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FLOOD RISK INDEX PATTERN ASSESSMENT: CASE STUDY IN LANGAT RIVER BASIN

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ABSTRACT

This study focus on the creation of flood risk index in the study area based on secondary data derived from the Department of Drainage and Irrigation (DID) since 1982-2012. Based on the result, it shows that the water level is the best variable to be taken for the purposed of flood warning alert system as the result for correlation coefficient was 1.000. The risk index has been created from the control limit value with range from 0-100. Result showed that 16.63% out of total result being classified as High Risk class for flood with risk index range from 70 and above. The accuracy of prediction of risk index being clarified by using ANN method and result obtained was 0.9936798 and the lowest RMSE of 0.662591 on the three hidden nodes to achieve an optimal result. The future prediction for UCL for water level in the river basin was 3.6 meter.

Keywords: flood risk index; PCA; SPC; artificial neural network; future prediction.

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1. INTRODUCTION

Flood risk in Malaysia had increased distressingly in recent decades, largely due to the alteration of physical characteristics of the hydrological system caused by developments of already heavily populated flood plains, intrusion on flood-prone areas, deforestation and hill slope expansion. Flood losses are high, but disastrous flood events which occurred in the past as a consequence of rapid development and environmental degradation are forgotten quickly. People only like to see the benefits of a bustling economy and turns a blind eye on the negative effects of uncontrolled development. Langat river basin also faced a series number of flooding after a massive development being constructed along this river basin. Historically, the Langat river basin provides water supply for almost 1.2 million citizens in the area of Cheras, Kajang, Bangi, Putrajaya and others. It consists of two reservoirs which are Semenyih and Langat dam with the support of 8 water treatment plants in order to ensure the supply of clean water [1]. The study described that Langat is one of the most populated and fastest growing economic region in Malaysia [2]. The phase of the river basin is classified into three different classes known as upstream, middlestream and downstream. The upstream describes the distribution of biodiversity located at the northeast of the Hulu Langat district and the highland area with an average height of 960 meters above sea level. This area contains less development with good environmental quality [3-4]. The second class is in the middle stream area where the area is normally lower, where it covers the areas of Putrajaya, Cyberjaya and Dengkil in Sepang.

The development in this part is active compared to the upstream area and the rate of sedimentation is also high due to the land use along the river basin and from the rock in the mountainous zone to sand and the silt from the upstream area. The third class is the lowest part of the river basin, where the condition is relatively flat alluvial plane and located at the southwest of the basin. As this area is the lowest compared to others, it is characterized to have peat with clay and silt soil. In the low flat ground area, the formation of sand and gravel with a thickness of 50m to 100m is made in this area (Japan International Cooperation Agency (JICA) [5]. The climate in the study area is influenced by the monsoon equatorial condition. The climate of the river basin area is high and uniform temperature, rainfall and humidity give an impact towards the hydrology and geomorphology of the study area. There are two types of monsoon season in the study area, which are wet season (April to November) and dry season (January to March). The area is most affected by the South-West monsoon, which normally occurred during the wet season. As the result from this condition, floods usually happens during this season when the heavy rainfall occurred during this season caused the river to become overflown and triggering flooding condition.

The study area is also covered by the forest known as Hulu Langat Forest reserve, which compromises of 26% out of the total forest reserves in Selangor. The altitude of the reserve forest ranges from 120m to 1265m above sea level and is fully protected by the State Government. Logging activity in this area has been prevented since 1987 in order to maintain the natural canopy from being disturbed and destructed by human development. One of the main economic activities in the river basin area is mining industry. The area is rich in minerals such as gold, ilmenite, monazite, zircon, pyrite and silica [6-7]. Most of the mining quarries are located in the North-East section of the Langat catchment area. The urbanization of the Langat area in 1970 had transformed the lands of the river basin from agriculture sector to industrial sector. The rapid growth of industrial activity has caused the increase of population. This condition leads to the high rate of discharge from residential area leading to high sedimentation towards the river basin from the domestic waste of residents along the river basin. The research in the Langat river basin being continued in this study by focusing on the flood risk pattern recognition by using integrated statistical analysis. The analysis of flood pattern being carried out in this area for 30 years started from 1982 to 2012. The purposed of this study is to determine the factor of flood occurrence, to set up the control limit for flood, to evaluate the accuracy of flood risk prediction and to predict the future control limit for flood in Langat River Basin.

2. METHODOLOGY

2.1. Experimental

The Langat River covers an area of approximately 1,815 km^2. The location of the study area is situated in a range of latitude 20°40’15.2” and longitude 30°16’15.0”. The Langat River

Basin consists of 15 sub-basins; Pangsoon, Hulu Lui, Hulu Langat, Cheras, Kajang, Putrajaya, Hulu Semenyih, Semenyih, Batang Benar, Batang Labu, Beranang, Bangi Lama, Rinching, Teluk Datok, and Teluk Panglima Garang. The basin is about 141 km in length and it has several tributaries with the principal ones being the Semenyih, Lui, and Beranang Rivers (Fig. 1). The basin also has two reservoirs; the Langat and the Semenyih Reservoirs, with catchment areas of 54 km² and 41 km², respectively. These reservoirs were built in 1982 to supply domestic and industrial water around those areas. The Langat Reservoir is also used to generate power supply at a moderate capacity for the population within the Langat Valley [8].

The climate in the study area is normally high in temperature, rainfall and humidity throughout the year. This climate has a dominant impact on the hydrology and geomorphology in the study area which explain the importance of land and atmosphere interaction that influences the regional climate Valley [9-11]. Generally, the study area faces two types of seasons; the wet season from April until November and a relatively drier period from January to March. The weather is very much influenced by the South-West monsoon that blows across the Straits of Malacca. Besides, flooding is a common disaster in the study area. In this study, the location of the monitoring station for the Department of Irrigation and Drainage is shown in Table 1 and the data were collected from 1982-2012.

Fig.1. Study areas and sampling location station map

Table 1. Location of the Department of Drainage and Irrigation at Semenyih reservoir in Langat River Basin

Variables	Station Number	Coordinates	Location
Rainfall	Site 3018101	3°5'7.31"N, 101°53'55.69"E	Semenyih Dam
Stream flow	Site 2918401	2°54'6.70"N, 101°48'28.98"E	Kg. Rinching
Suspended Solid	Site 2918501	2°55'47.96"N, 01°51'43.51"E	G. S. Rinching
Water Level	Site 2918443	2°57'19.37"N, 01°50'37.91"E	Semenyih

2.2. Statistical Analysis/Pre-Processed Data: Chemometric Techniques

The chemometric technique is an application of the Principle Component Analysis (PCA) to identify the reduction of variables into a set of factors for further analysis. This method compares sets of data and identifies the variables that affect the most towards the change of the hydrological modelling in the study area with lower cost and less time compared to other techniques [12,13].

2.3. Principle Component Analysis (PCA)

PCA is applied in this study to define large number of variables into smaller sets. Factor analysis variables and latent construct that are measured will establish the dimension between these two elements and construct validity evidence of self-reporting scales [14,15]. It also reduces the number of variables, examines the structure or relationship between variables, and detects and assesses unidimensionality of the theoretical construct [16]. This method also addresses multicollinearity (two or more variables that are correlated), which was carried out in this study as well. The equation for this method was:

$$Zij = ai^1xj^1 + ai^2xj^2 + ai^3xj^3 + aimx \quad (1)$$

where Z = Component score, a = Component loading, x = Measured of variable, I = Component number and m = Total variables.

2.4. Statistical Process Control

Time Series Analysis is very important in predicting the water level at the study area. With this method, we were able to evaluate the process from the performance of the analyzed data efficiently. It produced three important results, which were important in predicting the hydrological modelling in the future, and those results were Upper Control Limit (UCL), Average Value (AVG) and Lower Control Limit (LCL). The Sigma in the control chart is represented within the range value of a set of data. The Control Chart has the ability to uncover some trends and patterns, showing actual data deviations from the historical baseline and dynamic threshold, being able to capture unusual resource usage and becoming the best base lining to show how actual data are deviated from the historical baseline [17]. The equation that is used in this analysis was:

Moving Range = Plot: MRt for t = 2, 3, ..., m.

where MR = average moving range, t = time and m = individual values.

Average Value: $\tilde{x} = \frac{\sum_{i=1}^{m} x_i}{m}$ (2)

where $\overline{X}$ = moving range, m = individual values and x_i = difference between data point.

2.5. Artificial Neural Network

The concept of human brain has been utilized in Artificial Intelligent and this is also applied as a method in analyzing data and it is called Artificial Neural Network (ANN). This concept was created by McCulloch and Pitts in 1943 make as far as the process is concerned, the weighted sum of the inputs are transferred to the hidden neurons, where it is transformed using an activation function [18]. Learning process also has back propagation which applies error distribution, whereby this application can reduce errors up to a minimum level. This technique is used to minimize error functions and the iteration is terminated when the error function value reaches pre-defined goal, thus completing the process.

The function is:

f(x) = 1 / (1 + e - x) (3)

The performance data can be calculated by implementing cross validation to a data set where the algorithm was terminated during the process and this process was done by using back propagation. The learning ability of ANN depends on the architecture of network and the number of hidden unit. The size of the network plays a major role in capturing the connectivity of the data when the degree of freedom was functioned to capture the connection, and the size of the network must be sufficient with the degree of freedom or the process will fail. In Addition, the effectiveness of ANN for rainfall, run-off modelling and flood forecasting [14]. The research also highlighted the ability of ANN in predicting river flow and the quality of water downstream, which were focused in this study as well.

2.6. Flood Risk Index Model

Flood risk model has been created from the flood risk index based on a combination of several types of multivariate analysis, statistical process control (SPC) and ANN method. The formation of this model is to develop a precise guideline in determining the risk of flooding in the research area. This model is important and it is a new breakthrough in the study of the risk of flooding in Malaysia and shows the ability sustained in studies done in the research of flood.

The process of creating the risk index in this research must go through a few processes of statistical analysis. First, the selection of the best variable to be used in this model was being carried out by applying PCA. The variables with the highest correlation coefficient will be selected to be used for the next process in the analysis.

After the selection of variable has been made, the determination for control limit value was being progressed by implementing Statistical Process Control. From this method, the formation of Upper Control Limit value and Lower Control Limit will able to give a guideline in determining the ratio of the flood risk index in this research. The Upper Control Limit value is considered an intolerable value for a variable and treated as a high risk condition for flood. For the formation of flood risk index, the Upper Control Limit value was taken and risk index was calculated using the formula below:

$$UCLV/X \times 100 = 70 \text{ (Value of High Risk index)} \quad (4)$$

Based on the formula above, UCLV = Upper Control Limit Value of variable.

where X = The highest value of the data, 100 = The range of risk index which is from 1-100 and 70 = Significant value of the index for High Risk.

Based on the above equation, the formation of formulas for the risk index is designed to obtain the best risk model for flood. The flood risk index in this study was ranging from 0-100 where the range of 70-100 was being categorized as a High Risk Index for flood. The flood risk index from 35-69 was considered as Moderate Risk Index and 0-34 as a Low Risk Index for flood. The selection of range 70-100 was based on the Relative Strength Index (RSI), where 70 and above is considered as upper bound and an intolerable condition [16].

3. RESULTS AND DISCUSSION

3.1. The Factors That Contribute to Flood Occurrences

From the result, it showed that rainfall was less significant compared to the Stream flow, Suspended Solid and Water Level when the p-value for these elements were less than 0.001 compared to rainfall with p- value of 0.049. This clearly explains that the monsoon season does not pose risk of flood in the study area and the change of hydrological modelling is significant to be compared with the surface run-off at the study area rather than South-West monsoon. Table 2 shows the variables with significant impact towards the hydrological modelling in the study area.

From Table 2, the Stream flow, Suspended Solid and Water Level resulted in the highest coefficient; 1.000, 0.979 and 1.000 respectively. If the coefficient is more than 0.7, it is considered as strong coefficient. Hence, it is the human development that caused high rate in the surface run-off that affected the Water Level and the Stream Flow [19-21]. This analysis also reduced the variables by looking into the most significant variables for further analysis. There is high flood risk if no limitation is set for mitigating action. Based on this analysis, the highest coefficient variable has been selected for creation of flood control warning system.

Table 2. Correlation coefficient between variable factors

	F1	**Initial Communiality**	**Final Communiality**	**Specific Variance**
Rainfall	0.249	0.109	0.062	0.938
Stream flow	1.000	0.998	1.000	0.000
Suspended Solid	0.979	0.974	0.958	0.042
Water level	1.000	0.999	1.000	0.000

3.2. Flood Control Warning System

The variable of water level has been selected as the main parameter for flood control warning system. Compared to other variables such as stream flow and suspended solid, the water level show the highest correlation coefficient and the most practical to be taken for parameter in the flood control warning system. Based on Fig. 2, the lower control limit, the average value and the upper control limit for water level were 3.109 m, 3.501 m and 3.892 m respectively. The effect of this condition was the rate of water storage already become less when the river base continues to shallow down, due to the impact of human development in the particular area [22-24].

The moving range limit for water level in the Langat river basin was 0.481m for Upper Control Limit, 0.147m for Average Limit value and 0m for Lower Control Limit value. From the result, the tolerated value of the changes of water level in the Langat river basin was within range of Average Limit (3.501m, 0.147m for moving range) and within range of Lower Control Limit (3.109m, 0m for moving range). The river basin was incapable to tolerate with value of water level, which was within range of Upper Control Limit (3.892m, 0.481m for moving range). In order to deliver a quick and right response to prevent flooding, the limitation of the variables must be stated clearly. Bear in mind that it is not just the natural order that makes the flood occurs, but also the human destruction of the soil along the research area. This is caused by the surface runoff, which becomes higher and precipitated on the ground surface of the river. A condition like this definitely causes the research area to confront the flood even if the rainfall rate is low at the moment. Langat river basin is an area with a high population density and physical development environment as well as one of the economic centers of Selangor. Thus, serious flood monitoring and practical in practice in the analysis of this research was able to provide high impact on the development and better action plan for the Langat river basin flood. Lower Control Limit existence also allows the study of drought warning can also be practiced with care. The issue of water supply problems in 2014 in the state makes necessary the development of a model for the risk of water supply well in solving the problem of water supply in Selangor Langat District in general and in particular. The Upper Control Limit in this analysis is taken for the formation of risk index in the subsequent analysis.

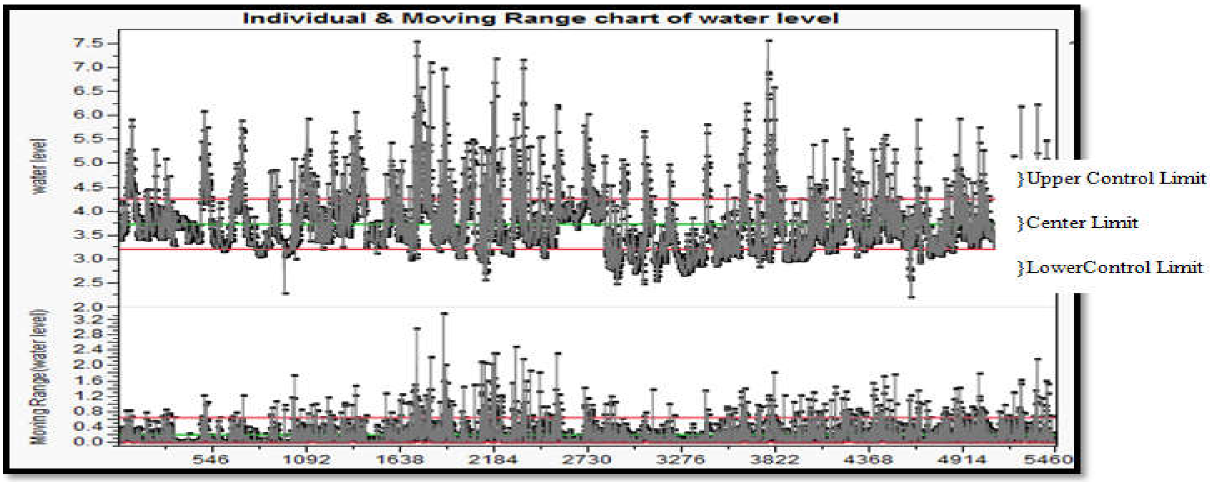

Fig.2. Result for SPC of water level in Langat River Basin

3.3. Prediction for Flood Risk Classification

For the Langat river basin, risk analysis is conducted to find out the actual level of flood risk for the research area. Risk index performed on control limits derived from the previous analysis. Risk index range of 0-100 and risk setting for High Risk class is 70 and above, followed by Cautionary Zone class, with risk index with range 35-69 and the Low Risk class in the range of 0-34.Based on the results from the statistical process control, the classification of risk based on its level of seriousness can be classified based on its points in the graph of control limit. The classification of risk for below the Lower Control Limit is No Risk, points between the line of Lower Control Limit and Average Limit are classified as Low Risk, points between Average and Upper Control Limit are Cautionary Zone and points above Upper Control Limit are classified as High Risk. Based on Fig. 3, it explains the level of risk for water level in the research area. The result shows that 16.63% out of total result being classified as High Risk class, with risk index range from 70 and above, 27.25% was being classified as a Cautionary Zone class, with risk index from 35-69, 35.6% was being classified as a Low Risk class with risk index from 0-34 and 20.52% was being classified as a No Risk class. From the total percentage, 43.88% was being classified within range of Cautionary Zone risk class and High Risk class which within this risk class the possibility for flood occurrence was high and requires precautionary action by the authority. Langat river basin is an important area for flood risk analysis as the activity of human development and economic sector development around the river basin to generate major revenue for state government is active. Thus, in the event of flooding, significant losses will be incurred by the state government and the civilian population on the damage to infrastructure and property which can reach the millions of dollars.

Risk reviews such as a risk review of this research makes it easier for local authorities like DID in Selangor state in scrutinizing the level of risk incurred for an area in the state. Through risk index, a standard value for the study of risk obtained for each monitoring station area throughout the state and through the standard range of risk standard, its application makes review of floods easy to assess and flood prevention plan will be very strong in the future. The study of flooding in the Langat river basin based on the amount of river discharge and the level of discharge varies depending on the year and the period of repetition of flooding calculated from the total river discharge [25]. Method of research if coupled with the risk index from this research will produce a steady flood risk study for the Langat river basin and also in other areas in the state. This can help DID of Selangor state in developing a flood prevention plan more efficient in overcoming the problems of flash floods deepening the surrounding areas around Langat river basin, which had sunk Kajang Town in 2011 that is the worst flash flood followed by the one 2012.

Risk index results for the Langat river basin continued with the performing of prediction towards the risk index to see a significant level of risk index obtained in the previous analysis. Based on the results in Table 3, the partition validate representing 60% of the total data, prediction accuracy is very good with the results of R^2 of 0.98491 and low RMSE of 1.4365 and in total of three hidden nodes to achieve optimal results. Prediction proceeds with train partition which represents 20% of the data and the results prove that the prediction accuracy is at the best level. The results show that R^2 is 0.9779 for the train partition with the lowest RMSE of 1.7283 with total four hidden nodes. Next, the test partition, representing 20% of the total data, prediction is done and the results prove the strength of prediction accuracy. The results obtained are 0.9936798 and the lowest RMSE of 0.662591 on the three hidden nodes to achieve an optimal result. Based on the future prediction in Fig. 4, control limit risk index in the future will be predicted based on this test group and the results showed that for the future, at a height of 3.60 meters above the river level is High Risk class, 3.36m-3.59m is categorized in Cautionary Zone class, 3.12m-3.34m is Low Risk and 3.11m class and below is at No risk class. Prediction results for test appears to prove that the future prediction for the hierarchy of risk index for the Langat river basin is statistically and significant, accurate and clearly can be applied in the study of sound flood risk and warning system alert for the Langat River Basin.

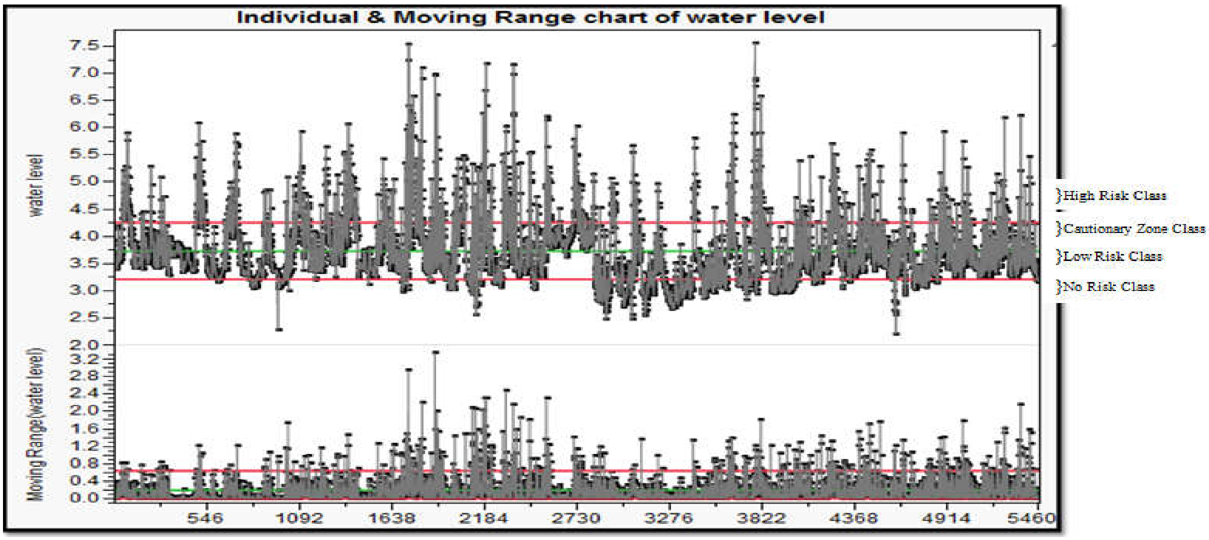

Fig.3. Result for prediction of flood risk index for Langat River Basin

Table 3. Result for prediction of flood risk index in Langat River Basin

Prediction Area	Validation	Train	Test	
Langat River Basin	R^2 RMSE	R^2 RMSE	R^2	RMSE
	0.98472	0.9771	0.9936735	
	1.4365	1.7614	0.662915	
	0.98489	0.9777	0.9936739	
	1.4354	1.7362	0.662902	
	0.984891	0.9778	0.9936798	
	1.4341	1.7314	0.662591	
	0.98489	0.9779	0.9936738	
	1.4356	1.7283	0.662906	
		0.9692		
		1.8139		

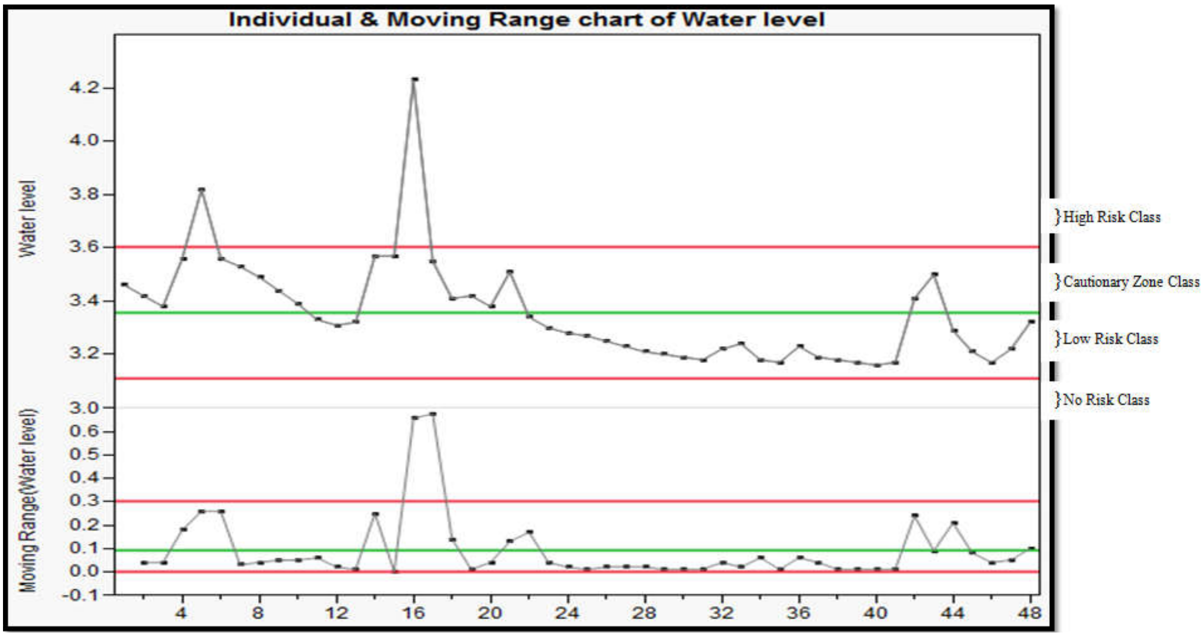

Fig.4. Future prediction for flood risk class in Langat River Basin

4. CONCLUSION

The most significant factor for the variables in this study were obtained and applied in the development of risk models for alert warning system for floods. The variables that have been proven statistically can give emphasis to the flood pattern visualization and optimal rates for the maximum limit for flood control Basin River in Malaysia, particularly in the study area. This obviously can help in planning DID flood control program in preparation for any eventuality of floods in Malaysia.

The formation of an efficient control limit that is sensitive to changes in water level can enable flood warning alerts to improve the existing system used by DID in managing flood control for Malaysia. Comparisons have been made in this study to confirm the ability of risk models developed with a history of flooding for each study area for 30 years. It turns out that the comparison proves the effectiveness of the risk model at optimum levels when the group of large-scale flood proved successful and is similar to the pattern of risk based on the risk index for flood risk model developed in this study. Thus, the used of risk models in this study were able to bring major changes to the global flood control issues in general and particularly in Malaysia.

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6. REFERENCES

[1] Elfithri R, M. B. Mokhtar, A. H. H. Shah and S. Idrus. Collaborative decision making issues in sustainable water resources management: A case study on Langat Basin. In International Conference on Environmental Management: Ten Years After Rio-Realising Agenda, 2002, pp. 304 -314

[2] Azrina M Z, Yap C K, Ismail A R, Ismail A, Tan S G. Anthropogenic impacts on the distribution and biodiversity of benthic macroinvertebrates and water quality of the Langat River, Peninsular Malaysia. Journal of Ecotoxicology and Environmental Safety, 2006, 64(3):337-347

[3] Kamarudin M K, Idris M, Toriman M E. Analysis of Leptobarbus hoevenii in control environment at natural lakes. American Journal of Agricultural and Biological Science, 2013, 8(2):142-148

[4] Toriman M E, Abdullah A, Mokhtar M, Gasim M B, Karim O. Surface erosion and sediment yields assessment from small ungauged catchment of Sungai Anak Bangi, Selangor. Malaysian Journal of Analytical Sciences, 2010, 14(1):12-23

[5] Japan International Cooperation Agency (JICA). Comprehensive management plan of Muda river basin. Final Report SSSCR (I) 95-154, Tokyo: JICA, 1995

[6] Heng L Y, Abdullah M P, Yi C S, Mokhtar M, Ahmad R. Development of possible indicator of sewage pollution for the assessment of Langat river ecosystem health. Malaysia Journal of Analytical Science, 2006, 10(1):15-26

[7] Gasim M B, Toriman M E, Idris M, Lun P I, Kamarudin M K, Azlina A N, Mokhtar M, Mastura S S. River flow conditions and dynamic state analysis of Pahang River. American Journal of Applied Sciences, 2013, 10(1):42-57

[8] Toriman M E, Yusop Z, Mokhtar M, Juahir H. Application of GIS for detecting changes of Sungai Langat channel. Malaysian Journal of Civil Engineering, 2006, 18(1):58-70

[9] Toriman M E. Developing a conceptual model of geomorphic change for channel management proposes. A case of Langat River Basin. Journal e-BANGI, 2008, 3(3):1-12

[10] Yusoff W A, Jaafar M, Kamarudin M K A, Toriman M E. Land exploration study and water quality changes in Tanah Tinggi Lojing, Kelantan, Malaysia. Malaysian Journal of Analytical Sciences, 2015, 19(5):951-959

[11] Mokhtar M B, Toriman M E, Hossain A A. Hossain. Social learning in facing challenges of sustainable development: A case of Langat River Basin, Malaysia. Research Journal of Applied Sciences, 2010, 5(6):434-444

[12] Kamaruddin A F, Toriman M E, Juahir H, Zain S M, Rahman M N, Kamarudin M K, Azid A. Spatial characterization and identification sources of pollution using multivariate analysis at Terengganu River Basin, Malaysia. Jurnal Teknologi, 2015, 77(1): 269-273

[13] Floyd F J, Widaman K F. Factor analysis in the development and refinement of clinical assessment instruments. Psychological Assessment, 1995, 7(3):286-299

[14] Saudi A S, Juahir H, Azid A, Toriman M E, Kamarudin M K, Saudi M M, Mustafa A D, Amran M A. Flood risk pattern recognition by using environmetric technique: A case study in Langat River Basin. Jurnal Teknologi, 2015, 77(1):145-152

[15] Ismail A, Toriman M E, Juahir H, Zain S M, Habir N L, Retnam A, Kamaruddin M K, Umar R, Azid A. Spatial assessment and source identification of heavy metals pollution in surface water using several chemometric techniques. Marine Pollution Bulletin, 2016, 106(1):292-300

[16] Saudi A S, Juahir H, Azid A, Azaman F. Flood risk index assessment in Johor River Basin. Malaysian Journal of Analytical Sciences, 2015, 19(5):991-1000

[17] Saudi A S, Juahir H, Azid A, Kamarudin M K, Kasim M F, Toriman M E, Aziz N A, Hasnam C N, Samsudin M S. Flood risk pattern recognition using chemometric technique: A case study in Kuantan River Basin. Jurnal Teknologi, 2014, 72(1):137-141

[18] Imrie C E, Durucan S, Korre A. River flow prediction by using artificial neural networks: Generalisation beyond calibration range. Journal Hydrology, 2000, 233(1):138-153

[19] Kamarudin M K, Toriman M E, Rosli M H, Juahir H, Aziz N A, Azid A, Zainuddin S F, Sulaiman W N. Analysis of meander evolution studies on effect from land use and climate change at the upstream reach of the Pahang River, Malaysia. Mitigation and Adaptation Strategies for Global Change, 2015, 20(8):1319-1334

[20] Toriman M E, Yun L Q, Kamarudin M K, Aziz N A, Mokhtar M, Elfithri R, Bhaktikul K. Applying seasonal climate trends to agricultural production in Tanjung Karang, Malaysia. American Journal of Agricultural and Biological Sciences, 2014, 9(1):119-126

[21] Toriman M E, Ata F M, Kamarudin M K, Idris M. Bed-load sediment profile and effect of river bank erosion on river cross-section. American Journal of Environmental Sciences, 2013, 9(4):292-300

[22] Toriman M E, Gasim M B, Yusop Z, Shahid I, Mastura S S, Abdullah P, Jaafar M, Aziz N A, Kamarudin M K, Jaafar O, Karim O. Use of ^{137}Cs activity to investigate sediment movement and transport modeling in river coastal environment. American Journal of Environmental Sciences, 2012, 8(4):417-423

[23] Kamarudin M K, Toriman M E, Wahab N A, Rosli H, Ata F M, Faudzi M N. Sedimentation study on upstream reach of selected rivers in Pahang River Basin, Malaysia. International Journal on Advanced Science, Engineering and Information Technology, 2017, 7(1):35-41

[24] Sulaiman N H, Kamarudin M K, Toriman M E, Juahir H, Ata F M, Azid A, Wahab N J, Umar R, Khalit S I, Makhtar M, Arfan A. Relationship of rainfall distribution and water level on major flood 2014 in Pahang River Basin, Malaysia. EnvironmentAsia, 2017, 10(1):1-8

[25] Wong W K, Manzur M, Chew B K. How rewarding is technical analysis? Evidence from Singapore stock market. Journal of Applied Financial Economics, 2003, 13(7):543-551

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