VOL. 10, NO. 15, AUGUST 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

ASSESSMENT OF IMPACTS OF CLIMATE CHANGE ON STREAMFLOW TREND IN UPPER KUANTAN WATERSHED

Mohd M. S. F.[1], Mispan M. R.[2], Juneng L.[1], Tangang F. T.[1], Rahman N. F. A.[3], Khalid K.[3], Rasid M. Z. A.[2] and Haron S. H.[1]

[1]Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Bangi, Malaysia
[2]Malaysian Agriculture Research and Development Institute, Serdang, Malaysia
[3]Faculty of Civil Engineering, Univeristi Teknologi Mara, Shah Alam, Malaysia
E-Mail: syazwannahrim@gmail.com

ABSTRACT

This paper examines the impact of climate change on the streamflow in the Kuantan watershed using coupled of statistical climate downscaling tools with hydrologic model - Soil and Water Assessment Tools (SWAT). This integrated modelling framework is designed to simulate and assess watershed-scale changes. The study evaluated the performance and suitability of SWAT model in assessing streamflow trend under the current and future climate. Observed streamflow data from 1978 to 1985 were used for model calibration and data from 2000 to 2006 were used for model validation. For the period of 1986 to 1999, the streamflow data are not available partially and not used in calibration and validation process. SWAT model was calibrated with an R2 value of 0.84 for the calibration and 0.59 for the validation period. The streamflow is expected to increase especially towards the end of the century particularly in the month of August and September which the percentage of increment were up to 106% under the RCP 8.5 scenario and almost more than 50% increase in the month of August during the middle term period under both the RCP4.5 and RCP8.5 scenarios. However, no decreasing trend is found significantly except a minor decreasing trend during the month of November for the near-term period. For the minimum streamflow projection, percentage of increment can be up to ~57% under the RCP 8.5 scenario and ~34% increase in the month of September during the middle term period under both scenarios with no significant decreasing trend is found except a minor decreasing trend in the month of March during the end of century under the RCP 4.5 scenario. For the maximum streamflow projection, percentage of increment can be up to ~157% under the RCP 8.5 scenario and up ~79% increase in the month of July and August during the middle term period under both scenarios with no significant decreasing trend is found except a minor decreasing trend in the month of November during the near term period under the RCP 4.5 scenario. The simulation results showed that SWAT can be used and implemented for planning and management purposes of watersheds.

Key words: climate change, streamflow, statistical downscaling, soil and water assessment tools.

INTRODUCTION

Precipitation plays a crucial role in the hydrological cycle. The warmer climate in the future is expected to change the rainfall pattern, leading to altered streamflow characteristics. Understanding the impact of climate change to the hydrological budget is crucial in order to assess the future water availability. This exercise is usually achieved by driving the basin-scale hydrologic model with climate scenarios output from the General Circulation Model (GCM) (Watson *et al*., 1996) either by dynamical downscaling using regional climate models (RCMs) (Hay *et al*., 2002) or by statistical downscaling (Wilks *et al*., 1995).

In this study, the upper Kuantan watershed, located in eastern Peninsular Malaysia, was selected. It is one of the important watersheds in Malaysia that provides water supply to more than half million of populations in the Kuantan District. The main objectives in this study are to calibrate and validate SWAT model for upper Kuantan Watershed and then simulate the impacts of climate change on future streamflow magnitude under the medium and worst case greenhouse gasses concentration scenarios. Nowadays, hydro-climate modelling is become more important tools in order to assess the impacts of climate change to hydrological regimes.

METHODOLOGY

This paper discusses the usage of statistical downscaling output in driving the hydrological model to project the (Moss, Edmonds *et al*. 2010) impact of climate change on streamflow under the different warming scenarios. Six GCMs including the Norwegian Earth System Model (NorESM), Max Planck Institute Earth System Model (MPI), The Canadian Earth System Model (CanESM), Centre National de Recherches Meteorologiques (CNRM), Institut Pierre-Simon Laplace Earth System Model (IPSL) and Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (MIROC) have been downscaled empirically to 5km x 5km grids using the quantile mapping technique (Li *et al*., 2010).

Two scenarios known as Representative Concentration Pathways 4.5 (RCP 4.5) and RCP 8.5 are considered (Moss *et al*., 2010). RCP 8.5 is characterized

ARPN Journal of Engineering and Applied Sciences

by increasing greenhouse gas emissions over time, representative of scenarios in the literature that lead to high greenhouse gas concentration levels (Riahi *et al*. 2007) while RCP 4.5 is a stabilization scenario in which total radiative forcing is stabilized shortly after 2100, without overshooting the long-run radiative forcing target level (Wise *et al*., 2009). RCPs are time and space dependent trajectories of concentrations of greenhouse gases and pollutants resulting from human activities, including changes in land use. RCPs provide a quantitative description of concentrations of the climate change pollutants in the atmosphere over time, as well as their radiative forcing in 2100 (for example, RCP 8.5 achieves an overall impact of 8.5 watts per square metre by 2100). The word "representative" signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing pathway. Radiative forcing is a measure of the additional energy taken up by the Earth system due to increases in climate change pollution (Moss *et al*., 2010).

The Soil and Water Assessment Tools (SWAT) was used as the hydrological simulation component in this study. SWAT has been shown to have a good performance in simulating at river basins scale and has been successfully used worldwide in many applications, from hydrologic assessment of watershed to the damage claims in court (White *et al*., 2011). The SWAT model (Arnold *et al*., 1998) is a long-term, continuous and semi-distributed hydrologic model that have a very good capability in assessing water management, sediment, nutrient and agriculture practices (Jha *et al*., 2004). The SWAT model required intensive Geographical Information System (GIS) setup using ArcSWAT extension in ArcGIS software [(Rahman *et al*., 2014). The spatial data required to run SWAT model are digital elevation model (DEM), land use map and soil map. The Digital Elevation Model was obtained from Department of Survey and Mapping Malaysia (JUPEM), while the land use map and soil map were obtained from Department of Agriculture of Malaysia (DOA).

For the calibration and validation period, gridded daily hydrometeorological data set such as rainfall, mean temperature, wind speed and solar radiation for Peninsular Malaysia developed by (Wong *et al*. 2012) was used. This dataset was developed purposely for the use of hydrologists and modelling practitioners in climate and hydrology research. However, this dataset only available from 1976 until 2006. Streamflow data were obtained from Department of Irrigation and Drainage of Malaysia (DID). The streamflow stations are located at Sungai Lembing near Bukit Kenau. Streamflow dataset of 15 years were used for this study. For model set up, 2 years data from 1976 to 1977 were used for model warm up. Data from 1978 to 1985 were used for model calibration and data from 2000 to 2006 was used for model validation. For the period of 1986 to 1999, the streamflow data are not available partially and not used in calibration and validation process.

During calibration period, several sensitive parameters that may influence the flow simulation results includes the initial curve number (II) value (CN2), base flow alpha factor (ALPHA_BF), groundwater delay (GW_DELAY) and threshold water depth in the shallow aquifer for flow (GWQMN) were selected and then optimized using the SUFI2 algorithm.

Then, the calibrated and validated SWAT model for Kuantan watershed was used for future simulation starting from 1976-2100 driven by the downscaled precipitation datasets under RCP 4.5 and RCP 8.5 scenarios. The outputs of all simulations were then ensemble and analyzed for details assessment. The period was separated into four-time slices namely baseline (1976-2005), near term (2010-2040), mid-term (2041-2070) and end of the century (2071-2100).

RESULTS AND DISCUSSIONS

SWAT calibration and validation

Optimization of four different sets of spatial input parameterization such as CN2, ALPHA_BF, GW_DELAY and GWQMN will reflect the sensitivity on the streamflow simulation. Manipulations of sensitive parameters were carried out within the reasonable ranges (Table-1).

Table-1. Initial and finally adjusted parameter values of flow calibration.

Sensitivity ranking	Parameter name	Lower and upper bound	Fitted value
1	CN2	-0.6 - 0.6	-0.5739
2	ALPHA_BF	0 - 1	0.13
3	GW_DELAY	30 - 450	48
4	GWQMN	0 - 2	1.82

The model achieves a good performance (Figure-1) with a value of coefficient of determination (R2) of 0.84 (Figure-3) and validation value of R2 is 0.59 (Figure-4) [(Moriasi *et al*., 2007). The calibration procedure was carried out using the SWAT-CUP Sequential Uncertainty Fitting Procedure version 2 (SUFI2) which was developed by (Abbaspour *et al*., 2004). During this calibration period, SWAT model performs well in capturing the higher peak flows and lower base flows. However during validation period (Figure-2), the model fails to capture two major storm event recorded during 2004-2006 and resulting in lower peak flow. According to the reviews of applications of some hydrological models by (Borah and Bera, 2004) (Borah *et al*. 2004), SWAT is reliable for yearly and monthly average or yield predictions but less for months with severe hydrological storms. Meanwhile, daily predictions from SWAT are less reliable, especially for the days that having intense storm. Therefore, SWAT is not suited for analyzing severe storm events (Borah *et*

VOL. 10, NO. 15, AUGUST 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

al. 2004). Lack of information regarding the watershed characteristics, hydrometeorological observed dataset, aquifer systems, both deep and shallow also can impact on the streamflow modeling processes (Jajarmizadeh *et al*., 2013).

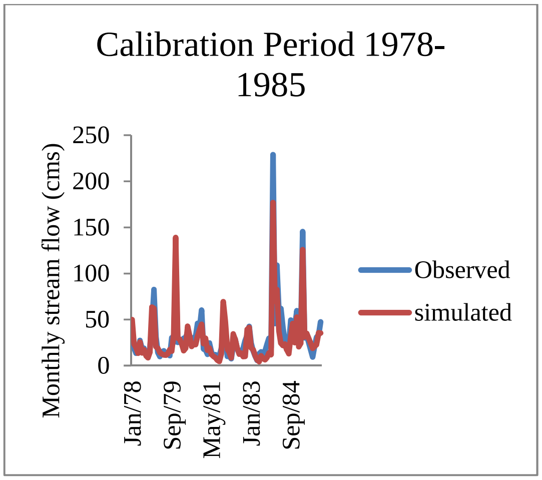

Figure-1. Calibration period 1978-1985.

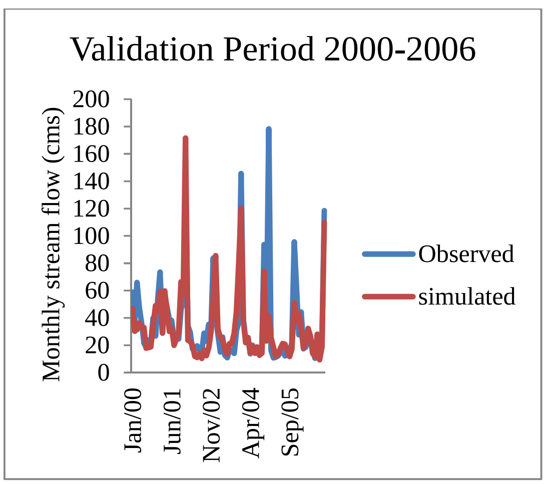

Figure-2. Validation period 2000-2006.

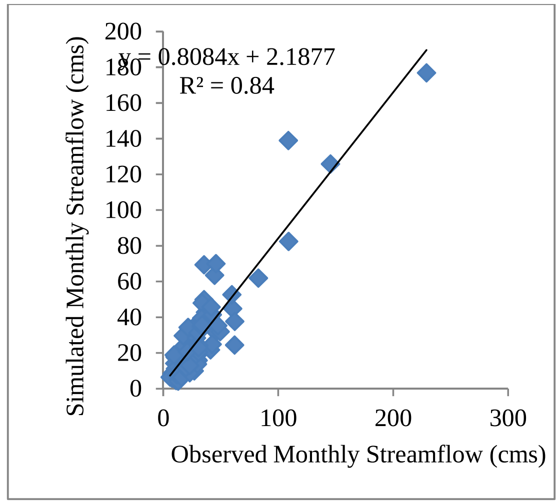

Figure-3. Value of R^2 for calibration period.

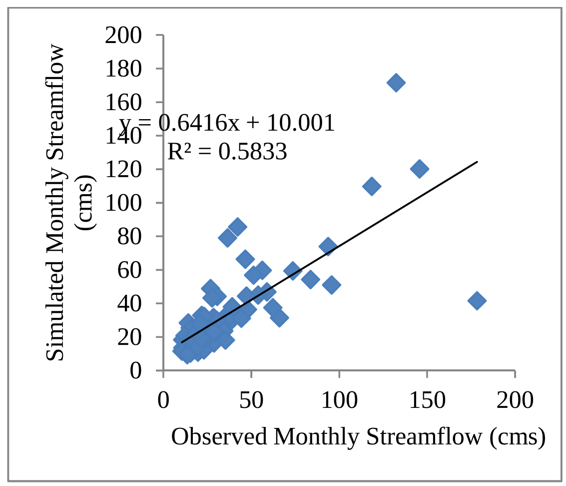

Figure-4. Value of R^2 for validation period.

FUTURE STREAMFLOW PROJECTION

Mean streamflow

For the streamflow projection under RCP 4.5 and RCP 8.5 scenarios, most of the monthly flows are projected to increase significantly (Figure 5 and 6) in the three time periods except one minimal increase in the near term month of November. The highest projected increase under this scenario is almost 50% in the month of August during mid-term period (Table 2). Meanwhile, for scenario RCP8.5 significant increase of more than 97% is projected to occur toward the end of the century especially for August and September (Table-3). In Peninsular Malaysia, the months of June, July and August is categorized as dry season or also call as South West Monsoon period. Usually during this period, the eastern part of Peninsular Malaysia received less rainfall compared to other seasons. The significant increase of projected streamflow for the

ARPN Journal of Engineering and Applied Sciences

month of August in future under both scenarios show that the dry season in future will become wetter. The projected increase in the dry season shows a positive sign which it could prevent the water demand shortage problem in this watershed. However, the magnitude of projected increase in the wet season (December, January, February) or called Northeast Monsoon period were not really large compared to the magnitude of changes in dry season. This can be an indicator for the condition of having very severe storm events and increased flooding risk under the warmer climate in future.

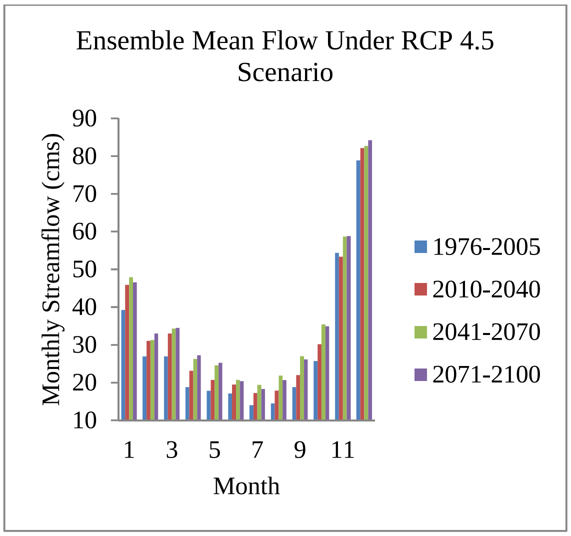

Figure-5. Ensemble mean flow under RCP 4.5 scenario.

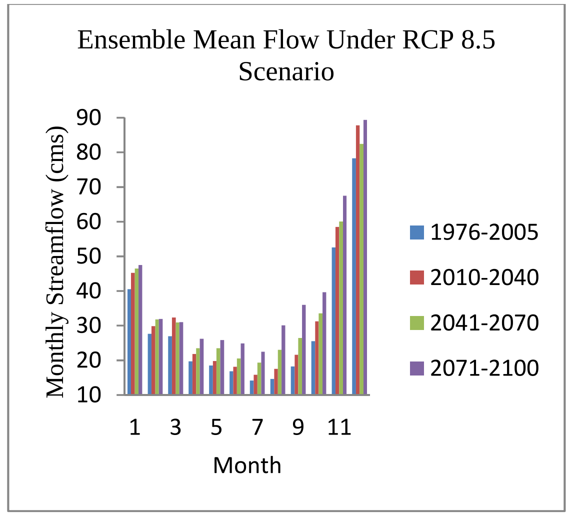

Figure-6. Ensemble mean flow under RCP 8.5 scenario.

Table-2. Monthly Mean Flow Projection under RCP 4.5 Scenario.

Period	**2010-2040**			**2041-2070**			**2071-2100**		
Month	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**
Jan	39.24	45.92	+17.0	39.24	47.94	+22.2	39.24	46.56	+18.6
Feb	26.97	31.05	+15.1	26.97	31.28	+16.0	26.97	33.03	+22.4
Mac	26.97	33.01	+22.4	26.97	34.34	+27.3	26.97	34.48	+27.8
Apr	18.83	23.12	+22.8	18.83	26.28	+39.6	18.83	27.25	+44.7
May	17.82	20.69	+16.1	17.82	24.56	+37.8	17.82	25.24	+41.6
Jun	17.11	19.50	+14.0	17.11	20.71	+21.1	17.11	20.39	+19.2
Jul	14.05	17.24	+22.7	14.05	19.44	+38.4	14.05	18.29	+30.2
Aug	14.48	17.86	+23.3	14.48	21.84	+50.9	14.48	20.65	+42.7
Sep	18.83	21.96	+16.6	18.83	27.00	+43.4	18.83	26.12	+38.7
Oct	25.74	30.16	+17.2	25.74	35.41	+37.6	25.74	34.92	+35.7
Nov	54.34	53.35	-1.8	54.34	58.69	+8.0	54.34	58.80	+8.2
Dec	78.85	82.14	+4.2	78.85	82.66	+4.8	78.85	84.23	+6.8

ARPN Journal of Engineering and Applied Sciences

Table-3. Monthly mean flow projection under RCP 8.5 scenario.

Period	2010-2040			2041-2070			2071-2100		
Month	Historical flows (cms)	Future flows (cms)	% of Changes	Historical flows (cms)	Future flows (cms)	% of Changes	Historical flows (cms)	Future flows (cms)	% of Changes
Jan	40.52	45.21	+11.6	40.52	46.49	+14.7	40.52	47.49	+17.2
Feb	27.64	29.85	+8.0	27.64	31.78	+15.0	27.64	31.95	+15.6
Mac	26.95	32.38	+20.2	26.95	30.92	+14.7	26.95	31.00	+15.0
Apr	19.70	21.79	+10.6	19.70	23.50	+19.3	19.70	26.25	+33.2
May	18.50	19.82	+7.1	18.50	23.49	+27.0	18.50	25.83	+39.6
Jun	16.87	18.16	+7.6	16.87	20.56	+21.9	16.87	24.89	+47.5
Jul	14.17	15.79	+11.4	14.17	19.33	+36.4	14.17	22.45	+58.4
Aug	14.62	17.56	+20.1	14.62	23.04	+57.5	14.62	30.12	+106.0
Sep	18.23	21.59	+18.4	18.23	26.43	+45.0	18.23	35.99	+97.4
Oct	25.56	31.24	+22.2	25.56	33.57	+31.3	25.56	39.65	+55.1
Nov	52.56	58.52	+11.3	52.56	60.10	+14.3	52.56	67.52	+28.4
Dec	78.28	87.77	+12.1	78.28	82.46	+5.3	78.28	89.42	+14.2

Minimum streamflow

Referring to the Figures 7 and 8, we may see the clear increasing trend for the all month in future under the both scenarios particularly from the month of April until the month of December under the RCP 4.5 scenario and from the month of June until the month of December under the RCP 8.5 scenario.

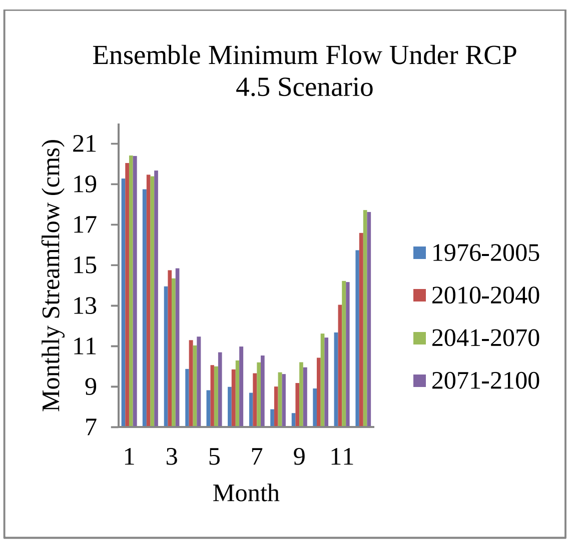

Figure-7. Ensemble minimum flow under RCP 4.5 scenario.

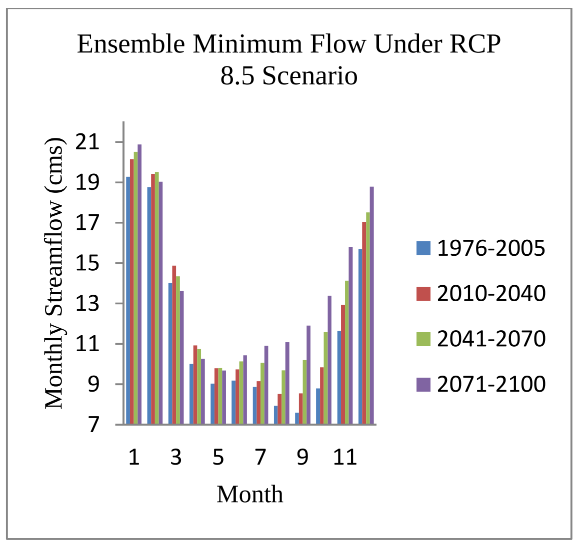

Figure-8. Ensemble minimum flow under RCP 8.5 scenario.

Based on Tables 4 and 5, the percentage of increase under RCP 4.5 scenario is up to ~32% during the mid-term period and up to ~29% at the end of century for the month of September. Under the RCP 8.5 scenario, no high significant increase during the near term and mid-term while significant higher increase is projected to occur during the end of century particularly in the month of September and October. The projected increase of minimum streamflow is actually a good indicator that we will probably have minimal drought events in the future and less water scarcity problem. However, by using only one technique of downscaling, the large uncertainties are still there and the water manager should always be prepared in facing such water scarcity problem in the future.

Table-4. Monthly minimum flow projection under RCP 4.5 scenario.

Period	2010-2040			2041-2070			2071-2100		
Month	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**
Jan	19.28	20.05	+4.0	19.28	20.42	+5.9	19.28	20.39	+5.8
Feb	18.76	19.47	+3.8	18.76	19.39	+3.4	18.76	19.67	+4.9
Mac	13.95	14.75	+5.7	13.95	14.36	+2.9	13.95	14.85	+6.4
Apr	9.88	11.30	+14.4	9.88	11.04	+11.8	9.88	11.47	+16.2
May	8.83	10.07	+14.0	8.83	10.01	+13.3	8.83	10.70	+21.1
Jun	8.99	9.86	+9.6	8.99	10.30	+14.5	8.99	10.99	+22.2
Jul	8.71	9.67	+11.0	8.71	10.21	+17.2	8.71	10.54	+21.1
Aug	7.89	9.01	+14.2	7.89	9.72	+23.2	7.89	9.63	+22.1
Sep	7.70	9.18	+19.2	7.70	10.21	+32.6	7.70	9.96	+29.4
Oct	8.92	10.43	+17.0	8.92	11.62	+30.4	8.92	11.43	+28.2
Nov	11.68	13.05	+11.7	11.68	14.23	+21.8	11.68	14.17	+21.3
Dec	15.75	16.60	+5.4	15.75	17.72	+12.5	15.75	17.63	+12.0

Table-5. Monthly minimum flow projection under RCP 4.5 scenario.

Period	2010-2040			2041-2070			2071-2100		
Month	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**
Jan	19.28	20.15	+4.5	19.28	20.52	+6.4	19.28	20.87	+8.3
Feb	18.77	19.42	+3.5	18.77	19.52	+4.0	18.77	19.03	+1.4
Mac	14.03	14.88	+6.1	14.03	14.35	+2.3	14.03	13.63	-2.8
Apr	10.01	10.92	+9.1	10.01	10.75	+7.4	10.01	10.26	+2.5
May	9.03	9.80	+8.5	9.03	9.80	+8.5	9.03	9.68	+7.2
Jun	9.19	9.74	+6.0	9.19	10.13	+10.3	9.19	10.43	+13.5
Jul	8.87	9.15	+3.2	8.87	10.07	+13.5	8.87	10.91	+23.0
Aug	7.94	8.52	+7.4	7.94	9.69	+22.1	7.94	11.08	+39.7
Sep	7.60	8.54	+12.5	7.60	10.20	+34.2	7.60	11.91	+56.7
Oct	8.80	9.84	+11.9	8.80	11.59	+31.7	8.80	13.39	+52.1
Nov	11.64	12.93	+11.1	11.64	14.14	+21.5	11.64	15.81	+35.8
Dec	15.70	17.05	+8.6	15.70	17.51	+11.5	15.70	18.79	+19.7

Maximum streamflow

Based on Figure-9, we may see a clear trend of increase particularly for the 10 months except some minor decrease for the month of November and December during the near period. under the RCP 4.5 scenario. While figure 10 described the higher projected changes for the maximum monthly flows during the mid-term and end of the century particularly for the months of April until October under the RCP 8.5 scenario. From the results, we may suggest that the dry season and inter-monsoon season

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

will become wetter in the future and more extreme event such flash flood could be expected to be happen.

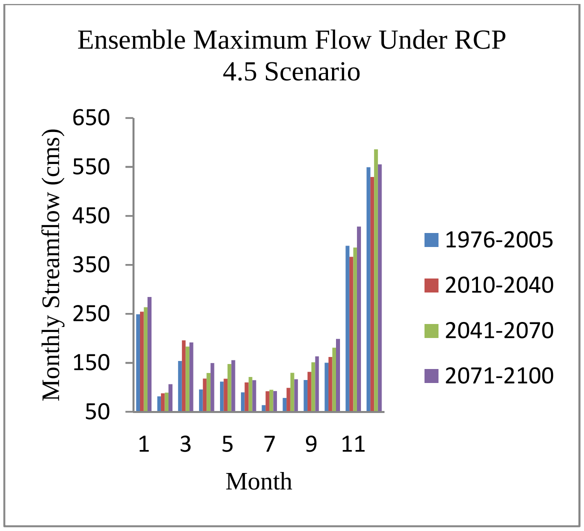

Figure-9. Ensemble maximum flow under RCP 4.5 scenario.

Figure-10 also showed that in the near future, the wet season particularly, during the month of November and December will become wetter. Under both scenarios, some months is projected to have an extremes increase which more than 40% to 157% compared to the baseline (Tables 6 and 7). This projected extreme should be taken into account by the local authority in order to make a precaution action such as deepening the riverbed and widening the river buffer zone so that it will help the excess water flow through the river easily during this season. In order to support such of a critical statement, the more downscaling technique is recommended to reduce the uncertainties coming from such one technique.

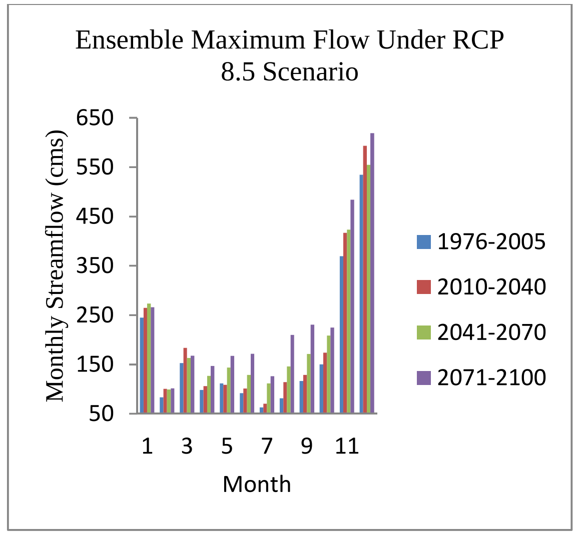

Figure-10. Ensemble maximum flow under RCP 8.5 scenario.

Table-6. Monthly maximum flow projection under RCP 4.5 scenario.

Period	**2010-2040**			**2041-2070**			**2071-2100**		
Month	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**	**Historical flows** (cms)	**Future flows** (cms)	**% of Changes**
Jan	249.11	254.31	+2.1	249.11	263.63	+5.8	249.11	284.69	+14.3
Feb	81.86	87.81	+7.3	81.86	89.20	+9.0	81.86	106.68	+30.3
Mac	153.88	196.00	+27.4	153.88	183.15	+19.0	153.88	191.70	+24.6
Apr	95.89	117.87	+22.9	95.89	129.38	+34.9	95.89	149.73	+56.1
May	111.93	117.73	+5.2	111.93	147.76	+32.0	111.93	155.44	+38.9
Jun	89.88	109.87	+22.2	89.88	121.25	+34.9	89.88	114.72	+27.6
Jul	63.58	92.25	+45.1	63.58	94.99	+49.4	63.58	92.44	+45.4
Aug	78.28	98.81	+26.2	78.28	129.80	+65.8	78.28	116.76	+49.2
Sep	115.08	131.41	+14.2	115.08	151.27	+31.4	115.08	163.63	+42.2
Oct	150.35	161.84	+7.6	150.35	180.90	+20.3	150.35	198.74	+32.2
Nov	389.18	366.68	-5.8	389.18	385.36	-1.0	389.18	428.39	+10.1
Dec	549.46	529.50	-3.6	549.46	585.88	+6.6	549.46	555.25	+1.1

Table-7. Monthly maximum flow projection under RCP 8.5 scenario.

Period	2010-2040			2041-2070			2071-2100		
Month	Historical flows (cms)	Future flows (cms)	% of Changes	Historical flows (cms)	Future flows (cms)	% of Changes	Historical flows (cms)	Future flows (cms)	% of Changes
Jan	244.67	264.49	+8.1	244.67	273.60	+11.8	244.67	266.18	+8.8
Feb	83.30	100.35	+20.5	83.30	99.29	+19.2	83.30	101.73	+22.1
Mac	152.46	183.37	+20.3	152.46	163.19	+7.0	152.46	167.54	+9.9
Apr	98.39	106.03	+7.8	98.39	126.56	+28.6	98.39	146.83	+49.2
May	111.49	108.72	-2.5	111.49	143.74	+28.9	111.49	167.21	+50.0
Jun	91.82	100.94	+9.9	91.82	128.75	+40.2	91.82	171.51	+86.8
Jul	62.97	70.47	+11.9	62.97	111.59	+77.2	62.97	125.97	+100.1
Aug	81.62	114.29	+40.0	81.62	145.83	+78.7	81.62	209.94	+157.2
Sep	116.59	128.73	+10.4	116.59	171.26	+46.9	116.59	230.71	+97.9
Oct	150.30	174.09	+15.8	150.30	208.35	+38.6	150.30	224.92	+49.7
Nov	369.47	417.04	+12.9	369.47	423.18	+14.5	369.47	484.04	+31.0
Dec	534.62	593.32	+11.0	534.62	554.76	+3.8	534.62	618.93	+15.8

CONCLUSIONS

Soil and Water Assessment Tool (SWAT) is used to model the streamflow of the upper part of Kuantan Watershed. The simulation results show very good performance for the calibration period and acceptable skill for validation period, with R2 values of 0.84 and 0.59, respectively.

The average streamflow future trend is projected to increase especially towards the end of the century particularly in the month of August and September with the percentage of increment can be up to ~100% under the RCP 8.5 scenario and ~50% increase in the month of August during the mid-term period under both scenarios. Additionally, no significant decreasing trend is found except a minor decreasing trend in the month of November during the near term period.

The minimum streamflow future trend is projected to increase especially towards the end of the century particularly in the month of September and October with the percentage of increment can be up to ~57% under the RCP 8.5 scenario and ~34% increase in the month of September during the mid-term period under both scenarios. Additionally, no significant decreasing trend is found except a minor decreasing trend in the month of March during the end of the century under the RCP 4.5 scenario.

The maximum streamflow future trend is projected to increase especially towards the end of the century particularly from the month of April until October with the percentage of increment can be up to ~157% under the RCP 8.5 scenario and up ~79% increase in the month of July and August during the middle term period under both scenarios. Additionally, no significant decreasing trend is found except a minor decreasing trend in the month of November during the near term period under the RCP 4.5 scenario.

However, the dynamical downscaling technique is recommended to be done in order to address the uncertainties coming from the downscaling techniques. Future consideration of this study is to conduct an assessment of the impact of sediment and nutrient. It is highly recommended that this type of study should be extended to the important watershed nationwide so that the results and findings from such nationwide could be used as a basis for adaptation and mitigation planning.

ACKNOWLEDGEMENTS

This project was funded by Malaysia Ministry of Higher Education under the ICONIC-2013-001 and AP-2013-005 projects. Special thanks to SWAT Network of Malaysia for their contribution.

REFERENCES

Abbaspour, K. C., Johnson, C. A. and van Genuchten, M. T. 2004. Estimating Uncertain Flow and Transport Parameters Using a Sequential Uncertainty Fitting Procedure. Vadose Zone J. 3(4), 1340-1352. doi: 10.2136/vzj2004.1340.

Arnold, J. G., Srinivisan R., Muttiah R. S., and Allen P. M. 1998. Large-area hydrologic modeling and assessment: Part I. Model development. J. American Water Resources Assoc. 34(1): 73-89.

Borah, D. K.; Arnold, J.y G.; Bara, Maitreyee; Krug, Edward C.; and Liang, X. 2007. Storm Event and Continuous Hydrologic Modeling for Comprehensive and Efficient Watershed Simulations. Publications from USDA-ARS / UNL Faculty. Paper 459.

Borah, D. K., and Bera, M. 2004. Watershed scale hydrologic and nonpoint source pollution models: Review of applications. Trans. ASAE. 47(3), 789-803.

Hay L. E., Clark M. P., Wilby R. L., Gutowski W. J., Leavesley Jr. G. H., Pan Z., Arritt R. W., And Takle E. S. 2002. Use of Regional Climate Model Output for Hydrologic Simulations, Journal of Hydrometeorology. Vol. 3, pp. 571-589.

Jajarmizadeh M., Harun S., and Salarpour M. 2013. An Assessment on Base and Peak Flows Using a Physically-Based Model.. Research Journal of Environmental and Earth Sciences. 5(2): 49-57.

Jha, M., Z. Pan, E. S. Takle and R. Gu. 2004. Impacts of climate change on streamflow in the Upper Mississippi River Basin: A regional climate model perspective. Journal of Geophysical Research: Atmospheres. 109(D9): D09105.

Li H., Sheffield J. and Wood E.F. 2010. Bias correction of monthly precipitation and temperature fields from Intergovernmental Panel on Climate Change AR4 models using equidistant quantile matching. Journal of Geophysical Research 115: D10101.

Moriasi, D. N., J. G. Arnold, M. W. Van Liew, R. L. Binger, R. D. Harmel, and T. Veith. 2007. Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. Trans. ASABE. 50(3): 885-900.

Moss, R. H., Edmonds J. A., Hibbard K. A., Manning M. R., S. K. Rose, van Vuuren D. P., Carter T. R., Emori S., Kainuma M., Kram T., Meehl G. A., Mitchell J. F. B., Nakicenovic N., Riahi K., Smith S. J., Stouffer R. J., Thomson A. M., Weyant J. P. and Wilbanks T. J. 2010. The next generation of scenarios for climate change research and assessment. Nature. 463(7282): 747-756.

Rahman N. F. A., Ali M. F., Khalid K., Ariffin J., Mispan M. R. 2014. A Frameworkfor Integrated Stream flow and Sediment Yield Using SWAT in Langat Watershed. J. Appl. Sci. and Agric. 9(18): 156-162.

Riahi, K., A. Grübler, and N. Nakicenovic. 2007. Scenarios of long-term socio-eco¬nomic and environmental development under climate stabilization. Technol. ForecastSoc Change. 74: 887-935.

Watson, R. T., M. C. Zinyowera, and R. H. Moss. 1996. Climate Change Impacts, Adaptations, and Mitigations of Climate Change. Cambridge University Press. p. 889.

Wilks, D. S. 1995. Statistical Methods in the Atmospheric Sciences: An Introduction. Academic Press. p. 467.

White, M. J., D. E. Storm, P. R. Busteed, M. D. Matlock, and R. R. West. 2011. Evaluating potential phosphorus management impacts in the Lake Eucha basin using SWAT. Trans. ASABE. 54(3): 827-835.

Wise, M., *et al*. 2009. Implications of limiting CO2 concentrations for land use and energy. Science. 324: 1183-1186.

Wong, C. L., R. Venneker, A. B. M. Jamil and S. Uhlenbrook. 2011. Development of a gridded daily hydrometeorological data set for Peninsular Malaysia. Hydrological Processes. 25(7): 1009-1020.