Big Data Analytics as Game Changer in Dealing Impact of Climate Change in Malaysia: Present and Future Research

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Keywords: Big Data Analytics, Analytical Capabilities, Decision Making, Climate Change.

Abstract: Data has become a vital and vigorous resource to support the organisation in a data-driven decision-making environment. The emergence of digital transformation has revolutionised data utilisation and management ecosystem, which translated and upscaled the value of data to become a new asset in the organisation. Realisation on the importance of data, Big Data Analytics (BDA) in organisations is part of initiatives to harvest and maximise the potential use of data through data analytics capabilities. N-HyDAA development has encapsulated BDA through integration and analytics of data, information, knowledge and expertise from the expert group in dealing with issues related to the impact of climate change such as water-related disaster and water resources management. Based on N-HyDAA capabilities, there are more potentials and opportunities in the new research area to explore for better cohesion in supporting decision-making.

1 CLIMATE CHANGE & MALAYSIA SCENARIO

Climate change (CC) is no longer rhetoric; it is real and confirmed as the impact of CC is real and happening. The changes in climate will aggravate the risks and effects to the country, where it will cause billions of losses from economic, environmental, and social aspects. CC is not just a meteorological issue. It is beyond such changes in temperature, rainfall pattern or sea-level rise. The changes in one aspect may lead to another aspect. Changes in rainfall intensity will cause a significant effect on water level and water quality. Changes in sea-level rise will affect the land use development in the coastal area.

The evidence for rapid CC is getting compelling and persuasive from series of indicators identified such as global temperature rise, warming oceans, shrinking ice sheets, glacial retreat, decreased snow cover, sea-level rise, declining arctic sea ice, extreme events, and ocean acidification. One of the significant impacts of CC is the frequency and incidence of a natural disaster where it becomes more extreme and created dangerous consequences such as severe flood and drought events. Unusual and unique events such as tsunami, typhoon, landslide, which are previously rare become more frequent and higher in magnitude compare to the past.

Thus, extensive strategies are required in employing mitigation and adaptation planning to undermine the impact and vulnerability of CC.

Malaysia Government has given a serious commitment in CC aspects at national and international levels. Through 21th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) in 2015, the implementation of CC adaptation has been emphasized by Malaysia especially for water security and availability, coastal, food and health sectors. During COP24, Malaysia has expressed its continuing commitment to reducing Greenhouse Gases emissions by 25% by 2030.

Climate-related natural disasters cost Malaysia approximately USD1.8b from 1998 to 2018, where the impact on Malaysia is apparent and varies from floods, storms, droughts and other extreme weather events (Zurairi, 2018). Recognising the impact of the CC in Malaysia, NAHRIM's involvement in issues related to impact of the CC has begun since 2008 with the appointment of NAHRIM as the Regional Water Knowledge Hub for Climate Change and Adaptation. Since then, various studies have been exercised by

Abdullah, M., Mat Amin, M., Zainol, Z. and Mohamad Ideris, M.
Big Data Analytics as Game Changer in Dealing Impact of Climate Change in Malaysia: Present and Future Research.
DOI: 10.5220/0009794404610469
In *Proceedings of the 5th International Conference on Internet of Things, Big Data and Security (IoTBDS 2020)*, pages 461-469
ISBN: 978-989-758-426-8

NAHRIM for adaptation, adoption, and mitigation strategies and policy in tackling issues in CC.

From studies conducted, voluminous data are created and recreated which supports various R&D activities aligned with sustainable development as well as reduce the risk and impact of CC. Abdullah, Ibrahim, and Zulkifli (2017a) mentioned data management process for a natural disaster is challenging due to its presence in large volume and heterogeneous sources. In addition to that, the emergence of technology and trend of using projection data plays imperative roles in managing issues related to CC nowadays.

2 BIG DATA ANALYTICS (BDA) & DATA ANALYTICS CAPABILITIES CONCEPT

2.1 Big Data Analytics (BDA) Concept

Kaisler, Armour, Espinosa, and Money (2013) defined BDA as the amount of data beyond technologies capability to store, manage and process efficiently which the limitations are only discovered by a robust analysis of the data itself, explicit processing needs, and the capabilities of the tools used to analyse it.

BDA has been escalating in various sectors as it increases the value of data in organisations for different purposes. The awareness and understanding of BDA among top management have been familiarised to ensure how data can be analysed, improved and enriched to become a new key economic factor that can alleviate an organisation's performance (Abdullah et al., 2017a).

As reported by Meulen and Rivera (2014) decision-maker must expand their efforts and understanding to move organisations from using traditional Business Intelligence that addresses descriptive analysis (what happened) to advanced analytics, which complements by answering the "why," the "what will happen," and "how we can address it".

BDA movement is driven by the fact that massive amounts of very high-dimensional or unstructured data are continuously produced and stored with much cheaper cost than they used to be (Fan, Han, & Liu, 2014). This trend will have a deep impact on science, engineering and business that offer new opportunities and new challenges in data analysis (Fan et al., 2014).

BDA creates a radical shift in how we think about research, thus reframing critical questions about the constitution of knowledge, research processes, information engagement, and the nature and categorisation of reality (Boyd & Crawford, 2012).

BDA give promises for (i) exploring the hidden structures of each subpopulation of the data, which is not feasible and been treated as 'outliers' when the sample size is small; (ii) extracting important common features across many subpopulations even when there are large individual variations (Fan et al., 2014).

2.2 Data Analytics Capabilities

BDA capabilities are a form of concept broadly used to determine the ability to exploit data analytics to develop capabilities which equip it to develop costly-to-imitate capabilities in the big data environment, where different levels of big data and BDA capability can influence and inform organisation decisions (Amankwah-Amoah & Adomako, 2019). Apart from that, data analytics support streamlining organisation internal processes, identify trends, interpret and monitor emerging risks and build a mechanism for feedback and improvement through analytical interpretation, recommendation, explanation and solutions (George, 2018; Singh, 2018).

Demand for delivery of data and analytics at the optimal point of impact will drive innovative machine learning and, predictive and prescriptive analytics integration from the core to the edge of the enterprise which capitalises and trigger opportunities that can be identified based on active, dynamic and empowered (Hagerty, 2016).

Data and analytics are the brains of the organisations that require proactive and reactive plans that drive modern organisation operations in decisions, interactions and processes to support the organisation and IT outcomes (Hagerty, 2016). Understanding the purpose behind analytics, trends, shifts, and patterns are among the critical elements that will avoid issues and misunderstanding of BDA project implementation where decision-makers need to understand the correlations between key variables and engaging in problem-solving (Mark, 2016).

3 BACKGROUND OF STUDY: BDA FOR CC IN MALAYSIA

Studies conducted by Yang, Su, and Chen (2017) and Rahman, Di, and Esraz-Ul-Zannat (2017) explained BDA play a vital role and can help in all four phases of disaster management: prevention, protection, mitigation, response and recovery, and also help in taking actions to improve resilience to disasters. The impact of BDA in environment and natural resources covered diversified areas such as data management (Faghmous & Kumar, 2014), decision-making (Abdullah et al., 2018; Ford et al., 2016); application (Hassani, Huang, & Silva, 2019; Lopez & Manogaran, 2016) and so forth.

Based on studies conducted in BDA for CC ecosystem, NAHRIM as a water and environment research institute had started data analytics journey in 2015 through development of framework on BDA for natural disaster management in Malaysia (Abdullah et al., 2017a) and later continued with development of Malaysia Climate Change Knowledge Portal (N-HyDAA) as a knowledge portal for analytical processing of hydro climatic data (Abdullah, Ibrahim, & Zulkifli, 2017b).

N-HyDAA used BDA technology to accelerate data processing with customisable computation functions by utilising multi-cores and many-cores (GPU) technologies. N-HyDAA was developed to assist NAHRIM in visualising and analysing 1450 simulation-years of projected hydro-climate data for Peninsular Malaysia based on 3,888 grids for 90 years. There are eight modules developed in N-HyDAA, namely Drought, Drought & Temperature, Rainfall & Runoff, Storm Centre, Streamflow, Climate Change Factor, Water Stress Index (WSI) and WSI Simulation.

Stimulation and optimisation of hydro climatic data using BDA technology support the digital transformation by revolutionising the way data has been treated to support decision-making in dealing with CC issues. The development of N-HyDAA was recognised at the national level and international level (Geospatial World, 2018) (APICTA, 2017) for its innovation on applying BDA technology as a new instrument for handling issues in environment and water resources, especially in CC.

Details on N-HyDAA's development and application in various domain related to water and environment can be read from Abdullah et al. (2018), Abdullah et al. (2017b), Mat Amin (2016), Mohamed, Mat Amin, Md Adnan, and Abdullah (2018) and Ideris, Abdullah, Mat Amin, and Zainol (2018).

4 N-HyDAA: CASES STUDY OF WATER YIELDS & WATER STRESS IN MALAYSIA

Future water yields based on simulated future runoff were evaluated on four different gas emissions scenarios (B1, A1B, A2 and A1FI) by means of an average of 14 projections (A1B, A2 and B1), average A1B, average A2 and average B1 for period 2010 – 2100. The historical simulations were based on the average runoff from three control run GCMs (CCSM3, ECHM5 and MRI). Using N-HyDAA the voluminous simulated data has been investigated thoroughly using N-HyDAA. The result of water yields for historical and future periods of 2030 and 2050 for 80 districts are given in Figures 1 and 2 respectively.

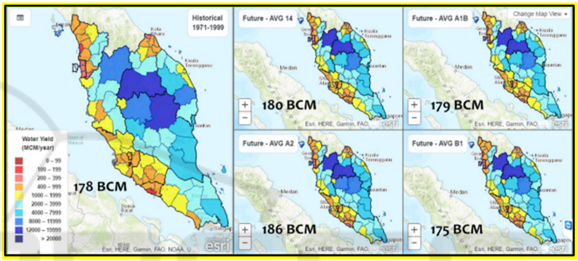

Figure 1: Comparison between simulated historical and future water yields in 2030 (billion cubic meter) BCM.

Water yields in 2030 under the average of 14 scenarios, A1B and A2 are projected to increase compared to historical period (by 2 BCM to 8 BCM) except for B1 where the water yield is projected to decrease by 3 BCM (Figure 1). In 2050, water yields for all scenarios are projected to increase with a range of 8 BCM to 17 BCM and the largest change of 195 BCM was obtained from the average A2 scenario. Generally, the projected water yields for all districts show increasing trends (more water), with the exception of a few districts in Kedah and Johor.

In the context of WSI, the approach developed by Stephen Pfister was used to construct the district-based water stress indices through projected water yield and water demand that is possibly impacted by CC conditions. WSI is defined as an index calculated based on Stephen Pfister's model to represent the level of water stress in a specific area by means of a ratio of total water demand or consumption against water yield or availability (Brown & Matlock, 2011).

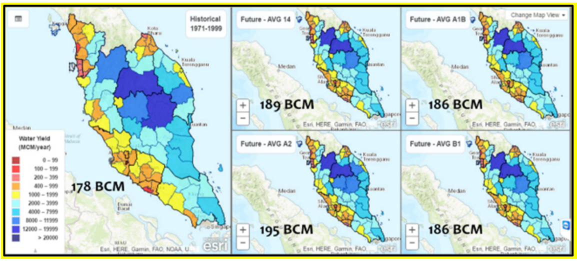

Figure 2: Comparison between simulated historical and future water yields in 2050 (BCM).

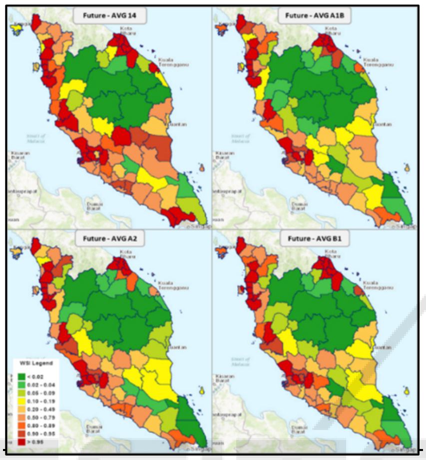

Figure 3: WSI for each scenario based on district in 2030.

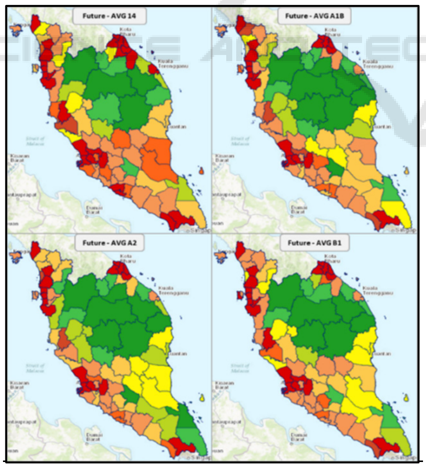

Figure 4: WSI for each scenario based on district in 2050.

The constructed district based on WSI for the respective districts and time horizons are given in Figure 3 and 4 for 2030 and 2050 respectively. WSI is divided in to five stress categories namely, low (<0.1); medium-low (0.1-0.2); moderate (0.2-0.5); high (0.5-0.8) and extremely high (>0.8). Nearly high and extremely high WSI are located in the West Coast particularly in urban and high populated areas, and also irrigation schemes. Overall, the highest and smallest average WSI are projected Penang-Perlis-Kedah-Klang Valley-Johor Bharu and Pahang-Terengganu respectively.

Figure 5 shows the constructed WSI for the average 14 scenarios in 2030 and 2050 whereby the marked areas are the projected districts with the increased WSI. For example, the high WSI in Sabak Bernam, Selangor would affect the irrigation water availability for Barat Laut Selangor Integrated Agricultural Development Authority (IADA-BLS) irrigation scheme, On the other hand, the extremely high WSI in Johor Bharu will pose challenges to Syarikat Air Johor (SAJ) to provide sufficient treated water supply to the consumers.

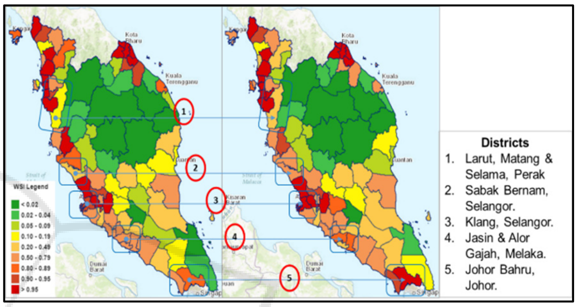

Figure 5: WSI Comparison for AIB scenario in 2030 and 2050.

5 DISCUSSION AND FUTURE RESEARCH AREA

BDA has reformed the way of data optimisation for better utilisation and value with the integration of analytical skills and representation of data and information. The capability of BDA to create and transform data to insight for supporting decision-making evolved since the introductory of BDA in various domains of application such as human resource, disaster management, and business and how it can improve the efficiency and effectiveness of the business process, whether in supporting, operational and management processes.

Decision-making becoming vital in managerial process for a quality and cohesive decisions. Multi-criteria decision making (MCDM), is a decision-making process based on the progression of using methods and procedure of multiple conflicting criteria into the management planning process (Umm e, Asghar, & Ieee, 2009) which is a target to resolve problems having multiple objectives (Liu & Stewart, 2004).

MCDM can be defined as a collection of methodologies for comparison, ranking and selecting multiple alternatives having multiple attributes (Levy, 2005). Numerous factors involved in decision-making, which is impossible to rely on a single criterion attribute or point of view (Zopounidis & Doumpos, 2000). Thus, decision-maker is required to select among several quantifiable or non-quantifiable and several criteria (Pohekar & Ramachandran, 2004). Therefore, MCDM emerged as a hallmark and new branch for supporting the decision-making process (Umm e et al., 2009).

Table 1 summarised initial finding based on the MCDM methods on three domains which revealed natural disaster, water resource management and policy and strategy planning are the most applied MCDM method. Through a further details study, the domain can be expanded and covering more extensive areas related to CC focusing on projection data from N-HyDAA.

Table 1: Application of MCDM in CC Domains.

Domain	Sub-Domain	Author
Natural Disaster	flood, drought	Karamouz, Zeynolabedin, and Olyaei (2015); Lee, Choi, and Jun (2017); Song and Chung (2016); Zahmatkesh and Karamouz (2017)
Policy & Strategy Planning	adaptation, mitigation, sustainable development, vulnerability	Buyukozkan and Uzturk (2018); Chakraborty, Sahoo, Majumdar, Saha, and Roy (2019); Mardani, Jusoh, Zavadskas, Cavallaro, and Khalifah (2015); Mensour, El Ghazzani, Hlimi, and Ihlal (2019); Ramya and Devadas (2019); Simsek, Watts, and Escobar (2018); Zavadskas, Cavallaro, Podvezko, Ubarte, and Kaklauskas (2017); Zhu, Li, and Feng (2019); ;
Water Resource Management	water allocation, groundwater study, water system,	Alhumaid, Ghumman, Haider, Al-Salamah, and Ghazaw (2018); Amineh, Hashemian, and Magholi (2017); Birgani and Yazdandoost (2018); Chung and Kim (2014); Duan, Deng, Deng, and Wang (2016); Golfam, Ashofteh, Rajaee, and Chu (2019)

Based on a study conducted by Akter and Wamba (2017), there are a lot of opportunities to discover significant research on big data and disaster management area. In the area of a crisis analytics platform, potential research can be focusing on prescriptive analytics and models that integrate the knowledge and expertise from subject matter experts, practitioner and stakeholders. Integration knowledge and insight from expert groups in N-HyDAA are crucial in supporting the decision-making process apart from relying on analytical data.

Leveraging the culture of BDA must be part of strategic management, where emphasising on a holistic and cohesive BDA culture across various business core function without neglecting the analytical competencies of the organisation either from aspect technology, analytical capacity (people) and process. It is imperative to develop skills in analytics capabilities and to nurture the competence for ensuring organisational agility, which requires more knowledge exploration and experience that needs to be shared and disseminate within the organisation.

Apart from that, in every analysis stage, different data analytics capabilities are essential and required further understanding of analytics elements and data, information, knowledge and wisdom concept can be implemented in supporting the decision-making process (Lokers, Knapen, Janssen, van Randen, & Jansen, 2016). Factors or elements that contributed to building data analytics capabilities need further consideration for better delivery of hindsight, insight and foresight among others is to practice right-fit analytics in the BDA project (Deloitte, 2019).

Analysing data in BDA helps in answering questions (1) What happened?, (2) Why did it happen?, (3) What will happen? and How we can make it happen? which requires automated and semi-automated analysis techniques (computation, statistical analysis, optimisation and AI) to detect patterns, identify anomalies and extract knowledge (S, 2017) which explores the potential and value of data for a better result.

Based on the data analytics techniques adopted in N-HyDAA, NAHRIM has implied a practice of using right-fit data analytics capabilities where statistical analysis is the analytics tools to optimise the value of the hydroclimatic data to support data and fact-driven decision-making. Analytics in N-HyDAA focusing on data-driven data analytics which eminence on answering questions. The analytics capabilities used in N-HyDAA are focusing more on descriptive, diagnostic and predictive analytics; meanwhile, prescriptive analytics is an area of opportunity to discover further. According to Delen and Demirkan (2013), predictive analytics used data and mathematical algorithms which can rely on data, expert knowledge or combination of both through optimisation, simulation, multi-criteria decision,

Table 2: Indicators for CC Vulnerability in Malaysia.

Sector	Indicator		
	Exposure	Sensitivity	Adaptive capacity
Water	1. Projected Change of Water Availability	2. Freshwater withdrawal rate	3. Water storage capacity
	4. Projected Decrease in Dry Season Flow	5. Low flow restricts water abstraction	6. Supplementary flow from Off River Storage
	7. Projected Change of Rainfall and Dry Spell	8. Number of farmers affected	9. Dam and pump capacity
	10. Projected change in Groundwater recharge	11. Changes in groundwater level	12. Conjunctive use of surface and groundwater
Food & Commodity	1. Projected change of paddy yields	2. Paddy field area	3. Agriculture capacity
	4. Projected change in palm oil production	5. Oil palm plantation area	6. Water conservation practices
Infrastructure	1. Projected change of flood	2. Flood prone area	3. Structural and non-structural approaches
	4. Sea Level Rise Projection	5. Population living below 3m above mean sea level.	6. Disaster preparedness
	7. Projected increase in extreme flow	8. Frequency of dam overspill	9. Risk Management Plan/dam upgrading/dam safety review
	10. Projected change of river runoff	11. Reduction in the hydropower energy generation	12. Renewable Energy (RE)

expert system and group support systems where the outcome either best course of action, rich set of information and expert opinions to be provided to decision-maker.

Apart from data analytics capabilities, data produced from N-HyDAA are valuable for further utilisation in potential CC studies such as CC index vulnerability and readiness. Using an approach developed by the University of Notre-Dame through the Notre-Dame Global Adaptation Index (Chen et al., 2015), future research in NAHRIM will be focusing on identifying the current status of CC vulnerability through assimilation of data from N-HyDAA with a various dataset. The research will deliberate various aspects of CC vulnerability through exposure, sensitivity and adaptive capacity by developing a customised indicator which significant in CC scenarios from Malaysia's context.

This potential research help Malaysia in identifying the vulnerable areas which are lacking attention to overcome the impacts of CC. Table 2 shows a list of indicators for vulnerability developed through customisation by NAHRIM based on Malaysia CC scenario. Three main sectors have been identified that are vulnerable and affected due to the impact of CC in Malaysia. The combination and simulation of N-HyDAA with identified indicator data able to provide an index of vulnerability where the mechanism of the index calculation is still open for future discussion. Methodology as discussed earlier, such as MCDM, has the potential to be imposed in this future research as well as normal statistical analysis or replicating the same method as developing in ND-GAIN.

For future research opportunities, N-HyDAA showing the potential and capability of serving an immerse application domain in the CC area and its analytical capabilities have a considerable potential to be explored and studied further.

6 CONCLUSIONS

As a conclusion, through the composition of data analytics capabilities, management of CC data would be improved, where data preparation, data integration and data analysis able to enhance decisions and decision-making process in handling issues impact of CC.

Innumerable BDA projects showed a significant and impactful result on how BDA give a competitive advantage in term valuing the data and improved decision-making in various domain. New research areas for BDA implementation should be explored more to improve the result and to expand the capability with the enablement of other domain such as analytical capabilities, decision-making methodology, strategic and knowledge management. The opportunity to discover beyond the current BDA technology would expand the capabilities and enrich the outcome and ability of BDA.

ACKNOWLEDGEMENTS

This project funded by the Ministry of Water, Land and Natural Resources of Malaysia (KATS) and we are thankful to our environmental engineer and hydrologist for the technical expertise.

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