

Development of Web-based Application for Trend Analysis

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Abstract

Understanding rainfall variations at the local, regional, and global scales is vital for water resource utilization planning and making irrigation decisions. The present investigation attempts to develop the web based application based on the Mann Kendal Test and to study the trend for climatic parameters. Web based application was developed using C & HTML language. The analysis of the rainfall data over 10 years period from 2014 to 2023 for the Rahuri region revealed that the monsoon starts effectively from 24th SMW (1st July to 7th July) in Rahuri region and remained active up to 43th SMW (1st October to 7th October). The expected good monsoon was observed for about 20 weeks (24th to 43th SMW).

Key words : Trend analysis, Man-Kendall test, Climate analysis.

Web based application development is the process of creating websites and web applications that are accessible over the internet. Webpage development can range from creating simple static websites to complex dynamic web applications. Effective webpage development ensures that sites are responsive, user-friendly, and optimized for search engines, enhancing user experience and engagement.

Trend analyser statistical software is basically a webpage performing advanced statistical analyses, including trend analysis. For trend analysis, Trend analyser offers tools to identify, model, and forecast data patterns over time. Users can apply methods such as linear and nonlinear regression, moving averages, and time series analysis to detect trends and make predictions. This makes Trend analyser an invaluable tool for researchers, analysts, and business professionals who need to analyse data trends and make data-driven decisions. Its user-friendly interface and comprehensive features simplify complex statistical analyses, making sophisticated data analysis accessible to users with varying levels of expertise.

Weather Parameters is influenced by a multitude of factors, ranging from atmospheric conditions to geographical features and human activities. Understanding these factors is crucial for accurate weather prediction, water resource management, and adapting to climate change. Trend analysis is normally performed using the Mann-Kendell test. It is a non-parametric test for identifying trends in time series data. The test compares the relative magnitudes of sample data rather than the data values themselves. One benefit of this test is that the data need not confirm to any particular distribution.

In view of the importance of the weather Parameters and its trend for proper resources planning and management, the study entitled “Development of Web-based application for Trend Analysis” and its application on rainfall data for Rahuri region” has been undertaken.

Materials And Methods

The aim of the study is to develop web based application for trend analysis and to test the developed web based application with XLSTAT.

Mann Kendall Trend Test Analyzer also used to study the variability or trend of rainfall for a decade (2014 to 2023).

Study Area : The study area comprises of Rahuri station. This rainfall is received from both branches of monsoon i.e. South-west as well as North-east monsoons. Rahuri is located at 19.38°N 74.65°E. It has an average elevation of 511 metres (1,676 feet). Area of the region is 1,035.11 km².

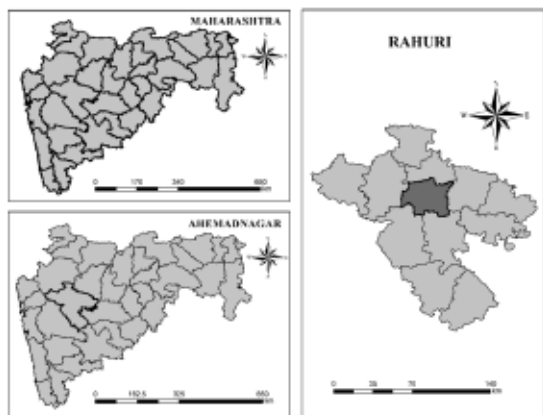


Fig. 1.

Design and Development of Trend Analyzer : Designing an HTML page in C language using Notepad involves several steps, although it is important to clarify that HTML and C are distinct: HTML is a markup language used to create web pages, while C is a programming language.

Phases Of The Webpage Development:

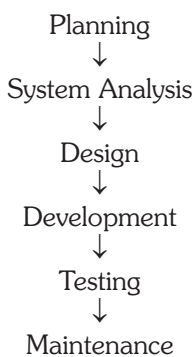


Fig. 2.

Language Used/ Coding Implementation : The implementation of this project involved majorly coding/ programming of the various interfaces. We have the project coordinator, supervisor, student and the clearance personnel inter faces. Described below are the programming languages employed in this project and the various functions they carried out in the actualization of the project.

i. C language (C) : C was employed as the programming language for the code behind file. It was used to write the codes in the event handlers for the various events employed in the web pages and the portal as a whole. It was also used in writing sub-routines for the various methods employed in the web pages.

Examples of some of the methods, out of the numerous methods present in the project, in which it was employed, include; the Page Load, get Report URL, get Report Text, btn Save Click, btn Upload The Data Click etc.

ii. Hypertext markup language (HTML): HTML was employed in the design of the portal. Below is a Screenshot of the HTML codes employed in designing a part of the home page.

Man Kendall Test of Trend Analysis : The Mann-Kendall test is a non-parametric test for identifying trends in time series data. The test compares the relative magnitudes of sample data rather than the data values themselves. One benefit of this test is that the data need not conform to any particular distribution. Moreover, data reported as non-detects can be included by assigning them a common value that is smaller than the smallest measured value in the data set. It is considered that there exists only one data value per time period. When multiple data points exist for a single time period, the median value needs to be used. The data values are evaluated as an ordered time series. Each data value is compared to all subsequent data values. The initial value of the Mann-Kendall statistic, S,

is assumed to be 0 (e.g., no trend). If a data value from a later time period is higher than a data value from an earlier time period, S is incremented by 1. On the other hand, if the data value from a later time period is lower than a data value sampled earlier, S is decremented by 1. The net result of all such increments and decrements yields the final value of S .

Let $x_1, x_2, \dots, x_n$ represent n data points where x_j represents the data point at time j . Then the Mann-Kendall statistic (S) is given by

$$S = \sum_{j=1}^{n-1} \sum_{k=j+1}^n \text{sign}(x_j - x_k)$$

$$\text{sign}(x_j - x_k) = \begin{cases} 1 & \text{if } x_j - x_k > 0 \\ 0 & \text{if } x_j - x_k = 0 \\ -1 & \text{if } x_j - x_k < 0 \end{cases}$$

A very high positive value of S is an indicator of an increasing trend, and a very low negative value indicates a decreasing trend. However, it is necessary to compute the probability associated with S and the sample size, n , to statistically quantify the significance of the trend.

Kendall described a normal-approximation test that could be used for datasets with more than 10 values, provided there are not many tied values within the data set. The test procedure is as follows:

Calculate S as described above.

Calculate the variance of S , $\text{VAR}(S)$, by the following equation

$$\text{VAR}(S) = \frac{1}{18} \left[n(n-1)(2n+5) - \sum_{p=1}^g t_p(t_p-1)(2t_p+5) \right]$$

where n is the number of data points, g is the number of tied groups (a tied group is a set of sample data having the same value), and t_p is the number of data points in the p^{th} group. In the sequence {2, 3, non-detect, 3, non-detect, 3}, we have $n=6$, $g=2$, $t_1=2$ for the non-detects, and $t_2=3$ for the tied value 3

Compute a normalized test statistic Z as follows:

$$Z = \frac{S-1}{[\text{VAR}(S)]^{1/2}} \quad \text{if } S > 0$$

$$= 0 \quad \text{if } S = 0$$

$$= \frac{S+1}{[\text{VAR}(S)]^{1/2}} \quad \text{if } S < 0$$

Compute the probability associated with this normalized test statistic. The probability density function for a normal distribution with a mean of 0 and a standard deviation of 1 is given by equation

$$f(z) = \frac{1}{\sqrt{2\pi}} e^{-\frac{z^2}{2}}$$

Decide on a probability level of significance (95% typically).

The trend is said to be decreasing if Z is negative and the computed probability is greater than the level of significance. The trend is said to be increasing if the Z is positive and the computed probability is greater than the level of significance. If the computed probability is less than the level of significance, there is no trend.

Steps For Using Trend Analyzer Webpage:

Step 1: Select the data from excel data file to create input file.

Fig. 3.

Step 2: Open another Excel sheet or in same sheet apply the formula (for e.g =C25&","")

as shown below. After this step we are able to copy comma separated data as per our requirement for calculation.

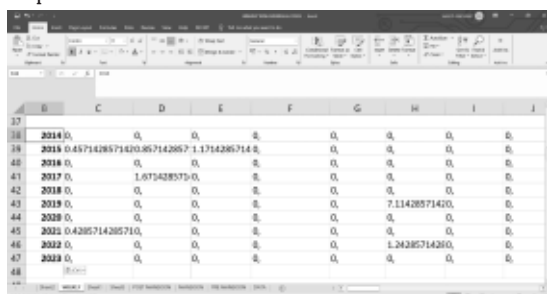


Fig. 4.

Step 3: Copy the observations from excel file.

Step 4: Open the Trend Analyzer webpage using any browser and Click to Next tab.



Fig. 5.



Fig. 6.

Step 5: Trend Analyzer Calculator page opens as follows.

Step 6: Paste the comma separated input data in enter data box.

Enter data (comma-separated):
0, 0.457142857142857, 0, 0, 0, 0, 0, 0.4285714285

Fig. 7.

Step 7: Click on the calculate tab to calculate and analyze the trend.

Calculate

Fig. 8.

Step 8: Calculated results of the inserted data are displayed on the screen as follows.

Results:

Mann-Kendall Statistic (S): -5
Normalized Test Statistic (Z): -0.311
Probability associated with Z (p-value): 0.755
Trend at 95% Confidence Level: not significant (decreasing)

Fig. 9.

Step 9: Now follow the steps above to create the output file of the data required.

Validation of Developed Web Based Application : Validation of developed web based application “Trend Analyzer” was verified by comparing the result with XLSTAT.

Data set of monthly values:
1.37, 1.60, 1.39, 1.66, 1.47, 1.35, 0.33

Output in XLSTAT:

Mann-Kendall trend test / Two-tailed test (Value (mm)):								
S	-7							
Var(S)	44.333							
p-value (Two-tailed)	0.368							
alpha	0.05							
An approximation has been used to compute the p-value								
Test interpretation:								
H0: There is no trend in the series								
Ha: There is a trend in the series								
As the computed p-value is greater than the significance level $\alpha=0.05$, There is a trend in the series, Ha(decreasing).								

Fig. 10.**Output in Trend Analyzer:**

Results:
Mann-Kendall Statistic (S): -7
Normalized Test Statistic (Z): -0.901
Probability associated with Z (p-value): 0.368
Trend at 95% Confidence Level: not significant (decreasing)

Fig. 11.**Rainfall Trend Analysis For Rahuri**

Region : The present investigation attempts to identify trend analysis of weekly rainfall data and variation in the rainfall over 10 year period between year 2014 to 2023.

Results and Discussion

A webpage named "Mann Kendall Calculator" has been developed using the methodologies and technologies discussed in the previous chapters. This app is designed to assist users in the Irrigation and drainage in accurately scheduling the crop water requirement. For users who need to calculate and analyse trends of various climatic parameters. Additionally, for

users the calculator offers Mann-Kendall Statistic (S), Normalized Test Statistic (Z), Probability associated with Z (p-value) values. This calculator aims to calculate increasing, decreasing or no trend, ensuring precise formulation in input data.

View of Final Webpage After Running The Program In Any Browser

i. View of the home page:**Fig. 12.**

Home screen of the " Trend Analyzer " webpage has been shown in Fig 4.2. It has following features:

Background : The page has a fixed background image with a blur effect for visual appeal.

Container : A centred container with a white background and rounded corners for content display.

Logo and Title : The logo of the Trend Analyzer is displayed prominently, along with the title of the app.

Button : A button to redirect users to another page, labelled "Next".

Developer Information: Details about the development team from the Department of Irrigation and Drainage Engineering at the Mahatma Phule Krishi Vidyapeeth, Rahuri.

Guidance information : Mentions

guidance from Mahatma Phule Krishi Vidyapeeth, Rahuri.

ii. View of the calculator page:



Fig. 13.

Mann Kendall Trend Calculator Page Includes:

- 1) Description and information of Trend Analyzer.
- 2) Input Data box: Here we need to insert data (Comma separated) for which we need to calculate trend.
- 3) Calculate box: After inserting data, we need to click on the calculate tab for further proceeding and calculation of the data. The output is obtained in the following form:
Value of Mann-Kendall statistic, (S)
Value of normalized Z statistic, (Z)
Probability associated with normalized Z statistic (p-value)
Trend at 95% Confidence Level: Increasing/Decreasing/No Trend



Fig. 14.

Features of The Application

Broadly, the features of the "Mann Kendall Calculator" are mentioned below:

Data Selection: Select parameter for which want to find trend and arrange the data accordingly.

Adjustment of data: Modify the climatic parameter data by formatting it comma separated.

Input Parameters: Enter specific observations for accurate calculations.

Detailed Output: View calculation results in simple format.

Trend analysis of weekly Rainfall data of 10 years (2014-2023) : It is seen from the table 1 that there is decreasing trend for week no. 1, 9, 10, 11, 16, 17, 20, 21, 22, 23, 24, 25, 28, 30, 31, 32, 33, 34, 35, 36, 38, 39, 43, 45, 46, 47; increasing trend for week no. 2, 4, 8, 12, 13, 15, 18, 19, 26, 27, 29, 37, 40, 41, 42, 48 & 49 and there is no trend for remaining weeks. The trend is shown in table 1.

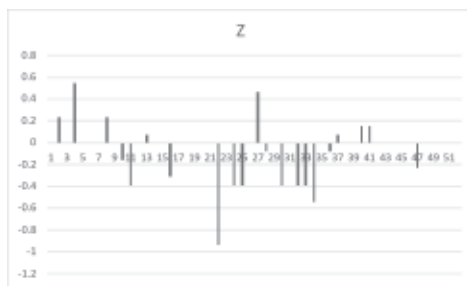


Fig. 15.

Table 1. Trend analysis of weekly Rainfall data of 10 years

Week	S	Z	Proba- bility with Z	Trend at 95% Prob- ability	Week	S	Z	Proba- bility with Z	Trend at 95% Prob- ability
1	-8	-0.545	0.586	Decreasing	27	7	0.467	0.64	Increasing
2	4	0.234	0.815	Increasing	28	-2	-0.078	0.938	Decreasing
3	0	0	1	No trend	29	2	0.078	0.938	Increasing
4	8	0.545	0.545	Increasing	30	-6	-0.389	0.697	Decreasing
5	0	0	1	No trend	31	-2	-0.078	0.938	Decreasing
6	0	0	1	No trend	32	-6	-0.389	0.697	Decreasing
7	0	0	1	No trend	33	-6	-0.389	0.697	Decreasing
8	4	0.234	0.815	Increasing	34	-8	-0.545	0.586	Decreasing
9	-15	-1.090	0.276	Decreasing	35	-5	-0.311	0.755	Decreasing
10	-3	-0.156	0.876	Decreasing	36	-2	-0.078	0.938	Decreasing
11	-6	-0.389	0.697	Decreasing	37	2	0.078	0.938	Increasing
12	11	0.778	0.436	Increasing	38	-2	-0.078	0.938	Decreasing
13	2	0.078	0.938	Increasing	39	-2	-0.078	0.938	Decreasing
14	0	0	1	No trend	40	3	0.156	0.876	Increasing
15	1	0	1	Increasing	41	3	0.156	0.876	Increasing
16	-5	-0.311	0.755	Decreasing	42	2	0.078	0.938	Increasing
17	-1	0	1	Decreasing	43	-2	-0.078	0.938	Decreasing
18	13	0.934	0.35	Increasing	44	0	0	1	No trend
19	1	0	1	Increasing	45	-1	0.000	1	Decreasing
20	-20	-1.479	0.139	Decreasing	46	-3	-0.156	0.876	Decreasing
21	-5	-0.311	0.755	Decreasing	47	-4	-0.234	0.815	Decreasing
22	-13	-0.934	0.350	Decreasing	48	1	0	1.000	Increasing
23	-18	-1.323	0.186	Decreasing	49	4	0.234	0.815	Increasing
24	-6	-0.389	0.697	Decreasing	50	0	0	1	No trend
25	-6	-0.389	0.697	Decreasing	51	0	0.000	1	No trend
26	16	1.168	0.243	Increasing	52	0	0.000	1	No trend

Conclusion

The present research was focused on trend analysis of rainfall for Rahuri region of Ahmednagar district. The following conclusions were drawn from this study:

1. The developed Web based application “Trend Analyzer” was used for trend analysis of various climatic parameters. This is user friendly and easy to access platform.

2. The weekly trend analysis of rainfall for last 10 years (2014-2023) in which out of 52 weeks 32.69 % (17 week) show increasing

trend, 50.00 % (26 weeks) show decreasing trend and 17.30 % (9 weeks) show No trend for Rahuri region(Ahmednagar).

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