→ EO4SD - EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

Climate Resilience | Lesotho

Soil Erosion Monitoring and Wetlands Mapping Services in Lesotho

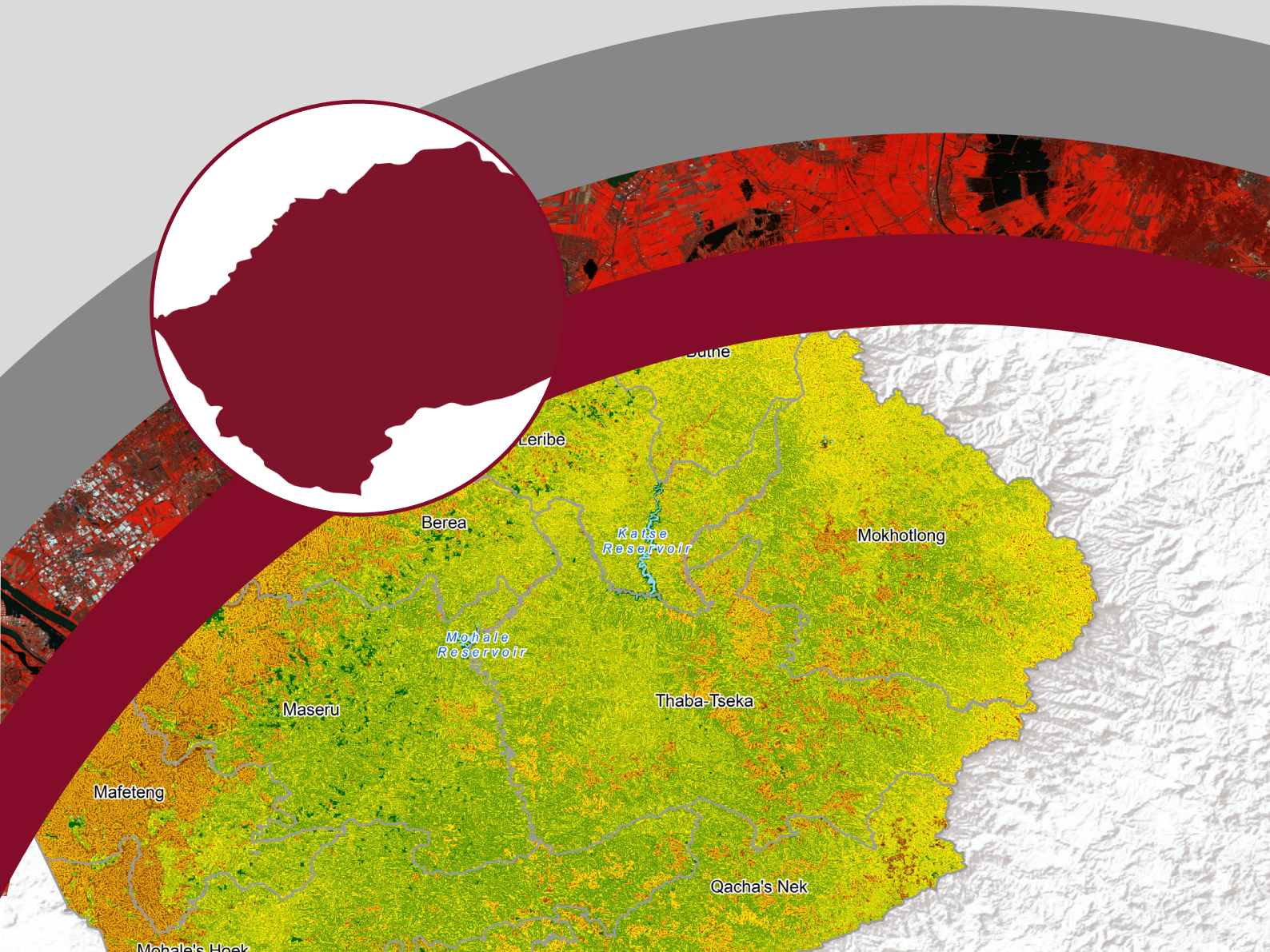


TABLE OF CONTENTS

1. INTRODUCTION

Earth Observation (EO) datasets and techniques can be used to support climate resilience intervention policies at country and regional levels. Since 2019, the European Space Agency's Earth Observation for Sustainable Development Climate Resilience (EO4SD CR) cluster has worked with several International Finance Institutions (IFIs) to apply EO-derived data and services to support real-world climate resilience projects.

One such collaboration is with the International Fund of Agricultural Development (IFAD) in Lesotho. The EO4SD CR cluster delivered bespoke EO soil erosion, wetland degradation, and climate risk analysis to support the design of the Fund's 'Restoration of Landscapes and Livelihoods' project. The project's goal is to identify sites for transformative landscape restoration investment, enhancing the resilience of ecosystems and communities alike.

About ESA's EO4SD Climate Resilience Cluster

Since 2008, the European Space Agency (ESA) has worked closely with International Financing Institutions (IFIs) and their client countries to harness the benefits of EO in their operations and resources management. Earth Observation for Sustainable Development (EO4SD) is a new ESA initiative that aims at increasing the uptake of EO-based information in regular development operations at the national and international level.

The ESA EO4SD Climate Resilience Cluster aims to provide insight into EO's potential to support climate-resilient decision making at the regional and national scale. In collaboration with several IFIs, the EO4SD CR cluster has developed EO-based integrated climate screening and risk management products and services to help manage climate-related risks and capitalise on the opportunities that climate resilience can create. The EO4SD CR cluster is also working to build the capacity of IFI staff and IFI client states, allowing stakeholders to use EO-based information for climate resilience decision making.

2. LESOTHO: AREAS OF HIGH CLIMATE VULNERABILITY

Lesotho, a high-altitude, landlocked kingdom encircled by South Africa, is divided into four physiographic regions: the mountain region in the east, the foothills in central Lesotho, the Orange River Valley from the north-east to the south-west, and the lowlands in the west. Lesotho has a temperate climate, with hot summers and cold winters. Maseru, the capital and largest city of Lesotho, and its surrounding lowlands often reach 30 °C (86 °F) in the summer. Winters can be cold with the lowlands getting down to −7 °C (19.4 °F) and the highlands to −20 °C (−4.0 °F)[1].

Poverty in Lesotho remains a considerable challenge, with 75 per cent of the population poor or at risk of poverty[2]. Unemployment is high at 24 to 28 per cent, while economic growth for the last three years averaged 1.3 per cent[3]. Climate change and poverty are deeply intertwined, with the impacts of climate change disproportionally affecting lower-income communities. Those in poverty have a higher chance of experiencing the ill-effects of climate change and its impacts due to their increased exposure and vulnerability. This is typically due to their high geographical exposure, high occupational vulnerability (poor households tend to work outdoors and in manual labor), and a low adaptive capacity (poor households have less access to physical and financial capital buffers)[4]. Additionally, climate change threatens food security, especially for those that work in the agricultural sector and rely on crop productivity for their livelihoods and income.

Lesotho's geographical characteristics, and the socioeconomic conditions that prevail among its rural population, make it one of the most vulnerable countries to climate change. As the climate changes, Lesotho is expected to experience a change in temperature and precipitation patterns, becoming both drier and hotter. The intensity and frequency of extreme events such as floods and drought are also expected to increase, especially in the western and northern lowlands[5].

1 Climates to Travel, World Travel Guide. Link: https://www.climatestotravel.com/climate/lesotho
2 World Bank, 2019. https://www.worldbank.org/en/news/press-release/2019/12/18/lesotho-reduces-poverty-but-nearly-half-of-the-population-remains-poor
3 Climate Change Knowledge Portal, World Bank Group. Link: https://climateknowledgeportal.worldbank.org/country/lesotho
4 World Bank, 2015. Climate Change and Poverty Conference Summary
5 UNDP, Climate Change Adaptation.
https://www.adaptationundp.org/explore/africa/lesotho#:~:text=Lesotho per cent20is per cent20expected per cent20to per cent20experience,the per-cent20western per cent20and per cent20northern per cent20lowlands.

Land degradation caused by soil erosion has been identified as one of Lesotho's most significant environmental challenges[6]. Severe erosion has caused deep gullies to develop, with eroded soil deposited as sediment in reservoirs and rivers. Climate change, and the more frequent and intense rainfall events associated with it, is likely to increase the rate of soil erosion and lead to greater amounts of sediment washing into rivers, lakes and streams.

Soil erosion is, to a large extent, a result of poor land management practices, chiefly the mismanagement of rangelands through overgrazing. Lesotho's alpine wetlands are also in poor condition due to overgrazing. Overgrazing has reduced vegetative cover and compacted the soil surface, resulting in increased surface runoff. The altered hydrologic state of the watershed has resulted in the formation of gullies, which are now functionally draining wetlands. Without wetlands, human communities lose many of the vital ecosystem services they provide, including water purification, flood control, and food supply[7].

3. RESTORATION OF LANDSCAPES AND LIVELIHOODS

In light of chronic challenges associated with land degradation and ecosystem health across Lesotho and persistent data gaps concerning these challenges, IFAD requested that the EO4SD CR cluster provide soil erosion and wetland products to assist the prioritisation of sites for landscape restoration investments. This led to the generation of two EO-derived products: soil erosion maps, and wetland mapping and monitoring maps.

Soil Erosion Mapping: Lesotho is regularly exposed to floods and drought. However, soil erosion has been identified as one of the foremost environmental challenges facing the country. Lesotho experiences amongst the most severe rates of soil erosion in the world[8]. As such, analysing the long-term change in the rate of soil erosion can help decision-makers understand patterns and trends related to erosion-related risks and identify hot spots likely to be prone to higher rates of erosion with increasing climate variability. In turn, this knowledge helps decision-makers design interventions that can reduce erosion-related risks, such as by earmarking land parcels for landscape restoration.

The EO4SD CR cluster leveraged Earth Observation data, including vegetation (Copernicus Global Land Service), topographical (SRTM digital elevation model), land use (Copernicus Climate Change Service) and rainfall data (CHIRPS), to estimate the average rate of soil loss due to water erosion across Lesotho using the Revised Universal Soil Loss Equation (RUSLE) method from the JRC's European Soil Data Centre (ESDAC). Satellite-derived data can be used to analyse soil loss at different periods, soil loss trends, and anomalies on a national scale. The EO4SD CR cluster provided maps depicting the average rate of soil erosion for two periods, 2001 to 2005 and 2016 to 2020. Anomaly maps presented the change in the rate of soil erosion between these periods. Data were processed to show the average rate of soil erosion per sub-catchment, and according to land cover type, further enhancing decision-makers ability to target interventions according to decision-relevant administrative units.

The results of the analysis show that the soil erosion rate in Lesotho is very much dependent on the rainfall patterns (accumulation and intensity). Averaged annual values are provided in Table 1. The total change between 2001-2005 and 2016-2020 for the averaged soil loss is higher than 5 Mt and about 2 tonnes per hectare regarding the erosion rate. In most areas, the erosion has actually worsen as shown in Table 2. The analysis per land cover type shows that grasslands, shrublands and rainfed agriculture (both over plain and mountainous areas) experience the highest rates of erosion. Overall, the rate of soil erosion has remained high across Lesotho over the last 20 years, projecting a rate of soil erosion of 43 Mt by 2035. The number of catchments experiencing 'severe' or "very severe"erosion has also increased over time, from 28 sub-catchments in 2001 to 2005 to 41 during 2016 to 2020. This provides evidence of an increasingly large proportion of Lesotho's surface area experiencing severe erosion.

6 IUCN, Lesotho. Link: https://www.iucn.org/pt/node/26924#:~:text=Land per cent20degradation per cent20as per cent20a per cent20result,greatest per cent20environmental per cent20challenges per cent20facing per cent20Lesotho.&text=Soil per cent20erosion per cent20and per cent20hence per cent20degradation,of per cent20rangelands per cent20due per cent20to per cent20overgrazing.
7 WWF, Wetlands. Link: https://www.worldwildlife.org/habitats/wetlands
8 Forbes, 2019. Link: https://www.forbes.com/sites/linhanhcat/2019/05/21/soil-erosion-washes-away-8-billion/

Table 1 Soil erosion rate and the total annual soil loss per year for Lesotho in the periods 2001-2005 and 2016-

Year	Soil loss (Mt)	Soil erosion rate (t/ha)
2001	37	12
2002	25	8
2003	23	8
2004	35	12
2005	33	11
2016	22	7
2017	35	12
2018	44	15
2019	43	14
2020	35	12

Table 2 2016-2020 soil loss average minus 2001-2005 soil loss average. Negative values correspond to a decrease in the soil erosion rates while positive values mean erosion increasing.

Periods averages soil loss changes (Mt)	Area (km2)	% Area
<-25	15.3	0.05%
≥-25 & <-10	43.0	0.14%
≥-10 & <-5	52.6	0.17%
≥-5 & <5	27910.5	91.57%
≥5 & <10	1629.3	5.35%
≥10 & <25	678.7	2.23%
≥25	149.5	0.49%

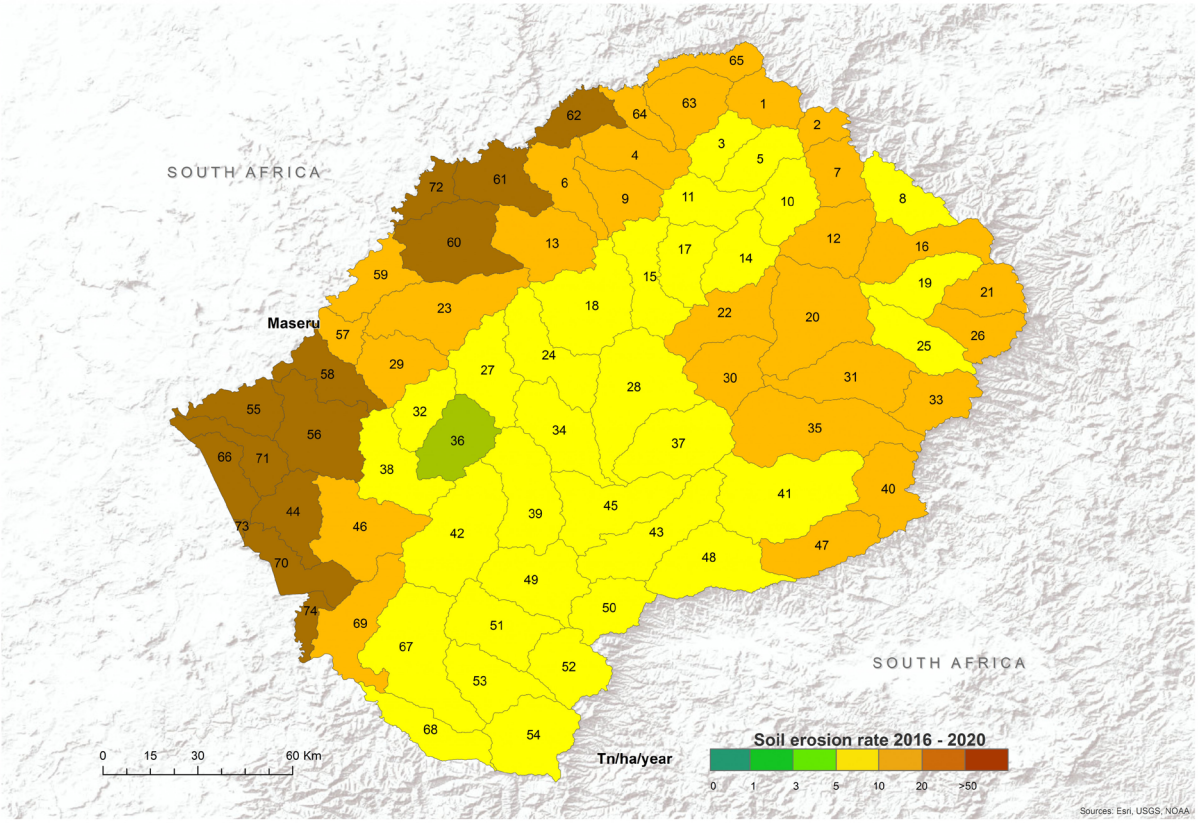


Figure 1: Map of change in soil erosion rate (Tn/Ha/yr) across Lesotho between 2016 and 2020 aggregated per sub-catchment (ID number presented). Source: GMV.

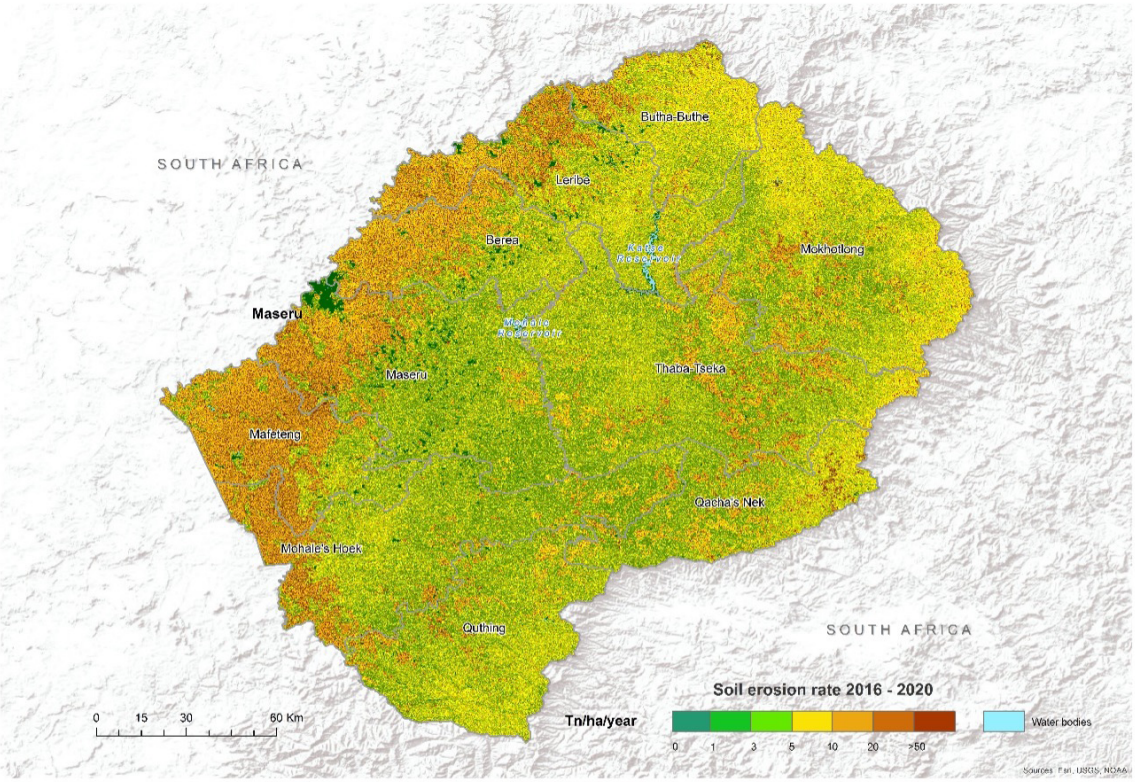


Figure 2: Map of change in soil erosion rate (Tn/Ha/yr) across Lesotho between 2016 and 2020.

Wetlands Mapping and Monitoring: From flood protection and erosion control to water purification, Lesotho's wetlands provide an array of ecosystem services that enable the country to reduce risks to communities and safeguard a resource that is of paramount Importance, socially and economically, to both Lesotho and South Africa.

However, wetlands in Lesotho have come under increasing pressure due to a combination of human and climatic factors (e.g. drought). Recognising this, IFAD launched a programme to promote the adoption of transformational land management practices among Lesotho's rural communities, with the ultimate ambition of realising to linked goals: 1) healthy and regenerated landscapes, and 2) rural livelihoods that are sustainable and prosperous.

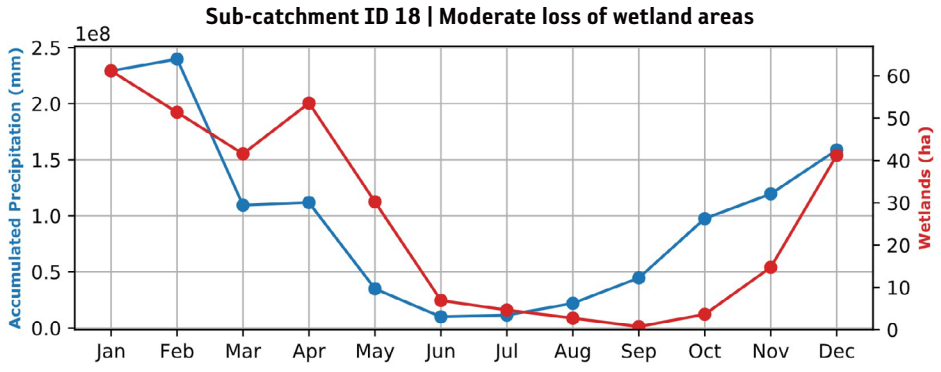
Given persistent gaps in the availability of quality and timely data about Lesotho's wetlands, IFAD requested the EO4SD CR cluster's support to help identify wetlands and assess trends in the total area of wetland in the country. The 'Wetlands Mapping and Monitoring' product was developed to answer this request, presenting wetland occurrence and productivity trends for catchments and (sub-)catchments across Lesotho. These products enable IFAD and IFAD's beneficiaries to possess clear evidence regarding trends in wetland area and productivity and hot spots of severe wetland loss.

Long-term patterns in wetland condition were assessed using maps that depict the evolution of permanent and temporary wetlands at the sub-catchment level. These maps were generated using 20m resolution EO data covering the period 2017 to 2019. This comprised four key elements: country-level wetland recurrence, change in wetland area, change in temporary and permanent wetland area, and monthly change in precipitation and wetland area.

The results show that wetlands are stable in 41 per cent of sub-catchments in Lesotho. However, more sub-catchments (43 per cent) are experiencing a loss of wetland area rather than an increase (16 per cent). Of catchments experiencing a decrease in wetland area, 24 per cent (19 per cent) – almost one-quarter of all sub-catchments – are experiencing a severe loss of wetland area (Figure 2). Finally, monthly precipitation and wetland area are strongly coupled, indicating that any forecast precipitation deficits are likely to precipitate a deterioration in wetland health. Whilst climate is a significant driver of wetland change, human activity is also an important trigger.

Using EO4SD CR cluster's EO data IFAD can assess where wetlands are least resilient to climate variability and where communities are most at risk as a consequence. This helps IFAD and its beneficiaries to target transformative resilience interventions that improve land and wetland management for the benefit of generations to come.

A



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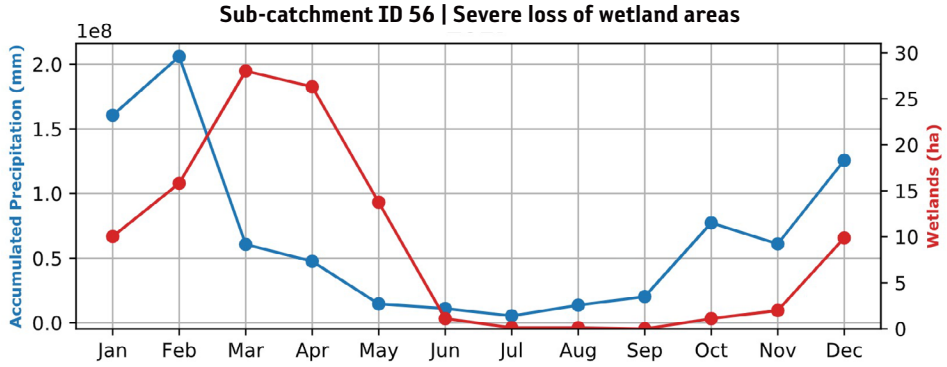

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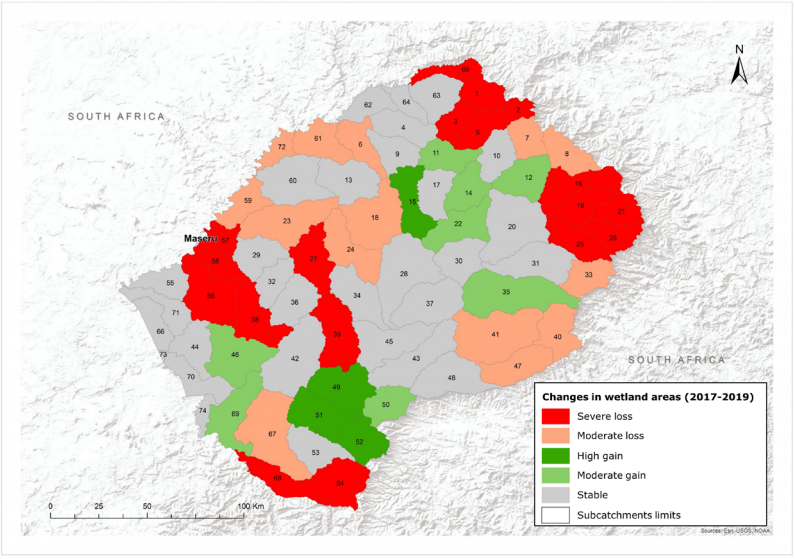

Figure 3: Analysis of the monthly changes in wetlands extent on sub-catchments 18 and 56 over the period 2017 to 2019 (A and B, respectively). Map of the wetland degradation at sub-catchment level (C). Red shading indicates sub-catchments experiencing loss of wetlands extent.Source: GMV.

Table 3 EO4SD produces and corresponding data sources.

Product	Data source(s)
Wetland mapping and monitoring	• NDVI and NDWI from Sentinel-2 A/B • STRM Digital Elevation Model • FAO Lesotho's Land Cover map • Copernicus GLS Land Cover
Soil erosion rate	• CHIRPS gridded rainfall • FAO Lesotho's Land Cover map • SoilGrids • STRM Digital Elevation Model • Copernicus C3S Land cover • Copernicus GLS Vegetation Fraction Cover • USGS' Global Food Security-support Analysis Data (GFSAD)

Partners of the Climate Resilience Cluster

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Cover image: Mean soil erosion rate in Lesotho occurring between 2001 and 2005