SEASONAL DROUGHT PATTERN CHANGES DUE TO CLIMATE VARIABILITY IN AFGHANISTAN

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DEDICATION

This project report dedicated to my parents who have always been an incredible source of support and encouragement through my entire study life, and my beloved wife and daughter who eased this journey to be happened with their genuine love and encouragement. And to my brother and sisters whom I am proudly grateful for having them in my life. Also this work is dedicated to all my friends and each individual who contributed towards my Master study. Ishanch couldn’t have been a success without your genuine support and prayers.

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ABSTRACT

This study assessed the changes in meteorological droughts severity and its return periods during cropping seasons of Afghanistan for the period 1901-2010. Reconstruction of droughts for the country was conducted using standardized precipitation evapotranspiration index (SPEI). Global precipitation climatology center (GPCC) rainfall and climate research unit (CRU) temperature data both at 0.5º resolutions were used for this purpose. Seasonal droughts return periods were estimated using the values of the SPEI fitted with the best distribution function. Unidirectional trends in climatic variables and SPEI were assessed using modified Mann-Kendal trend test, which has the ability of removing the influence of long-term persistence on trend significance. The study revealed increases in drought severity and frequency in Afghanistan over the study period. Temperature, which increased up to 0.14 º C/decade, is the major factor influencing decreases in the SPEI values at the northwest and southwest of the country during rice and corn growing seasons, while increasing temperature and decreasing rainfall are the cause of decrease SPEI during wheat growing season. The study concluded that temperature plays a more significant role in decreasing the SPEI values and therefore, more severe droughts in future due to global warming.

ABSTRAK

Kajian ini dijalankan bagi menilai perubahan tahap keterukan dan kala kembali kemarau meteorologi semasa musim tanaman di Afghanistan dalam tempoh waktu 1901 hingga 2010. Pembinaan semula kejadian kemarau untuk negara ini telah dijalankan dengan menggunakan indeks sejatpeluhan (SPEI). Curahan yang diperolehi dari pusat curahan dan iklim sejagat (GPCC) dan unit penyelidikan iklim (CRU) kedua-duanya pada resolusi 0.5º digunakan untuk tujuan ini. Kala kembali bagi kemarau bermusim dianggarkan dengan berasaskan nilai SPEI dari fungsi pengagihan yang disesuaikan. Corak peralihan dalam pembolehubah iklim dan SPEI dinilai melalui ujian Mann-Kendall yang diubahsuai, yang mampu menyaring kesan terhadap pengaruh corak jangka panjang. Kajian ini menunjukkan peningkatan tahap keterukan kejadian kemarau dan kekerapannya di Afghanistan sepanjang tempoh kajian ini. Suhu yang meningkat sehingga 0.14 º C/dekad didapat menjadi factor utama yang mempengaruhi penurunan nilai SPE dibaratlaut dn baratdaya negara semasa musim penanaman padi dan jagung, manakala peningkatan suhu dan pengurangan hujan adalah punca penurunan SPEI semasa musim penanaman gandum. Kesimpulannya dari kajian ini mendapati pengaruh penurunan suhu memainkan peranan yang lebih penting dalam pengurangan nilai SPEI yang mempengaruhi fenomena kemarau yang lebih teruk pada masa hadapan disebabkan oleh pemanasan global.

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LIST OF ABBREVIATIONS

CRU - Climate Research Unit
GPCC - Global Precipitation Climatology Centre
LTP - Long Term Persistence
MMK - Modified Mann-Kendall
PDF - Probability Distribution Function
PET - Potential Evapotranspiration
RPs - Return Periods
SPEI - Standardized Precipitation Evapotranspiration Index
UTM - Universiti Teknologi Malaysia
CRU - Climate Research Unit
GPCC - Global Precipitation Climatology Centre

LIST OF SYMBOLS

α	-	Scale Parameter
β	-	Shape Parameter
γ	-	Origin Parameter
F	-	Drought occurrence probability
F’	-	Non-Exceedance drought probability

CHAPTER 1

INTRODUCTION

1.1 Overview

The changes in global energy balance due to warming have changed the patterns of the atmospheric variables (Salman et al., 2017; Khan et al., 2019; Ahmad et al., 2019). The global temperature rises in particular has influenced the occurrence of droughts as well as its frequency and severity in many regions (Mishra and Singh 2011; Ahmad et al., 2016; Shiru et al., 2019). Water availability is the main element that changes in response to the changes in drought patterns (Ahmad et al., 2018) and thus, it is an important for defining water stress, agricultural productivity and food security (Farooq et al., 2009; Samarah et al., 2005; Lake et al., 2003; Trenberth et al., 2014). Compared to other natural disasters, droughts are unique due to their slowly onset and their often-prolonged occurrence (European Commission, 2017). As its effects accumulate slowly over time, the determination of its onset, duration, and termination are ambiguous (Wilhite et al., 2007). Therefore, the impact of droughts on agriculture is much more devastating compared to other natural disasters (Wilhite et al., 2014). Drought of 1998 in Oklahoma caused loses in agriculture exceeding US$2 billion (Thurman, 2019). Droughts caused severe famine in the horn of Africa between 2011 – 2012, and projections have shown the likelihood of increased droughts in future (Shiru et al., 2019) which would affect agriculture (Kalaugher et al., 2017).

The variability of climate has devastating impacts on droughts characteristics particularly in areas that are arid or semi-arid. Hence, the consequences of climate change are remarkably affecting drought patterns and are having far-reaching impacts on several human benefits including social, economic, agricultural, and environmental benefits (Dale et al., 2015; Miyan, 2001). Comprehending the association between climate variability and droughts pattern is vital for discerning the changes in droughts due to changes in climate (Wilhite et al., 2007). However, such relationship is highly vary widely from one region to another (Rezaeianzadeh et al., 2016) which emphasizes the need for more region specific studies. Besides, the coinciding of droughts with the cropping season could be more devastating due to crops water demands during such periods, understanding of meteorological droughts during different cropping seasons is paramount for sustainable agricultural practices.

Among the all hydro-climatic disaster, droughts are more devastating in term of social and economic impacts in Afghanistan. Severe droughts for longer duration often cause crop damage for successive years and force large migration of population from drought prone regions. A recent report estimated that more migration due to droughts compared to long wars and conflicts in Afghanistan (Figure 1.1). Climate change will certainly change different properties such as duration, severity and areal extents of droughts. Understanding ongoing changes in hydro-climate and droughts are essential for planning necessary adaptation and mitigation planning. Therefore, studies in this regard is highly important for Afghanistan.

Figure 1.1 People fled from mountainous villages after they had lost their owned livestock and crops for drought hazard. (Adopted from BBC-News)

1.2 Problem Statements

Afghanistan is frequently ranked among the countries most vulnerable to climate change due to a combination of low adaptive capacity and high exposure to climate fluctuations. Over the past four decades, armed conflict has destroyed the country's infrastructure, damaged its institutions, and led to widespread poverty and underdevelopment, which collectively underpin Afghanistan's vulnerability and lack of adaptive capacity to climate change (Figure 1.2).

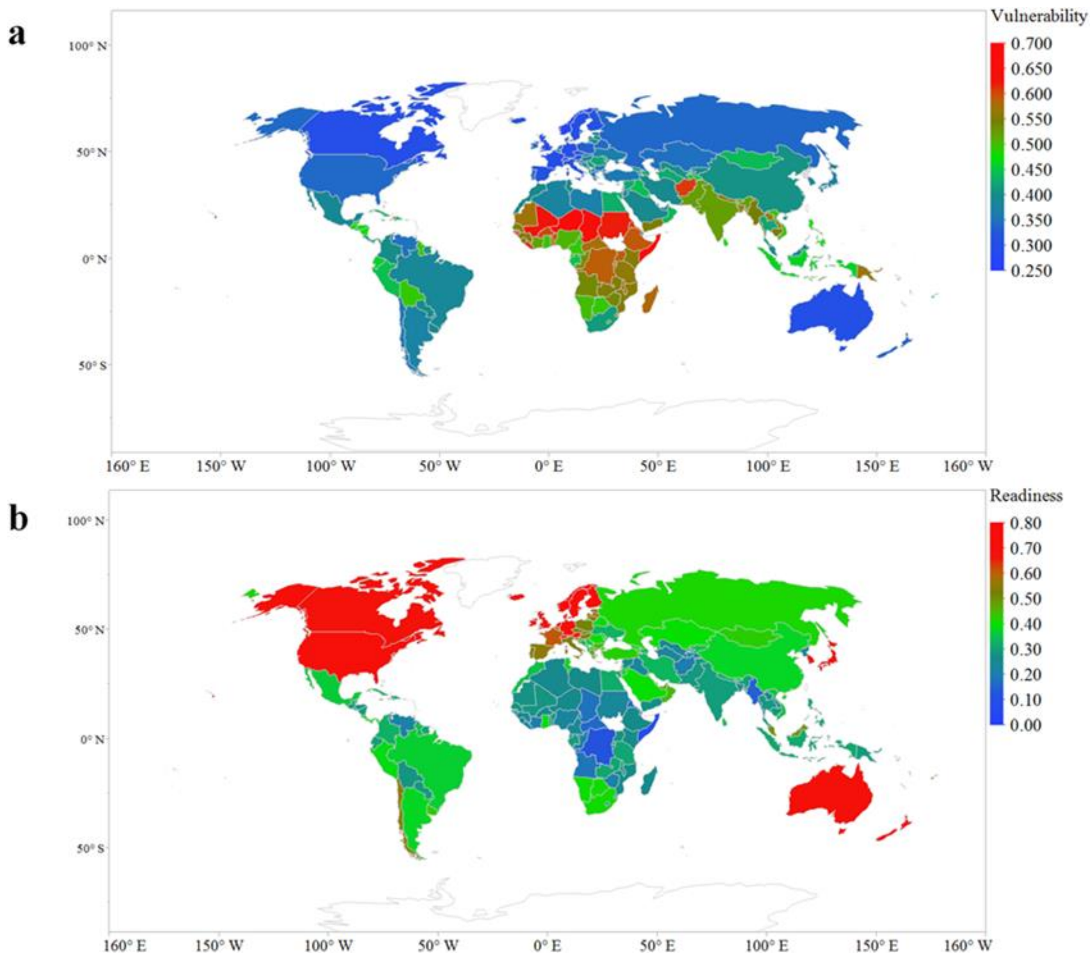

Figure 1.2 showing geographical mean of vulnerability and adaptation readiness indicators of climate change. (a) Vulnerability [mean range: 0.25–0.70]; (b) readiness [mean range: 0.00–0.80] (Adopted from: Sarkodie and Strezov, 2019)

The population and the economy are almost completely dependent on agricultural production, particularly subsistence farming and key sectors, including water, energy, agriculture, are among the most vulnerable to climate change. The country is regularly hit by extreme weather or climatic events, causing substantial economic damage and loss of lives, showing that even today Afghanistan is not sufficiently adapted to the current climate (Figure 1.3).

Figure 1.3 ongoing drought leaving communities in deep distress, many cattle and sheep died from hunger. (Adopted from https://www.unocha.org/)

Afghanistan being a semi-arid to arid area is prone to droughts and prolonged droughts are commonly occurring in the country. The country receives a meagre precipitation of between 200 – 400 mm per annum (Reddy and Saranya, 2017) indicating the significance of natural resource management and requirement of adaptation and mitigation measures against climate change. The changing climate in the country will significantly affect most rural communities where water, soil, forests, and grazing areas are very essential factors (Atef et al., 2019)(Figure 1.4). The climate change impacts on water resources have been reported in Afghanistan e.g. impaction of the glacier and snowmelts feeding the Kabul River which has caused an increase in a trend; shifting the river basins seasonal monsoons (Atef et al., 2019).

Figure 1.4 water shortages worsen in rural areas as drought persist (Adopted from https://www.independent.co.uk/)

According to United Nation (2018) report the worst drought in recent history, that hit two out of three provinces in Afghanistan, has destabilized the lives of tens of thousands of civilians, some of whom have already been displaced, United Nation reported. The United Nation has predicted that over two million people are expected to become severely food insecure in the coming period in Afghanistan. Among the most vulnerable are women and children (Figure 1.5).

Climate of Afghanistan is changing in the line of global climate change. Though there are very limited study on climate change in Afghanistan, the studies in nearby countries revealed rises in temperature and changes in precipitation in the region. Changes in mean and variability of climate significantly changes the probability of extremes. Therefore, it can be clearly anticipated that global warming induced climate change will cause an increase in hydro-climatic extremes in Afghanistan and make aggravate the existing condition.

Figure 1.5 Destabilized people due recent drought in Afghanistan (adopted from Norwegian Refugee Council-2018).

It is anticipated that the changes in climate have changed the characteristics of droughts in Afghanistan. However, owing to high diversity of climate and various patterns of the changes in climate in different regions and seasons, the impact of climate change would have a different impact on droughts in different parts of the country. Furthermore, the influence of climate on droughts can also vary with time. Besides, it is important to assess the climate change impacts on droughts during cropping season as the droughts are found to be more destructive when they occur during cropping seasons.

1.3 Research Goal

1.3.1 Research Objectives

The general objective of the study is to analyse impact of climate changes and variability on drought characteristics during two major cropping seasons (Summer and Winter) over the diverse climate of Afghanistan. The specific objectives are:

(a) To validate gauge-based gridded rainfall and temperature data for hydro-climatic study in Afghanistan using available observed data.

(b) To assess the changes in meteorological drought and drought return period during cropping seasons in Afghanistan.

(c) To use standardized precipitation evapotranspiration index (SPEI) for the reconstruction of historical droughts of Afghanistan for the period 1901-2010.

(d) To prepare maps for spatial assessment of the changes in climate and droughts.

(e) To assess the trends in droughts for different 50-year periods with a 10-year moving window over the period 1901-2010 to understand the influence of climatic variables on droughts.

1.3.2 Scope of the study

The scope of the study are outlined below:

(a) The proposed study will be conducted within the geographical boundary of Afghanistan. The gridded rainfall data GPCC and temperature data of CRU are used for the assessment of droughts.

(b) The droughts were reconstructed using SPEI where Thorn Waite method was used for the estimation of evapotranspiration.

(c) Non-parametric Mann-Kendall test was used for the assessment of trends in climate and droughts.

1.3.3 Significant of the study

Drought is a long term resulting phenomena which has crucial consequences on livelihood and regions crops production (Figure 1.6). Afghanistan is agricultural based country with widely exposed of climate change vulnerability. The impact of climate change is supposed to be different for different climatic regions. It is expected that the assessment of the changes in seasonal drought characteristics over a diverse climate of Afghanistan would help to understand how future climate variations may affect droughts in different types of climates and cropping seasons. The maps of drought severity and intensity developed in this study can be used to assist decision makers in providing suitable mitigation measures.

Figure 1.6 Crops failure due drought (adopted from https://www.feedstrategy.com/)

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