SPATIO TEMPORAL PATTERN IN THE CHANGES IN AVAILABILITY AND SUSTAINABILITY OF WATER RESOURCES IN AFGHANISTAN

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Hydraulic & Hydrology)

School of Civil Engineering
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DECEMBER 2019

DEDICATION

This project report dedicated firstly to my parents and my brothers whom put their hands together and sacrificed their lives to make me grow and develop. Secondly to my wife that really helped me during my work. Finally this project report is dedicated to all researchers and students who work in this field.

ACKNOWLEDGEMENT

In preparing of this project report, I have had close contact with many researchers, academicians, and practitioners. They have contributed towards my and thoughts developments through their literatures and oral guidance. I wish to express my sincere appreciation to my main supervisor Associate Professor Dr. Shamsuddin Shahid for the encouragement, critics, guidance and friendship. Furthermore I am also very thankful to my co-supervisors Professor Dr. Xiaojun Wang for his supportive guidance and motivations. Without their continued support and interest, this project report would not have been the same as presented here.

I wish to thank again from Associate Prof. Shahid and his family, for giving love to me and my family. The frequent of invitations and hostings at your home, the many gifts to my sons are greatly appreciated. It was always a great feeling to join at your home.

I am also indebted with to Afghanistan ministry of education through higher education development program (HEDP) for funding my master study.

Finally, my immense gratitude goes to my parents, wife, children and siblings, I thank you all for your unending support, encouragement, and love. This would not have been possible without you.

ABSTRACT

Water is gradually becoming scarce in Afghanistan like in many other regions of the globe. The objective of this study was to evaluate the spatial changes in the availability and sustainability of water resources in Afghanistan. The Terrestrial Water Storage (TWS) data of the Gravity Recovery and Climate Experiment (GRACE) satellite obtained from three different institutes, having 1° × 1° spatial resolutions for the period 2002–2016 was used for this purpose. Sen's slope method was used to assess the rate of change, and the Modified Mann–Kendall test was used for the evaluation of the significance of trends in TWS. After, the concept of reliability–resiliency–vulnerability (RRV) was used for assessing the spatial distribution of sustainability in water resources. The results revealed a significant decrease in water availability in the country over the last 15 years. The decrease was found to be highest in the central region where most of the population of the country resides. The reliability in water resources was found high in the northeast Himalayan region and low in the southwest desert; resilience was found low in the central region, while vulnerability was found high in the south and the southeast. Overall, the water resources of the country were found most sustainable in the northeast and southwest and least in the south and the central parts. The maps of water resource sustainability and the changes in water availability produced in the present study can be used for long-term planning of water resources for adaptation to global changes. Besides, those can be used for the management of water resources in a sustainable and judicious manner.

ABSTRAK

Air secara beransur-ansur menjadi kurang di Afghanistan seperti di banyak kawasan lain di dunia. Objektif kajian ini adalah untuk menilai perubahan spasial dalam ketersediaan dan kelestarian sumber air di Afghanistan. Data Penyimpanan Air Darat (TWS) dari satelit Pemulihan Graviti dan Eksperimen Iklim (GRACE) diperolehi dari tiga institut yang berbeza, yang mempunyai resolusi spasial 1° × 1° untuk tempoh 2002-2016 telah digunakan untuk tujuan ini. Kaedah kecerunan Sen digunakan untuk menilai kadar perubahan, dan ujian Ubah Suaian Mann-Kendall digunakan untuk penilaian arah aliran yang signifikan dalam TWS. Selepas itu, konsep kebolehpercayaan-kelangsungan-kerentanan (RRV) tealh diguna untuk menilai pengagihan spasial bagi kelestarian dalam sumber air. Hasilnya menunjukkan penurunan yang signifikan dalam ketersediaan air di negara ini dalam tempoh 15 tahun yang lalu. Penurunan ini didapati tertinggi di rantau tengah di mana kebanyakan populasi di negara ini tinggal. Kebolehpercayaan sumber air didapati tinggi di wilayah timur laut Himalaya dan rendah di padang pasir barat daya; kelangsungan ditemui rendah di rantau tengah, manakala kerentanan didapati tinggi di selatan dan tenggara. Keseluruhannya, sumber air negara didapati paling lestari di timur laut dan barat daya dan paling kurang di selatan dan bahagian tengah. Peta kelestarian sumber air dan perubahan ketersediaan air yang dihasilkan dalam kajian ini boleh digunakan untuk perancangan sumber air jangka panjang bagi penyesuaian dengan perubahan global. Selain itu, kaedah ini boleh digunakan untuk pengurusan sumber air dengan cara yang lestari dan bijaksana.

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LIST OF ABBREVIATIONS

CRU	-	Climate Research Unit
CSR	-	Center for Space Research
GFZ	-	German Research Center for Geosciences
GIS	-	Geographic Information System
GPCC	-	Global Precipitation Climatology Center
GRACE	-	Gravity Recovery and Climate Experiment
IPCC	-	Intergovernmental Panel on Climate Change
JPL	-	Jet Propulsion Laboratory
MMK	-	Modified Mann–Kendall
NASA	-	National Aeronautics and Space Administration
RRV	-	Reliability–Resiliency–Vulnerability
TWS		Terrestrial Water Storage
N		North
E		East
C		Centigrade
R		Rank
V		Variance
S		Sustainability

LIST OF SYMBOLS

+	-	Positive
-	-	Negative
%	-	Percentage
°	-	Degree
∞	-	Infinity
>	-	Greater than
<	-	Less than
ρ_l		autocorrelation function of lag l
×	-	Multiply

CHAPTER 1

INTRODUCTION

1.1 Background

One of the challenges faced by many countries around the globe today is attaining adequate water supply considering both increasing human water demands and looming climate-related changes. It has been projected that half of the population of the world may be faced with clean water shortage by 2080 (Morrison et al., 2009). Estimates by the Intergovernmental Panel on Climate Change (IPCC) show that by 2050, 2 billion people will not have access to clean supplies of water, which will double the number of people already lacking access to consistent safe supplies of water. Most parts of Asia will likely be more affected by water scarcity due to the fast rise in temperature and alteration in precipitation pattern (Ahmed et al., 2017; Nashwan et al., 2019; Hadi pour et al., 2019). The situation will be aggravated by groundwater pollution (Shahid, S, 2000) and continuous increase in population and lesser coping capabilities to climate change (Shahid et al., 2016; Wang et al., 2014; Wang et al., 2016; Ahmed et al., 2016).

Climate change has significant impacts on several sectors including agriculture, health, water resources, energy, and industry among others. Of these, the water resources sector will be the most affected by the variability of the climate, and this will subsequently impact other sectors (Nashwan et al., 2019; Ahmed et al., 2018; Shiru et al., 2019; Alamgir et al., 2019), causing severe economic loses.

Majority of population in the world is in danger of different types of the climate change impacts. Therefore, for mitigation of climate change impacts which effects our existence and environment, knowing the entire process of climate variables effects which had previously and may happen in the future is very important. Globally climate change impact would be more on developing countries due to their less mitigation plan

and worse adjustment abilities (Collins et al. 2013). Furthermore, these countries with high rate of population do not have proper awareness program in order to decrease climate change effects (Lee et al., 2015).

Droughts between other natural hazards, are riskier and can be continued until making their impacts very overwhelming and have become increasingly critical in recent years in most of countries in the world. Droughts can happen due to less precipitation, temperature increase, reducing the relative humidity and high winds. Additionally, they can occur in both dry and wet climates (Mishra and Singh, 2010). Among the different impacts of droughts on an environment or natural society, water shortage or scarcity is the major concern. Ensuring a sufficient amount of water is one of the greatest challenges nations are facing due to increasing human requirements and climate change impacts all over the world (NSF, 2011).

1.2 Problem Statement

Afghanistan, a semi-arid to arid nation receives between 200–500 mm rainfall per year and often faces prolonged droughts (Schimann, 2000). The 2017 Global Adaptation Index ranked Afghanistan as the 11th most vulnerable country worldwide to climate change (Chen et al., 2015). During the 30 years of conflicts and political fighting in Afghanistan, the country faces many different environmental issues that the principle causes is in water sector. Due to this devastating conflicts all water infrastructures was demolished all over the country and Afghanistan experienced prolonged drought from 1998 to 2002.

According to trans-boundary water, Afghanistan is located in upstream of the water basin and as a landlocked country all its major rivers drain off into neighbouring countries (Habib, 2014). Water availability for the purpose of irrigation in Afghanistan is dependent on effective rainfall as well as the availability of surface and groundwater resources, which in turn depend on the spatial and temporal distribution and amount of rainfall (Qureshi, 2002).

Although nearly half of the country has an arid climate, it is estimated that Afghanistan possesses 75 billion m^3 of potential water resources of which 20 billion cubic meters is groundwater (Klemm and Shobair, 1996). Around 98% of the 20 billion m^3 of annual water is used for agriculture (Mahmoodi, 2008), and the rest is used for domestic and industrial purposes. Three billion-m^3 of the total water usage is extracted from groundwater. This figure is expected to increase to 8 billion m^3 by the projected increase of water requirement of the domestic and irrigation use.

The rapid increase in water use has affected sustainability in water resources in Afghanistan. The changes in sustainability in water resources and the driving factor of the changes are required to understand for taking necessary adaptation measures and sustainable development of the country.

1.3 Research Goal

Terrestrial water storage (TWS) is the total land and subsurface water (Tomas et al., 2017). It represents all water in river, lakes, ice, soil, and groundwater and indicates the total water available at a location. TWS greatly affected by climate changes and human activities and acting a fundamental role in the global water cycle (Prakash et al, 2014). The goal of this study is to use TWS as the total water amount for assessment of the changes in water availability and sustainability in water resources of Afghanistan.

1.3.1 Research Objectives

The general objective of the study is to use the gravity remote sensing data for the assessment of the changes in sustainability in the terrestrial water storage of Afghanistan. The specific objectives including:

1. To map the spatial distribution of annual and seasonal variability in terrestrial water storage in Afghanistan.

2. To assess the trends in annual and seasonal amount of water storage in Afghanistan

3. To evaluate the changes in sustainable in terrestrial water storage using the concept of resilience-reliability-vulnerability

4. To assess the impacts of climate variability and changes in sustainability in water storage of Afghanistan

1.3.2 Scopes of the Study

This study primarily aimed to assess the spatial and temporal changes in availability and sustainability of terrestrial water resources, finding the annual and monthly trend in water availability and also to assess the impact of climate variability in water resources. The scopes of the study are outlined below:

1. The proposed study will be conducted within the geographical boundary of Afghanistan using Gravity Recovery and Climate Experiment (GRACE) data

2. Estimation of the changes in the trends and sustainability in terrestrial water storage (TWS) for the period of 2002 – 2016. Due to unavailability of gauged based data, the satellite based gridded GRACE data was used as it's available for this time span.

3. Non-parametric Mann-Kendall test was used for the assessment of trends and Sen's slope was used for the evaluating the significant of the change in terrestrial water storage (TWS).

4. The concept of reliability-resiliency-vulnerability (RRV) will be used for the assessment of sustainability in terrestrial water storage (TWS)

1.4 Significant of the Study

A number of maps will be prepared in the present study to show the spatial and temporal distribution of terrestrial water storage (TWS) in different climate zones in Afghanistan. There will be figures that shows the trends and significant of the changes in TWS which was obtained by using Non-parametric Mann-Kendall and Sen's slope methods. And finally maps will be prepared in three solutions (CSR, GFZ and JPL) for sustainability which is a function of reliability, resiliency and vulnerability in terrestrial water storage TWS. The maps can be used for water resources management planning. The trends in terrestrial water storage (TWS) can be used to understand the impacts of climate change on water resources in order to plan necessary adaptation. The maps of sustainability in water resources can be used for sustainable management of water resources of Afghanistan.

1.5 Project report Outline

This project report is separated into five chapters. Each of the chapter is described as follows.

In Chapter 1, there is a general introduction and comprises the study background, problem statements, research goals, objectives of the study, scope of the study, and the significance of the study.

Chapter 2 arranged for the general review of the literature related to the study, reviewing the papers which are used satellite based gridded GRACE data and the reviews are based on each of the objectives of the study.

In chapter 3 contains methodology used in the study. Study area description, data and sources, the details of the methods used for assessment of trends and significant of the change in water availability, sustainability in water resources and

assessment of the spatial patterns of the changes in terrestrial water storage (TWS) are given in this chapter.

In Chapter 4 obtained results according to each of the objectives of the study are presented. Discussions based on each of the objectives are also given in this chapter.

Lastly, Chapter 5 includes conclusions which obtained from the study and giving recommendations.

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