THE FLUCTUATION OF LONG-TERM STREAMFLOW PATTERN WITH CONSIDERED THE CLIMATE CHANGE IMPACTS

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion this thesis is adequate in terms of scope and quality for the award of the Bachelor's Degree of Civil Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Peningkatan suhu permukaan global sebagai tindak balas terhadap perubahan komposisi atmosfera akan memberi kesan kepada corak hidrologi tempatan dan sumber air. Keadaan ini kemudiannya akan membawa kepada keperluan penilaian terhadap kesan perubahan iklim. Tujuan utama kajian ini adalah untuk menentukan corak iklim semasa dan meramalkan aliran sungai pada masa hadapan dengan menggunakan *Statistical Downscaling Model* (SDSM) dan *Identification Of Unit Hydrograph & Component Flow From Rainfall, Evaporation & Streamflow Data* (IHACRES). Dalam kajian ini, siasatan dilakukan oleh potensi IHACRES untuk meramalkan perubahan aliran sungai dalam jangka panjang yang dipengaruhi oleh pembolehubah atmosfera berskala besar yang memberi tumpuan kepada Sg. Yap, Pahang. Kajian ini dilakukan dengan penentukuran dan pengesahan dari 26 data NCEP-reanalysis dan *General Circulation Models* (GCMs), dan seterusnya ramalan hujan dan suhu masa depan dari tiga senario pelepasan gas rumah hijau (RCP2.6, RCP4.5 dan RCP8.5). Berdasarkan hasil penentukuran dan pengesahan, SDSM menghasilkan prestasi yang baik dalam simulasi suhu dan prestasi rendah dalam simulasi hujan. Unjuran purata suhu bulanan untuk tahun-tahun akan datang (2020-2099) untuk setiap senario, diperkirakan terdapat penurunan suhu purata dari September hingga Disember mencapai -6.13% (RCP2.6), -5.94% (RCP4.5) dan -6.25% (RCP8.5) manakala peningkatan trend dari Januari hingga Ogos mencapai +7.07% (RCP2.6), +6.80% (RCP4.5) dan +7.00% (RCP8.5). Sementara itu, untuk purata unjuran hujan bulanan pada 2020-2099, peningkatan hujan bulanan dari September hingga Disember mencapai +67.39% (RCP2.6), +71.14% (RCP4.5) dan +66.60% (RCP8.5) manakala menurunkan trend dari Januari hingga Ogos mencapai -69.69% (RCP2.6), -46.11% (RCP4.5) dan -39.00% (RCP8.5). Di samping itu, model IHACRES dapat menunjukkan simulasi aliran sungai yang baik dalam kajian ini. Unjuran corak aliran sungai di masa depan (2020-2099), bersamaan dengan unjuran iklim masa depan yang menurun dengan membandingkan trend masa depan dengan rekod sejarah, aliran sungai untuk purata bulanan menurun dengan jelas -52.00%, -54.68% dan -53.05% untuk senario RCP2.6, RCP4.5 dan RCP8.5. Keadaan fluktuasi aliran sungai pada masa depan dapat dilihat dengan jelas dari corak aliran sungai bulanan, tahunan dan dekad dalam senario yang berbeza.

ABSTRACT

The escalation of global surface temperature in response to the alter of composition of the atmosphere will notably effect upon local hydrological patterns and water resources. This circumstance will later lead to the necessity for an assessment of climate change impacts. The main purpose of this study is to determine the current climate pattern and predict the future streamflow by using the applicability of statistical downscaling model (SDSM) and identification of unit hydrographs and component flows from rainfall, evaporation and streamflow data (IHACRES) models, respectively. In this study, the investigation was done by the potentiality of IHACRES to predict the fluctuation of long-term streamflow influenced by large-scale atmospheric variables which focused on Sg. Yap, Pahang. The study was done by the calibration and validation of from 26 NCEP-reanalysis data and the general circulation models (GCMs) outputs, and the subsequent the prediction of future rainfall and temperature in term of three different greenhouse gas emission scenarios (RCP2.6, RCP4.5 and RCP8.5). Based on the calibration and validation results, SDSM produced good performance in temperature simulation and low performance in rainfall simulation. The projection of mean monthly temperature for future years (2020-2099) for each scenario, it is predicted there is decreasing mean temperature from September to December achieving -6.13% (RCP2.6), -5.94% (RCP4.5) and -6.25% (RCP8.5) while the increasing trends from January to August reaching +7.07% (RCP2.6), +6.80% (RCP4.5) and +7.00% (RCP8.5). Meanwhile, for average monthly rainfall projection in 2020-2099, the increasing monthly rainfall from September to December achieving +67.39% (RCP2.6), +71.14% (RCP4.5) and -+66.60% (RCP8.5) while the decreasing trends from January to August reaching -69.69% (RCP2.6), -46.11% (RCP4.5) and -39.00% (RCP8.5). On top of that, IHACRES model able to show reliable simulation of streamflow in this study. The projection of future streamflow pattern (2020-2099), corresponding to the downscaled future climate projection by comparing the future trends with the historical records, the average mean monthly streamflow is decreasing obviously with -52.00%, -54.68% and -53.05% for the scenario RCP2.6, RCP4.5 and RCP8.5, respectively. The fluctuation of future flows is can be clearly seen from its pattern of monthly, annual and decade inflow in the different scenarios.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Presently, demands on water resources are vastly increasing throughout the world. Thus, decision making in the prediction of future of hydrological pattern within a context of climate change impact requires relevant models in hydrological studies. Rainfall-runoff models have been extensively applied as the standard tools designed for hydrological study such as hydrological forecasting, climate change impact studies, water resources management, flood assessment, streamflow prediction and land use impact estimation. It involves with the complex task in interacting various complex transformation process from rainfall to runoff. Thus, the rainfall-runoff models have been introduced. They are can be classified into 3 difference models: (1) metric model, (2) conceptual model, and (3) hybrid model which combination of metric and conceptual model or so called as conceptual-metric model. Metric model is the approach with the simplest model among the three types of model. Conceptual modelling basically describes all the components of hydrological processes or simplified as conceptualization and this leads to a system interconnected store. Meanwhile, hybrid model will be used the simplicity of metric model to overcomes the parameter uncertainty and conceptual will be functioned for continuous simulation of the rainfall-runoff model.

Nowadays, global rainfall patterns are being influenced by climate change. It is mainly resulted from the concentration of greenhouse gases (GHGs) in the atmospheric system (Gulacha and Mulungu, 2017). Climate change assessment also has leads to the changes of rainfall and rainfall-related extremes such as maximum daily rainfall, number of rainy days, average rainfall intensity, heavy rainfall days, extreme rainfall days, and rainfall concentration index. (Ab. Ghani et al., 2012) states that the climate change has begins to transform the rainfall pattern in Malaysia and may create extreme flood events in more frequently at several states. It is significant to consider the climate change impacts on the hydrologic process for a robust and resilient water management approach (Amin et al., 2017).

The application of Identification of Unit Hydrograph and Component Flow from Rainfall, Evaporation and Streamflow Data (IHACRES) (Jakeman et al., 1990) model has been used in this study to obtain the rainfall-runoff relationship which applied widely for the land use and climate change studies, as well as regionalization ungauged catchments (Lee et al., 2005). It optimized the conceptual model to capture the hydrological processes which requires three sets of data, there are data are observed rainfall, temperature and observed streamflow. The model consists of a nonlinear module to convert rainfall effective and linear module to route this effective rainfall to streamflow and it does not require the assumptions of constraints. Moreover, the relationship between the climate change and streamflow can be analysed by this hydrological model by using the output from downscaling method to make it as the input. Statistical Downscaling Method (SDSM) is used to downscale the coarse Global Circulation Models (GCMs) to local scales by involving predictor predictand relationship (Gulacha and Mulungu, 2017). SDSM has an ability to converting coarse spatial resolution into fine resolution and involving of generating station data of a specific area.

1.2 Problem of Statements

Based on the 5th Assessment Report (AR5) of the Inter-Governmental Panel on Climate Change (IPCC), the global average temperature with considered land and ocean was increased to 0.85°C over the period of 1800 to 2012 and 0.78°C over the period of 2003 to 2012. This trend is under all the Representative Concentration Pathways (RCPs), the global mean surface temperature which projected by RCPs for year 2081 to 2100 shows the increment value of 0.3-1.7℃ (RCP 2.6), 1.1-2.6℃ (RCP 4.5), 1.4-3.1℃ (RCP 6.0), and 2.6-4.8℃ (RCP 8.5). Considering the warming trend in Malaysia, average temperature increase of 0.5℃ to 1.5℃ recorded in Peninsular Malaysia and East Malaysia

(Malaysian Meteorological Department, 2009). Due to the global temperature, the rainfall peaks also getting more extreme in many region of the world and these changes in rainfall are leading to changes in river streamflow since streamflow is increasing during wet season and decreasing during dry season. (Amin et al., 2017) found that the overall mean monthly streamflow increases significantly during the future period in Kelantan and Pahang watersheds. On top of that, the streamflow assessment is important for water resource management as its information is useful water resource appraisal and allocation; engineering design such as reservoirs, bridges, roads, culvert and treatment plants; operation for reservoirs, power production and navigation; identification of past, ongoing and future land use, water use and climate; flood planning and warning; streamflow forecasting; support the quality of sampling; and characterizing and evaluating instream conditions for habitat assessment, instream flow requirements and recreation.

Sungai Yap is one of the small rivers forming the Sungai Pahang River Basin. In January 2017 Jerantut recorder as the worst-affected by flooding with 1,078 evacuees and one of the highest number of evacuees among other districts of Pahang (Bernama, 2017). The unexpected heavy rainfall was one of the main reasons of the flooding and the flood has been caused massive destruction of land use infrastructure, agriculture and irrigation system, loss of live and properties, which ultimately giving Government the revenue loss. Flood events are often catastrophic leads to damages of physical and social life. From the past decades, increasing flood incidences have been observed due to variations of rainfall patterns, climate change condition (Zaidi et al., 2014).

Therefore, to understand the climate change impacts on the unpredictable streamflow pattern, researches have been started and actively doing the study on the effects of climate change with the help of development of various and widely used of climate modelling (global and regional) in predicting and analysing its effect to the fluctuating streamflow in the past, now and future. The simulation of the climate change modelling is done by General Circulation Models (GCMs) which employs the numerical models of the general circulation using horizontal grid resolution and vertical grid resolution over the globe including finer spatial resolution, associated with more complex orography of the region and different greenhouse gases emission scenarios (Taylor et al, 2012). Unfortunately, GCMs are restricted in their usefulness for local impact studies by

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