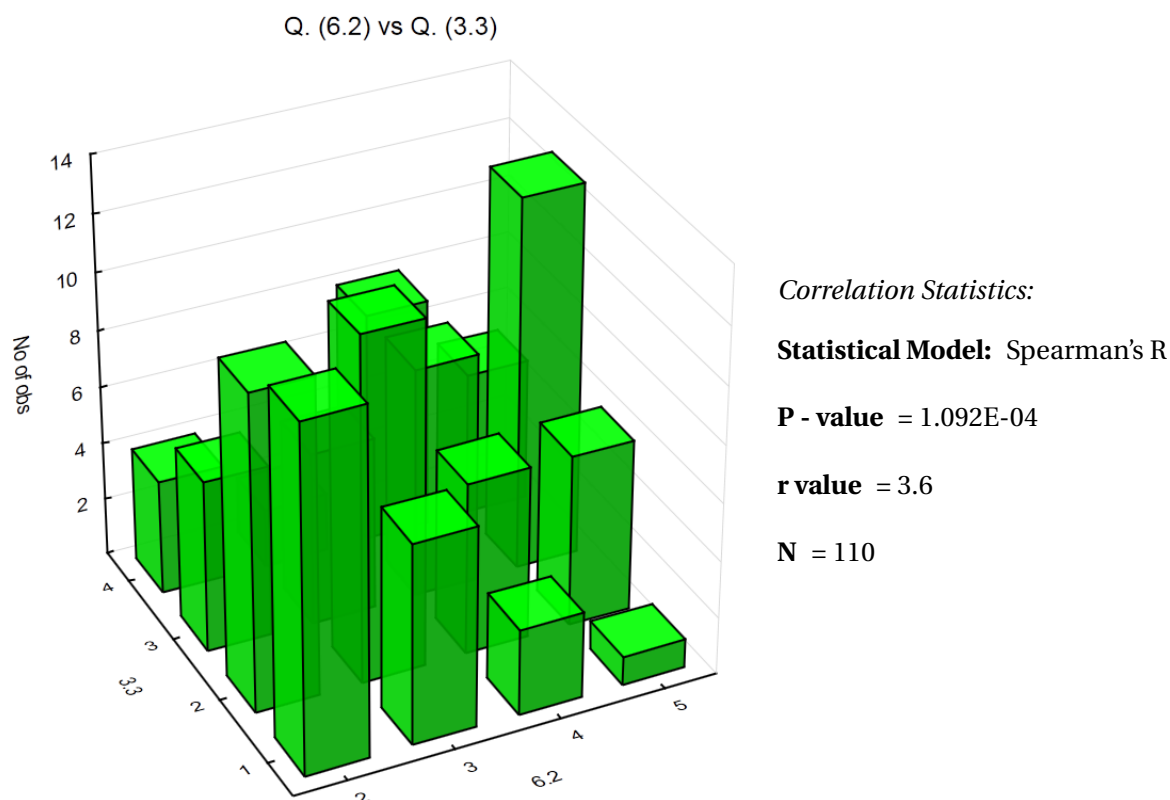


Figure 5.4: Bivariate histogram of Q. (6.2) vs. Q.(3.3)

Significance of relationship:

It is of no surprise that the relationship between network repair staff's skills and NRW is very significant. The repair of leaks and maintenance of water networks has become a backlog issue in South Africa, and it is visible from the countries NRW status. It is of utter importance that municipalities employ staff that are capable of performing their duties in order to reduce NRW, especially in the form of leakages, illegal connections and replacement of aging infrastructure such as pipes and meters.

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 6.3 What percentage of connections are metered and billed (residential and non-residential (commercial, industrial, etc))?

Discussion of Figure 5.5:

It is clear from Figure 5.5 that in the cases where no metering and billing is taking place, 90% of municipalities responded that they did not know the percentage unaccounted for water. Surprisingly Figure 5.5 shows that there is a large portion of municipalities falling in the 75% to 98% for percentage connections metered and billed not knowing their percentage NRW, this might be due to a lack of commitment from management to reduce NRW. Of the municipalities who do meter and bill more than 98% of their connections, 55.5% have a NRW percentage of less than 20%. This is a great indi-

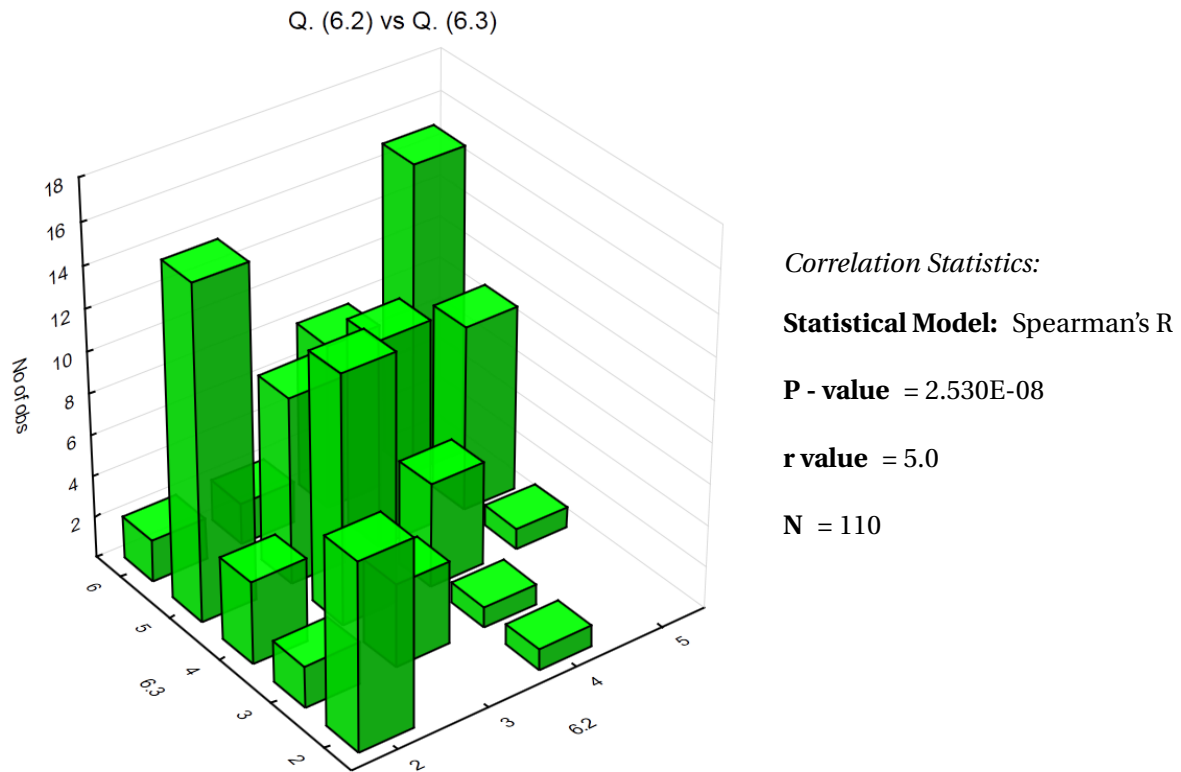


Figure 5.5: Bivariate histogram of Q. (6.2) vs. Q.(6.3)

Table 5.4: Response scale: Q.6.2 & Q.6.3

Q. (6.2)		Q. (6.3)	
Score	Response	Score	Response
5	Less than 20%	6	>98%
4	Less than 30%	5	75 - 98%
3	Less than 40%	4	50 - 75%
2	Don't know	3	<50%
		2	No metering/Don't know

cation that metering and billing of connections helps reduce NRW.

Significance of relationship:

Measurement should be one of the first steps towards improvement of a benchmark, without measurement there is no means by which to gauge success or failure of a system. It is evident from Figure 5.5 that municipalities must meter connections to be able to know their NRW status. Once this has been achieved it will be possible to strive towards improvement. However, metering alone will not improve NRW. Once a client has been metered it is essential that proper billing be performed for the service delivered to ensure income for the municipality.

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 6.4 Is effective pressure management practised in reticulation systems (i.e. optimized

pressure (20 - 50 m or 2 - 5 bar), use of pressure reducing valves (if required), minimization of night flows)?

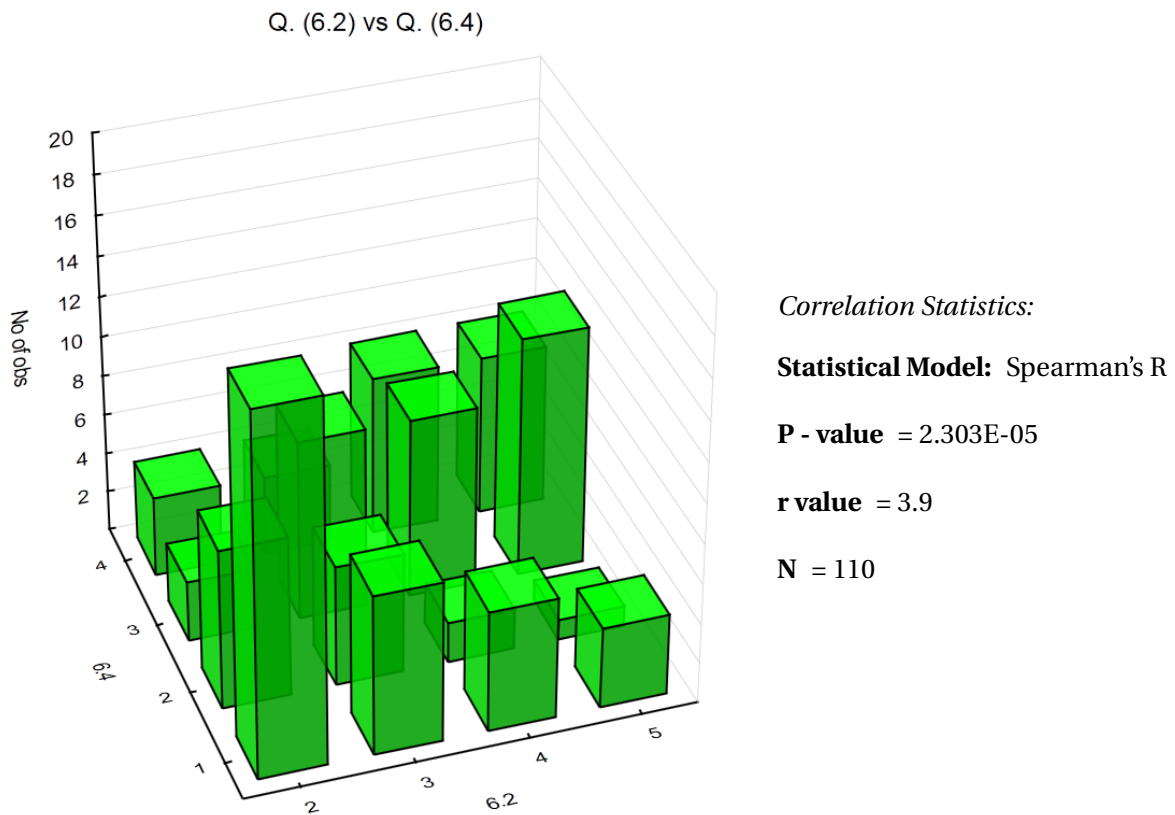


Figure 5.6: Bivariate histogram of Q. (6.2) vs. Q.(6.4)

Table 5.5: Response scale: Q.6.2 & Q.6.4

Q. (6.2)		Q. (6.4)	
Score	Response	Score	Response
5	Less than 20%	4	Yes, All (i.e. 100%)
4	Less than 30%	3	Most (i.e. >75%)
3	Less than 40%	2	Some (i.e. > 50%)
2	Don't know	1	< 50%/None/Don't know

Discussion of Figure 5.6:

Consider the municipalities responding "<50%/None" to the practicing of pressure management on reticulation systems; 50% of them did not know the percentage NRW while only 16.6% and 11.1% could achieve NRW statuses of less than 30% and less than 20% respectively. The same trend is visible for municipalities only performing pressure management on "Some(>50%)" of reticulation systems, with the majority either not knowing the percentage NRW (47%) or only achieving less than

40% NRW (27.2%). Of the municipalities practicing pressure management on "Most(>75%)" of reticulation systems; 27% have NRW percentage less than 30%, 36% have NRW percentage less than 20% and only 9% of them do not know their NRW status. The similar trend is visible for those practising pressure management on "All(100%)" reticulation systems with 33.3%, 33.3%, 16.6% and 16.6% with NRW statuses of less than 20%, 30%, 40% and "Don't know" respectively. The practicing of pressure management on all reticulation systems significantly increases the potential of a municipality to reduce NRW percentages to below 20% and 30%.

Significance of relationship:

Pressure management is an effective water loss reduction tool in reticulation systems, and its impact on the reduction of NRW is evident from the results in Figure 5.6. The reduction of NRW will mostly occur in the form of leak reductions. Night flows are reduced and sequentially leaks are minimized when distribution networks fail and often go unnoticed until morning hours, if not monitored. It is very important to perform pressure management on all reticulation systems to help reduce NRW.

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 6.5 Does your WSA actively monitor and remove illegal connections?

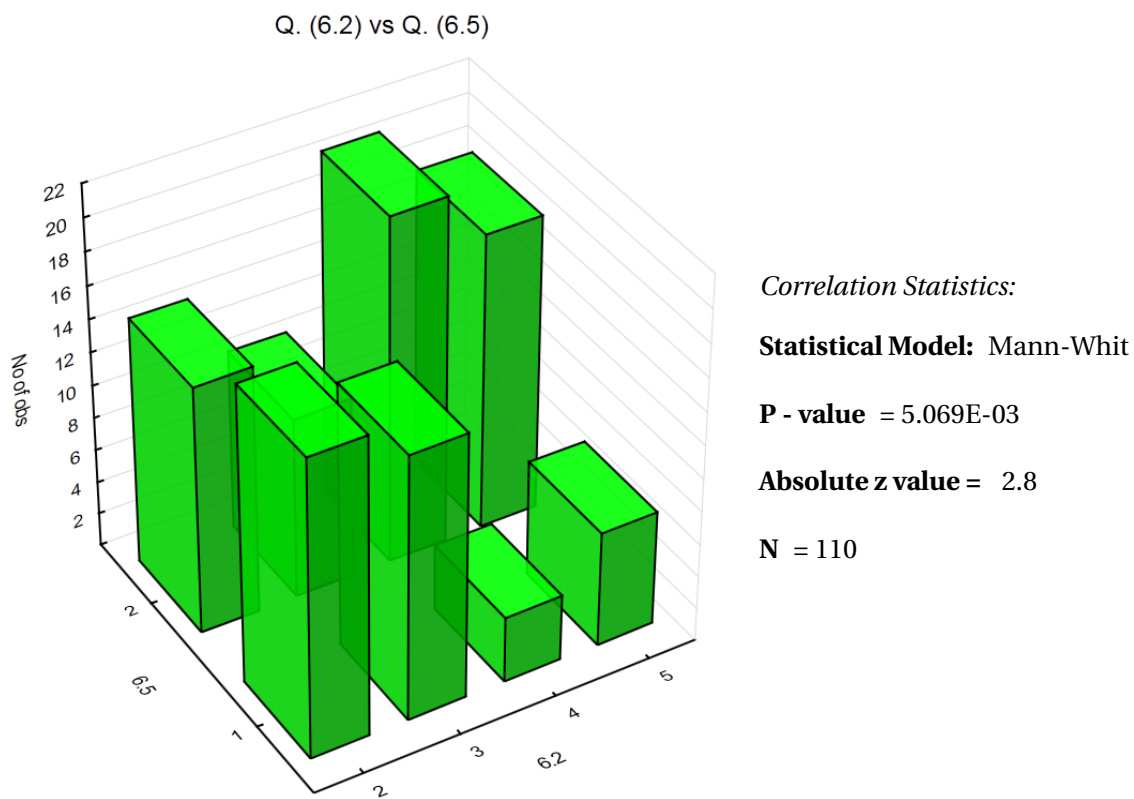


Figure 5.7: Bivariate histogram of Q.(6.2) vs. Q.(6.5)

Table 5.6: Response scale: Q.6.2 & Q.6.5

Q. (6.2)		Q. (6.5)	
Score	Response	Score	Response
5	Less than 20%	2	Yes, strongly agree
4	Less than 30%	1	No, disagree/Don't know
3	Less than 40%		
2	Don't know		

Discussion of Figure 5.7:

Monitoring and removal of illegal connections have a significant affect on NRW. Of the municipalities not performing monitoring and removal of illegal connections, 75% did either not know their NRW status (35%) or could only achieve less than 40% NRW (40%). Of the municipalities that do monitor and remove illegal connections, 65% have a NRW percentage below 30%. This shows the significant impact the removal of illegal connections has on the reduction of NRW.

Significance of relationship:

Although provision of a basic water supply is a human right, many communities still connect illegally to networks. Due to the acceptance thereof very few people from the community report these activities. Municipalities need to perform monitoring of illegal connections, but also in conjunction remove these connections. To help the process of the removal of illegal connections it is suggested that ways should be found for the community to become more actively involved.

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 9.1 Do you have an appropriate and up-to-date Asset Register (includes asset name, location, condition, useful life, risk analysis etc.)?

Table 5.7: Response scale: Q.6.2 & Q.9.1

Q. (6.2)		Q. (9.1)	
Score	Response	Score	Response
5	Less than 20%	3	Yes, strongly agree
4	Less than 30%	2	In development
3	Less than 40%	1	No, disagree/Don't know
2	Don't know		

Discussion of Figure 5.8:

It is clear from Figure 5.8 that the majority municipalities lacking asset registers either did not know their NRW status or performed poorly in terms of NRW. There are very few municipalities, 11 of the sample, where asset registers are still under development, of these 18% did not know their NRW status while 45% have more than 30% NRW. Municipalities developing asset registers show no clear

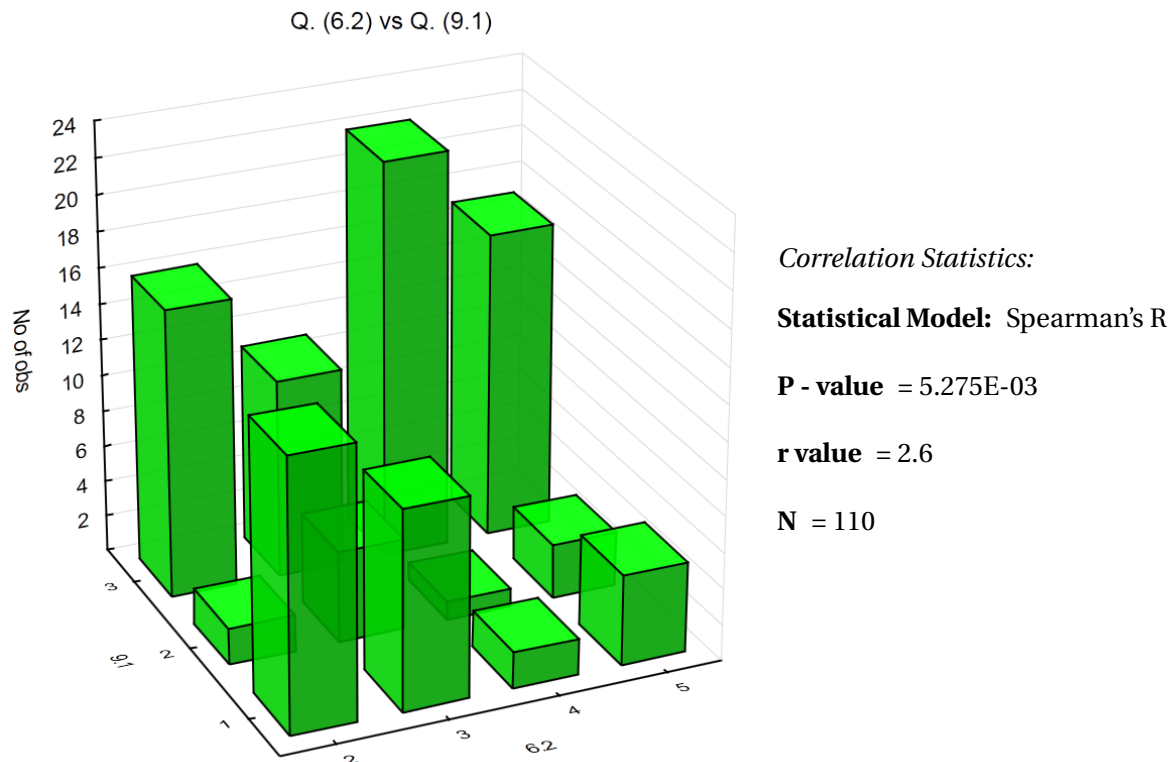


Figure 5.8: Bivariate histogram of Q.(6.2) vs. Q.(9.1)

improvement in reducing NRW. Figure 5.8 shows that of the municipalities having a complete asset register, 58% reported a NRW status of less than 30%.

Significance of relationship:

It is no secret that South Africa is confronted with the issue of aging infrastructure. The timely replacement of infrastructure, critical to NRW reduction is of utmost importance. One of these components are water meters. Aging meters tend to under measure and results in up to a 30% revenue loss [23]. This highlights the importance of having the remaining useful life as part of the asset register, allowing replacement or refurbishment of components that require such action at known time intervals. A proper asset register will enhance the capabilities of a municipality to reduce NRW.

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 9.2 Do you have an appropriate Infrastructure Asset Management (IAM) Plan for your WSA (including replacement values)?

Discussion of Figure 5.9:

From Figure 5.9 it can be seen that the lack of an IAM plan drastically decreases a municipality's ability to reduce NRW. Of the municipalities not having an IAM plan; 47% did not know their percentage NRW, while only 26% could achieve a NRW status less than 30% (includes less than 20%). In the cases where an IAM plan is in development it is clearly a step in the right direction, with the percentage of

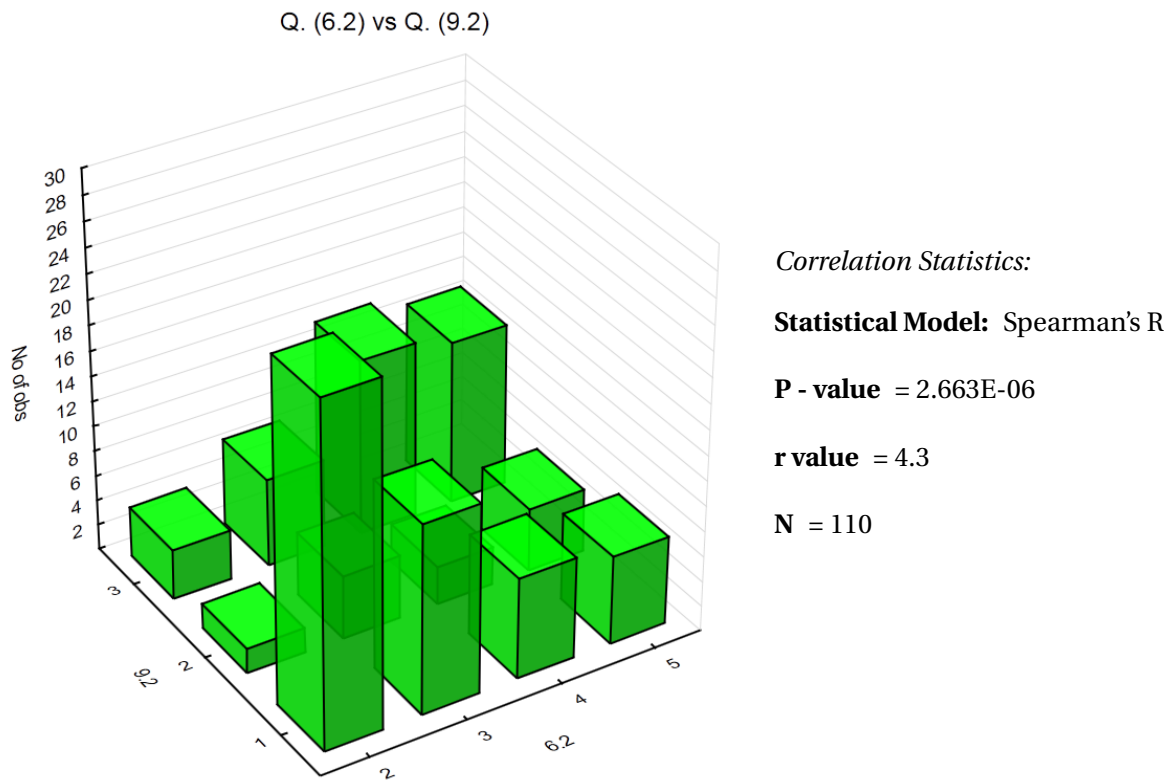


Figure 5.9: Bivariate histogram of Q.(6.2) vs. Q.(9.2)

Table 5.8: Response scale: Q.6.2 & Q.9.2

Q. (6.2)		Q. (9.2)	
Score	Response	Score	Response
5	Less than 20%	3	Yes, strongly agree
4	Less than 30%	2	In development
3	Less than 40%	1	No, disagree/Don't know
2	Don't know		

municipalities not knowing their NRW status dropping to 13%. A significant impact is noticed in the cases where complete IAM plans are in place, of these municipalities 71% achieved a NRW percentage below 30%.

Significance of relationship:

As previously mentioned, South Africa is facing the issue of aging infrastructure and the mismanagement of the existing infrastructure in the past decade [2; 1; 44]. Major leakages occur from aged pipelines that have surpassed useful lives and also failing storage infrastructure[44]. The development of a complete IAM plan plays a major role in the reduction of NRW in municipalities through the improved management of existing infrastructure, allowing quality service delivery and improved revenue collection.

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 9.3 Have you implemented an IAM Program in you WSA?

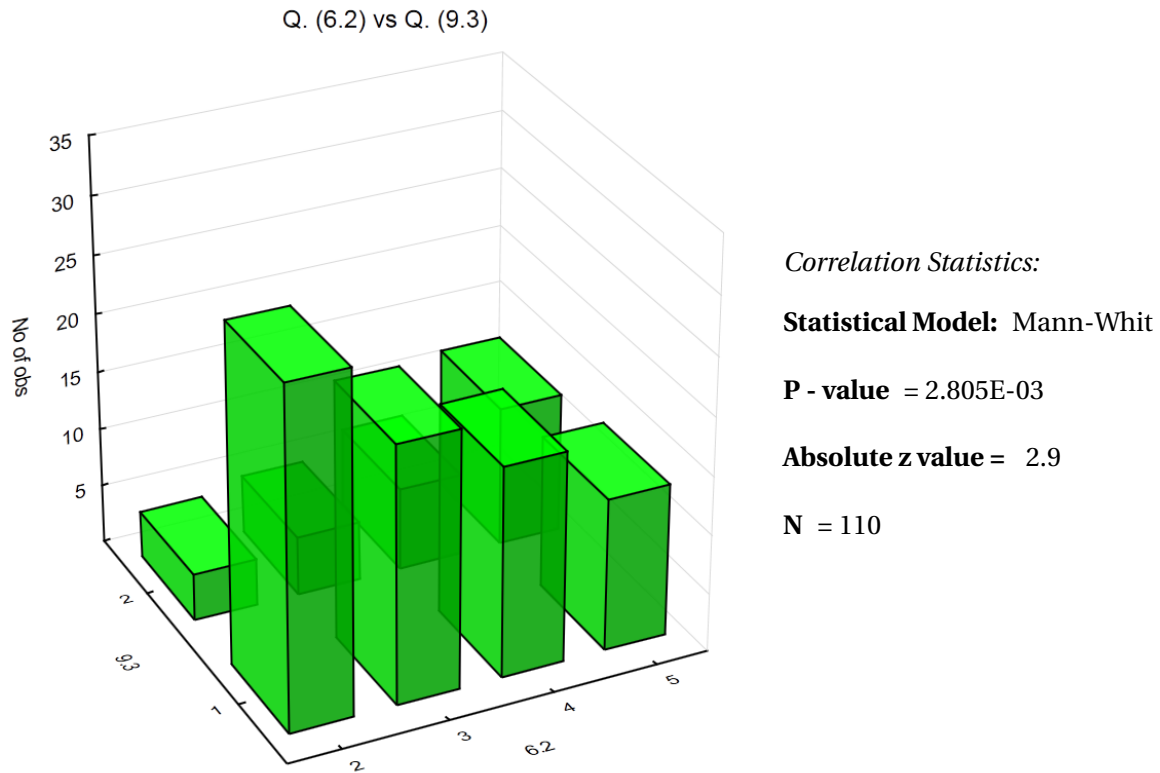


Figure 5.10: Bivariate histogram of Q.(6.2) vs. Q.(9.3)

Table 5.9: Response scale: Q.6.2 & Q.9.3

Q. (6.2)		Q. (9.3)	
Score	Response	Score	Response
5	Less than 20%	2	Yes, strongly agree
4	Less than 30%	1	No, disagree/Don't know
3	Less than 40%		
2	Don't know		

Discussion of Figure 5.10:

Of the municipalities that implemented an IAM program 67% have a NRW percentage below 30% (includes less than 20%). Of those not implementing an IAM program only 37% could achieve this level of NRW status. Of the municipalities not implementing an IAM program, 35% are unable (responded "Don't know") to report the percentage NRW. The responses to question 9.3 also indicates that few municipalities implement IAM programs, only 28 of the 110 municipalities in the sample implemented an IAM program. Of the municipalities implementing an IAM program, 42.8% achieved a NRW status less than 20% which is a significant achievement.

Significance of relationship:

The maintenance of infrastructure is essential to the sustainability of a municipality, and can only be done if an IAM program is implemented. Implementation of an IAM program increases a municipalities ability to reduce its NRW, while the lack thereof drastically reduces the ability to improve NRW status.

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 10.1 Is an effective infrastructure operations and maintenance team available (i.e. sufficient artisans, mechanical and electrical support with correct skills/qualifications and experience)?

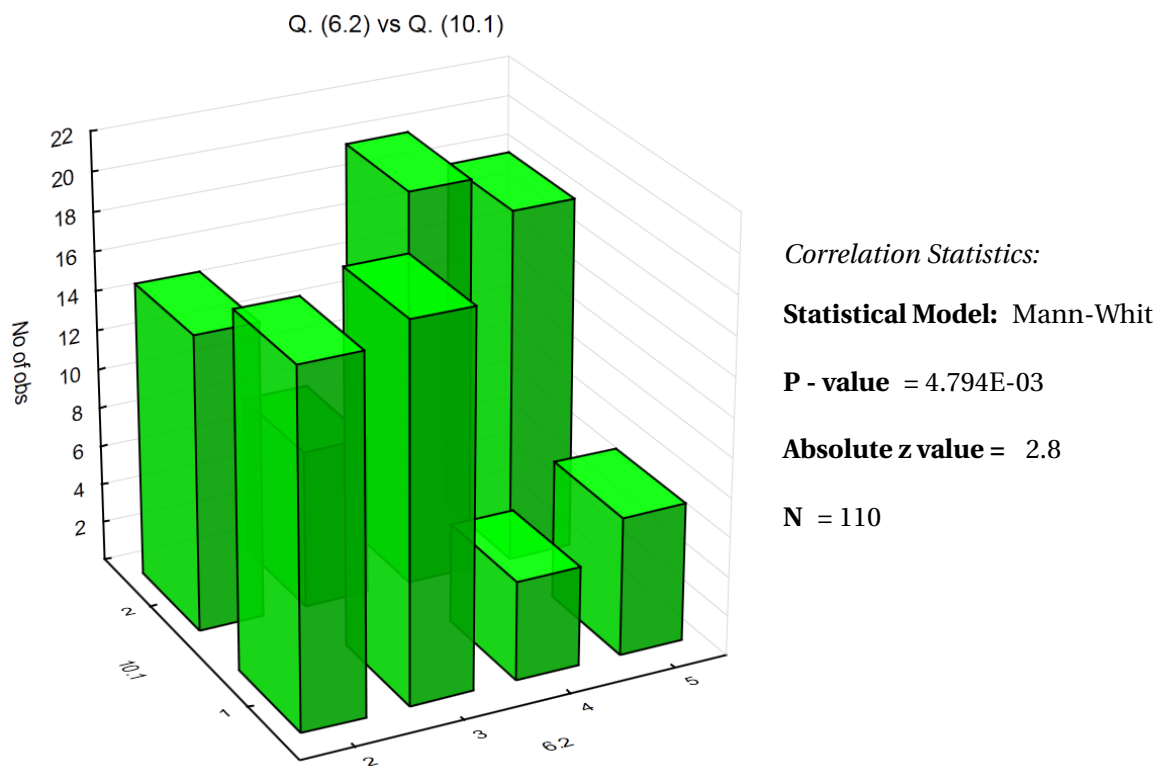


Figure 5.11: Bivariate histogram of Q.(6.2) vs. Q.(10.1)

Table 5.10: Response scale: Q.6.2 & Q.10.1

Q. (6.2)		Q. (10.1)	
Score	Response	Score	Response
5	Less than 20%	2	Yes, strongly agree
4	Less than 30%	1	No, disagree/Don't know
3	Less than 40%		
2	Don't know		

Discussion of Figure 5.11:

The percentage of municipalities having an effective operations and maintenance team available and having a NRW status below 30% (includes less than 20%) is 62%. In the case where no effective operations and maintenance team is available, 75% either didn't know their NRW percentage (36.7%) or could only achieve less than 40% NRW (38.7%).

Significance of relationship:

Planning is an important part of maintenance but having an effective team to execute planned activities is critical. As many of South Africa's municipal assets are aged, it is important that they are well maintained and managed in order to maximize the remaining useful lives. Effective and skilled infrastructure operations and maintenance teams significantly enhance a municipality's ability to reduce its NRW. The reductions will especially take place in the areas of leakages at storage units, replacement of aged pipelines and removal of illegal connections.

Question 6.2 What is the percentage unaccounted for water?

vs.

Question 13.1 Are IT systems policies and procedures in place and adhered to (e.g. users are registered, access is controlled, IT systems have firewalls, active protection from viruses, etc.)?

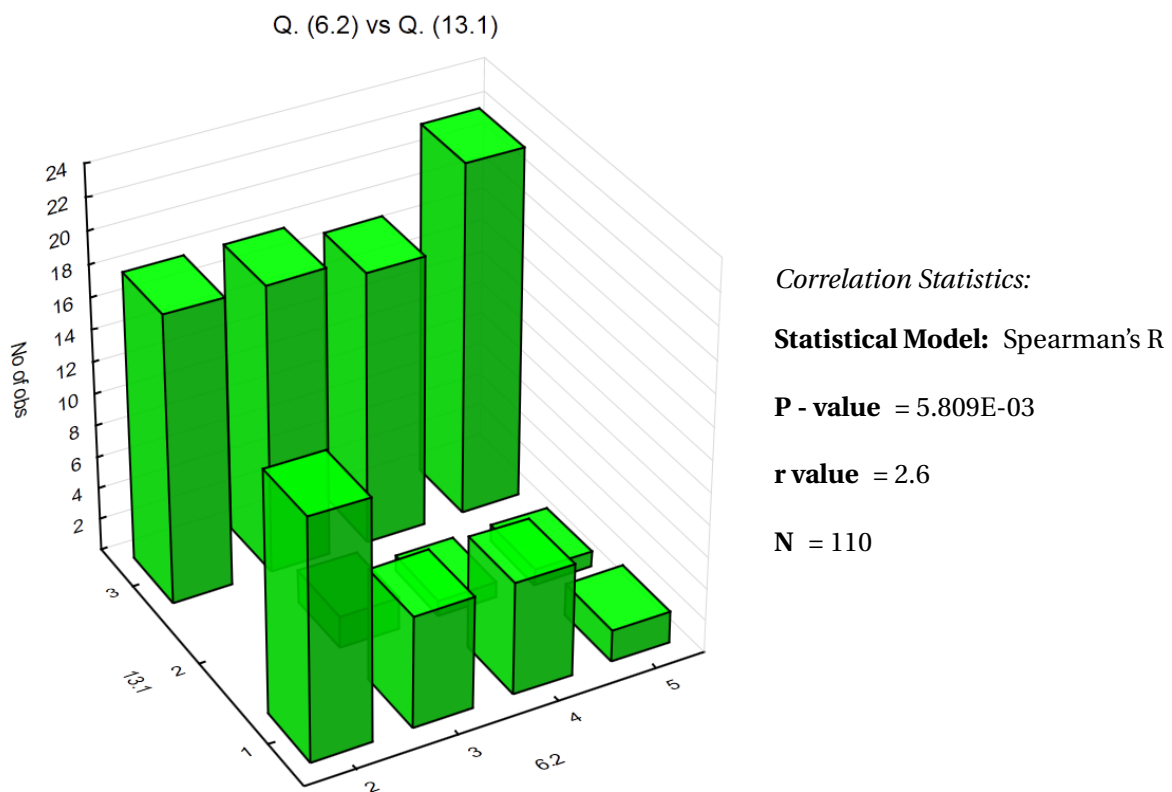


Figure 5.12: Bivariate histogram of Q.(6.2) vs. Q.(13.1)

Discussion of Figure 5.12:

Municipalities not having IT systems policies and procedures in place responded in a 48.4% majority

Table 5.11: Response scale: Q.6.2 & Q.13.1

Q. (6.2)		Q. (13.1)	
Score	Response	Score	Response
5	Less than 20%	3	Yes, strongly agree
4	Less than 30%	2	In development
3	Less than 40%	1	No, disagree/Don't know
2	Don't know		

that they don't know the percentage NRW, a mere 6.4% were able to achieve a NRW percentage less than 20%. Only 4 of the 110 municipalities in the sample have IT systems that are in development, no clear conclusion can be made on their responses. When IT systems policies and procedures are in place the percentage of the municipalities who don't know the percentage NRW reduced to 24%. Of the municipalities with IT systems procedures and policies, 29% have a NRW percentage below 20%.

Significance of relationship:

It might seem strange that IT systems policies and procedures have a significant impact in NRW, but there are a several reasons for the correlation. IT systems play an important role in communication within the organization, hence the high percentage of municipalities who didn't know the NRW percentage when lacking IT systems. The first step towards improvement is to measure what needs to be improved. Even though it does not seem as if IT systems directly reduce NRW percentages it does improve awareness and knowledge about NRW within the municipality. It is seen from Figure 5.12 that when IT systems are in place the variations across the percentage NRW is small, it can be concluded from this that when IT systems are in place other factors determine the success of NRW reduction.

This concludes the areas significantly influencing the percentage unaccounted for water as revealed by the data.

5.1.1.2 Areas influenced by the percentage unaccounted for water: MuSSA output

All operations in organizations are reliant on funds, thus in essence all areas in the MuSSA analysis will be affected by the percentage NRW to some extent. There are however six areas of the 16 key business attributes in the MuSSA analysis that revealed particularly strong correlations with NRW, as being areas that are influenced by NRW. These six areas can be seen in Figure 5.1. As the focus of this chapter is not towards the areas affected by NRW but rather towards improving NRW, these six areas and the relation they have with NRW will only be briefly discussed. The histogram and statistical information for the following correlations are given in Appendix C.

1. Water conservation and demand management, Figure C.2

The development of a standard water balance is heavily dependent on the knowledge a municipality has regarding its NRW percentages. Without the knowledge of the percentage NRW it is

theoretically impossible to develop a water balance. This can be seen in Figure C.2, where not a single municipality not knowing its NRW percentage had a fully developed water balance.

2. Drinking water & Blue Drop score, Figure C.3

In the Blue Drop assessment, one of the areas municipalities are judged on is the design capacity versus the operational capacity [45, p.22]. With the reduction of NRW the ratio of design capacity to operational capacity can drastically improve, especially in municipalities with high NRW percentages. From Figure C.3 it can be seen that with decreasing NRW percentages, the more likely the municipalities are to score relatively high on Blue Drop.

3. Wastewater/environmental safety & Green Drop status, Figure C.4

In the Green Drop Handbook there is no direct scoring involved for NRW. The majority of South Africa's municipalities are relatively small and in many cases the water and wastewater systems are managed by the same task force. The correlation shown in Figure C.4 is mainly due to this fact and is an indication of either good or bad practice throughout the municipality.

4. Revenue collection

a) Revenue collection, Figure C.5

The percentage NRW has a great affect on a municipality's revenue income. Figure C.5 indicates that of the municipalities not knowing the NRW percentage only 30% feel that revenue collection is acceptable. As the NRW percentage reduces the percentage of municipalities with acceptable revenue collection drastically increases. Of municipalities with less than 20% NRW, 76% have acceptable revenue collection. As soon as the NRW percentages falls below 30%, the majority of municipalities indicate that revenue collection became acceptable.

b) Cash reserves, Figure C.6

NRW amounts to money lost for an organization and greatly affects a municipality's ability to build up cash reserves. Figure C.6 shows that there is a turning point at less than 30% NRW and ability to build up cash reserves. Municipalities should strive to reduce NRW percentages to below 30% enabling them a chance at building up cash reserves.

5. Operational performance and reporting to council, Figure C.7

It is very interesting to note that only half of the municipalities that don't know the NRW percentage regularly presented reports to council, this is largely because a lack of data would make it difficult to report meaningfully. It is also clear that as the percentage NRW decreases, the percentage of municipalities frequently presenting reports to council increases drastically. Reporting to council allows the municipality to gain support in favor of urgent matters, resulting in the allocation of funds to these matter. It must be noted that measurement must first take place before it is possible to report to council.

6. Water service quality

a) Water supply interruptions, Figure C.8

Figure C.8 indicates that of the municipalities not knowing the NRW percentage, 42% do not have any households experiencing major water interruptions. Municipalities with less than 30% NRW have 50% or more of household not experiencing major water supply interruptions. The reduction of NRW seems to make a slight contribution towards ensuring uninterrupted water supply.

b) Water pressure problems, Figure C.9

Not a single municipality from the sample with a NRW percentage less than 20% has more than 50% of households experiencing water pressure problems, with 68% of these municipalities indicating that no households have any water pressure problems, as shown in Figure C.9. Leakages causing NRW also causes pressure drops in water networks, thus the reduction of NRW will directly contribute to consistent network pressures. It is positive to note that there are few municipalities that have extensive pressure problems.

5.1.2 The percentage of connections metered and billed

One of the major contributing factors to NRW or the percentage unaccounted for water and also to revenue collection is unmetered and unbilled connections. In Section 5.1.1.1 it can be seen that NRW and the percentage connections metered and billed had a very significant correlation, therefore it can be assumed that factors affecting the percentage connections metered and billed will also influence the percentage NRW. In the MuSSA data, municipalities were asked to indicate what percentage of connections were metered and billed in the organization. As it is a goal of this study to help municipalities reduce the percentage NRW and to increase revenue collection, a brief look will be taken at the factors contributing to the percentage of connections metered and billed. The MuSSA question aimed at revealing the percentage of connections metered and billed is, as stated in the MuSSA questionnaire:

Q. 6.3 What percentage of connections are metered and billed (residential and non-residential (commercial, industrial, etc.)?)

The statistical non-parametric analysis of the MuSSA data revealed that the percentage connections metered and billed has significant correlations with twenty three other MuSSA questions, as shown in Figure 5.13. The layout of the flow chart in Figure 5.13 is the result of expert opinion to classify the correlations into factors contributing to percentage connections metered and billed, factors being influenced by the percentage connections metered and billed or factors having an uncertain relation to the percentage connections metered and billed. The factors classified as having an uncertain relationship with the percentage of connections metered and billed are either due to the nature of the data or partial correlations, as discussed in Chapter 3. From Figure 5.13 it can be seen that five of the 16 MuSSA key business attribute areas were identified as; (i) having a significant relationship with revenue collection and (ii) being contributing factors towards the percentage connections metered and billed by way of at least one of the questions in its category. Each of the attribute areas are listed in the following sections and the significant correlating questions are then discussed under the head-

ing of the attribute area. The histograms and statistical information for the following correlations are in Appendix C.

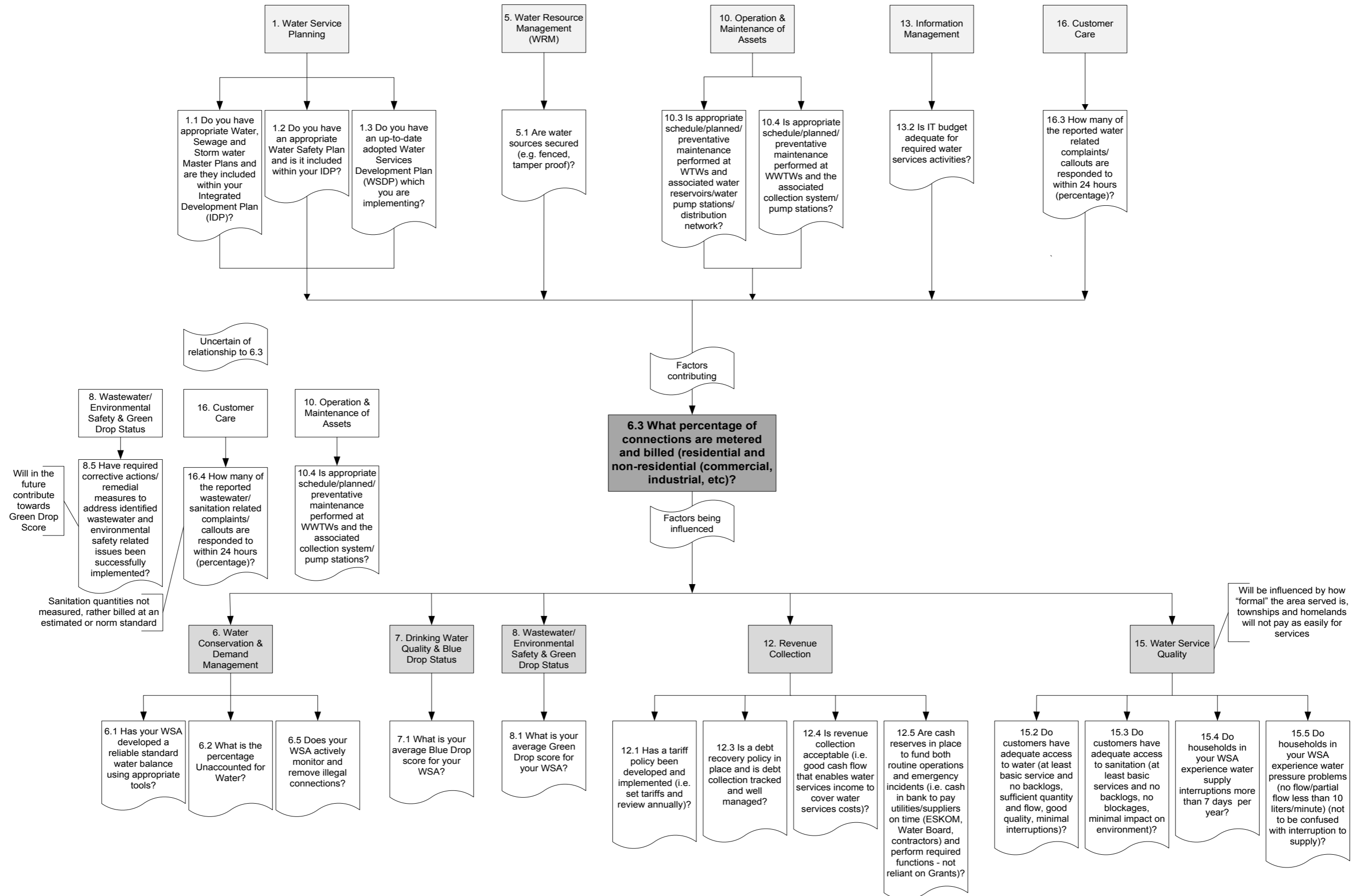


Figure 5.13: What percentage of connections are metered and billed? : MuSSA Model.

1. Water service planning

a) Inclusion and development of water, sewage and storm water master plans, Figure C.10
Not a single municipality without a master plan and it included in the IDP has more than 98% of its connections metered and billed. The percentage of municipalities with more than 98% of connections metered and billed increased to 48% for municipalities with master plans in development, and to 51.8% for those having complete master plans and implementing them in the IDP. It is clear that master plans allow municipalities to perform proper metering and billing of water. Thus aiding in the reduction of NRW which could result in increasing revenue collection. Even the act of having master plans in development drastically increases the percentage of connections metered and billed. This is largely due to the fact that with a master plan there exists a methodology to address key operational issues within the municipality, ranging from plumbing to administration of networks.

b) Water safety plan (WSP) and its inclusion in the IDP, Figure C.11

A WSP is a plan that assess the risks that a municipality faces in order to deliver safe and sustainable drinking water. The WSP process is steered by a group of people that includes the technical, financial and management staff of the municipality [38]. There is no direct link in the functioning of the WSP and metering and billing of connection. The correlation can be attributed to partial correlations between the WSP, (i) WSDP and (ii) Water Master Plan, showing the strong interactions between the planning processes. Both (i) and (ii) have direct affects on metering and billing, this correlation can give an indications of good or bad practice throughout the organization.

c) Implementation of water service development plan (WSDP), Figure C.12

Municipalities construct WSDP's to ensure that they will be able to continuously provide safe and sustainable drinking water by addressing long term goals and issues. Metering and billing are heavily affected by the implementation of a WSDP. Of the municipalities with a WSDP, 37% metered at least 98% of connections while a further 37% metered and billed 75 - 98% of connections. Not a single municipality, not implementing a WSDP was able to meter and bill more than 98% of connections. New developments and the ability to provide water to them forms part of a WSDP, and as our country has been undergoing vast growth in low cost housing it is self evident that the implementation of a WSDP is necessary to ensure successful metering and billing of connections.

2. Water resource management(WRM), Figure C.13

Tampering with water sources, including water meters and vandalism is an issue of concern especially in the South African context. Figure C.13 shows that of the municipalities that secured all the water sources, 43.6% have more than 98% of connections metered and billed. The percentage municipalities with 98% of connections metered and billed decreased to 15.8% for

municipalities only having 75% of resources secured. The protection of metering equipment is a true contributor to successful metering and billing of connections.

3. Operations and maintenance of assets, Figure C.14

Planned preventative maintenance on WTW and networks includes the timely replacement of water meters to ensure that accurate metering is taking place. As water meters age they tend to under-measure water quantities [23]. Preventative maintenance will also ensure the stoppage of leaks and the frequent occurrence thereof. Of the municipalities that perform all the planned maintenance activities, 44% have more than 98% of the connections metered and billed.

4. Information management, Figure C.15

Billing of customers is a challenging job, and doing so without the help of proper tools such as digital programs to manage and track who has been and who needs to be billed will result in major errors. Of the municipalities that don't have proper IT budgets for water services; 39.7% were only able to meter and bill 75%-98% of the connections while only 16% were able to meter and bill more than 98% of connections. Of those with proper IT budgets, 38% metered and billed more than 98% of connections and a further 40% billed and metered 75 - 98% of connections.

5. Customer care, C.16

Water related complaints include water meter problems at connection points, and the ability of a municipality to respond to such complaints within 24 hours will affect its ability to meter and bill connections. Not a single municipality responding to less than 75% of call outs within 24 hours was able to meter and bill more than 98% of connections. Of the municipalities responding to all water related call outs within 24 hours, 81% metered and billed more than 75% of connections. 65% of those who respond to "Most" call outs within 24 hours metered more than 75% of connections. The monitoring of 75% or more of connections drastically decreases, as the cases of call outs responded to drops below 75%.

5.2 The contributing factors to non-revenue water as per expert opinion

In order to have a model to compare to the one yielded by the analysis of the MuSSA data, several experts in the field of the South African municipal environment together with literature have been consulted. This resulted in the model shown in Figure 5.14.

Six main areas were identified as contributing to the state of NRW namely;

1. Maintenance of equipment and infrastructure
2. Illegal connections and the management of illegal connections
3. Staff capabilities and capacity
4. Functionality and operation of financial department

5. Current state of service delivery infrastructure
6. Water service planning
 - a) Water Service Development Plan (WSDP)
 - b) Water Safety Plan (WSP)
 - c) Water and Storm Water Master Plan

Under NRW the two areas of interest are leakages and unbilled connections, see Figure 5.14. These two areas directly affect the question, "Is revenue collection acceptable?". With the aim on improving revenue collection, it is self-evident that NRW water must be reduced and can be achieved by focusing on these six areas identified. The six areas identified have been achieved by consulting experts and relies on no concrete evidence other than their experience and knowledge. In Section 5.1 the analysis of the MuSSA data is used to construct a NRW model, it would be ideal if the areas identified in Section 5.2 are confirmed but also potentially added to by way of a scientific procedure.

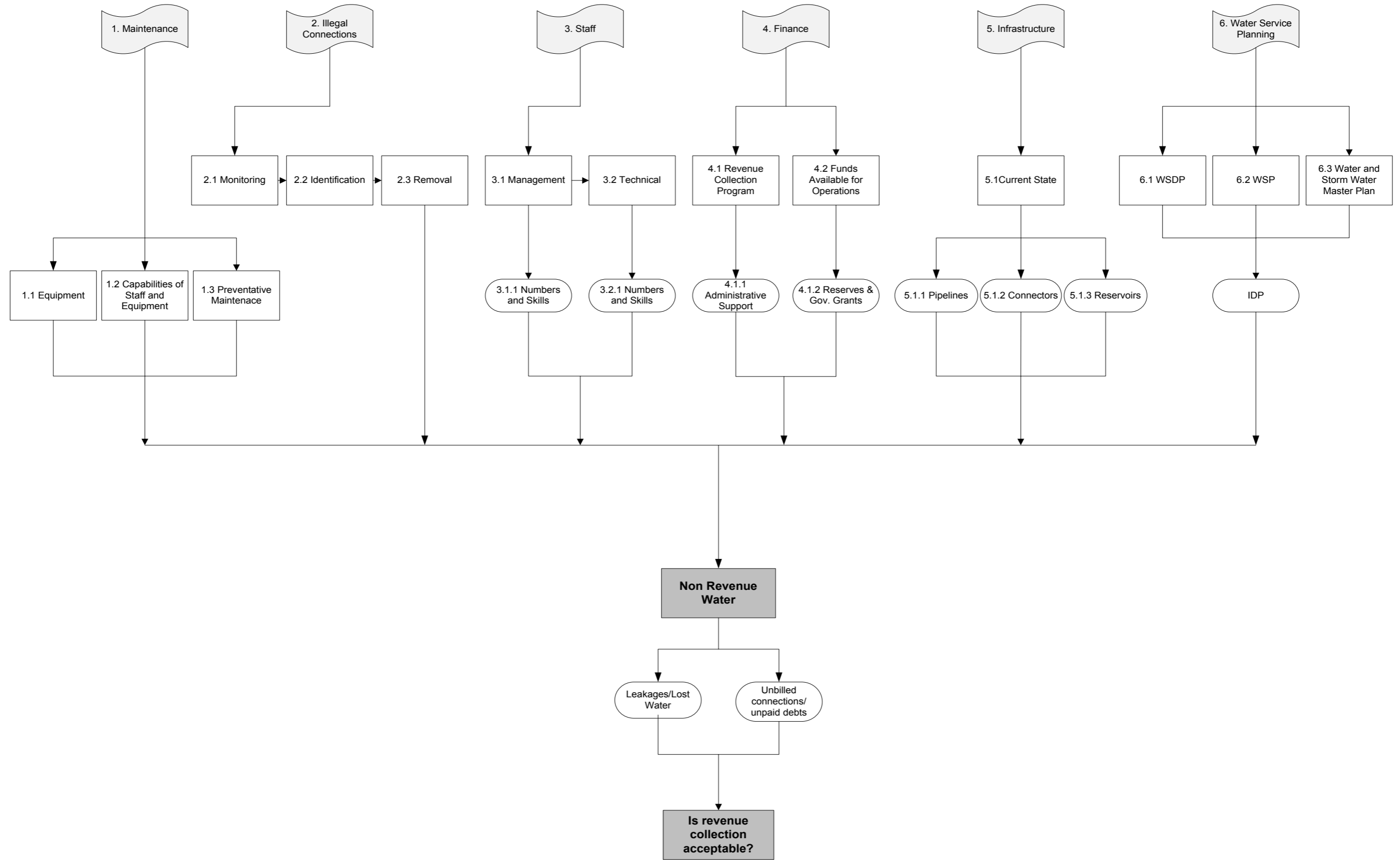


Figure 5.14: Non-Revenue Water Model Per Expert Opinion.

5.3 Conclusion and the way forward

South African municipalities are operating under unique circumstances and face unique challenges in reducing NRW. Detailed investigations into the output of the MuSSA analysis has been conducted to determine what the critical contributing factors are to NRW, but also what is being affected by the percentage NRW a municipality is operating at, see Figure 5.1.

Seven of the 16 key business attributes from the MuSSA analysis showed strong correlation with the percentage unaccounted for water with at least one of the questions in its category as being contributing factors towards NRW;

1. Water service planning
2. Management skill level (Technical)
3. Staff skill level (Technical)
4. Water conservation and demand management
5. Infrastructure asset management
6. Operation and maintenance of assets
7. Information and planning

By way of expert opinion a model, as seen in Figure 5.14, has been created to depict the functionality of NRW and to compare to the model yielded by analysis of the data. The results from the analysis holds a strong resemblance to that of the expert opinion, in that the same factors are present in both models, not necessarily in the exact words. The expert opinion model shows that planning is a necessity to reduce NRW percentages. Similarly, the data analysis showed that water services planning, especially master planning, significantly influences the ability of a municipality to reduce NRW. The importance of staff skill levels and capacity for management and operational staff is present in both the expert model and the analysis results. The experts identified water conservation and demand management, as did the analysis results, under the heading of illegal connections. The questions in the MuSSA data revealed to be significant to the reduction of NRW are listed under the heading of illegal connections in the expert model as monitoring, identification and removal. These coincide with the metering of connections and removal of illegal connections as described in questions 6.3 and 6.5. Both the expert and analysis results model show that infrastructure asset management and maintenance of assets are key to the reduction of NRW. From this it can be concluded that, the MuSSA analysis results model coincides well with that of the expert opinion model on the factors influencing NRW reduction. The detailed discussions of each correlation revealed that planning is essential to the success of a municipality. Water service planning provides a platform for the municipality to operate from and gives insight into long term needs with regards to NRW. The lack of planning, but also the lack of the execution of planned activities such as IAM, impact the ability of a municipality to reduce NRW percentages especially in the form of leaks. One of the key components

of the planning process should without any doubt be the inclusion of a WCDM program to ensure the management of illegal connections and proper metering and billing of connections to the network. WCDM extends the need for new developments by reducing current needs, by way of minimizing water losses. Infrastructure asset management in terms of the distribution network, storage units and the protection of these asset from vandalism needs to be conducted, enhancing the reduction of NRW in the form of leaks, water breaks and illegal connections. When performing infrastructure asset management the contribution of the skill levels of the staff involved on a management and technical level, must not be underestimated. It is important that training of the staff throughout the organization is conducted, to ensure complete success in the reduction of NRW.

Municipalities are advised to strongly consider the factors explored in this chapter as contributing towards NRW when creating action plans to improve their NRW percentages. The involvement of community leaders should be of high priority, to ensure the successful prevention of illegal connections to water networks. The delivering of a good service will encourage users to not only pay bills easier, but also to respect the infrastructure and the municipality as a business.

Chapter 6

Execution of water service plans: MuSSA output

In recent years, despite the major strides made by South Africa, municipalities continue face the fact that many more people are in need of basic water and sanitation services. Rumors of mismanaged funds and resources plague municipalities in the quest to provide residents with the required services. This chapter seeks to help municipalities better understand the critical areas that require attention to help them execute a greater percentage of planned water service activities, which may help them to put these rumors to rest.

6.1 Planning alone will not solve the problem

In Chapter 2.4 the municipal water services planning process, and how the different planning processes interact were explored. The detailed planning at ground level takes place by way of the Water Safety Plan (WSP) and the water and wastewater Master Plans. These two planning processes are in depth assessments of the state and situation within the municipality, and are not directly required by law. They do however, feed into the overall Water Service Development Plan (WSDP), which is a five year business plan required by law for water and wastewater services. Without the detail in the WSP and the Master Plans, the development of a complete and accurate WSDP will be near impossible. The Integrated Development Plan (IDP) is also required by law, and the WSDP is a prescribed section within the IDP. Knowing this it is logical to state that, directly or indirectly, the WSP Master Planning, WSDP and IDP are all required by law. In Chapters 4 and 5 the effect of not executing planned activities had a negative impact on staff skill levels and capacity and non-revenue water (NRW).

Figures 6.1a and 6.1b show that majority of the ground level planning processes are either in development or fully implemented and complete, for the bulk of municipalities. 55.4% of WSP are in development and 31.8% are complete, while 43.6% of Master Plans are in development and 33.6% complete. The majority of the planning, legally required for water services, is also being conducted with 39.1% of WSDP in development and 56.3% of them complete. The problem starts with the execution of the planned activities. Municipalities make all the effort to go through rigorous planning

activities, and draw up large documents that require an enormous amount of resources. What can be seen from Figure 6.1d is that the bulk of municipalities are only executing >50% (36.3%) to >75% (35.4%) of their planned activities. By addressing the critical issues, it might be possible for more municipalities to enhance the execution of planned water services activities to 75% or more. This chapter aims to help a greater percentage of municipalities execute more than 75% and 100% of planned water services activities.

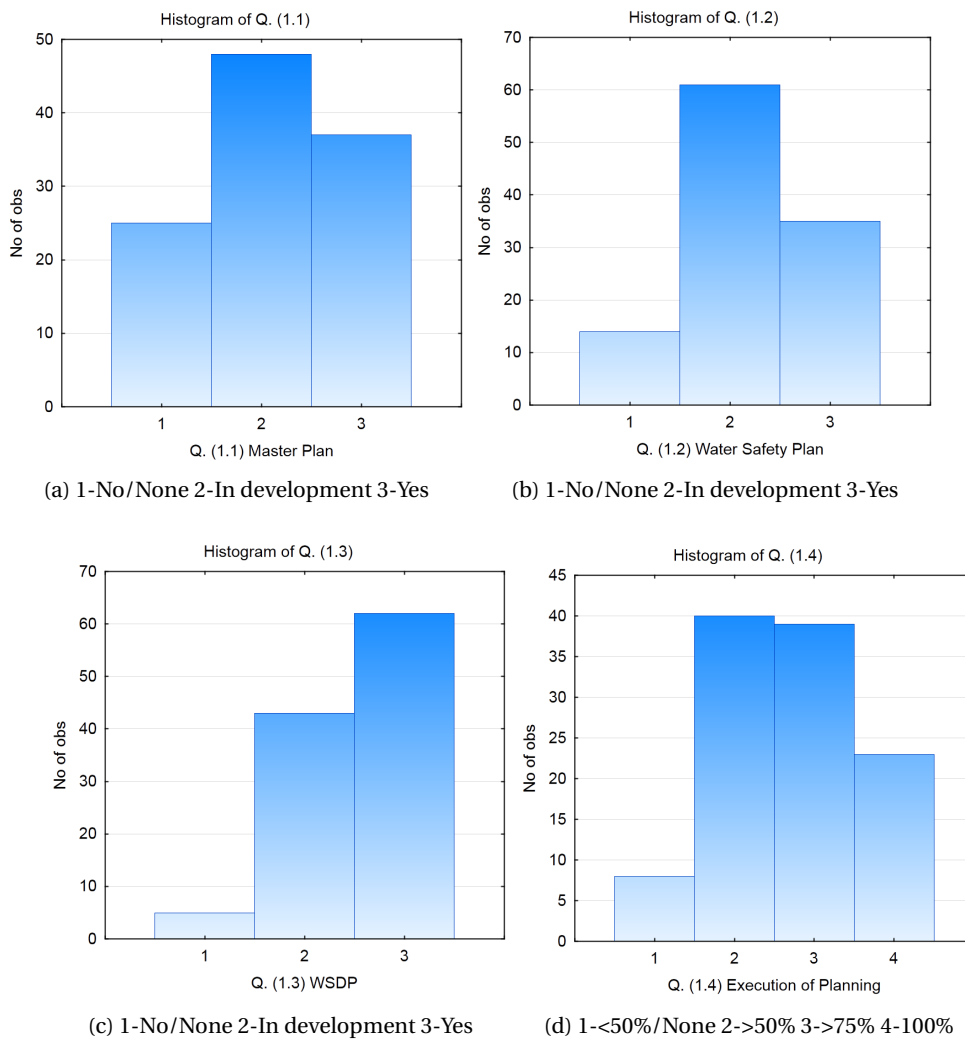


Figure 6.1: Water service planning and execution of municipalities as indicated in the MuSSA data

In short this part of the investigation seeks to improve the execution of planned water service activities. In this part of the study the factors influencing the execution of planned activities will be investigated, as to how they relate to question 1.4 of the MuSSA analysis.

6.2 Execution of planning

The MuSSA question investigating the execution of planned activities is;

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

Question 1.4 seeks to determine what percentage of planned activities are being executed by the organization. Statistical analysis of the MuSSA data revealed several strong correlations with the execution of planned activities and results are shown in Figure 6.2, after engineering judgement has been applied. Detail of the interpretation and of the analysis results can be found in Section 3.3. By addressing the issues indicated as contributing factors, in Figure 6.2, it is hoped that municipalities will be able to enhance their performance with regards to execution of planned activities.

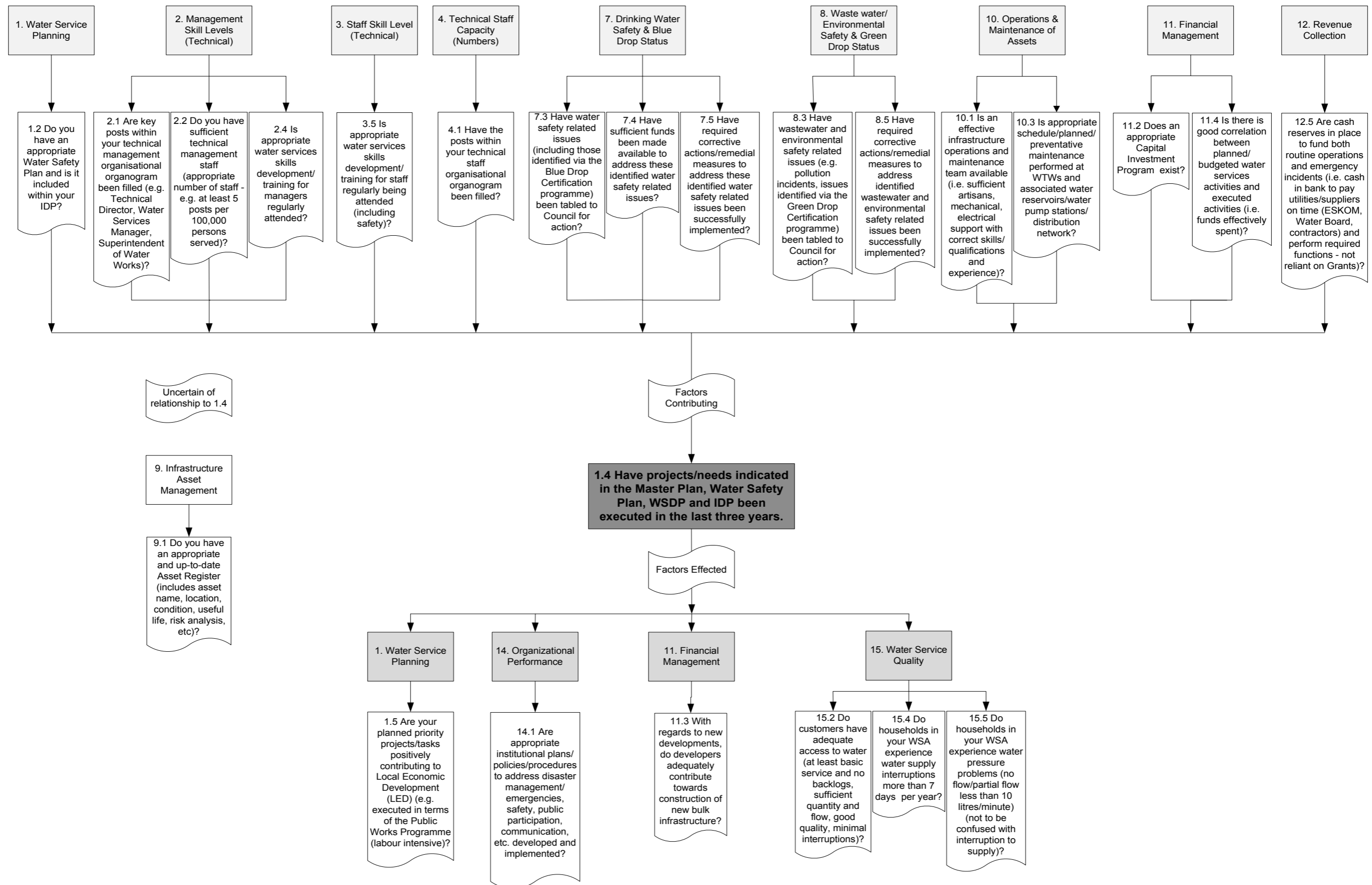


Figure 6.2: Have needs indicated in the Master Plan, WSP, and WSDP and IDP been executed?: MuSSA Output

6.2.1 Areas influencing the execution of planned activities

This section discusses the areas significantly influencing the execution of planned water services, as revealed from the MuSSA data.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 1.2 Do you have an appropriate Water Safety Plan and is it included within your IDP?

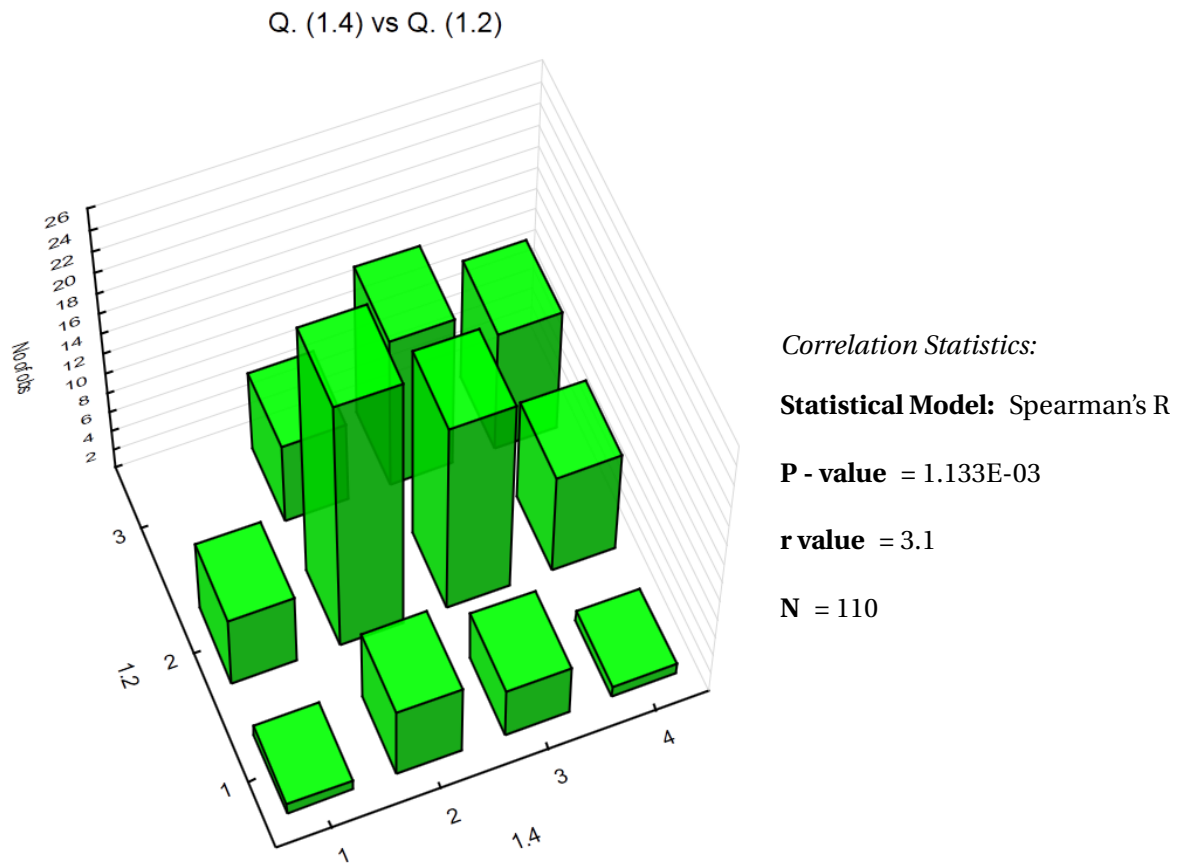


Figure 6.3: Bivariate histogram of Q.(1.4) vs. Q. (1.2)

Table 6.1: Response scale: Q.1.4 & Q.1.2

Q. (1.4)		Q. (1.2)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In development
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		

Discussion of Figure 6.3:

The percentage of municipalities with no WSP and with "Some(>50%)" of the project needs executed

is 50%. Of the municipalities with a WSP in development; 40.9% have "Some (>50%)" and 31.2% have "Most(>75%)" of the project needs executed. This is an improvement on those with no WSP, but there is still a tendency of not being able to execute the majority of planned activities. Consider the municipalities with a fully developed and implemented WSP; of them 34.3% have all the project needs executed while 42.9% have "Most(>75%)" of planned needs executed. Question 1.1 and 1.2 regarding Master Planning and WSDP also have very strong correlations with question 1.4 at P-values of 0.027 and 0.0158 respectively. These P-values fall just outside the cut-off level of 99% significance for this study.

Significance of relationship:

As seen in Section 2.4, question 1.1, 1.2 and 1.3 all form part of the IDP, which leads to the execution of planned activities. Therefore, this correlation is expected. The planning process must take place before projects can be executed, and it is good to see that 55.45% of municipalities have WSP in development and 31.8% have fully developed WSP.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 2.1 Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Service Manager, Superintendent of Water Works)?

Table 6.2: Response scale: Q.1.4 & Q.2.1

Q. (1.4)		Q. (2.1)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

Discussion of Figure 6.4:

Municipalities with "<50%/None" of technical management posts filled show a slight tendency to complete "Some(>50%)" to "Most(>75%)" of the project needs. Of the municipalities with "Some(>50%)" of the technical management posts filled, only 11.1% executed "All(100%)" of the project needs. Consider the municipalities with "Most(>75%)" of the technical management posts filled; 41.5% executed "Most(>75%)" of the project needs and 17.1% executed "All(100%)". Those with all the technical management posts filled show a real improvement in projects executed, of them 41.4% executed "Most(>75%)" and 38% executed 100% of the planned project needs.

Significance of relationship:

When technical management staff in a municipality is lacking, there is a severe lack of decision making capabilities and project needs are not executed [6; 2]. Technical management plays a very sig-

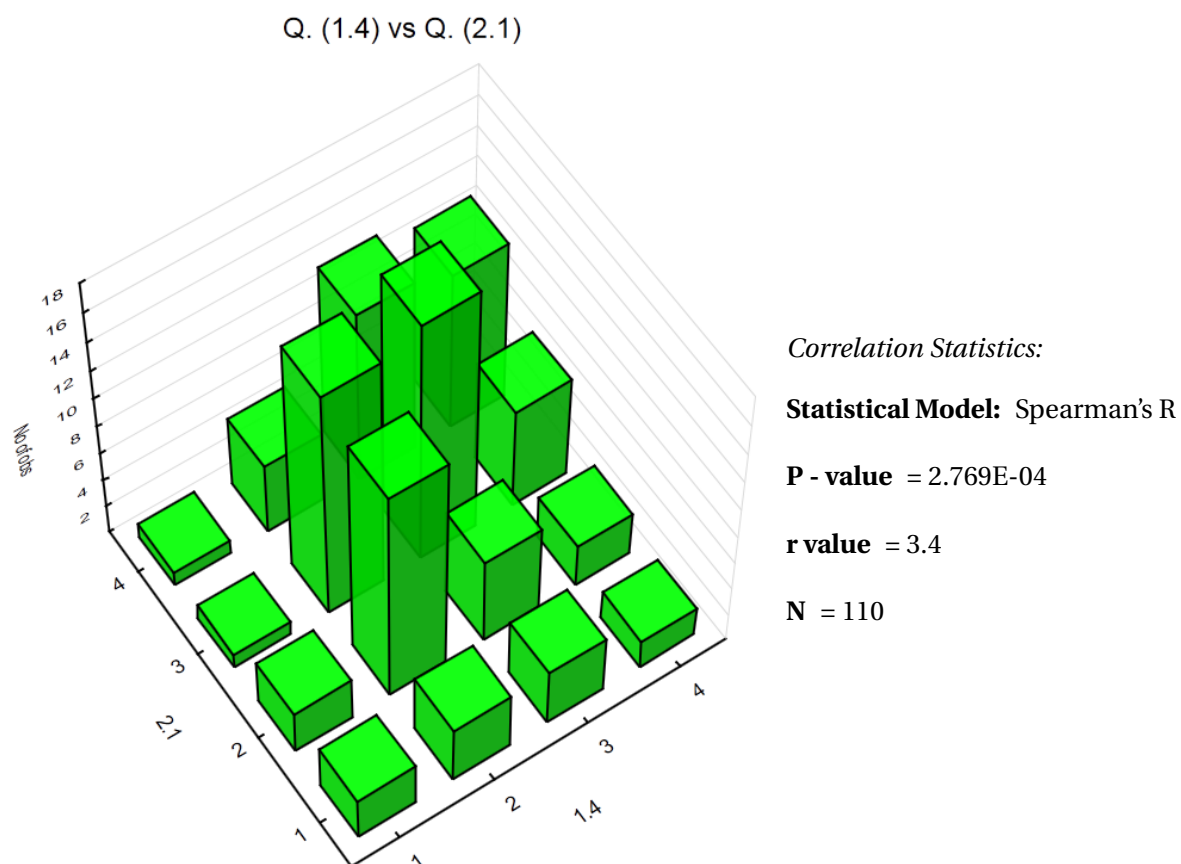


Figure 6.4: Bivariate histogram of Q.(1.4) vs. Q.(2.1)

nificant role in the execution of project needs within a municipality, and officials must realize the importance of having educated and experienced technical management staff to the sustainability of the organization. Figure 6.4 shows that municipalities having all their organogram posts filled have a much higher success rate in achieving their project needs. Municipalities must strive to have all the technical management organogram posts filled. This greatly enhances the capability to execute more than 75% of the planned water service needs. Having all the posts in your organogram filled does not mean that sufficient technical management staff is employed, but it is a good start to having technical management capacity.

Question 1.4 *Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?*

vs.

Question 2.2 *Do you have sufficient technical management staff (appropriate number of staff - e.g. at least 5 per 100 000 persons served)?*

Discussion of Figure 6.5:

The percentage of the municipalities with "<50/None" sufficient technical management staff and "Some(>50%)" of the project needs executed is 60%. Consider the municipalities with "Some(>50%)" sufficient technical management staff; 40% executed "Some(>50%)" and 43% executed "Most(>75%)" of the planned project needs. Of the municipalities with "Most(>75%)" sufficient technical manage-

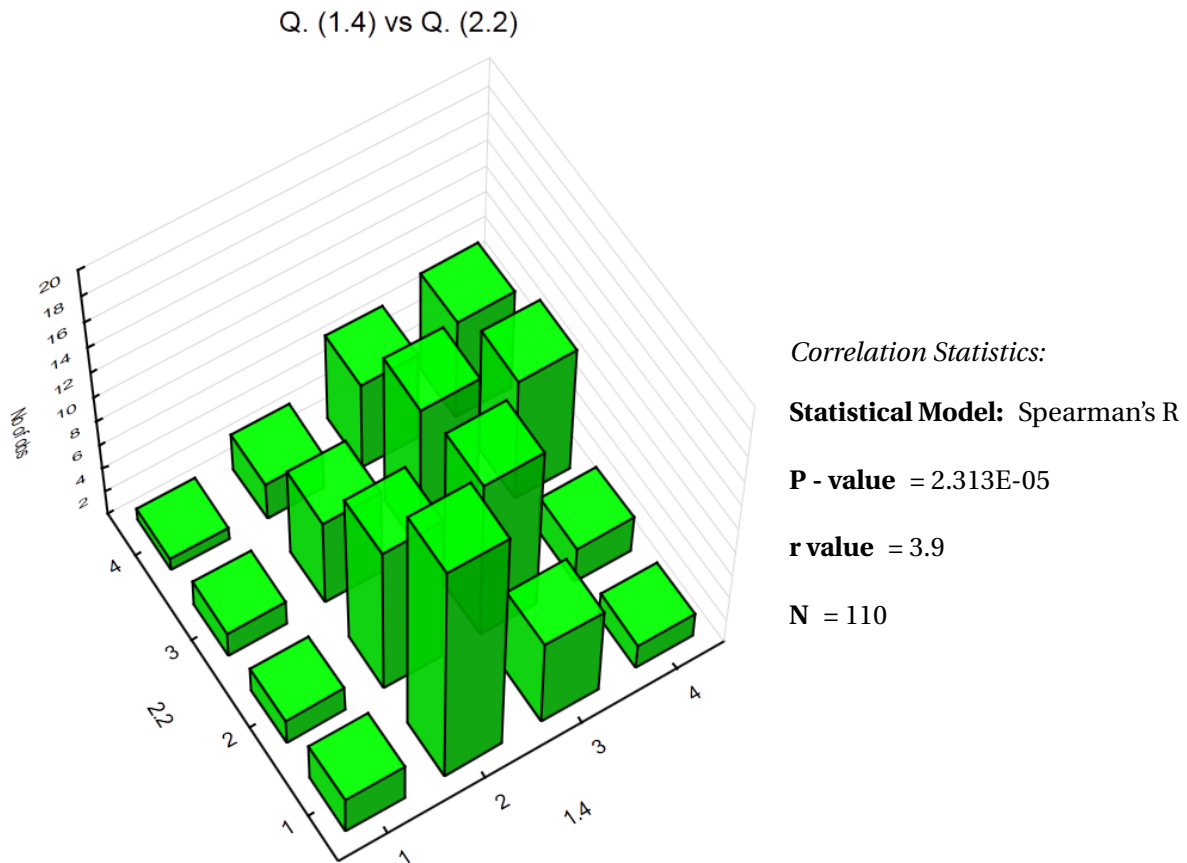


Figure 6.5: Bivariate histogram of Q.(1.4) vs. Q.(2.2)

Table 6.3: Response scale: Q.1.4 & Q.2.2

Q. (1.4)		Q. (2.2)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

ment capacity, 38.7% executed "Most(>75%)" of the planned project needs while 32.2% completed all the planned project needs. The best execution rate of project needs is achieved by municipalities having 100% sufficient technical management staff, where 36.8% executed "Most(>75%)" and 42.1% executed 100% of the planned project needs.

Significance of relationship:

The previous question asked if all the organogram posts were filled, but this does not mean that sufficient technical management capacity is employed at a municipality. Question 2.2 asks if at least five technical management staff members are employed per 100 000 persons served, which is in line with the recommended number by experts such as Allyson Lawless. It is once again stressed that if technical management capacity with correct skills and qualifications do not exist, project needs will in most cases not be executed. This is mainly due to the fact that in the cases where there are not

enough technical managers they will not be able to handle the large work loads and execute all the project needs. Where there are no technical management staff, non-technical staff are required to make technical decisions, and this in most cases is a failure.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 2.4 Is appropriate water service skills development/training for managers regularly attended?

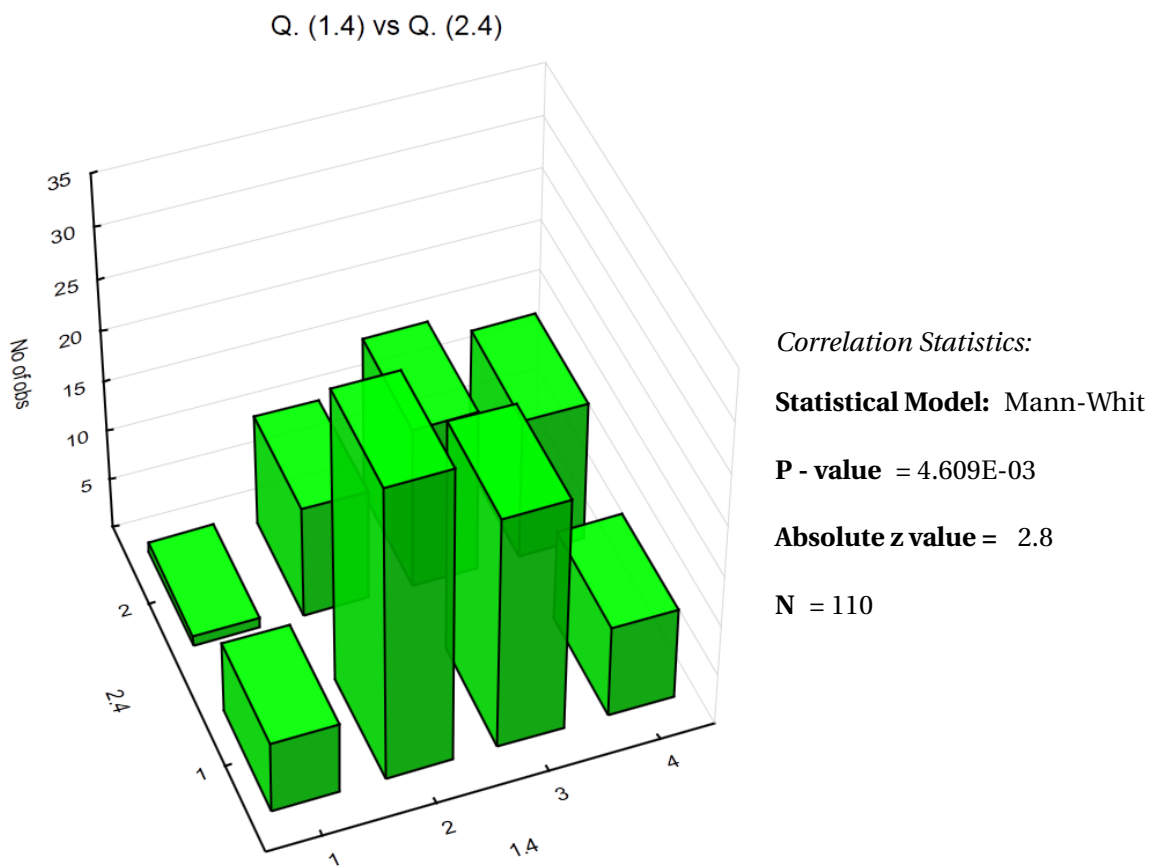


Figure 6.6: Bivariate histogram of Q.(1.4) vs. Q.(2.4)

Table 6.4: Response scale: Q.1.4 & Q.2.4

Q. (1.4)		Q. (2.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

Discussion of Figure 6.6:

Of the municipalities not performing skills development training on technical managers, 42.6% only executed "Some(>50%)" of the project needs while 33.8% executed "Most(>75%)". Those performing training on technical managers show a great improvement, of them only 2.4% executed "<50%/None" of the planned project needs, 38.1% executed "Most(>75%)" and 33.3% executed 100% of the project needs.

Significance of relationship:

Not only is technical management staff capacity important to the functionality of a municipality, but their skills is equally influential in the execution of planned projects. Where young and unskilled technical staff are in charge they make ill technical decisions. In most cases they are not able to spend budgets allocated to projects, due to their insecurity in decision making[2]. This correlation shows the importance of not appointing technical managers based purely on equity targets but rather to take the time and appoint quality staff based solely on skills and experience required to fill the vacant post, and then also develop them while they are employed. This will ensure better decision making and a higher rate of project needs execution in the future.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 3.5 Is appropriate water service skill development/training for staff regularly being attended (including safety)?

Table 6.5: Response scale: Q.1.4 & Q.3.5

Q. (1.4)		Q. (3.5)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

Discussion of Figure 6.7:

The percentages of the municipalities not perform training, that either executed "Some(>50%)" or "Most(>75%)" of the planned project needs are 44.8% and 37.3% respectively. Those performing training on staff show good improvement, with 32.6% of them executing "Most(>75%)" of the project needs, while a further 37.2% executed all the project needs.

Significance of relationship:

Technical management are the persons responsible for the planning of project needs, and ensuring that they are executed by lower level technical staff. Without properly skilled and developed technical operational staff, management can do all the planning they want, but they will not be able to

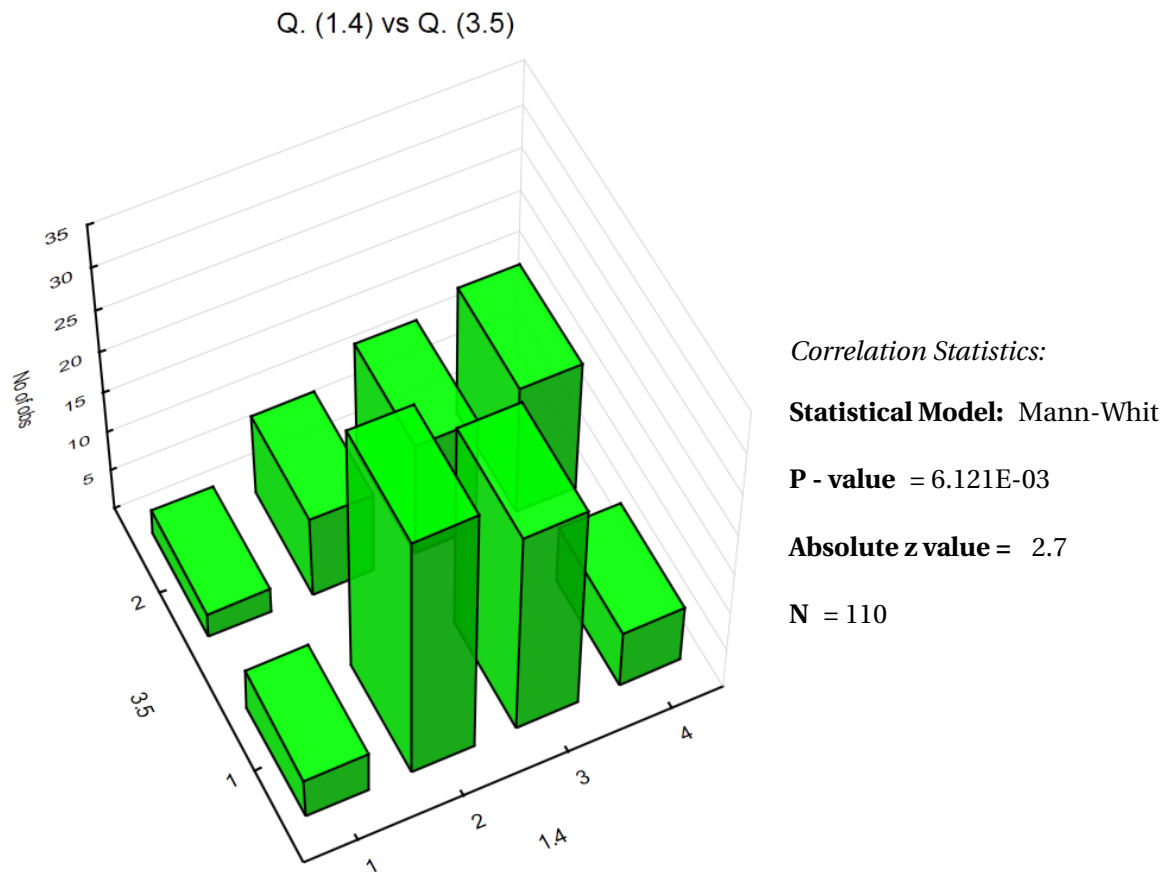


Figure 6.7: Bivariate histogram of Q.(1.4) vs. Q.(3.5)

execute the project needs. Municipalities must develop their in-house skills to ensure enough technical skill capacity to execute planned project needs.

Question 1.4 *Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?*

vs.

Question 4.1 *Have posts within your technical staff organizational organogram been filled?*

Table 6.6: Response scale: Q.1.4 & Q.4.1

Q. (1.4)		Q. (4.1)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

Discussion of Figure 6.8:

Of the municipalities with "<50%/None" of the technical posts filled, 20% executed "<50% /None"

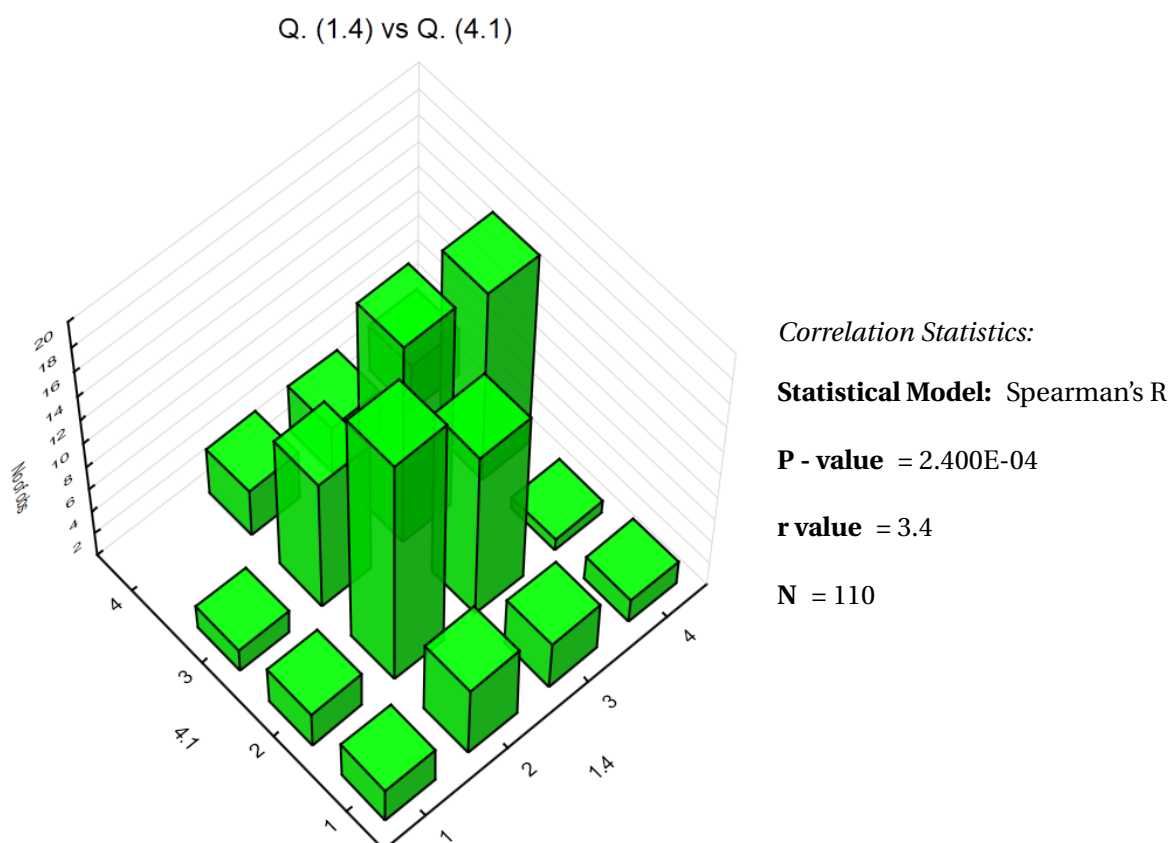


Figure 6.8: Bivariate histogram of Q.(1.4) vs. Q.(4.1)

and 40% executed "Some(>50%)" of the planned project needs. Consider the municipalities with "Some(>50%)" of the technical posts filled; of them 51.4% only executed "Some(>50%)" of the project needs, while 37.8% executed "Most(>75%)" of the project needs. The municipalities with "Most(>75%)" of their technical posts filled show a significant improvement in the execution of planned water services activities. 37% of them executed "Most(>75%)" of the project needs and a further 34.8% executed all the project needs. Not a single municipality, with all its technical staff posts filled executed less than 50% of the project needs, with the general majority performing relatively well. 66.6% of them either executed "Most(>75%)" (33.3%) or 100% (33.3%) of the planned project needs.

Significance of relationship:

The execution of project needs is mainly done by technical staff at ground level, and not having all the posts in the organogram filled most probably means that the municipality does not have sufficient technical operational staff to execute planned activities. As the percentage technical posts filled reaches more than 75%, the majority (more than 50%) of the municipalities start to execute 75% or more of the planned project needs. It is important to fill organogram posts to ensure technical staff capacity and the execution of planned project needs.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 7.3 Have water safety related issues (including those identified via the Blue Drop Certification program) been tabled to council?

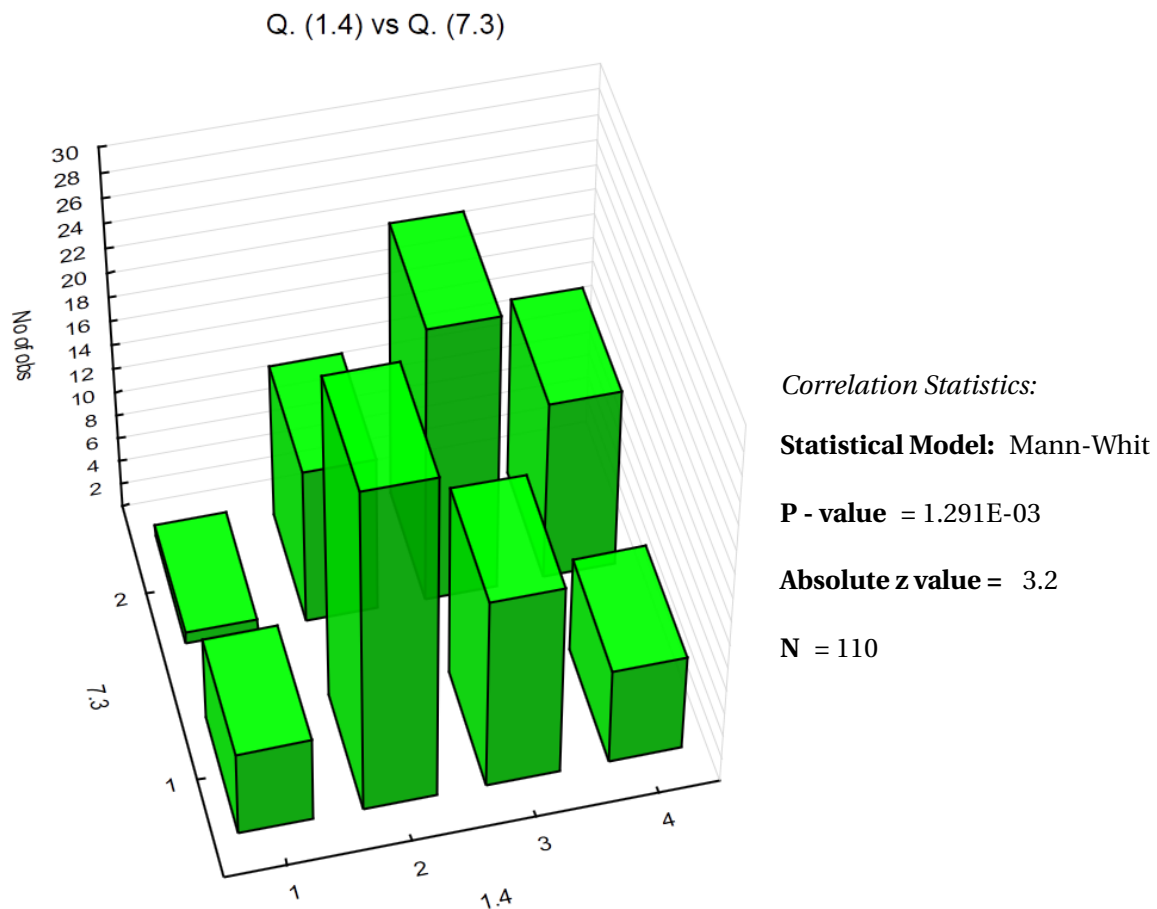


Figure 6.9: Bivariate histogram of Q.(1.4) vs. Q.(7.3)

Table 6.7: Response scale: Q.1.4 & Q.7.3

Q. (1.4)		Q. (7.3)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

Discussion of Figure 6.9:

Consider the municipalities not tabling related issues to council; of them 46.6% executed only "Some (>50%)" of the planned project needs, 27.6% executed "Most(>75%)" and only 13.8% were able to execute 100% of the planned project needs. In the case where municipalities are tabling related issues to council an improvement is seen in the number of municipalities executing a higher rate of

projects. 25% of them executed "Some(>50%)" of the planned project needs and 44.2% executed "Most(>75)", while 28.8% of these municipalities executed "All/100%" of the planned project needs.

Significance of relationship:

The South African municipal environment is heavily influenced by politics, especially when it comes to the allocation of funds. Tabling issues to council with complete and accurate data will help win the support of the council to endorse the execution of project needs. Having all the members, from technical to political, of a municipality on the same page with the same goals in mind will not only help to reduce friction within the organization, but will also enhance the productivity of the municipality. The MuSSA results show the tendency of municipalities tabling issues to the council to have a higher success rate in executing planned projects.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 7.4 Have sufficient funds been made available to address these identified water safety related issues?

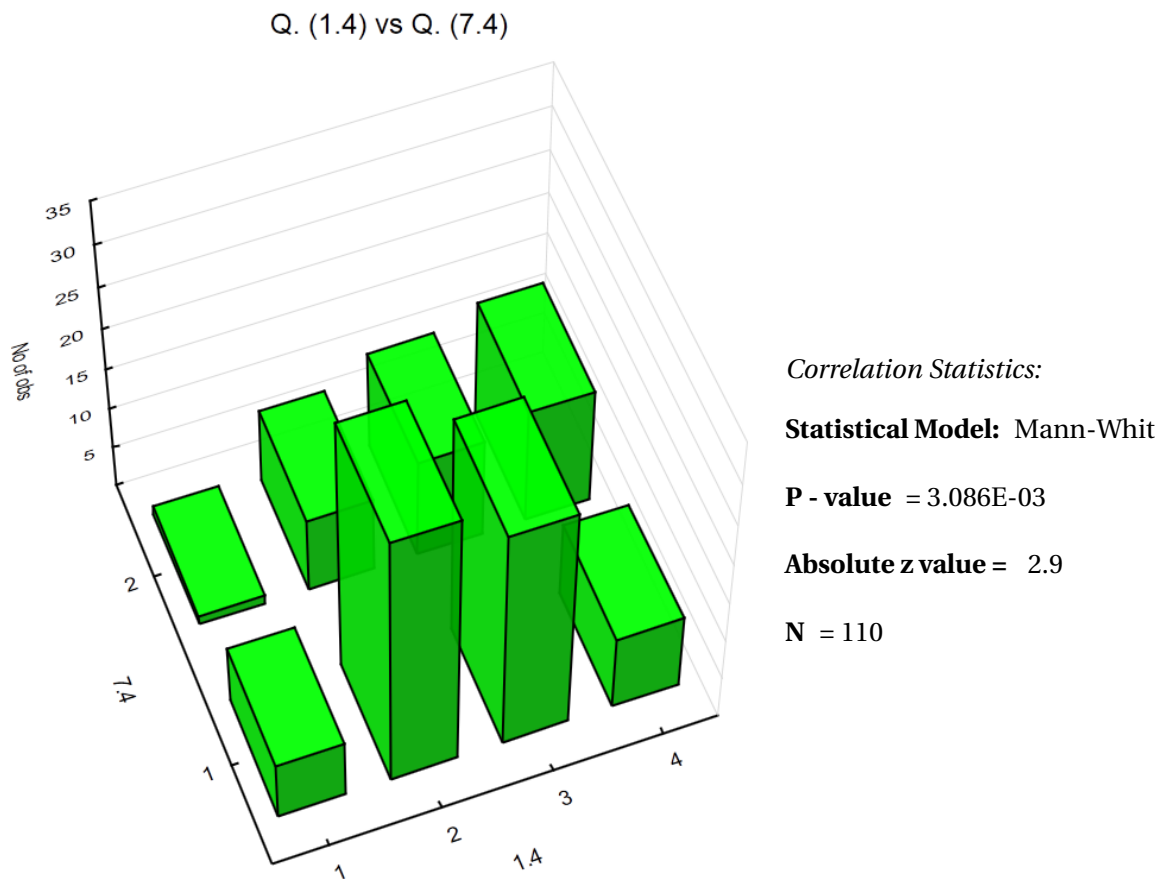


Figure 6.10: Bivariate histogram of Q.(1.4) vs. Q.(7.4)

Table 6.8: Response scale: Q.1.4 & Q.7.4

Q. (1.4)		Q. (7.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

Discussion of Figure 6.10:

Of the municipalities not having sufficient funds to address issues, 41.9% executed "Some (>50%)" and 36.5% executed "Most(>75%)" of the planned project needs. Only 12.2% could execute all the project needs without having sufficient funds made available. Municipalities with sufficient funds available have a much higher success rate of executing all planned project needs, at 38.9%. Of the municipalities with sufficient funds 33.3% executed "Most(>75%)" of the planned project needs.

Significance of relationship:

Funds play a major role in a municipality's ability to execute planned projects. Without funds allocated to address water safety related issues, risks identified in the WSP will not be able to be properly addressed due to lack of financial resources. This once again goes back to having the financial, political and technical department on the same team with the same goals. The allocation of funds to water safety related issues and Water Services Development Planning can also be improved by ring fencing water service delivery within the municipality.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 7.5 Have required corrective actions/remedial measures to address these identified water safety related issues been successfully implemented?

Table 6.9: Response scale: Q.1.4 & Q.7.5

Q. (1.4)		Q. (7.5)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In Process
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		

Discussion of Figure 6.11:

Consider the municipalities not taking the required corrective actions; of them 42.3% executed "Some (>50%)", 34.6% executed "Most(>75%)", and only 11.5% executed all the planned project needs. Those in the process of taking action to address the required corrective actions, indicated that 35.7%

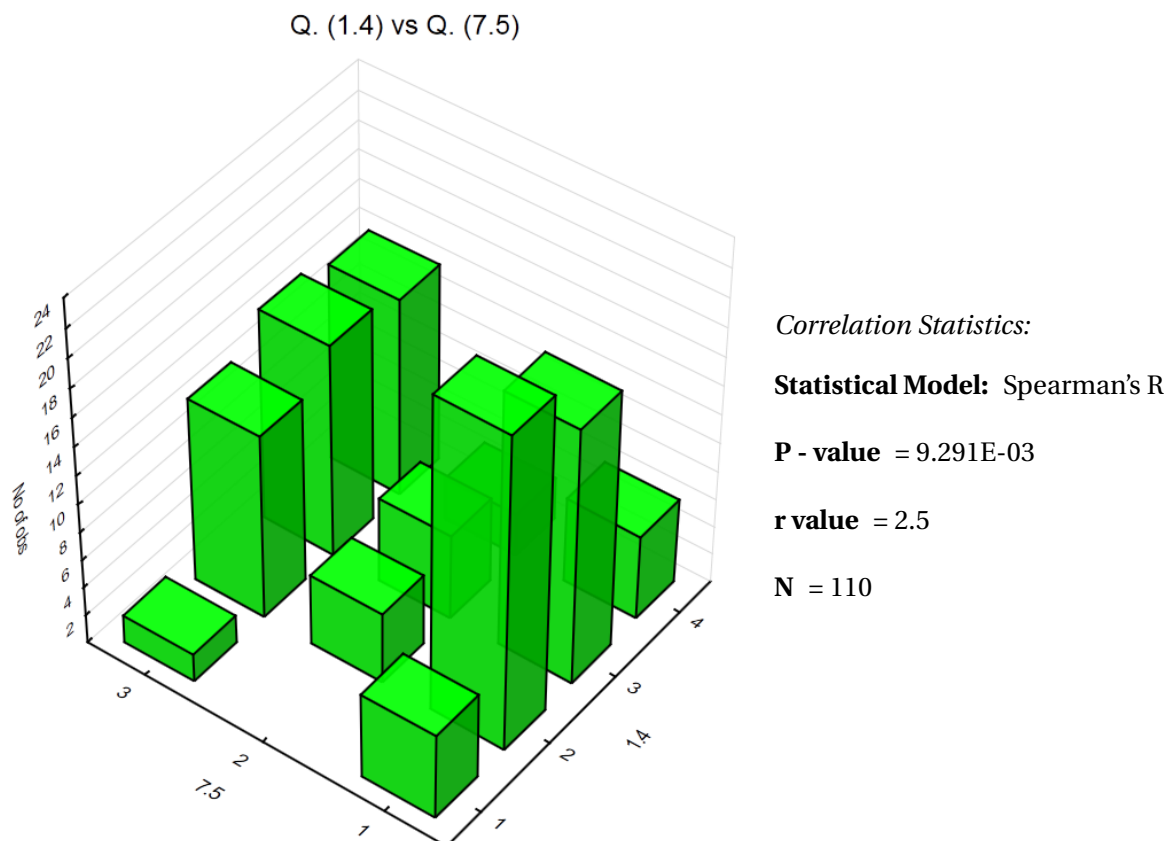


Figure 6.11: Bivariate histogram of Q.(1.4) vs. Q.(7.5)

of them execute "Some(>50%)" of the project needs, 42.8% "Most(>75%)" and 21.4% execute all their project needs. This is only a slight improvement on those not taking action. Municipalities taking the required remedial actions to address water safety related issues have the best success rate of 31.8% in executing all the planned project needs, while 34.1% execute "Most(>75%)" and 29.6% execute "Some(>50%)" of the planned project needs.

Significance of relationship:

The water safety related issues are ones that will be identified in the WSP. From Figure 2.5 it can be seen that the issues raised in the WSP are ones that are to be planned for in the further planning processes. The WSP is also mentioned in question 1.4, thus this correlation is expected and the execution rate of planned activities in the WSP will enhance the execution of planned activities. Municipalities must start to execute planned projects at some point, and executing smaller planned activities will help enhance their capability to do so with larger projects.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 8.3 Have wastewater and environmental safety related issues (e.g. pollution incidents, issues identified via Green Drop Certification program) been tabled to Council for action?

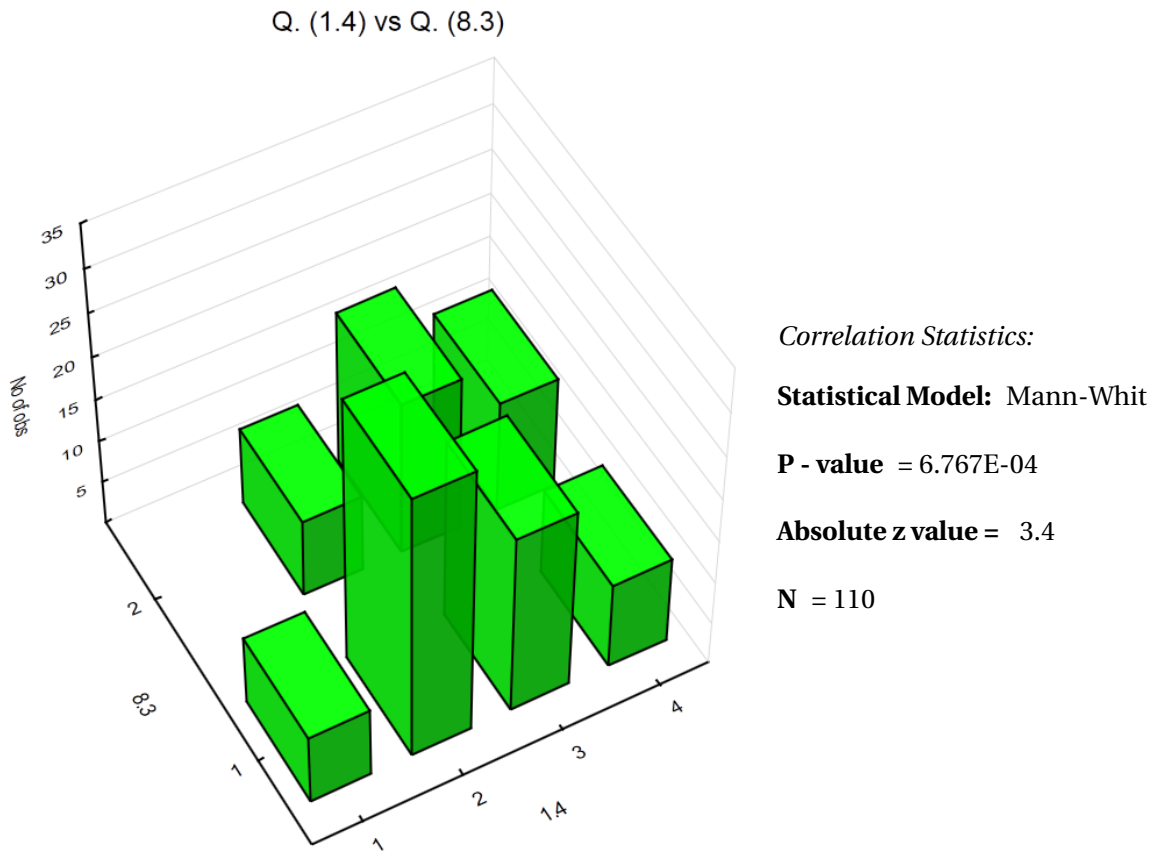


Figure 6.12: Bivariate histogram of Q.(1.4) vs. Q.(8.3)

Table 6.10: Response scale: Q.1.4 & Q.8.3

Q. (1.4)		Q. (8.3)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

Discussion of Figure 6.12:

The majority of the municipalities not tabling wastewater and environmental issues to council struggle to perform on the high end of question 1.4. Of them, 44.3% only executed "Some(>75%)", 30% executed "Most(>75%)" and 14.3% executed all of the planned project needs. Of the municipalities tabling wastewater and environmental safety related issues to council; 45% executed "Most(>75%)", 32.5% executed all and none executed "<50%/None/" of the planned project needs. This is a drastic improvement on those not tabling issues to council.

Significance of relationship:

Winning the support of council is crucial to the success of a municipality. When the council members do not support a project, there will most likely be a lack of funds allocated to the relevant cause. Tabling clear and accurate data to council regarding wastewater and environmental safety related is-

sues will help to win their support in the allocation of funds and resources to execute project needs. As seen from the MuSSA data, tabling issues to council does not automatically ensure the successful execution of project needs, but a much higher percentage of the municipalities doing so executed "Most(>75%)" and 100% of the project needs.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 8.5 Have required corrective actions/remedial measures to address identified wastewater and environmental safety related issues been successfully implemented?

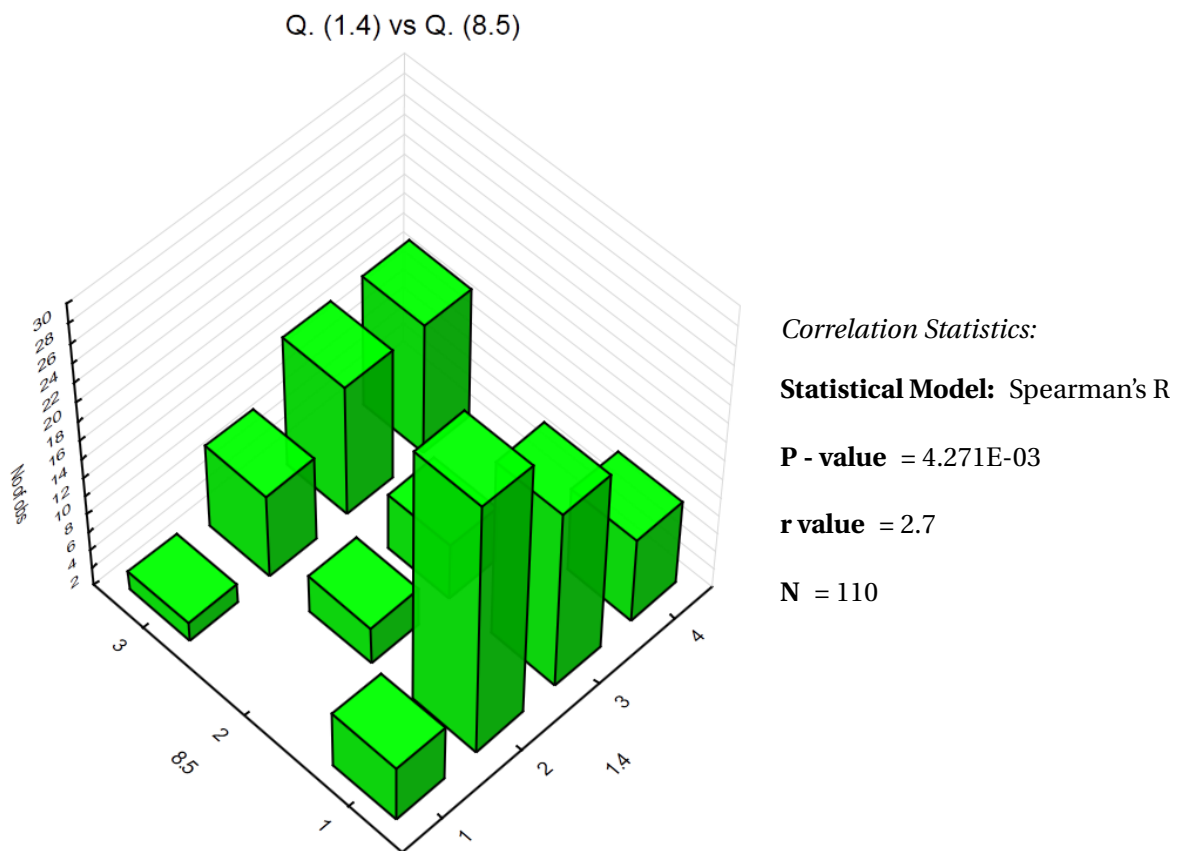


Figure 6.13: Bivariate histogram of Q.(1.4) vs. Q.(8.5)

Table 6.11: Response scale: Q.1.4 & Q.8.5

Q. (1.4)		Q. (8.5)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In Process
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		

Discussion of Figure 6.13:

Consider the municipalities not taking remedial measures to address the identified issues; of them 44.3% only executed "Some(>50%)", 31.2% executed "Most(>75%)" and only 14.8% executed all of the planned project needs. Not a single municipality in the process of taking remedial measures to address identified issues was able to execute all the planned project needs. Of the municipalities in the process of taking the required actions, 60% executed "Most(>75%)" and 40% executed "Some(>50%)" of the planned project needs. A positive improvement is shown for the municipalities taking the required corrective actions, of them 35.9% executed all the project needs, 35.9% executed "Most(>75%)" and 23% executed "Some(>50%)" of the project needs.

Significance of relationship:

Implementing remedial actions to address wastewater and environmental safety related issues will contribute to the completion of project needs identified in the WSP, Master Plan, WSDP and IDP, as these planning processes will identify wastewater and environmental safety related issues. This correlation shows the impact of taking action in the various sectors to correct identified issues to the completion of project needs.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 10.1 Is an effective infrastructure operations and maintenance team available (i.e. sufficient artisans, mechanical, electrical support with correct skills/qualifications and experience)?

Table 6.12: Response scale: Q.1.4 & Q.10.1

Q. (1.4)		Q. (10.1)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

Discussion of Figure 6.14:

Consider the municipality not having effective maintenance teams available; of them 49% only executed "Some(>50%)", 34.7% executed "Most(>75%)" and only 6.12% executed all the planned project needs. The municipalities with effective operations and maintenance teams are much better at executing planned project needs. 32.8% of these municipalities executed 100% of the planned project needs, while 36% executed "Most(>75%)" and 26.2% executed "Some(>50%)" of the planned project needs.

Significance of relationship:

Doing in-house operations and maintenance of assets should be included in all municipalities' plan-

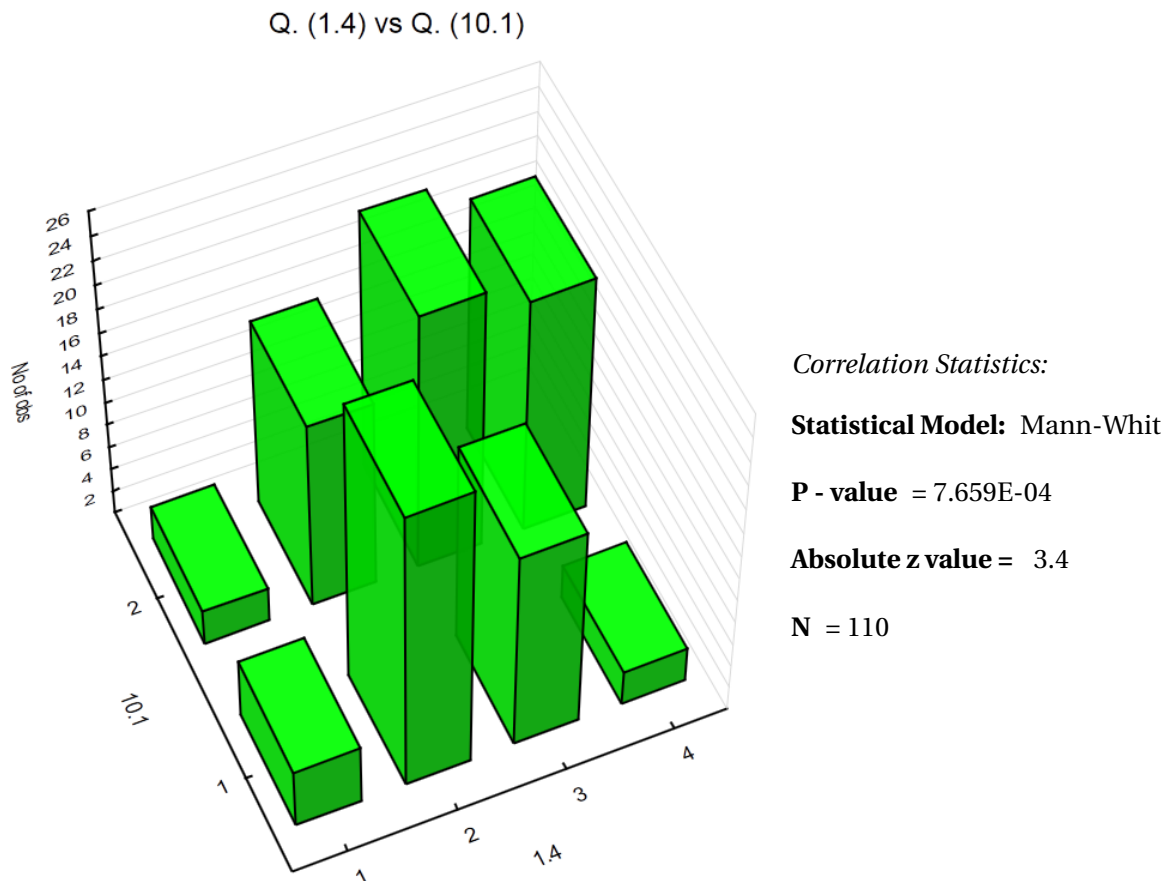


Figure 6.14: Bivariate histogram of Q.(1.4) vs. Q.(10.1)

ning. By having an effective operation and maintenance team available, the municipality will be able to execute more of the planned project needs. The data proves this, by showing that a greater percentage of municipalities with effective teams available are able to execute "Most(>75%) and 100% of the projects needs, than those without effective teams available.

Question 1.4 *Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?*

vs.

Question 10.3 *Is appropriate scheduled/planned/preventative maintenance performed at WTW and associated water reservoirs/water pump stations/distribution network?*

Discussion of Figure 6.15:

Of the municipalities doing "<50%/None" preventative maintenance on WTW and networks, 44.4% executed "Some(>50%)" of the project needs and only 18.5% executed all the project needs. No noticeable improvement is visible in the percentage of the municipalities doing "Some(>50%)" preventative maintenance, with 51.2 of them executing "Some(>50%)" of the project needs. Of the municipalities doing "Most(>75%)" preventative maintenance, 62.1% executed "Most(>75%)" of the project needs while only 13.79% could execute all the project needs. Consider the municipalities doing 100%

Q. (1.4) vs Q. (10.3)

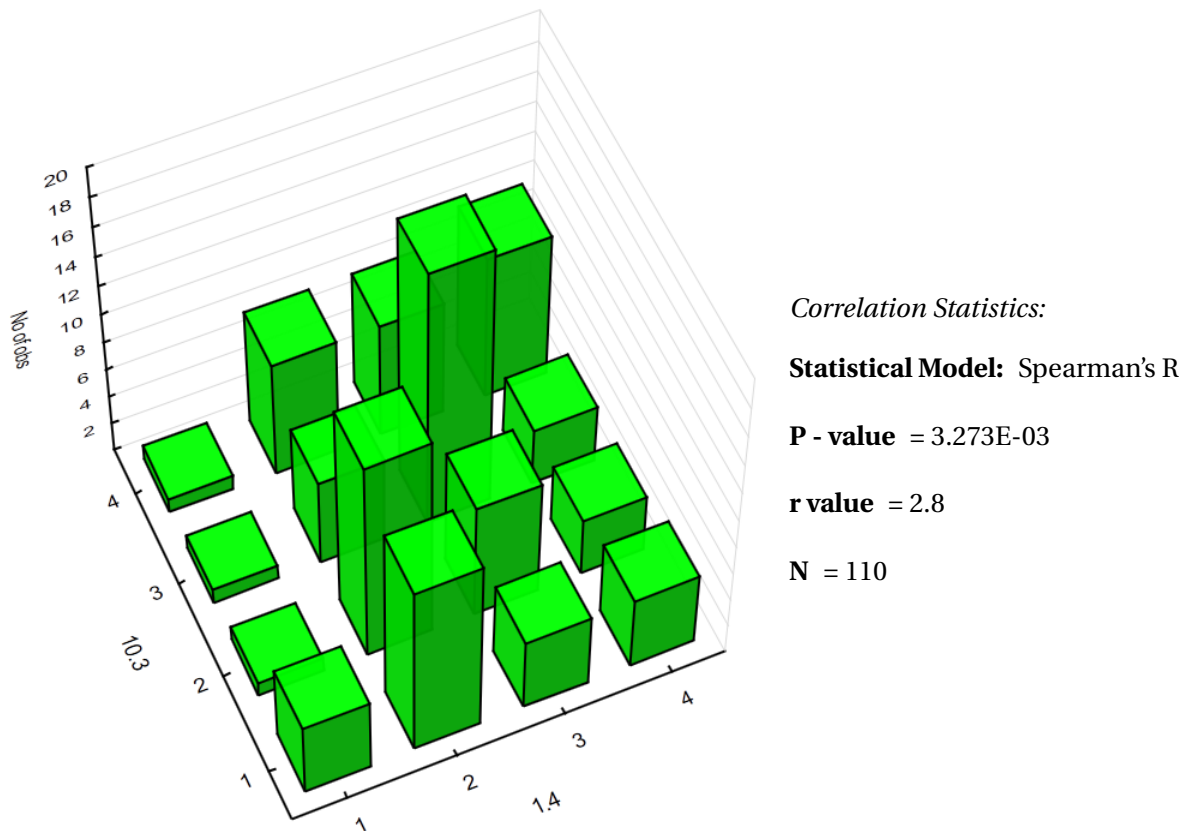


Figure 6.15: Bivariate histogram of Q.(1.4) vs. Q.(10.3)

Table 6.13: Response scale: Q.1.4 & Q.10.3

Q. (1.4)		Q. (10.3)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

preventative maintenance; of them 37% executed 100% of the planned project needs, while 29.6% executed "Most(>75%)" and 29.6% executed "Some(>50%)". It must be noted that preventative maintenance in the WWTW sector (question 10.4) also strongly correlated with question 1.4 at a P-value of 0.0101, which is expected.

Significance of relationship:

Preventative maintenance on water and wastewater infrastructure does not necessarily have a direct relationship with project needs indicated in the WSP, Master Plan, WSDP or IDP. It does however, show good practice and the capability of the organization to plan and execute required project needs at given times in a proactive manner. It is seen from the results that those performing preventative maintenance have a much higher success rate of executing their required project needs, as they have

developed the skills for planning and executing those plans at given times. They are also more proactive in performing project needs and most likely have less backlogs.

Question 1.4 *Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?*

vs.

Question 11.2 *Does an appropriate Capital Investment Program exist?*

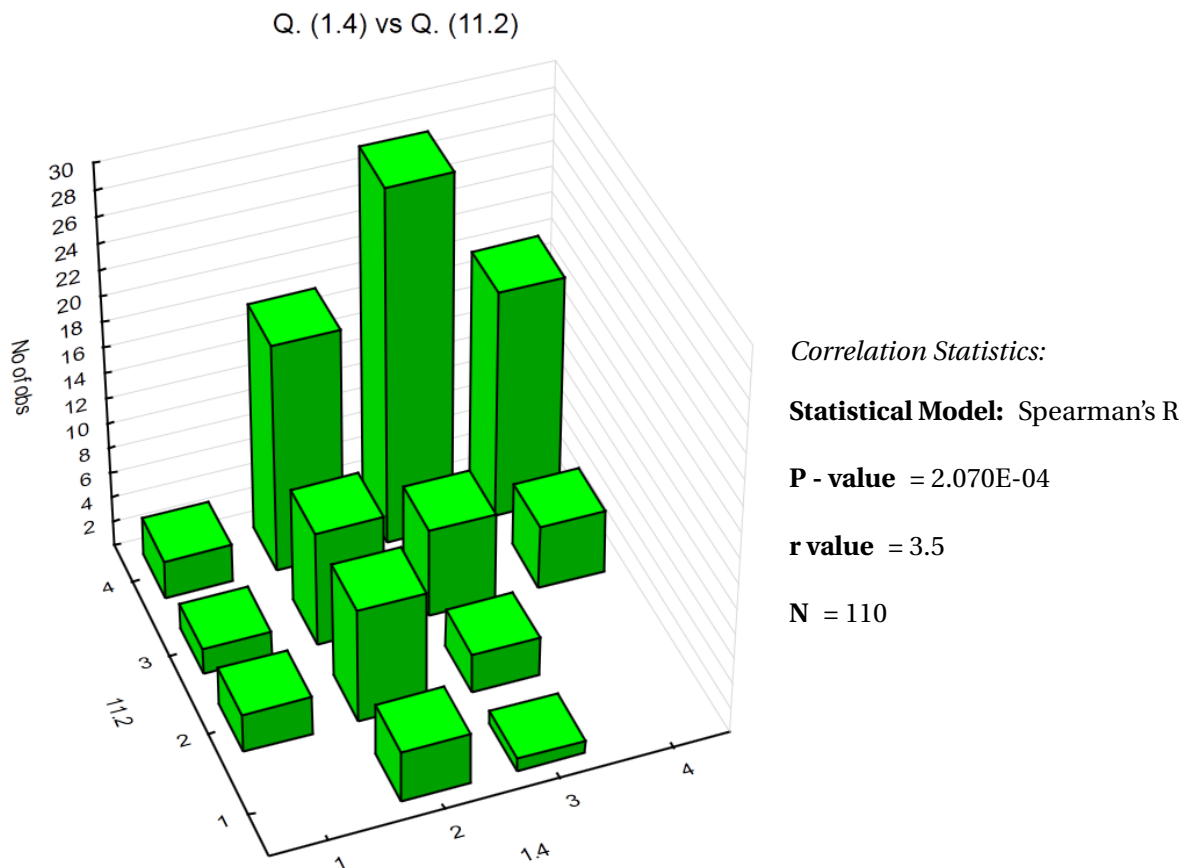


Figure 6.16: Bivariate histogram of Q.(1.4) vs. Q.(11.2)

Table 6.14: Response scale: Q.1.4 & Q.11.2

Q. (1.4)		Q. (11.2)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, strongly agree
3	Most (i.e. >75%)	3	Mostly agree
2	Some (i.e. > 50%)	2	Agree somewhat
1	< 50%/None/Don't know	1	No, disagree/Don't know

Discussion of Figure 6.16:

Not one municipality without a Capital Investment Program could execute all its project needs, of them 80% only executed "Some(>50%)" of the planned project needs. Of the municipalities agreeing somewhat that they have a Capital Investment Program, 60% executed "Some(>50%)" of the planned project needs. Municipalities mostly agreeing that they have a Capital Investment Program generally executed in the range of "Some(>50%)" (39.13%) to "Most(>75%)" (30.43%) of the planned project needs, which shows they start to have a slight tendency towards improvement. Of the municipalities with a complete Capital Investment Program; of them 26.8% executed 100% of the planned project needs, 41.8% executed "Most(>75%)" and 26.8% executed "Some(>50%)". It is good to note that, 67 out of the 110 municipalities in the sample indicated that they strongly agree to having Capital Investment Programs.

Significance of relationship:

The WSDP looks at future needs of the municipality and how it needs to develop in order to continuously serve the community, the Master Plan looks at what resources are available versus the needs of the municipality. If a Capital Investment Program does not exist, the planned activities in the WSDP and Master Plan will not be able to be executed due to lack of funds, as seen in the results. Municipalities must develop Capital Investment Programs to allow for the development of future needs which will enhance the project execution rate. A Capital Investment Program will also allow the municipality to become less reliant on government grants for future developments, which is a more sustainable business indication.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 11.4 Is there a good correlation between planned/budgeted water services activities and executed activities (i.e. funds effectively spent)?

Table 6.15: Response scale: Q.1.4 & Q.11.4

Q. (1.4)		Q. (11.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

Discussion of Figure 6.17:

Of the municipalities that do not have a good correlation between budgeted and executed water service activities; 55.6% only executed "Some(>50%)" of the planned project needs as mentioned in question 1.4, while 25.93% executed "Most(>75%)", and only 3.7% executed 100% of the planned

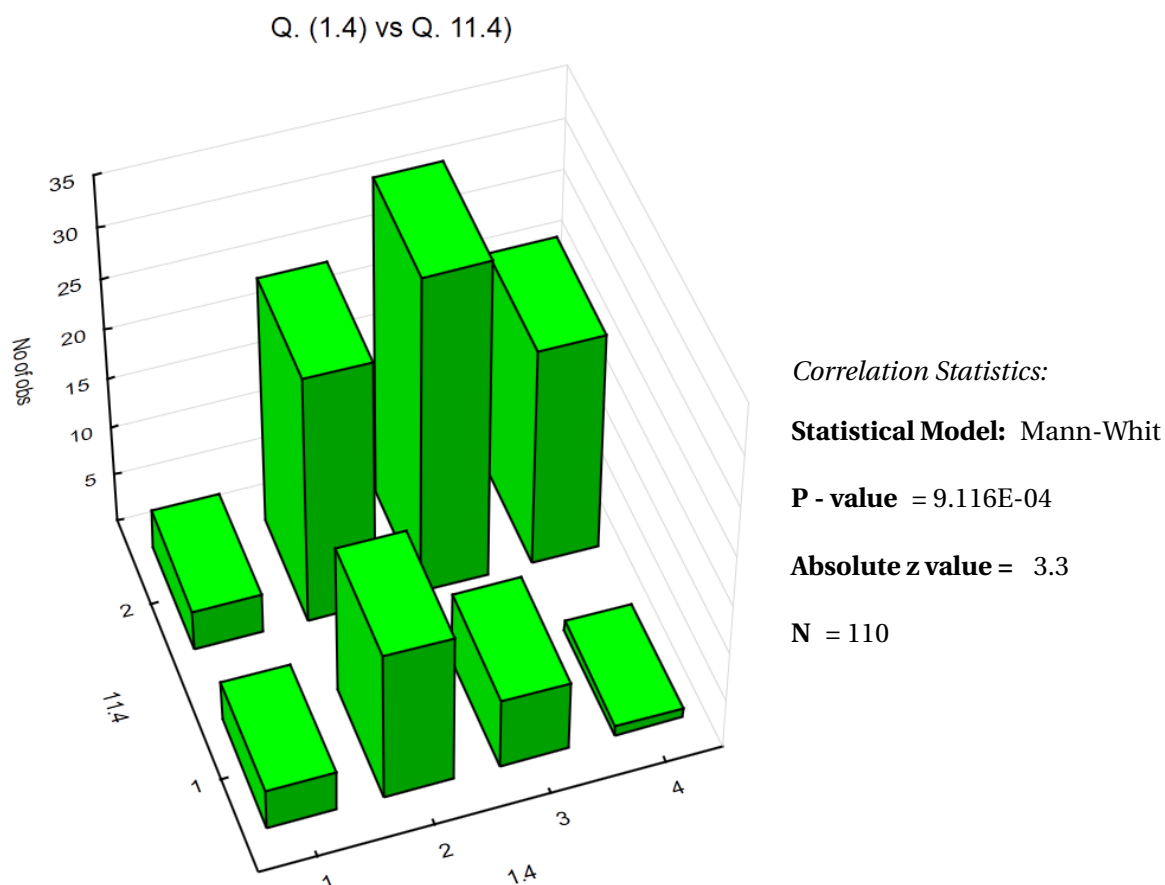


Figure 6.17: Bivariate histogram of Q.(1.4) vs. Q.(11.4)

project needs. The municipalities showing a good relationship between budgeted and executed water services activities are more successful in executing planned activities. 26.5% of them executed 100% of the planned project needs, 38.6% executed "Most(>75%)" and 30.1% executed "Some(>50%)" of the planned project needs. It is good to see that 75.5% of municipalities feel that they have a good correlation between budgeted and executed activities.

Significance of relationship:

It is very good to see that 75.5% of municipalities feel that they are executing budgeted water services activities, or in other words effectively spending funds towards allocated activities. This is however, not reflected in the execution rate of project needs in question 1.4, as only 20.9% of municipalities feel that they are executing 100% of the project needs indicated in the planning processes. This can be an indication that more funds are needed to execute the planned project activities identified during the planning phase. This is where the municipality needs to win the council's trust, to help gain more funds for executing project needs in the WSP, Master Plan, WSDP and IDP.

Question 1.4 Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)?

vs.

Question 12.5 Are cash reserves in place to both fund routine operations and emergency incidents

(i.e. cash in bank to pay utilities/suppliers on time (ESKOM, Water Board, contractors) and perform required functions - not reliant on Grants)?

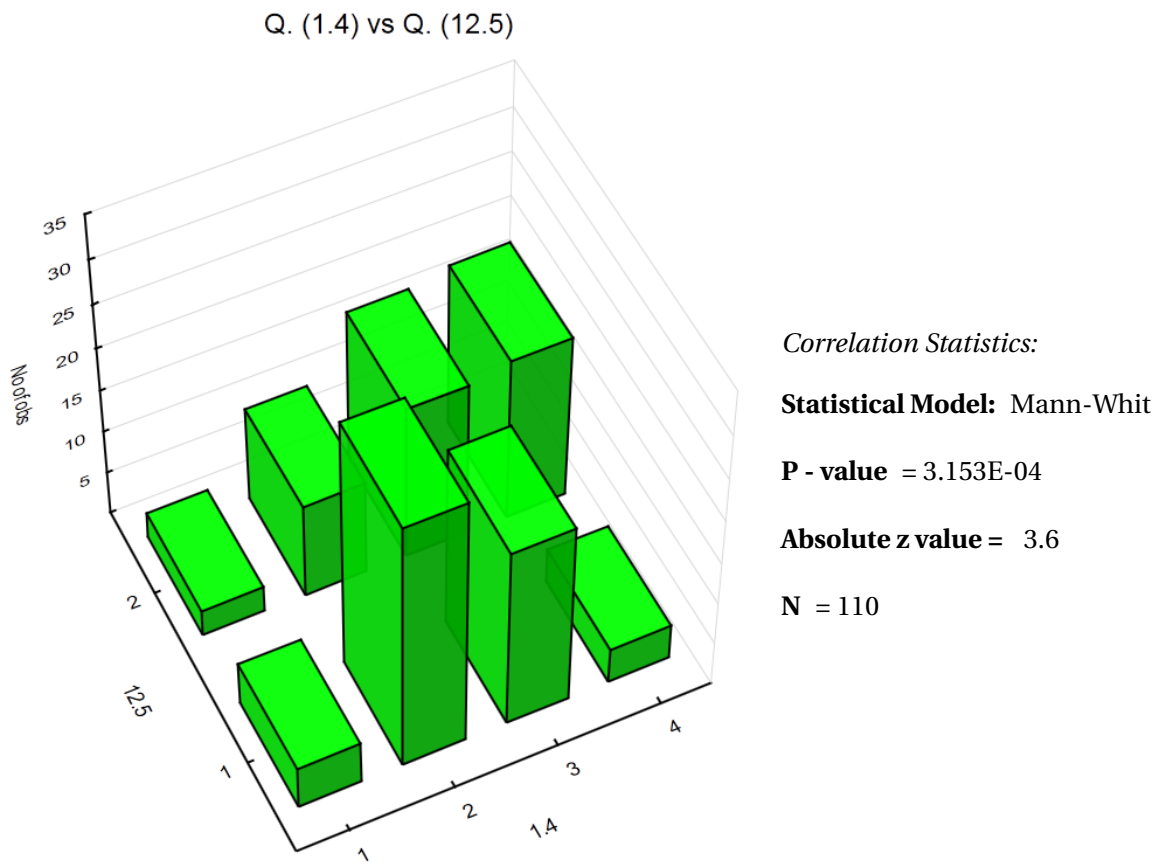


Figure 6.18: Bivariate histogram of Q.(1.4) vs. Q.(12.5)

Table 6.16: Response scale: Q.1.4 & Q.12.5

Q. (1.4)		Q. (12.5)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

Discussion of Figure 6.18:

Consider the municipalities not having cash reserves; of them 49.2% only executed "Some(>50%)" of the planned project needs, 35.6% executed "Most(>75%)" and only 6.8% executed all the planned project needs. The municipalities with cash reserves in place show a significant improvement in executing higher percentages of planned activities. Of them 37.3% executed all the planned project needs, while a further 35.3% executed "Most(>75%)". It is very worrying to see that 59 of the 110

municipalities feel that they do not have cash reserves in place to fund routine activities.

Significance of relationship:

From the correlation with question 11.4, we saw that 75% of municipalities felt that they were effectively spending funds allocated to projects, but this percentage is not reflected in the percentage of the project needs executed. One of the reasons is the lack of funds that municipalities are receiving for future and further development of assets towards water services delivery. The needs of the municipality are identified in the planning process, and can only be executed if funds are available. Many of South Africa's municipalities have become reliant on government grants, due to the small percentage of user paying for service. Municipalities must manage the organization like a business and strive to maximize the financial assets, in order to become sustainable and non-reliant on grants. This will not only be good practice, but also allow them to execute a greater percentage of the planned project needs.

6.3 A summary of significant correlations influencing the execution of planned water services activities

The correlations discussed in this chapter will contribute to the enhancement of the execution rate of planned activities, helping the majority of municipalities to strive towards executing 75% or more of planned water services activities and needs. The analyzed data revealed several factors that municipalities should address in order to help better the execution rate of planned project needs namely;

1. Water service planning

Planning is essential to the execution of project needs within the municipality. It is clear from the data that WSP, WSDP and Master Planning all have a strong correlation with the execution rate of planned projects needs as stated in question 1.4. Planning must be done as a prerequisite to the execution of planned activities.

2. Technical management skill level and capacity

Technical management capacity allows municipalities to execute planned projects need. The first step to capacity building should be the filling of vacant organogram posts. Many South African municipalities do not have enough posts in technical management organograms allowing for sufficient technical management staff, five per 100 000 persons served as recommended by experts [2]. Therefore, once organogram posts have been filled municipalities should strive to employ additional staff to reach the recommended target of at least five technical management staff per 100 000 persons served. The majority of municipalities employing 75% or more sufficient technical management staff are able to execute 75% or more of planned project needs. The employment of skilled and experienced management staff is also very important to the ability of a municipality to execute planned activities. The data has shown that a higher percentage of municipalities performing in-house training on at least 75% of the technical management staff execute more than 75% of the planned activities than does those not

performing training on managers. Having well trained management staff gives them the confidence to make accurate technical decisions.

3. Staff skill technical

Many of the staff employed at South African municipalities are not formally trained, thus lacking in skills. The training of in-house staff at a technical operational level helps the municipality to enhance technical staff capacity building. This leads to more planned projects being executed. Skilled technical staff capacity is essential to the sustainability of a municipality and can be enhanced by the training of the staff at hand, and should be done by all municipalities.

4. Technical staff capacity

The execution of planned activities is mostly done by the technical staff at ground level. When they are not in place or the capacity does not exist, planned project needs will not be executed. The filling of at least 75% of organogram posts is essential to the execution of 75% or more of planned project needs.

5. Drinking water safety & Blue Drop status

In many of the South African municipalities politics play a major role in the allocation of funds, which directly influences the organizations ability to execute planned activities. It is crucial that municipal managers and technical managers table water safety related issues to council with complete and accurate data to help win their support towards solving the problem. This will in most cases enhance the allocation of funds to the related matters, thus helping to raise the percentage of planned projects being executed, especially those identified in the WSP.

6. Wastewater/environmental safety & Green Drop status

The importance of having the support of council members to address wastewater and environmental related issues is extremely important. Technical departments not having the support of the council found it very difficult to execute all their planned project needs, as can be seen from the data. Issues experienced by the technical department should be tabled to council. This will directly enhance the capability of the municipality to execute planned project needs, mainly by way of having proper funds allocated.

7. Operations & maintenance of assets

Even though it has become common practice in many South African municipalities to out-source maintenance of assets, there is still a dire need for in-house maintenance teams that are effective and available. Municipalities not having such asset management teams found it difficult to execute more than 75% of the planned project needs. The occurrence of planned and scheduled maintenance of assets in a municipality is a good indication that good practice is taking place with regards to planning and execution of projects.

8. Financial management

Funds are one of the most critical factors when it comes to the execution of planned projects. One of the ways new development projects are funded, such as those identified in the WSDP,

is through the Capital Investment Program. Capital investment from developers and the government will fund many new projects and is key in the execution of these projects. It is very positive that 75% of municipalities felt that they are effectively spending funds allocated to projects. This is however not reflected in the percentage of municipalities that are executing all the planned projects. Only 20.9% of municipalities reported that they are executing all planned project needs. This suggests that not enough funds are allocated to the execution of planned activities as stated in question 1.4.

9. Revenue collection

The sustainability of a municipality in terms of not being reliant on government grants has a great impact on its ability to execute planned projects. Relying on government grants to fund the execution of projects is not sustainable. Politics have too much of an influence in the South African environment with regards to the spending of government funds. Municipalities must strive to become financially independent of government grants. The municipalities from the sample that are able to build up cash reserves are more successful at funding and executing projects.

Municipalities are strongly urged to consider the correlations discussed in this chapter as being contributing factors towards the execution of planned project needs when aiming to enhance the rate of execution of planned projects.

Chapter 7

Conclusions and recommendations

The aim of this study has been to investigate the use of Municipal Strategic Self-Assessment data to aid municipal decision making regarding (i) staff skill levels and capacity, (ii) non-revenue water (NRW) and (iii) execution of planned water services activities by way of investigating significant correlations. (i), (ii) and (iii) have been extensively investigated in Chapters 4, 5 and 6. This chapter will summarize the results from the investigation and set forth recommendations for future research.

7.1 Conclusions and recommendations from data analysis results

The following conclusions can be drawn from each section regarding the results from the statistical analysis of the MuSSA data. For in depth discussions and conclusions, refer to the relevant chapters;

Staff skill levels and capacity

- Technical management capacity, especially the filling of vacant organogram posts, has a significant impact on 11 of the 16 MuSSA business attribute areas.
 - Municipalities filling at least 75% of their technical management organogram posts generally perform better in (1)Water service planning, (2)Management skill level, (3)Staff skill level (4)Technical staff capacity, (5)Water conservation and demand management, (6)Infrastructure asset management, (7)Operations and maintenance of assets, (8)Financial management, (9)Revenue collection, (10)Water service quality and (11)Customer care.
 - Having less than 75% of organogram posts filled led to significant reductions in performance with regards to the above mentioned eleven attribute areas.
 - The filling of vacant organogram posts is an appropriate starting point for municipalities in the quest to build appropriate technical management capacity, and will make major contributions to the performance of the eleven above named business attribute areas.
- The lack of performance due to lacking technical management capacity is confirmed in literature, especially by Allyson Lawless. She found that the hand full of remaining key technical

staff are expected to perform many non-technical roles and attend numerous meetings and workshops resulting in a significant number of municipalities[2, p.81];

- being unable to spend municipal infrastructure grants
 - being unable to plan and access other sources of development funding
 - being unable to cope with operations and maintenance
 - being unable to cope with new development
 - suffering from high losses of water and electricity
 - being unable to improve their service income
- A study conducted by the CSIR found that one of the major underlying issues causing failure of water and wastewater treatment plants is lacking staff skill levels and experience. The results from this research project's analysis revealed several attribute areas municipalities can focus on as factors contributing to the state of operational staff skill levels and experience. The improvement of water and wastewater operational staff skill levels and experience requires commitment by the municipality in the following areas, as revealed by this study, and municipalities are to consider them in plans to improve treatment plant staff skills levels and experience;
 - Water service planning
The implementation of a Water Safety Plan and Water and wastewater Master Plan leads to an increase of skilled and experienced staff being employed at water and wastewater treatment works. The implementation of these planning processes allow municipalities to identify technical staff skill and experience shortages and correct them before resulting in crisis situations.
 - Management skill level
The filling of 75% or more of organogram posts allows municipalities to have enough technical management staff capacity to devote time to non-technical issues, such as staff appointments and shortages. The training of in house technical management staff in water service skills, along with the appointment of technical management staff with the correct skills and qualifications, empowers the municipality with a group of decision makers who understand the importance of trained operational staff.
 - Staff skill level
Due to the water services skill shortage in South Africa, municipalities performing in-house training on operational staff are generally able to employ skilled operational staff at at least 75% of their water and wastewater treatment works.
 - Technical staff capacity
Municipalities filling more than 75% of their technical staff organizational organogram posts start to show an increased number of skilled and experienced operational water

and wastewater staff being employed. This can be contributed to good practice within the organization.

– Drinking water safety & Blue Drop status

The allocation of funding to address water safety related issues directly affects the appointment of skilled and experienced operational staff at treatment plants. The majority of municipalities having sufficient funding allocated are able to employ skilled and experienced operational staff at at least 75% of their works. As shown in Table 2.2, 18% of operational problems are caused by budget constraints. The appointment of staff has also become an administrative nightmare for management and requires pro-active planning.

– Wastewater and environmental safety & Green Drop status

Taking remedial actions to correct wastewater and environmental safety related issues should without any doubt include the appointment of skilled and experienced operational staff. The majority of municipalities taking these remedial actions are able to employ skilled and experienced staff at 75% or more of treatment works.

• Water and wastewater operational staff capacity

The numbers of staff employed at water and wastewater treatments works are heavily dependent on;

– Water service planning

A large percentage municipalities have their Water Safety Plans and Water Services Development Plans in the development stage, and are not showing any improvement towards operational staff capacity building. Municipalities must move beyond just the development of their planning and implement the planned activities to see improvement in operational staff capacity building.

– Management skill level

The skill level of the technical decision maker has a significant impact on the number of staff employed at operational works. These individuals grasp the importance of staff capacity towards proper operation of the treatment works. However skills alone are not enough, and it is seen from the data that municipalities are also in need of sufficient technical management capacity (numbers) to allow them to devote time to non-technical issues such as staff appointments.

– Staff skill level and capacity

It has been found that when skilled and experienced operational staff are employed, the municipalities are also more capable of capacity building. This can be contributed to (i) the fact that skilled and experienced staff will be able to identify shortages and inform management and (ii) the presence of good practice throughout the organization.

– Infrastructure asset management

The development of in-house staff to perform day-to-day maintenance operations helps to build capacity within the municipality.

Non-revenue water (NRW)

The reduction of NRW is of great importance to South Africa, not only due to the financial implications but also due to the fact South Africa is one of the world's 30 most water scarce countries. Seven of the 16 key business attribute areas were revealed as being factors contributing to NRW from the analysis and are factors to be considered by municipalities.

- Water services planning

The planning for future needs in terms of NRW enhances the reduction of NRW, while the lack of planning has the opposite implication. The ability to reduce NRW below 20% is particularly noticeable for the municipalities that perform and implement a Water, Sewage and Storm Water Master Plan.

- Management skill level

Municipalities that train the management staff in the field of water services, are very capable of reducing NRW to below 20%.

- Staff skill level

Municipalities employing 75% or more network operations and repair staff with the correct skill and experience generally succeed in keeping the NRW percentage below 30%. The Water Research Commission states in a report regarding the state of plumbing in South Africa, that one of the root causes of high percentages of NRW is the lack of skilled staff to repair water networks [24].

- Water conservation and demand management

One of the strongest correlations from the data with NRW percentages, is the metering and billing of connections. Municipalities metering and billing 98-100% of connections are generally able to keep their NRW below 30%. This is also due to commitment from management to reduce NRW. The implementation of pressure management on more than 75% of reticulation systems shows a turning point, in that municipalities start to show positive results in NRW reduction. The failure of a municipal organization to monitor and remove illegal connections will result in an increase of the organizations NRW and in most cases to above 30%.

- Infrastructure asset management

Municipalities failing to keep an up-to-date asset register, or having it in development are almost certain to have NRW percentages above 30%. Of those with a complete asset register, 58% reported that they have less than 30% NRW. The same trend is apparent for municipalities regarding an infrastructure asset management (IAM) plan. Not having a IAM plan or being in the development stage of the plan does not help reduce NRW. The implementation of the IAM plan is vital to the reduction of NRW below 30%. Of the municipalities implementing a

IAM plan, 42.8% have a NRW percentage below 20%. Ageing infrastructure has been plaguing South African municipalities for the past few years, and having accurate asset registers with a IAM plan will allow for the timely replacement of infrastructure, drastically reducing NRW.

- Operations and maintenance of assets

The data has shown that an IAM plan is vital to the reduction of NRW. Equally vital is an infrastructure operations and maintenance team. Failure to have an infrastructure operations and maintenance team resulted in 75% of the municipalities in the sample to have a NRW percentage above 30%, while 62% of those with a team available has a NRW percentage below 30%.

- Information management

Not having a IT system in place and accessible reduces the ability of the municipality to decrease its NRW percentage below 30%. An IT system that is in place helps distribute information and improves communication in the organization. When an IT system is in place it has been concluded that other factors influence the reduction of NRW, such as management commitment.

The data shows that having a NRW percentage below 30% greatly improves the financial sustainability of a municipality. The majority of municipalities reporting to have a NRW percentage below 30% also felt that their revenue collection is acceptable. A NRW of 30% or less also allows the majority of municipalities to build up cash reserves to fund routine operations and maintenance activities, thus becoming non-reliant on government grants.

Execution of planned water service activities

The MuSSA data revealed the following attribute areas municipalities are to focus on towards improving the execution rate of the planned water service activities;

- Water service planning

The observed correlation between planning activities with the execution and implementation of the planned activities was expected. When planning does not occur, there are no plans to be executed. It confirms that planning is needed in the long and short term as a preliminary requirement to the execution of activities.

- Technical management skill level and capacity

The percentage of municipalities with all technical management organogram posts filled and that are able to execute all the planned water services activities is 38%. This is a vast improvement on the municipalities with less than 50% of the technical management organogram posts filled. It has been found in the literature that when technical management capacity is absent, project needs are not executed [2; 6]. Technical management capacity is very crucial to operational success and the execution of planned activities. Equally visible from the analysis results is the impact of technical management skills and development through training of technical

management staff on the ability to execute planned activities. Those not developing management staff find it hard to execute planned water service activities.

- Technical staff skill level

Municipalities not performing training on staff could generally only execute 50-75% of the planned water services activities, while 37.2% of those performing training were able to execute all the planned projects. Due to the severe skill shortage, especially in the water sector, it is difficult for municipalities to find skilled personnel. Performing training of staff will help build an educated group of staff capable of executing their assigned tasks.

- Technical staff capacity

A major increase in execution of planned water service activities is seen for the municipalities filling 75% or more of their technical staff organizational organogram. Having technical staff allows for capacity to execute the planned activities.

- Drinking water safety & Blue Drop status

The tabling of water safety related issues to council on a regular basis has surprisingly shown positive contribution towards the execution of planned water services activities. This is accompanied by the allocation of funds to address these water related issues. Politics play a major role in the functionality of South African municipalities and the situation requires constructive communication between technical and political members. Technical management is strongly urged to table accurate data to council on a regular basis, to help strengthen the bond and develop understanding between technical and political members.

- Wastewater and environmental safety & Green Drop status

As seen with water safety related issues, the tabling of issues on a regular basis to council has a significant positive impact on the rate of execution of planned activities.

- Operations & maintenance of assets

Of the municipalities with effective operations and maintenance teams available, 32.8% were able to execute 100% of the planned water services activities, which is vastly better than those without maintenance teams. This links back to the major maintenance backlogs existing within South African municipalities found in the literature.

- Financial management

It is positive to note that 75% of municipalities feel that they are executing budgeted water services activities. However, this is not reflected in the percentage of activities planned for and being executed. This leads to the conclusion that there is a lack of funding for the execution of water services activities, restricting the execution rate of the planned activities. This fact is confirmed by Douglas Flint, chairman of HSBC banking giant when he stated in a news report that "*total aid for water access and sanitation has actually declined*[11]. Municipalities with a proper infrastructure investment program showed positive indications towards the execution of a higher percentage of planned water services activities.

- Revenue collection

The financial self sustainability of a municipality and its ability to execute planned activities are strongly related. Of the municipalities with cash reserves in place to fund both routine and emergency operations, 37% were able to execute all the planned water services activities, while only 6.78% of those that do not have cash reserves could achieve this rate of execution.

Taking all these facts into consideration it is recommended that municipalities take great care to appoint technical management staff and operational staff with the correct skills and qualifications. It is also believed that there is a need for municipalities to become financially self sustainable, allowing them to fund projects without relying on government grants. This may lead to the execution of more planned activities and enhanced service delivery. The development of the skills of technical management and operational staff currently employed has a very positive impact on skills and capacity building, and is a must in an industry where skills are hard to come by. Municipal managers are encouraged to become organizational champions, and to take responsibility for the growth of their organization. Their ability to win the support and improve communication with political parties will result in improved functioning of the organization, and present a better image to the public. This in turn will earn the respect of the public and can be used to develop a sense of ownership, leading to a decrease of vandalism and destruction of municipal property. Municipalities are strongly urged to consider the factors investigated in this study as factors contributing to the state of the three attribute areas. This will lead to the reduction of NRW and financial gain, in turn leading to improved execution rates of planned activities. The interaction between the key attribute areas, as briefly discussed here, are shown in Figure 7.1. The starting point must be management skills and capacity, once this has been put in place the rest should follow, however not without great commitment and efforts from the municipal staff and community co-operation.

The analysis of the MuSSA data has proven to yield useful data with regards to attribute areas influencing one another. The results from the statistical analysis confirms some of the trends identified by other researchers in the literature consulted. Therefore, it can be concluded that the statistical analysis of the MuSSA data can be used to help improve municipal decision making regarding staff skill level, NRW and the execution of planned water service activities by way of investigating correlations among performance indicators.

On a more practical note, the results from the data should be interpreted to answer the following two questions; (a) *So what?* and (b) *What next?*. In other words, what do the results mean for municipalities and what should they do next?

Three areas have been identified as areas that require extensive attention and resources for South African municipalities to improve the performance of water and wastewater service delivery, as shown in Figure 7.2. Each of these three areas namely (1) technical management staff, (2) financial management and planning and (3) water services planning have components unique to it that requires attention to allow improvement. These components that are exclusive to each area, not overlapping with the others, are called mutually exclusive components as defined by the MECE business model [53]. Each of the areas also have components that overlap with the other areas. These overlapping

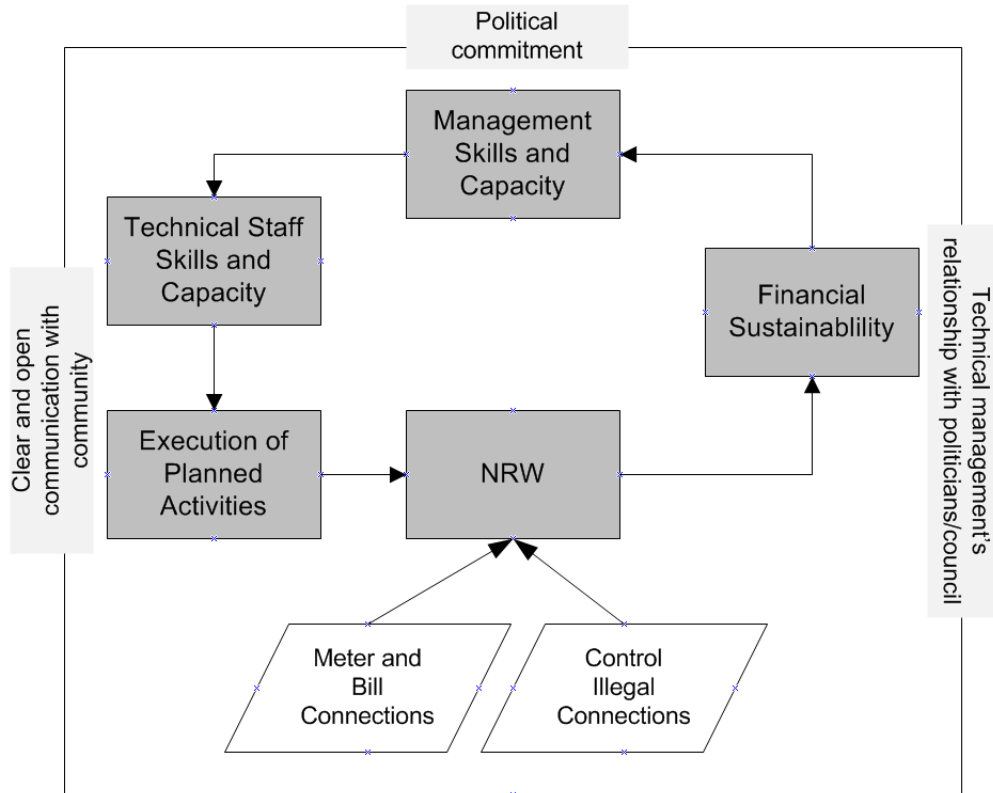


Figure 7.1: Interaction between key attribute areas

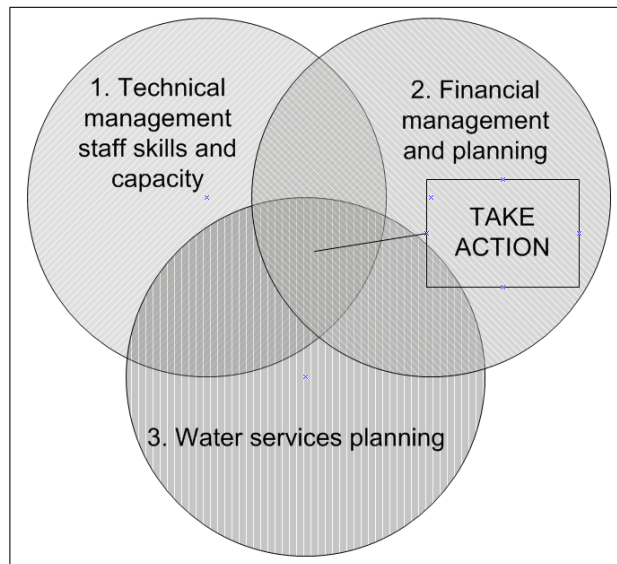


Figure 7.2: Three areas to focus on

areas require input from components in the overlapping areas to help enhance holistic improvement of the relevant area.

When a municipality wishes to improve one of these areas, it is recommended that it considers all the mutually exclusive components that requires attention, but also the overlapping components.

This will result in a collectively exhaustive improvement model, providing a holistic model for the improvement of the area requiring attention. This is mainly recommended, due to the fact that it was seen from the analysis that these three areas, in particular, significantly influence each other through a noticeable number of components. In the middle of Figure 7.2, the overlap of the three areas is labeled by the statement "take action". It is recommended that municipalities consider all the areas revealed from this investigation, that depicts the interaction between (1) to (3), and develop an action plan around the areas requiring action to work towards improvement on all three areas. This action plan should then be presented to authorities and implemented with great care. After completing this study the author feels that the performance of (1) to (3) can significantly be improved by taking action and initiative to strive towards bettering South Africa's water service delivery.

With this at hand (a) and (b) can be answered. The answer to "so what" is; consider the results from this analysis and improve the understanding of the interaction among the municipal areas and form a collectively exclusive improvement plan. This plan must be complete and holistic in nature. To answer "what next" the author makes the following statement; take initiative and responsibility, and start the required action to work towards improvement of South Africa's water and waste service delivery.

7.1.1 Recommendations for future studies

In this study no distinction was made between the various levels of municipalities. It is believed that the interaction between attribute areas will differ in the various levels of municipal organizations, and that this factor should be taken into consideration in future studies of the MuSSA data.

The MuSSA data analyzed was for a single year. Therefore, it is recommended that future MuSSA data be analyzed in the same manner. This may lead to the development of a municipal performance predictor model. Such a model will be extremely useful in the prediction of municipal services failures based on current situations and performance with regards to the 16 key business attribute areas, before failure within an attribute areas occurs. The model may consist of an online interface, where the municipal manager rates the performance of his organization on a regular basis in a selected group of attribute areas. The output from the his self assessment may include attribute areas that require attention in order to prevent failure of, say for instance NRW percentages or IAM.

An area that may lead to a better understanding of the impact that the lack of leadership has on the various levels of municipalities would be, to identify a sample of municipalities in each of the various levels of municipalities that (i) have well skilled and qualified management and (ii) lack skilled and qualified management staff. An investigation can then be performed on the spending of funds, level of service delivery and operations and maintenance patterns in both (i) and (ii) to reveal the impact, or lack thereof, when qualified and skilled management are employed versus when they are lacking.

The possible investigation to determine the optimum structure of the various levels of municipalities in terms of management, monitoring and control, capacity and capability may be meaningful and contribute to the industry.

It was noticed during the course of the study that municipalities that employ 75% or more skilled and experienced staff, but also 75% of staff capacities required, tend to show vast improvement in the performance of most of the attribute areas investigated. If future analysis of the MuSSA data continues to show this trend, a possible study investigating why municipalities start to improve at 75%, could help enhance the understanding of the functionality of the municipal environment.

Future studies may also consider the impact of partial correlations and how they might enhance or suppress correlations within the data.

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Appendices

Appendix A



Literature

A.1 MuSSA

Municipal Strategic Self-Assessment (MuSSA) of Water Services

Version: 11 January 2011

NOTE:

1. The worksheet contains 16 sections (with 5 questions per section) that need to be completed.
2. The MuSSA therefore contains 80 key questions.
3. Please use colour coding for selecting the most appropriate answer (use either  or .
4. If you have any queries regarding the MuSSA, please contact A Wensley (DWA) (012 336 8767) or G Mackintosh (Emanti) (021 880 2932).

1. Water Services Planning		Answers						
1.1	Do you have appropriate Water, Sewage and Stormwater Master Plans and are they included within your Integrated Development Plan (IDP)?	Yes, strongly agree	In development	No, disagree/Don't know				
1.2	Do you have an appropriate Water Safety Plan and is it included within your IDP?	Yes, strongly agree	In development	No, disagree/Don't know				
1.3	Do you have an up-to-date adopted Water Services Development Plan (WSDP) which you are implementing?	Yes, strongly agree	In process	No, disagree/Don't know				
1.4	Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last 3 years (i.e. planning activities are implemented)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know			
1.5	Are your planned priority projects/tasks positively contributing to Local Economic Development (LED) (e.g. executed in terms of the Public Works Programme (labour intensive)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know			
2. Management Skill Level (Technical)		Answers						
2.1	Are key posts within your technical management organisational organogram been filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know			
2.2	Do you have sufficient technical management staff (appropriate number of staff - e.g. at least 5 posts per 100,000 persons served)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know			
2.3	Do technical management staff have the correct skills/qualifications and experience (e.g. PrEng, PrTech, CPM)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know			
2.4	Is appropriate water services skills development/training for managers regularly attended?	Yes, strongly agree	No, disagree/Don't know					
2.5	Do key technical managers have signed Performance Agreements?	Yes, strongly agree	No, disagree/Don't know					
3. Staff Skill Levels (Technical)		Answers						
3.1	Are WTWs operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know	Not applicable		
3.2	Are WWTWs operated by staff with the correct skills/qualifications and experience (as per Regulation 2834)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know	Not applicable		
3.3	Do water network operations and repair staff/plumbers have the correct skills/qualifications and experience?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know			
3.4	Do wastewater collection system operations and repair staff/plumbers have the correct skills/qualifications and experience?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know			
3.5	Is appropriate water services skills development/training for staff regularly being attended (including safety)?	Yes, strongly agree	No, disagree/Don't know					
4. Technical Staff Capacity (Numbers)		Answers						
4.1	Have the posts within your technical staff organisational organogram been filled?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know			
4.2	Are WTWs operated by the appropriate number of staff (as per Regulation 2834)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know	Not applicable		
4.3	Are WWTWs operated by the appropriate number of staff (as per Regulation 2834)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know	Not applicable		
4.4	Do you have sufficient water and sewerage/sanitation network operations and repair staff/plumbers (appropriate number of staff)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	<50%/None/Don't Know			
4.5	Is an active mentoring/shadowing programme in place where experienced staff train younger, inexperienced staff?	Yes, strongly agree	No, disagree/Don't know					
5. Water Resource Management (WRM)		Answers						
5.1	Are water sources secured (e.g. fenced, tamper proof)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know	Not applicable		
5.2	Are water sources protected (e.g. no effluent discharges from community, industry)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know	Not applicable		
5.3	Are there alternative water resources available as back-up (e.g. transmission line failure)?	Yes, strongly agree	No, disagree/Don't know	Not applicable				
5.4	Is the quantity of water available from the resources sufficient for WSA needs for the next 10 years (i.e. no shortage)?	No shortage (i.e. sufficient water)	1 - 10% shortage	11-20% shortage	21-30% shortage	31-40% shortage	41-50% shortage	>50% shortage/Don't know
5.5	Is the source water quality in accordance with the design assumptions of the various water treatment works?	Yes, strongly agree	No, disagree/Don't know	Not applicable				

6. Water Conservation & Demand Management (WCDM)		Answers					
6.1	Has your WSA developed a reliable standard water balance using appropriate tools?	Yes, strongly agree	In development	No, disagree/Don't know			
6.2	What is the percentage Unaccounted for Water?	Less than 20%	Less than 30%	Less than 40%	Don't know		
6.3	What percentage of connections are metered and billed (residential and non-residential (commercial, industrial, etc)?)	>98%	75% - 98%	50% - 75%	<50%	No metering/Don't know	
6.4	Is effective pressure management practised in reticulation systems (i.e. optimised pressures (~20 - 50 m or 2 - 5 bar), use of pressure reducing valves (if required), minimisation of night flows)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None/Don't know		
6.5	Does your WSA actively monitor and remove illegal connections?	Yes, strongly agree	No, disagree/Don't know				
7. Drinking Water Safety & Blue Drop Status		Answers					
7.1	What is your average Blue Drop score for your WSA?	>90% (Excellent)	75% - 90% (Very Good)	50% - 75% (Good)	33% - 50% (Needs Attention)	<33% (Needs Urgent Attention)	Don't know
7.2	Have you registered ALL your supply schemes, monitoring programmes, sample points, laboratories and users on the BDS?	Yes, strongly agree	No, disagree/Don't know				
7.3	Have water safety related issues (including those identified via the Blue Drop Certification programme) been tabled to Council for action?	Yes, strongly agree	No, disagree/Don't know				
7.4	Have sufficient funds been made available to address these identified water safety related issues?	Yes, strongly agree	No, disagree/Don't know				
7.5	Have required corrective actions/remedial measures to address these identified water safety related issues been successfully implemented?	Yes, strongly agree	In process	No, disagree/Don't know			
8. Wastewater/Environmental Safety & Green Drop Status		Answers					
8.1	What is your average Green Drop score for your WSA?	>90% (Excellent)	75% - 90% (Very Good)	50% - 75% (Good)	33% - 50% (Needs Attention)	<33% (Needs Urgent Attention)	Don't know
8.2	Have you registered ALL your wastewater works, monitoring programmes, sample points, laboratories and users on the GDS?	Yes, strongly agree	No, disagree/Don't know				
8.3	Have wastewater and environmental safety related issues (e.g. pollution incidents, issues identified via the Green Drop Certification programme) been tabled to Council for action?	Yes, strongly agree	No, disagree/Don't know				
8.4	Have sufficient funds been made available to address identified wastewater and environmental safety related issues?	Yes, strongly agree	No, disagree/Don't know				
8.5	Have required corrective actions/remedial measures to address identified wastewater and environmental safety related issues been successfully implemented?	Yes, strongly agree	In process	No, disagree/Don't know			
9. Infrastructure Asset Management (IAM)		Answers					
9.1	Do you have an appropriate and up-to-date Asset Register (includes asset name, location, condition, useful life, risk analysis, etc)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	<50%/None/Don't Know		
9.2	Do you have an appropriate Infrastructure Asset Management (IAM) Plan for your WSA (including replacement values)?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	<50%/None/Don't Know		
9.3	Have you implemented an IAM Programme in your WSA?	Yes, strongly agree	No, disagree/Don't know				
9.4	Do you have appropriate budget and staff for your IAM Programme?	Yes, strongly agree	No, disagree/Don't know				
9.5	Have you conducted annual technical audits/assessments/inspections of your WTWs and WWTWs and have you implemented required follow-up actions?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None (Crisis)/Don't know	Not applicable	
10. Operation & Maintenance of Assets		Answers					
10.1	Is an effective infrastructure operations and maintenance team available (i.e. sufficient artisans, mechanical, electrical support with correct skills/qualifications and experience)?	Yes, strongly agree	No/Don't know				
10.2	Is a maintenance facility/workshop available, secure and stocked with critical spare equipment, tools, etc?	Yes, strongly agree	No/Don't know				
10.3	Is appropriate schedule/planned/preventative maintenance performed at WTWs and associated water reservoirs/water pump stations/distribution network?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None (Crisis)/Don't know		
10.4	Is appropriate schedule/planned/preventative maintenance performed at WWTWs and the associated collection system/pump stations?	Yes, All (i.e. 100%)	Most (i.e. >75%)	Some (i.e. > 50%)	< 50%/None (Crisis)/Don't know		
10.5	Are infrastructure maintenance costs more than 5% of total operating costs?	Yes, strongly agree	No/Don't know				
11. Financial Management		Answers					
11.1	Are appropriate financial systems in place and adhered to (as per Municipal Finance Management Act) (e.g. Supply Chain Management, Procurement Protocol, etc.)?	Yes, strongly agree	No, disagree/Don't know				
11.2	Does an appropriate Capital Investment Programme (including Municipal Infrastructure Grant (MIG), Provincial Infrastructure Grant (PIG), Bulk Infrastructure Grant (BIG) budgets) and Operating Budget (including sufficient funds for O&M, appropriate use of equitable share) exist?	Yes, strongly agree	Mostly agree	Agree somewhat	No, disagree/Don't know		
11.3	With regards to new developments, do developers adequately contribute towards construction of new bulk infrastructure?	Yes, strongly agree	Mostly agree	Agree somewhat	No, disagree/Don't know		
11.4	Is there good correlation between planned/budgeted water services activities and executed activities (i.e. funds effectively spent)?	Yes, strongly agree	No, disagree/Don't know				
11.5	Is an annual financial audit conducted and are financial statements submitted to National Treasury?	Yes, strongly agree	No, disagree/Don't know				

A.2 Self assessment guidelines

Self-Assessment Surveys Guidelines Version 1 (October 2011)

Developing the Survey...

1. Try and ensure the survey is standard for all (i.e. try to ensure statements are relevant to all participants by minimizing “not applicable” as an option).
 - a. If the participants are too dissimilar, create standalone surveys (e.g. can we assess a “large” municipality and a “small municipality” using the same tool?).
2. Ensure the survey covers all aspects of the assessed topic (e.g. water services – all key business attributes; asset management – all infrastructure components; project health check – key attributes of a successful project).
3. Use statements (not questions).
4. As far as possible keep to one topic/theme per statement
 - a. Try to avoid “this AND that AND that” in one statement
5. It is preferable to have the same number of questions per component (i.e. “leg”) as this makes the scoring easier.
6. Wherever possible, try to minimize subjective answers (often a criticism of self-assessment surveys) by providing guiding categories.
 - a. E.g. Please state the percentage of posts filled:
 - i. 100%
 - ii. 80% – 99%
 - iii. 60% – 79%
 - iv. 40% - 59%
 - v. < 50%

Is preferable to options such as “often” or “frequently” or “rarely” as “often” could mean “every day” or “once a week” or “once a month” depending on who has provided the answer.
7. Keep statement structure consistent
 - a. **Caution:** If “yes” is a “positive” scoring answer try to ensure that it is always a positive scoring answer for all statements. This might require re-writing the statement to ensure that yes is a positive answer.
8. If possible, engage with sector/field experts to ensure statement appropriateness.
9. Keep scoring simple and consistent throughout
 - a. Simple addition/summation (with conversion to a percentage) is acceptable
 - b. Try and keep to “scale of 5” (i.e. 5 options as an answer)
 - i. A “scale of 3” (i.e. 3 options) is too small for the typical number of questions whereas a “scale of 10” (i.e. 10 options) is too detailed.
 - ii. Examples include 0 – 4 or 1 – 5 (note that if 1 – 5 scale is used an overall score of 0% will never be achieved)
 - iii. The above concept could also be modified as follows: score of 1 for positive answers (yes, excellent, strongly agree) and a score of 0 for negative answers no (poor, strongly disagree) with ranges in between (e.g. in development = 0.25)

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- iv. A true “not applicable” should be scored as a “yes” and receive maximum points (e.g. score = 1)
 - v. A “don’t know” should be scored as a “no” and receive minimum points (e.g. score = 0 as I don’t know my business)
 - c. **Caution:** For consistency in overall scoring, ensure that the desired answer/best result scores the maximum points (see point 3 (a) above).
10. Weights can be added to certain components (i.e. “legs”) if it is considered more important than another component (e.g. finances (20%) vs. customer satisfaction (10%); use of show-stoppers).

Conducting the Survey...

1. Be persistent!
2. Understand the survey, topics and associated statements. Preparation is key!
3. It is preferable if more than 1 person completes the survey (e.g. 3 persons discuss and complete together) as this ensures a better answer.
4. If uncertainty surrounding a statement and/or answers arises, contact the “survey master” to resolve.

After the Survey...

1. Present draft findings to persons assessed for final review.
2. Highlight key gaps for associated improvement.
3. Follow-up to see if required actions are implemented.
4. Re-evaluate (i.e. re-conduct the survey) to see if gaps have been closed.

Appendix B

Staff skill levels and numbers

B.1 Areas affected by key posts in technical management organograms being filled

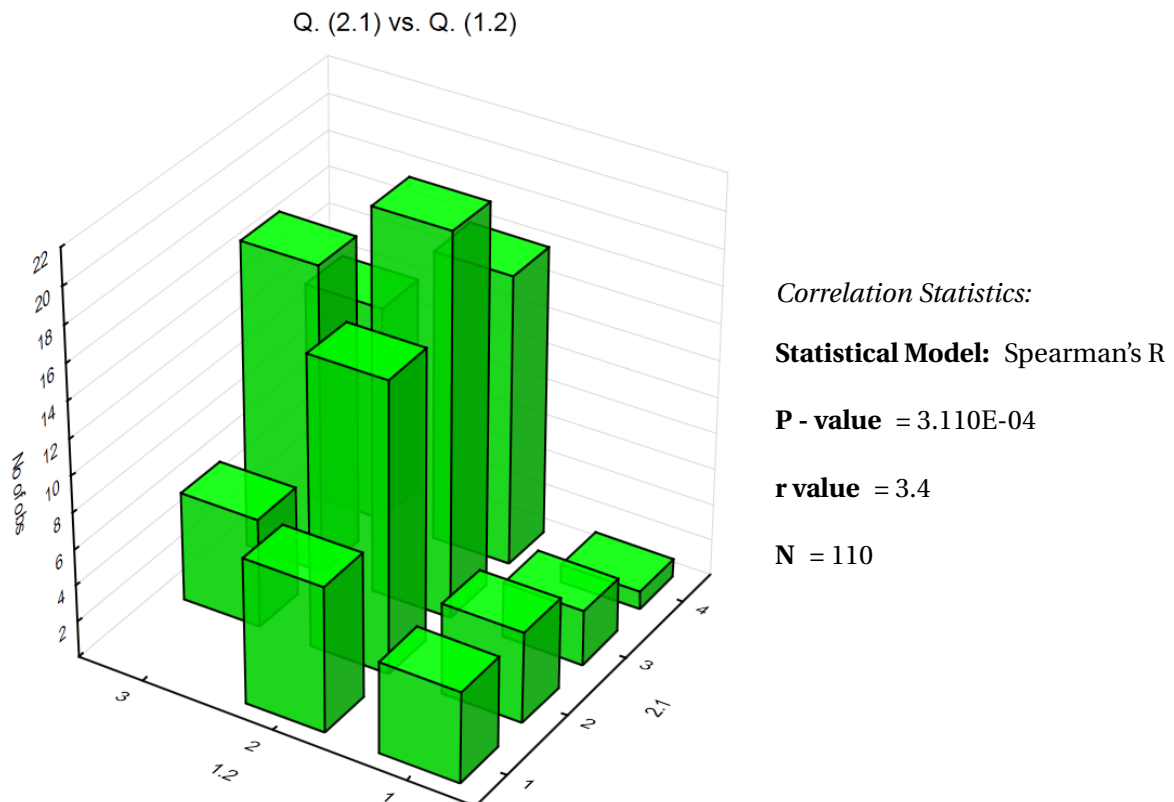


Figure B.1: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(1.2) Do you have a Water Safety Plan (WSP) and is it included within your IDP?

Table B.1: Response scale: Q.2.1 & Q.1.2

Q. (2.1)		Q. (1.2)	
Score	Response	Score	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In development
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		

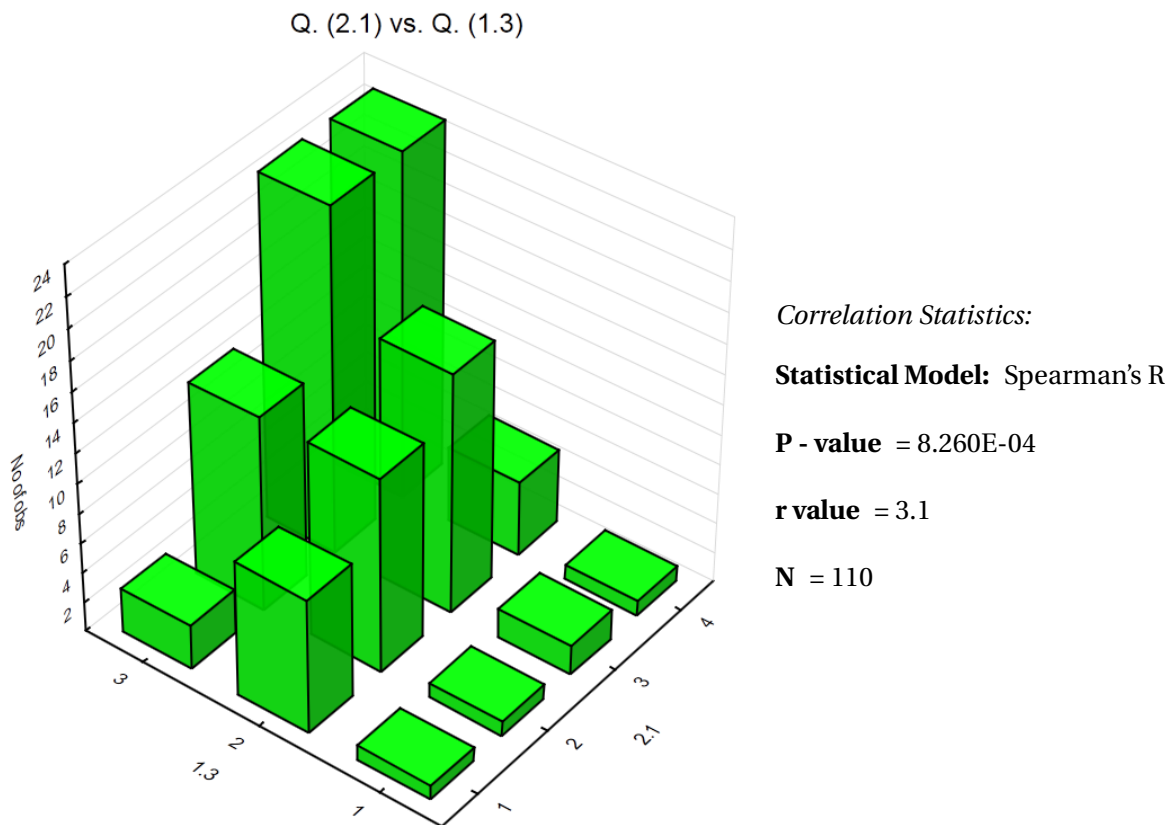


Figure B.2: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q. (1.3) Do you have an up to date adopted Water Service Development Plan (WSDP) which you are implementing?

Table B.2: Response scale: Q.2.1 & Q.1.3

Q. (2.1)		Q. (1.3)	
Score	Response	Score	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In development
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		

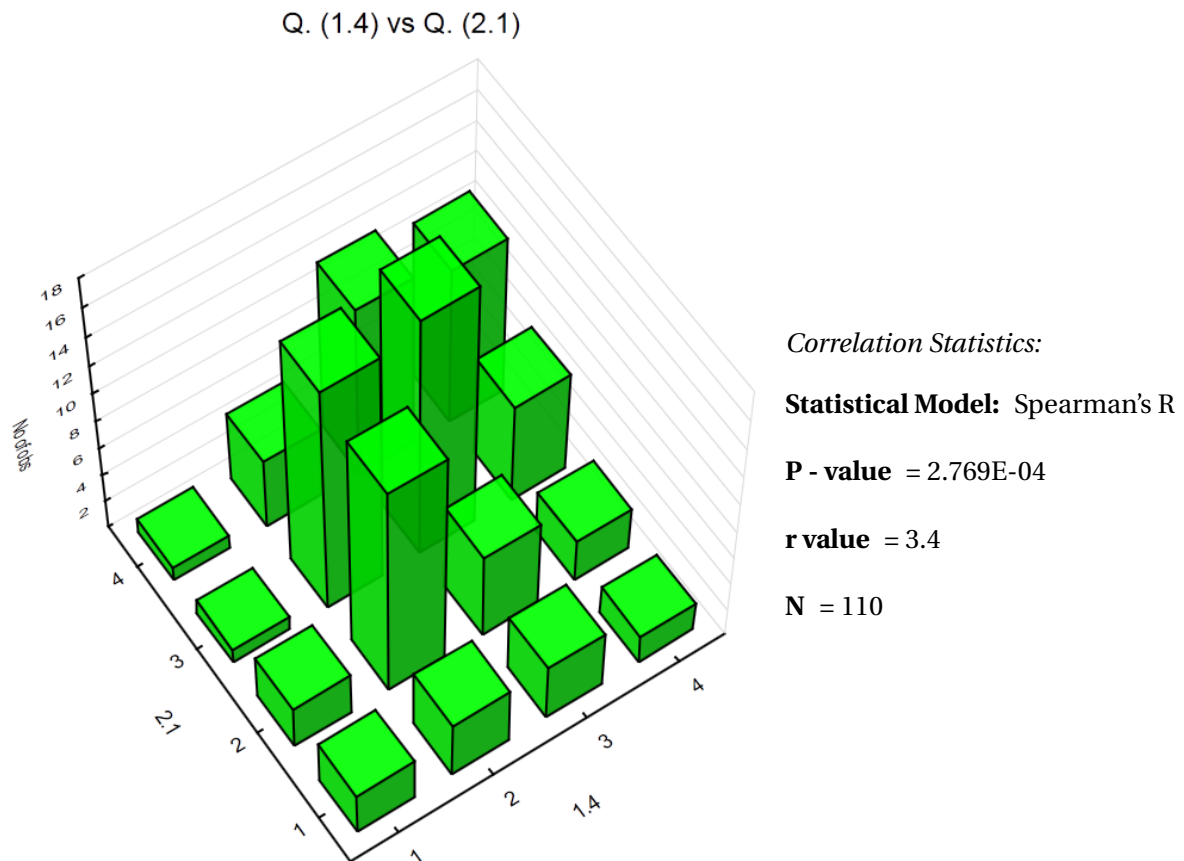


Figure B.3: Bivariate histogram of Q.(1.4) Have projects/needs indicated in the Master Plans, Water Safety Plan, WSDP and IDP been executed in the last three years (i.e. planning activities are being implemented)? vs. Q.(2.1) Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Service Manager, Superintendent of Water Works)?

Table B.3: Response scale: Q.1.4 & Q.2.1

Q. (1.4)		Q. (2.1)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

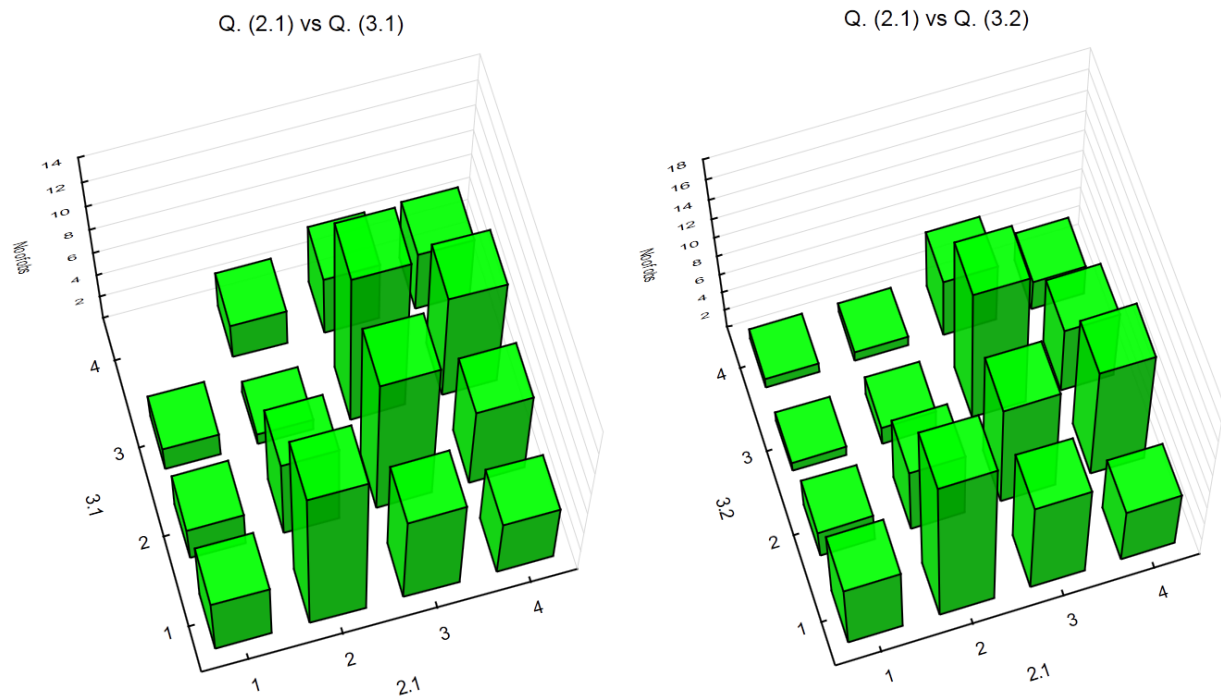


Figure B.4: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q. (3.1) Are WTW operated by staff with the correct skills/qualifications and experience (as per Regulations 2834)? & Q. (3.2) Are WWTW operated by staff with the correct skills/qualifications and experience (as per Regulations 2834)?

Correlation Statistics: 2.1 vs 3.1

Correlation Statistics: 2.1 vs 3.2

Statistical Model: Spearman's R

Statistical Model: Spearman's R

P - value = 1.118E-03

P - value = 1.429E-03

r value = 3.2

r value = 3.0

N = 98

N = 107

Table B.4: Response scale: Q.2.1 & Q.3.1 & Q.3.2

Q. (2.1)		Q. (3.1) & (3.2)	
Score	Response	Score	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know
		B	Not applicable

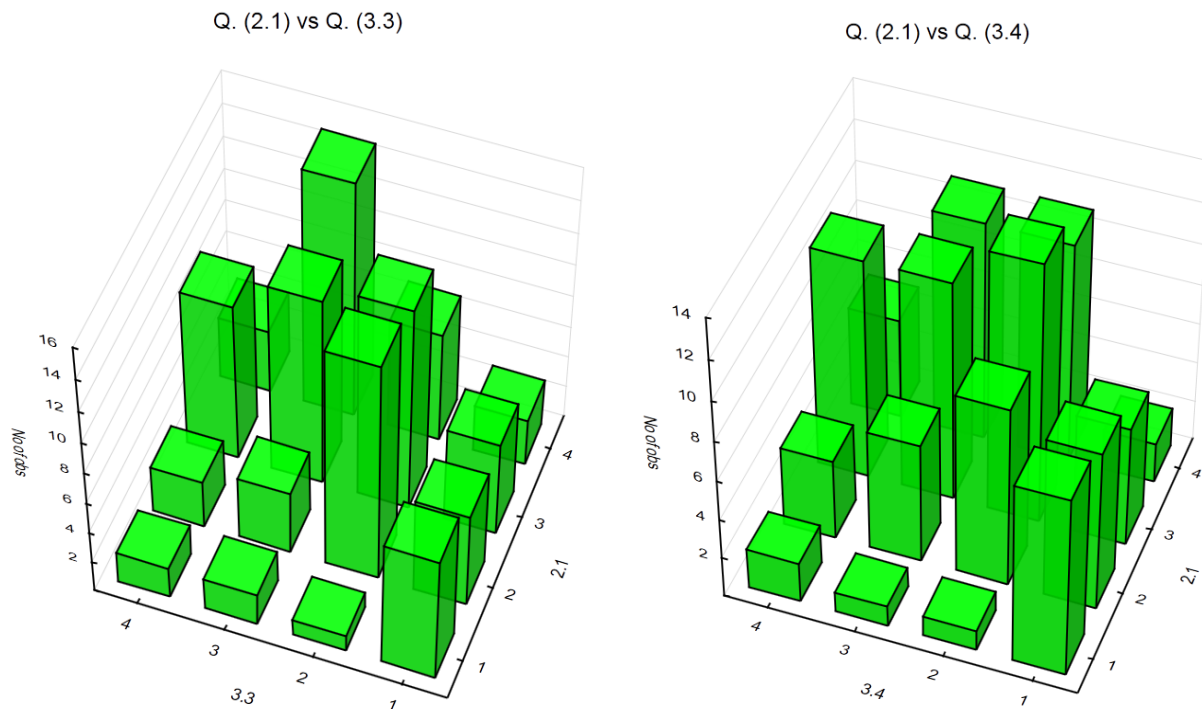


Figure B.5: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(3.3) Do water network operations and repair staff/plumbers have the correct skills/qualifications and experience? & Q.(3.4) Do wastewater collection system operation and repair staff/plumbers have the correct skills/qualifications and experience?

Correlation Statistics: 2.1 vs 3.3

Correlation Statistics: 2.1 vs 3.4

Statistical Model: Spearman's R

Statistical Model: Spearman's R

P - value = 2.169E-03

P - value = 3.545E-03

r value = 2.9

r value = 2.8

N = 110

N = 110

Table B.5: Response scale: Q.2.1 & Q.3.3 & 3.4

Q. (2.1)		Q. (3.3) & (3.4)	
Score	Response	Score	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

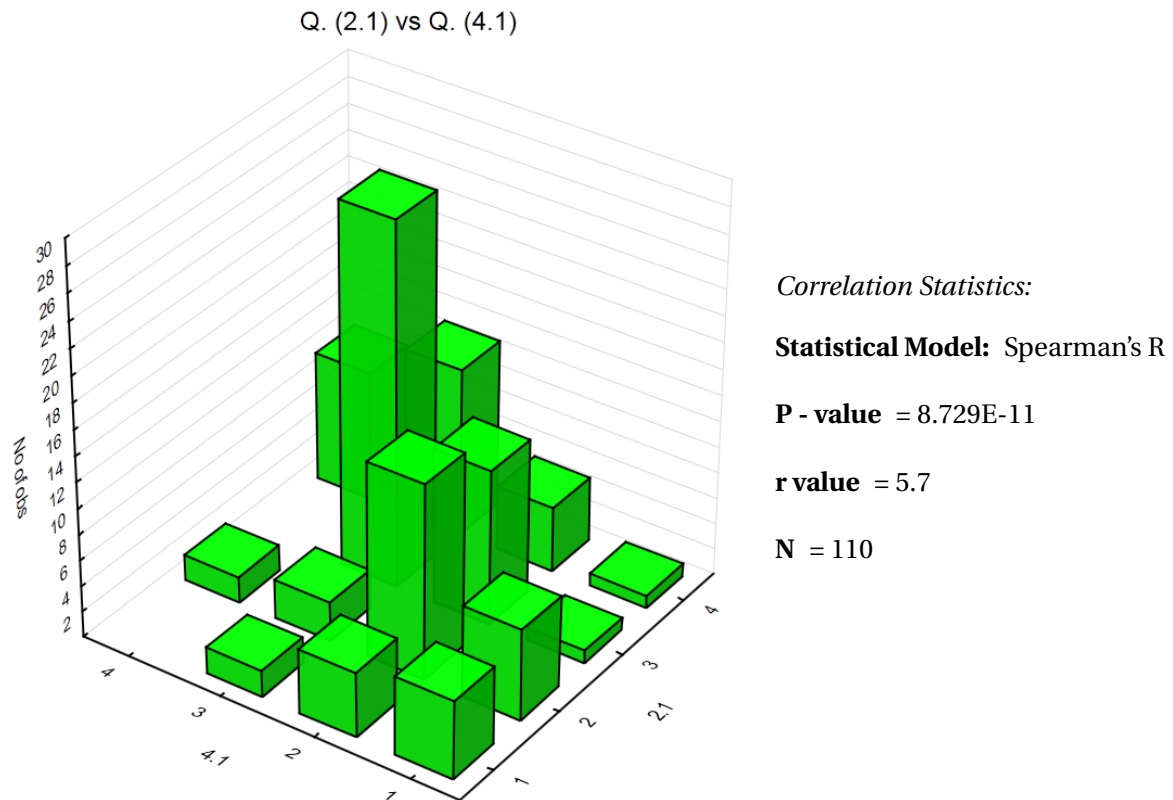


Figure B.6: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram been filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(4.1) Have posts within your technical organizational organogram been filled?

Table B.6: Response scale: Q.2.1 & Q.4.1

Q. (2.1)		Q. (4.1)	
Score	Response	Score	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

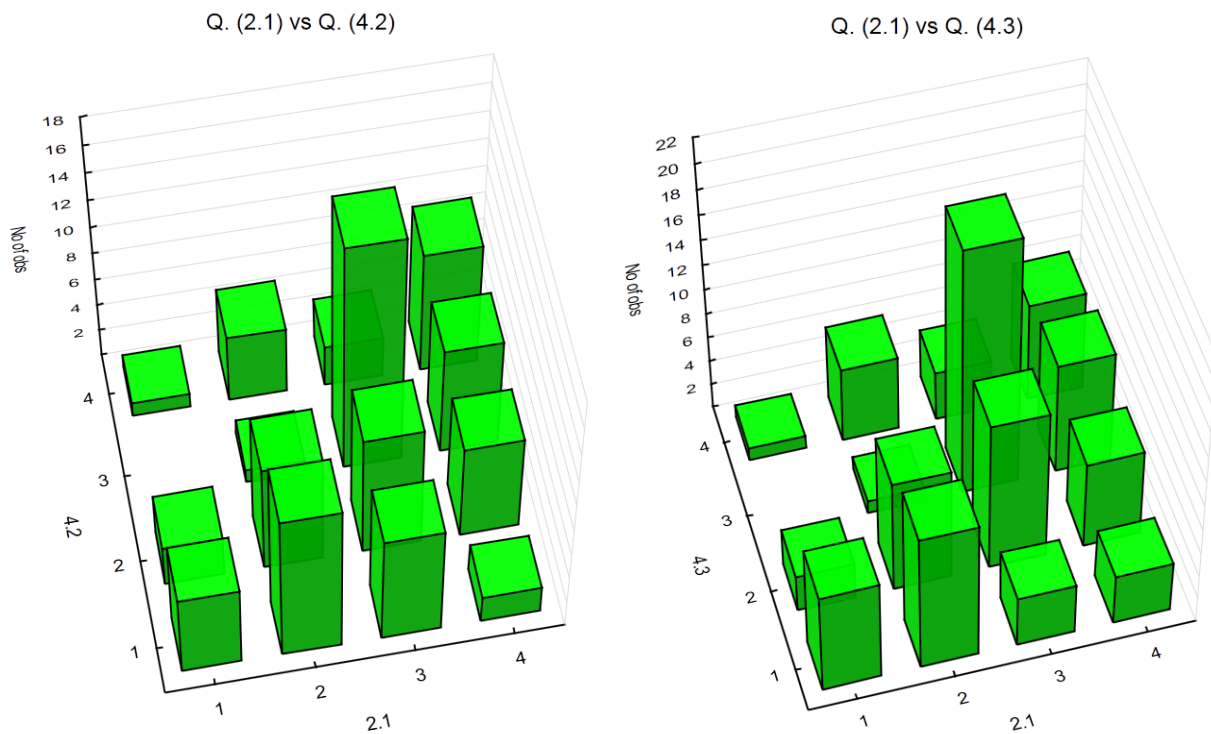


Figure B.7: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(4.2) Are WTW operated by the appropriate number of staff (as per Regulation 2834)? & Q.(4.3) Are WWTW operated by the appropriate number of staff (as per Regulation 2834)?

Correlation Statistics: 2.1 vs 4.2

Correlation Statistics: 2.1 vs 4.3

Statistical Model: Spearman's R

Statistical Model: Spearman's R

P - value = 4.700E-05

P - value = 8.000E-05

r value = 3.9

r value = 3.7

N = 98

N = 107

Table B.7: Response scale: Q.2.1 & Q.4.2 & 4.3

Q. (2.1)		Q. (4.2) & (4.3)	
Score	Response	Score	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know
		B	Not applicable

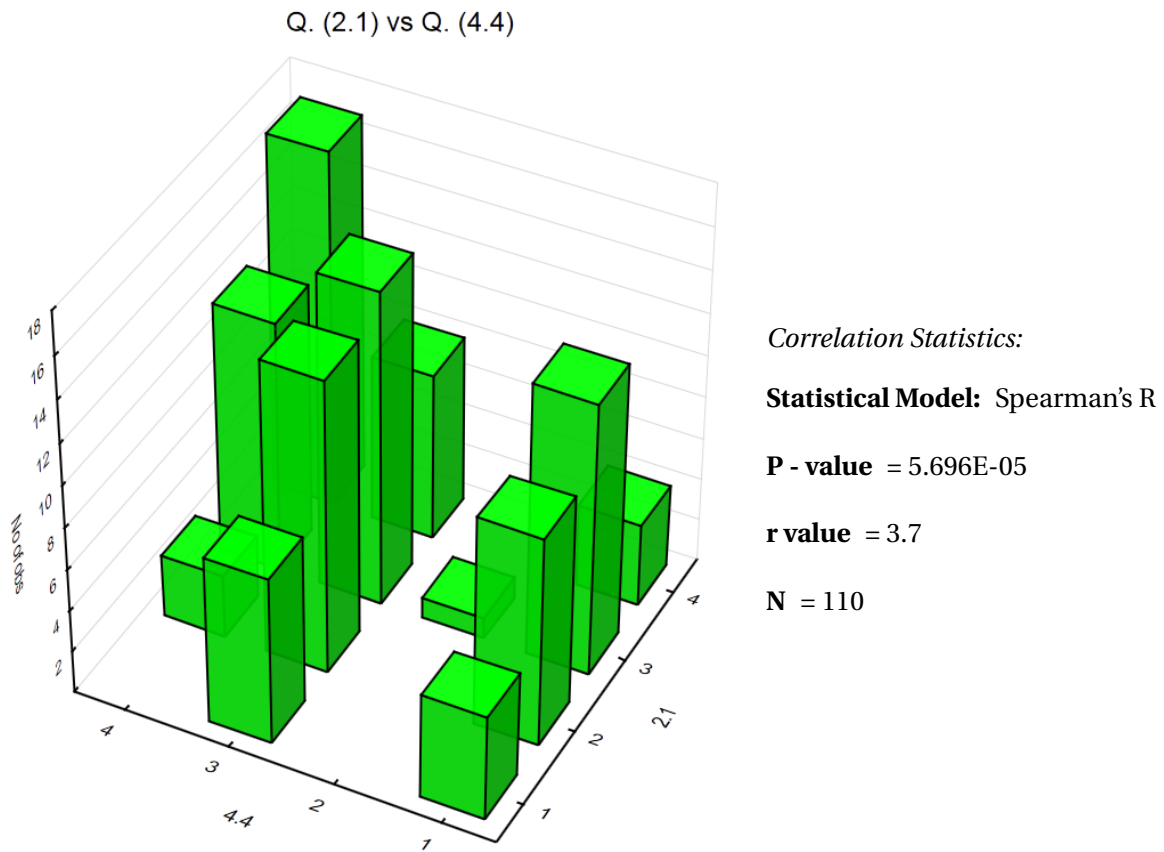


Figure B.8: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram been filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(4.4) Do you have sufficient water and sewerage/sanitation network operations and repair staff/plumbers (appropriate number of staff)?

Table B.8: Response scale: Q.2.1 & Q.4.4

Q. (2.1)		Q. (4.4)	
Score	Response	Score	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

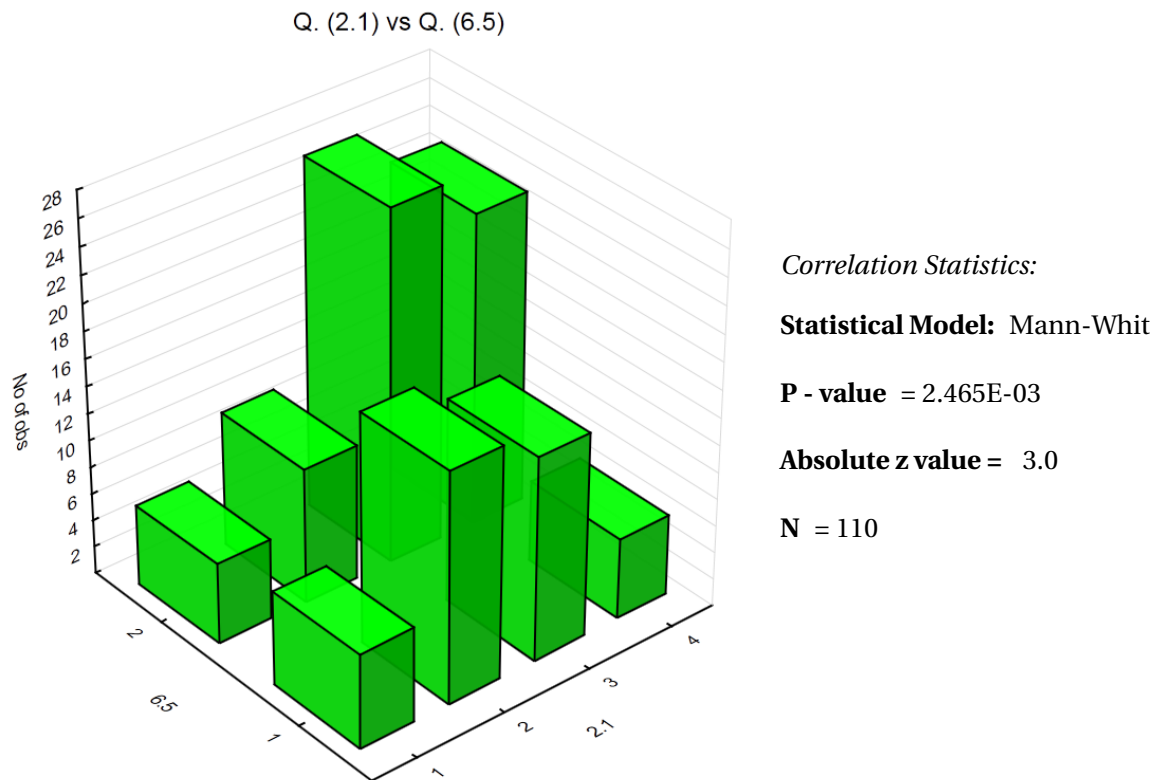


Figure B.9: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(6.5) Does your WSA actively monitor and remove illegal connections?

Table B.9: Response scale: Q.2.1 & Q.6.5

Q. (2.1)		Q. (6.5)	
Score	Response	Score	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

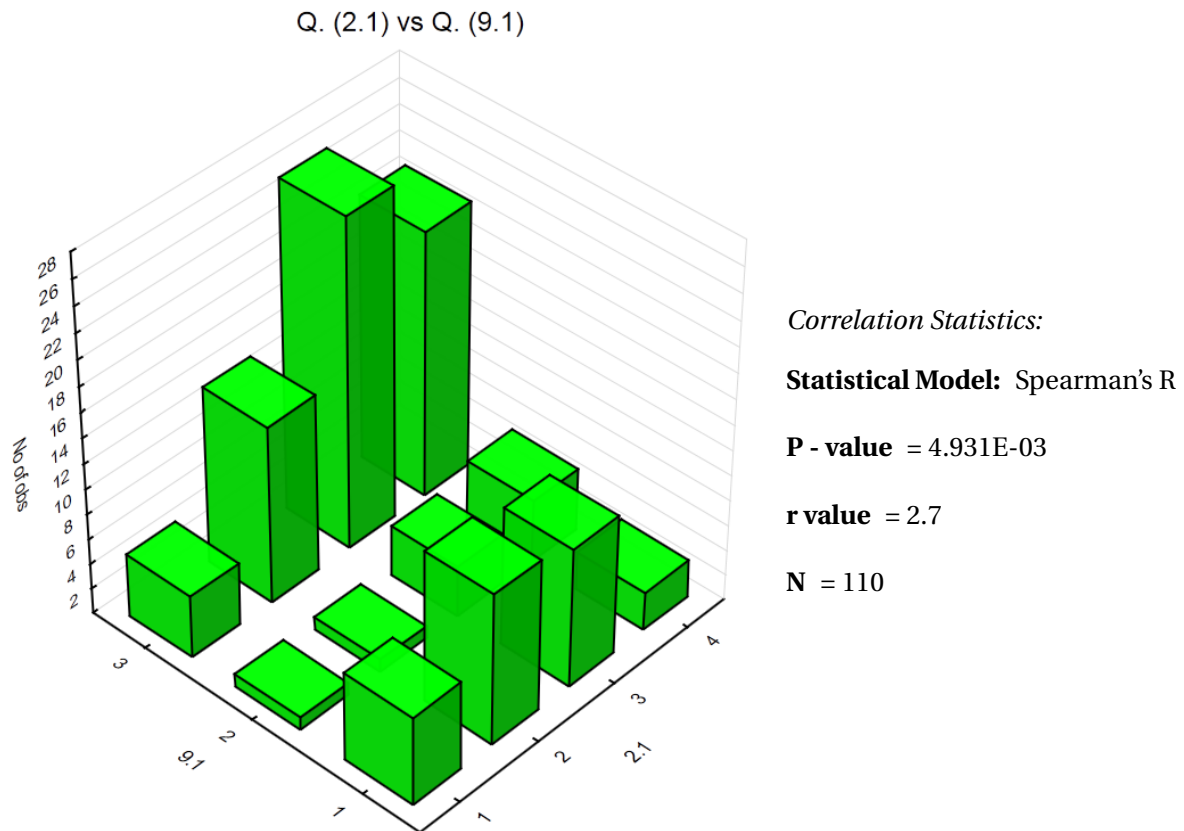


Figure B.10: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram been filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q. (9.1) Do you have an appropriate and up to date Asset Register (includes asset name, location, condition, useful life, risk analysis, etc.)?

Table B.10: Response scale: Q.2.1 & Q.9.1

Q. (2.1)		Q. (9.1)	
Score	Response	Score	Response
4	Yes, All (i.e. 100%)	3	Yes, strongly agree
3	Most (i.e. >75%)	2	In development
2	Some (i.e. > 50%)	1	No, disagree/Don't know
1	< 50%/None/Don't know		

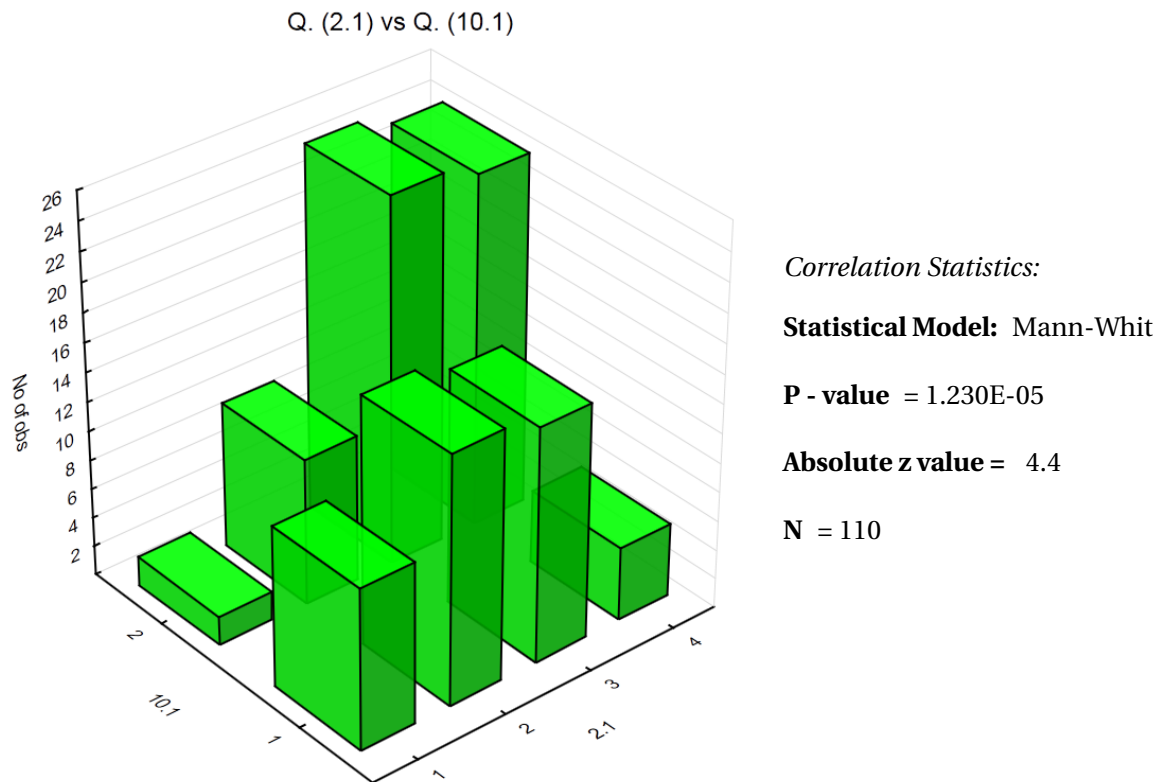


Figure B.11: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram been filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(10.1) Is an effective infrastructure operations and maintenance team available (i.e. sufficient artisans, mechanical, electrical support with the correct skill/qualifications and experience)?

Table B.11: Response scale: Q.2.1 & Q.10.1

Q. (2.1)		Q. (10.1)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

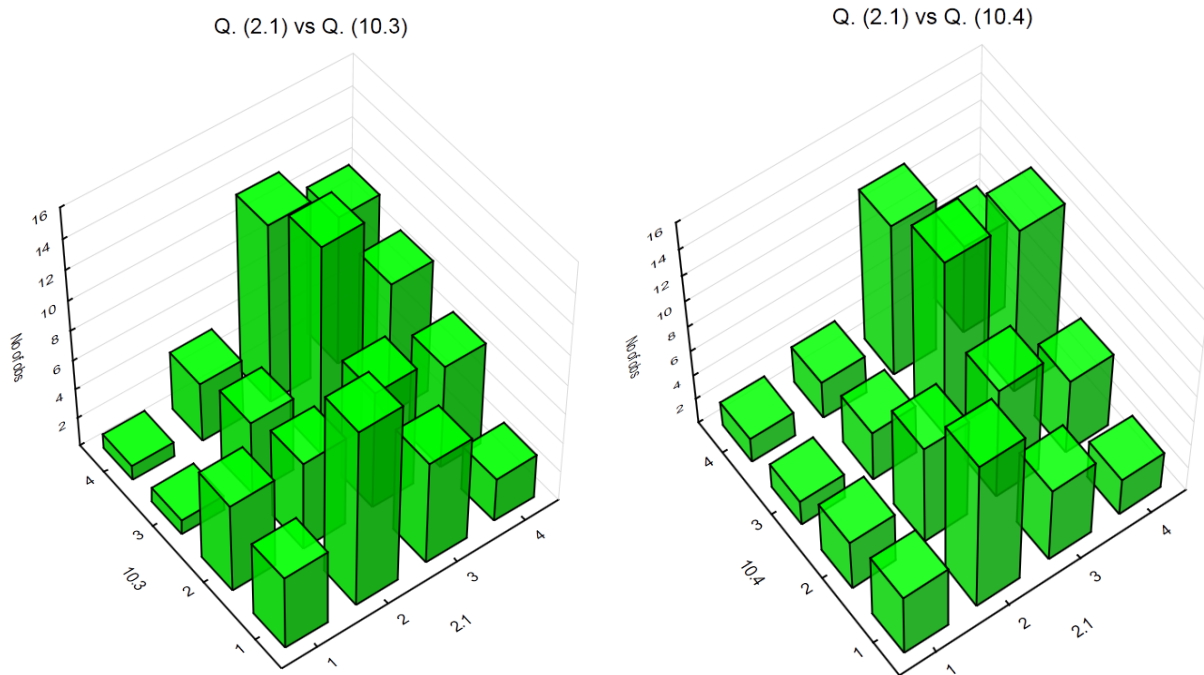


Figure B.12: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(10.3) Is appropriate scheduled/planned/preventative maintenance performed at WTW and associated water reservoir/water pump stations/distribution networks? & Q.(10.4) Is appropriate scheduled/planned/preventative maintenance performed at WWTW and the associated collection system/pump stations?

Correlation Statistics: 2.1 vs 10.3

Correlation Statistics: 2.1 vs 10.4

Statistical Model: Spearman's R

Statistical Model: Spearman's R

P - value = 1.920E-04

P - value = 6.176E-04

r value = 3.5

r value = 3.2

N = 110

N = 110

Table B.12: Response scale: Q.2.1 & Q.10.3 & 10.4

Q. (2.1)		Q. (10.3) & (10.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

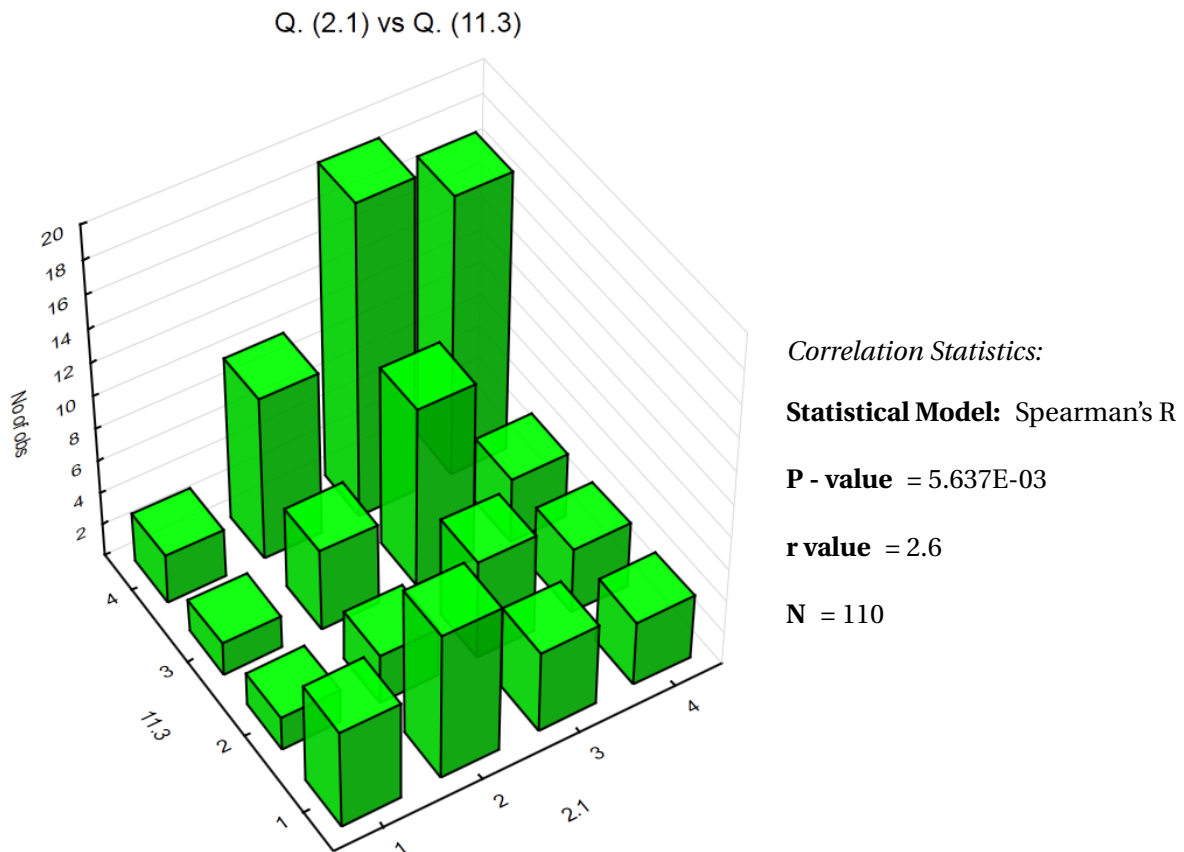


Figure B.13: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram been filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(11.3) With regards to new developments, do developers adequately contribute towards construction of new bulk infrastructure?

Table B.13: Response scale: Q.2.1 & Q.11.3

Q. (2.1)		Q. (11.3)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, strongly agree
3	Most (i.e. >75%)	3	Mostly agree
2	Some (i.e. > 50%)	2	Agree somewhat
1	< 50%/None/Don't know	1	No, disagree/Don't know

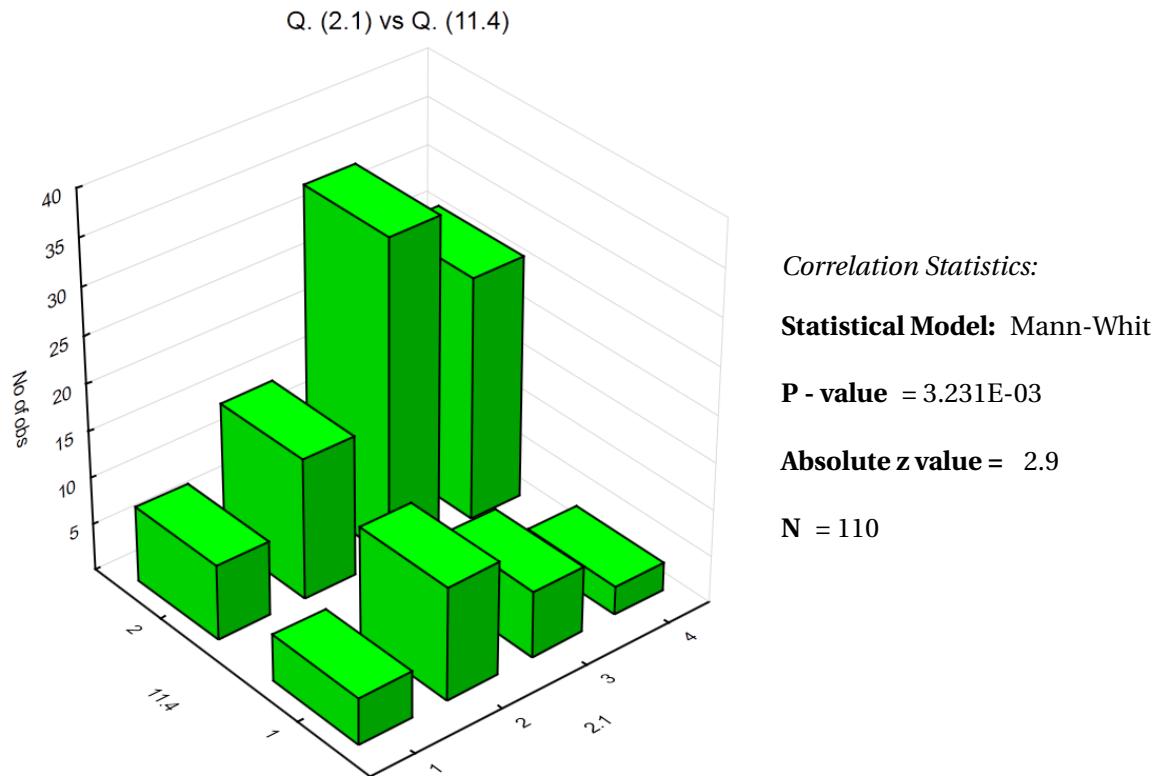


Figure B.14: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram been filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(11.4) Is there good correlation between planned/budgeted water services and executed activities (i.e. funds effectively spent)?

Table B.14: Response scale: Q.2.1 & Q.11.4

Q. (2.1)		Q. (11.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

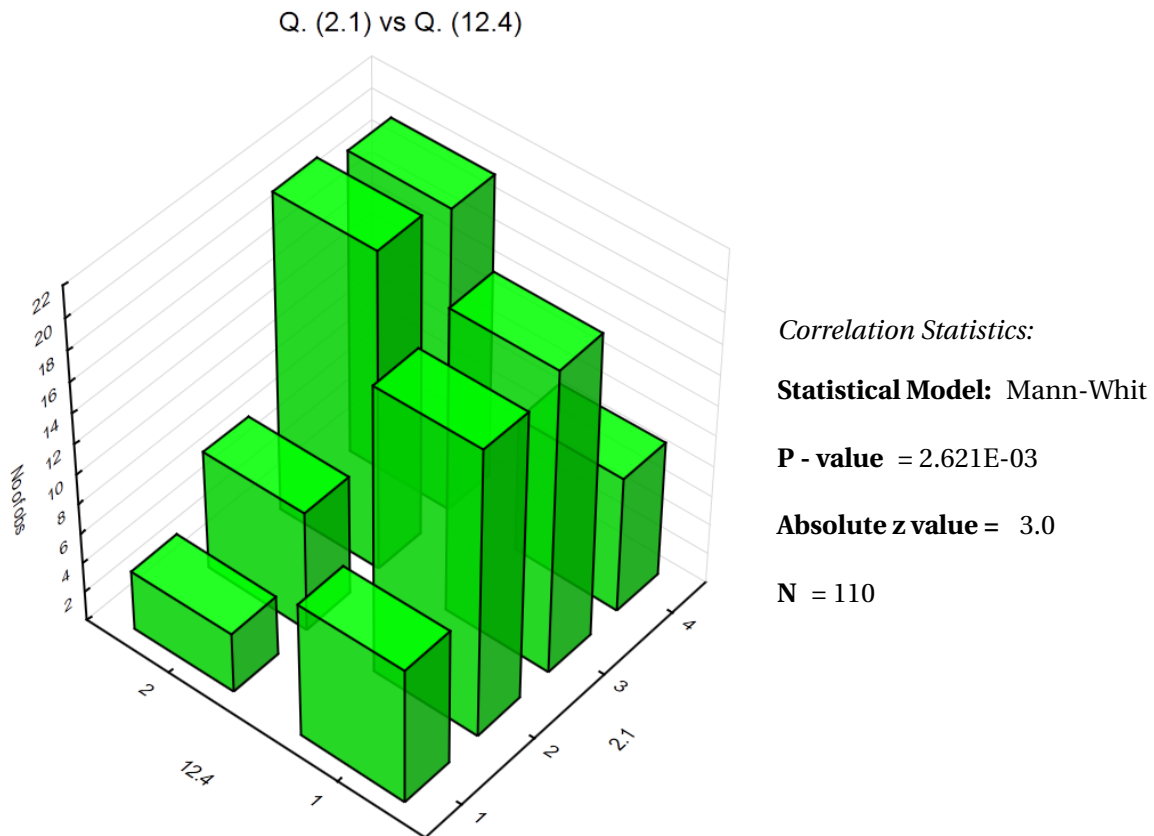


Figure B.15: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram been filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q. (12.4) Is revenue collection acceptable (i.e. good cash flow that enables water services income to cover water services costs)?

Table B.15: Response scale: Q.2.1 & Q.12.4

Q. (2.1)		Q. (12.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	2	Yes, strongly agree
3	Most (i.e. >75%)	1	No, disagree/Don't know
2	Some (i.e. > 50%)		
1	< 50%/None/Don't know		

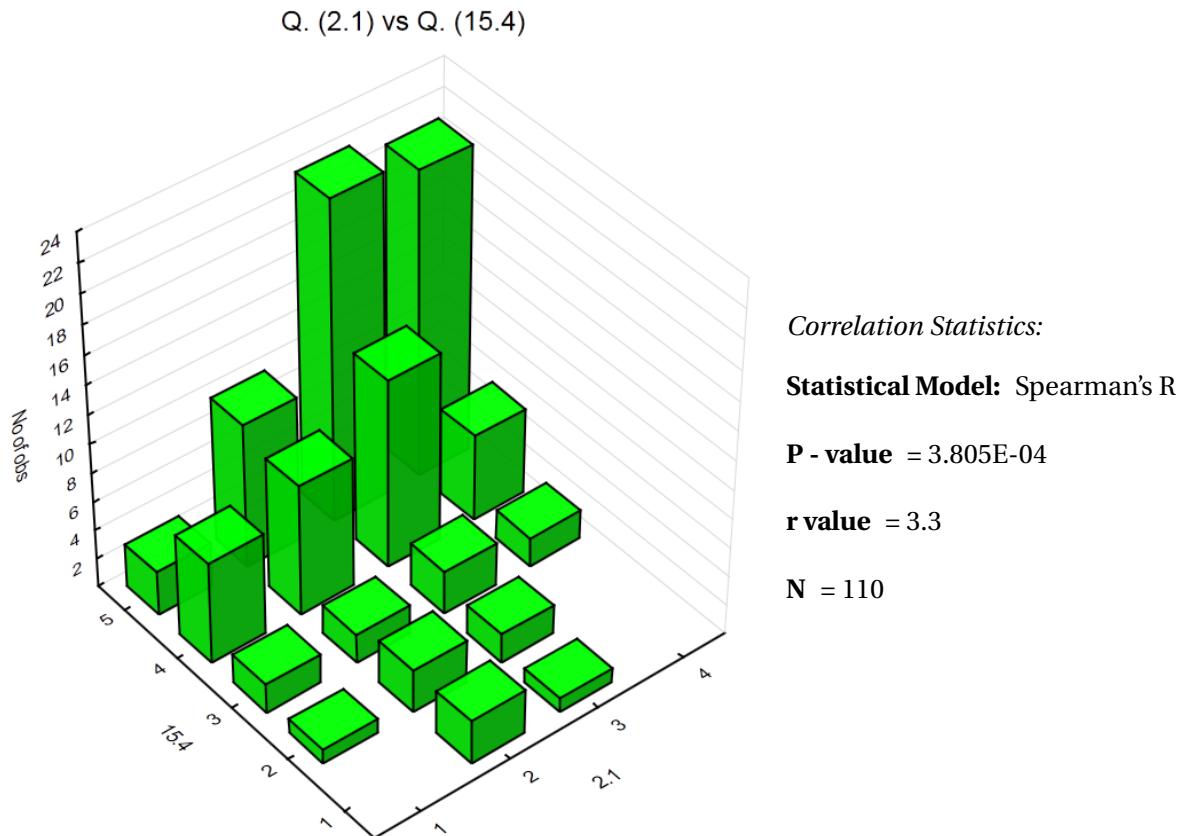


Figure B.16: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram been filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q.(15.4) Do households in your WSA experience water supply interruptions more than 7 days per year?

Table B.16: Response scale: Q.2.1 & Q.15.4

Q. (2.1)		Q. (15.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	5	No, None (i.e. 0%)
3	Most (i.e. >75%)	4	Some (i.e. >25%)
2	Some (i.e. > 50%)	3	Most (i.e. >50%)
1	< 50%/None/Don't know	2	Yes (i.e. >75%/All)
		1	Don't know

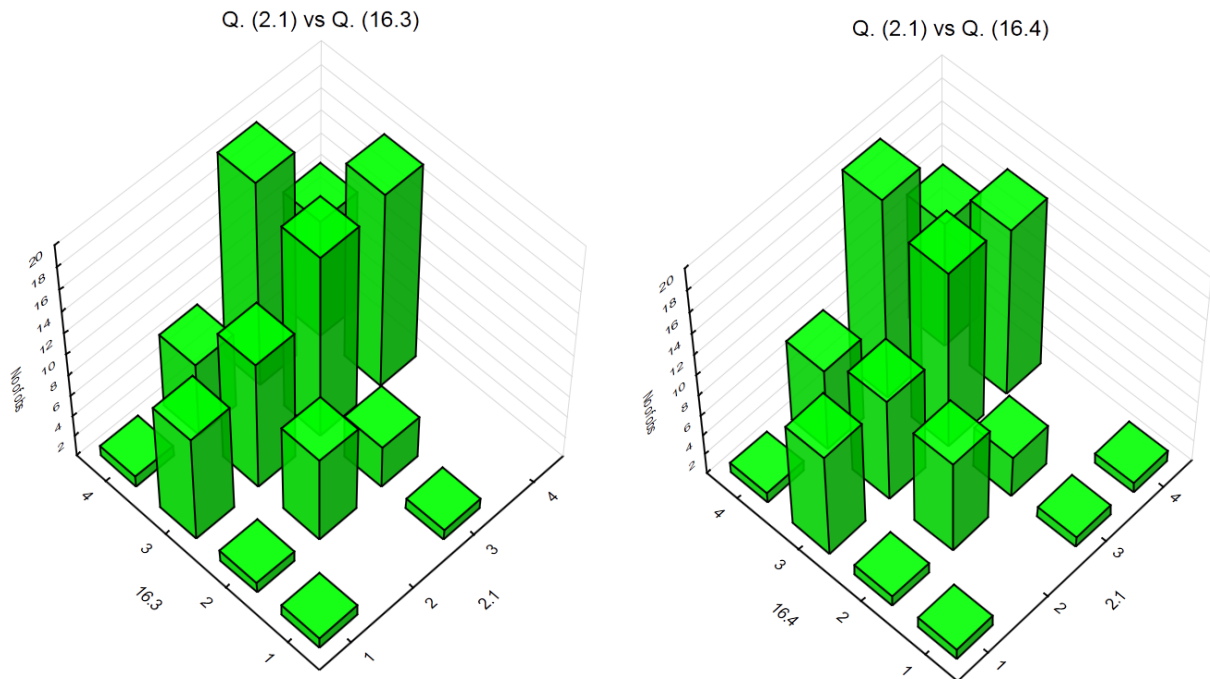


Figure B.17: Bivariate histogram of Q.(2.1) Are key posts within your technical management organizational organogram filled (e.g. Technical Director, Water Services Manager, Superintendent of Water Works)? vs. Q. (16.3) How many of the reported water related complaints/callouts are responded to within 24 hours (percentage)? & Q. (16.4) How many of the reported wastewater/sanitation related complaints/callouts are responded to within 24 hours (percentage)?

Correlation Statistics: 2.1 vs 16.3

Correlation Statistics: 2.1 vs 16.3

Statistical Model: Spearman's R

Statistical Model: Spearman's R

P - value = 5.772E-03

P - value = 8.646E-03

r value = 2.6

r value = 2.5

N = 110

N = 110

Table B.17: Response scale: Q.2.1 & Q.16.3 & 16.4

Q. (2.1)		Q. (16.3) & (16.4)	
Scale	Response	Scale	Response
4	Yes, All (i.e. 100%)	4	Yes, All (i.e. 100%)
3	Most (i.e. >75%)	3	Most (i.e. >75%)
2	Some (i.e. > 50%)	2	Some (i.e. > 50%)
1	< 50%/None/Don't know	1	< 50%/None/Don't know

Appendix C

Non-revenue water

C.1 Flow charts

*Note: The numbers accompanying each question in the flow charts refers to the question numbers in the MuSSA analysis.

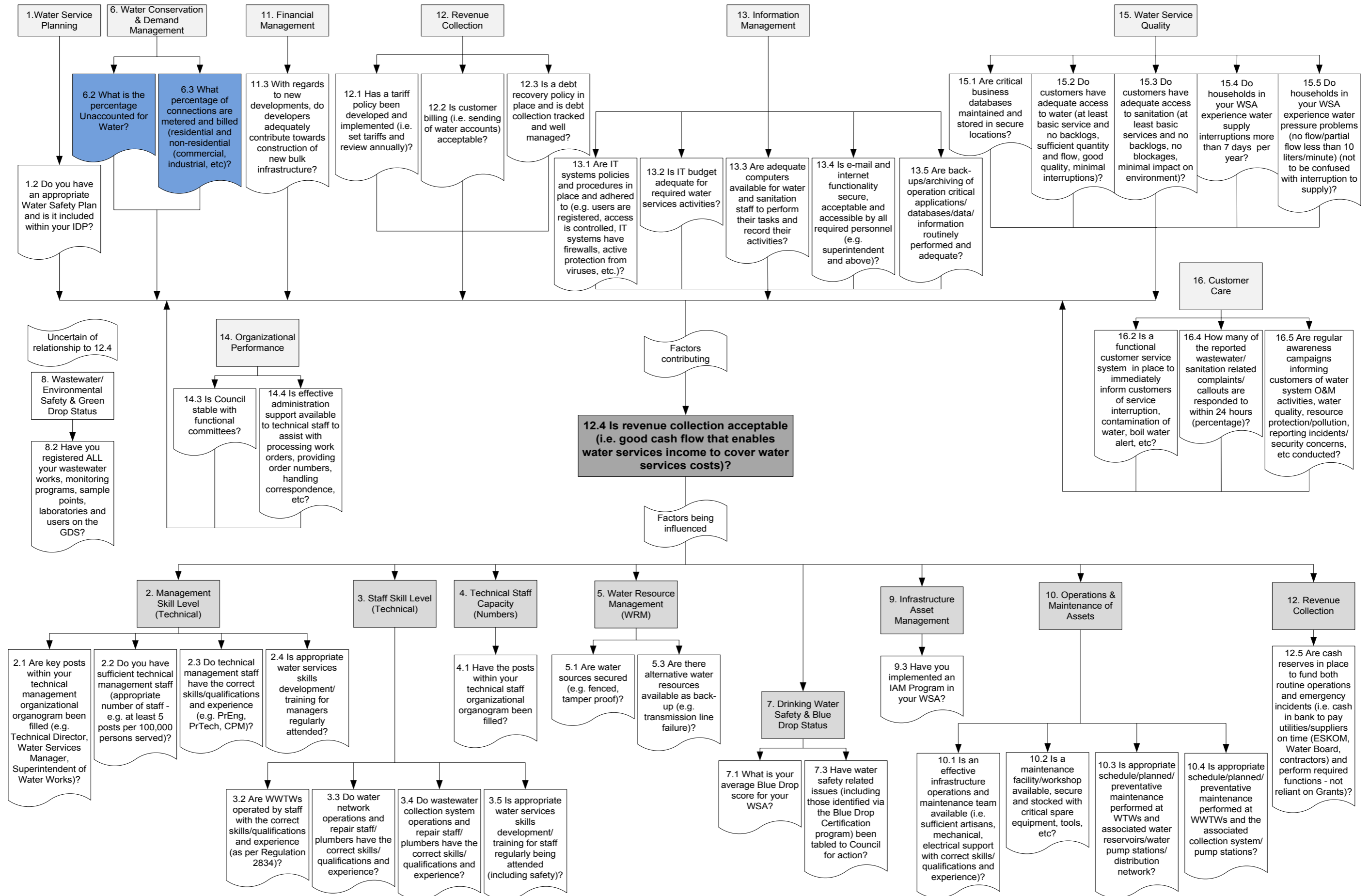


Figure C.1: Non-Revenue Water Model.

C.2 Areas influenced by the percentage unaccounted for water

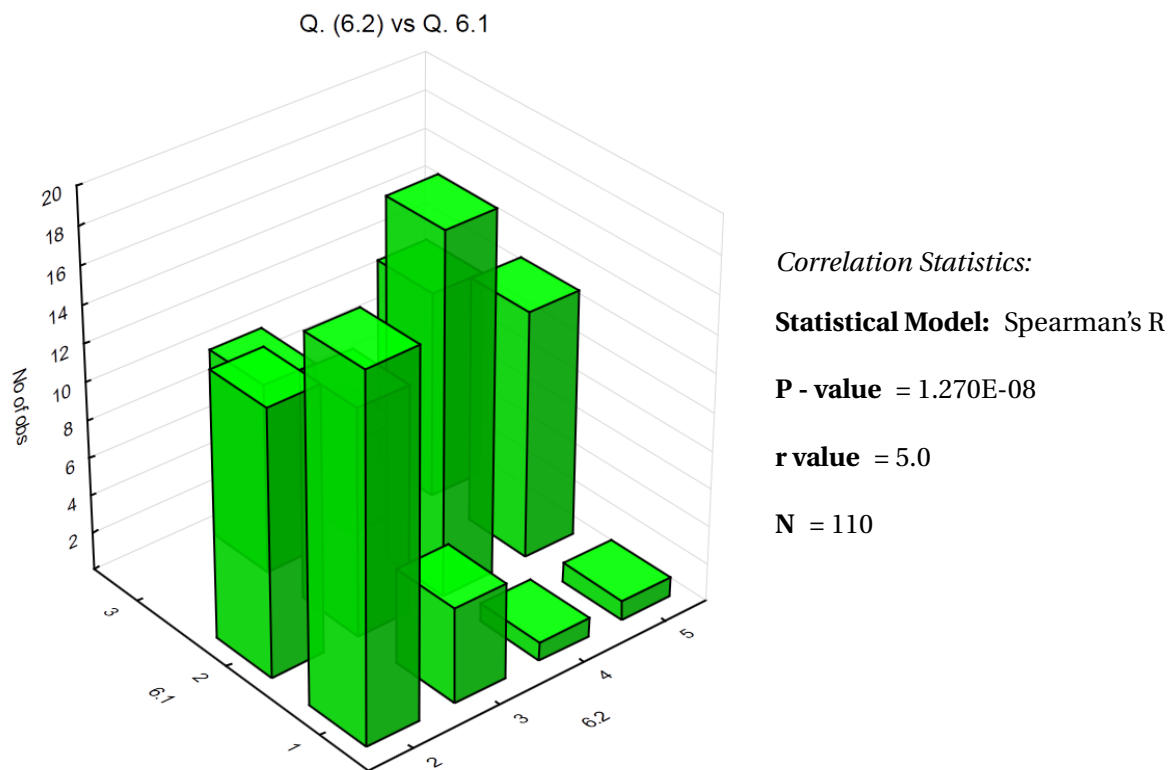


Figure C.2: Bivariate histogram of Q.(6.1) Has your WSA developed a reliable standard water balance using appropriate tools? vs. Q. (6.2) What is the percentage unaccounted for water?

Table C.1: Response scale: Q.6.2 & Q.6.1

Q. (6.2)		Q. (6.1)	
Score	Response	Score	Response
5	Less than 20%	3	Yes, strongly agree
4	Less than 30%	2	In development
3	Less than 40%	1	No, disagree/Don't know
2	Don't know		

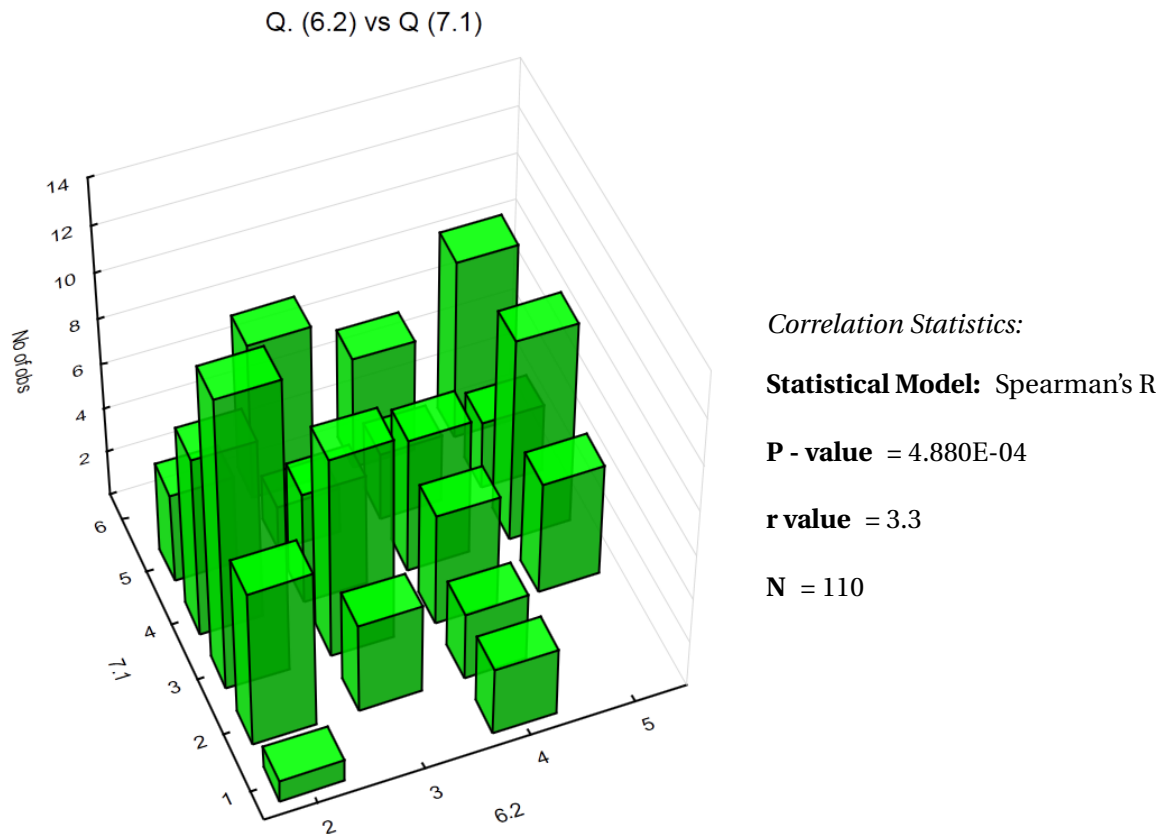


Figure C.3: Bivariate histogram of Q.(7.1) What is your average Blue Drop score for you WSA? vs. Q. (6.2) What is the percentage unaccounted for water?

Table C.2: Response scale: Q.6.2 & Q.7.1

Q. (6.2)		Q. (7.1)	
Score	Response	Score	Response
5	Less than 20%	6	>90% (Excellent)
4	Less than 30%	5	75% - 90% (Very Good)
3	Less than 40%	4	50% - 75% (Good)
2	Don't know	3	33% - 50% (Needs Attention)
		2	<33% (Needs Urgent Attention)
		1	Don't know

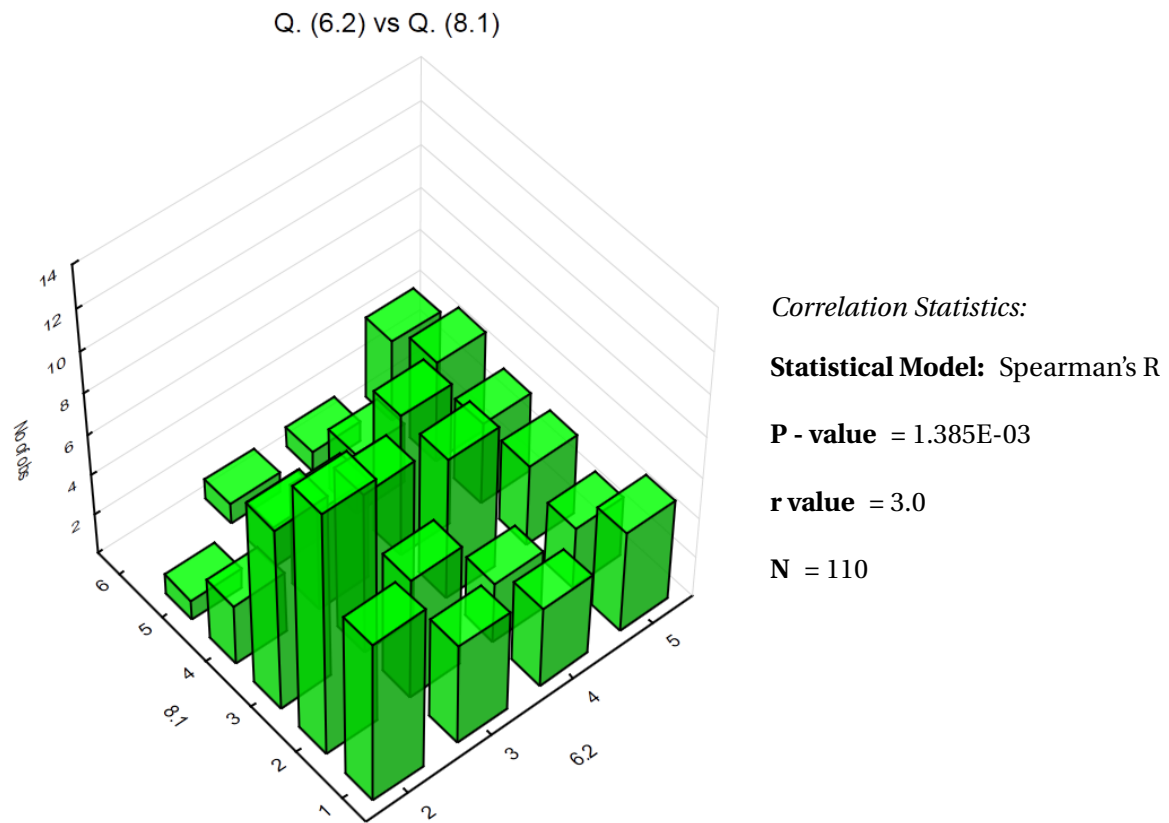


Figure C.4: Bivariate histogram of Q.(8.1) What is your average Green Drop score for you WSA? vs. Q. (6.2) What is the percentage unaccounted for water?

Table C.3: Response scale: Q.6.2 & Q.8.1

Q. (6.2)		Q. (8.1)	
Score	Response	Score	Response
5	Less than 20%	6	>90% (Excellent)
4	Less than 30%	5	75% - 90% (Very Good)
3	Less than 40%	4	50% - 75% (Good)
2	Don't know	3	33% - 50% (Needs Attention)
		2	<33% (Needs Urgent Attention)
		1	Don't know

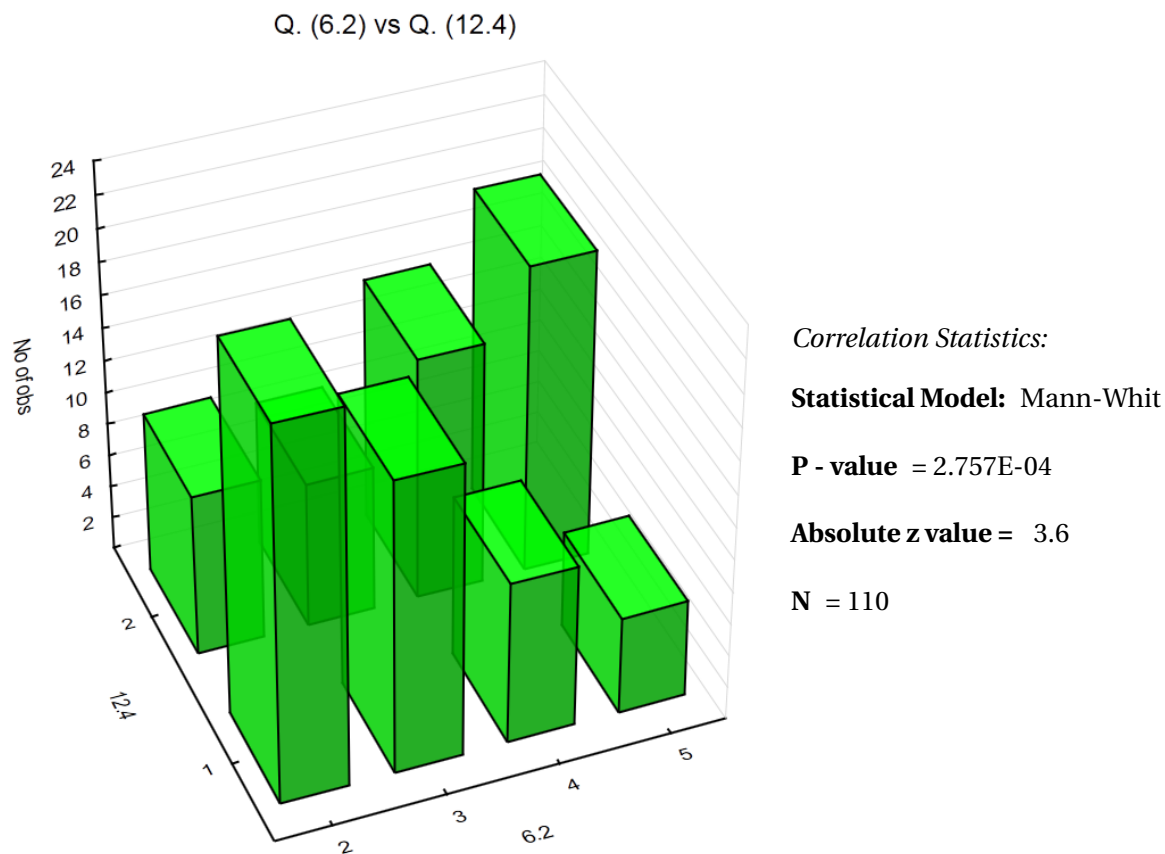


Figure C.5: Bivariate histogram of Q.(12.4) Is revenue collection acceptable (i.e. good cash flow that enables water services income to cover water services costs)? vs. Q. (6.2) What is the percentage unaccounted for water?

Table C.4: Response scale: Q.6.2 & Q.12.4

Q. (6.2)		Q. (12.4)	
Score	Response	Score	Response
5	Less than 20%	2	Yes, strongly agree
4	Less than 30%	1	No, disagree/Don't know
3	Less than 40%		
2	Don't know		

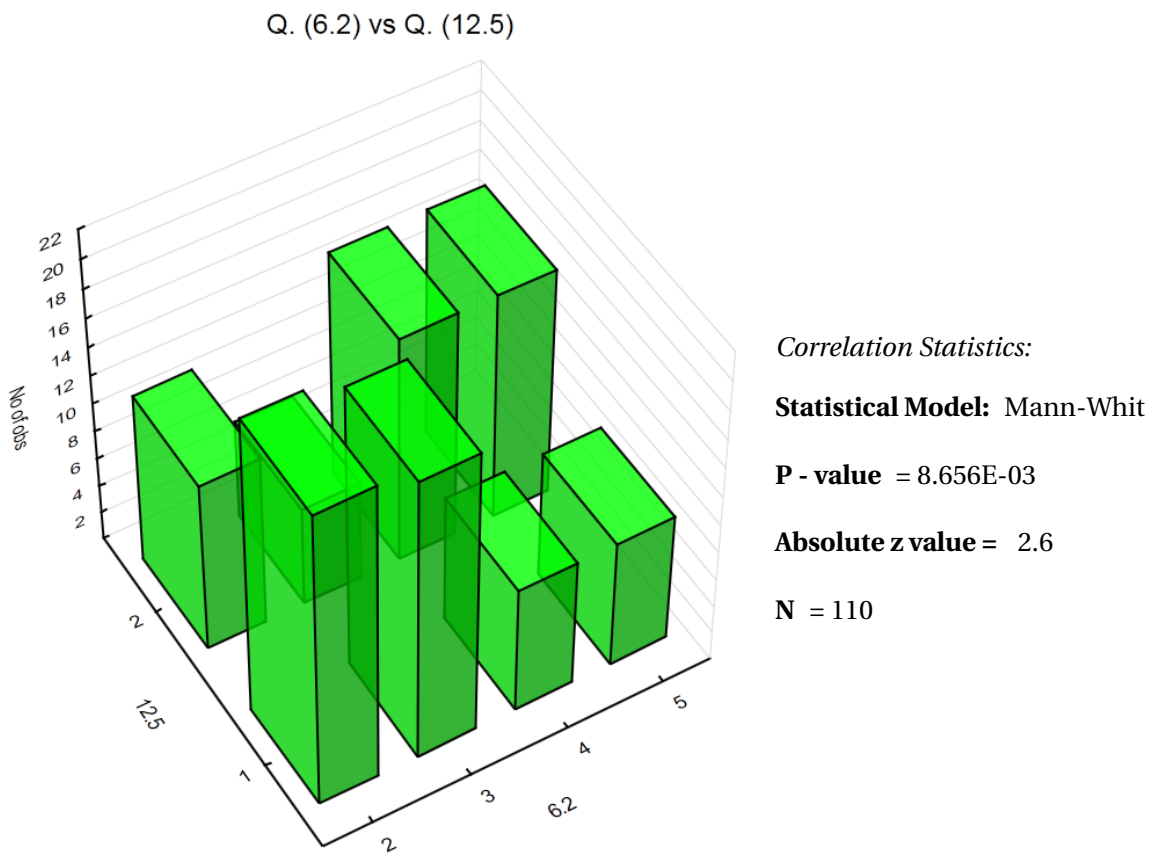


Figure C.6: Bivariate histogram of Q.(12.5) Are cash reserves in place to fund both routine operations and emergency incidents (i.e. cash in bank to pay utilities/suppliers on time (ESKOM, Water Board, contractors) and perform required functions - not reliant on Grants)? vs. Q. (6.2) What is the percentage unaccounted for water?

Table C.5: Response scale: Q.6.2 & Q.12.5

Q. (6.2)		Q. (12.5)	
Score	Response	Score	Response
5	Less than 20%	2	Yes, strongly agree
4	Less than 30%	1	No, disagree/Don't know
3	Less than 40%		
2	Don't know		

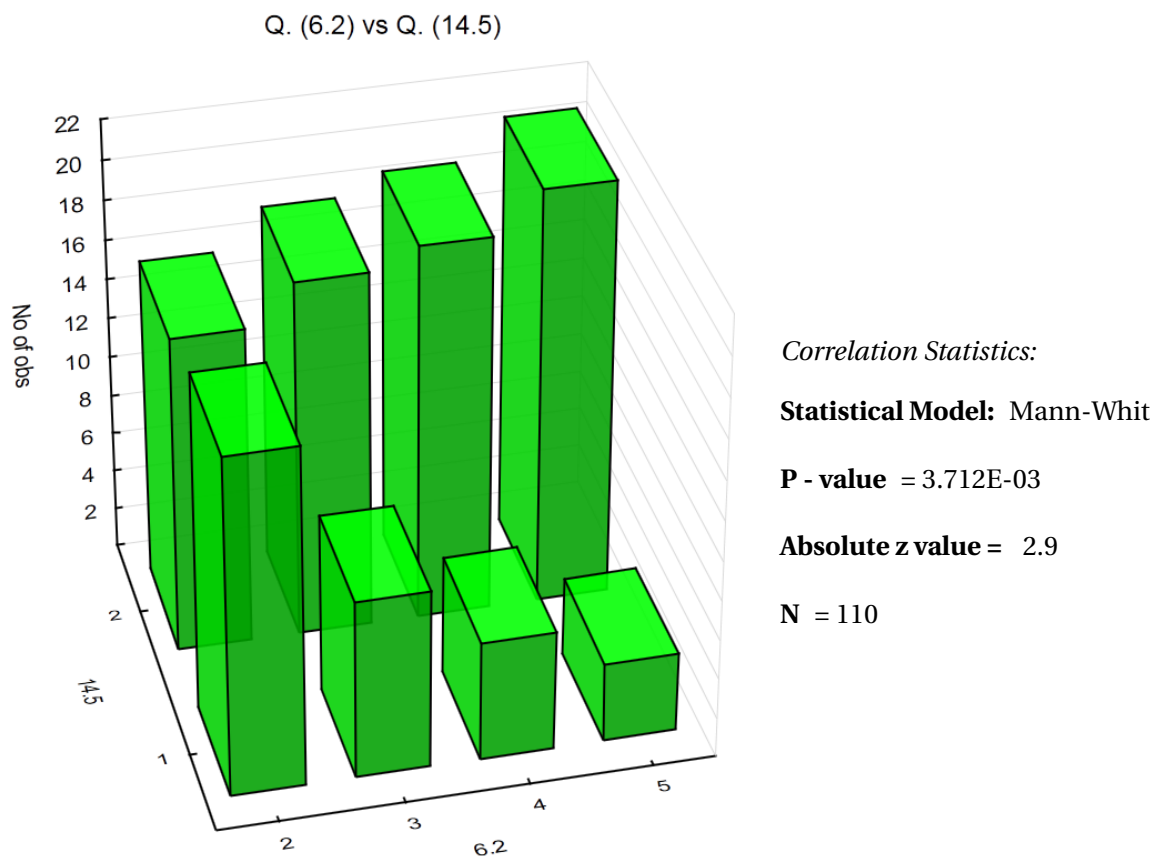


Figure C.7: Bivariate histogram of Q.(14.5) Are reports showing water and sewage water statistics frequently produced and presented to council for discussion, action and follow-up (e.g. at least quarterly)? vs. Q. (6.2) What is the percentage unaccounted for water?

Table C.6: Response scale: Q.6.2 & Q.14.5

Q. (6.2)		Q. (14.5)	
Score	Response	Score	Response
5	Less than 20%	2	Yes, strongly agree
4	Less than 30%	1	No, disagree/Don't know
3	Less than 40%		
2	Don't know		

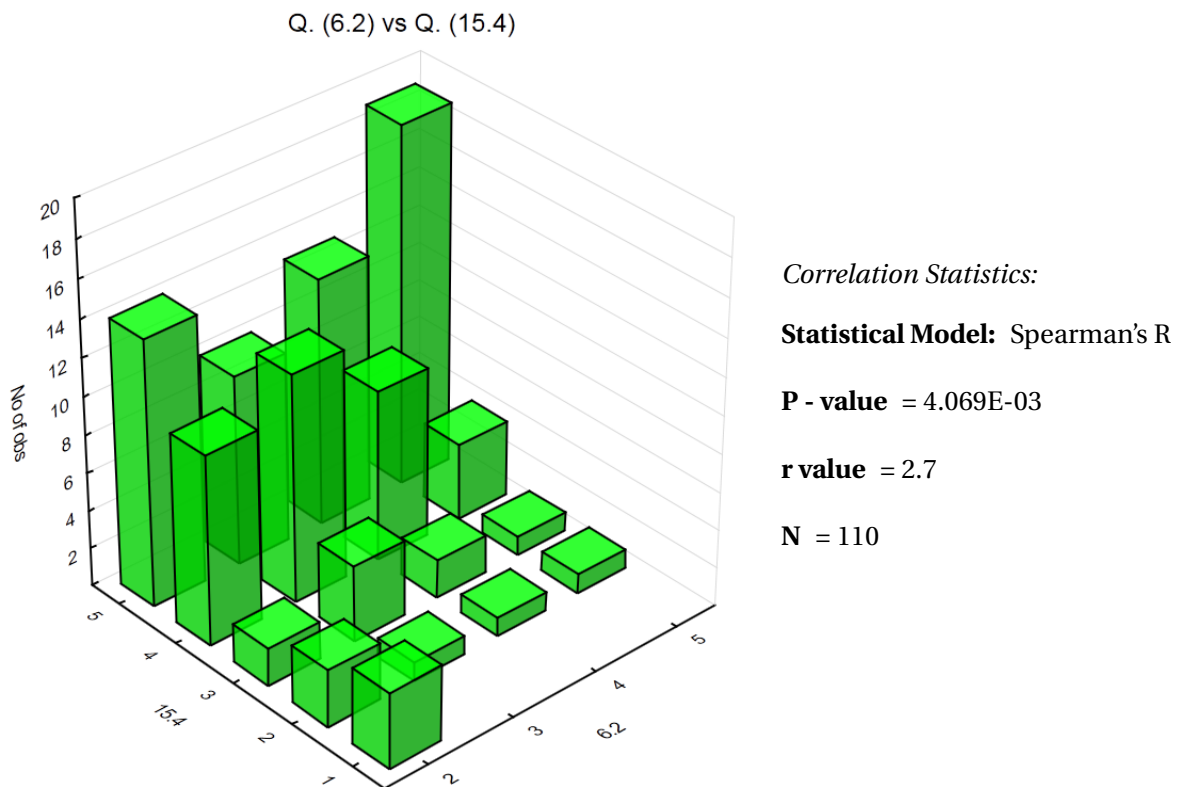


Figure C.8: Bivariate histogram of Q.(15.4) Do households in you WSA experience water supply interruptions more than 7 days per year? vs. Q. (6.2) What is the percentage unaccounted for water?

Table C.7: Response scale: Q.6.2 & Q.15.4

Q. (6.2)		Q. (15.4)	
Score	Response	Score	Response
5	Less than 20%	5	No, None (i.e. 0%)
4	Less than 30%	4	Some (i.e. >25%)
3	Less than 40%	3	Most (i.e. >50%)
2	Don't know	2	Yes (i.e. >75%/All)
		1	Don't know

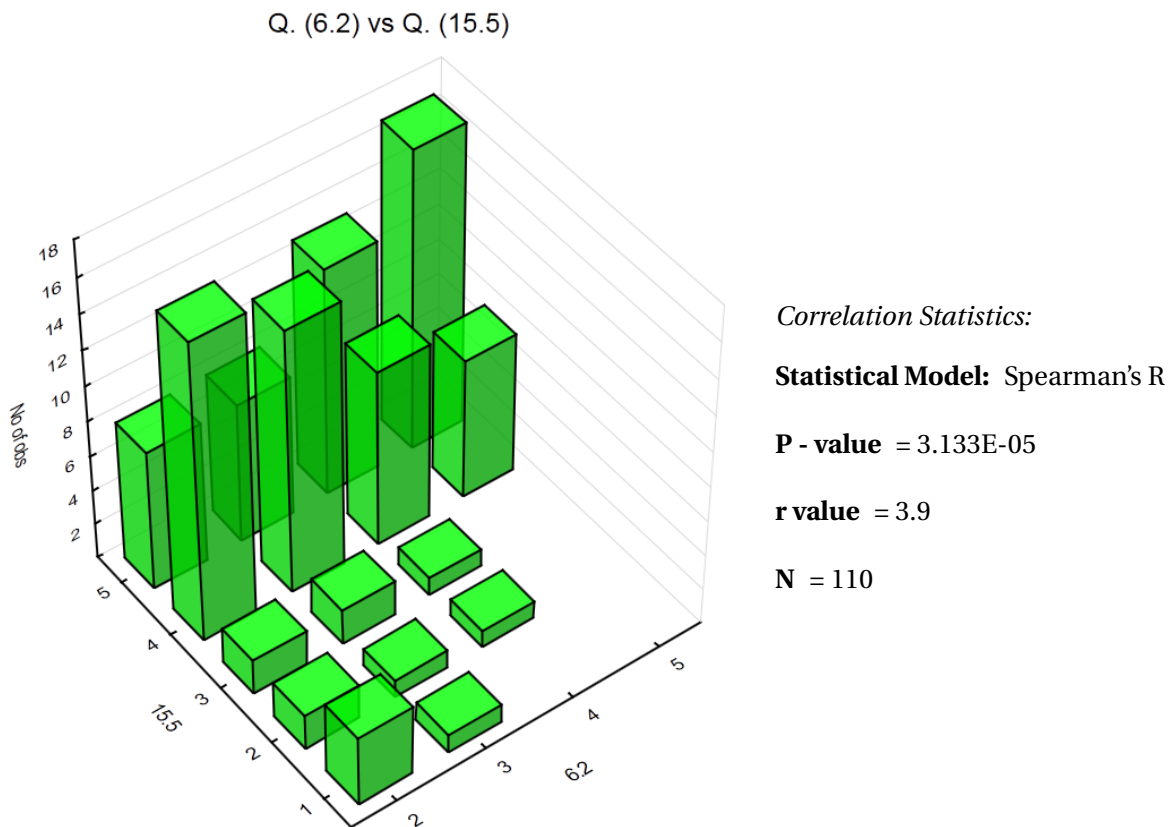


Figure C.9: Bivariate histogram of Q.(15.5) Do households in your WSA experience water pressure problems (no flow/partial flow less than 10liters/min),(not to be confused with interruption to supply)? vs. Q. (6.2) What is the percentage unaccounted for water?

Table C.8: Response scale: Q.6.2 & Q.15.5

Q. (6.2)		Q. (15.5)	
Score	Response	Score	Response
5	Less than 20%	5	No, None (i.e. 0%)
4	Less than 30%	4	Some (i.e. >25%)
3	Less than 40%	3	Most (i.e. >50%)
2	Don't know	2	Yes (i.e. >75%/All)
		1	Don't know

C.3 Factors contributing to metering and billing of connections

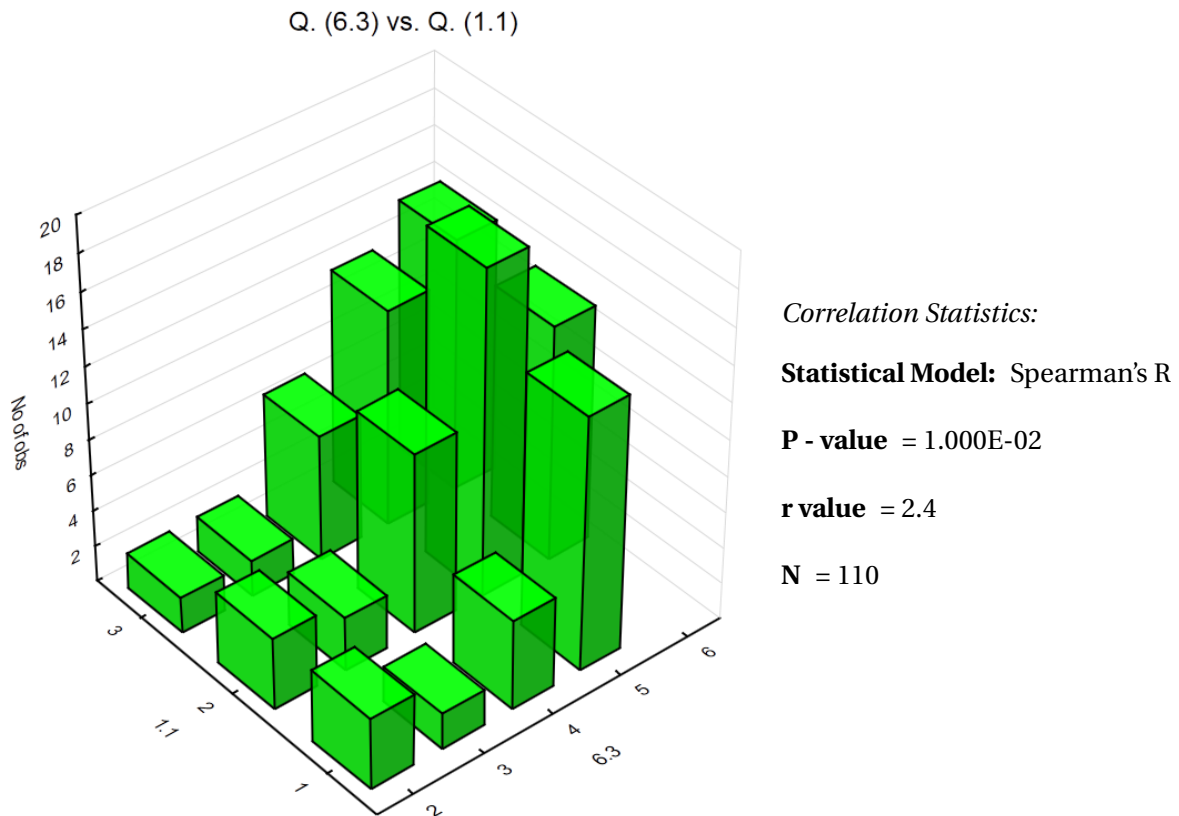


Figure C.10: Bivariate histogram of Q.(1.1) Do you have appropriate Water, Sewage and Storm water Master Plans and are they included in your Integrated Development Plan vs. Q. (6.3) What percentage of connections are metered and billed?

Table C.9: Response scale: Q.6.3 & Q.1.1

Q. (6.3)		Q. (1.1)	
Score	Response	Score	Response
6	>98%	3	Yes, strongly agree
5	75 - 98%	2	In development
4	50 - 75%	1	No, disagree/Don't know
3	<50%		
2	No metering/Don't know		

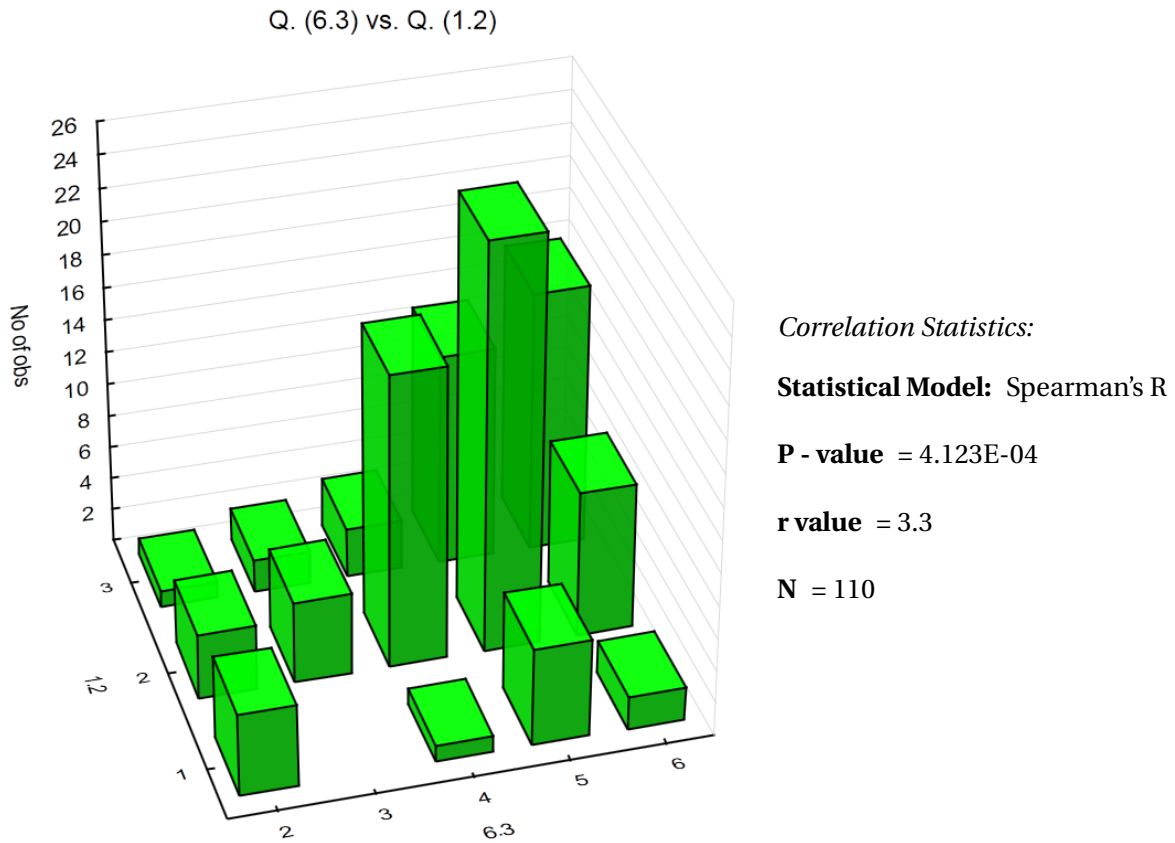


Figure C.11: Bivariate histogram of Q.(1.2) Do you have an appropriate Water Safety Plan and is it included within your IDP vs Q.(6.3) What percentage of connections are metered and billed?

Table C.10: Response scale: Q.6.3 & Q.1.2

Q. (6.3)		Q. (1.2)	
Score	Response	Score	Response
6	>98%	3	Yes, strongly agree
5	75 - 98%	2	In development
4	50 - 75%	1	No, disagree/Don't know
3	<50%		
2	No metering/Don't know		

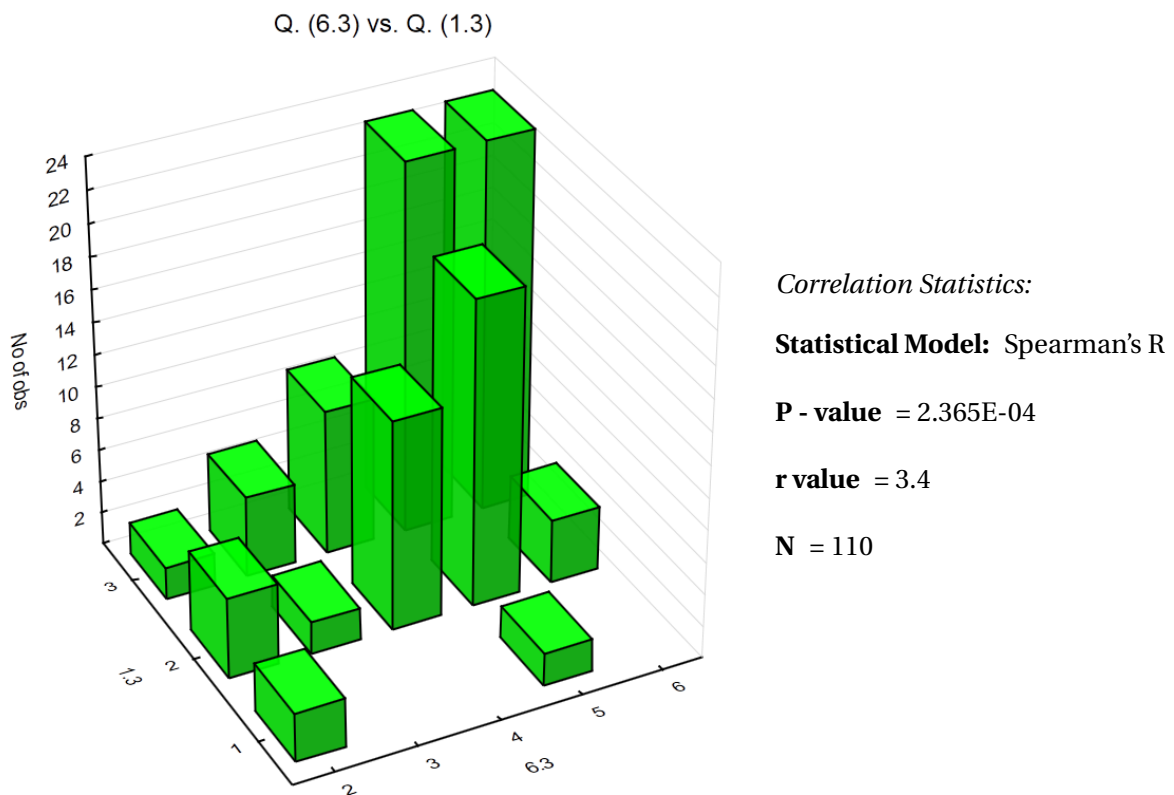


Figure C.12: Bivariate histogram of Q.(1.3) Do you have and up-to-date adopted Water Service Development Plan (WSDP) which you are implementing? vs Q.(6.3) What percentage of connections are metered and billed?

Table C.11: Response scale: Q.6.3 & Q.1.3

Q. (6.3)		Q. (1.3)	
Score	Response	Score	Response
6	>98%	3	Yes, strongly agree
5	75 - 98%	2	In development
4	50 - 75%	1	No, disagree/Don't know
3	<50%		
2	No metering/Don't know		

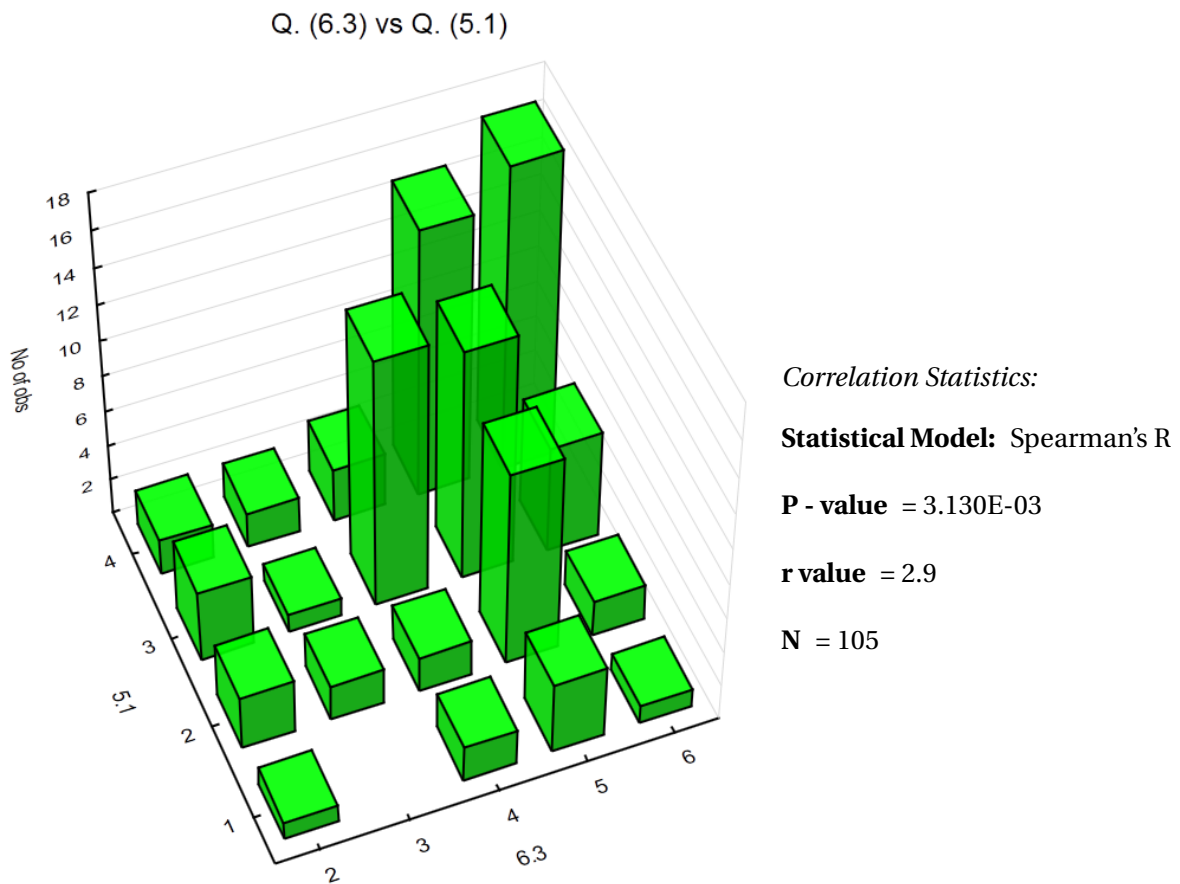


Figure C.13: Bivariate histogram of Q.(5.1) Are water sources secured (e.g. fenced, tamper proof)? vs Q.(6.3) What percentage of connections are metered and billed?

Table C.12: Response scale: Q.6.3 & Q.5.1

Q. (6.3)		Q. (5.1)	
Score	Response	Score	Response
6	>98%	4	Yes, All (i.e. 100%)
5	75 - 98%	3	Most (i.e. >75%)
4	50 - 75%	2	Some (i.e. > 50%)
3	<50%	1	< 50%/None/Don't know
2	No metering/Don't know	B	Not applicable

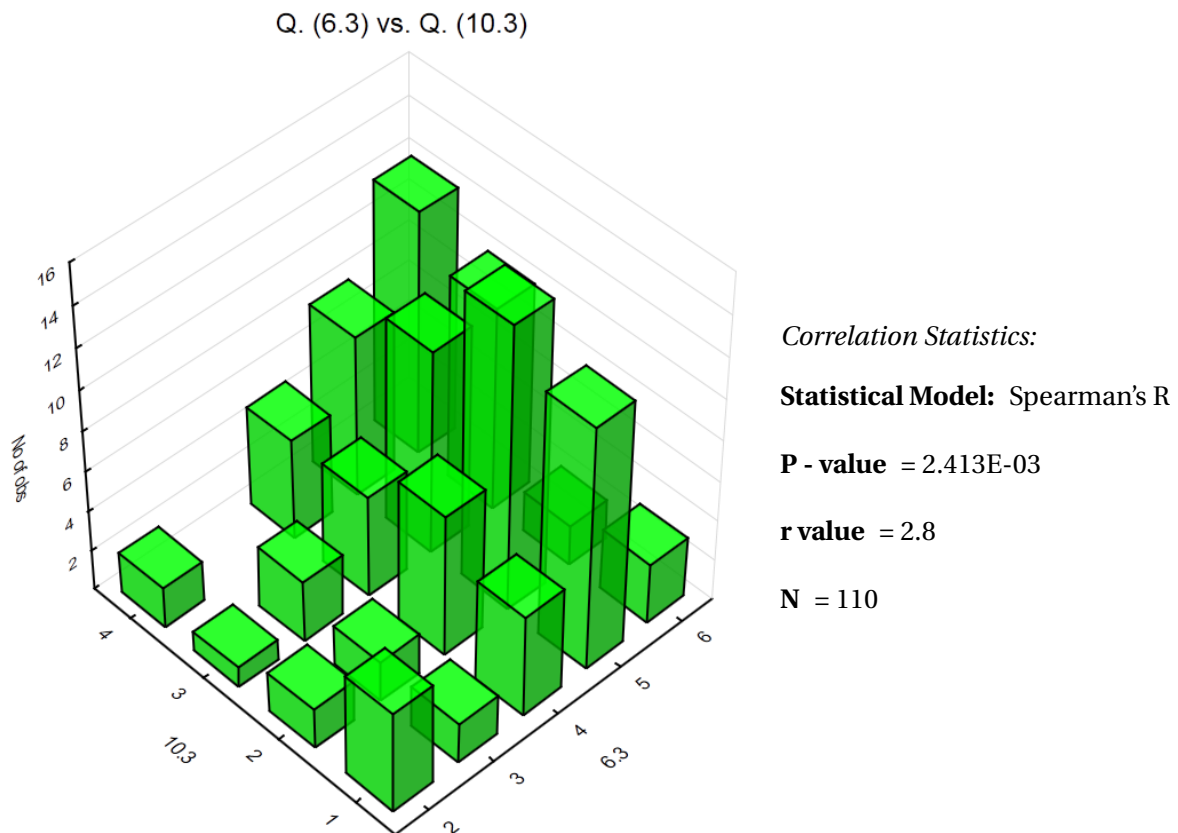


Figure C.14: Bivariate histogram of Q.(10.3) Is appropriate scheduled/planned/preventative maintenance performed at WTWs and associated water reservoirs/water pump stations/distribution network? vs Q.(6.3) What percentage of connections are metered and billed?

Table C.13: Response scale: Q.6.3 & Q.10.3

Q. (6.3)		Q. (10.3)	
Score	Response	Score	Response
6	>98%	4	Yes, All (i.e. 100%)
5	75 - 98%	3	Most (i.e. >75%)
4	50 - 75%	2	Some (i.e. > 50%)
3	<50%	1	< 50%/None/Don't know
2	No metering/Don't know		

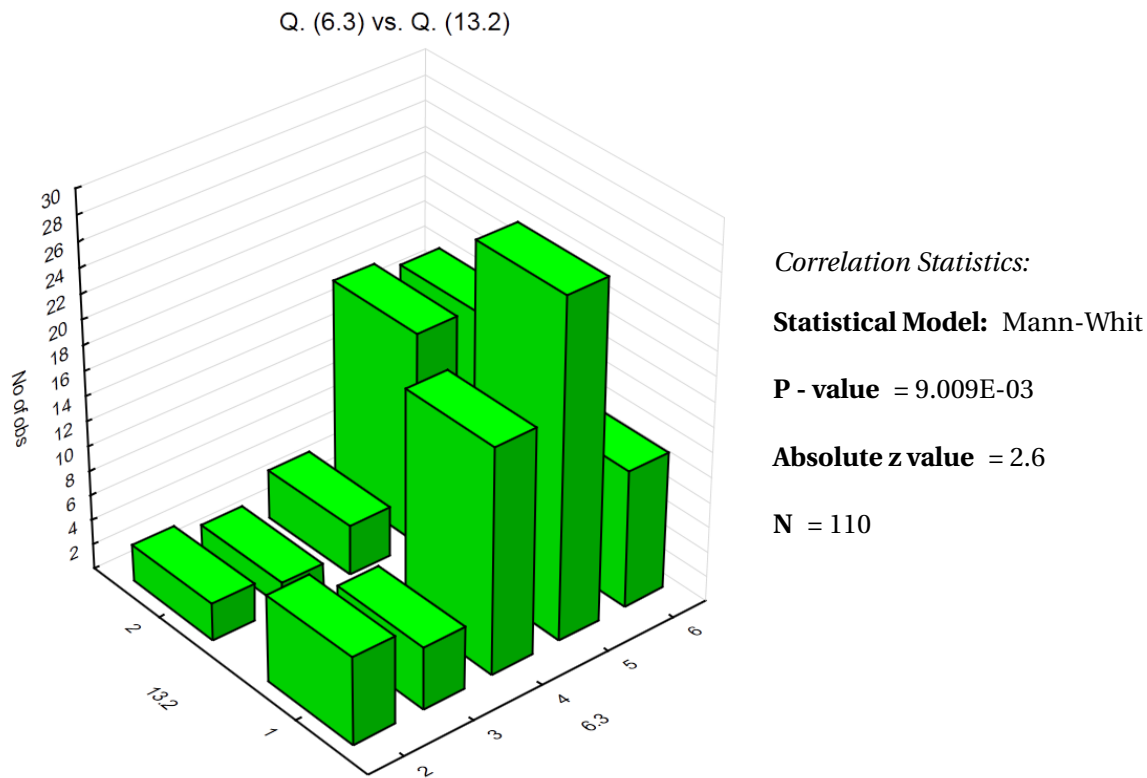


Figure C.15: Bivariate histogram of Q.(13.2) Is IT budget adequate for required water services activities? vs Q.(6.3) What percentage of connections are metered and billed?

Table C.14: Response scale: Q.6.3 & Q.13.2

Q. (6.3)		Q. (13.2)	
Score	Response	Score	Response
6	>98%	2	Yes, strongly agree
5	75 - 98%	1	No, disagree/Don't know
4	50 - 75%		
3	<50%		
2	No metering/Don't know		

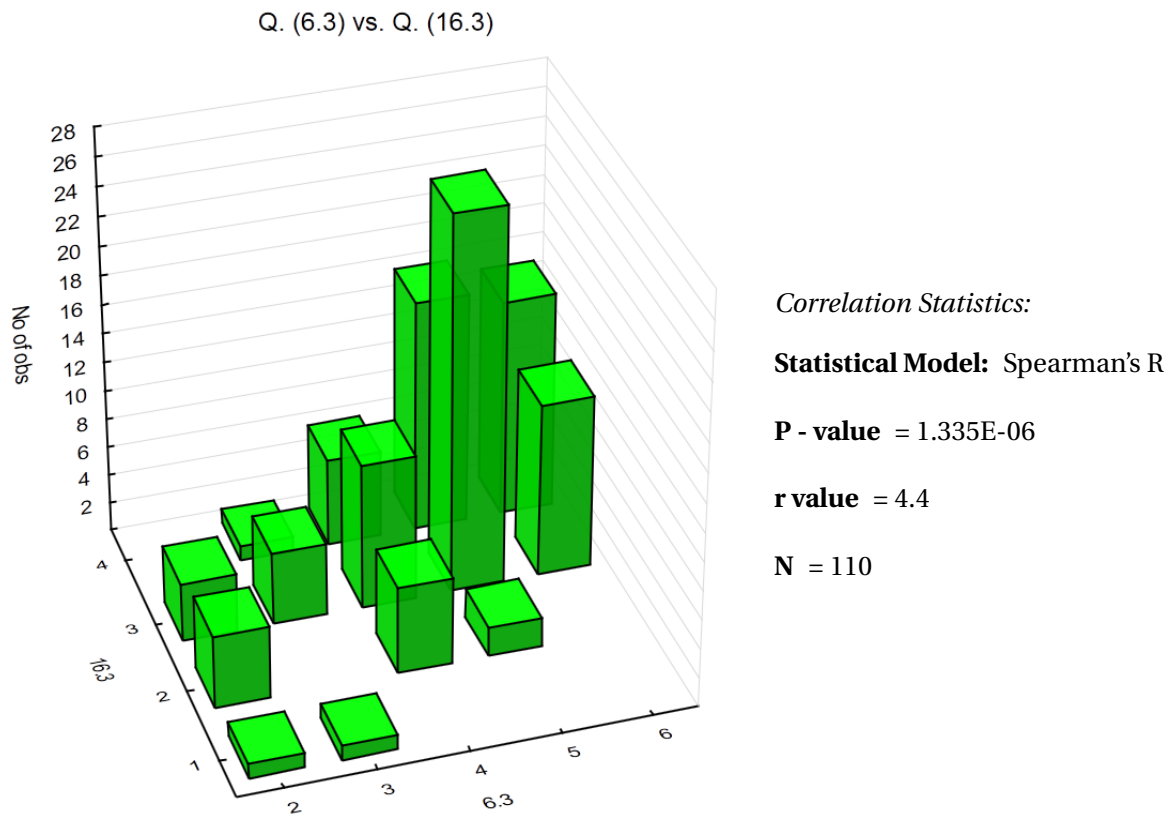


Figure C.16: Bivariate histogram of Q.(16.3) How many of the reported water related complaints/callouts are responded to within 24 hours (percentage)? vs. Q. (6.3) What percentage of connections are metered and billed?

Table C.15: Response scale: Q.6.3 & Q.16.3

Q. (6.3)		Q. (16.3)	
Score	Response	Score	Response
6	>98%	4	Yes, All (i.e. 100%)
5	75 - 98%	3	Most (i.e. >75%)
4	50 - 75%	2	Some (i.e. > 50%)
3	<50%	1	< 50%/None/Don't know
2	No metering/Don't know		