The Economic and Social Value of Water in Lesotho and South Africa: A Macroeconomic Baseline Analysis

renoka
We are a river

European Union

german cooperation
DEUTSCHE ZUSAMMENARBEIT

ReNOKA is a national programme and citizen movement for the restoration of land and water in Lesotho and the Orange-Senque basin. Support for ReNOKA is provided through a partnership between the Government of Lesotho, the European Union (EU) Delegation to the Kingdom of Lesotho and the German Federal Ministry for Economic Cooperation and Development (BMZ). The EU provides € 27.5 million financial contribution through the 11th European Development Fund with Lesotho, while BMZ provides € 6 million contribution through its Transboundary Water Management Programme in the SADC Region. The Government of Lesotho provides LSL 80 million in parallel financing. The EU and BMZ contributions are implemented through a technical assistance project "Support to Integrated Catchment Management in Lesotho" by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Produced by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in collaboration with StratEcon. Maseru, Lesotho – December 2020

StratEcon Applied Economic Research

Disclaimer: StratEcon is an economics consultancy. Some of the analysis in this report is based on observations of physical changes in water supply and quality. The conclusions that are drawn are evidence-based. It may be that physical scientists would draw a different conclusion based on a more detailed understanding of the scientific aspects of water supply.

Reading of Dates: For ease of reading all financial years are referred to as the final year in the text.For example, the financial year 2017/18 is referred to as 2018. These years are shown in full in tablesand diagrams.

Contents

List of Figures .... *ii*
List of Tables .... *iii*
Acknowledgements .... *iv*

Executive Summary 1

Introduction 5

CHAPTER 1: Objective and Approach 6

CHAPTER 2: Water Related Issues 7

2.1 Water Resources 7
2.2 Precipitation 9
2.3 Water Quality 11
2.4 Water Usage 16
2.5 Dam Levels 24

CHAPTER 3: Economic Implications 32

3.1 Lesotho Fiscal and Economic Implications 32
3.2 South Africa Economic Implications 34

CHAPTER 4: Ecosystems and Climate Change 39

4.1 Wetland Ecosystems 39
4.2 Climate Change 45

CHAPTER 5: Stakeholder Contribution 48
CHAPTER 6: Future Research 49

Conclusion *51*
References *52*
Appendix A: The Vaal River Economy, Water Dependency and Scarcity *54*

List of Figures

Figure 1: Main Catchments 13
Figure 2: Lesotho Highlands Water Project 14
Figure 3: Annual Rainfall 2014 - 2017 15
Figure 4: Annual Rainfall - Average of 44 Rain Stations 16
Figure 5: Nitrate and Phosphate: Katse and Muela Dam 18
Figure 6: Chlorophyll-a and TSS: Katse and Muela Dams 19
Figure 7: E. coli: Katse Dam 20
Figure 8: Treated Water Quality – Annual 2012 to 2019 21
Figure 9: Treated Water Quality – Monthly 2018 21
Figure 10: Water Use in Lesotho 23
Figure 11: Water Use – Economic 23
Figure 12: Urban Water Usage – Geographic Distribution 24
Figure 13: Potable Water Urban Usage 25
Figure 14: Potable Water Use – Economic 26
Figure 15: Projected Lesotho Water Use and Capacity (base data 2016/17) 27
Figure 16: Projected Lesotho Water Use and Capacity Proportions (base data 2015/16) 28
Figure 17: National and Cross-border Water Usage 29
Figure 18: Katse Dam Levels 30
Figure 19: Mohale Dam Levels 31
Figure 20: Annual Rainfall – Three Catchments 32
Figure 21: Monthly Rainfall – Senqu Catchment (close to Katse and Mohale Dams) 2000 – 2019 32
Figure 22: Annual Rainfall – Mohlanapeng Weather Station – Senqu Catchment 2000 to 2019 32
Figure 23: Annual Rainfall – St Martins Weather Station – Senqu Catchment 2000 to 2017 33
Figure 24: Annual Rainfall in the Katse, Motsuko and Mohale Catchments (CHIRPS Data) 33
Figure 25: Actual and Planned Annual Water Transfers 34
Figure 26: Comparison of Cross-Border Transfers 35
Figure 27: Matsoku Diversion Weir Siltation – May 2020 36
Figure 28: Stream Flow, Losses and Consumption 36
Figure 29: Water Balance by Main Catchment 37
Figure 30: LHWP Water Royalties and Electricity Sales 39
Figure 31: LHWP Revenues & Government 39
Figure 32: LHWP Revenues & Economy 40
Figure 33: Vaal River System Economy 42
Figure 34: Vaal River System – Water Intensive Sectors – Absolute Expenditure 42
Figure 35: Vaal River System – Water Expenditure per R1m GDP 43
Figure 36: Vaal River System – Water Expenditure per Job 43
Figure 37: Vaal River System – GDP Loss 44
Figure 38: Vaal River System – Job Losses 44

Figure 39: Four Ecosystem Service Groups 47
Figure 40: Lesotho Wetland Ecosystem Valuation 49
Figure 41: Comparison of Adapted Regional Studies 50
Figure 42: Long Term Precipitation Trends 52
Figure 43: Historic Temperatures 53
Figure 44: Temperature and Precipitation Projections 53
Figure 45: Lesotho GDP by Economic Activity (M million) 62
Figure 46: Agricultural Output by Available Water 64

List of Tables

Table 1: Household Water Access 25
Table 2: Water Transfer Volume 29
Table 3: Electricity Generation 30
Table 4: Monthly Precipitation Volumes (mm) 34
Table 5: Dams of the Integrated Vaal River System 40
Table 6: Assessed River Condition (October 2017 to September 2018) 51
Table 7: Long-Term Sectoral Changes in GDP from a 17% Water Scarcity 63

Acknowledgements

Our thanks and appreciation go the people and organisations whose input and cooperation made this work possible. These include:

- Faith Lawrence and Lea Derr of GIZ
- Giuliana Branciforti of GIZ
- Members of the Integrated Catchment Management Coordination Unit in Lesotho
- Ntsane Mahkea of the Liqhobong Mine
- Fred Tlhomola and Palesa Monongoaha of the Lesotho Highlands Development Authority
- Mothusi Mohai of the Metolong Authority
- Moliehi Lephoto of WASCO (the Water and Sewerage Company)
- Nandha Govender and Ian Midgley of Eskom
- Rivash Panday and Martin Ginster of SASOL
- Kobus Harbron of the Vaalharts irrigation scheme
- Tawanda Nyandoro of Rand Water

Executive Summary

Lesotho is the mountain kingdom. It is also one of the most important rainfall catchments in Southern Africa. This blesses Lesotho with abundant water and there is rarely, if ever, a shortage of natural water. Lesotho also capitalizes on this water bounty by transferring some of these resources to South Africa. One of the important transfers is to the Vaal River, which sustains Gauteng and surrounds, the industrial heartland of South Africa. Any restraint on these water transfers will, arguably, have a significant and negative impact on the South African economy.

This report analyses the water situation in Lesotho and assesses this within the context of the cross-border water transfers to South Africa. It is a major input into establishing a cross-border stewardship initiative between Lesotho and South Africa by the Natural Resource Stewardship Programme (NatuReS) and the Integrated Catchment Management Programme (ICM). This report should not be read as an encyclopaedic analysis of the water demand and supply position within Lesotho and between Lesotho and South Africa. Rather it followed the approach of a desktop analysis, using available information. Part of the brief was to identify areas for which additional evidence is needed and where further research is required.

There are two major water supply systems in Lesotho. The first is the Lesotho Lowlands Water Supply Scheme, incorporating the Metolong Dam filled by the Phuthiatsana River and supplying water to the capital city of Maseru. The second is a system of dams and weirs which feeds the cross-border transfer to South Africa known as the Lesotho Highlands Water Project. There is a remarkably disproportionate use of water between these two systems. Cross-border transfers totally dwarf the local usage of water. The combined use of water was in the region of 5 000Mm^3 between 2012 and 2017. Of this 95% went through the Lesotho Highlands Water Project and was transferred out of the country.

There is, on the surface, no obvious indication of water shortages. Total streamflow exceeds all water uses including evapotranspiration. The situation is less clear within each of the three major catchments. The first, and largest, catchment is the Senqu. It is also the catchment that feeds the Lesotho Highlands Water Project. The available evidence shows that there is ample water in the Senqu catchment with streamflow well in excess of evapotranspiration. The other two catchments are Mohokare, which supplies water to Maseru, and the Makhaleng, the smallest of the catchments. In these cases, evapotranspiration exceeds stream flow. These conclusions are based on a relatively small time period (2014 to 2017) and it is not clear how, over a longer period, water use can exceed water availability.

Part of the need to understand rainfall patterns is to anticipate what may happen to water in the storage dams. The Metolong Dam, which supplies water to Maseru and completed in 2016, was at capacity by 2018. This, along with the observations about consistent rainfall over time, suggests that there is no immediate water supply threat to Maseru. The situation appears to be quite different with the dams that supply the Lesotho Highlands Water Project. Again, data limitations bedevil firm conclusions.

The alarming observation is that there have been major drops in water levels in the two important dams that supply the Lesotho Highlands Water Project. These are the Katse and Mohale Dams. The Katse Dam was, with some variation, largely full until 2015. There has been a steady decline in water levels in this dam over the last five years, despite the ample rainfall in 2016 and 2017. **The dam was at 22% capacity on 15 November 2020.** The Mohale Dam was at 100% capacity in 2011 and early in 2012. This was the last time the dam was full. It was at 70% in 2017, despite the good rains in that year. This trend continued into 2020 and it **was, by 15 November 2020, at less than 3% capacity.**

Such trends, if sustained, would clearly have major negative impacts on the economies of both Lesotho and South Africa even though Lesotho has sufficient water for its own needs. Lesotho relies on the cross-border water transfers both for revenue from these transfers and electricity generation. South Africa relies on these transfers to keep the wheels of the economy turning and to ensure that people have drinking water. The potential economic impact of a pending water transfer shortage was modelled to assess the possible impact on the two countries.

For Lesotho, the water transfers were worth M615m in 2012 and the electricity sales an additional M63m (this makes electricity sales 9% percent of total revenue). Total revenue in 2012 was M677m. By 2019 this total revenue had increased to M994m and the proportion of electricity sales was 6%. It is clearly not known what the revenue outlook would be, given that the water supply outlook is also unclear. Some perspective is given by comparing the value of these revenues to the Lesotho economy. The most important comparison is to the overall size of the economy, GDP, where the value of cross-border transfers and electricity was 3.7% in 2019. This means that any change in water transfers will have a proportionate impact on the Lesotho economy. In short, should there be no water transfers, the Lesotho economy would shrink by 3.7%. The economic impact would have a direct effect on the Lesotho government because it is an important part of government finance. It is the equivalent of 14% of taxes, 48% of government health expenditure and 41% of government education expenditure.

The cross-border economy that relies on water transfers is valued at R1 730bn. Some of the challenges in making assessments on the economic impact in Gauteng were around the extent to which the Lesotho water contributes to the Gauteng economy, the existence of substitute water supplies, and the changing impact of different water shortages. The latter is problematic because the impact of a water shortage is not linear. For example, the economic impact of a water shortage of 30% is not double the impact of a 15% water shortage.

The economic impact of three water shortage levels were modelled. These are 17%, 25% and 50% water shortages. A 17% water shortage would result in this economy losing R3.6bn, equivalent to 0.2% of GDP and 26 000 job losses – 0.3% of all jobs. A 25% water shortage would reduce the economy by R34bn with 244 000 job losses. This would be 3.0% of jobs and 2.0% of GDP. Finally, a 50% water shortage would cost R129bn in GDP, 11% of total, and 924 000 jobs, also 11% of total.

The most obvious, and logical, cause of these falling water levels would be from less rain. This could not be shown. The information from six weather stations close to the dams was analysed. It was found that, despite incomplete information, there has been little long-term change in rainfall at these six weather stations. Additional precipitation information was provided after the submission of the draft report by the Project Steering Committee for the Katse, Matsoku and Mohale catchments. The information did not change the initial conclusions.

The contradictions noted above between rainfall and dam capacity warrant further investigation. Many reasons could account for this anomaly. There may have been an unusual amount of water released, the dams may be leaking, there might be siltation blockages within the system or there may simply be higher evaporation . One possible reason for this anomaly is that the ecosystems may be compromised. Wetlands are to be found in all of Lesotho's agro-ecological zones with an area of over 96 000 hectares. There are three types - palustrine, lacustrine and riverine wetlands. The biggest threats to wetlands include encroachment, livestock grazing and trampling, erosion, droughts, cultivation, overexploitation, and siltation. There is some evidence that several ecosystems are not operating as desired. For example, five out of seven sites monitored by the Lesotho Highlands Development Authority are performing worse than predicted. These threats have resulted in several ecological problems such as habitat change, species richness loss, reduction in quantities of surface water, increase in water treatment cost and increases in water borne diseases. These changes may be responsible for the disconnect between rainfall and dam water levels noted above. They also potentially threaten the well-being of thousands of people living along the rivers that feed the Katse Dam.

Human, livestock or industrial encroachment can compromise water quality. There is official concern that increasing population, industrialisation, mining, landfill and rural-urban migration may contribute towards reducing water quality. In addition, unplanned settlements are contributing towards groundwater quality reduction from using septic tanks, pit latrines, cemeteries and open defecation. There appears to be some negative impact on water quality which are different between water supply for Maseru and that destined for the LHWP. A tentative conclusion is that water quality has historically been good. There has recently being an increase in contaminants in the storage dams and potable water. In the storage dams it appears to be total suspended solids and E. coli which are the problems. In potable water the Langelier index suggests that pH levels are highly problematic as are residual chlorination levels.

There are at least five important areas for additional research. First is the need to compile a comprehensive precipitation (rainfall and snowfall) profile nationally and for individual catchments. This would give more clarity on whether or not it is precipitation that is a contributing cause of the falling dam levels. Second, it is possible that climate change may account for many of the biophysical phenomena that have been noted. These may include higher temperatures, increased evaporation and evapotranspiration and shifts in the seasonal distribution of precipitation. This needs investigation or a synthesis of existing analyses. Third, wetlands are to be found in all the agro-ecological zones. There is some evidence that several ecosystems are not operating optimally and warrants further investigation. Fourth, there is the need for an engineering assessment of structural and water supply issues into the LHWP dams. For example, there is visual evidence that the Matsoku Weir, which diverts water from the Matsoku river into the Katse Dam via a tunnel, is silted and not operating as planned. This may be affecting the yield of Katse and Mohale dams. On-going siltation of the dams and the magnitude of transfers from the dams may also have played a role in the declining water levels. The reasons for discrepancies in the cross-border transfer data need to be investigated. Finally, the research should be brought together and the cost of the identified interventions aggregated. This would facilitate the revision of the economic analysis which would allow for informed policy decisions.

The overall conclusions are given by degree of certainty. It is clear that there is ample water in Lesotho and there will be no water shortages in the country in the short or medium term. It is reasonably clear that, while there is some compromised water quality, this is limited and would not appear to be a problem. What is less clear, and the major cause for concern, is the water availability for the LHWP cross-border transfers. Indications are that water levels in the scheme reservoirs are dangerously low. The social and economic implications are dependent on whether these supply levels are temporary and can be addressed or long term. There would be dangerous economic consequences for both Lesotho and South Africa if these are long-term problems. The way forward is to implement the identified research needed to understand these long-term bio-physical issues and revisit the economic analysis for more concrete conclusions and policy recommendations.

Introduction

Lesotho is a small, mountainous, and beautiful country in southern Africa. Its mountains play a pivotal role in the region because they are a major water catchment area that supplies water to its neighbour, South Africa. In particular this water feeds the industrial heartland of South Africa. Lesotho is critical to the functioning of the South African economy.

Many countries in Southern Africa, Lesotho included, are either water constrained or face the danger of becoming water constrained. To this end the Natural Resource Stewardship Programme (NatuReS) and the Integrated Catchment Management Programme (ICM) intend establishing a cross-border stewardship initiative between Lesotho and South Africa. One step in this process is a macro economic baseline study. The intention is to foster understanding on the social and economic importance of water in Lesotho and South Africa. This study would help to establish a partnership platform by promoting an improved integrated catchment management through cross-border collective action.

During the process of the analysis for this report if became apparent that there are issues which extend beyond the economic and social value of water. The evidence-based analysis suggests that there is no immediate threat to urban water supplies. However, the evidence also suggests that while there is no obvious change in rainfall, water levels in the reservoirs that feed the cross-border supplies has been declining. These trends, if they continue, will have serious and negative economic consequences. The South African economy will suffer. The payment for the cross-border water transfers will diminish if not cease entirely. These are large financial flows which will have a major impact on Lesotho.

This report should not be read as a definitive analysis of these key water related and resultant economic trends. The work started out as the establishment of a baseline macroeconomic profile of water in Lesotho. The analysis began to focus on the identified key issues as evidence emerged from the research. This report is the first step in fully understanding these issues.

This report has seven sections. The first describes the objective, how the subject has changed and the resultant approach to the research. It moves on to outlining several and relevant water related issues. The third part draws out the economic implications of the identified water related issues. The fourth considers ecosystems and the value of ecosystem services. Five summarizes key stakeholder inputs that were made over the course of the analysis. The sixth outlines future research needed to draw more definitive conclusions. There is also a brief conclusion.

CHAPTER 1

Objective and Approach

The initial brief had four objectives. The first was to establish a broad understanding of the physical elements of water supply in Lesotho and those parts of South Africa that rely on the Vaal River transfers. Second was an analysis of the role of water in the economies of Lesotho and those parts of South Africa dependent on the cross-border transfers. Third, was to identify potential water security risks and the fourth was to identify information gaps.

These objectives have been achieved but became more focused during the analysis. The overall objective can now best be described as "**The identification of key economic issues - water demand and supply in Lesotho**".

StratEcon is an economics consultancy. As such it specialises in economic science but not physical science. This project has covered both areas. The approach was to identify important water supply issues, which was evidence based. Stakeholder input was of major importance in this regard. These supply issues, and their economic implications, were subsequently analysed. It also emerged that ecosystems and ecosystem services could lie at the heart of the water related issues. This resulted in the collection and drawing of conclusions from existing evidence. An important part of the assignment, and one which was followed throughout the work, was to identify necessary future research. This has been found to be water related, in the first instance, and a further economic analysis of the potential consequences that may emerge from this further research.

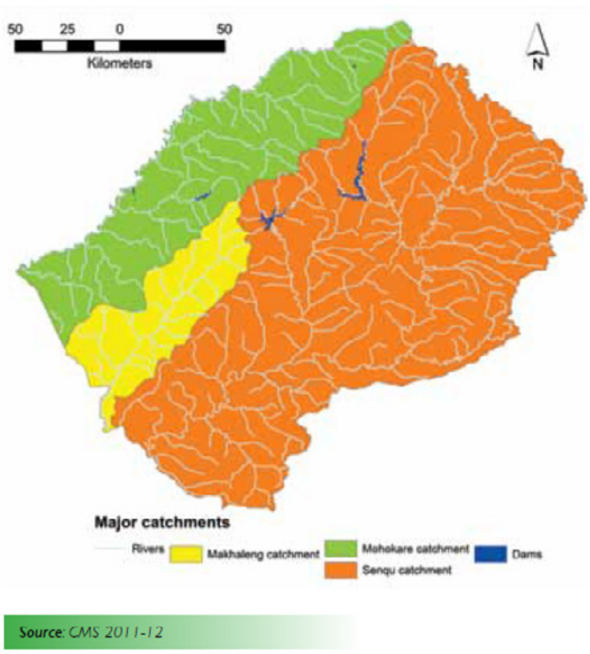
It is important to note that this work was specified as a baseline analysis. This means that it was desktop work and while there was no field work there was extensive consultation with stakeholders. There was also no primary research and all analysis relied on existing information and input by the stakeholders. Where reference is made to cross-border transfers the focus is specifically on the Lesotho Highlands Water Project (LHWP).

CHAPTER 2

Water Related Issues

Lesotho is blessed with three major water catchment areas, and some highly sophisticated water storage and reticulation systems. It is fitting to start this section with such a description. The section then moves on to an analysis of water usage both in Lesotho and the cross-border water transfers. A key water security issue that emerged during the research was the water levels in the dams that supply the cross-border water transfer to the integrated Vaal River system (IVRS). This issue has prominence here as does the potential causes of these falling water levels. Water quality is reported for both the LHWP and domestic use in Lesotho. The section closes with the discussion of ecosystems and relevant ecosystem services.

Figure 1: Main Catchments



Source: (Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014, p. 82)

2.1 Water Resources

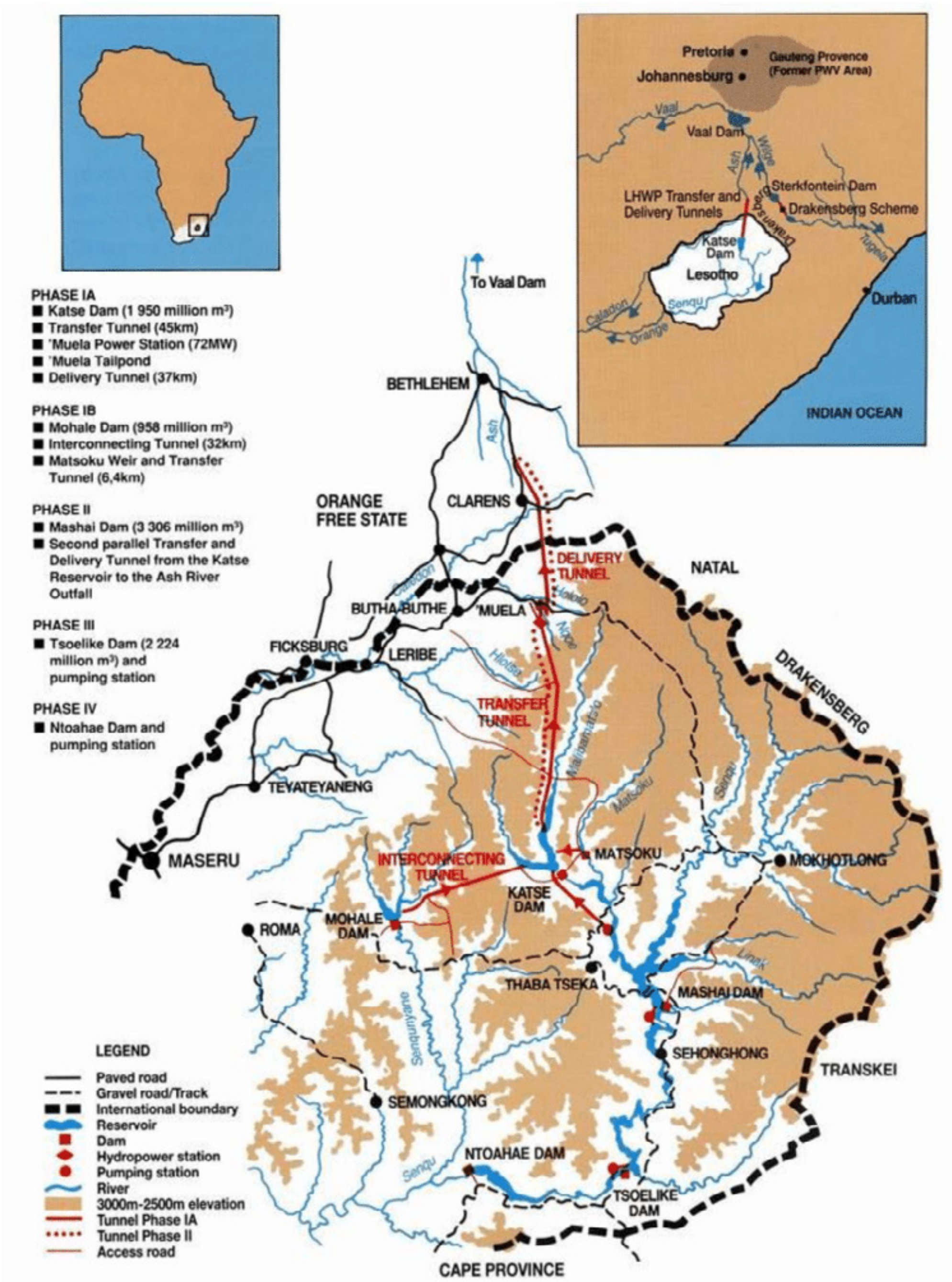
It is clearly important to understand water availability. This section starts with a discussion on available water resources, which are mainly in the form of precipitation. This water flows into the main catchment areas. The water quality is directly influenced by ecosystems and related services. Water quality is also affected by human interventions.

There are three main catchments with their location shown in Figure 1. These are the Senqu, Mohokare and Makhaleng catchments.

The Mohokare catchment fills the Metolong Dam, which provides water to Maseru and other towns in the west. It has a catchment area of 13 370 km². Historically Maseru drew its water directly from the Mohokare (Caledon) River or the off-channel Maqalika storage dam (Lesotho Ministry of Natural Resources, 2012, p. 36). This was supplemented in 2016 by the construction of the Metolong Dam. This is part of the Lesotho Lowlands Bulk Water Supply Scheme with storage capacity of 53Mm³. This dam also supplies bulk water to Berea, Roma, Mazenod and Morija (Lesotho Ministry of Water, 2018, p. 4).

The Makhaleng is the smallest of the catchments and lies between the two larger ones. It has an area of 2 988 km².

Figure 2: Lesotho Highlands Water Project



The Senqu is the largest catchment, drains two thirds of the country and has an area of 24 485 km². It supplies the Lesotho Highlands Water Project (LHWP), illustrated in Figure 2. There are currently five reservoirs. The largest is the Katse Dam, in the central Maloti Mountains with a storage capacity of 1 950Mm³. It impounds the Malibamatšo River. The Mohale Dam impounds the Senqunyane River and has a storage capacity of 860Mm³. The Matsoku Weir diverts floodwater through the Matsoku tunnel into the Katse Reservoir. The Muela Dam acts as the tail pond of the Muela hydropower station with a capacity of 6Mm³. The Polihali Dam is currently under construction for Phase II of LHWP.

2.2 Precipitation

Rainfall forms the bulk of precipitation with up to 85% of this falling between October and April. Groundwater (boreholes) and surface springs contribute about 10% to Lesotho's urban water supply (Lesotho Ministry of Water, 2018, p. 60). There is some snowfall, but data could not be sourced.

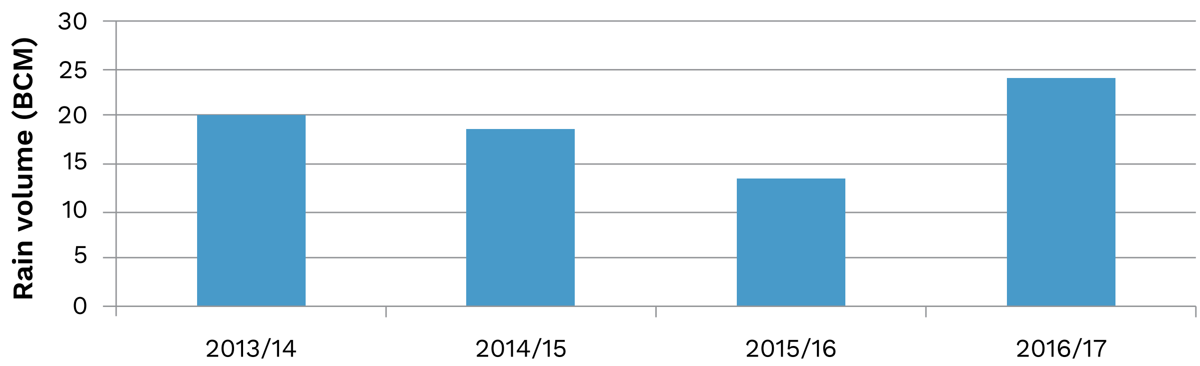
There is a remarkable quantity of rain for a southern African country. Mean annual rainfall averages 800mm and varies below 300mm in the western lowlands to 1 600mm in the north-eastern highlands. To put in context, South Africa has less than 500mm and Botswana just over 400mm.

This section describes the total rainfall for the country and the catchments that feed the LHWP dams. This detailed reporting has been done because it is necessary to show the dichotomy between rainfall and changes in dam levels.

The cautionary note from the introduction is repeated here. There is a paucity of data on both rainfall and water runoff. There is some information on total rainfall, but it is for a limited time. There is also information for specific weather stations, but it is unknown whether this reflects total rainfall in the country. The conclusions are therefore tentative.

The only historical information that could be sourced on total national rainfall was for the years 2013 to 2017 and is illustrated in Figure 3. It will be appreciated that this short timescale is insufficient to draw any firm conclusions. It will be noted that the quantity of rain reduced between 2014 and 2016 before increasing in 2017.

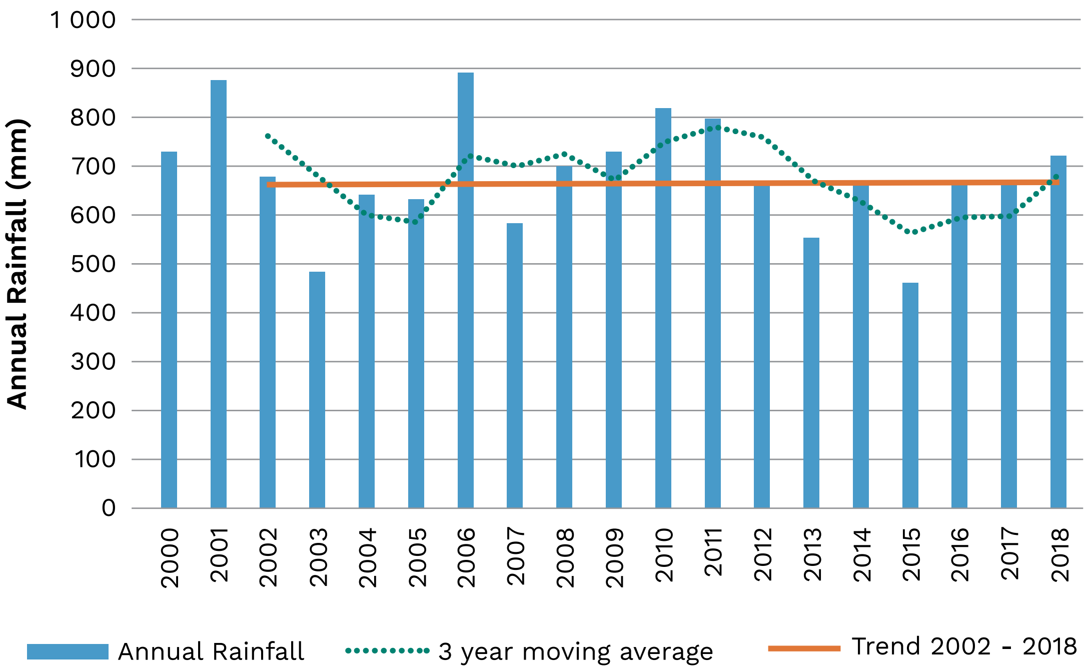
Figure 3: Annual Rainfall 2014 – 2017



Source: (Lesotho Ministry of Water, 2018, p. 27)

Because of the limited information, an analysis was done using a selection of rainfall stations for which there were longer timeseries data. The dataset for some rainfall stations appeared to be incomplete and a final sample of 44 stations was used. The total rainfall at these stations is illustrated in Figure 4 for 2000 to 2018.

Figure 4: Annual Rainfall – Average of 44 Rain Stations



Source: Calculated from data supplied by the Lesotho Meteorological Services

Three items are shown in the figure. The first is annual rainfall. The second is a three-year moving average. The third is the trend line for the years 2002 and 2018.

As can be expected there has been considerable rainfall variation. It peaked at nearly 900mm in 2006, closely followed by 2001. The low years were 2015 with rainfall in the region of 460 mm followed in 2003 with rainfall of 480mm. There is no definitive pattern as is evident by the three-year moving average. More importantly the linear trend line between 2002 and 2018 shows that average rainfall has been unchanged.

2.3 Water Quality

A variety of contaminants affect water quality. These are typically differentiated into contaminants in storage dams and in potable water. The most important in storage dams are nitrates (NO^3), phosphates (PO^4), E. coli, chlorophyll-a and total suspended solids (TSS). The analysis for drinking water is typically for residual chlorine, microbiology, turbidity and the Langelier Index (which is a measure of the alkalinity / acidity of water).

Chlorophyll-a is an important measure because it indicates the concentration of algae in the water, the result of high nutrient levels. Too many algae can cause bad odours and result in decreased levels of oxygen. They can also cause toxins that can be of public health concern if found in high concentrations. Low levels of Chlorophyll-a mean that the overall catchment is contributing to low levels of nutrients (Lesotho Highlands Development Authority, 2018, p. 26).

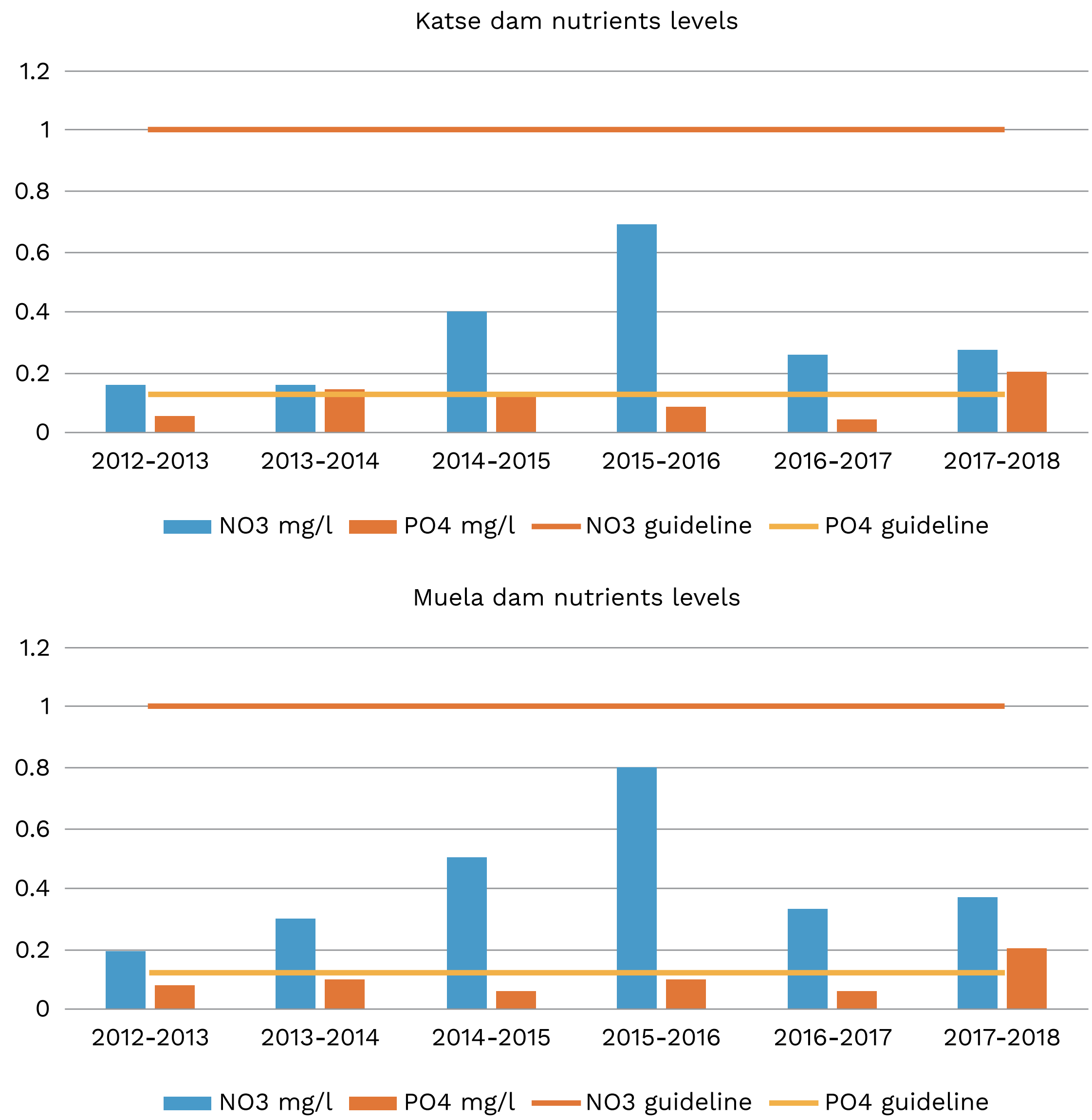
TSS is important because it is one of the most visible indicators of water quality. Suspended particles can come from soil erosion, runoff, discharges, stirred bottom sediments or algal blooms. Excessive suspended sediment can impair water quality for aquatic and human life and increase flooding risks . High levels of TSS on their own are not indicative of problems but variations show changes in the catchment environment. These can also lead to increased sedimentation in the storage reservoirs. TSS may result in costly dredging. One estimate was annual dredging costs of more than US$2/$m^3$ which would have exceeded M1.6m on 2010 dredging volumes (Lewis, et al., n.d., p. 23).

Information is readily available for the Katse and Muela dams, both part of the LHWP, and reported in Figure 5, Figure 6 and Figure 7. The diagrams, where appropriate, also report contaminant targets.

It is clear, as shown in Figure 5, that there is little cause for concern about nitrate levels in either of the dams, at least in the years for which data is available. Current nitrate levels are well below the target. Levels did increase during the 2016 financial year but have since fallen off. They reached 0.69 and 0.8 respectively for the two dams with a target of 1.0. These levels, in the 2018 financial year, were approximately 0.27 and 0.37, respectively. There is a noticeable trend where nitrate levels increased in both dams from 2013 to 2016 before decreasing.

The picture is rather different for phosphates. Phosphate levels exceeded the guidelines in the Katse dam in 2014 and 2018 and were close to the guideline in 2015. Phosphate levels were lower than guidelines in 2013, 2016 and 2017. Phosphate levels were below target in Muela in all years but 2018. There is no obvious trend in the change in phosphate levels in either of the dams. There are fluctuations but these appear to be visually random. There were increases in 2018, the last year for which information is available.

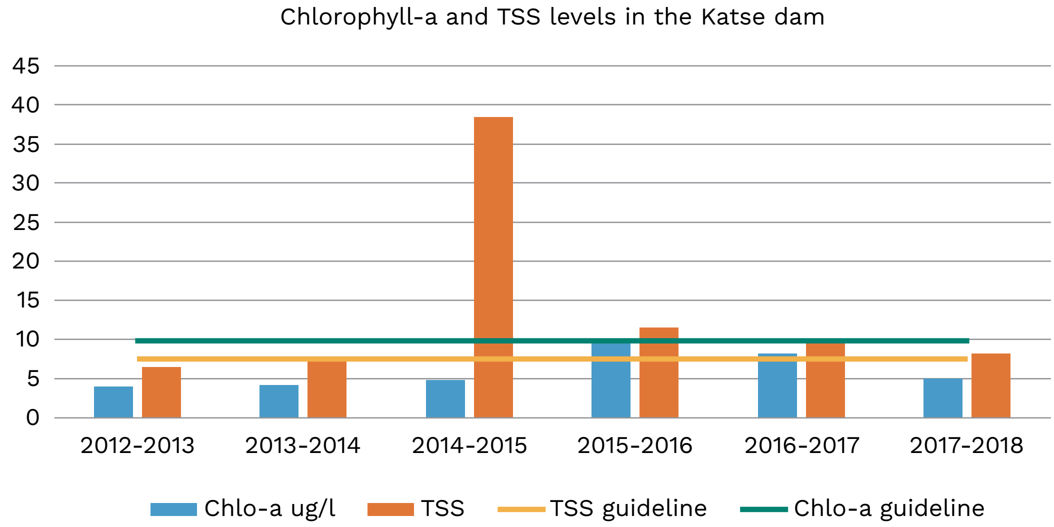
Figure 5: Nitrate and Phosphate: Katse and Muela Dam

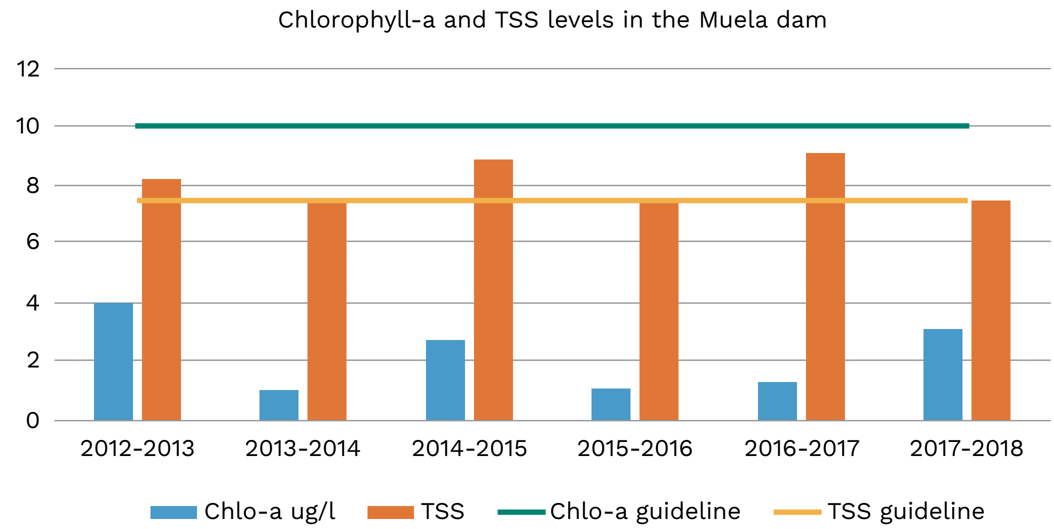


Source: (Lesotho Highlands Development Authority, 2018, p. 25)

With the exception of 2016 at Katse, the levels of Chlorophyll-a were below the guidelines in both dams. These levels are shown in Figure 6. There is a different story with TSS. The guidelines have been exceeded in both dams on many occasions. In the Katse dam, TSS levels were below guidelines only in 2013. They were at the guideline levels in 2014 and 2018. They exceeded the guideline in 2015, 2016 and 2017. In the Muela dam TSS levels were at the guidelines in 2014, 2016 and 2018. They exceeded the guidelines in 2013, 2015 and 2017. Stakeholders also indicated that siltation is a problem in the LHWP, particularly in the case of the Matsoku Weir.

Figure 6: Chlorophyll-a and TSS: Katse and Muela Dams





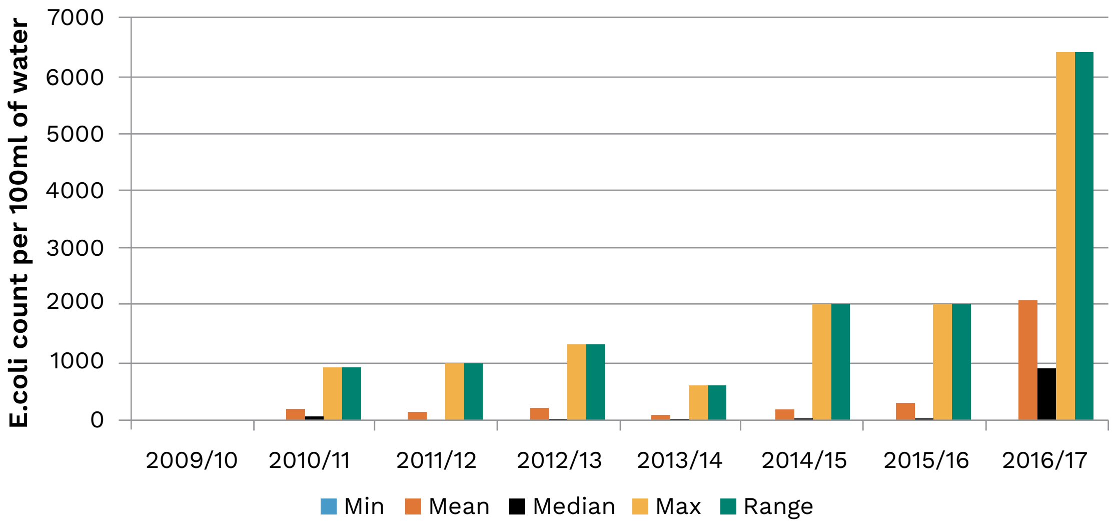
Source: (Lesotho Highlands Development Authority, 2018, p. 26)

E. coli levels are only available for the Katse dam and are reported in Figure 7. There has been an increase in concentration since 2011 and with a marked increase in 2017. It is thought that this is due to increasing population and economic activities along the reservoir (Lesotho Ministry of Water, 2018, p. 55).

The conclusion on water quality in dams in the LHWP is that there are two contaminants which are cause for concern. These are TSS and E. coli. All other potential contaminants are either well within guidelines or fluctuate marginally around guideline levels.

The rest of the section focuses on the water quality of treated water that is supplied to urban areas in the country. In this case there are four important contaminants. These are residual chlorine, microbiology, turbidity and the Langelier index. The target rate is a 98% pass rate for all these parameters (WASCO, 2018, p. 15).

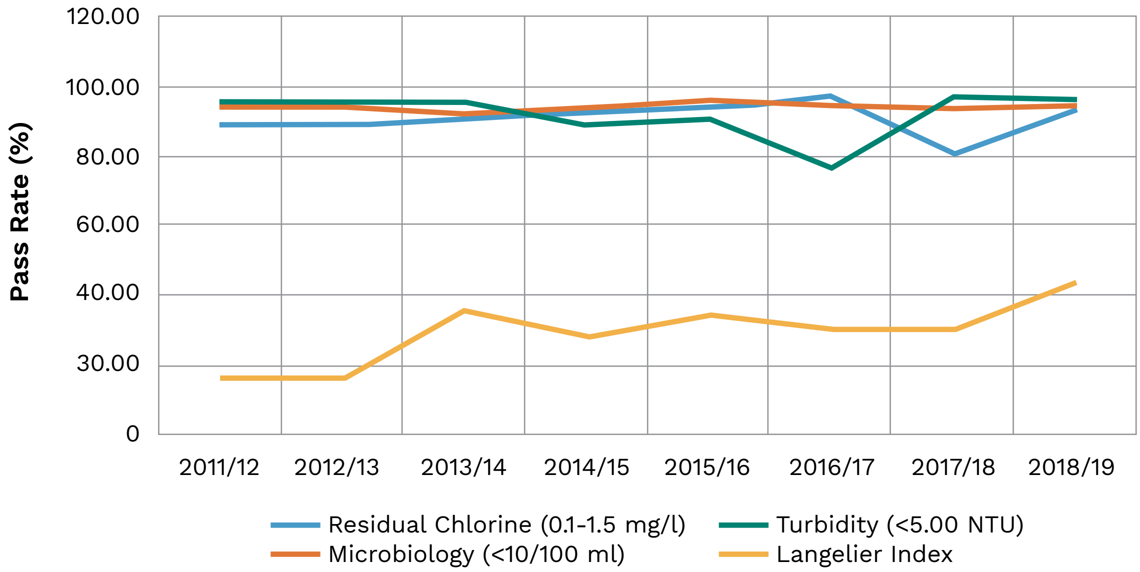
Figure 7: E. coli: Katse Dam



Source: (Lesotho Ministry of Water, 2018, p. 55)

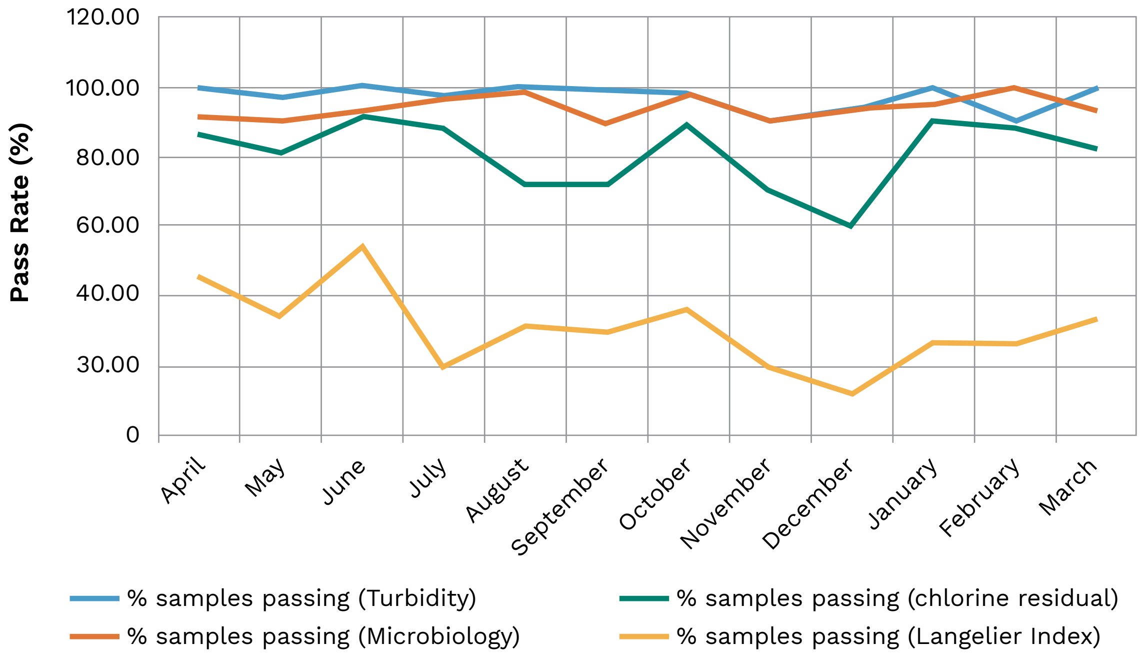
The water quality relative to targets is given in Figure 8 for 2012 to 2019 and monthly in Figure 9. It would appear, from the annual information, that residual chlorine and microbiology are generally acceptable although below the 98% target. Turbidity is close to target but there was a decline between 2014 and 2017, recovering in 2018 and 2019. The Langelier index is well below target.

Figure 8: Treated Water Quality – Annual 2012 to 2019



Source: (WASCO, n.d., p. 9)

Figure 9: Treated Water Quality - Monthly 2018



Source: (WASCO, 2018, p. 16)

In 2018, as shown in Figure 9, none of the contaminant measures achieved the 98% target. These were 77.25% for residual chlorination levels and 96.0% for turbidity levels. The bacteriology measure was 93.75% which is understood to be from under-dosing at treatment plants, long retention times and burst pipes. pH levels, measured on the Langelier Index, were only 35.75% (WASCO, 2018, pp. 15, 16).

A tentative conclusion is that water quality has historically been good. There has recently been an increase in contaminants both in the storage dams and in potable water. In the storage dams it appears to be TSS and E. coli which are the problems. In potable water the Langelier index suggests that pH levels are problematic and residual chlorination levels are a problem.

There is official concern that increasing population, industrialisation, mining, landfill and rural-urban migration may contribute to reducing water quality. In addition, unplanned settlements are contributing towards groundwater quality reduction through the use of septic tanks, pit latrines, cemeteries and open defecation (Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014, p. 89).

2.4 Water Usage

The discussion on the usage of water is separated into Lesotho use and cross-border transfers to the Vaal River system.

2.4.1 Lesotho

This descriptive section makes a distinction between all and potable water, as well as its geographical dispersion and economic use. Some evidence is also given on the ability to meet future potential water demand.

2.4.1.1 Current Use

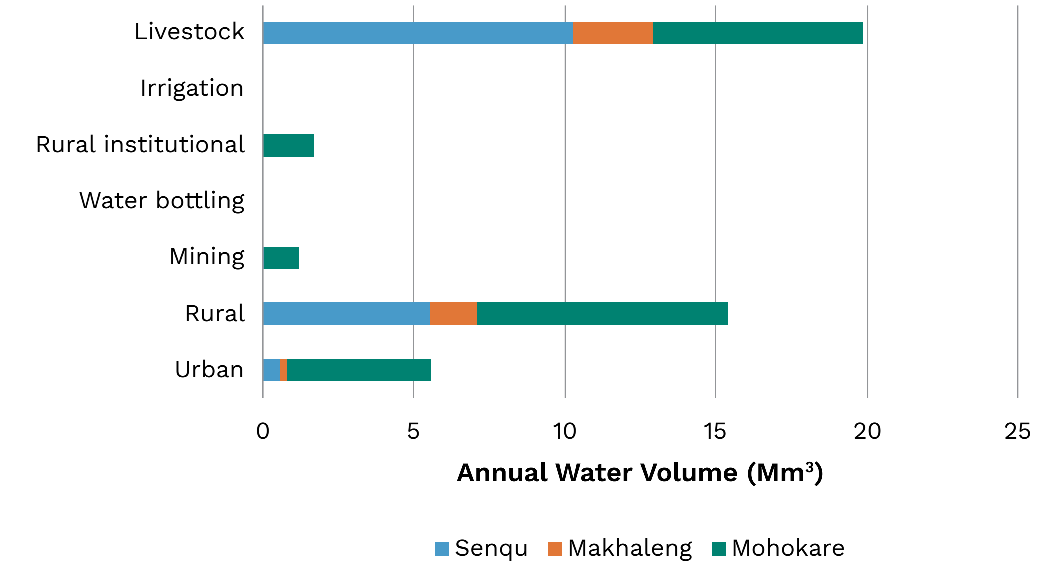
Lesotho is a country with a large rural population and some subsistence agriculture based on livestock. These characteristics are reflected in water usage geographically, illustrated in Figure 10, and economically in Figure 11.

The total water use in the country reflects these characteristics. The most abundant water use is for livestock, which is clearly rural based. Collectively this uses 45% of all water. The second major use, as illustrated in Figure 10, is in rural areas which adds a further 35%. Urban areas use 13% while a small amount of water is used by the mining industry and in "rural institutional". The second key characteristic illustrated in the figure is the importance of the Senqu catchment in rural areas and the Mohokare catchment for urban area, predominantly Maseru. The Makhaleng catchment is relatively unimportant in this national water use.

The water distribution illustrated in Figure 10 is given a different dimension in Figure 11, which looks at water usage from an economic perspective. Again, it is clear that agriculture is the main user of water of which livestock is the dominant user in this context and consumes 46% of water. This is followed by "non-revenue water" (16%) and that used by households (15%). Government institutions are the fourth most important users followed by textiles (7% each). All other economic sectors, including mining make up the small remaining balance.

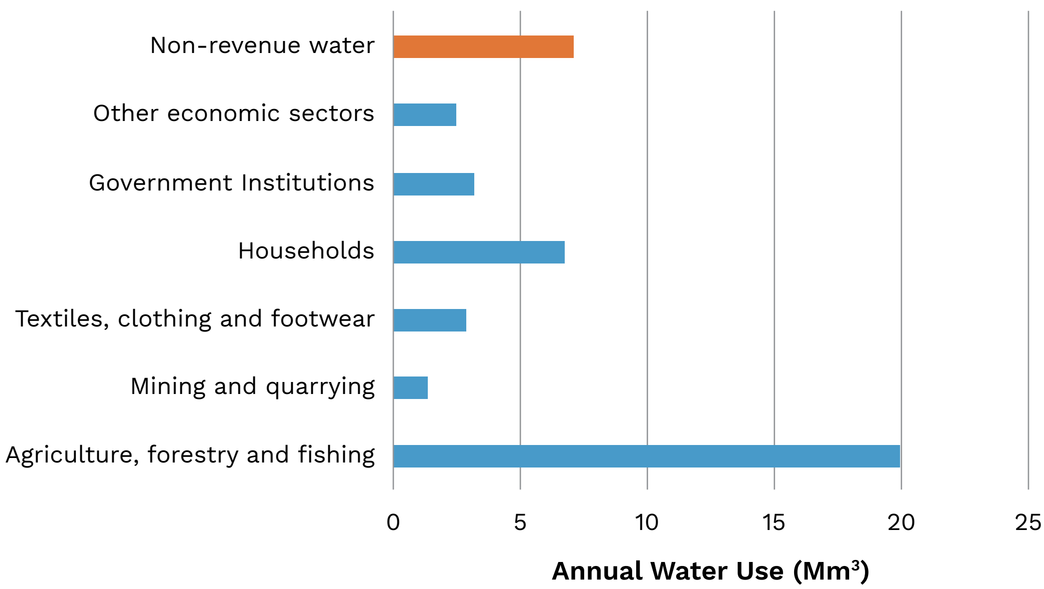
Non-revenue water is potable water for which no charge can be made. It is understood that this 'uncharged water' is the consequence of a variety of factors including other urban uses, water leakages and illegal connections.

Figure 10: Water Use in Lesotho



Source: (Lesotho Ministry of Water, 2018, p. 89)

Figure 11: Water Use – Economic



It would be understood that potable water is mostly confined to urban areas. This is illustrated in Figure 12 where urban water usage is predominantly in Maseru. This usage, excluding non-revenue water, makes up 79% of all possible water usage . Water usage in Maseru, except for non-revenue water, is distributed evenly between domestic and industrial use at 38% each.

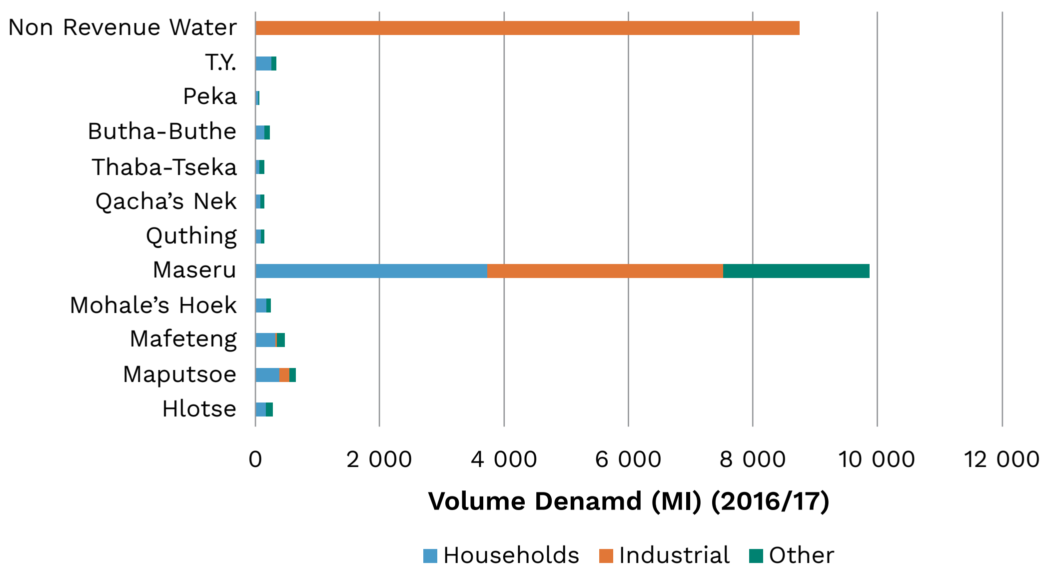
The most startling illustration in the diagram is the proportion of non-revenue water that makes up 41% of all potable water. This is clearly an issue of concern and probably needs to be addressed from a policy perspective. The issue of non-revenue water is not pursued further in this analysis

The analysis of water usage is shown at a more fine-grained level, purely for urban use, between the years 2014 and 2017. Urban water supply was 21 300 ML in 2017, the latest year for which information could be sourced. There has been some variation for years where information is available. Supply was 17 200 ML in 2014, increased to 22 500 ML in 2016 before declining to the usage in 2017. This is illustrated in Figure 13.

Household use of potable water, again with the exclusion of non-revenue water, is the major water user averaging in the region of between 26 and 30%. There was an exceptional increase in 2015 where this increased to 47%. Industry tends to use in the region of 16% to 19% of potable water and “other” uses less than 20%.

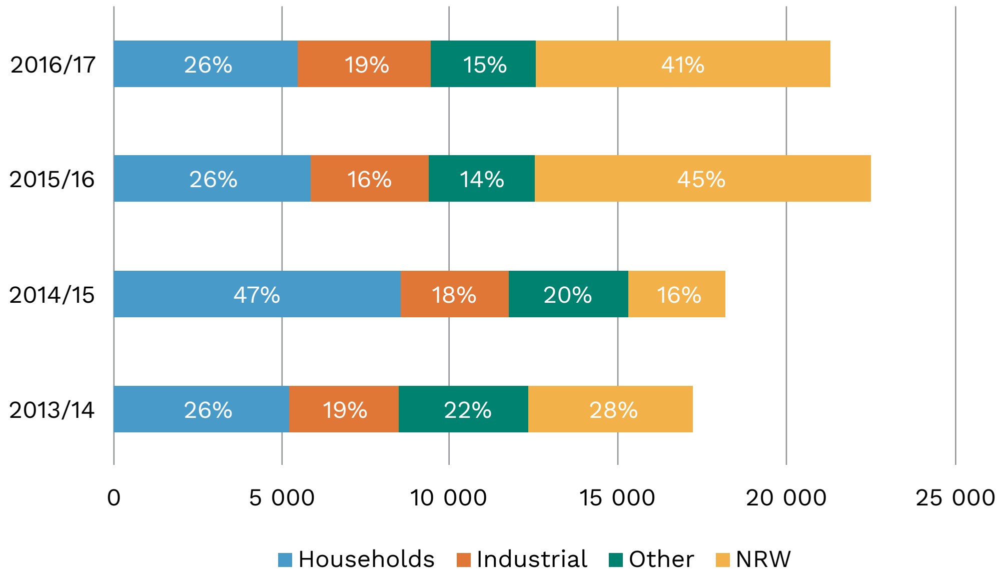
The limited time series on information on water usage makes it difficult to draw any firm conclusions. Again, the issue of non-revenue water is clearly evident, and arguably a matter of concern.

Figure 12: Urban Water Usage – Geographic Distribution



Source: (Lesotho Ministry of Water, 2018, pp. 61, 62)

Figure 13: Potable Water Urban Usage



Source: Calculated from State of Water Resources Table 5-4 and 5-4 (Lesotho Ministry of Water, 2018, pp. 61, 62). Data excludes Mokhotlong, Roma, Morija, Semonkong and Mapoteng

Table 1: Household Water Access

	Piped Water				Other Improved Sources	Unimproved Sources
	Into Dwelling	Into Yard	Into Neighbour	Public Tap		
Area						
Urban	6.2%	64.7%	9.7%	13.3%	4.3%	1.7%
Rural	0.6%	7.6%	2.3%	57.9%	15.4%	16.3%
Wealth Index Quintile						
Poorest	0.0%	0.1%	1.0%	54.6%	16.4%	27.8%
Second	0.0%	2.8%	6.9%	62.8%	13.7%	13.9%
Middle	0.0%	19.0%	7.6%	51.1%	14.0%	8.4%
Fourth	0.3%	47.3%	7.2%	31.5%	8.6%	5.1%
Richest	12.5%	71.0%	2.0%	9.6%	4.3%	0.5%
Total	**2.6%**	**28.0%**	**4.9%**	**41.9%**	**11.4%**	**11.2%**

Source (Bureau of Statistics, 2019, p. 202)

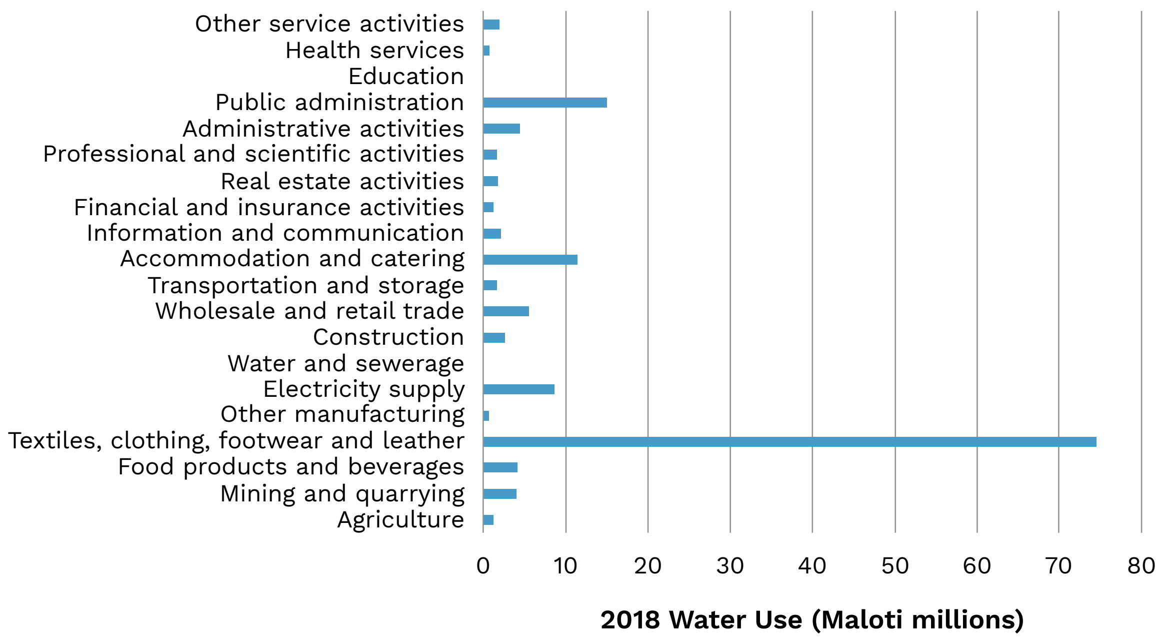
There is always concern that people have access to water. The available information shows that while more than three-quarters of households across the country have access to piped water, less than 3% have water piped into their dwelling. This is reported in Table 1. A further 28% have water piped into their yard. By far the majority need to use public taps. These proportions vary substantially between urban and rural areas and by wealth.

Over 90% of urban households have access to piped water, although only 6% receive this water in their dwellings. In rural areas this proportion drops to two-thirds of households having access to piped water. Over 95% of the richest quintile of households have access to piped water, compared to slightly more than half of the poorest households. Over 80% of the richest quintile have water piped either into their dwelling or onto their yard. None of the poorest households have this luxury and most of them must make use of a public tap if such piped water exists.

The focus of the discussion narrows onto industrial use which, as illustrated above, is in the region of 15% to 20% of all potable water usage. This distribution is illustrated in Figure 14. In most economies the largest sectors tend to be the "wholesale and retail trade", the financial sector and public administration. Textiles and clothing are also important in Lesotho. The approach to determining the amounts indicated in the figure is provided in Appendix A.

From an economic perspective the productive sectors are the most important because public administration and trade rely on the income generated by the productive sectors. In the case of Lesotho these are clearly textiles and clothing, mining, electricity supply, food and beverage products and agriculture. In the latter it is only potable water that is illustrated for agriculture. It was shown above that non potable water has a far larger use in farming and the rearing of livestock. The textile industry is dependent on 52% percent of all potable water, electricity supply 6%, mining 3% and food and beverage products also 3%.

Figure 14: Potable Water Use - Economic



2.4.1.2 Future Capacity

Lesotho is clearly a country with abundant rainfall relative to both its population and the economic use of water. The same appears to be true of future projections. Some brief comments are made here on these future projections. These projections are made for both proportionate water usage for the three important catchments and total water usage.

The projected water usage in Lesotho from the three major catchments is illustrated in Figure 15. The figure illustrates local usage relative to catchment capacity (Lesotho Ministry of Water, 2018, p. 89). The Senqu catchment, which also supplies the LHWP, has been netted out so that it only illustrates local water usage from this catchment. The projected local water usage, based on the growth rates over the last three years, from all three important catchments up to the year 2030 is negligible. The largest water draw is expected to be from the Mohokare catchment where the draw starts at 2.7% in 2021 and increases to 3.2% by 2030. The draw from the Makhaleng catchment is little different in 2021 and is expected to rise to 3.1% by 2030. The lowest draw of water, excluding the LHWP transfers, is from the Senqu catchment. These draws are currently 0.4% and are expected to rise to 0.5% by 2030.

The proportions presented in Figure 15 are based on the latest available information, which is catchment yields for 2016/17. This was a year of average rainfall. A different perspective is presented in Figure 16, which shows the local usage compared to the catchment yield in 2015/16, the driest year for which these statistics could be obtained (Lesotho Ministry of Water, 2018, p. 89). Anticipated usage is still expected at less than 14% of catchment yield. There would be water usage between 12% and 14% in Makhaleng, between 8% and 10% and 1.2% and 1.4% in Mohokare and Senqu respectively.

The most obvious conclusion from these observations is that there is no cause for concern about water supply for domestic use in Lesotho.

Figure 15: Projected Lesotho Water Use and Capacity (base data 2016/17)

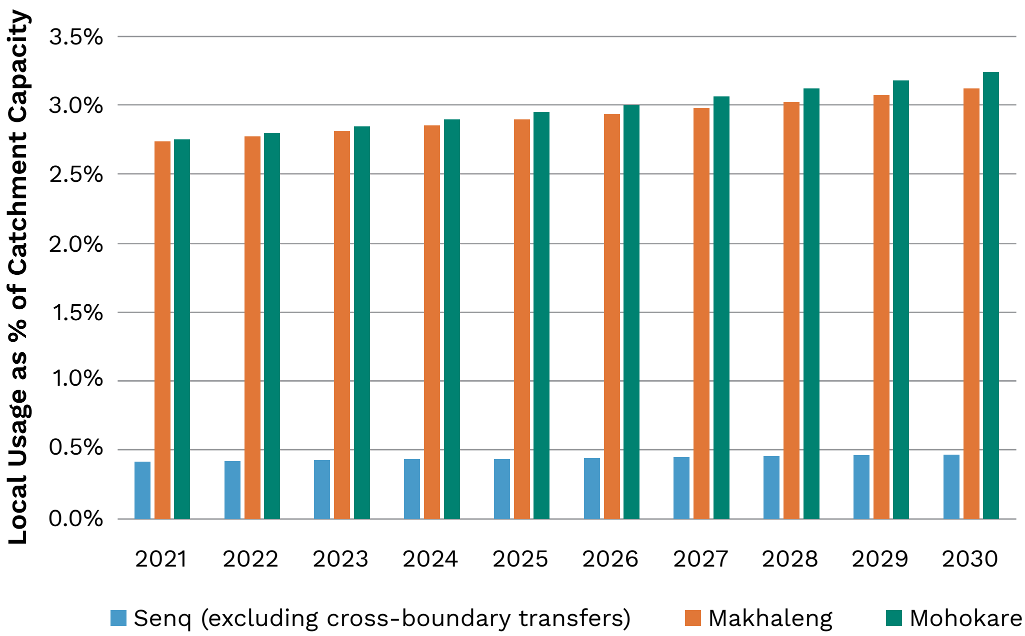
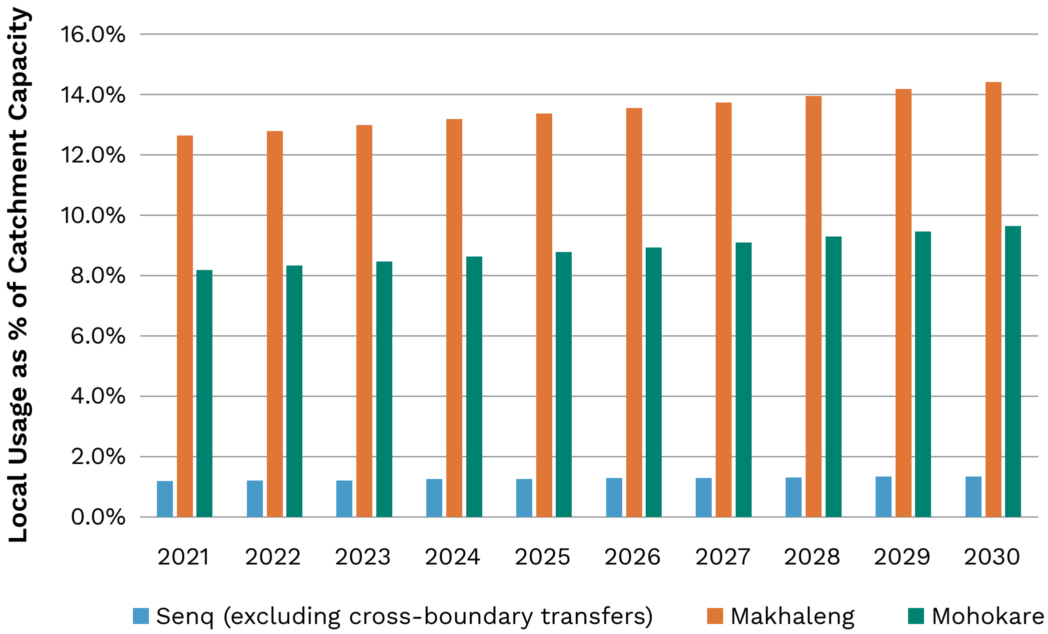


Figure 16: Projected Lesotho Water Use and Capacity Proportions (base data 2015/16)



2.4.2 LHWP

The Lesotho Highlands Water Project is of major importance because of the money it makes and ultimately its contribution to the economy. Lesotho is bound to transfer 780 million cubic meters annually to South Africa (Lesotho Ministry of Water, 2018, p. 76). The relative proportions of this treaty volume compared to local usage are illustrated in Figure 17 for the years 2012 to 2017. The conclusions are obvious and striking. Water usage in Lesotho pales in comparison to cross-border water volumes. In 2012 local usage was 4% and by 2017 had increased to 6% of cross-border transfers.

The LHWP delivered nearly 16 000Mm³ of water between January 1998 and May 2020 and was paid M405.1bn. Deliveries averaged 783.7 Mm³ between 2011 and 2019 with a low of 723Mm³ in 2011 and a high of 876 Mm³ the following year[3]. By 2019 payments had increased to M937.5m. There was a 10% average increase in royalties between 2011 and 2019. This is an increase in real revenue because it exceeds the South African inflation rate of 4.5% and the Lesotho rate of approximately 5%.

Lesotho generates electricity from the LHWP. Most of this is used locally and the rest sold to South Africa. The detail is reported in Table 3. Planned generation is close to 500GWhr. There was under generation in 2011 and 2013, and over generation in 2014, 2015, 2016 and 2018. On average, 507GWhrs was produced between 2011 and 2019 and earned M506m in Lesotho and M15m from South Africa.

Figure 17: National and Cross-border Water Usage

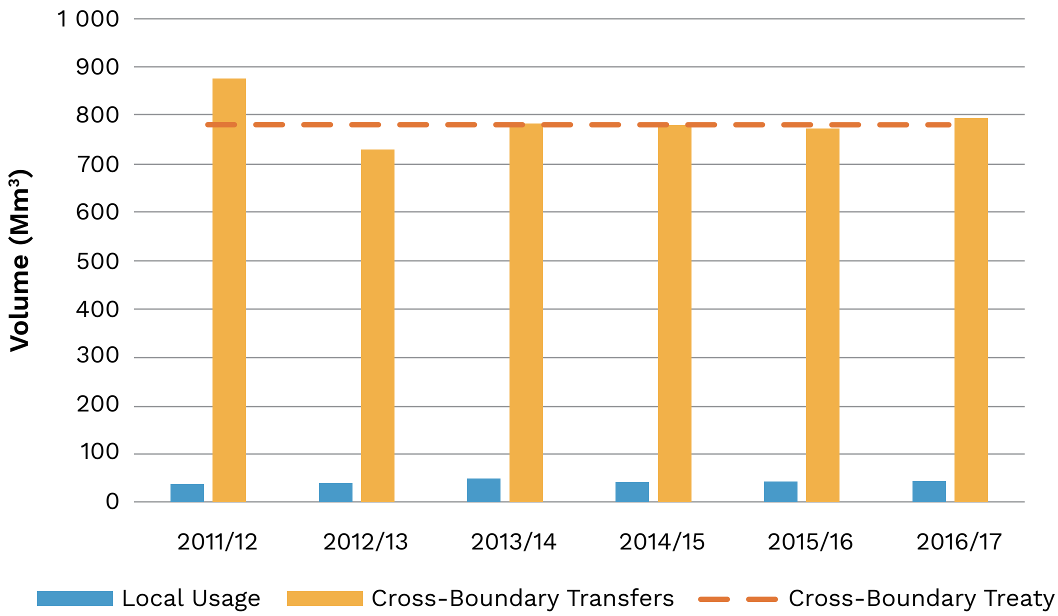


Table 2: Water Transfer Volume

Year	Water Transfer (Mm^3)		& Variation	Actual Royalties (M million)
	Planned Deliveries	Actual Deliveries		
2010/11	780	723	–7.3%	437.2
2011/12	780	876	12.3%	614.7
2012/13	780	730	–6.4%	630.7
2013/14	780	783	0.4%	733.9
2014/15	780	780.1	0.0%	735.9
2015/16	780	779.9	0.0%	736.9
2016/17	780	794.005	1.8%	861.8
2017/18	780	810	3.8%	942.5
2018/19	780	777.7	–0.3%	937.5

Source: Various LHDA Annual Reports (2013, p. 9), (2015, p. 25) & (2019, p. 29)

Table 3: Electricity Generation

Year	Generation (GWhr)		& Variation	Actual Value (M million)	% Export of Total Annual Production	Export Value (M million)
	Planned Deliveries	Actual Deliveries				
2010/11	509	460	–9.6%	55.6	1.2%	0.74
2011/12	507	549	8.3%	54.9	8.3%	7.75
2012/13	490	461	–5.9%	50.1	3.0%	2.71
2013/14	502	517	3.0%	56.7	0.3%	0.36
2014/15	502	518.9	3.4%	54.86	1.2%	0.66
2015/16	502	530.7	5.7%	60.6	0.8%	1.10
2016/17	500	508	1.6%	57.29	1.4%	0.80
2017/18	500	520.1	4.0%	60.04	0.8%	0.50
2018/19	500	496.5	–0.7%	56.3	0.4%	0.60

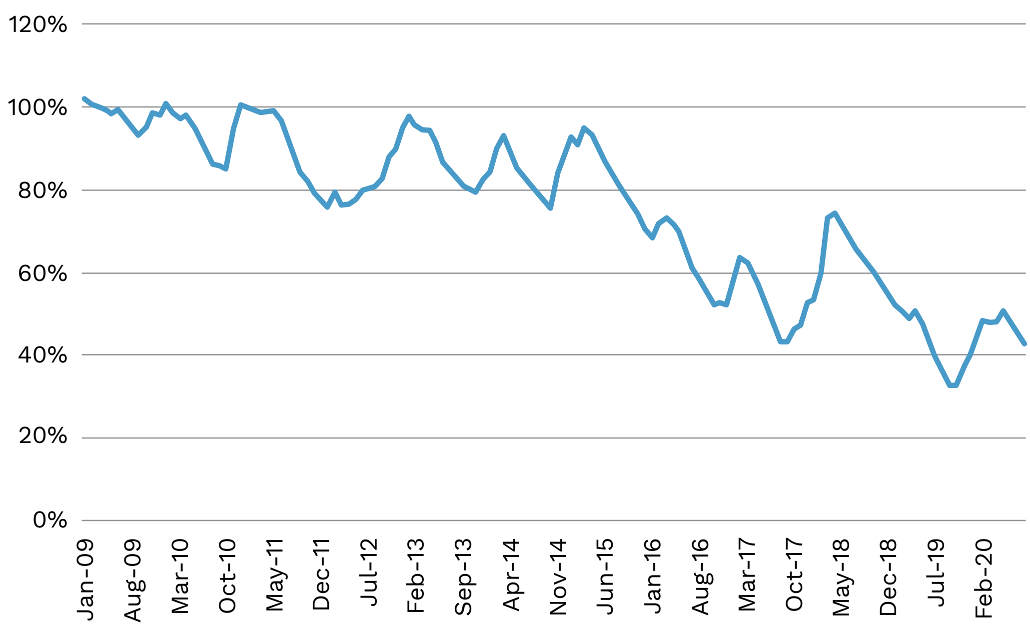
Source: Various LHDA Annual Reports (2013, p. 9), (2015, p. 25) & (2019, p. 29)

2.5 Dam Levels

The Metolong dam, which supplies Maseru (and urban areas from Teyateyaneng to Morija) is a key part of the Lesotho Lowlands Water Scheme (LLWS). This dam was completed in 2016 and reached full capacity in 2018. Stakeholders felt this dam has the capacity to supply water for three years without any rainfall.

The Katse Dam, as shown in Figure 18, was largely full until 2015, albeit with notable dips. There has been a steady decline in water levels in this dam over the last five years, despite the ample rainfall in 2016 and 2017. **The dam was at 22% capacity on 15 November 2020.**

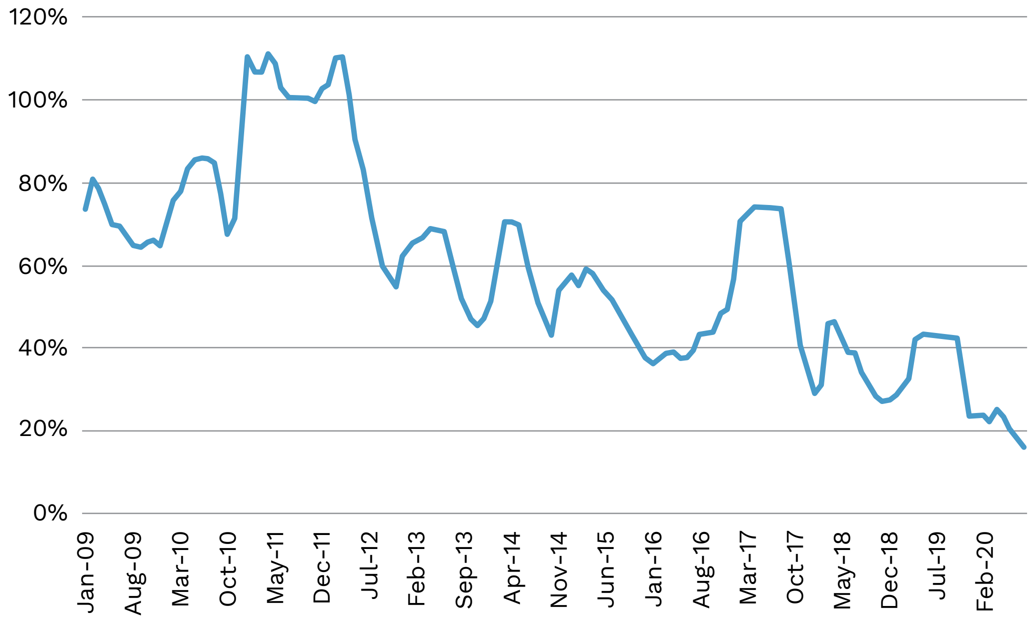
Figure 18: Katse Dam Levels



Source: Data provided by Lesotho Highlands Development Authority (email dated 2020 09 30)

The Mohale Dam reached 100% capacity in 2011 and early in 2012, which was the last time it was full. It was at 70% in 2017, despite the good rains in that year. This downward trend continued into 2020. **It was, by 15 November 2020, at less than 3% capacity.**

Figure 19: Mohale Dam Levels



Source: Data provided by Lesotho Highlands Development Authority (email dated 2020 09 30)

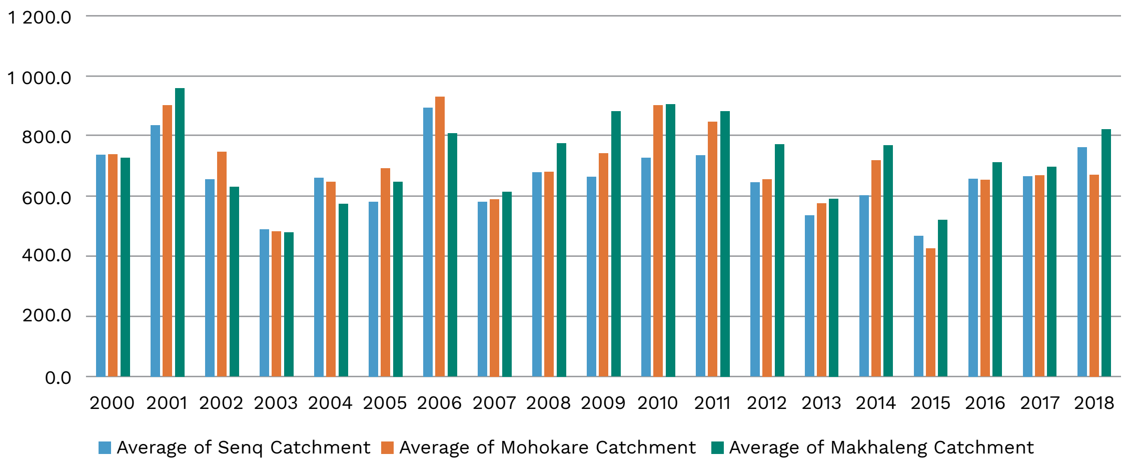
Many reasons could account for these changes and can be grouped into four categories – water related, dam and system integrity, evapotranspiration, and natural causes in the form of climate change and ecosystem damage. The first three are discussed below and the latter in Section 4.

It is expected that there would be a direct correlation between rainfall and water volume in storage dams. Evidence since 2012 shows that this has not been the case for either the Katse or Mohale Dams. Annual rainfall in the main catchments is shown in Figure 20. The annual rainfall fluctuation in the three catchments is little different to that found using the dispersed rainfall stations discussed above. As before, the lowest rainfall occurred in 2003 and 2015. The evidence does not indicate any obvious long-term rainfall changes.

Lesotho generates electricity from the LHWP. Most of this is used locally and the rest sold to South Africa. The detail is reported in Table 3. Planned generation is close to 500GWhr. There was under generation in 2011 and 2013, and over generation in 2014, 2015, 2016 and 2018. On average, 507GWhrs was produced between 2011 and 2019 and earned M506m in Lesotho and M15m from South Africa.

The monthly rainfall from six weather stations close to the Katse and Mohale dams in the Senqu catchment is illustrated in Figure 21 for 2000 to 2019. A simple visual impression, despite incomplete information, suggests that there has been little long-term change in rainfall at these six weather stations.

Figure 20: Annual Rainfall – Three Catchments



Source: Calculated from information supplied by the Lesotho Meteorological Services

Figure 21: Monthly Rainfall - Senqu Catchment (close to Katse and Mohale Dams) 2000 - 2019

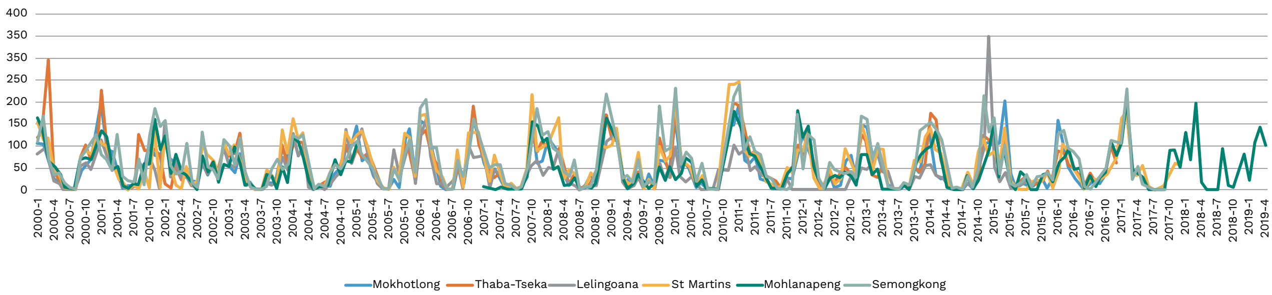


Figure 22: Annual Rainfall - Mohlanapeng Weather Station - Senqu Catchment 2000 to 2019

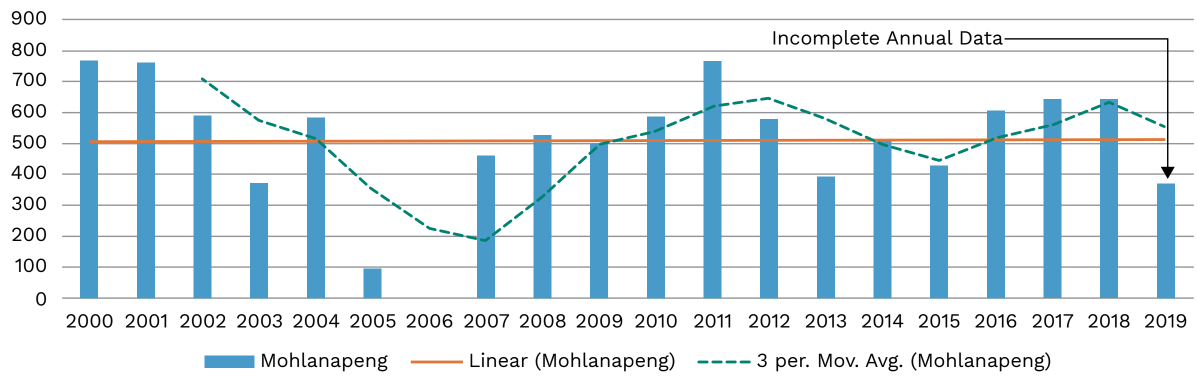


Figure 23: Annual Rainfall - St Martins Weather Station - Senqu Catchment 2000 to 2017

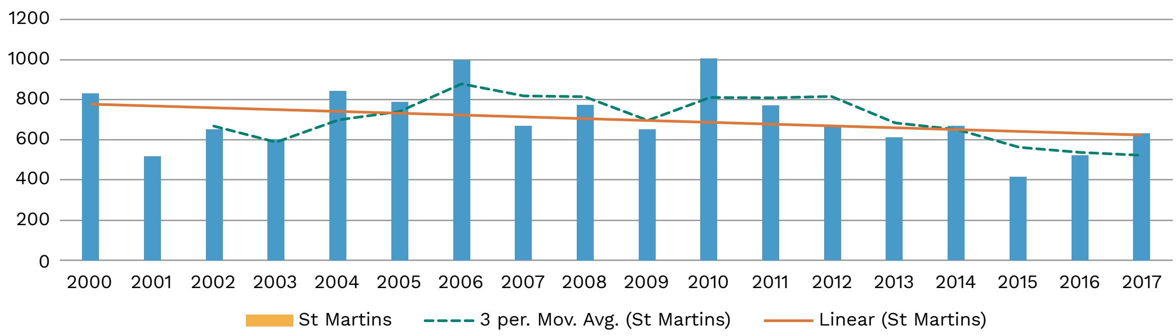
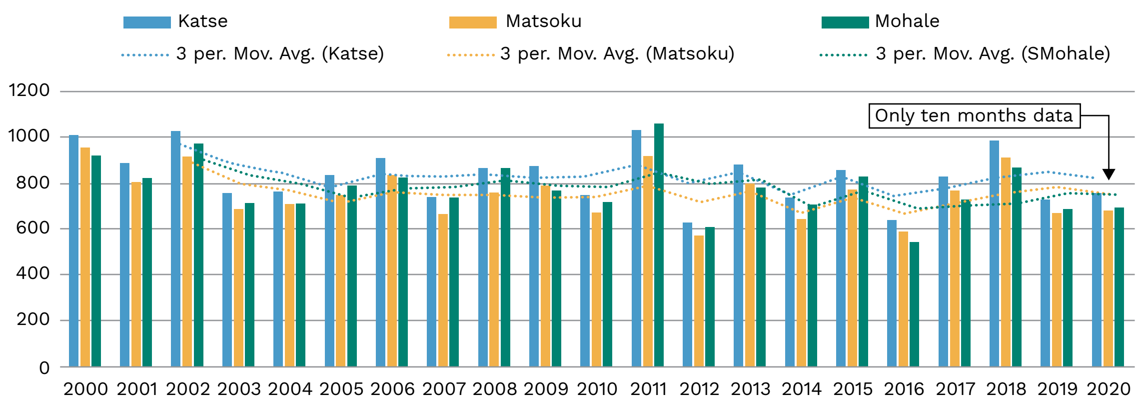


Figure 24: Annual Rainfall in the Katse, Motsuko and Mohale Catchments (CHIRPS Data)



A more detailed analysis was made for two stations close to the relevant dams for which information is available. These are Mohlanapeng, shown in Figure 22, and St Martins in Figure 23. Mohlanapeng had data up to April 2019 (the longest dataset of the Senqu catchment stations) and St Martins, the closest station to the Katse and Mohale dams, data to 2017.

Three types of information are given for the Mohlanapeng and St Martins weather stations. The first is the annual rainfall (blue and yellow columns). The second is a long-term linear regression trend. The third is a three-year moving average. Mohlanapeng data is incomplete with missing data for 2005, 2006 and partially for 2019. St Martins data is only available to 2017. Clearly, for both rain stations, there have been fluctuations in annual rainfall. The moving average suggests that this is a random walk with no discernible trend. Conversely, the linear regression line shows that there has been a marginal increase in rainfall in Mohlanapeng and a marginal decrease in Saint Martins.

Monthly precipitation data was provided after the submission of the draft report from CHIRPS for 1982 for the Katse, Matsoku and Mohale catchments. The CHIRPS data uses satellite-based estimates of precipitation and corrected by actual on-the-ground data where available. A brief analysis is provided here. There has been an overall downward trend in volumes for the three catchments. There has also been a change in the seasonality of the rainfall. However, this trend is not as clear when focussing on the period 2000 to 2020, which is illustrated in Figure 24 for the three catchments. The reason for focussing on this period and not the full dataset from 1982 is that the LHWP reservoirs filled up between 2000 and 2012 but reduced thereafter. If precipitation is the reason for the lower levels after 2012 then there should be observable differences in precipitation volumes in the period 2000 to 2015 and 2015 to 2020. The three-year moving average for annual precipitation levels for two of the catchments, Katse and Matsoku, indicate that there is no discernible difference in precipitation levels. For the Mohale catchment there is a difference in the three-year moving average before 2015 and after 2015. However, it is unclear that this reduction in precipitation volumes would result in the alarming drops observed in the Mohale Dam.

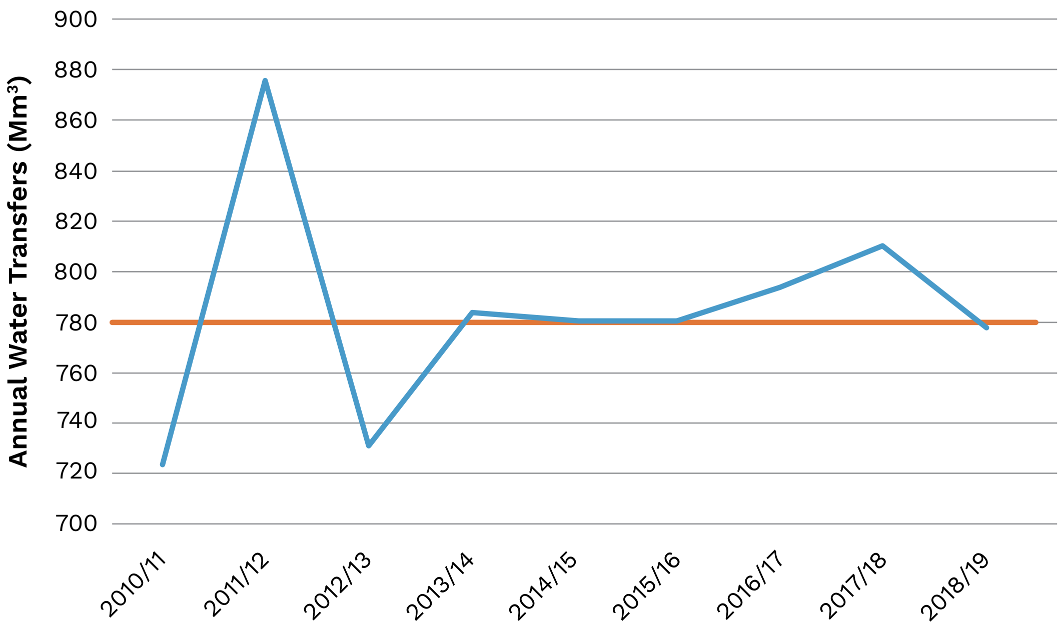
Table 4: Monthly Precipitation Volumes (mm)

	Catchment		
	Katse	Matsoku	Mohale
2000 to 2015	69.0	62.2	64.9
2015 to 2020	68.7	62.9	62.4
Difference	-0.3	0.8	-2.6

The monthly average precipitation volumes of the three catchments are shown in Table 4, for the period 2000 to 2015 and then 2015 to 2020. The difference in average monthly volumes for the two periods indicates that there is almost no difference for Katse, with only a 0.3mm reduction. In Matsoku the period from 2015 to 2020 was marginally wetter with a 0.8mm increase in precipitation. The reduction in monthly precipitation was highest in Mohale, with 2.6mm less.

The second possible cause is a water outflow from the storage dams. These are illustrated in Figure 25 with the detail given in Table 2 for 2011 and 2019. The contractual target of 780 million cubic meters is also shown. There clearly have been some variations in outflows. Outflows were above target in only 2012 and 2010 and below in 2013. These, arguably, are insufficient to account for the falling water levels starting in 2015.

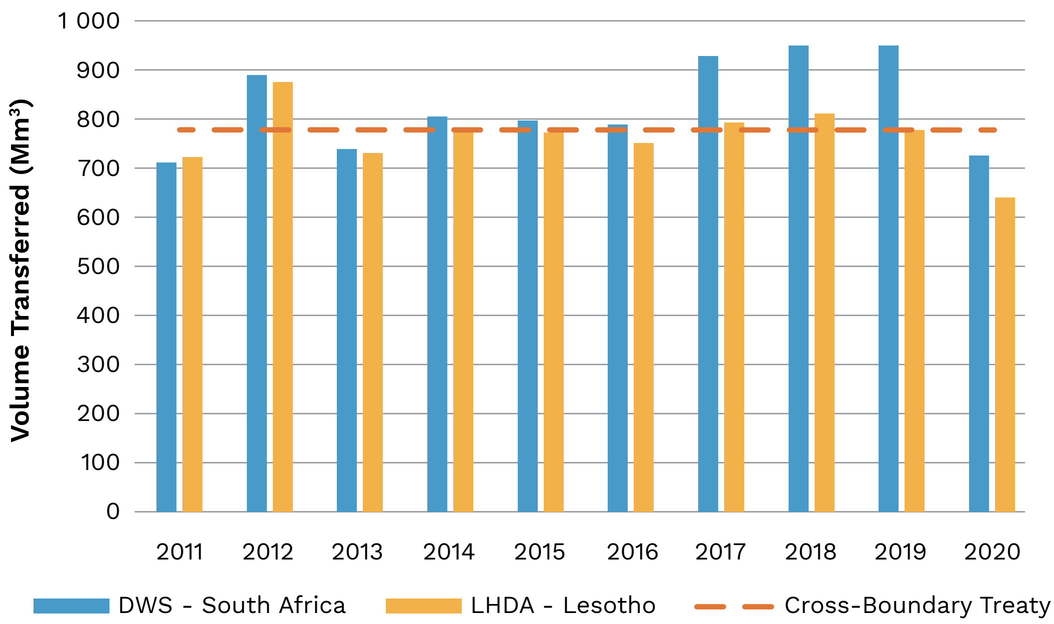
Figure 25: Actual and Planned Annual Water Transfers



Source: (Lesotho Highlands Development Authority, 2013, p. 9), (Lesotho Highlands Development Authority, 2015, p. 25) and (Lesotho Highlands Development Authority, 2019, p. 29).

Additional data was provided after the submission of the draft report[1]. This data is sourced through the DWS data portal for volumes of water abstracted from the LHWP. This data contrasts with that provided by the LHDA and is shown in Figure 26. Between 2011 and 2016 the data compares well but major discrepancies exist from 2017 onwards. The LHDA data compares very well with the treaty level but that from the DWS exceeds this level in each of 2017, 2018 and 2019. The DWS data indicates that in those three years alone transfers collectively exceeded the treaty requirement by 463Mm³. This is a staggering 60% of one year's volume of transfers and could explain the declining levels of the LHWP dams. It is unclear why this discrepancy exists and which is the more accurate data set but clearly needs further investigation.

Figure 26: Comparison of Cross-Border Transfers



Source: LHDA (http://www.lhda.org.ls/lhdaweb/Uploads/documents/royalties/Water%20Royalties.pdf) and DWS (https://www.dws.gov.za/Hydrology/Verified/HyDataSets.aspx?Station=C8H036)

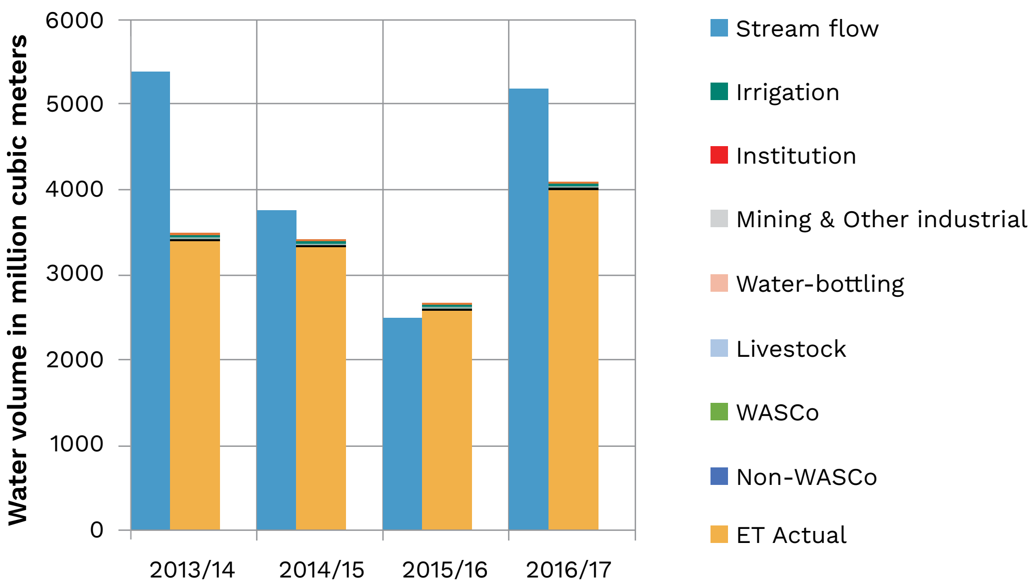
A third possible cause is that the integrity of the dam or the water system has been compromised. Stakeholders identified the silting of the Matsoku Diversion Weir. The Matsoku Diversion Weir and tunnel were constructed and commissioned as part of Phase IB in 2002 to divert some water from the Matsoku River to Katse Dam, on the Malibamatso River. The Matsoku River joins with the Malibamatso River downstream of the Katse Dam. The annual expected diverted yield from the weir to Katse Dam is approximately 73 Mm³/year out of the system yield of 780 Mm³/year. This is 9% of the system yield. This silting is shown in Figure 27.

1 Data from DWS provided by Project Steering Committee on 14 December 2020 for the Ash River Outfall (Tunnel Outlet from Katse) - https://www.dws.gov.za/Hydrology/Verified/HyDataSets.aspx?Station=C8H036.

Figure 27: Matsoku Diversion Weir Siltation – May 2020[2]

A fourth possible explanation is rising evapotranspiration which would be evidenced by falling stream flow relative to rainfall and shown in Figure 28 for 2014 to 2017, the only years with data. As can be expected stream flow reflects the variations in rainfall shown in Figure 3 and Figure 4. The extent of water evapotranspiration is labelled as ET actual[3]. It is clear that stream flows exceeded evapotranspiration in three of the four years suggesting that this is not a likely cause, at least between 2014 and 2017.

Figure 28: Stream Flow, Losses and Consumption



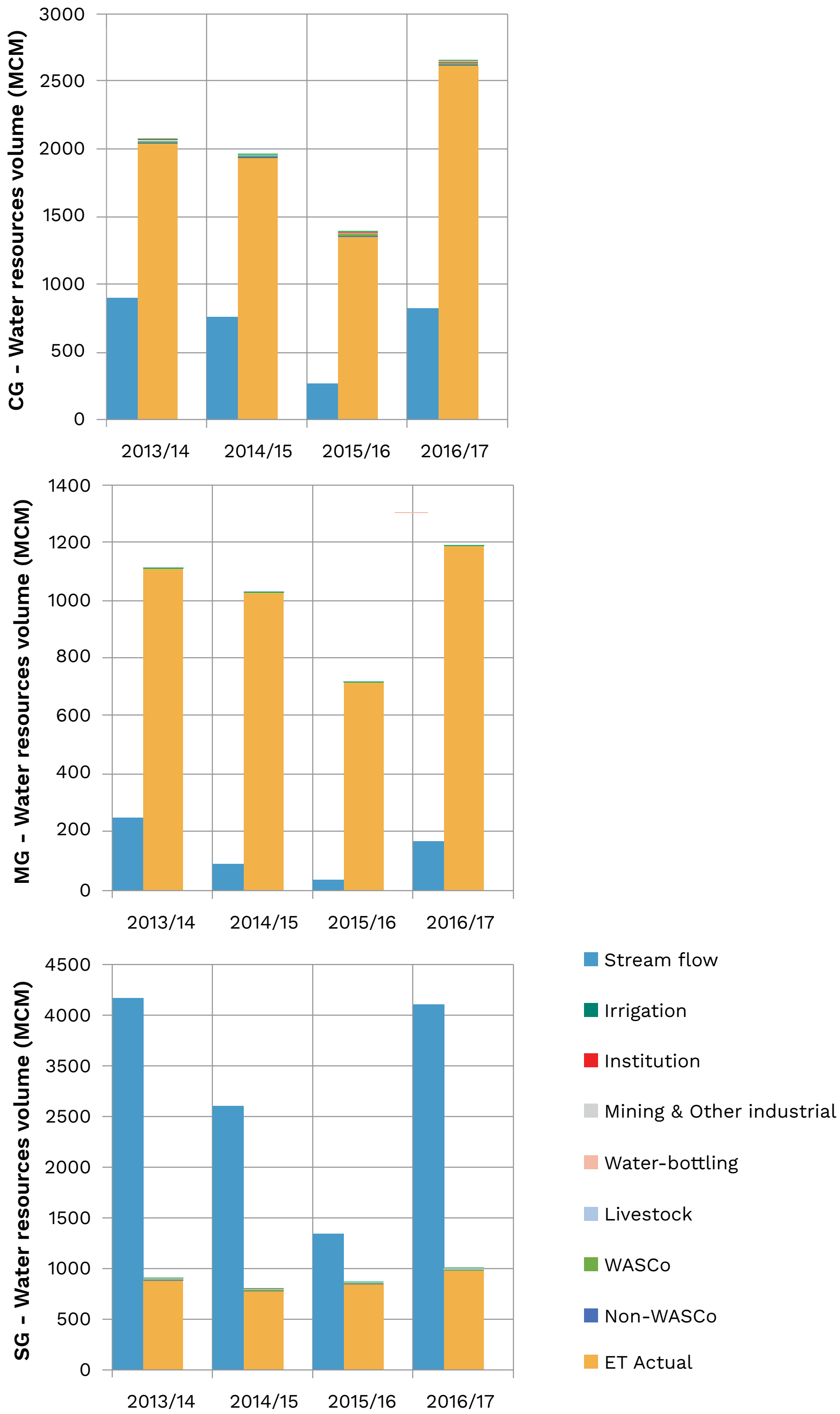
Source: *State of Water Resources Figure 6-3* (Lesotho Ministry of Water, 2018, p. 85)

The position is different for individual catchments. It is clear that there is ample water in the Senqu catchment with streamflow well in excess of evapotranspiration. This is not the case in the Mohokare and Makhaleng catchments.

The figures indicate that significant amounts of catchment waters are lost through evapotranspiration.

2 Photo supplied by LHDA to Ian Midgley of Eskom.
3 Evapotranspiration is a term used to describe the transfer of water from land to the air by evaporation and plant transpiration.

Figure 29: Water Balance by Main Catchment



Source: State of Water Resources Figure 6-5 (Lesotho Ministry of Water, 2018, p. 87)

CHAPTER 3

Economic Implications

Water is important. It is important for people and it is important economically. Not only is this true within Lesotho but the country also relies economically on the revenues that are generated from the cross-border transfers and the associated sale of electricity. It was shown above that there are unexplained water level drops in the dams that supply the LHWP. These trends have been noted for several years and appear ongoing. This has serious implications for Lesotho, on the one hand, and for the industrial heartland of South Africa on the other.

From an analytical perspective the simplest illustration of the financial and economic consequences is to model the situation where the dam levels fall to such an extent that there can be no cross-border transfers. In this case all financial related contributions in Lesotho would cease and the Vaal River economies would have to rely purely on water from South Africa. This position is possibly too extreme and too dramatic. Therefore, the modelling has been undertaken for a 25% and 50% reduction in water availability. It would not be justified to undertake extensive research, at this stage of the analysis, to fine tune this reduction. Practically there are too many variables to do such an analysis with any degree of certainty but can be done after more rigorous biophysical analysis.

This section describes the economic implications of water shortages for both countries. The methodology required to develop these implications is described in Appendix A.

3.1 Lesotho Fiscal and Economic Implications

LHWP revenues are illustrated in Figure 30 where the most immediate feature is importance of water revenues compared to electricity sales. On average electricity sales are 8% of total revenue. Total revenue, in nominal values, increased from M677m in 2012 to M938m by 2019. The increase was generally consistent although there was a small, unexpected increase in 2014 and between 2017 and 2018.

Some perspective is needed about the relative size of these revenues, which is shown in Figure 31. Water revenues, just like taxes, fund government expenditure. The total water revenues from the LHWP was equivalent to 14% of all taxes in 2019. Simply put, taxes would have to increase by 14% to ensure that government could continue to fund its social programs. An alternative perspective would be for government to keep taxes unchanged and reduce expenditure, either on education by over 40% or on health services by nearly 50%. These are remarkably large adjustments and clearly would have undesirable consequences.

An alternative but equally distressing comparison is to compare the water revenues to the overall size of the economy and jobs, illustrated in Figure 32. Water revenues are nearly 4% of the total size of the economy, measuring M1.3bn. Water revenues supported over 16 000 jobs in Lesotho in 2019 and would be lost if all LHWP revenues were to cease.

Figure 30: LHWP Water Royalties and Electricity Sales

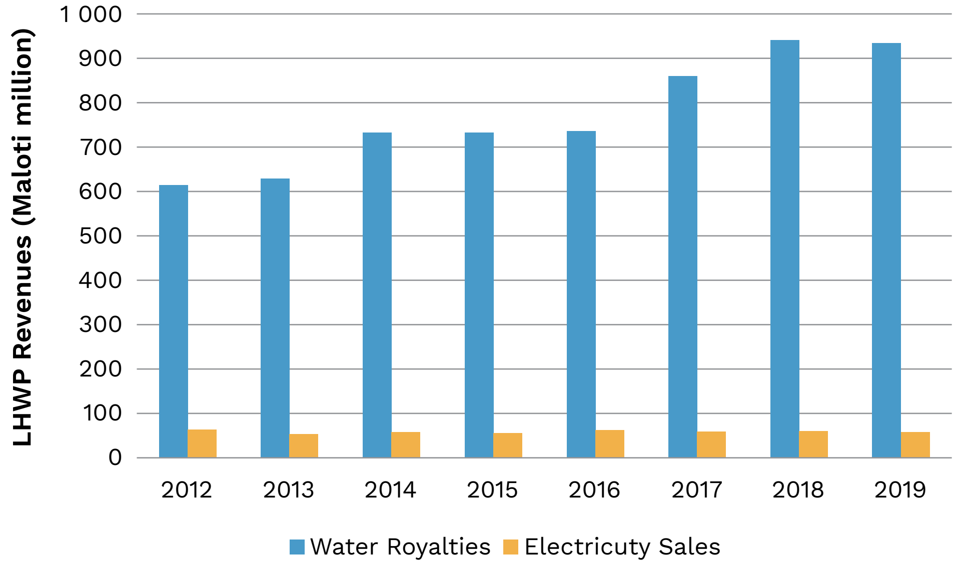


Figure 31: LHWP Revenues & Government

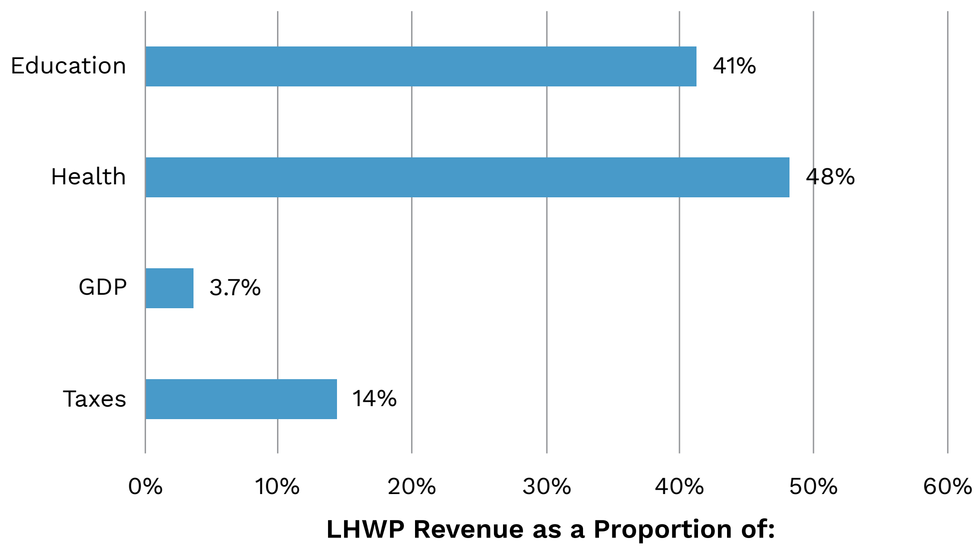
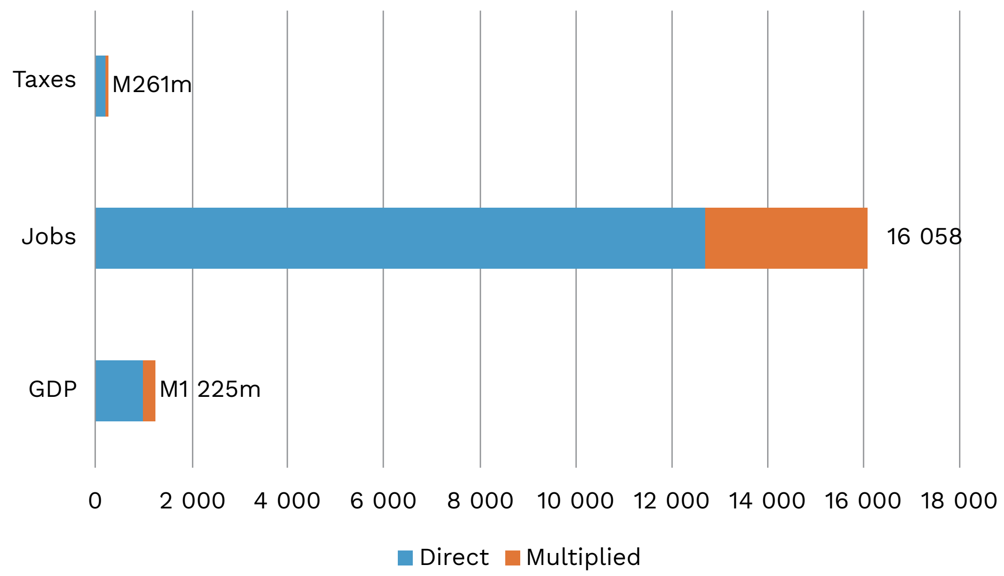


Figure 32: LHWP Revenues & Economy



3.2 South Africa Economic Implications

The impact on the South African economy is less clear cut because it is not clear what proportion of the integrated Vaal River system (IVRS) is supplied from Lesotho. The most authoritative stakeholder suggested this was between 60% and 70% at the point of abstraction from the Vaal River.

It is estimated that the annual usage of water from the IVRS is 2 200Mm³. This is based on the amount of water used by Rand Water (Rand Water, pp. 27, 189) and adding that used by Eskom (Eskom, p. 2) and SASOL (SASOL Limited, 2019, p. 96). The Department of Water and Sanitation (DWS) indicates a volume of between 2 900Mm³ and 3 100Mm³ in their scenario planning (Department Water & Sanitation, 2018, p. 311), or an implied average of 3 000Mm³. This means that the full volume of cross-border transfers could form between 26% (if annual usage is 3 000Mm³) and 35% (annual usage of 2 200 Mm³).

Table 5: Dams of the Integrated Vaal River System

Dam	River	FSC (Mm³)
Bloemhof Dam	Vaal	1 242.9
Grootdraai Dam	Vaal	349.5
Heyshope Dam	Assegaai	444.9
Jericho Dam	Mpama	59.3
Katse Dam	Malibamatso	1 519.1
Mohale Dam	Senqunyane	843.5
Morgenstond Dam	Ngwempisi	100.0
Nooitgeclacht Dam	Komati	78.3
Sterkfontein Dam	Nuwejaarspruit	2 616.9
Vaal Dam	Vaal	2 603.5
Vygeboom Dam	Koamti	78.0
Westoe Dam	Usutu	60.1
Woodstock Dam	Tugela	373.3
Zaaihoek Dam	Slang	184.3
Total		**10 553.6**

Source: (Rand Water, p. 157)

Dams, including the Katse and Mohale Dams, forming part of the Integrated Vaal River System (IVRS), are shown in Table 5.

The full supply capacity (FSC) of the LHWP dams forms 22% of the overall system. This is an analytical start point. The proportion would change without the:

- Vaal Dam where the LHWP dams become 30% of the system. The reason for excluding the Vaal Dam is because it is the main storage reservoir of water from all other dams.
- Sterkfontein and Bloemhof Dams where LHWP dams become 58% of the system. It is understood that the Sterkfontein Dam is only used when transfers from the LHWP need supplementing. The Bloemhof Dam could be excluded because it is well downstream of the Vaal Dam.

This means that the LHWP dams typically form between 22% and 60% of the IVRS system capacity and more if smaller, emergency dams are excluded.

Three different water shortage levels have been modelled. First is 17% which was used by the DWS and in the computable general equilibrium modelling (CGE) that was done by the Toulouse School of Economics for GIZ. It is half the LHWP transfers with an annual water usage from the IVRS of 2 200 Mm^3. Second is a shortage of 25% without LHWP water and the DWS estimated usage of 3 000Mm^3. Third is a 50% shortage based on stakeholder opinion that 60% of the IVRS water is from the LHWP but can be supplemented from the Sterkfontein Dam and Tugela scheme.

The results start by reporting the size and composition of the Vaal River system economy. This moves to an understanding of the water intensive sectors before reporting the expected economic impact. The total value of the economy of the Vaal River water system was in the region of R1.7bn in 2018. The largest sector was financial services (21%), followed by general government services (18%) and trade (12%), as illustrated in Figure 33.

It is shown in Figure 34 that the most water intensive sectors are trade, which spent R1.59bn on water in 2018, followed by financial services at R1.46bn, and mining and metal products at R836m.

An important metric in understanding water dependence is water expenditure relative to GDP and jobs. The GDP measure is illustrated in Figure 35. The mining industry emerges as a sector which is highly dependent on water. Here there is the need to spend R23 000 on water for each R1m contribution to GDP. This is followed by the food sector which requires R17 000, agriculture with R11 500 and metal products at just less than R10 000 for each R1m contribution to GDP.

This comparison moves to a focus on jobs, illustrated in Figure 36, with a measure of water expenditure per job. Mining again has the highest water reliance with R13 100 per job. Food and beverage is second at R9 000 and agriculture and metal products also being important.

The final and, most important output of this section is to indicate the economic damage which may occur because of water shortage. This is done for GDP and jobs and illustrated in Figure 37 and Figure 38.

The economic impact of a 17% reduction in water supply is likely to have a very moderate impact on the South African economy. GDP would contract by 0.2% and there would be a 0.3% job loss.

A 25% water shortage would see a sudden ratcheting up in the impact and GDP would decline by 2% and jobs by 3%.

A 50% water shortage, which guided by stakeholders could be the consequence of a sudden termination of water from Lesotho, would have a dramatic economic impact. GDP would decline by 7.5% and there would be over an 11% loss in jobs. This is a R129bn loss in GDP and 924 000 jobs.

Figure 33: Vaal River System Economy

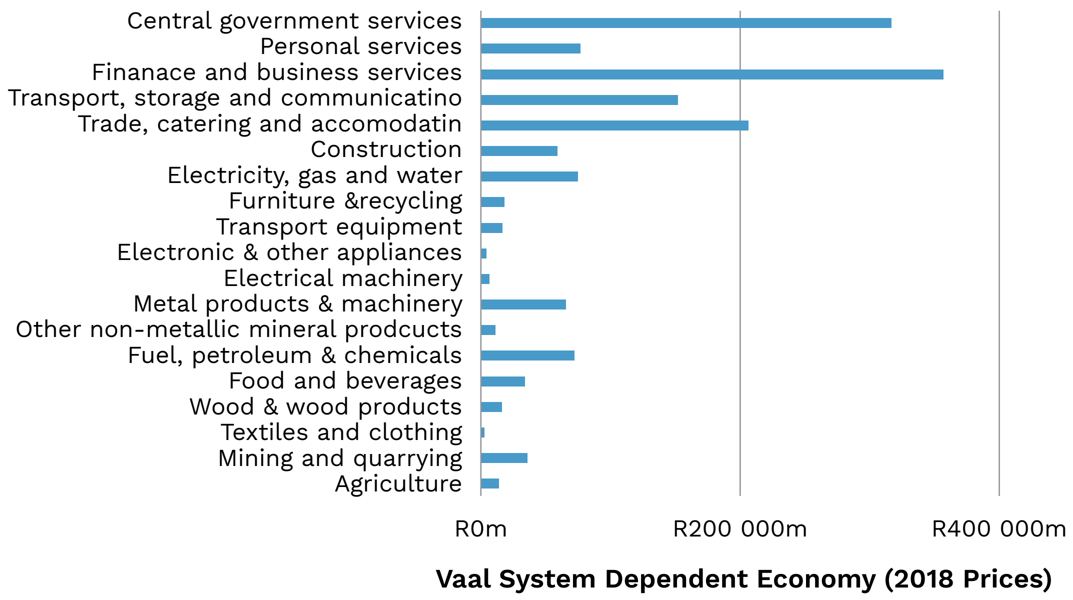


Figure 34: Vaal River System – Water Intensive Sectors – Absolute Expenditure

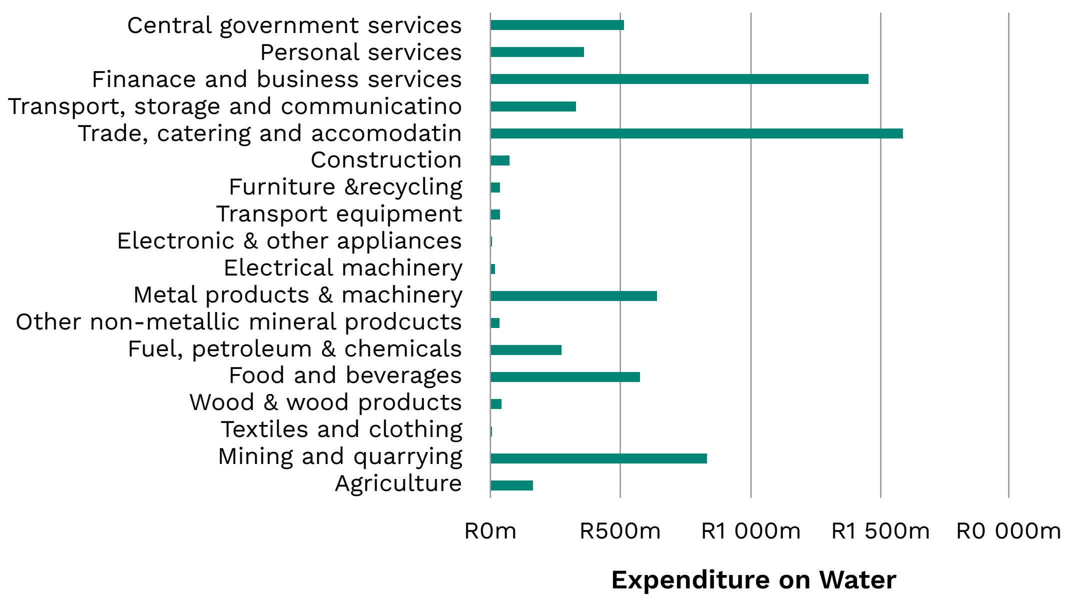


Figure 35: Vaal River System – Water Expenditure per R1m GDP

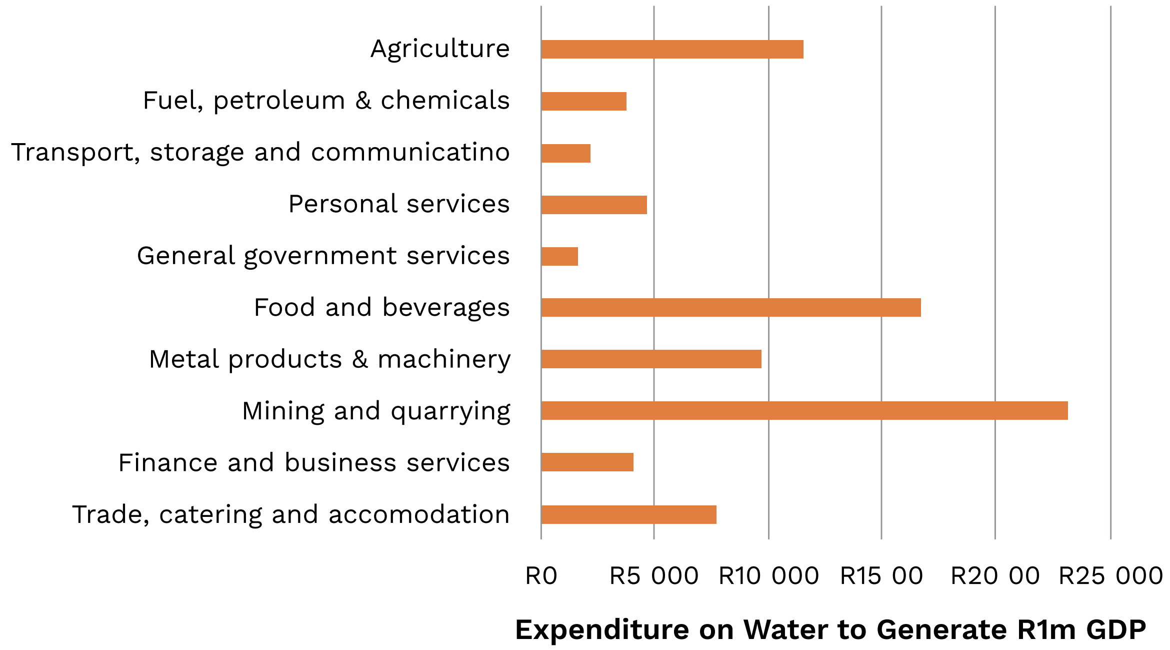


Figure 36: Vaal River System – Water Expenditure per Job

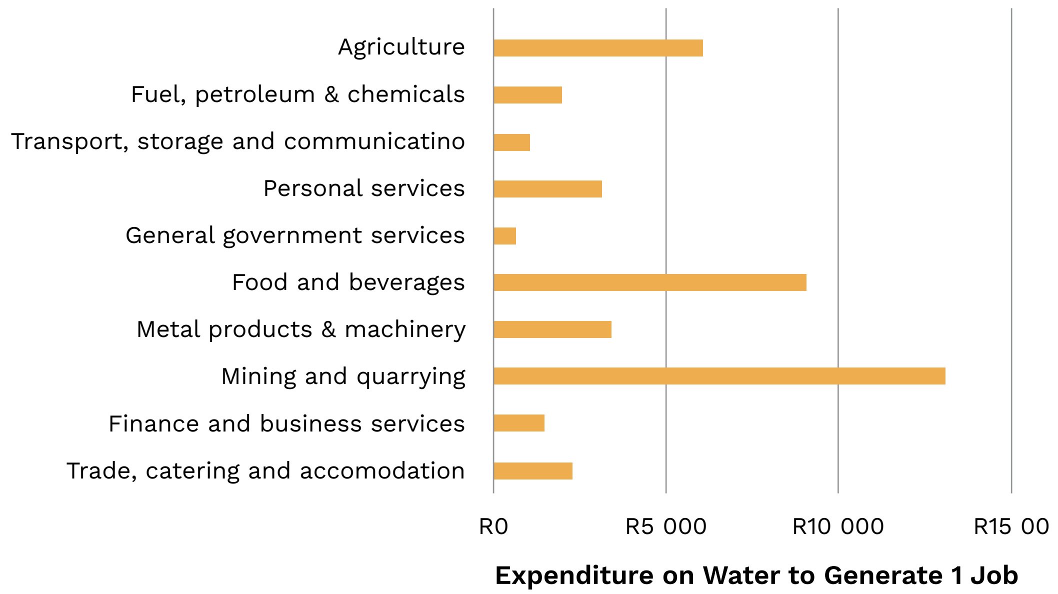


Figure 37: Vaal River System – GDP Loss

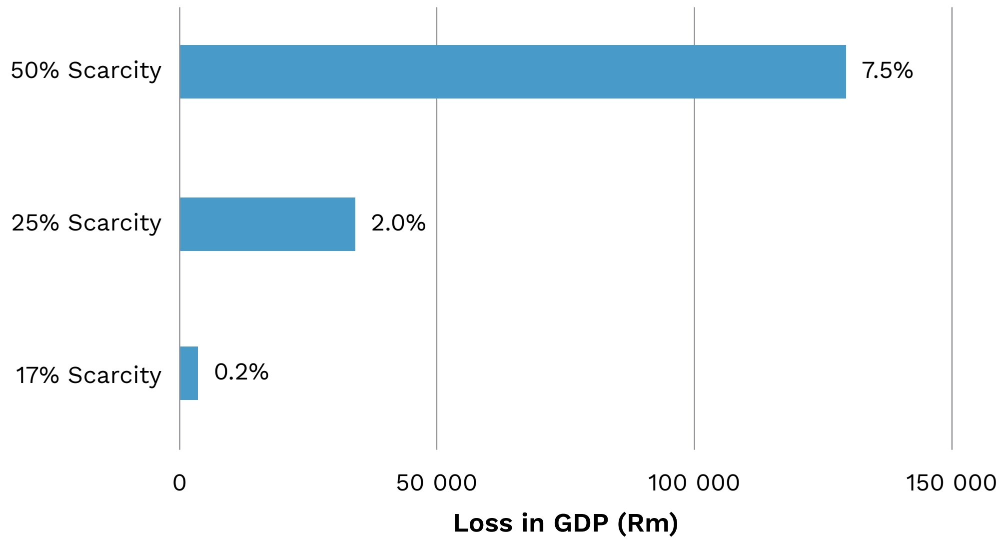
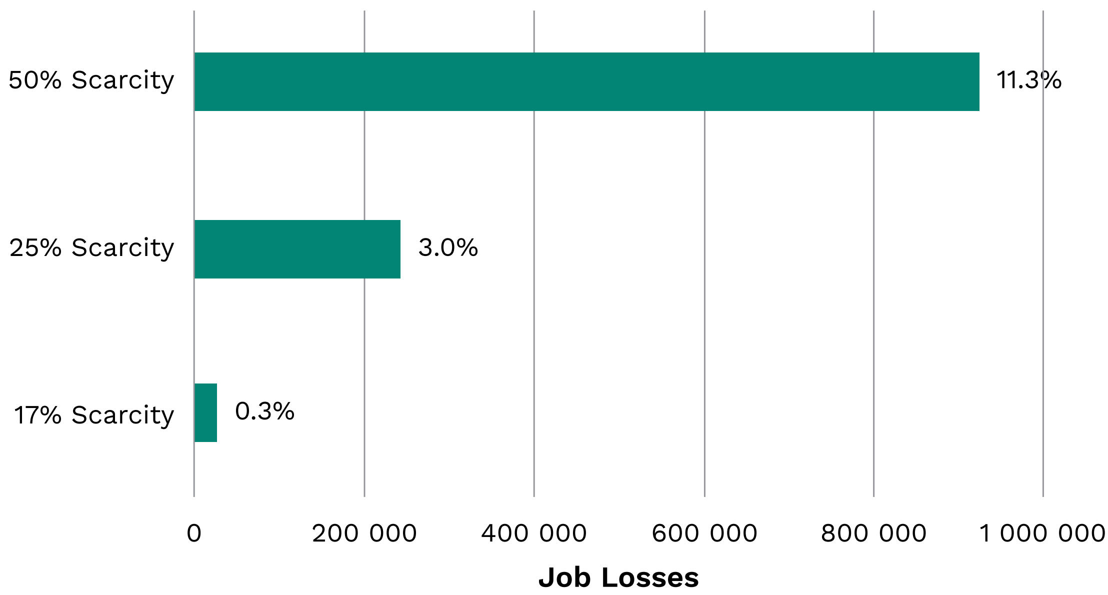


Figure 38: Vaal River System – Job Losses



CHAPTER 4

Ecosystems and Climate Change

Ecosystems are important. In Lesotho wetland ecosystems purify water, hold water and prevent erosion. They moderate the flow between variable rainfall and water in storage dams. This section describes the important ecosystems in Lesotho and highlights some of the known risks before reviewing the value of the wetland ecosystems.

4.1 Wetland Ecosystems

> *The wetland systems play a crucial role in the hydrological cycles. Through their retention and slow release of water, these high-altitude wetlands help stabilise the stream flow, attenuate flooding, reduce sedimentation loads, absorb of nutrients and purify water. Indeed, the majority of the water in Lesotho's rivers originates from precipitation that has been temporarily stored and processed in wetlands, thereby regulating base flow recharge of the river system. As such, these distinct wetlands facilitate the sustained flow of clean water for Southern Africa*

(Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014).

Wetlands are to be found in all of Lesotho's agro-ecological zones with an area of over 96 000 hectares. There are three types - palustrine, lacustrine and riverine wetlands (Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014, p. 87).

Palustrine wetlands, which include mires (bogs and fens), are generally found at high altitude, at valley heads and at the upper reaches of rivers. They are often referred to as "sponges" and have a high concentration of organic soils.

The lacustrine systems are the result of artificial impoundments for water supply and soil conservation work. The most important are the Katse and Letšeng-la-Letsie. High altitude lacustrine is the most important for hydrological functioning of the Senqu (Orange) River. The Letšeng-la-Letsie wetland in the Quthing district was designated as a RAMSAR site by the Government as part of its accession to the RAMSAR Convention (Lesotho Ministry of Water, 2018, p. 3).

The riverine wetlands of the Senqu and Mohokare rivers are important for over 3 000 species of high-altitude flora, of which 30% are endemic. The eastern alpine areas of Lesotho support an internationally unique network of high-altitude bogs and sponges (Lesotho Ministry of Natural Resources, 2012, p. 13). This type of the ecosystem is vulnerable to climate change (Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014, p. 63).

Three wetland areas were, until 2013, monitored as part of the Wetlands Restoration and Conservation Project (Lesotho Ministry of Natural Resources, 2012, p. 13). There are different levels of health in the different ecosystems. Some wetlands are pristine while many others have varying degrees of degradation (Ministry of Water, 2016, p. 16). There is no generalised wetland monitoring programme although there are proposals to monitor wetland ecosystem conservation (Ministry of Water, 2016, p. 11).

The biggest threats to wetlands include encroachment, livestock grazing and trampling, erosion, droughts, cultivation, overexploitation, and siltation. These threats have resulted in habitat change, species richness loss, reduction in quantities of surface water, increase in water treatment cost and water borne diseases (Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014, p. 87).

4.1.1 Functions

The National Wetlands Conservation Strategy 2013/14 – 2017/18 (Ministry of Energy, Meteorology and Water Affairs, 2013, pp. 20,21) has identified Lesotho wetlands functions which include:

Recharge of groundwater storage: Wetlands facilitate the movement of large volumes of water into the underground aquifers, resulting in the recharge of the groundwater storage. This process maintains a high-water table and supports healthy plant growth. Such groundwater may also be drawn for human consumption and industrial activities.

Flood and Erosion Prevention: *Wetlands prevent surface run-off from moving swiftly and overflowing the river banks downstream* thus preventing erosive flood conditions.

Water Purification: *Wetlands remove sediments, nutrients, toxic substances and other pollutants in surface run-off*. This improves the water quality and prevents the siltation of downstream river and lake watercourses.

Micro-climate Stabilization: Wetlands vegetation may also evaporate or transpire water into the atmosphere. This falls as rain which helps to maintain stable climatic conditions. This, in turn, supports stable agriculture and other resource-based activities.

Forage: Wetland grasslands provide critical areas for livestock grazing, especially during the dry season.

Water Supply: Because of their ability to purify and retain large volumes of water, wetlands provide clean and reliable sources of water for human consumption, agriculture and industry. *Many rivers flow throughout the year because the wetlands release their stored water slowly* into them, thus extending the period when water is available in drier times. Wetlands are, therefore, important in maintaining perennial rivers and streams.

Recreation/Tourism: The spectacular concentration of different species of animals and plant in wetlands provide opportunities for tourism and recreational activities. These include bird- watching and game-viewing

Biological Diversity: Most wetlands are hotspots for plant and animal species. This attribute is of value in itself as it contributes immensely to the maintenance of their ecological processes for the benefit of the present and future generations.

Cultural/Heritage Value: Many wetlands are protected through various structural and non-structural practices aimed at maintaining and preserving them for ecosystems' conservation and socio-economic development.

4.1.2 Opportunities

The Conservation Strategy identified opportunities associated with the wetlands (Ministry of Energy, Meteorology and Water Affairs, 2013). Some of the more relevant are:

Traditional Management Practices: Some traditional management practices for protection of wetlands through indigenous management systems exist in Lesotho. These traditional practices involve customary laws and indigenous knowledge which underscore socio-cultural values are accepted as means of regulating the utilization of wetland resources.

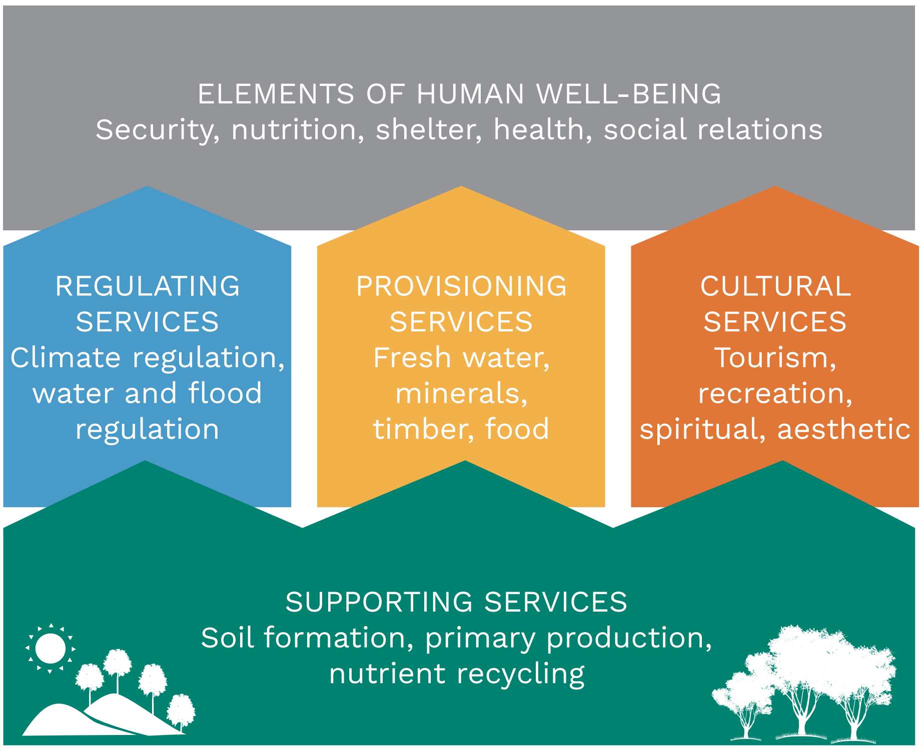
Socio-economic Demands: The socio-economic demand for wetland resources is in itself an opportunity. With increasing degradation of the wetlands resulting in the depletion of related resources, there will be pressure from users to ensure their sustainable exploitation.

Recognizable value of Wetlands: The wetland is recognized as a valuable resource because of its nature which is a mixture of soil, water, nutrients as well as plant and animal species. These resources are of ecological, hydrological, socio-economic and biological importance to the society through their wise and sustainable use and conservation.

4.1.3 Valuation Approach and Assessment

The Millennium Ecosystem Assessment report defined ecosystem services as “the benefits people obtain from ecosystems” and categorized them as supporting, provisioning, regulating, and cultural (Millenium Ecosystem Assessment, 2005). These are illustrated in Figure 39. The concept of ecosystem services shows the value of nature and the role it plays in society, the economy and for human wellbeing. Looking at the key ecosystem services can indicate how nature supports the economy of the area, even if they cannot be financially quantified.

Figure 39: Four Ecosystem Service Groups



Source: Extracted from Natural Capital4 and based on (Millenium Ecosystem Assessment, 2005)

4 Copied from https://altusimpact.com/altus-impact-work/themes/natural-capital/

The only definitive valuation of Lesotho's Ecosystem Services is the report on the strategic performance assessment of the Lesotho Wetlands Restoration and Conservation Project (Euroconsult Mott MacDonald et al, 2013, pp. 39, 40), which valued the wetlands in Lesotho according to the Total Economic Valuation (TEV) methodology. The TEV methodology not only considers the market values of environmental resources (such as agriculture and tourism) but also the non-market benefits, indirect values (such as ecological services that support and protect human life and production – for example flood attenuation and storm water run-off regulation) and existence values (intrinsic work of biodiversity and ecosystems not associated with their market use) (Euroconsult Mott MacDonald et al, 2013, pp. 65, 66).

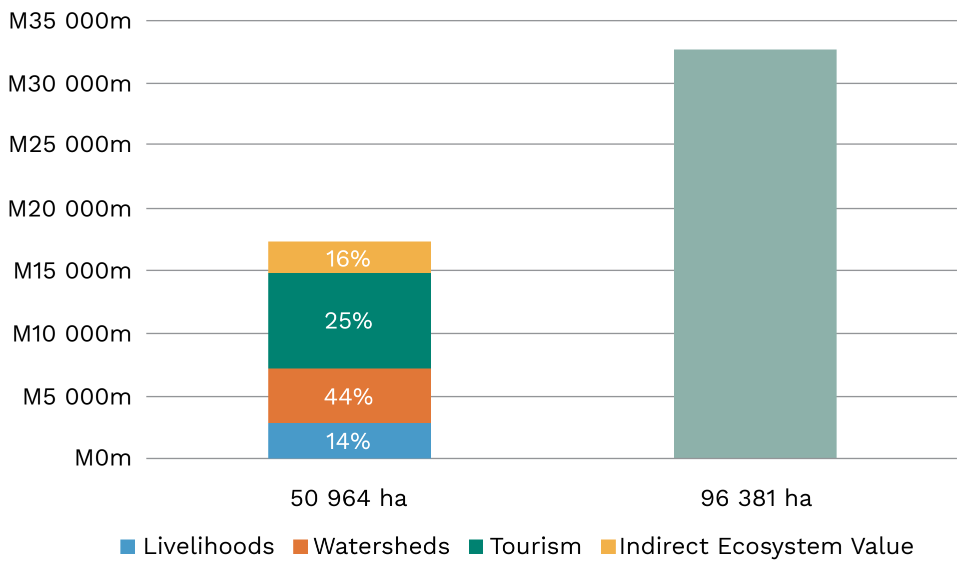
The report on the strategic performance assessment of the Lesotho Wetlands Restoration and Conservation Project only considered 'wetland use values', which are composed of direct and indirect use values and including ecosystem services such as livelihoods, natural resources, tourism and natural disaster mitigation (Euroconsult Mott MacDonald et al, 2013, p. 68). Due to lack of data, 'wetland non-use values' or 'wetland intrinsic values', such as biodiversity and culture, were excluded from their analysis. The report goes on to describe these non-use and intrinsic values as the most difficult of the ecosystem values to quantify but also potentially as their most valuable. The usual way of assessing the non-use values is through a Willingness to Pay approach, which assesses the perceived value of the natural resource to its users. This is both time consuming and expensive (Euroconsult Mott MacDonald et al, 2013, p. 67).

The TEV methodology of the Lesotho Wetlands Restoration and Conservation Project valued the Lesotho wetlands at 22% of GDP (US$910m) and more than 30% of total employment, in 2011/12 indicators. This was considered remarkable, given that the 50 964ha of wetlands valued constitute less than 2% of Lesotho's total area (Euroconsult Mott MacDonald et al, 2013, p. 62). The report stated that tourism and livelihood, in the form of livestock feeding and agriculture, were important.

The contribution of wetlands considers both direct and indirect ecosystem use values. Direct use values are services that are traded on markets and are easily quantified. Direct use values constituted 19% of the value-of-GDP amount and 29% of employment. In this context they include livelihoods, tourism and water supply. Indirect use values are where markets do not necessarily exist, but they can be quantified. For this context indirect use values are natural hazard mitigation costs (Euroconsult Mott MacDonald et al, 2013, p. 67). Other examples of indirect use values, but not quantified in their valuation, are damages caused by floods and inundations and carbon sequestration. Indirect use values made up the remaining 3% of the value of GDP and 2% employment.

The values above were given in 2011/12 indicators and only for 50 964 ha of wetlands. Various government sources indicate that this wetland ecosystem area is over 96 000 ha (Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014, p. 87), (Lesotho Ministry of Water, 2018, p. 3). When updated to the 2020 economic prices and context and adjusted for the increased area, the overall value of the wetland ecosystems is US$1.9bn (M32.7bn) with over 500 000 jobs dependent on them. This is 98% of the Lesotho economy and 70% of all jobs. The initial valuation by Euroconsult Mott Macdonald and the subsequent adjustment to 96 381ha is illustrated in Figure 40.

Figure 40: Lesotho Wetland Ecosystem Valuation



4.1.3.1 Regional Comparisons and Benefits Transfer

There is merit in comparing the values above with those in the rest of southern Africa where information is available. Three valuations were identified and adapted to Lesotho for comparative purposes. The approach is to determine valuation rates per hectare for similar wetland ecosystems in nearby countries, to apply the rate to the size of Lesotho's wetlands and to adjust the value by the ratio of GDP per capita for Lesotho to the country of analysis.

The first study is on ecosystem service valuations in South Africa (Anderson, et al., 2017) and allocates values to various ecosystems in the country. The valuation for swamps/floodplains and lakes/rivers are taken as pertinent to the wetland ecosystem services to be valued for the palustrine, lacustrine and riverine wetlands in Lesotho. They have a value of M143bn (in 2020 prices) when applied to the size of Lesotho's wetland ecosystems, but this needs to be adjusted by GDP per capita for the two countries[5]. When this is done, the value of Lesotho's wetland ecosystems using this study is M27bn.

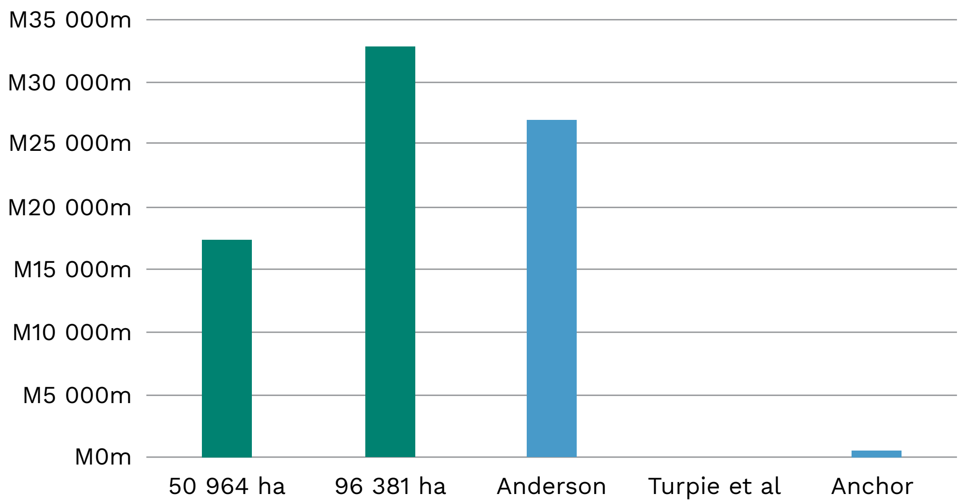
The second focusses on the direct and indirect use values of provisioning, regulating and cultural services in South African ecosystems and derives a value of R275bn (Turpie, et al., 2017, pp. 1, 2). This value excludes cropland and plantations and the value of water. The report acknowledges that R275bn is a low estimate. This would be M327m (2020 prices) if applied to the 96 000 ha of wetlands and only M62m when adjusted for per capita GDP.

This value cannot be compared to the full estimate of Euroconsult Mott Macdonald because the latter includes croplands and pastures. This makes up about one-sixth of the Euroconsult Mott Macdonald valuation. However, even with this exclusion the valuation of M62m is substantially less than the adjusted M32.7bn of Euroconsult Mott Macdonald.

5 South Africa had a GDP per capita of $7 346 in 2019, compared to $1 384 for Lesotho (www.tradingeconomics.com). The ratio of Lesotho to South Africa GDP per capita is 0.19.

A final report on comparing the provisioning services of urban and rural wetlands indicates a value of US$220/ha for the Leseng-la-Letsie rural wetland in Lesotho (Anchor Environmental Consultants, 2009, p. 15). This is the equivalent of M500m in today's prices. This is only for provisioning services.

Figure 41: Comparison of Adapted Regional Studies



The comparison of the three studies to the Euroconsult Mott Macdonald valuation is illustrated in Figure 41. The study by Anderson compares very well and its valuation of M27bn is 83% of the Euroconsult Mott MacDonald valuation. The Turpie et al and Anchor valuations are much lower. These studies do not include all the components of the Eurostar Mott Macdonald and Anderson studies and they acknowledge that their valuations are lower.

The preliminary conclusion is that Lesotho's wetland ecosystems are valued between M27bn and M32bn. This needs further investigation, however, because some studies indicate that this could be lower.

4.1.4 Potential Damage

There is evidence that several ecosystems are compromised. These include both the wetlands and the rivers. For example, five out of seven river sites monitored by the Lesotho Highlands Development Authority (LHDA), as shown in Table 6, are performing worse than predicted (Lesotho Highlands Development Authority, 2019, p. 21). This section discusses the type of potential damage to the wetland ecosystems as identified by stakeholders.

There is some possible evidence of increased evaporation in the wetlands. There are two possible causes. The first could be increasing ambient temperatures because of damaged ecosystems and/or climate change. The second may be reduced water absorption in the mountainous peat areas because of ecosystem damage. This could result in higher evaporation through water ponding rather than being held in the peat.

Table 6: Assessed River Condition (October 2017 to September 2018)

IFR site	Pre-dam condition	Predicted condition	Ecological category	Integrated ecostatus	State/class	Actual relative to Prediction
1	2	3 (C)	53.80	D	Largely modified	Worse
2	2	4 (D)	36.69	E	Seriously modified	Worse
4	2	4 (D)	69.89	C	Moderately modified	Better
4	2	3 (C)	51.52	D	Largely modified	Worse
5	2	2 (B)	66.52	C	Moderately modified	Worse
6	2	2 (B)	63.52	C	Moderately modified	Worse
7	2	4 (D)	64.44	C	Moderately modified	Better

Source: (Lesotho Highlands Development Authority, 2019, p. 21)

The statements above are all based on stakeholder views. In their opinion, one of the causes of the lower dam levels is ecosystem damage in the upper regions of the Lesotho mountains. The peat in these regions acts as a sponge to absorb and hold water. It appears that this peat has been damaged and no longer fulfils this function. The consequence is that there is rapid runoff from rainfall and no water absorption, so that in the dry seasons the peat can no longer release water into the catchments, and soil erosion. The rapid runoff results in water wastage and the soil erosion in sediment that settles in the storage dams. Furthermore, the inability of the peat to store water results in surface ponding, which evaporates.

4.2 Climate Change

It is reported that Lesotho is vulnerable to climate and environmental stresses. These include land degradation, loss of biodiversity, wetlands degradation, food insecurity, water scarcity and extreme weather events such as droughts, floods and strong winds (Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014, p. 34).

Lesotho has long-term warming as well as variation in the timing, frequency and volume of precipitation across the country. Lesotho's temperatures are on the rise and have increased by 0.76°C between 1971 and 2000 (Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014, p. 36). Furthermore, Lesotho experienced a series of extreme weather events, such as the late onset of rains, heavy rains and flooding, prolonged dry spells and the early occurrence of frost. These events had a negative impact on the country's economy and damages were estimated to have amounted to 3.2% of GDP (Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014, p. 37).

A case study on the impact of climate change on the Katse Dam Catchment indicates that longer dry spells and increased rainfall intensity would have at least three effects (Lewis, et al., p. 21). First is to increase erosion and compound sedimentation challenges, such as reducing storage capacity. Second is to increase flooding through high velocity run-off that would cause reservoir spill overs, losing water downstream. Finally, reduced infiltration, resulting in less water being released slowly over time, thus affecting the perennial flow of rivers and streams.

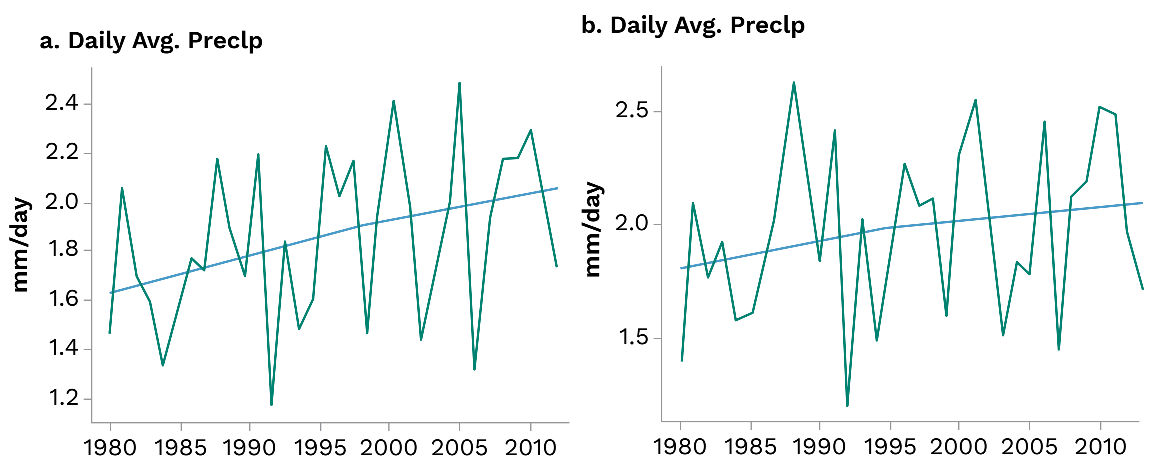
High intensity rainfall could render much of the mean annual runoff unusable or even hazardous. A World Bank Report analysed observational data from the Lesotho Meteorological Services (LMS) across several stations across Lesotho. The stations were categorised into two groups and the precipitation trends from 1980 to 2013 for both groups developed. These are shown in Figure 42. The conclusion to the analysis is that there was a slight increasing trend in total annual precipitation over the analysis period for both sets of data (World Bank, 2016, p. 24).

The same report found temperatures increased by 2°C between 1980 and 2003, as shown in Figure 43 (World Bank, 2016, p. 25).

The study forecast precipitation and temperatures for 2030 to 2050, based on 121 climate projections. These forecasts are illustrated in Figure 44. The black dot in the bottom centre of the diagram represents historic temperature and precipitation. The blue, green and orange dots represent the projected outcomes of the various climate change models and scenarios. Although the models differ on rain projections of precipitation, they concur on temperature. The future will be hotter, it is just the degree of wetness that varies.

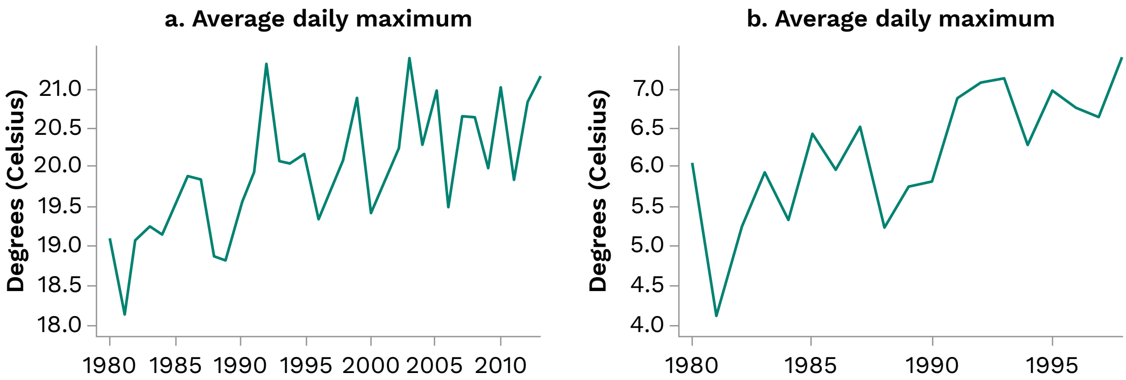
The ramifications of the projections are profound. If the degradation to the wetland ecosystems are the causes of the reduced LHWP reservoir levels, then the projected climatic conditions will exacerbate this. Lower precipitation would cause lower run-off. Higher precipitation could mean more intense storms and with the degraded environment unable to handle higher velocity run-off. Higher temperatures would mean more evaporation.

Figure 42: Long Term Precipitation Trends



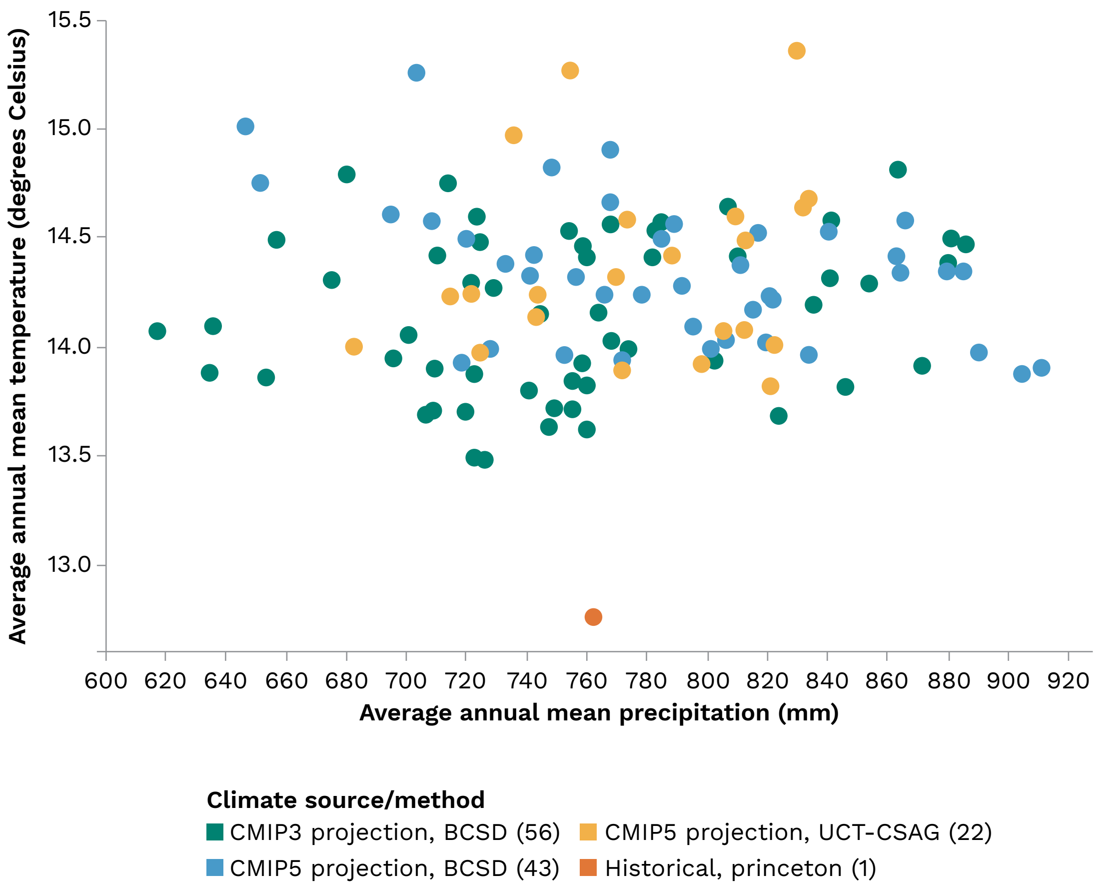
Source: Extracted from Figure 2.1 (World Bank, 2016, p. 25)

Figure 43: Historic Temperatures



Source: Extracted from Figure 2.1 (World Bank, 2016, p. 25)

Figure 44: Temperature and Precipitation Projections



Source: Extracted from Figure 2.1 (World Bank, 2016, p. 25)

CHAPTER 5

Stakeholder Contribution

Eight stakeholders groups met with StratEcon over the course of this project. In Lesotho these were representatives from the Lesotho Highlands Development Authority (LHDA), the Liqhobong Mine, WASCO and the Metolong (Water) Authority. In South Africa these were representatives of Eskom, Rand Water, Sasol and the Vaalharts irrigation scheme.

The meeting minutes are summarized in this section. There are four themes around water quality, water supply, cross-border stewardship and 'other' important issues

1. The discussion around water quality identified elevated nitrates and the manganese levels in the Metolong Dam as problems. There was common consensus that the water from the LHWP played an important role in improving water quality in the Vaal River. This is important because it lowers nitrate, phosphate and E coli concentrations in the Vaal River. South African stakeholders raised two economic issues. There is a cost to treating the Vaal River water and that any reduction in water from the LHWP would further increase these costs. In addition, poor water quality deters economic activity.

2. Stakeholders voiced concern about declining water levels in South African catchments. These concerns were particularly robust from strategic water users. All stakeholders have adaptation plans in place and there are contingency measures. Some contingency measures have long lead times and sudden supply shortages could not be accommodated. Falling water supply would exacerbate water quality problems.

3. The issue of cross-border stewardship, and participation in this stewardship, was generally received favourably. Three strategic water users indicated that they would be willing to explore involvement in cross-border stewardship. Two concerns were raised. The first is that there are currently no catchment management agencies with which to interact. Second, there is resource competition from other, South African, catchment areas.

4. The final category of issues does not fall under a common theme. There are five of these. The first relates to acid water draining from old mines in South Africa and sewage spills from aging and under maintained infrastructure upstream of the Vaal River. The second is that there is illegal abstraction of the relatively pure water from LHWP en-route to the Vaal River system. Third is that community protests about social dislocation do affect water supply and supply infrastructure. Fourth were a series of concerns around the LHWP phase two construction and potential delays in this construction. The final area of concern related to the perceived lack of maintenance and siltation at the Katse and Mohale Dams and weirs.

CHAPTER 6

Future Research

Part of this assignment is to identify missing or incomplete information. It has become clear that some of these issues are more than just incomplete information and warrant further research.

Rainfall:

Many of the observations and conclusions drawn in this report are based on rainfall data. The available rainfall data was either incomplete or had a limited time dimension. The data on total national rainfall was only available for 2014 to 2017. Information was available for several weather stations. In this case the data was incomplete. Improved information may show different rainfall trends from which different conclusions would be drawn. It is recommended that procedures be implemented that would ensure a comprehensive data collection process to give a full picture of all rainfall in the country. This would give aggregated information.

Allied to this is a snowfall assessment. Stakeholders have indicated that variable snowfalls may account for the falling water levels in some of the major dams. No information could be sourced on snowfalls. It is recommended that this information should be included in rainfall monitoring.

After the submission of the draft report, CHIRPS precipitation data was made available by the Project Steering Committee for the Katse, Motsuko and Mohale catchments. An analysis of this data indicated that over the longer term (1982 to 2020) there was an observable reduction in precipitation. However, this was less clear for the shorter-term period after 2000. A simple average of monthly precipitation volumes comparing the period 2000 to 2015 with that of 2016 to 2020 (to coincide with the periods when the LHWP dams filled up and then emptied) indicated marginally more rainfall in one catchment, almost no change in a second and a marginal reduction in the third. These changes are unlikely to have caused the dramatic drop in the LHWP reservoir levels but it is recommended that a more detailed, statistical analysis of the precipitation patterns be undertaken.

Climate Change:

It is possible that climate change may account for many of the biophysical phenomena that have been noted in this report and which may be responsible for the possible economic consequences. The evidence suggests that there has not been major rainfall reduction and this does not appear to be the cause of the falling water levels in some of the major dams. However, climate change may be causing higher temperatures which, in conjunction with ecosystem damage, may result in increased evapotranspiration. For example, evidence shows that there is ample water in the Senqu catchment with streamflow in excess of evapotranspiration. This is not the case with Mohokare and Makhaleng where evapotranspiration exceeds stream flow.

Wetlands Damage:

Wetlands are to be found in all the agro-ecological zones. There is some evidence that several ecosystems are compromised and causing habitat change, species richness loss, reduction in quantities of surface water, increase in water treatment cost and hence increase of water borne diseases. These changes may be responsible for the disconnect between rainfall and dam water levels noted above. They also potentially threaten the well-being of thousands of people living along the rivers that feed the Katse Dam and LHWP.

Coupled with this is the need to revaluate the Lesotho wetland ecosystems. Different reports indicate substantially different values for the Lesotho wetland ecosystems.

Silting and Dam Infrastructure:

Some of the lower water levels in the dams may be the consequence of infrastructural problems. For example, there is visual evidence that the Matsoku Weir is silted. This may be reducing flows to the Katse Dam and placing pressure on the Mohale Dam. The impact of this siltation should be assessed and the siltation cleared as a matter of urgency.

Cross-border Water Transfers:

Data on cross-border water transfers from two different sources differed substantially for the last four years. Data from the LHDA indicated that transfers matched the treaty requirements of 780Mm^3 a year. Data from the DWS indicated that in three of the last four years transfer volumes were at or exceeded 900Mm^3 and that the combined excess transfer for those three years amounted to a staggering 60% of the transfer for a single year. This could well be the reason for the decline in levels. It is unknown why the data sources differ or why cross-border transfers would be so high in the context of declining dam levels.

Intervention Costing and Revised Economic Analysis:

The further research should be brought together and the cost of the identified interventions aggregated. This would facilitate the revision of the economic analysis which would allow for informed policy decisions. It would be inefficient to attempt to cost issues which are yet to be defined. The same applies to possible future economic analysis. It would be best to wait for the problem to be clearly defined before specifying additional research. One exception may be the configure the water scarcity CGE model for the Gauteng economy and for varying degrees of water scarcity.

Conclusion

The overall conclusions are given by degree of certainty. It is clear that there is ample water in Lesotho and there will be no water shortages in the country in the short or medium term. It is reasonably clear that, while there is some compromised water quality, this is limited and would not appear to be a problem. What is less clear, and the major cause for concern, is the water availability for the LHWP cross-border transfers. Indications are that water levels in the scheme supply dams are dangerously low. The social and economic implications are dependent on whether these supply levels are temporary and can be addressed or long term. There would be dangerous economic consequences for both Lesotho and South Africa if these are long-term problems. The way forward is to implement the identified research needed to understand these long-term bio-physical issues and revisit the economic analysis for more concrete conclusions and policy recommendations.

References

Anchor Environmental Consultants, 2009. *Valuing the Provisioning Services of Wetlands: Contrasting a Rural Wetland in Lesotho with a Peri-Urban Weland in South Africa,* s.l.: Ecology and Society.

Anderson, S., Ankor, B. & Sutton, P., 2017. *Ecosystem service valuations of South Africa using a variety of land cover data sources and resolutions,* s.l.: s.n.

Bureau of Statistics, 2019. *Lesotho Multiple Indicator Cluster Survey 2018, Survey Findings Report,* Maseru: Lesotho: Bureau of Statistics.

Bureau of Statistics, 2019. *National Statistical System of Lesotho, Statistical Reports, No. 33: 2019 - Annual National Accounts of Lesotho 2009-2018,* Maseru: Bureau of Statistics.

Department Water & Sanitation, 2018. *National Water and Sanitation Master Plan Volume 1: Call to Action, Version 10.1 - Ready for the Future and Ahead of the Curve,* s.l.: s.n.

Eskom, n.d. *Rish and Sustainability: Water Supply Factsheet,* s.l.: s.n.

Euroconsult Mott MacDonald et al, 2013. *Strategic Performance Assessment of the Lesotho Wetlands Restoration and Conservation Project,* s.l.: Millemium Challenge Corporation.

Hortgro: Bureau for Food and Agricultural Policy, 2018. *Economic Implications of Water Restrictions in Langkloof Production Area,* Port Elizabeth: Hortgro.

Lesotho Highlands Development Authority, 2013. *Annual Report 2012/13,* s.l.: LHDA.

Lesotho Highlands Development Authority, 2015. *Annual Report 2014/15,* s.l.: LHDA.

Lesotho Highlands Development Authority, 2018. *Annual Report 2017/18,* s.l.: LHDA.

Lesotho Highlands Development Authority, 2019. *Annual Report 2018/19,* s.l.: LHDA.

Lesotho Ministry of Natural Resources, 2012. *1st Annual State of Water Resources Report (1 April 2010 - 31 March 2011),* Maseru: The Government of the Kingdom of Lesotho.

Lesotho Ministry of Water, 2018. *State of Water Resources Report for Fiscal Year 2016/17,* Maseru: Lesotho Commissioner of Water.

Lewis, F. et al., n.d. *Mapping Climate Change Vulnerability and Potential Economic Impacts in Lesotho: A Case Study of teh Katse Dam Catchment,* Pietermaritzburg: Institute of Natural Resources.

Millenium Ecosystem Assessment, 2005. *Ecosystems and Human Well-Being,* Washington D.C.: Island Press.

Ministry of Energy, Meteorology and Water Affairs, 2013. *National Wetlands Conservation Strategy 2013/14 - 2017/18,* Maseru: Kingdom of Lesotho.

Ministry of Tourism, Environment and Culture, Government of Lesotho, 2014. *Lesotho Environment Outlook Report 2014: Environment for National Prosperity,* Maseru: Lesotho Department of Environment.

Ministry of Water, 2016. *National Wetlands Conservation Strategy 2016/17 - 2020/21,* Maseru: Government of Lesotho.

Rand Water, n.d. *2019 Integrated Annual Report,* s.l.: s.n.

Rouen Normandie University, Sorbonne University Paris and Toulouse School of Economics, 2020. *Assessing the Macroeconomic Effects of Water Security in South Africa,* s.l.: GIZ and NatuReS.

References continued

SASOL Limited, 2019. *Integrated Report 2019: Positioning for a Sustainable Future,* s.l.: s.n.

Statistics South Africa, 2020. *Census of Commercial Agriculture, 2017,* s.l.: StatsSA.

Turpie, J. et al., 2017. *Mapping and valuation of South Africa's ecosystem services: A local perspective,* s.l.: Elsevier.

Vaalharts Water User Association, 2019. *Annual Report 2018-2019,* s.l.: VHWA.

van Seventer, D., 2014. *A 2007 Social Accounting Matrix for Lesotho,* Washington, D.C.: International Food Policy Research Institute.

van Seventer, D., Hartley, F., Gabriel, S. & Davies, R., 2016. *A 2012 Social Accounting Matrix (SAM) for South Africa,* s.l.: United Nations University World Institute for Development Economics Research.

WASCO, 2018. *2017/2018 Annual Report,* Maseru: The Water and Sewerage Company.

WASCO, n.d. *Strategic Plan 2020-25,* Maseru: The Water and Sewerage Company.

World Bank, 2016. *Lesotho Water Security and Climate Change Assessment,* Washington, D.C.: World Bank.

Appendix A: The Vaal River Economy, Water Dependency and Scarcity

This appendix describes the methodology and approach to assessing the size of the Vaal River economy used for this analysis. It then goes on to describe how water dependency of the various economic sectors in both Lesotho and South Africa is determined. The final section relates to quantifying the impact of various levels of water scarcity on the Vaal River economy.

6.1 Size of the Vaal River Economy

The starting point of estimating the Vaal River Economy is to use provincial GDP-R estimates provided by StatsSA (data set P0441) for Gauteng. The latest available estimates is that the Gauteng regional GDP was R1.67trn in 2018.

This was then supplemented with the following sectors, which included the South African stakeholders who contributed to this study:

- **Eskom:** The full size of the electricity, gas and water sector in Mpumalanga is included. In 2018 this was R24.8bn.
- **SASOL:** The economic contribution of SASOL was determined from its integrated annual report for 2019. Turnover in 2018 was R181bn while wages totalled R30bn and EBIT[6] R17.7bn (SASOL Limited, 2019, p. 28). The SASOL contribution to GDP is taken as the sum of wages, taxes, interest and profit, which in this instance is R47.7bn. According to the integrated annual report South African operations contribute 50% of turnover (SASOL Limited, 2019, p. 21). This means that SASOLs South African operations, which are dependent on the Vaal River, contributed an estimated R23.9bn to GDP in 2018.
- As a check, stakeholders indicated that 80% of SASOL's local water consumption is from its Secunda plant in Mpumalanga and the remaining 20% from its plant in Sasolburg, in the northern Orange Free State. If SASOL's contribution to GDP is split according to its water use, 80% (R19.1bn) is from Secunda and 20% (R4.8bn) from Sasolburg. These figures form 43% of Mpumalanga's manufacturing sector and 20% of that of the Orange Free State.
- **Vaalharts Irrigation Scheme:** According to their 2019 annual report, the Vaalharts Irrigation scheme irrigates 39 820 ha (Vaalharts Water User Association, 2019, p. 15). The irrigation scheme is part of the Phokwane Local Municipality and according to the Northern Cape Census of Commercial Agriculture 18 369ha of farmland is arable land with a combined turnover of R1.2bn for field and horticultural crops and 49 177ha is grazing land with a turnover of RR236m (Statistics South Africa, 2020, p. 15). If the full area of arable land is assumed as under irrigation and with the remainder of the irrigated land as grazing land than this means a combined turnover of R1.2bn. A Social Accounting Matrix (SAM) for

6 EBIT is Earnings Before Interest and Taxes. It also includes Retained Income. These three components, along with wages, are used to estimate GDP.

South Africa, developed by the United Nations University World Institute and the National Treasury (van Seventer, et al., 2016), indicates that GDP forms 34% of turnover in agricultural products and 31% of turnover for livestock. This means that the Vaalharts Irrigation Scheme contributed an estimated R412m to GDP in 2018.

It is recognised that there are additional sectors in Mpumalanga, northern Free State and the North West Province that are also dependent on the Vaal River Transfer scheme. The precise establishment of this economy was beyond the scope of this project. Consequently, the economic size reported here is seen as a lower bound estimate of the Vaal River economy.

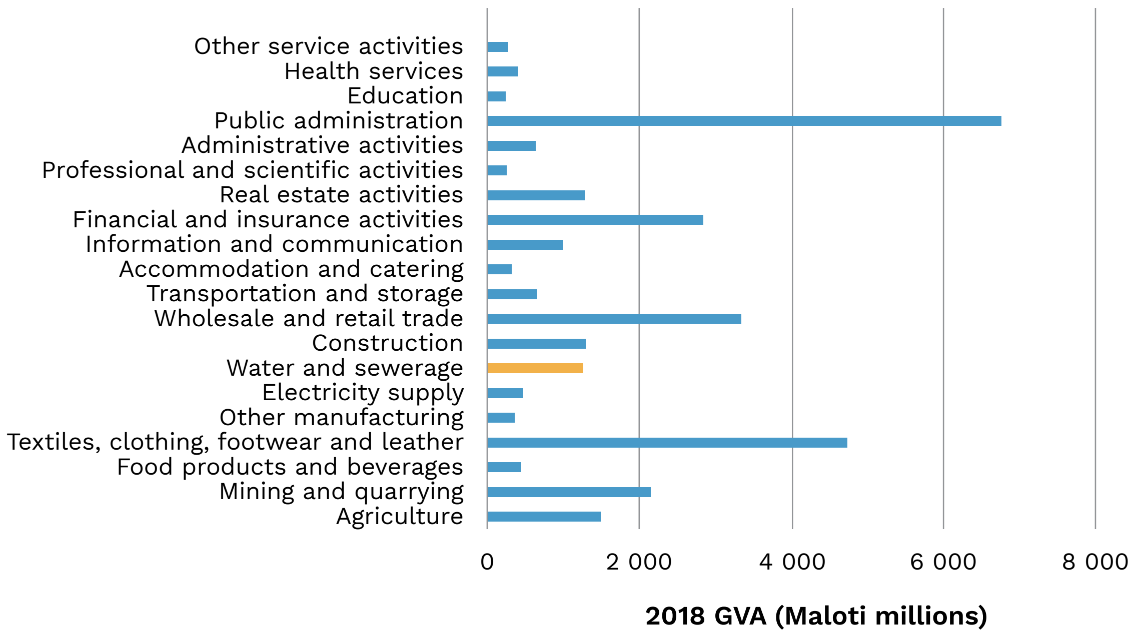
The estimated size of the Vaal River dependent economy is R1 730bn in 2018 prices. The sectoral contribution is illustrated in Figure 33. The largest sectors are finance and business at R358bn▯ general government services at R318bn▯ trade, catering and accommodation at R206bn▯ and transport, storage and communication at R152bn.

6.2 Water Dependence - Lesotho

The starting point of determining the water usage by economic sectors in Lesotho is to get an economic profile of the country. This is based on the latest set of National Accounts (Bureau of Statistics, 2019, p. 6) and is illustrated in Figure 45: Lesotho GDP by Economic Activity (M million) Figure 45. Public administration is the largest sector, contributing M6.76bn to the Lesotho economy. This is followed by textiles at M4.73bn, trade at M3.34bn and finance and insurance at M2.83bn. Lesotho GDP was M34.09bn in 2018. The water and sewerage sector is highlighted in the figure and contributed M1.26bn, or 3.7% of the country's GDP.

A Lesotho SAM (van Seventer, 2014) is then used to estimate the amount of water consumed by the economic sectors. The SAM indicates the proportion of turnover by economic sector that is spent on various input items, including water. These proportions are multiplied by the size of each economic sector and the resultant volume cross checked against other sources, such as WASCO and the State of the Water Resources reports. The resultant use of water by the economic sectors is illustrated in Figure 14. The sectors that consume the most amount of potable water relative to turnover are accommodation and catering (1.18% of turnover), the electricity supply sector (0.77%), textiles (0.39%) and professional and administrative services (0.25%).

Figure 45: Lesotho GDP by Economic Activity (M million)



6.3 Water Dependency - Vaal River Economy

The water dependence of the economic sectors is based on the SAM developed for South Africa by the United Nations University World Institute and the National Treasury (van Seventer, et al., 2016). The SAM indicates the proportion of turnover spent on natural and potable water.

As an example, in the processing of fruit and nuts 0.05% of turnover is spent on natural water and 0.07% on potable water. The mining of metals and ores is one of the more water intensive sectors and 0.19% and 1.45% of turnover is spent on natural water and potable water.

These sectoral proportions of expenditure on water are applied to the economic profile of the Vaal River. So, while one sector might be more water dependent than another, it is the relative contribution to the economy that would determine which are the major water users. These main water users are illustrated in Figure 34.

6.4 Water Scarcity for the Vaal River Economy

The starting point of valuing water scarcity is to use the output of research commissioned by the GIZ on valuing the effect of a 17% gap in demand for water and supply on the national economy by 2030. The effect of a 17% scarcity in the volume of water was determined to have the long-term sectoral reduction shown in Table 7.

Table 7: Long-Term Sectoral Changes in GDP from a 17% Water Scarcity

Change in GDP (Source: CGE Model) % Change Compared to 2006 Sectors	Long-Term		
	No Scarcity	17% Increase	Difference
Agriculture, Hunting, Forestry & Fishing	20.76%	20.42%	−0.34%
Mining, Food & Textiles	25.53%	25.16%	−0.37%
Oil, Mineral Products, Transport Equipment & Electricity	25.64%	25.37%	−0.27%
Production and distribution of water	13.51%	12.08%	−1.43%
Construction	22.27%	22.11%	−0.16%
Services	21.91%	21.63%	−0.28%
Public services	4.28%	4.18%	−0.10%

Source: (Rouen Normandie University, Sorbonne University Paris and Toulouse School of Economics, 2020, p. 46)

While the 17% gap in supply and demand is a national figure, the figure could be substantially higher for the Vaal River economy. It was discussed in section 3.2 that the potential gap between water supply and demand could be as much as 50%.

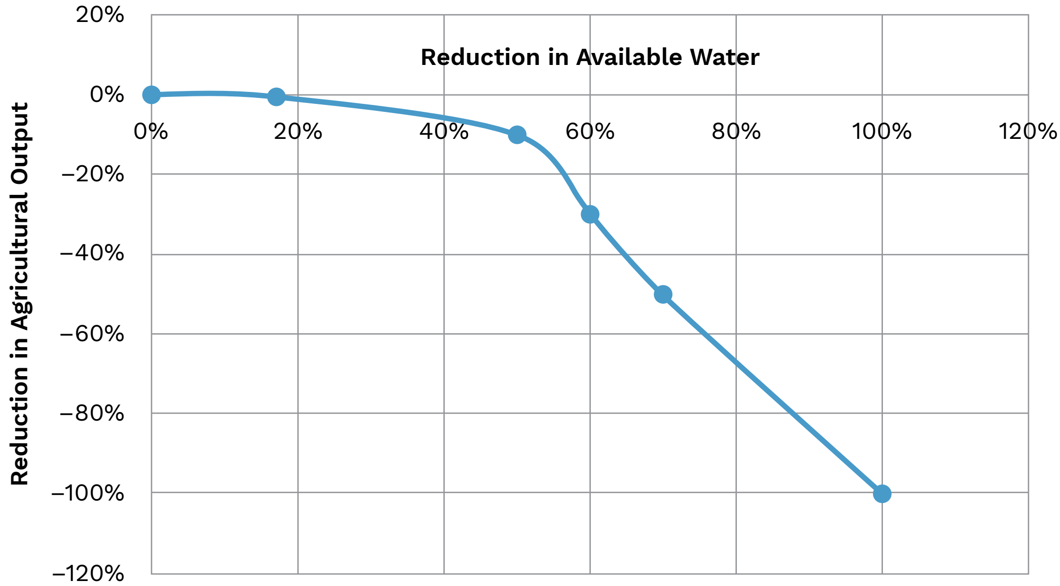
The long-term sectoral effects of a 17% scarcity therefore needed to be adjusted to a bigger gap between demand and supply. The complexity is that more severe gaps have proportionally deeper impacts than those of the 17%. The smaller the reduction the easier for the economy to absorb the shock and replace it internally with other production factors[7].

The following procedure was adopted to address these complexities:

- The GIZ report indicated that a 17% gap in supply and demand would have a long-term reduction in GDP of 0.34% in the agriculture sectors▯ 0.37% in the mining, food and textile sectors▯ 0.27% in the oil, mineral products, transport equipment, electricity and gas sectors▯ 1.43% in the production and distribution of tap water and the reuse of waste water▯ 0.16% in the construction sector, 0.28% in the private services sector▯ and 0.1% in the public services sector (Rouen Normandie University, Sorbonne University Paris and Toulouse School of Economics, 2020, p. 46).
- Hortgro and BFAP presented the impacts of water scarcity on agricultural output. Yield reduced at a relatively low 10% for a 50% reduction in available water for irrigation purposes but then increased dramatically for further reductions. A 60% reduction in available water would result in a 30% production decrease and a 70% reduction a 50% production decrease (Hortgro▯Bureau for Food and Agricultural Policy, 2018, p. 20).
- Figure 46 shows the reduction in agricultural output of combining the various studies, for a 17%, 50%, 60% and 70% reduction in water. The exponential decrease in agricultural output from 50% less water onwards is evident in the diagram.

7 Pers. Comm – email from GIZ dated 2020/08/27

Figure 46: Agricultural Output by Available Water



- The ratio of reduction in the sectors identified in the GIZ report to reduced agricultural output for a 17% water gap is applied to the 50%, 60% and 70% less water scenarios.
    - To illustrate, 60% less water means 30% less agricultural output. This in turn means a 31% reduction in the mining, food and textile sectors; 23% less in the oil, mineral products, transport equipment, electricity and gas sectors; 60% less in the production and distribution of water; 14% less in the construction sector, 24% in the private services sector; and 10% in the public services sector.
- All other water scarcity scenarios are linearly interpolated between those described above.

For more information contact
Stephan Huppertz
Programme Manager
Support to Integrated Catchment Management in Lesotho
E-mail: stephan.huppertz@giz.de

Disclaimer:
This publication was produced with the financial support of the European Union (EU) and the German Federal Ministry for Economic Cooperation and Development (BMZ). Its contents are the sole responsibility of GIZ and StratEcon and do not necessarily reflect the views of the EU or BMZ.

renoka
We are a river

www.renoka.org
hello@renoka.org

@renoka_movement
Renoka Movement
Renoka Movement
Renoka Movement

European Union
german cooperation
DEUTSCHE ZUSAMMENARBEIT
giz
NatuReS
NATURAL RESOURCES STEWARDSHIP PROGRAMME
Joint solutions for resilient economic growth