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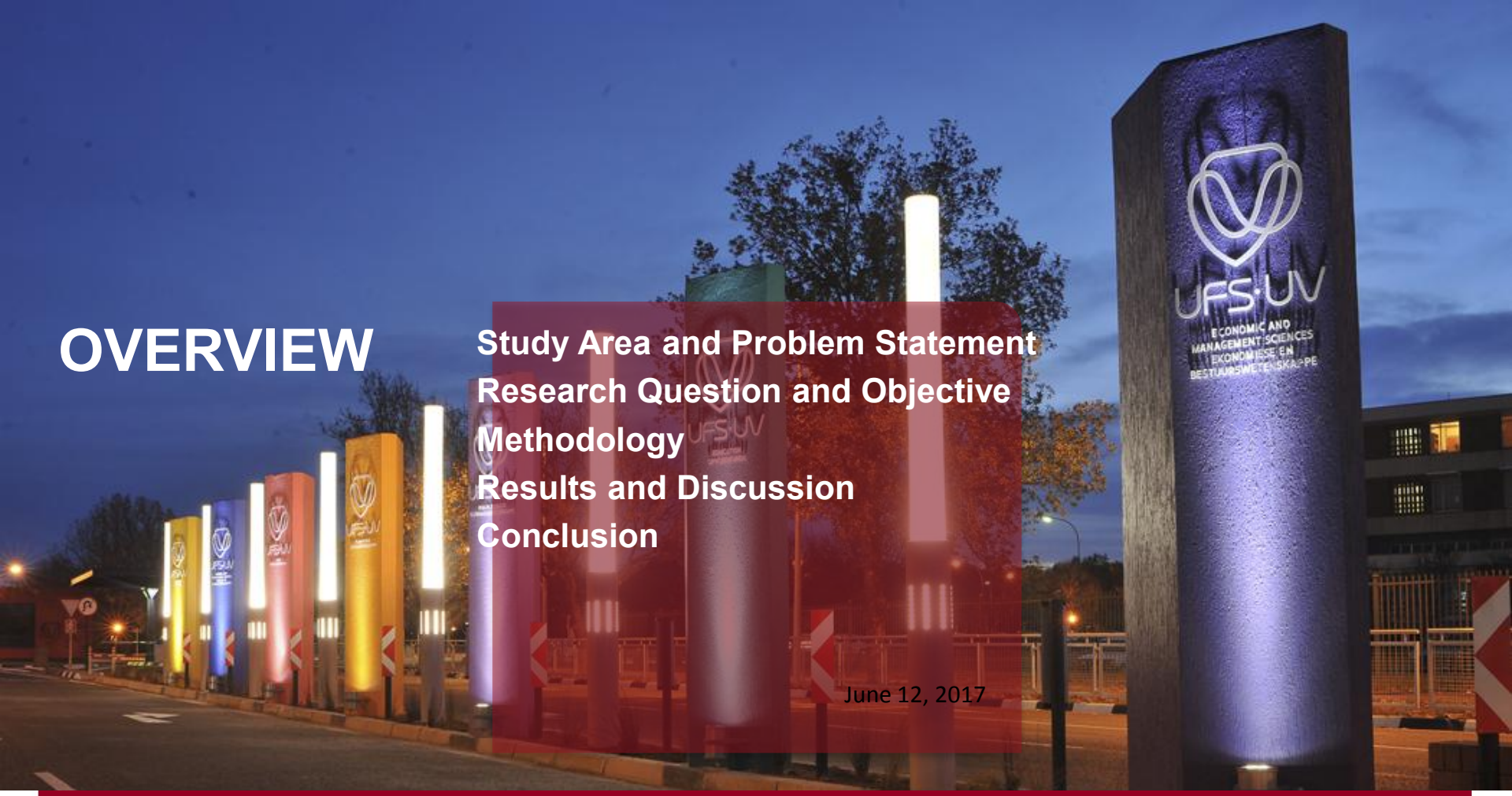
Spatiotemporal Analysis of the Impact of Climate Change on the State of Vegetation Cover in the Namahadi Catchment Area in South Africa

•**Paper Presented at the** st International Conference on **Natural Hazards and Disaster Management** June 1-3, 2017 Osaka, Japan

Professor Geoffrey Mukwada
Afromontane Research Unit
University of the Free State
mukwadag@ufs.ac.za



OVERVIEW

- Study Area and Problem Statement
- Research Question and Objective
- Methodology
- Results and Discussion
- Conclusion

June 12, 2017

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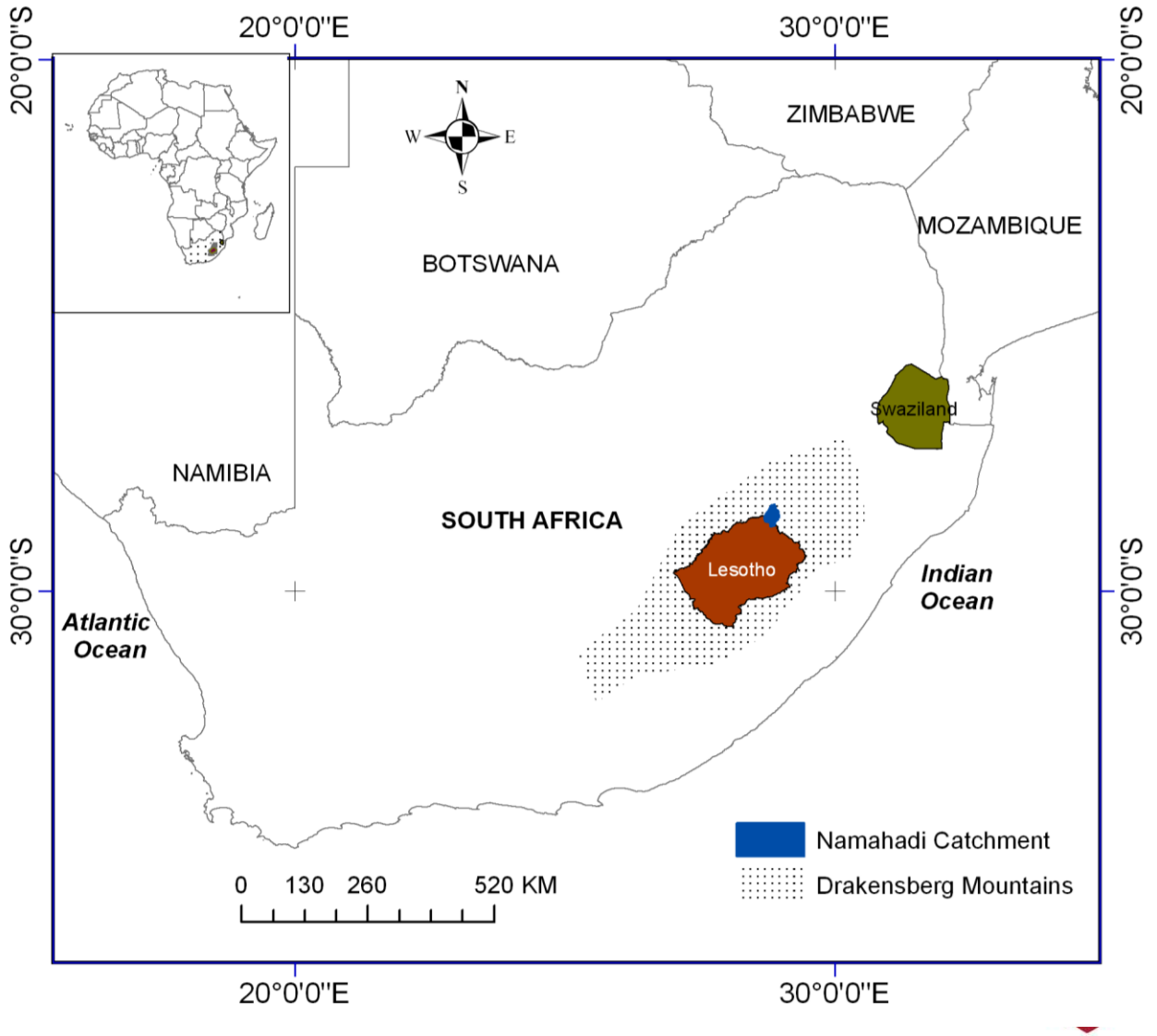
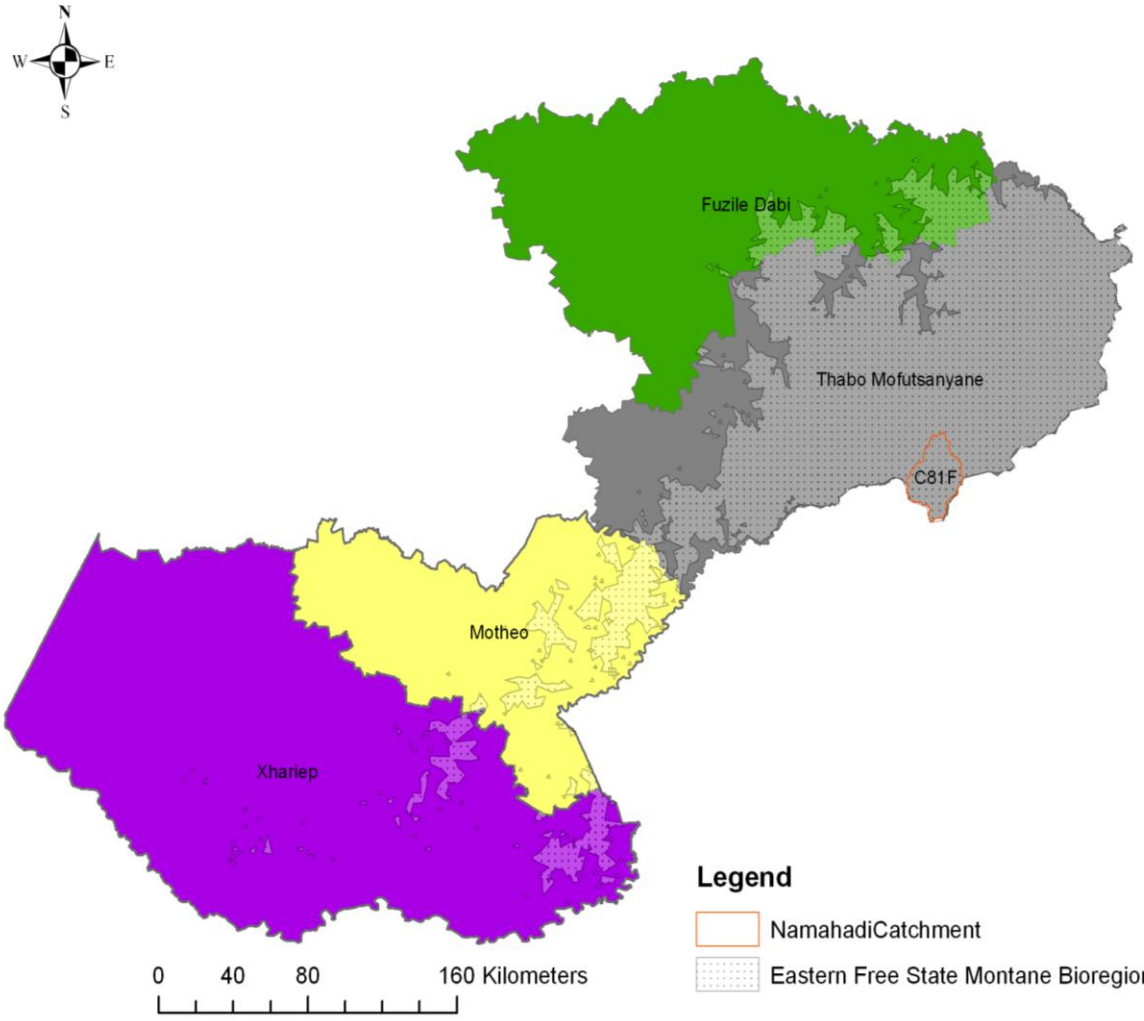
Location of Study Area

Location: -28.370 to -28.776 degrees South, and 28.694 to 28.972 East



Eastern Free State Montane Bioregion



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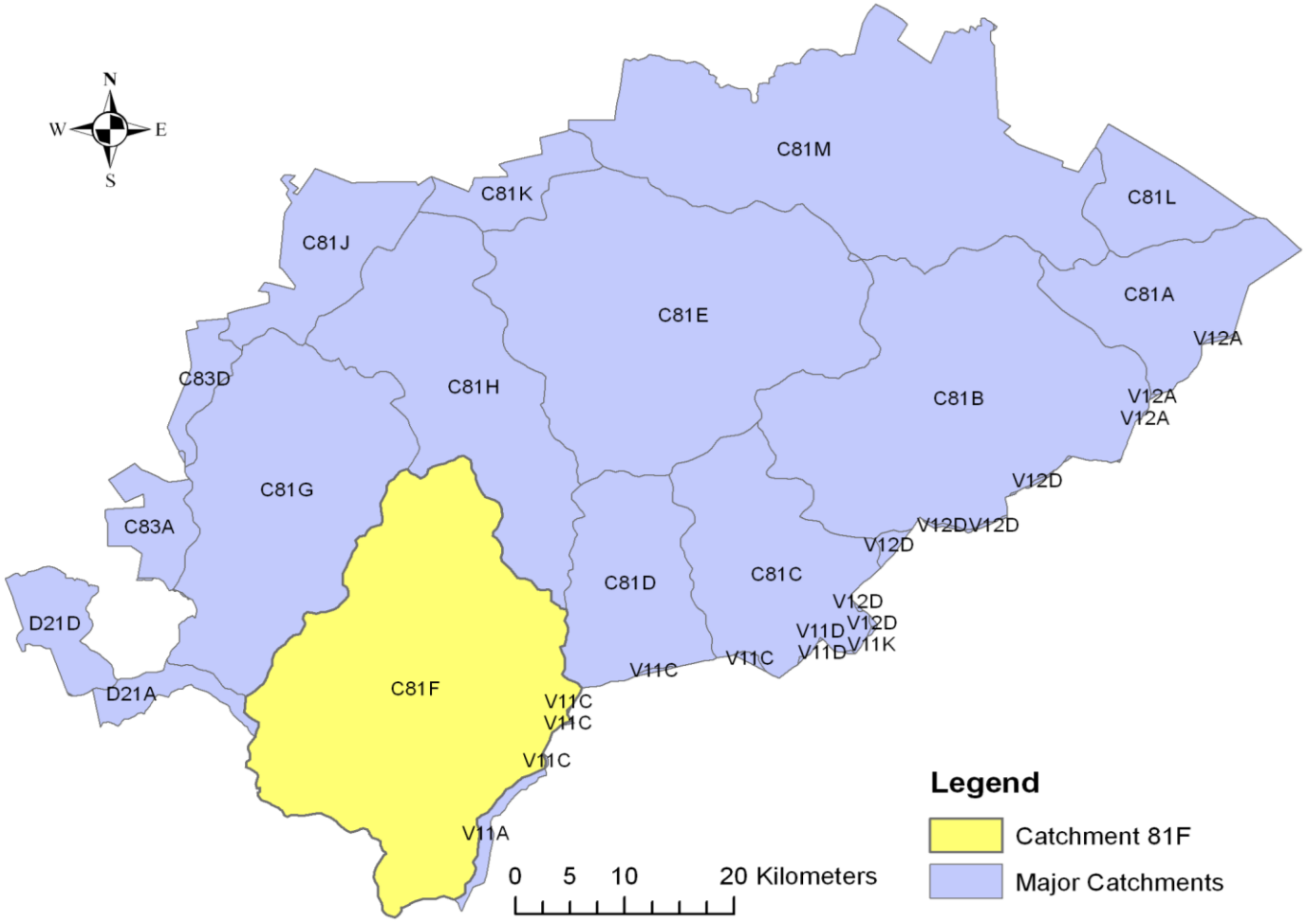
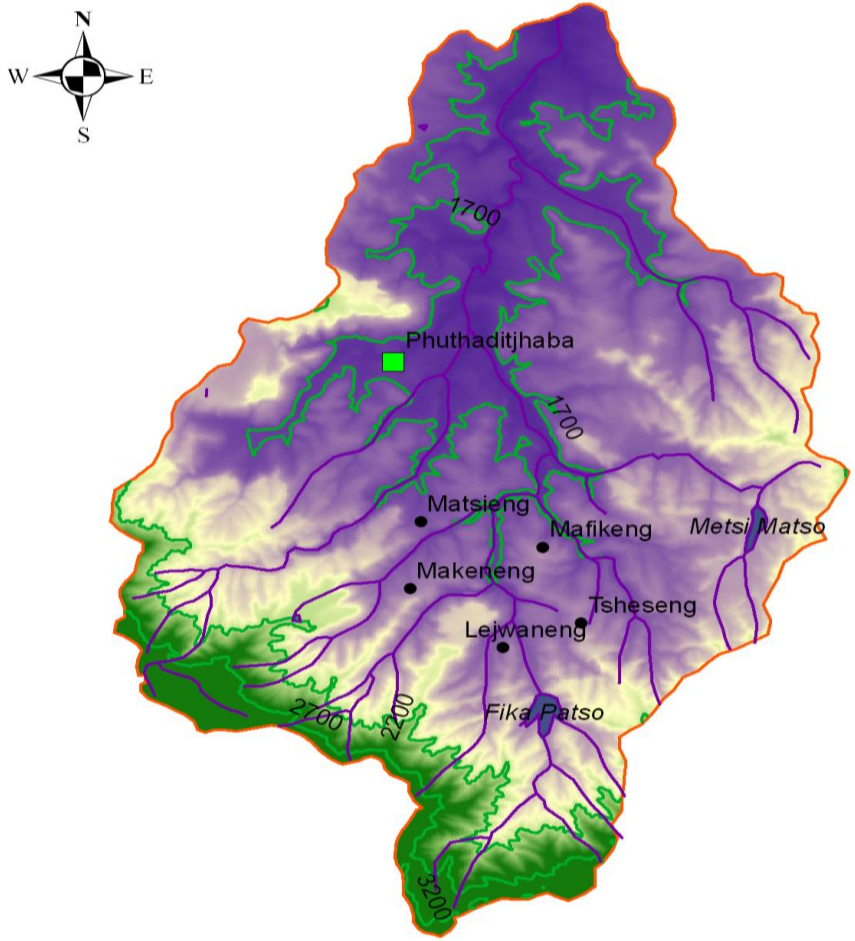
Catchment areas in Maluti-a-Phofung Municipality



Namahadi Catchment Area



Legend

- Villages
- Phuthaditjhaba
- Rivers
- Altitude (Masl)
- Reserviors
- Catchment Boundary

Namahadi Catchment (Masl)

High : 3275

Low : 1616

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Description of Study Area

- The Namahadi Catchment Area (NCA) is located in the Maluti-Drakensberg Mountains, a unique Afro-Alpine region in southern Africa.
- Precipitation ranges between 635 mm and 650 mm per annum
- Maximum temperatures range from 15 Degrees Celsius in winter to 26 Degrees Celsius in summer, while average minimum temperatures range between -1 Degree Celsius to 5 Degrees Celsius in winter and summer, respectively.
- Home to a rich diversity of plant and animal species

- Characterized by a variety of landscapes, rare ecosystems and endemic species
- Agricultural economy – cereals, dairying and beef
- The Maluti-Drakenberg Mountain Region accounts for about 25% of water supply in South Africa and supporting almost 50% of the country's GDP
- It contributes significantly to all water-related economic activities downstream, including agriculture, tourism and manufacturing

Problem Statement

- Climate change is a threat to ecosystem goods and services derived from the Afro-Alpine region
- Impacts of climate change are expected to be disproportionately higher in mountainous regions than in other regions (Bhusal *et al.* 2016).
- This undermines the South African economy and rural livelihoods
- High mountain vegetation is generally considered to be particularly vulnerable to climate change (Pauli, 2014).

- Paucity of historical data about which areas of this Afro-Alpine region are affected by climate change.

- Reliable records on climate data do not exist for the greater part of the area due to inaccessibility of some areas within the region.

- Without reliable data on climate change the state of vegetation health can be used as a sensitive "ecological indicator" for climate change effects (Pauli, 2014).

Research Question and Objective

Research Question:

- In what way has climate change impacted vegetation in the NCA and what spatiotemporal forms have the impacts taken?

Research Objective:

- To assess how climate change has impacted vegetation and determine the spatiotemporal forms that the impacts have taken.

Methodology

- Gridded precipitation and temperature data for the NCA were acquired from Climate Explorer for the period 1960-2014
- The data source was CRU-TS and the resolution was 0.5 X 0.5 degrees
- Standardized Precipitation Index (SPI) values were calculated from the rainfall data while temperature data were used to divide the time series into epochs
- McKee's et al (1993) classification was used to classify precipitation

McKee et al (1993)

Table 1. SPI values

2.0+	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-.99 to .99	near normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry
-2 and less	extremely dry

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- Sequential Regime Shift Detection Software (RSDS) – Version 6.1 (Rodionov, 2015) was used to determine epochs

- Normalized Difference Vegetation Index (NDVI) values were calculated from Landsat 8 images for the last 2 drought years (one in each epoch) and 2 years of normal precipitation in the second epoch.

- NDVI values for equidistantly distributed points were extracted at a 0.005 X 0.005 degrees resolution and kriged in an ArcGIS (Version 10.3) environment to determine spatial variability of vegetation health.

RESULTS AND DISCUSSION

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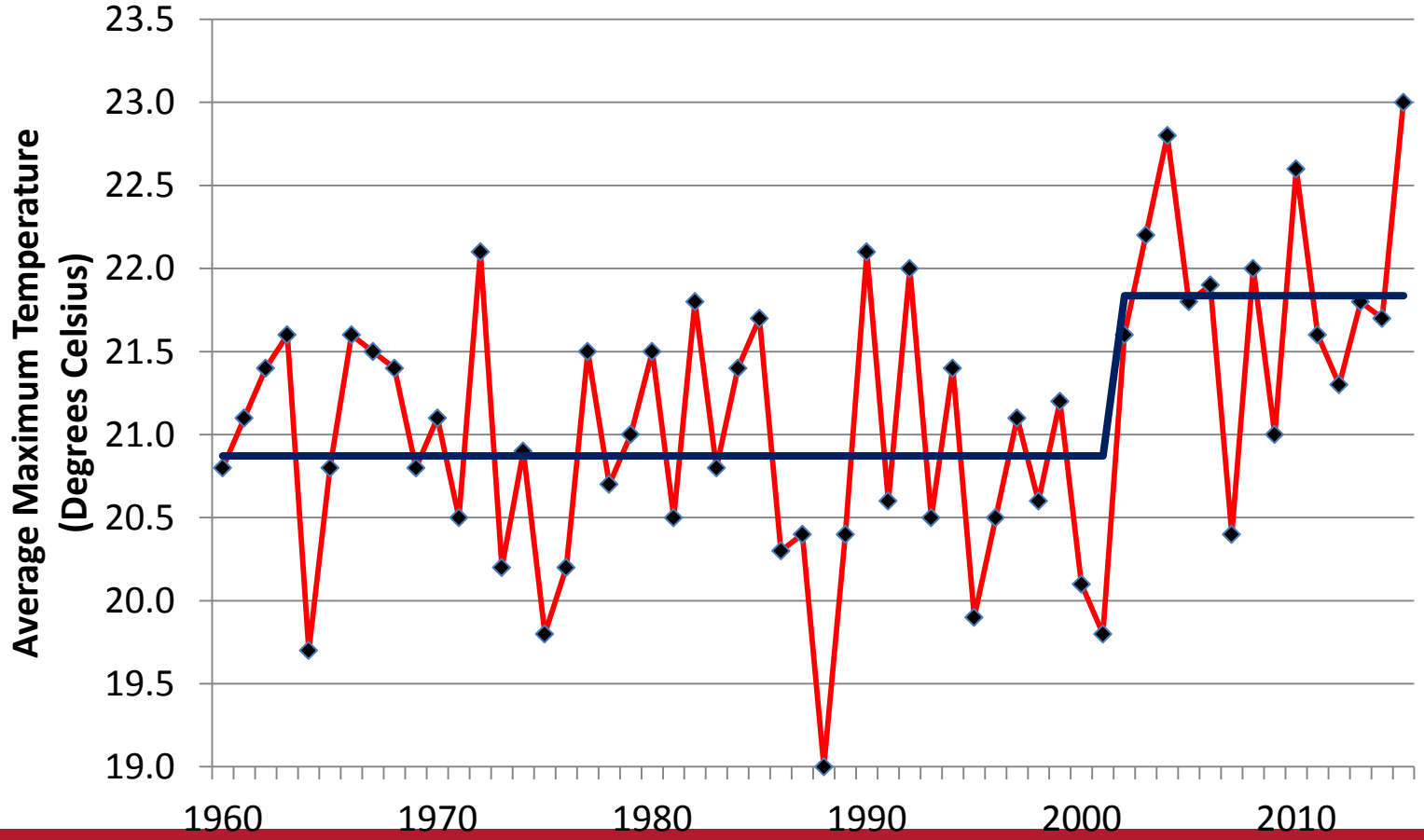
Trends in Average Maximum Temperature



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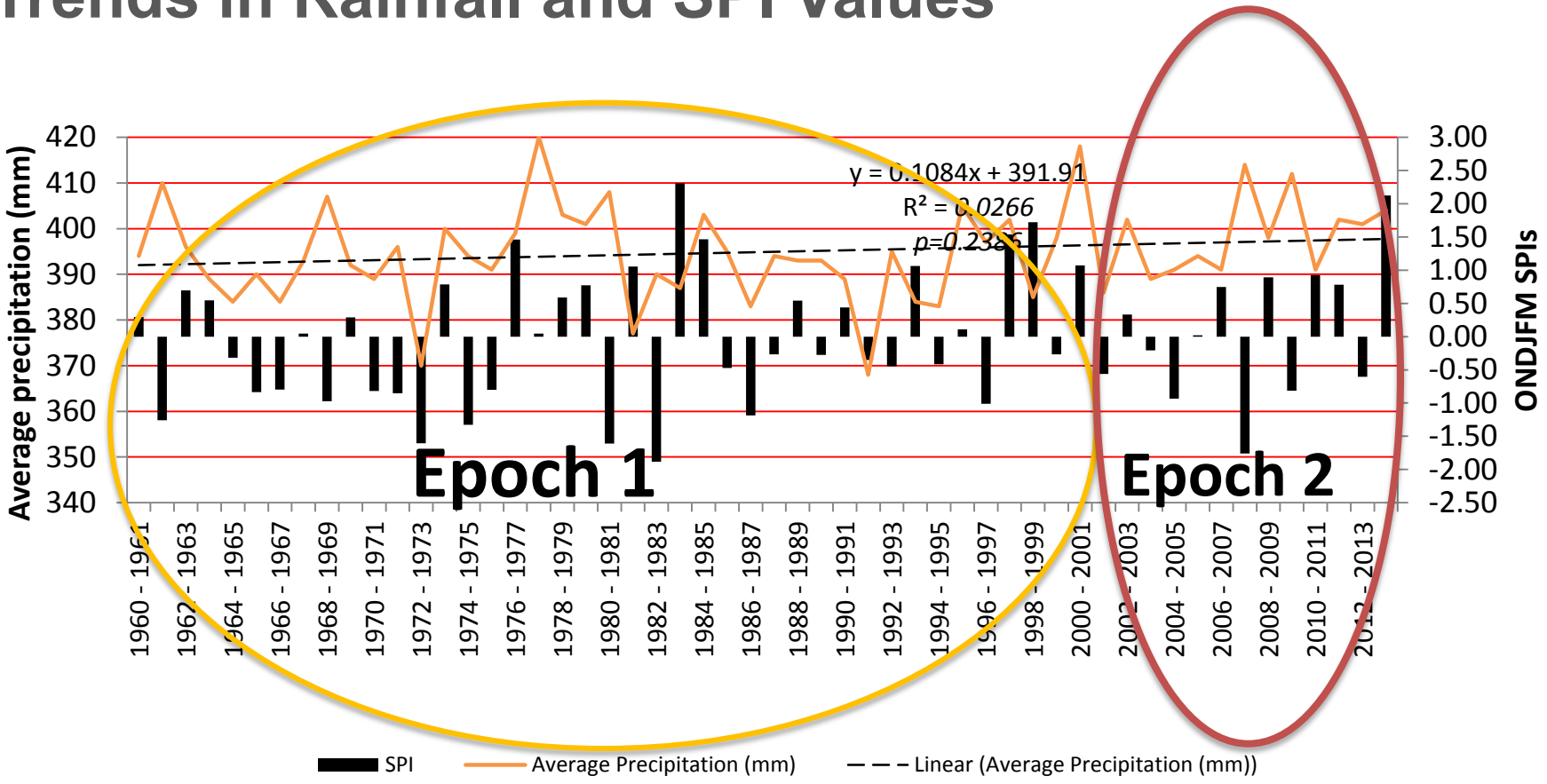
- SRDS revealed two epochs – one between 1960 and 2001, and another during the post 2001 period.

- Average maximum temperature in NCA was 20.9 Degrees Celsius between 1960 and 2001, compared to 21.8 Degrees Celsius in the post 2001 epoch (p=0.000155)

- Average maximum temperature increased by 0.9 Degrees Celsius

Trends in Rainfall and SPI Values



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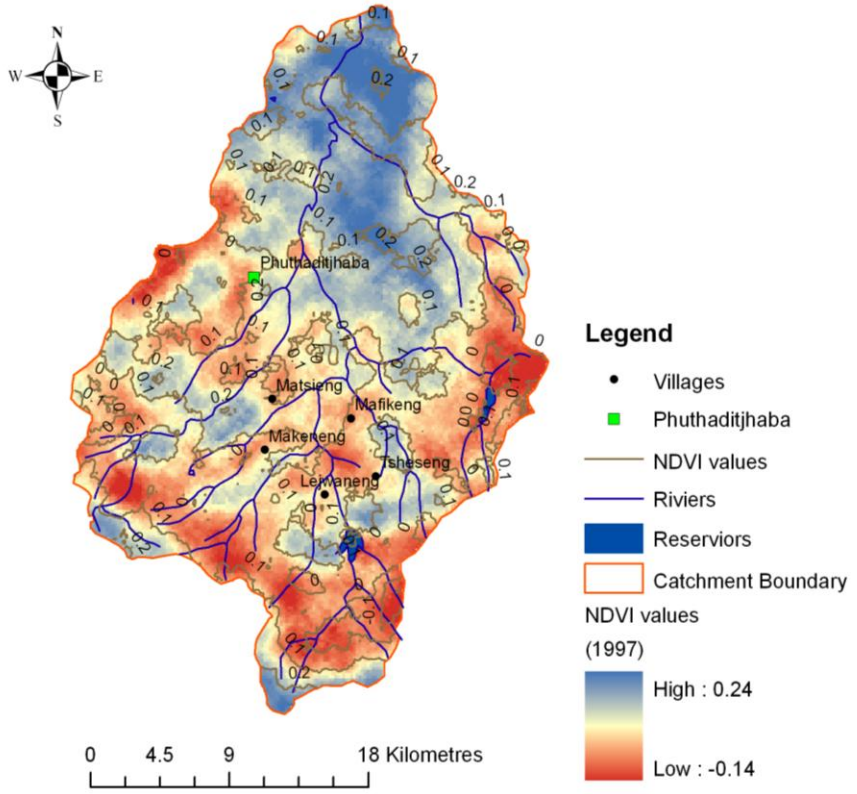
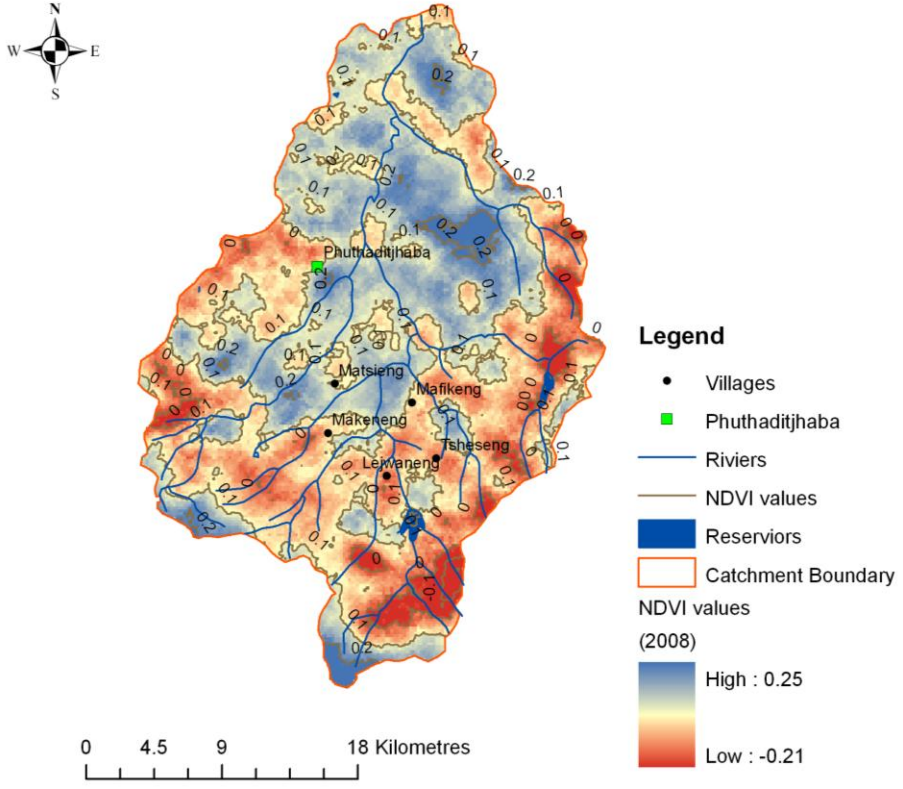
- Precipitation has increased during the study period
- During the first epoch drought frequency was 1 per every 5.3 years, compared to 1 in 17 years in the second epoch

NDVI Values for 1997 and 2008 Droughts





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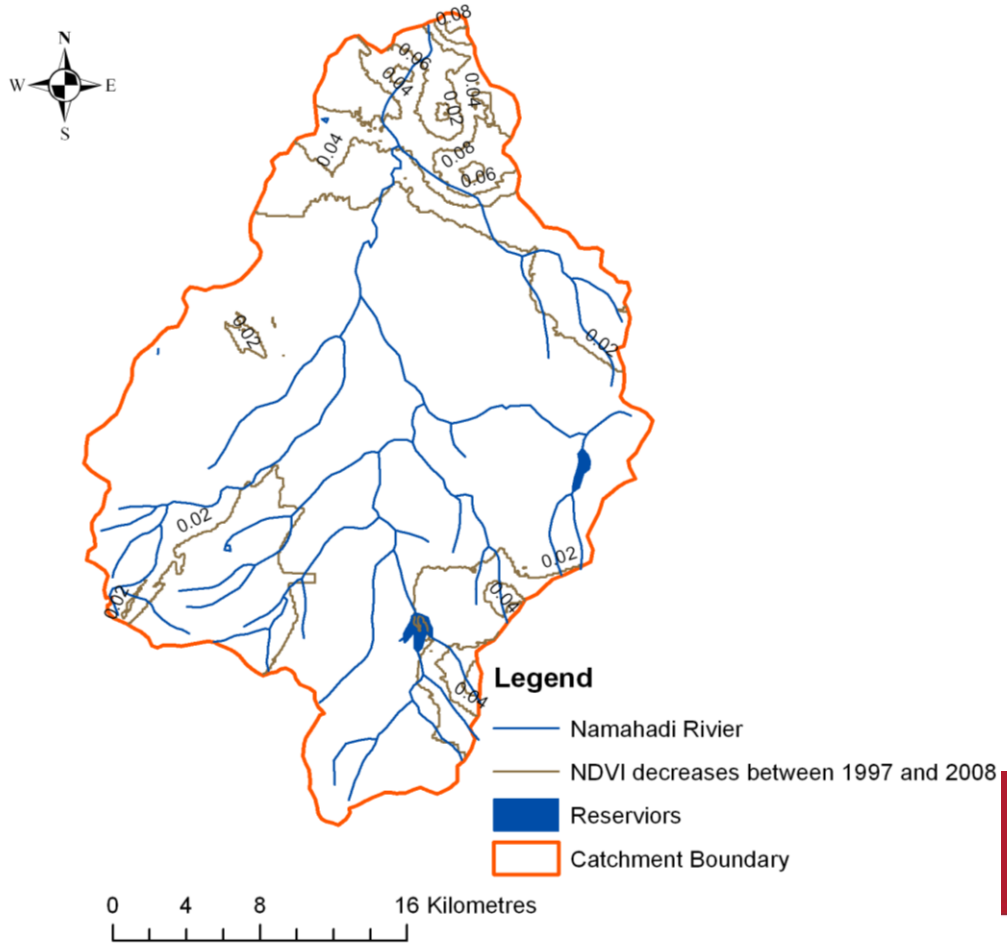
Areas Where Vegetation Deteriorated Most



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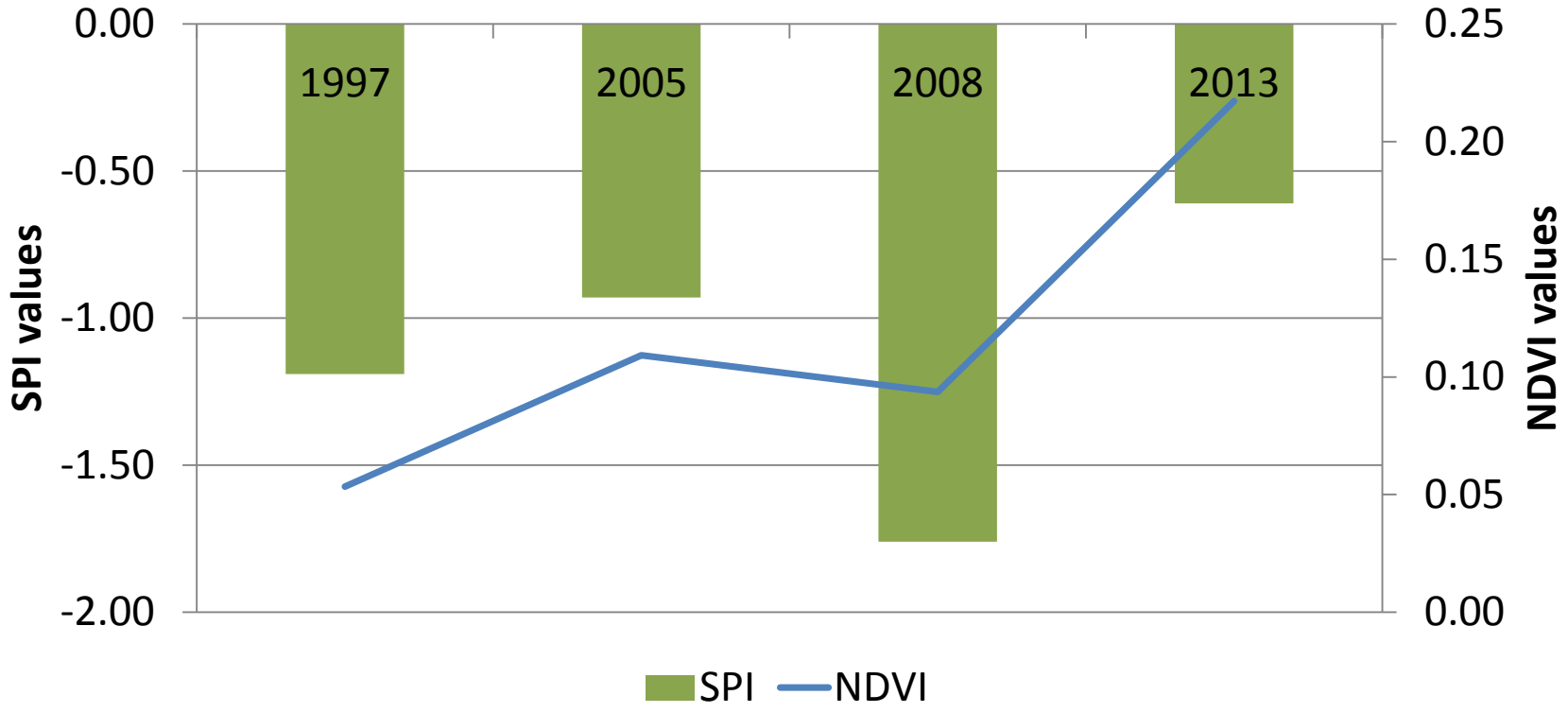
Relationship Between SPI and NDVI Values



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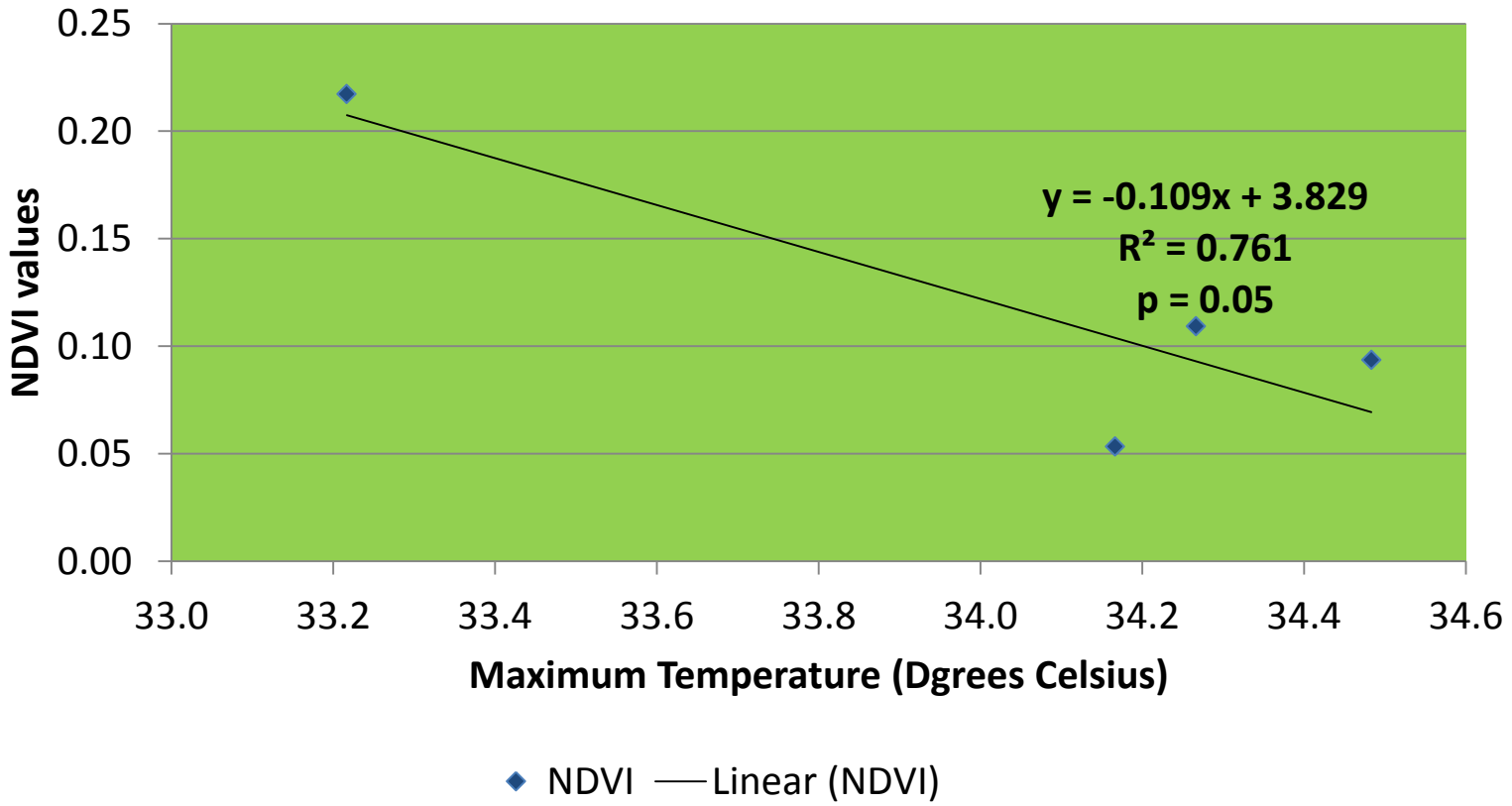

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ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
NDVI values for 1997	Between Groups	10.837	3	3.612	6660.655	.000
	Within Groups	1.373	2532	.001		
	Total	12.210	2535			
NDVI values for 2005	Between Groups	6.763	3	2.254	252.699	.000
	Within Groups	22.589	2532	.009		
	Total	29.352	2535			
NDVI values for 2008	Between Groups	3.411	3	1.137	653.342	.000
	Within Groups	4.407	2532	.002		
	Total	7.818	2535			
NDVI values for 2013	Between Groups	.232	3	.077	17.768	.000
	Within Groups	11.033	2532	.004		
	Total	11.265	2535			

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How Has Vegetation Health Changed in Response to Climate Change?

- Positive relationship between SPI values and average NDVI values, with a correlation coefficient of 0.68
- Negative relationship between NDVI values and Maximum Temperature, with a correlation coefficient of -0.87
- The differences between the mean NDVI values for different years are statistically significant

Conclusion

- Climate change has occurred in NCA, where both precipitation and maximum temperature have increased
- Increase in precipitation is not statistically significant
- The frequency of drought has decreased during the study period
- The effect of climate change on vegetation in the NCA is spatially variable
- Both the increase of precipitation and maximum temperature are related to the variability to the state of vegetation health in the catchment

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- It is difficult to conclude whether precipitation or maximum temperature is the dominating factor in determining the state of vegetation health
- In the NCA monitoring changes in NDVIs can be used for improving environmental planning and for mitigating climate change
- Further research involving the use of the **Standardized Precipitation and Evaporation Index (SPEI)** is needed in order to check the synergistic effect of precipitation and temperature on vegetation health

Reference

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- Pauli, H., Gottfried, M. and Grabherr, G., 2014. Effects of climate change on the alpine and nival vegetation of the Alps. *Journal of mountain ecology*, *7*: 1-4.

Thank You

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