FORECASTING THE STREAMFLOW CHANGES TREND BY SDSM-IHACRES MODEL AT SG JERAM, PAHANG

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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 degree of Bachelor of Civil Engineering

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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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To my beloved parents and family
for moral and physical support:

Yem Bin Ibrahim

Zamri Bin Yem

Wahid Bin Yem

Mariati Binti Yem

Siti Ruzana Binti Yem

Siti Hasmah Binti Yem

Siti Aidah Binti Yem

Siti Maszirah Binti Yem

Muhammad Najib Bin Yem

And the late my mother:

Dawamah Binti Tambrain

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ABSTRAK

Kesan rumah hijau merupakan fenomena semulajadi untuk memastikan Bumi kekal hangat. Rumah hijau memainkan peranan mereka apabila rumah hijau menyerap haba daripada tanah. Pada masa kini, kekurangan haba yang hilang ke ruang angkasa disebabkan peningkatan suhu global yang mendadak. Karbon dioksida (CO_2) merupakan penyumbang utama kepada kesan rumah hijau (Sumner,2015). Semakin tinggi jumlah gas rumah hijau di atmosfera, semakin tinggi suhu di tempat tersebut. Suhu di sesuatu tempat bergantung terus dengan hubungan hujan-larian. Secara umumnya, air larian akan meningkat apabila jumlah hujan meningkat. Sebaliknya, air larian akan menurun apabila suhu udara meningkat. Pada masa kini, turun naik hujan, suhu dan alian sungai menjadi tidak dijangka apabila dibandingkan dengan data yang direkodkan. Beberapa tempat diatas muka Bumi menerima terlalu banyak air dan yang lainnya menerima terlalu sedikit sahaja air untuk mengekalkan ekonomi dan kehidupan penduduk. Oleh itu, pengurusan takungan air perlu diberi perhatian dengan corak aliran aliran masa hadapan terutamanya di Malaysia di mana bencana alam seperti kemarau dan banjir tidak dapat dijangkakan. Dalam kajian ini, rekod hujan dan suhu di Sg. Jeram Bungor, Pahang dianalisis di menggunakan model *Statistical Downscaling (SDSM*) untuk menjana curah hujan dan aliran suhu yang akan dating. Kemudian, keputusan daripada model *SDSM* dianalisis menggunakan *Identification of unit Hydrographs And Component flows from Rainfall, Evapotranspiration and Streamflow (IHACRES)* untuk menjana pola aliran masa depan di Jeram Bungor.

ABSTRACT

Greenhouse gases (GHGs) is a natural phenomenon to keep the Earth warm. Greenhouse effect plays their role when GHGs absorb heat from the ground. Nowadays, less heat escapes from the space and more re-emitted heat trapped by GHGs which rapid increasing the global temperature. Carbon dioxide (CO2) is the major contributor of abnormally greenhouse GHGs (Sumner,2015). The higher the amount of those gases in the atmosphere, the higher the local temperature of specific location. The local temperature is directly related with rainfall-runoff relationship. In general, the water runoff increases when the amount of precipitation increases. On the other hand, the water runoff decreases when the air temperature increases. Nowadays, the fluctuation of rainfall, temperature and streamflow becomes unexpected compared to historical recorded data. Some places on Earth receive too much water and some receive very little amount of water to sustain the economy and the people’s living. So, it is vital to assist water reservoir management by evaluating future streamflow pattern especially in Malaysia where the natural disasters such as droughts and flood cannot be expected. In this study, historical rainfall and temperature data at Sg. Jeram Bungor, Pahang were analysed in Statistical Downscaling (SDSM) model to generate future rainfall and temperature trend. Then, the results from the SDSM model were analysed in Identification of unit Hydrographs And Component flows from Rainfall, Evapotranspiration and Streamflow (IHACRES) to generate future streamflow pattern at Jeram Bungor.

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LIST OF SYMBOLS

ppm	Parts per million. The symbol of “ppm” is a unit to measure the ratio of the number of greenhouse gas molecules to the total number of molecules of dry air. As an example, 245 ppm of carbon dioxide means 245 molecules of carbon dioxide molecules in 1 million molecules of dry air
ppb	Parts per billion. 1 billion equals to 1000 millions
W/m^2	Watts per meter square
kcal	Kilo calories. 1Kcal equals to 1000 calories
m^3/s	Metre cube per second

LIST OF ABBREVIATIONS

SDSM	Statistical Downscaling Model
DID	Department of Irrigation and Drainage of Malaysia (JPS)
MET	Malaysian Meteorological Department
CO_2	Carbon dioxide
LARS-WG	Long Ashton Research Station Weather
DO	Dissolved Oxygen
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
MMD	Malaysian Meteorological Department
HBV	Hydrologiska Byrans Vattenavdelning
CH_4	Methane
N_2O	Nitrous Oxide
CFCs	Chlorofluorocarbons
FLEGT	Forest Law Enforcement, Governance And Trade
HOV	High Occupancy Vehicle
CanRCM4	Canadian Center for Climate Modelling and Analysis Regional Climate Model
SWAT	Soil and Water Assessment Tool

CHAPTER 1

RESEARCH BACKGROUND

1.1 Introduction

The streamflow fluctuation in the future year might give large impact to the consumers, global economy and environment. Thus, streamflow study nowadays becomes significant in monitoring and managing the efficiency of water resources in the long term. The nature of streamflow changes will depend on the magnitude and direction of the climate change. Rainfall and temperature are the importance parameters in managing the streamflow changes. Monthly temperature and rainfall data were taken to predict streamflow changes in Little Blue River basin located at the south-central of Nebraska (Rowe et al.,1994). The study was to predict the streamflow in the south-central of Nebraska using the climatic parameter to prove the relationship between climates and streamflow. The research proved that the climate change fluctuates the streamflow pattern. For every increment of 20% of precipitation will contribute twice times to the streamflow volume. Meanwhile, 20% of decrement of precipitation will reduce half of annual streamflow volume. Due to the temperature, the increases of 3 °C yields 60% decline of streamflow volume meanwhile the decrement of 3 °C will increase more than 80% of streamflow volume. It as proved that climate change gives huge impact to the water streamflow based on the investigation. Water streamflow trend determines the amount water resources accessible for agriculture activities, drinking, house usage, industrial and energy generation. Assessment of climate change must be conducted for areas that show high possibility of droughts such as Tseng-Wen catchment in Southern Taiwan to provide sufficient water supply (Yu et al., 2014).

Regional resolution is popular among hydrologists to run climate change assessment to investigate climate change impact. The Global Climate Models (GCMs) leading method to predict the global climate changes in the coarser spatial resolution

(Hassan & Harun, 2012). However, the GCMs characteristic covers huge spatial resolution where not focused on the local area. To overcome this issue, the Statistical Downscaling Model (SDSM) is adopted to downscale rainfall from the GCMs output. This statistical method is applying Regression Models to carry out this study. These models involved in forming nonlinear and linear relationships between finer resolution and coarser resolution predictor variables. This type relationship is called as transfer function (Wilby & Wigley, 2007). Rainfall data from a hydrological station belonged to Department of Irrigation and Drainage (DID) at Sg. Jeram Bungor (Station ID no: 4121413) and temperature data from Malaysian Meteorological Department (MMD) are used as input in the SDSM model. The results from the SDSM model will be used as inputs to predict water streamflow of Pahang River basin. These results are used in IHACRES model which is one of hybrid model used nowadays to predict future streamflow pattern at a regional site.

1.2 Problem Statement

Greenhouse gases (GHGs) is a natural phenomenon to keep the Earth warm. Greenhouse effect plays their role when GHGs absorb heat from the ground. Nowadays, less heat escapes from the space and more re-emitted heat trapped by GHGs which rapid increasing the global temperature. Carbon dioxide (CO_2) is the major contributor of abnormally greenhouse GHGs (Sumner,2015). Other than CO_2, Methane (CH4), Nitrous oxide (N_2O), Chlorofluorocarbons (CFCs) and Hydrofluorocarbons (HCFCs) are the various GHGs which makes global warming a serious matter to the environment and its residents.

Shaftel (2017) stated that the carbon dioxide level increased to 400 ppm since 1950s. About 95% of the carbon dioxide content in the atmosphere induced by human activities such as logging, open burning, gas emission from moving vehicles and industrial residue. Urbanisation and development of rural areas are the major causes of global climatic changes which completely water streamflow in regional areas (DeWalle et al., 1998). The rapid urbanization also contributes to the increment of streamflow due to runoff comes from larger impermeable man-made structures and reduces the infiltration rate. The evapotranspiration rate also reduces due to the less vegetation space.

In general, the water runoff increases when the amount of precipitation increases. On the other hand, the water runoff decreases when the air temperature increases. Surprisingly, the resultant combination of temperature and precipitation showed upward trend of streamflow (DeWalle et al., 1998). Precipitation change has dominated streamflow pattern for Northeast, North-Central, Western, and Southern regions in the United States rather than temperature in the study areas. The report proved that 20 % increase in precipitation and 4 ^{o}C increase in temperature for 21 rural basins resulted in 15% increases of mean annual flow. Moreover, the increase of 4 °C of temperature and 20 % decrease of precipitation resulted a decrease of 45 % of mean annual flow. These statistics were very critical for extreme climate change impact for streamflow assessment.

In the Pahang state, the forest area becomes less year by year due to urbanisation. Illegal logging activities at the upstream of Pahang River especially in Kuala Tahan is also contributed to rapid increment of runoff (Gasim et al., 2011). Silva (2017) found that these activities took place at the catchment areas which cause the imbalance of water cycle components. This causes abnormally runoff occurrence and streamflow in the river.

The fluctuation of the river flow in Malaysia is also one of the consequences from climate change. At the end of December 2014, a massive flood gave huge impacts to the environment and society in the Pahang River basin. There were 35,560 of evacuees transferred to various evacuation centres in 9 districts of Pahang. Moreover, there were 10 deaths due to this major flood (Chi, 2014). This is the worst flood were recorded in the history of Pahang River since 1999. Crops losses, public facilities damages and diseases were the extreme results of this disaster. The occurrence of this major flood was triggered by the non-stop of rainfall in Pahang River basin and overflow of water from the river. The flood occurrence at East Coast of Peninsular Malaysia is an annual natural disaster especially in the state of Terengganu, Kelantan and Pahang (Alias, 2015). Therefore, it is very important to study the streamflow of Pahang River for the long-term planning in effort to reduce life loss, property damages and environmental effects of streamflow sensitivity of climate change. It is impossible to avoid a natural disaster but precautions must be taken especially when the stream level is over the danger level.

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