INFLUENCE OF STATION DENSITY AND INTERPOLATION METHODS ON SPATIAL AVERAGING OF RAINFALL FOR WATER RESOURCES MANAGEMENT

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Degree of Master of Science

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Thesis submitted in partial fulfillment of the requirements for the degree of
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Supervised by
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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person expect where the acknowledgment is made in text.

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Thisuni Kaushala Abeysing Kodippili Date

The above candidate has carried out research for the Master's thesis under my supervision.

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Professor N.T.S. Wijesekera Date

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Abstract

Rainfall is a major concern when dealing with water resources because it is the major input for estimation of streamflow using mathematical models. Rainfall which is a point measurement, needs conversion as a spatially distributed entity for watershed applications. Though there are many concerns regarding the representativeness of the method, conversion of rainfall from several stations generally use station configuration as the basis. However, going further towards the reality, some methods suggest the use of watershed characteristics for this purpose. There are diverse views regarding the recommended station densities. Some work indicate that higher station densities do not lead to the watershed average rainfall value while there is documentation supporting that even one station would be adequate for hydrologic modelling. Based on a comprehensive literature review it was identified that focused research efforts on the selection of rainfall stations to determine areal average rainfall is required. The ongoing literature show that most opted option to compute the areal average is the Thiessen method. The present study explored the influence of station density and spatial intepolation methods when computing spatially averaged rainfall using monthly data for water resources planning and engineering applications. Monthly rainfall data of twelve stations from the Ellagawa (1395 km^2) sub catchment in Kalu Ganga basin over the period from 2006-2014 was used. Station density influence on areal average rainfall was evaluated with different station configuration scenarios while selecting mostly opted Thiessen rainfall method as the spatial averaging method. Monthly, seasonal and annual watershed average rainfall was evaluated using 283 rational configurations determined by the location of raingauges. The comprehensive study of station density influence was carried out by evaluating only rainfall input and by evaluating runoff estimated with a water balance model. Mean ration of absolute error was selected as the objective function for the comparative analysis. The influence of spatial interpolation method for spatial averaging of rainfall was tested by comparing Thiessen polygon, Inverse Distance, and Spline and Kriging methods and using four types of station layouts under two different station density configurations.

Annual, seasonal and monthly rainfall only analysis revealed that 8 stations and above a density of 175 km^2 per station will provide consistent rainfall for any configuration. Comparison of rain gauging density influence on watershed streamflow by using a set of parameters derived from atypical model also indicated that consistent streamflow estimations can be achieved only with a station configuration denser than 175km^2/station. Streamflow comparisons carried out by optimising model parameters for each rainfall configuration also resulted in the same threshold density for consistent streamflow estimations. However the best model performance was with a two gauging stations layout having a density of 698 km^2/station. Comparison of Thiessen weights corresponding to best streamflow estimation inputs revealed that there are three rain gauges mostly contributing to the streamflow of Ellagawa watershed. These results showed that it is prudent to commence watershed modelling with a consistent station density and then carryout optimisation of station weights along with model parameters. Analysis of the influence of spatial interpolation methods on streamflow estimations indicated only a marginal difference in the output derived from selected methods. In all methods, the weakest results were when maximum stations were located outside the watershed. Consideration of computation resource requirement concluded that the Thiessen method is the best option to compute watershed areal rainfall.

Achieving both rainfall input consistency and consistent streamflow estimations using a monthly watershed model, was at a threshold density of one station per 175 km^2. The best streamflow estimations could be obtained with a two-rain gauging station layout.

KEYWORDS: Rainfall, Spatial Interpolation, Station Configuration, Station Density, Two-Parameter model, Thiessen Average, Inverse Distance weighted, Spline, Kriging, Mean Ration of Absolute Error

TABLE OF CONTENTS