Impact of Subtropical Thicket Restoration Project in Baviaanskloof Nature Reserve (South Africa): An Insight into the Changing Climate

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Introduction

The Baviaankloof is popularly known as "Valley of Baboons". It is one of the global biodiversity hotspots contain endemic species. But unsustainable pastoralism has degraded this region. The South African government invested in planting cuttings of Spekboom (*Portulacaria afra*) to restore the degraded landscape. In the period 2004-2016 Spekbooms were planted under the Subtropical Thicket Restoration Project (STRP) in the Baviaanskloof Nature Reserve (BNR). Many studies have been done to analyse the survivorship of planted Spekboom. Some studies also focussed on studying the effect of restoration methods on the condition of the soil, water, carbon sequestration and biodiversity. It would also be interesting to study the change in meteorological variables over a long period to understand climate change over this area. The status of vegetation has also been studied.

Study Area and dataset

The location of BNR has been shown in Figure 1. The area of BNR is 199 986 hectares (Boshoff 2008). The BNR plays a vital role for the Kouga Dam water security; irrigation and farming of nearby areas. The data sets used for the current study has been shown in Figure 2.

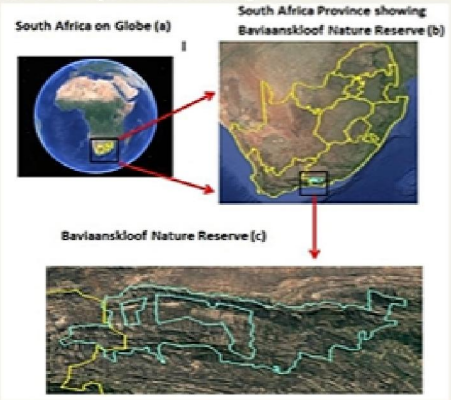

Figure 1. Google earth image of the study area

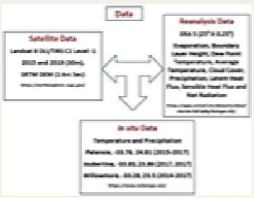

Figure 2 . Details of Data used in the present study

Methodology

The Triangular Irregular Network (TIN) calculated from Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM). LANDSAT data have been used to calculate NDVI (normalized difference vegetation index) for 2015 and 2019. The percentage change and statistical parameters (mean, mode, maximum and minimum) have been calculated for 2015 and 2019. To compare the NDVI, ten random regions have been selected and analysed statistically. The weather data from the nearby station of BNR have also been analysed. The monthly average ERA5 datasets have been used for the analysis of meteorological parameters variation over the site during 1990-2018. Linear trend variation and Mann-Kendall statistical test are employed in the study to understand the trend of parameters. The whole region has been selected and the area-averaged time series has been analyzed for the linear trend analysis. The spatial regional average values and Sen-slope values from Mann-Kendall analysis are also calculated to get a complete picture of micro-scale variation of these parameters over the study region.

Results

In Figure 3, TIN has been shown for BNR. The TIN represents the land elevation. The topography of BNR is highly variable and ranged between 87 -1744 m. The elevation in western part of BNR solar is higher compared to rest of the region.

Figure 3. TIN surface of Baviaanskloof Nature Reserve

The monthly data (ERA5) has been used for the variation of meteorological parameters during 1990-2018, shown in Figure 4, fitted with a linear trend line and the equation for each parameter. The dew-point temperature is showing a slightly decreasing trend over the region, which temperature is increasing supported by the consequent increase in the boundary layer height. The cloud cover, evaporation and total precipitation over the region are also decreasing. The increase/decrease in these parameters indicates a change in climate is visible at the site.

When analyzing the radiation fluxes at the site (Figure 5), the net-radiation and latent heat flux both are showing a decreasing pattern, while sensible heat flux is increasing over time. The flux pattern indicates that over time, the vegetation cover may be decreasing over the study region.

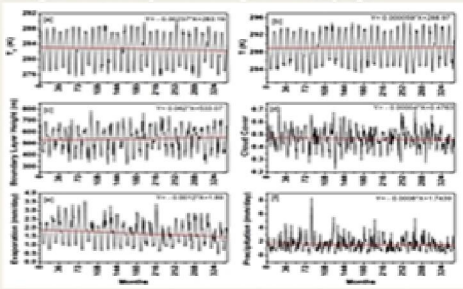

Figure 4. Monthly variation of area averaged (a) Dew Point temperature, (b) Air Temperature, (c) Boundary Layer height, (d) Cloud Cover, (e) Evaporation and (f) precipitation

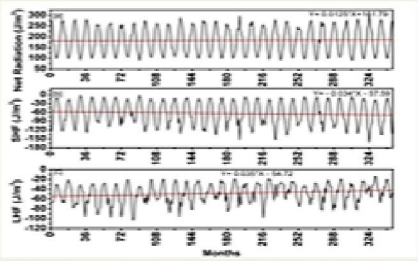

Figure 5. Monthly area averaged (a) Net Radiation, (b) Sensible heat Flux and (c) Latent Heat flux values

Interestingly, there is a contrasting pattern observed at two ends of our study region (Figure 6a), with almost 1.5 K difference. The trend is positive for temperature with higher rates on the colder side of the region (Figure 6b). The dew-point temperature also shows north-south contrast over the region, the area towards the sea showing higher values (Figure 6c). The dew-point temperature trend is negative for the area, with almost constant values for the total area (Figure 6d). The average precipitation picture is in agreement with dew-point and showing more rainfall towards the sea area giving north-south differences over the area (Figure 6e).

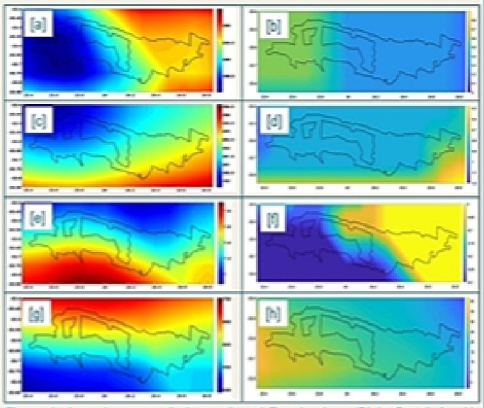

Figure 6. Annual average (Left panel) and Trend values (Right Panel) for Air Temperature (a,b), Dew-Point Temperature (c,d), Precipitation (e,f) and Boundary Layer Height (g,h)

The trend of rainfall variation (Figure 6f) is negative for the region with higher temperature while the other side is not showing any trend (value is 0). The average variation of boundary layer height (Figure 6g) is depicting a reverse pattern to that of rainfall, with higher values towards the land side, as expected. However, the variation is high over the area (~150 m), considering its spatial extent. There is an overall increasing trend in boundary layer height over the region (Figure 6h), with higher values in the higher temperature side.

We have observed a negative percentage change in precipitation and positive percentage change in diurnal temperature in the *in-situ* data of weather stations (Figure 7). These results has shown similarity with ERA5 data findings over the region.

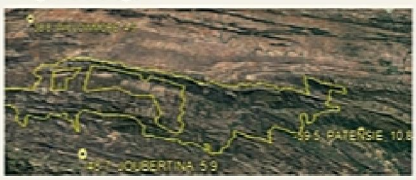

Figure 7. The percentage (%) change in nearby stations (Willowmore, Joubertina and Patensie) of BNR shown as (% change precipitation Station name %change diurnal temperature change)

The vegetation over BNR for the year 2015 and 2019 can be seen in Figure 8a and 8b. The NDVI ranged from -0.2 to 0.6. In most of the area NDVI values are not very high, it indicates the sparse vegetation over this region.

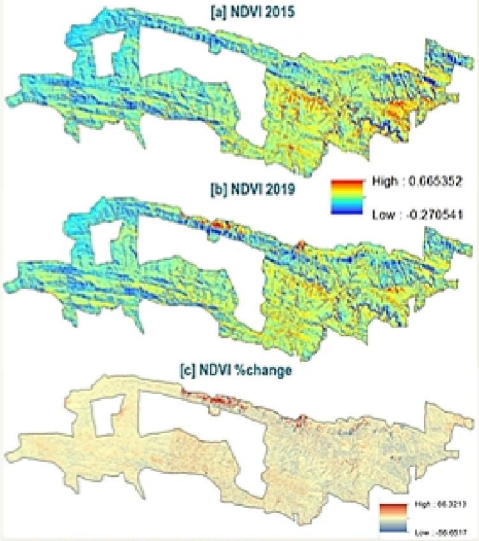

Figure 8. Variation of NDVI over BNR (a) NDVI for the year 2015, (b) NDVI for the year 2015, (c) % change in NDVI

The % change in NDVI are shown in Figure 8c. Except for the northern region, we have observed the negative change in most of the area of BNR. To understand NDVI change, we have randomly selected ten regions in BNR (Figure 9a). We have calculated statistical parameters like mean, mode, maximum and minimum NDVI for randomly selected area (Figure 9b and 9 c).

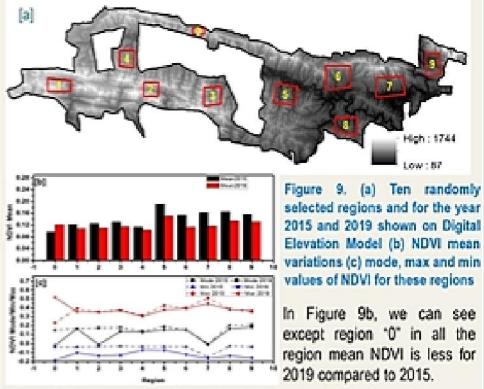

Figure 9. (a) Ten randomly selected regions and for the year 2015 and 2019 shown on Digital Elevation Model (b) NDVI mean variations (c) mode, max and min values of NDVI for these regions

In Figure 9b, we can see except region "0" in all the region mean NDVI is less for 2019 compared to 2015.

The NDVI never crossed 0.7, which indicates the sparse vegetation cover. Low and negative NDVI indicates barren rock or sand.

Conclusion

The present work can be concluded in the following points:

- The area is experiencing an increasing trend of air temperature, boundary layer height and sensible heat flux, while the trend for dew-point temperature, cloud cover, evaporation, rainfall and latent heat flux is decreasing.
- The area is also showing a contrast between east-west and north-south direction for the variation and trend of values, with one side of the area showing higher trend values.
- *In situ* data of precipitation and diurnal temperature range of nearby weather station have shown a decreasing and increasing trend, respectively.
- Vegetation index (NDVI) indicated the sparse vegetation over BNR. Percentage change in NDVI has shown decrease in vegetation over BNR.
- The present analysis suggests that there is a need for more extensive and long term projects like STRP to improve the degraded ecosystem.

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