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Szerkesztő:

DR. ZÁKÁNYI BALÁZS
egyetemi docens
Miskolci Egyetem
Környezetgazdálkodási Intézet

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EXAMINING THE DIFFERENCES AND THE SIMILARITIES OF THE PRECIPITATION PATTERNS OF HUNGARY AND KENYA

VALERIE A. J. A. WENDO¹–CSABA ILYÉS^{1,2}–PÉTER SZÜCS^{1,2}

¹*University of Miskolc Institute of Environmental Management*

²*MTA-ME Geoengineering Research Group*

1. INTRODUCTION

Climate change is expected to significantly affect the world this will be felt through modified weather patterns (IAH 2012). How this will affect the human population is through the water resources which include groundwater resources and disasters for example floods and droughts (Richard G. TAYLOR et al. 2013). Extreme weather conditions is experienced all over the world. However Hungary and Kenya experience different aspects of extreme weather. In Hungary extreme weather means heat waves, heavy precipitation events, drought and winter storms. In Kenya the country is vulnerable to be affected by heavy precipitation (floods) and high temperatures (resulting in drought). These affects different sectors of the countries from food production, water access, health and tourism. (BENISTON et al. 2007; TROCAIRE 2011; CSETE–PÁLVÖLGYI–SZENDRO 2013; PONGRÁCZ–BARTHOLY–KIS 2014)

Analysis of rainfall data is important for many agricultural, ecological and engineering activities. Design of irrigation and drainage systems, for instance, needs to take account not only of mean expected rainfall, but also of rainfall volatility. In agricultural planning, changes in the annual cycle, e.g. advances in the onset of winter rain, are significant in determining the optimum time for planting crops. Estimates of crop yields also depend on the distribution of rainfall during the growing season, as well as on the overall amount. Such problems require the extrapolation of longer term trends as well as the provision of short or medium term forecasts (WILLIAMS 1998).

2. METHODOLOGY

The purpose of time series analysis is to determine some of the system's key properties by quantifying certain features of the time series. These properties can then help understand the system's behavior and predict its future. This approach then moves on to determine the periodic components found in the time series by computing the associated periods, amplitudes, and phases, (ILYÉS et al. 2017; ILYÉS–TURAI–SZÜCS 2018). The Fourier Transform transforms a function f which is defined over space (or time) into the frequency domain, so that it is defined in terms of Fourier coefficients. The Fourier transform calculates the Fourier coefficients as:

$$a_k = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \cos(kx) dx, b_k = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \sin(kx) dx \quad (1)$$

A discrete Fourier Transform converts a list of $2N + 1$ equally spaced samples of a real valued, periodic function, f_n , to the list of the first $2N + 1$ complex valued Fourier coefficients:

$$A_k = \frac{1}{N} \sum_{n=-N}^N f_n e^{-\pi n k x / N} \quad (2)$$

Truncated fourier series

$$f_k \approx \sum_{k=-N}^N A_k e^{i k x} \quad (3)$$

On a computer this is done with a Fast Fourier Transform (or fft). The inverse Fourier transform (sometimes called ifft) transforms the Fourier coefficients back to the f values (transforming from spectral back to real space): (WELLER 2015)

$$\begin{aligned} f_0, f_1, f_2, \dots, f_{2N}, &\rightarrow A_0, A_1, \dots, A_{2N} \\ A_0, A_1, \dots, A_{2N} &\rightarrow f_0, f_1, f_2, \dots, f_{2N} \end{aligned} \quad (4)$$

The data set used for this study was precipitation and groundwater levels from Kenya and Hungary. The precipitation data was for the range of

- 110 years (1901–2010) for Hungary consisting of the following regions; Budapest, Debrecen, Pécs, Szeged and Szombathely.
- 116 years (1901–2016) for Kenya obtained from World Bank data website (World Bank Group, 2019) and 37 years (1980–2016) of additional data from the following regions – Dagoretti corner Meteorological, Moi international Airport – Mombasa, Mtwapa Agromet Station, Machakos Agromet Station and Nyahururu Agromet Station.

3. RESULTS

Analyzing the precipitation data of Hungary involved the creation of time series models for a 110 year range.

Out of all the five locations Budapest it seems experiences the most recurrence of rainfall patterns as compared to the rest and Szombathely experiences the least cyclic pattern. However a common factor is that the dominant cyclic nature of the rainfall is every 12 months or 1 year. This is only different in the case of Budapest whose dominant cyclic nature is every 6 months or $\frac{1}{2}$ year.

The data from Kenya shows that the most common cycles are in the 6 month, and 12 months of the year. What this means is that every 6 months there is a precipitation occurrence. Kenya has two rainfall patterns the long rains between March and May and the short rains between October and December.

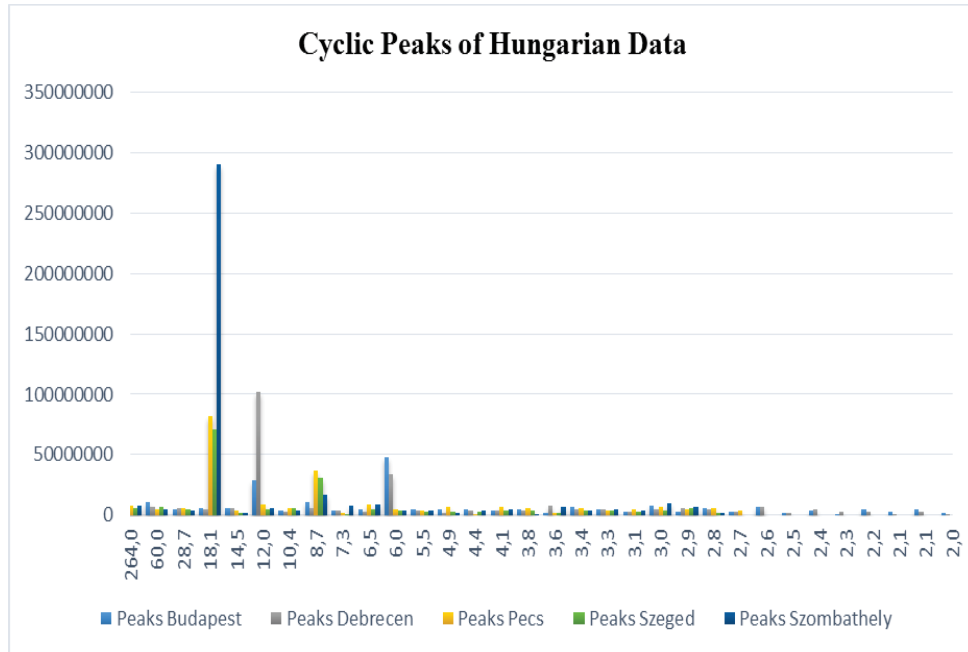


Figure 1: Summarized Cyclic Peaks of the 5 Stations

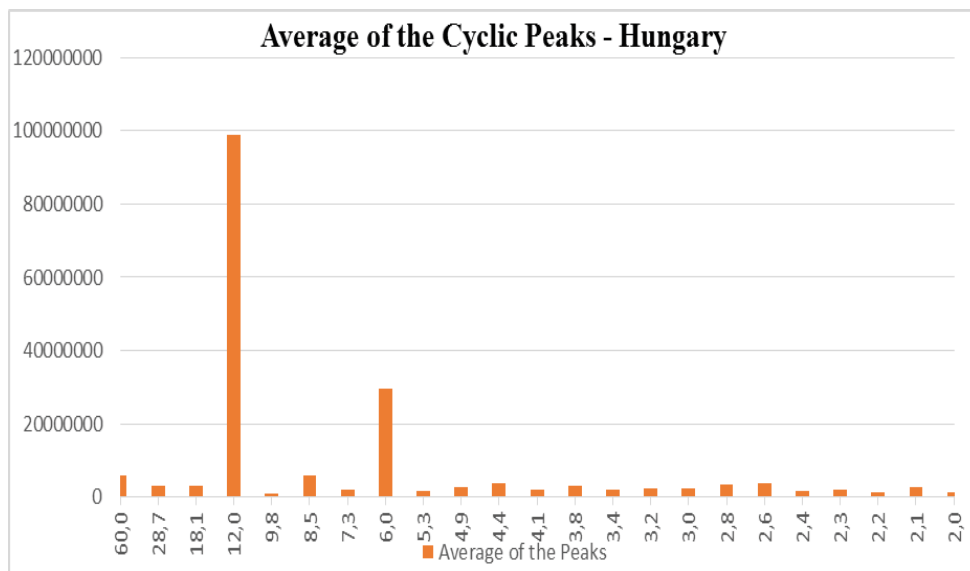


Figure 2: Average of the Cyclic Properties of Precipitation Data for the entire country

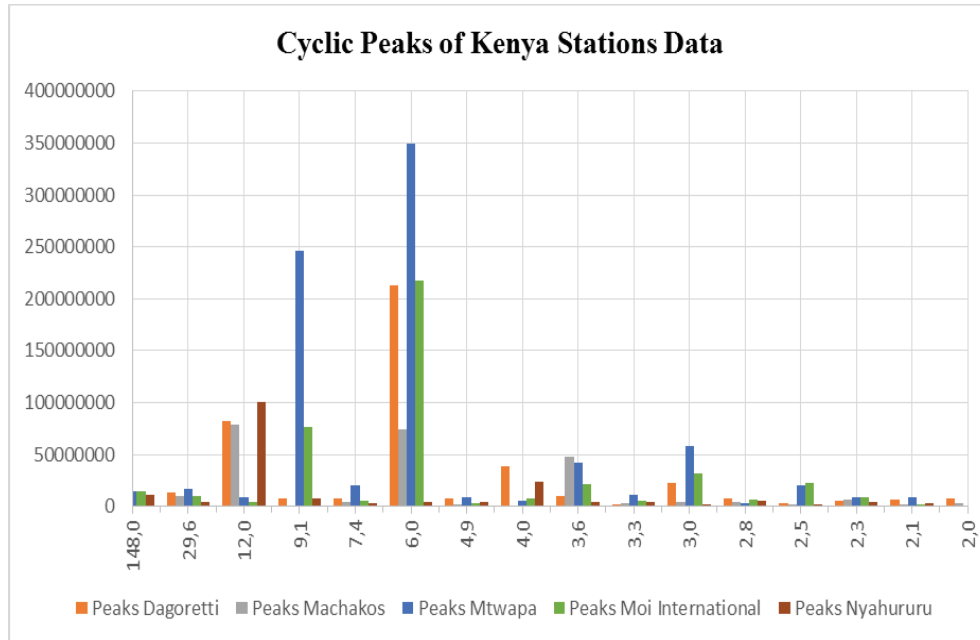


Figure 3: Summarized Cyclic Peaks of Sample Stations x-axis is period and y-axis is the power

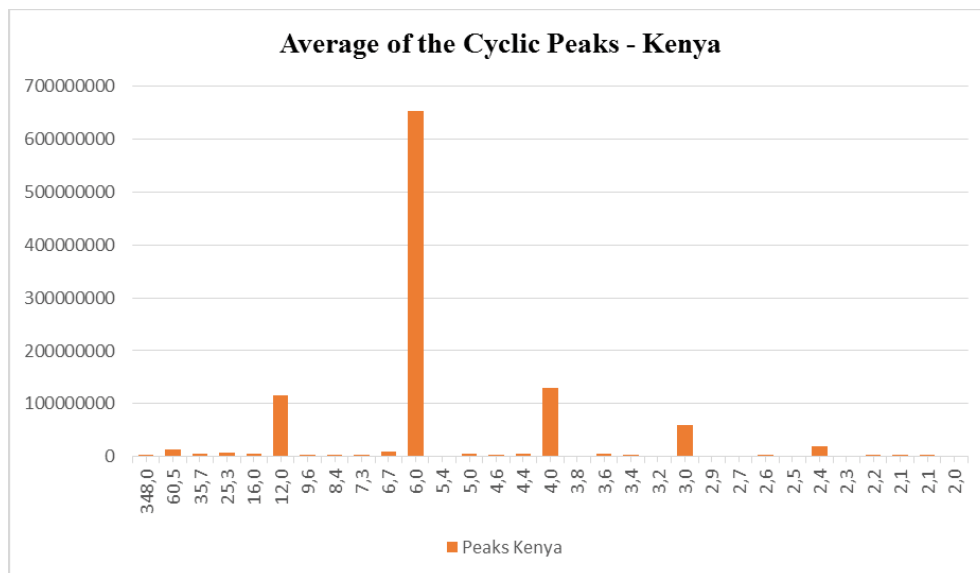


Figure 4: Average of the Cyclic Properties of Precipitation Data for the entire country. X – axis is the period (months) and the y – axis represents the power of the data

On the ground this can be interpreted as the rainfall in the countries recur very 12 and 6 months for Hungary and Kenya respectively. However this can be true for Kenya because of it being a tropical country it mainly has only two seasons rainy and dry. The rainfall period is felt on most occasions twice a year between March and May and between October and December. This confirms the 6 month cycle. In the case of the 12 month cycle for Hungary at first glance it does not make sense how rainfall is only recurring every 1 year but one thing to note is that unlike Kenya, Hungary experiences 3 climates (oceanic, continental and Mediterranean) and at times in winter they may experience a fourth climate (Arctic). Each year the country will most times experience one of the three climates and this explains cycle of 1 year. Throughout the year there is moderate distribution of precipitation.

4. CONCLUSION

This analysis demonstrated the use of time series and spectral method as an effective method for studying variations in precipitation and groundwater level data. From the precipitation data above, one can clearly see the variability in the climate. The Fourier transform and statistical analysis reduced the data to a more manageable format thus improving interpretation, prediction, monitoring, or control of the data. Based on my analysis, the inclusion of climate change scenarios into national disaster management plans, will aid the countries in coming up with better strategies to prevent and reduce disaster occurrence. Hungary being considered a “water country” for its extensive groundwater resources, has a long standing history of its meteorological and hydrogeological observations since the 18th century therefore it has over a century of data that can be used to understand historical periodicities. Kenya started its maiden journey in climate studies in the year of 1929 which is young compared to Hungary.

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