بسم الله الرحمن الرحيم

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تم رفع هذه الرسالة بواسطة / سلوي محمود عقل

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى مسئولية عن محتوى هذه الرسالة.

ملاحظات: لا يوجد

A NEW COMPOSITE INDEX FOR IDENTIFYING DROUGHT EVENTS: A CASE STUDY OF THE BLUE NILE RIVER BASIN

By

Marwa Ali Sayed Ali

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
in
Irrigation and Hydraulics Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

A New Composite Index for Identifying Drought Events: A Case Study of the Blue Nile River Basin

Key Words:
Composite Drought Index (CDI); Drought Indices; Blue Nile; Principal Component Analysis (PCA); Drought Monitoring

Summary:
Drought is a slow-onset phenomenon that evolves over a season or even years. Drought affects people more than any other natural disaster due to its widespread and significant negative impacts. Population growth and associated water demand add further stress to water resources, especially in periods of drought. Drought indices represent a single value resulting from processing a considerable amount of data. These indices provide a short message to stakeholders to adapt water resource management strategies. Since drought results from interconnected phenomena, designing a composite drought index that includes several drought indices can accurately capture drought events. Drought assessment over a large-scale basin (e.g., the Blue Nile) is a challenging objective that has not been deeply tackled before except for small portions of the basin. This research assessed droughts over the whole basin by evaluating meteorological, agricultural, and hydrological drought indices. The calculated drought indices (Standardized Runoff Index (SRI), Standardized Precipitation Index (SPI), and Standardized Soil Moisture Index (SSI)) in addition to the development of a new standardized evapotranspiration index (sETI) are jointly integrated into a novel composite drought index for the Blue Nile (BNI). The optimal weights for SPI, SRI, sETI, and SSI were 0.33, 0.26, 0.19, and 0.22, respectively, in the designed BNI.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Marwa Ali Sayed Ali Date: … /… / 2022

Signature:

Dedication

I dedicate this work to the memory of my beloved brother Mohammed Ali, who is no longer with us and has left a void in our lives that will never be filled. Despite the fact that your life was brief, I will ensure that your memory goes on for as long as I live. I love you and miss you beyond words. May Allah (SWT) grant you Jannah Firdaws. Amen.

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Table of Contents

List of Tables

List of Figures

Nomenclature

asl	above sea level
BN	Blue Nile
BNI	Blue Nile Drought Index
CDI	Composite Drought Index
CHC	Climate Hazards Center
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
CMIP5	Coupled Model Intercomparison Project Phase 5
CRU	Climatic Research Unit
D	Drought Duration
EM - DAT	Emergency Events Database
ENB	Eastern Nile Basin
GAR	Global Assessment Report on Disaster Risk Reduction
GLDAS	Global Land Data Assimilation System
GCM	Global Climate Models
I	Drought Intensity
LBN	Lower Blue Nile
LSMs	Land Surface Models
M	Drought Magnitude
MAP	Mean Areal Precipitation
NB	Nile River Basin
NDMC	National Drought Mitigation Center
PCA	Principal Component Analysis
PET	Potential Evapotranspiration
RCPs	Representative Concentration Pathways
RMSE	Root Mean Square Error
RS	Remote Sensing
S	Drought Severity
sETI	Standardized Evapotranspiration Drought Index
SM	Soil Moisture
SMrz	Soil Moisture in the root zone
SDGs	Sustainable Development Goals
SPI	Standardized Precipitation Index
SRI	Surface Runoff Index
SSI	Standardized Soil Moisture Drought Index
UBN	Upper Blue Nile
USGS	U.S. Geological Survey
WCRP	World Climate Research Project
WMO	World Meteorological Organization
WRF	Weather and Forecasting model

Abstract

Drought is a normal part of climate just like floods, and hurricanes. Although floods and hurricanes have a beginning, and end, drought is a slow-onset phenomenon that evolves over a season or even years. Drought affects people more than any other form of a natural disaster, due to its widespread and significant impacts on the environment, and the communities.

Egypt is the most sensitive country to any change within the Blue Nile (BN) system. The population growth and associated water demand will add high pressure in periods of droughts and will generate a long-term environmental, economic, and health impact on the population. Therefore, efforts should focus on improving drought management by enhancing resilience and early detection of droughts. Drought indices represent a single value that is a result of processing a huge amount of data. These indices are easy to convey an important message to diverse stakeholders. Since drought is a result of interconnected phenomena, many experts advise designing a composite drought index (CDI) which includes several types of drought indices and could capture the drought event more accurately.

Recently many studies have been carried out in different parts of the Blue Nile with a concentration in meteorological drought investigation using the Standardized Precipitation Index (SPI), and a few attempts using different indices. Up to now, no study investigated the whole basin nor developed a unique CDI for the BN.

The main objectives of this research are to develop a CDI namely, Blue Nile Drought Index (BNI), that will contribute to the drought assessment over the BN, and to propose a new index for the Evapotranspiration (ET) namely, the Standardized Evapotranspiration index (sETI). Moreover, we will assess the historical drought events over the basin at different timescales by using four drought indices namely, SPI, Standardized Runoff Index (SRI), sETI, and Standardized Soil Moisture Index (SSI).

We designed the BNI based on two approaches. The first one was the Principal Component Analysis (CPA), which is widely used for designing a combined index out of many variables. The second one is the Empirical Weight method (EW), which is recently used to show the effect of each index instead of giving equal weight. The BNI takes four agricultural and hydro-meteorological parameters into account (i.e., precipitation, runoff discharge, evapotranspiration, and root zone soil moisture). The optimal weights for SPI, SRI, sETI, and SSI were 0.33, 0.26, 0.19, and 0.22, respectively, in the designed BNI.The main innovation of this research piece is to introduce the BNI to the water resources experts of the Nile.