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Assessment of Temporal and Spatial Variation of Pan Evaporation with Related Climatological Factors in Bangladesh

Shakil Ahmed [a*], Md. Mafizur Rahman [b], Shahriar Shams[c] and Md. Mosabbir Pasha[d]

[a,d]*Department of CEE, Islamic University of Technology, Gazipur-1704, Bangladesh*
[b]*Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh*
[c]*Department of Civil Engineering, Institut Teknologi Brunei, Gadong-2909, Brunei Darussalam*

Abstract

Pan evaporation is an effective way to analyze the multidimensional impact of climate change on irrigation water requirement since pan evaporation measures the integrated effect of radiation, wind, temperature and humidity on the evaporation from an open-water surface. The characteristic trends of pan evaporation and related climatological factors, as developed in this paper, indicate that most of the regions of Bangladesh have undergone a significant amount of decrease in evaporation through the years. The reduction in sunshine duration as a consequent of climate change can be attributed to be the principal reason for the decrease in evaporation. The spatial distribution of seasonal variation of pan evaporation along with solar radiation and humidity was analyzed, and solar radiation seemed to have the major influence on evaporation. The study also reveals that summer and spring are the seasons of highest evaporation in most of the regions. The characteristic trend and spatial distribution of seasonal pan evaporation correlated with related climatological factors developed in this study could aid in water resources development and planning for irrigation purposes.

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Keywords: Climate Change, Humidity, Irrigation, Pan Evaporation, Radiation, Trend Analysis.

1. Introduction

Bangladesh is recognized as one of the countries potentially vulnerable to the impacts of global warming

* Corresponding author. Tel.: +880-171-8210471
E-mail address: shakil5_buet@yahoo.com

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and climate change [1]-[5]. Rising temperatures and changes in rainfall patterns have direct effects on crop yields, as well as indirect effects through changes in irrigation water availability [6]. The agriculture is the major sector for consumption of water in Bangladesh, a country with population of about 162 million in 2009 and is projected to be about 215 million in 2040 [7]. Demand for water will increase with the rising population for increased agricultural productivity particularly for growing demand of rice which consumes a lot of water. Therefore, it is essential to estimate the agricultural water demand in the changing environment for long term water resources development and planning. This paper reports studies on characterization and trend analysis of pan evaporation with related climatological factors in various regions of Bangladesh.

2. Scope

The overall objective of this study is to characterize the pan evaporation under changing climate and analyze its future trend. This would allow the development of agricultural water demand planning, and appropriate adaptation and climate risk management strategies. The specific objectives of the study are:

- Analyze the seasonal changes in pan evaporation, solar radiation and humidity at different regions of Bangladesh and identify the controlling parameter affecting pan evaporation by a comparative study.
- Evaluation of long-term changes in pan evaporation in different regions of Bangladesh.
- Analysis of spatial distribution of mean seasonal pan evaporation in different regions of Bangladesh

It must be mentioned that the study is limited to the period from 1988-2010; the result, thereby, exhibit the very recent trends and not long term trends.

3. Methodology

3.1. Data and selection of study area

The data were collected from different hydro-meteorological stations of Bangladesh Meteorological Department (BMD). Class A evaporation pan was used to measure the pan evaporation. The data were initially available for a period of 23 years ranging from 1988 to 2010. To reduce the analysis volume, only some selected locations spread over the Bangladesh have been considered for trend analysis. In this study, Bangladesh is divided into eight regions for analysis purpose. One climatic station was selected for analysis from each of the eight regions. The stations are Dinajpur (North West), Joydebpur (North Central), Sylhet (North East) Faridpur (Central), Khulna (South West), Barisal (South Central), Comilla (south East) and Rangamati (Eastern Hill).

3.2. Assessment of seasonal variation

To analyze the seasonal variation, data of the parameters (pan evaporation, radiation and humidity) for all of the study stations were collected for the year 2010. The whole year was divided into four seasons: spring (February to April), summer (May to July for), autumn (August to October) and winter (November to January). The seasonal variations of the variables were spatially distributed in different regions by using ArcGIS 9.2 map to evaluate the relationship between the pan evaporation and related climatological factors.

3.3. Trend analysis of daily pan evaporation and humidity

To analyze the changing pattern of pan evaporation as an effect of climate change, spatial distribution of normalized value of average daily pan evaporation in January for recent two span years (2006-2010 and 2001

to 2010) relative to long term daily pan evaporation of 23 years (1998 to 2010) are plotted using ArcGIS 9.2.

To facilitate the trend analysis of pan evaporation, the average daily pan evaporation of January for the period of 1988 to 2010 has been plotted for different regions in Excel. "2 year moving average curve" is adopted to overcome the effect of any missing data. The trend has been analyzed assuming a linear variation.

3.4. Assessment of spatial distribution of seasonal pan evaporation

To assess the distribution of seasonal pan evaporation spatially all over the country, the seasonal average data for daily pan evaporation was collected for the study regions and then spatial distribution map for the year 2002 was plotted using ArcGIS 9.2.

4. Results and discussions

4.1. Seasonal variation of daily pan evaporation, radiation and humidity

To analyze seasonal variation of pan evaporation with related climatological factors, GIS map was plotted in Fig. 1(a), 1(b) and 1(c) showing spatial distribution of seasonal variations of pan evaporation, radiation and humidity, respectively in different regions of Bangladesh for the year 2010. As shown in Fig. 1(a), almost all over the regions, spring shows the highest and winter shows the lowest daily pan evaporation except North Central region where summer and autumn were found the seasons of highest and winter was found the season of lowest daily pan evaporation.

Comparing Fig. 1(a) and 1(b), it is obvious that seasonal variation of pan evaporation follows a quite similar pattern to that of radiation; evaporation reaches to highest value in the season when radiation is highest and vice versa in almost all of the regions. In contrast, comparing Fig. 1(a) and 1(c), no significant match in the pattern of seasonal variation between evaporation and humidity was found. From this analysis it may be concluded that between the two climatological factors (radiation and humidity); radiation is the major controlling factor affecting pan evaporation.

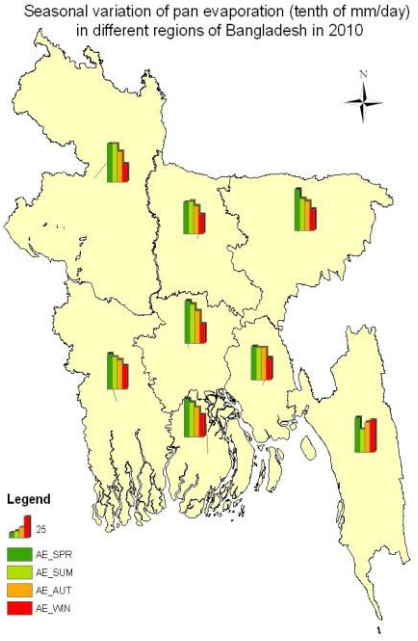
4.2. Trend analysis of pan evaporation

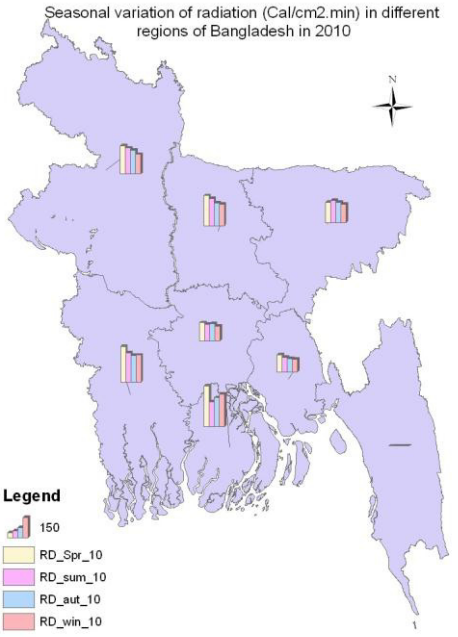
The spatial distribution of normalized change of average daily pan evaporation in January for different spans of years (5years and 10 years) relative to long term daily pan evaporation of 23 years (1998 to 2010) are plotted in Fig. 2, which reflects a combined effect of related climatological factors. It is clear from the figures that both of the recent 5 years and 10 years spans show a similar kind of spatial distribution. As seen from Fig. 2 (b), in the last ten years, average daily pan evaporation in January is found to be decreased for all regions except Eastern Hill, South Central and North East regions where increasing trends were observed. The reduction in sunshine duration can be attributed to be the principal reason for the decrease in evaporation [8]. The maximum decrease (around 12%) was found in the South East region and minimum decrease (around 5%) was found in the Central region. Conversely, average daily pan evaporation in January was found to be increased (nearly 3 to 5%) in Eastern Hill, South Central and North East region.

4.3. Spatial distribution of seasonal variation of daily pan evaporation

The spatial distributions of mean seasonal pan evaporation for the year 2002 are plotted (not shown in figure). In spring, higher values are found in the Western regions (North West and South West) of the country. On the other hand, the lower values are found in the Eastern regions (Easter Hill and North East) and

minimum value is found in the North Central region. In summer, the spatial distribution of pan evaporation is similar to that in the spring, though minimum value in this season is found in both North East and Eastern Hill region. In autumn, South West region remains the zone of highest value and, the South Central and Eastern Hill region are found as minimum evaporation zones. In winter, the spatial distribution changes to a different pattern where the higher values are found in the Eastern part while the lower values in the western part.





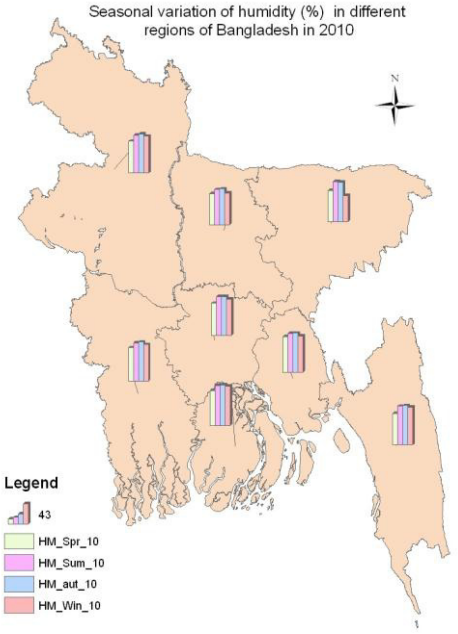


Fig. 1. Seasonal variation of (a) daily pan evaporation (tenth of mm/day) (b) radiation (Cal/cm^2.min) and (c) humidity (%) in different regions of Bangladesh in 2010

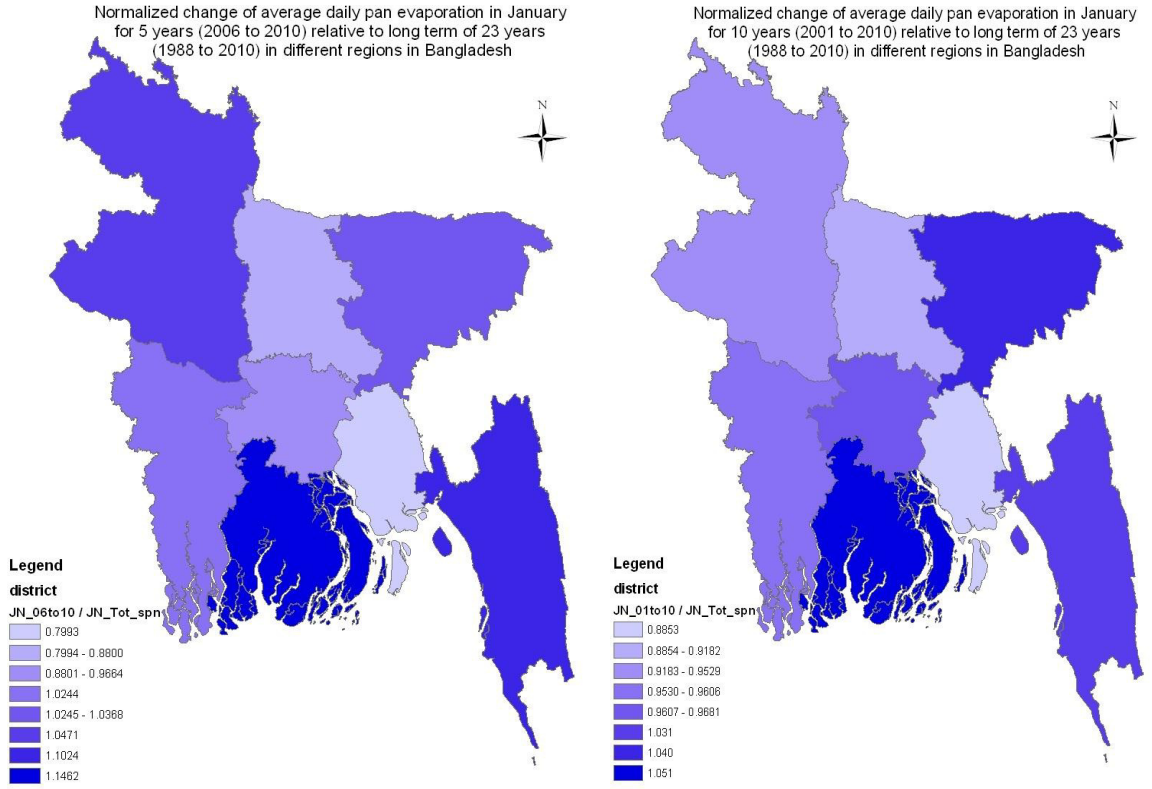


Fig. 2. Normalized change of average daily pan evaporation in January for recent (a) 5 years (2006-2010) and (b) 10 years (2001-2010) relative to long term of 23 years (1998 to 2010) in different regions of Bangladesh

5. Conclusion

Seasonal variation of daily pan evaporation is analyzed and almost all over the regions, highest and lowest evaporation are found in spring and winter, respectively. Only exception is North Central region, where summer and autumn are found the seasons of higher, and winter is found the season of lower daily pan evaporation. Apart from this, the spatial distribution of seasonal variation of pan evaporation along with radiation and humidity was analyzed, and radiation was found to be the major controlling factor for evaporation. Moreover, from the trend analysis of pan evaporation, evidence of climate change impact on pan evaporation in Bangladesh is apparent and it can be expected that that rate of change of average daily pan evaporation in Bangladesh will continue in future years as a result of ongoing climate change.

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