

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in
fulfilment of the requirements for the Doctor of Philosophy

**AN INTEGRATED ANP-DEMATEL METHOD BASED ON THE HESITANT
BIPOLAR-VALUED NEUTROSOPHIC SETS AND THEIR APPLICATION
TO COASTAL EROSION**

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Analytic network process (ANP) and decision-making trial and evaluation laboratory (DEMATEL) are two commonly used multi-criteria decision making methods in the literature. The integration between these two methods has been widely investigated thanks to their mutual compatibility and the fascinating advantages that both offers. However, it was noticed that the DEMATEL-based ANP (DANP) method was not exposed to the indeterminacy and uncertainty problems. Therefore, this study aims to extend the DANP method based on the hesitant bipolar-valued neutrosophic set. In order to achieve this main objective, firstly, the hesitant bipolar-valued neutrosophic set is proposed to deal with the indeterminacy, hesitancy and bipolar judgmental thinking in the decision-making problem. The basic operational laws, union, intersection and complement for hesitant bipolar-valued neutrosophic elements are defined. Secondly, this research established a hesitant bipolar-valued neutrosophic Shapley normalized weighted Bonferroni mean (HBN-SNWBM) operator to improve the traditional approaches that have neglected the significance of the interrelationship among the aggregated arguments and their coalitions. Along with the proposed aggregation operator, this research investigated and proved their desirable properties such as commutativity, monotonicity, idempotency and boundedness. Finally, the applicability of the proposed extended DANP method with the hesitant bipolar-valued

neutrosophic set is illustrated by a case study of the coastal erosion problem along the Kuala Terengganu coastline, where twelve factors were considered. Three experts of coastal erosion from different organizations were invited to elicit their linguistic judgments on the cause and effect of the coastal erosion. The seven-step decision approach was developed to acquire the weightage of each coastal erosion factor. The outcome of this study reveals that “coastal development” is the riskiest factor toward coastal erosion. The weight of factors and the cause–effect diagram could be very helpful to government and stakeholders to project a better mitigation plan for the coastal erosion problem. Comparative analysis is also provided to check the feasibility of the proposed method.

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**KAEDAH ANP-DEMATEL BERSEPADU BERDASARKAN SET
NEUTROSOFIK NILAI DWI-UFUK RAGU-RAGU DAN APLIKASINYA
TERHADAP HAKISAN PANTAI**

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Proses rangkaian analitik (ANP) dan ujian penilaian dan cubaan membuat keputusan (DEMATEL) adalah dua kaedah membuat keputusan pelbagai kriteria yang biasa digunakan dalam kesusasteraan. Gabungan antara kedua-dua kaedah ini telah diselidiki secara meluas hasil daripada keserasian bersama dan kelebihan menarik yang ditawarkan oleh kedua-duanya. Namun, dapat diperhatikan bahawa kaedah ANP berdasarkan DEMATEL (DANP) bersepadu belum terdedah kepada masalah ketidakpastian dan ketidaktentuan. Oleh itu, kajian ini bertujuan untuk mengembangkan kaedah DANP berdasarkan set neutrosodik nilai dwi-ufuk ragu-ragu. Untuk mencapai objektif utama ini, pertama, set neutrosodik nilai dwi-ufuk ragu-ragu diusul untuk menangani pemikiran penilaian yang ketidaktentuan, ragu-ragu dan dwi-ufuk dalam masalah membuat keputusan. Hukum operasi asas, kesatuan, persilangan dan pelengkap bagi unsur neutrosodik nilai dwi-ufuk ragu-ragu telah ditakrif. Kedua, kajian ini memantapkan satu operasi min Bonferroni berpemberat ternormal Shapley neutrosodik nilai dwi-ufuk ragu-ragu (HBN-SNWBM) untuk menambahbaik pendekatan tradisional yang mana telah mengabaikan kepentingan saling perkaitan diantara hujah-hujah terkumpul dan campuran mereka. Bersama dengan operasi pengumpulan yang diusulkan, kajian ini menyiasat dan membuktikan ciri yang diinginkan seperti komutatif, monotonisiti, idempoten dan keterbatasan. Akhir sekali, aplikasi kaedah DANP lanjutan yang diusul bersama set neutrosodik nilai dwi-ufuk

ragu-ragu dijelaskan oleh satu kajian kes masalah hakisan pantai di sepanjang pesisir pantai Kuala Terengganu, di mana dua belas faktor dipertimbangkan. Tiga pakar hakisan pantai dari pelbagai organisasi diundang untuk mendapatkan penilaian linguistik mereka mengenai sebab dan akibat hakisan pantai. Pendekatan membuat keputusan tujuh langkah dihasilkan untuk memperoleh pemberat bagi setiap faktor hakisan pantai. Hasil kajian ini mendedahkan bahawa “pembangunan pesisir” adalah faktor yang paling berisiko terhadap hakisan pantai. Berat faktor dan gambarajah sebab akibat boleh menjadi sangat membantu kepada kerajaan dan pihak berkepentingan untuk mengunjurkan satu perancangan pencegahan yang lebih baik untuk masalah hakisan pantai. Analisis perbandingan turut disediakan untuk menyemak kebolehlaksanaan kaedah yang diusulkan.