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Addressing Water Sustainability in the 21st Century: The Role of Engineering and Technology

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Water crisis ahead

Water, although plentiful on Earth, poses a paradox of scarcity due to its uneven distribution and limited accessibility. Earth contains around 326 million trillion gallons of water, but the majority of it, roughly 97% is saline, and another 2% is trapped in polar ice caps. This means that humanity depends on only 1% of Earth's water for survival for life. This small proportion is primarily located underground, which is challenging and expensive to reach, influencing the development of human settlements and economic activity towards more easily accessible surface waters such as rivers and lakes.

Throughout history, societies who efficiently controlled and utilized water resources thrived, whilst those that failed to do so experienced a fall. Contemporary instances, such as Cape Town, which came close to being the first big metropolis to experience water scarcity, emphasize the ongoing challenge. The experience of this city serves as a cautionary tale for other global cities, such as Sao Paulo, Melbourne, Jakarta, and Beijing, who may face "Day Zeroes" in the future. These "Day Zeroes" refer to the complete depletion of water supplies in metropolitan centers. To avoid this issue, dramatic adjustments in water usage must be implemented.

Water usage patterns expose other disparities, whereas human activities such as drinking, cooking, and hygiene only account for a small 8% of the available freshwater, the bulk is dedicated to agricultural and industrial purposes. This distribution not only emphasizes the unequal utilization of water, but also sheds light on the economic undervaluation of this important resource. Water is often underpriced in various areas, which means its actual cost is not accurately reflected. This leads to excessive use and wastefulness, which is not sustainable in the long run.

Economic activity frequently worsens local water shortages. For instance, Mexico City,

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although it receives a greater amount of rainfall compared to London, experiences significant water scarcity as a result of the previous drainage of lakes and excessive use of groundwater. The city is experiencing subsidence, causing certain portions to sink at a rate of up to 20 cm per year. Comparable difficulties are apparent in areas such as northern India, where underground water reservoirs are disappearing rapidly, posing a threat to the water security of millions.

The participation of the private sector in water management is on the rise, as institutions such as hedge funds are acquiring water rights. This has raised concerns about the potential commercialization and exploitation of water scarcity for financial gain. The implementation of this method has sparked ethical questions over the fair distribution of water resources, specifically the effect of pricing techniques on low-income communities who are disproportionately impacted by rising costs. Climate change exacerbates the burden on water resources by making precipitation patterns more unpredictable and less consistent. The lack of freshwater is leading to an increase in conflict, as seen by ongoing disagreements and violence in regions such as Darfur and northeastern Nigeria.

The growing crisis has stimulated interest in technology solutions such as desalination, which has experienced a more than twofold increase in capacity in the last decade. Nevertheless, desalination is characterized by high energy consumption and significant expenses, which renders it a less feasible choice for wider implementation considering the present economic assessments of water.

Innovation for water sustainability management

Different models have been tried by many towns and countries to tackle these difficulties. In 2017, Philadelphia implemented a system where water costs are modified according to income levels. The objective is to protect essential human requirements while avoiding additional financial strain on those with lower incomes. This paradigm exemplifies an increasing acknowledgment of the necessity to oversee water not just as a commodity with economic value but also as an essential entitlement of every human being.

The experience of Cape Town facing Day Zero in 2018 demonstrates both the possibility of a crisis and the ability of the community to respond collectively. The implementation of stringent water restrictions and active participation from the public in conservation endeavors successfully averted the predicted catastrophe, showcasing the efficacy of immediate collaborative measures. However, depending on crisis-driven conservation is not a sustainable approach, it is crucial to take proactive actions instead.

Accurate assessment and control of water require acknowledging its crucial significance in worldwide sustainability and the preservation of human life. Investments in infrastructure to mitigate leakages, which can constitute as much as 42% of the municipal water supply in areas such as Mexico City, are important. In addition, the implementation of water-efficient farming practices, enhancement of industrial water usage, and promotion of responsible consumption patterns might help alleviate some of the most urgent challenges.

With the ongoing increase in global populations and the changing climate conditions, the significance of water management becomes increasingly evident. With the intention of fostering global cooperation and tangible progress, the 10th World Water Forum in 2024, held in Bali, Indonesia, seeks to serve as a crucial milestone in bringing nations and people together to pledge to concrete and effective measures in ensuring universal access to clean water and proper sanitation. The experiences of places such as Cape Town (Capital of South Africa) and the current efforts being made globally offer both warnings and models for achieving a sustainable water future.

Ultimately, addressing the worldwide water crisis necessitates a comprehensive approach that encompasses policy restructuring, technical advancement, and active involvement of communities. By assigning the proper value to water and making investments in sustainable management practices, humanity can protect this essential resource for future generations, guaranteeing its ability to support life and prosperity on our planet.

This issue covered the role of engineering and technology and proof of concept for multiple sectors

This volume documents the inquiry into cleaner energy, human mobility, and industrial and manufacturing practices that prioritize the well-being of individuals. Additionally, reports were generated about a proof of concept involving value chain and artificial intelligence. Multiple publications emphasize an innovative approach that advocates environmental concerns.

The first paper is written by H. Attia and F.T.K. Suan. The paper explains a Mode Controller (SMC) for DC-DC boost converters, starting with the modeling of the converter circuit and deriving dynamic equations during continuous conduction mode (CCM). It details the steps for constructing an SMC that effectively maintains output voltage stability amidst variations in input voltage and load conditions. The performance and robustness of the proposed controller are demonstrated through MATLAB/Simulink simulations, highlighting its fast and accurate response to changes in reference voltages. The results validate the controller's effectiveness in managing different operational scenarios, proving its suitability for advanced power electronic systems in renewable energy applications.

The second paper is written by J. Sentanuhady, W. Prasidha, A.I. Majid, M.A. Muflikhun. The study investigates the instability of detonation waves in a natural gas-oxygen mixture as they pass downstream of an aluminum crimped ribbon, focusing on enhancing safety in industrial settings by managing detonation risks. It uses a 3000 mm long detonation test tube equipped with pressure sensors and a soot track record plate to analyze the effects of various initial pressures on wave propagation. Results indicate that the crimped ribbon arrester model effectively modulates the detonation wave, converting it into a less intense deflagration wave under certain conditions, thereby reducing shock wave pressures and controlling detonation risks. The study confirms that increasing the initial pressure intensifies the combustion reactions, leading to varied behaviors of the wave, including quenching at lower pressures and reinitiation at higher pressures, illustrating the arrester's effectiveness in mitigating detonation impacts.

The third paper is written by J.L. Dapito and A.Y. Chua. The paper details the development of a Coefficient of Performance (COP) prediction model for a vapor compression refrigeration system using an Artificial Neural Network (ANN). The study focused on enhancing refrigeration efficiency by accurately predicting COP using real-time operational data, aiming to reduce energy consumption in refrigeration systems which are significant consumers of global electricity. The ANN model achieved a high accuracy with a root mean squared error (RMSE) of 0.0621 and a coefficient of determination (R2) of 0.8162, validating the model's effectiveness in predicting COP under various conditions. This approach not only optimizes performance but also contributes to strategic energy management by enabling precise monitoring and maintenance scheduling, highlighting the model's potential application in decentralized industrial cooling systems.

The fourth paper is written by H. Pyykkö, A. Lauhkonen, V. Hinkka, H. Karvonen and P. Leviäkangas. The paper examines how benchmarking can aid managerial decisions on investing in technology, particularly in the context of last-mile distribution in online retail.

It emphasizes the challenges of integrating new technologies into existing distribution models due to a variety of available technological solutions, stressing the importance of choosing technologies that align with company and customer needs. Through a survey involving logistics and supply chain managers, the paper assesses sixteen technologies, using benchmarking indicators like applicability, tangibility, and maturity to evaluate their feasibility for last-mile applications. The study demonstrates the use of domain-specific benchmarking as an effective tool for improving strategic decisions related to technology investments, aiming to facilitate better management of the logistical challenges in online retail.

The fifth paper is written by T.T.K. Dat and T.T. Phuc. The paper focuses on improving the accuracy of CNC machining toolpaths, particularly for high-speed machining of curved surfaces. It addresses the discrepancies caused by the acceleration and deceleration (Acc/Dec) characteristics of CNC machine tools, which result in differences between the commanded and actual feed rates, leading to toolpath trajectory errors. By modelling feed rate changes and employing a novel toolpath generation method in the post-processing level, the research aims to minimize these discrepancies. Experimental results confirm the effectiveness of these methods, showing significant improvements in machining precision, thereby validating the proposed approach for enhancing toolpath accuracy in CNC machining.

The sixth paper is written by M. Asrol. The paper presents a systematic literature review exploring the adoption of Industry 4.0 within supply chain operations, highlighting its growing significance and the need for a readiness and maturity model specifically tailored for supply chains. It identifies five comprehensive dimensions for assessing readiness: technology and IT infrastructure, supply chain integration and coordination, manufacturing operations and inventory, leadership and human resources, and sustainability. The study emphasizes that while digital technology is crucial, a broader application across various supply chain aspects is necessary for truly leveraging Industry 4.0's potential. Finally, it calls for further research to develop a detailed readiness and maturity model, incorporating these dimensions to guide supply chains in their digital transformation journeys.

The seventh paper is written by H. Munawir, M. Kausar, I. Pratiwi and A.K. Alghofari. The paper focuses on managing and mitigating risks at Batik Laweyan during the COVID-19 pandemic by identifying various risks that disrupt sales and income using Failure Mode Effect Analysis (FMEA) and the Analytical Hierarchy Process (AHP). It highlights the major risks such as changes in consumer behavior, decreased demand, budget changes, and the implications of large-scale social restrictions (PPKM). To address these risks, 14 mitigation strategies were developed, prioritized using AHP, emphasizing the adaptation of digital technologies, product innovation, and strategic marketing. The study aims to enable Batik Laweyan to sustain operations during the pandemic by effectively managing identified risks and implementing targeted mitigation strategies.

The eighth paper is written by N.P. Ezdina, E.Y. Dotsenko, E.V. Shavina and Y.S. Valeeva. The paper investigates the impact of convergent and hyperconvergent technologies on productivity within the extractive sector, emphasizing the adoption of Industry 4.0 technologies as essential for overcoming productivity stagnation. The research identifies a cyclical problem of declining investments leading to lower productivity, further exacerbated by the sector's dependence on traditional technologies and imported equipment. It proposes a solution through the application of advanced convergent technologies, such as nanotechnology and information-computing technologies, to modernize production processes and transition from automated to fully unmanned

systems. Additionally, the study introduces a platform for the dissemination of these technologies within the sector, aiming to address and revitalize the extractive industry's productivity through technological innovation.

The ninth paper is written by M. Naghipour, L.S. Ling, and T. Connie. The paper analyzes artificial intelligence (AI) techniques in the agricultural industry, specifically focusing on fruit detection and classification using oil palm fresh fruit bunches as a primary example. The paper discusses various AI models and data capturing devices used in agriculture, with a significant emphasis on the performance metrics such as accuracy and sensitivity, where most studies exceeded 90% performance levels. It also highlights the challenges and limitations of current AI applications in agriculture, suggesting the necessity for further advancements in technology to improve the accuracy and utility of AI in this field. The document aims to provide a comprehensive overview of the state of AI in agriculture, noting its critical role in addressing labor-intensive processes and enhancing productivity and decision-making through more refined data analysis techniques.

Tenth paper is written by C. Budiyantoro, H.S.B. Rochardjo, S.E. Wicaksono, M.A. Ad, I.N. Saputra, R. Alif. The document investigates the influence of processing parameters on the impact and tensile properties of injection-molded glass fiber reinforced polyamide 6. It utilizes the Taguchi method to optimize barrel temperature, holding pressure, and injection pressure to determine their effects on the mechanical properties of the composite. Findings suggest that barrel temperature is the most critical factor affecting both tensile and impact strengths. The study concludes by offering optimal processing conditions for enhancing the performance of glass fiber reinforced polyamide 6, useful for industrial applications requiring high-strength, lightweight materials.

Next, the eleventh paper is written by F. Aziz, A.K. Rivai, M. Panitra, M. Dani and B. Suharno. The document explores the neutronic characteristics of candidate accident-tolerant fuel (ATF) cladding materials for light water reactors to enhance nuclear safety. FeCrNi alloy and oxide dispersion strengthened steels, FeCrY2O3 and FeCrZrO2, were analyzed for their high-temperature strength, radiation resistance, and corrosion resistance compared to the conventional Zircaloy-4. Results indicate that the new materials can improve safety margins by managing the neutron spectrum and maintaining reactor core safety despite reduced initial excess reactivity and lower fuel burnup, which can be compensated by higher fuel enrichment. The study concludes that the investigated materials are viable alternatives to Zircaloy-4 for enhancing the safety and efficiency of nuclear reactors.

Twelfth paper written by M. Zulkarnain, I. Harny, M.I. Insdrawaty, M.I.F. Azman, M.I.A Azmi, and E. Kusrini. The paper investigates the development of natural fiber composites for noise control materials, focusing on coconut, palm oil, and sugarcane fibers. The research aims to enhance the sound absorption coefficients and transmission loss characteristics of these fibers by experimenting with different filler content levels in a polyester matrix. Significant findings indicate that sugarcane bagasse fibers exhibit the most consistent performance across varied filler content levels for both sound absorption and transmission loss. This research supports the use of local natural fibers as effective materials for reducing environmental noise pollution, particularly in areas close to high-noise transportation tracks.

Thirteenth paper written by K. Indriawati, B. Sudarmanta, B.L. Widjiantoro, N.A. Hafiizh and A.H. Said. The paper provides an in-depth analysis of a regenerative anti-lock braking system (ABS) integrated into a quarter electric vehicle model, focusing on the synergy of motor and hydraulic braking torques. It introduces a sliding mode control algorithm to optimize the distribution of braking force, enhancing energy regeneration and preventing

wheel slip. Experimental results show that this regenerative ABS can effectively manage the slip ratio, optimizing braking efficiency and energy recovery, reflected by a significant increase in the battery's state of charge (SOC). The study underscores the potential of combining motor and hydraulic braking to improve both vehicle safety and energy efficiency in electric vehicle systems.

Fourteenth paper written by N. Hasan, A.A. Aziz, A. Mahmud, Y.B. Alias, R.B. Besar, L. Hakim and M.A.B. Hamidi. The paper reviews vehicle sensing and localization technologies within vehicular networks, focusing on autonomous driving applications. It discusses the architecture and types of Vehicular Ad Hoc Networks (VANETs), which facilitate vehicle-to-vehicle and vehicle-to-infrastructure communication and are crucial for intelligent transportation systems. Various vehicle positioning techniques are analyzed, including GPS-based communication and reflection-based methods involving RADAR and LIDAR, highlighting the challenges faced in non-line-of-sight environments and the impact of new technologies like 5G on vehicular communications. Additionally, the paper emphasizes the importance of accurate vehicle localization for safety and efficiency in traffic management and discusses the potential of 5G networks to enhance these systems.

Fifteenth paper written by W. Shafik, K. Kalinaki and S.M. Matinkhah. The paper explores the evolving dynamics and challenges within UAV communications. It highlights the increasing integration of UAVs with advanced technologies such as machine learning and deep learning to enhance functionalities such as autonomous navigation, energy efficiency, and real-time data processing. The study addresses significant technical loopholes in UAV systems that could be exploited if not addressed, emphasizing the need for robust security measures in future developments. Additionally, it outlines current trends in UAV communication technology, including the application of deep reinforcement learning for efficient trajectory planning and resource management, marking a pivotal shift towards more autonomous and intelligent UAV operations.

Sixteenth paper is written A.S. Pramono, A. Wikarta and F. Mu'iz. The paper focuses on the experimental comparison of standard and modified linear profile involute gears, aimed at reducing interference and extending gear lifespan under varying torque loads and speeds. Using 18-pin teeth with a base diameter of 72 mm, the experiment measured strain using a dynamic torque meter and a strain gauge on pinion gears. Results indicated that the linear profile modification significantly reduced tooth leg strain by 5.6% to 13.99%, with the most substantial decrease observed at higher speeds and torque loads. This modification could potentially improve gear performance by reducing the risks associated with mechanical loads and extending the operational life of the gears.

The seventeenth paper is written by A. Masrianto, H. Hartoyo, A.V.S. Hubeis and N. Hasanah. The paper explores the enhancement of firms' Digital Marketing Capability (DMC) in Indonesia by examining the interplay between innovation ecosystem readiness, digital transformation, and digital marketing adoption. The study utilized a sample of 217 firms, analyzing the data through Partial Least Squares Structural Equation Modeling (PLS-SEM) to assess how these components influence digital marketing effectiveness. Key findings suggest that innovation ecosystem readiness significantly boosts DMC directly and indirectly through digital transformation, which also plays a critical mediating role between ecosystem readiness and digital marketing adoption. The study underscores the importance of integrating digital transformation and marketing technologies into business strategies to elevate digital marketing capabilities effectively.

The eighteenth paper is written by S.H. Teoh, G. Narayanan, S.R.S. Aris, N. Ibrahim and B. Isa. The paper investigates the factors influencing confidence among preservice teachers in STEM practices, focusing particularly on the domains of algebra and statistics. It reveals

that a strong foundation in these subjects enhances the confidence of teachers in delivering STEM education effectively, emphasizing the integration of real-world applications into the curriculum. Using a correlational study design with a sample of 113 preservice teachers, the research identifies a significant relationship between the effort put into mastering these subjects and the teachers' confidence in teaching them. The findings suggest that enhancing pedagogical approaches in STEM education can significantly impact the readiness and confidence of future educators to teach these crucial subjects.

The ninetieth paper is written by J. Ockerman, J.R. Octavia, J. Joundi, A. Penders, L. Bar-On and J. Saldien. The paper discusses the development and application of "Matti," a tangible user interface (TUI) designed to enhance patient engagement in physical therapy for children with Developmental Coordination Disorder (DCD). It highlights the use of Matti in creating an interactive and enjoyable rehabilitation environment through exergames that stimulate motor skills and motivation. The iterative design process involved collaboration with therapists, patients, and engineers to ensure the tool meets clinical needs and enhances patient therapy outcomes. The study emphasizes the potential of such innovative tools to transform rehabilitation practices by integrating technology with therapeutic exercises, ultimately aiming to improve treatment efficacy and patient motivation.

Next paper is written by E.B.B. Nicart, B.R. Arellano and M.L. Acunin. The paper introduces the Machine Algorithm-based Journey Assistant (MAJA), an intelligent interface designed for tourism websites to enhance visitor experiences through personalized recommendations. The system utilizes collaborative filtering algorithms to analyze user preferences, ratings, and reviews, tailoring suggestions for tourist spots, activities, and itineraries. MAJA aims to improve tourism in the Philippines by providing a smart platform that supports local and foreign tourists with accurate and relevant information, thereby increasing destination competitiveness. Evaluation metrics such as Mean Average Precision (MAP) and recall demonstrate MAJA's effectiveness in delivering personalized experiences, highlighting its potential as a valuable tool for the tourism industry.

The twenty-first paper is written by A.A. Lukito, M. Tyrayoh, E.A. Prasetyanto and E. Rukmini. The study developed a paper-based glucose sensor using artificial sweat and saliva to measure glucose non-invasively, providing a practical and affordable method for routine glucose checks. This sensor utilizes a colorimetric technique with the enzymes Glucose Oxidase (GOx) and Horseradish Peroxidase (HRP), and the chromogen 3,3'-diaminobenzidine (DAB), allowing for visual detection of glucose levels through color changes on the sensor. The sensors demonstrated high sensitivity and accuracy, effectively measuring glucose levels across a range of 0 to 3000 μM in both artificial sweat and saliva, which are correlated with blood glucose levels, hence suitable for diabetes monitoring. This method offers a promising alternative for non-invasive glucose monitoring, potentially easing the daily management of diabetes by using readily accessible bodily fluids instead of blood samples.

The twenty-second paper is written by N. Victorova, E. Vylkova, V. Naumov, and N. Pokrovskaia. The study assesses the state of top-priority and socially important industries in Russian regions, focusing particularly on the use of digital tax burden calculators for 2020 in St. Petersburg. It investigates the determinants of tax burden and average salary across different sizes and types of businesses, applying a mathematical approach to argue for enhanced state support measures through taxation methods. The analysis involves two main statistical techniques: a two-way analysis of variance examining relationships between average salary, organization size, and industry type, and a refined one-way analysis using regression on dummy variables to evaluate the impact of business scale and

industry type on tax burden and salaries. The study finds no significant differences in average salary and tax burden among prioritized sectors compared to other industries, suggesting that current state support is inadequate and that additional preferences are necessary.

The twenty-third paper is written by E. Rismana, A.D. Arbianto and S. Kusumaningrum. The paper outlines a detailed study on developing an efficient and scalable process for producing analytical grade sodium chloride (NaCl) at a laboratory scale, with the potential for application in various industries due to its high purity level. The process involves several stages including purification, acidification, neutralization, crystallization, and drying, aimed at reducing impurities such as sulfate, magnesium, and calcium to acceptable levels for analytical use. This study introduces a novel two-stage precipitation method and multiple re-crystallizations to control impurities, particularly focusing on reducing potassium content without the use of expensive resins. The process yields analytical grade salt with over 99.50% purity and produces high-quality brine as a by-product, which can be further processed into pharmaceutical and food-grade salts, presenting a significant advantage in terms of simplicity and cost-effectiveness compared to existing technologies.

Twenty-fourth paper is written by M. Alauhdin, R. Adnan, A.D. Hatmanto and I. Kartini. The paper provides a systematic literature review on the functionalization of cotton fabric using phytosynthesized silver nanoparticles (AgNPs), highlighting the use of plant extracts in nanoparticle synthesis for textile applications. It discusses various methodologies like pad-drying and dip-drying for embedding AgNPs into cotton fabrics to impart multifunctional properties such as antibacterial, UV protection, and wound healing capabilities. The review also addresses future challenges in achieving stable and permanent AgNPs immobilization on cotton fabric while developing new functional properties. The document synthesizes data from various studies to emphasize the growing interest and technological advancements in using green chemistry approaches for textile enhancement, advocating for sustainable practices in the textile industry.

Twenty-fifth paper is written by R. Rasyid, D. Prasetyo, N. Fitriani and T. Syarif. The document discusses the catalytic cracking of palm fatty acid distillate using NaOH and KOH catalysts supported by gamma alumina to produce biofuels like biogasoline and biodiesel. It details the experimental setup involving a batch reactor, characterizes catalysts through X-ray diffraction and scanning electron microscopy, and describes the process parameters like temperature and catalyst concentration. The results highlight that KOH/γ-Al2O3 catalysts are more effective for producing biogasoline, whereas NaOH/γ-Al2O3 catalysts favor biodiesel production, both demonstrating high selectivity and yield. The study underscores the potential of using palm fatty acid distillate as a sustainable raw material for biofuel production, contributing to energy security and environmental sustainability.

Twenty-sixth paper is written by F. Soetandar, I.M. Hidayatullah, T.S. Utami, M. Yohda, and H. Hermansyah. The paper proposes a novel kinetic model for enzymatic biodiesel production using a recirculating fixed bed reactor, utilizing Candida rugosa lipase encapsulated in calcium alginate beads. This model is predicated on the Ping-Pong Bi-Bi mechanism, aiming to enhance yield and process reproducibility by optimizing enzyme utilization and reaction conditions. The study developed three different models to describe the kinetics of the transesterification process, with varying assumptions about alcohol availability and intermediate product formation. Experimental validation demonstrated that while all models align closely with observed data, differences in error metrics underscore the complexities of accurately simulating real-world biodiesel production dynamics, particularly regarding intermediate product management and enzyme efficiency.

Lastly, the final paper is written by G. Maldybayev, R. Shayakhmetova, S. Nurzhanova, R. Sharipov, E.-S. Negim, A. Alimzhanova, P. Osipov, A. Mukhametzhanova, and A. Usman. The paper focuses on the synthesis of a chemical adsorbent derived from technogenic asbestos waste for purifying heavy oil residues, specifically targeting the removal of heavy metals and sulphur. The study evaluates the performance of the synthesized adsorbent at high temperatures, finding optimal conditions for demetallization and desulfurization of heavy oil residues. It incorporates thermal and chemical activation processes to enhance the adsorbent's efficiency, with experimental results showing significant reductions in vanadium, nickel, iron, and sulphur contents from the oil. This research contributes to the development of cost-effective and environmentally friendly technologies for the petroleum industry, addressing the pressing need for cleaner fossil fuel processing methods.

To summarize, the combination of current technology with a modern innovation has created new opportunities for addressing intricate issues in various domains. As science progresses, it is probable that innovation will have a progressively significant role in shaping our future. IJTech warmly welcomes and eagerly receiving your articles and disseminating your research to our readers.