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Application of Toyota Way Incorporating Kaizen, Kaikaku and 5S in Agricultural Sector

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Abstract: ***A noble operational framework – 2K5S, a modified form of Toyota production system (TPS) incorporating Kaizen, Kaikaku and 5S is introduced in this paper. Kaizen is continuous improvement concept implementing a small step at a time to produce a small or moderate improvement in productivity. Kaikaku is a moderate innovative approach implementing new work method or means to produce a drastic improvement in productivity by eliminating wastes at the same time. The 2K5S is then implemented in the operations of a pineapple farm and a series of case studies are conducted. The outcomes of the case studies have revealed that through the introduction and implementation of the 2K5S operational framework, some significant organisational improvements have been witnessed. Apart from significantly increment in productivity, other advantages achieved including increasing in effectiveness and efficiency in the operational processes, improved visual management of the process, improved operational health and safety and morale of the workers, improved housekeeping, waste elimination and process standardization. The outcomes of this study have demonstrated that 2K5S is a powerful and practical operational framework model which is applicable for agricultural organisation.***

Keywords: Toyota production system (TPS), 2K5S, Kaizen, Kaikaku, 5S, continuous improvement, agricultural sector.

I. INTRODUCTION

The main objective of this paper is to explore into the feasibility of adopting Toyota production system (TPS) and applied it to agricultural sector in a farm. The success of Toyota is often attributed to its unique TPS. TPS accords a great emphasis to kaizen as the central element of this production system (Fujimoto,et al, 1999; Womack et al., 1990). Kaizen, or continuous improvement, is an essential component of the Japanese management system for quality and productivity improvement. Kaikaku is the Japanese term for "radical change". In business, Kaikaku is concerned with making fundamental and radical changes to a production system, unlike kaizen which is focused on incremental changes. Both Kaizen and Kaikaku can be applied to activities other than production. 5S is defined as a methodology that results in a workplace that is clean, uncluttered, safe, and well organized to help reduce waste and optimize productivity. It's designed to help build a quality work environment, both physically and mentally. The 5S philosophy applies in any work area suited for visual control and lean production. The 5S condition of a work area is critical to employees and is the basis of customers' first impressions. Pineapple is the third most important tropical fruit in the world production after banana and citrus (Bartholomew, 2003). According to the data reported by Food and Agriculture Organization of the United Nation (FAOSTAT), the pineapple production quantity in Malaysia decreases from year 2015 until year 2017 as shown in the Figure 1. The decrease in production is mainly due to its labour intensive and other bottlenecks in their operations . Pineapple is also known as *nanas* in Malay language. *Nanas Morris* and *Nanas Sawit* are the two main types of pineapple planted in the plantation that took part in this study. Previous studies have reported that improved efficiency on agricultural farm level can lead to cost reduction and revenue increment by continuously improving and strengthening the competitiveness and sustainability of farms in long term (Andersson and Andersson, 2014). Since the farm involved in this study is still very young as it is formed in 2017, operators are new to pineapple cultivation too, therefore, they need significant level of in-house training and educational briefing to improve their competency in farm operations. The researchers started to visit the farm frequently in the early stage to make observation at the farm in order to identify the weaknesses in the operations. On-site trainings are provided to the operators on Kaizen and 5S every month. Regular meetings with the supervisor and manager are conducted in exploring ways to improve the farm's productivity. The researchers suggested to borrow the TPS from Japanese manufacturing industries to be implemented in agricultural sector, aiming to reach a breakthrough in overall operational performance. However, there are limited studies which could provide evidence or "know-how" to substantiate or guide how kaizen continuous improvement management can be implemented in the agricultural sector. Therefore, this research paper attempts to describe how a noble operational framework incorporating kaizen, kaikaku and 5S to form a 2K5S operational model, aiming in helping the pineapple farm towards the goal of improving the productivity of crops cultivation throughout its life-cycle, starting from land development, planting row preparation, planting, weeding, applying fertilizer, harvesting.

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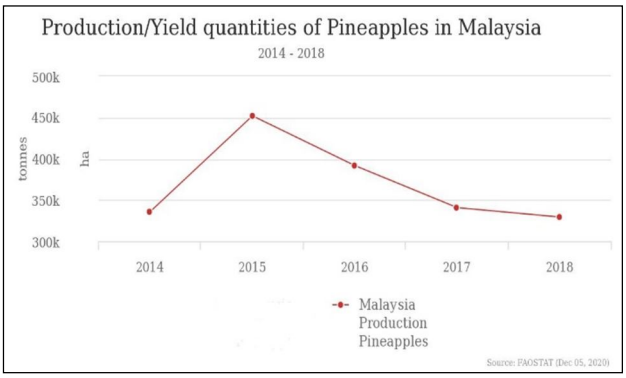

Figure 1: Pineapple Production Quantity in Malaysia from year 2014 to year 2018
(Source: FAOSTAT)

II. LITERATURE REVIEW

A. Kaizen

Kaizen, the synonym for continuous improvement, is an essential component of Japanese management system. Kaizen programs have long been employed with great success in Japanese companies. Imai (1986) called Kaizen the key to Japanese competitive success. The benefits from kaizen implementation are numerous and are reported along both social and technical dimensions of organization and include cost reduction, productivity improvement, reduction in defects, and improvement in employees‟ morale and motivation (Bessant, 2003). It is kaizen, the Japanese business philosophy that says step-by-step improvement – process refinements and enhancements – are the surest, easiest, quickest road to maximizing productivity and quality. According to Imai (1997), the Japanese philosophy of Kaizen assumes that our way of life should concentrate on the constant improvement of efforts in our working life, home life as well as social life. Kaizen means continuous improvement in Japanese, where “kai” means to change and “zen” means good or well. Masaaki Imai stressed in his book Gemba Kaizen, the word “Kaizen” signifies improvement that involves everyone – both managers and employees at the workplace. The concept of kaizen has the potential to cause the alignment necessary between management and employees to exist as it requires all employees to actively participate in continuous improvements (Gondhalekar et al, 1995). In the book “Kaizen for the Shopfloor” created by The Productivity Press Development Team, it concludes that kaizen activities concentrate on each process and every operation for value-added mean and waste elimination.

Van et al. (2010) defines kaizen event as a focused and structured improvement project by using a dedicated cross-functional team to improve a targeted work area, with specific goals, in an accelerated time frame. The authors have suggested a framework to carry out kaizen events. The framework is primarily consisting of four phases: planning, implementing, sustaining and supporting. Furthermore, it is developed so it can be self-assessed in order to enhance particular topics and itself. The authors also conclude that the use of the framework as a layout and evaluation tool seemed to make the kaizen events program more effective in the case study organization.

B. Kaikaku

Kaikaku is a Japanese word which means a drastic change, reformation or radical change. Most of the Japanese manufacturing industries identify Kaikaku as a mean of improvement in production that is more radical than Kaizen (Yamamoto, 2010). According to Imai (1986), Kaikaku is a radical improvement by allocating a significant level of investment in technology or equipment. Kaikaku also defined as a process to obtain vivid or dramatic outcomes by replacing the existing practices with new practice, knowledge and methodologies (Kondou, 2003). Stewart and Raman (2007) report that the Takaoka factory in Toyota reopened in summer 2017 has cut the lead times, assembly line and logistics in half by adopting Kaikaku as a radical improvement approach.

Kaikaku means a radical change, during a limited time, of a production system. Kaizen, on the other hand, is a system of incremental production system changes, often with the primary goal of solving team-related problems. Kaizen is based on all employees involvement wherein singular changes generally reach an improvement of less than 20%. A cross between Kaikaku and Kaizen is kaizen Blitz (or Kaizen Events), which target a radical improvement in a limited area, such as a production cell, typically during an intense week.

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Kaikaku means that an entire business is changed radically, typically in the form of a project. Kaikaku is most often initiated by management, since the implementation and the result will significantly impact business. Kaikaku is about introducing new knowledge, new strategies, new approaches, new production techniques or new equipment. Kaikaku can be prompted by external factors, e.g. new technology or market conditions. Kaikaku can also be initiated when management judges that diminishing improvements from ongoing Kaizen efforts suggest a need for more radical change. Kaikaku projects often result in improvements in the range of 30-50% and a new base level for continued Kaizen. Kaikaku may also be called System Kaizen.

Kaikaku projects can be of four different types:

1) Locally innovative implementation - e.g., introducing a production robot, well-known to the industry, but new to the company
2) Locally innovative methodology - e.g., introducing Six Sigma or TPM methods, well-known to the industry, but new to the company
3) Globally innovative implementation - e.g., introducing a new robot *design* to the industry
4) Globally innovative methodology - e.g., introducing a new production *theory* to the industry

Yamamoto (2010) highlights that Kaikaku is often initiated by top management, fundamental changes are made through replacements or reformations of the production system by introducing new strategies, work methods, technologies, equipment and so forth. Yamamoto also claims that the performance increase as a result of implementing Kaikaku is often 20% to 50% or even more. There are two types of Kaikaku, namely incrementally innovative and radically innovative Kaikaku. A model of Kaikaku types developed by Yamamoto is shown in Figure 2.

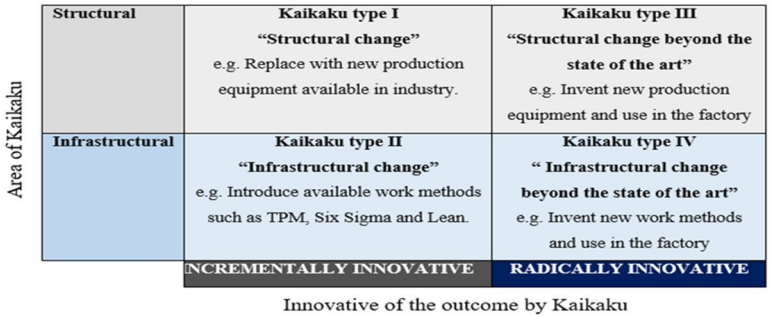

Figure 2: Model of Kaikaku types (Adapted and modified from Yamamoto, 2010)

Kaikaku type I involves basic changes in the structural area by importing existing solutions which provides an incrementally innovative outcome. For instance, increasing the level of automation with off-the-shelf equipment. Kaikaku type II involves basic changes in the infrastructural area result in an incrementally innovative outcome by implementing a standard set of work processes developed by improvement initiatives such as TPM, Six Sigma and Lean production. Kaikaku type III is related to basic changes in the structural area where new technologies, production equipment or other solutions are invented and applied to the organisation which result in a radically innovative outcome. In Kaikaku type IV, basic changes in the infrastructural area by creating and using innovative work processes, production flows or other unique solutions also achieve a radically innovative outcome. Yamamoto (2010) mentions that Kaikaku contributes to the competitiveness of the production and it has been actively conducted among Japanese manufacturing companies.

C. Pineapple Farming

Pineapple (*Ananas* comosus) is a type of tropical plant which is the third most produced fruit in the world after bananas and citrus fruit (Bartholomew et al, 2003). According to the data retrieved from FAOSTAT (2018), Malaysia is not one of the top 10 producers of pineapple around the world. This might be due to the insufficient technology-based knowledge and improper operational management within the farm.

Wali (2019) states that there are few factors contribute to the effective production of pineapple including rainfall, type of soil, drainage, temperature and nutrient requirement. Dorey et al. (2018) suggests a SIMPINA model to optimise pineapple Victoria ('Queen') management sequences on Reunion Island. SIMPINA model is a model of management sequences which is based on four indicators: yield, N leaching, prices of product, total soluble solids (TSS) and titratable acidity (TA) to estimate commercial, agronomic, fruit quality and environmental conditions.

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N leaching refers to temperature, rainfall, global radiation and practices such as planting date, irrigation, fertilization, planting density, date of forcing and sucker weight during planting. The study conducted shows that pineapple farmers can achieve a high level of productivity and fruit quality by using SIMPINA model to stimulate or improve their environmental criteria. However, other criteria should be taken into consideration in different production countries with other issues.

Weeds are one of the main problems in obtaining high yields of pineapple as they compete with pineapple for nutrients, water and sunlight as well as serving as an alternate breeding place for pests or rodents (Arcelo, 2009). The methods suggested by Arcelo (2009) include preventive, cultural and chemical methods. Preventive method refers to the use of high quality and disease-free planting material; cultural methods refers to hand-weeding or hoe slashing while chemical methods means the use of herbicides or weedicides to kill the weeds with minimum or no harm to the pineapple.

To stabilize production of pineapples, flower induction is recommended as it allows year-round production, ensures more uniform flowering and fruiting and gives a higher income especially during off-season. For small scale farms, the time of flower induction is determined by plant size which is approximately when the pineapples have 55 to 60 functional leaves (Arcelo, 2009).

Based on the literature, the researchers found out that there is limited research study on how to increase the production of pineapple in Malaysia, particularly in Sarawak which has plenty vacant farm lands. No literature can be sourced on the topic of how the integration of kaizen, kaikaku and 5S program can be implemented within an agriculture related industries such as pineapple farming and their effectiveness and suitability.

D. 5-S Japanese House-keeping Common Sense

Japanese 5-S common-sense is developed by Hiroyuki Hirano. The concept of 5-S concentrates on how the visual workplace can be used to eliminate inefficiencies, especially unnecessary wastes that have generated during the manufacturing process and to improve the work environment consistent with the tenets of Lean manufacturing systems. Besides, the occupational health and safety of workplace can also be enhanced through 5-S practice. Hirano also indicates that without the successful implementation of 5-S in the organization, the other Lean manufacturing tools are more likely to fail (Shil, 2009).

Peterson and Smith (1998) states that 5-S is a system of steps or procedures and techniques that can be utilized by individuals and groups to arrange the workplace in the best method to optimise overall performance, comfort, safety, hygiene and cleanliness. Sii (2004) defines 5-S in his book “Cultivating A Total Quality Culture- Using Japanese`s Common Sense 5S” as “the common sense in the fundamental study, design and maintenance of working environments and their components, work practices, and work procedures for the benefit of the worker`s productivity, efficiency, effectiveness, health, comfort and safety”.

The 5S quality tool is derived from five Japanese terms beginning with the letter "S" used to create a workplace suited for visual control and lean production. The pillars of 5S are simple to learn and important to implement:

1) *Seiri:* To separate needed tools, parts, and instructions from unneeded materials and to remove the unneeded ones.
2) *Seiton:* To neatly arrange and identify parts and tools for ease of use.
3) *Seiso:* To conduct a cleanup campaign.
4) *Seiketsu:* To conduct *seiri*, *seiton*, and *seiso* daily to maintain a workplace in perfect condition.
5) *Shitsuke:* To form the habit of always following the first four S’s.

Below, the Japanese terms are translated into the English language version of the 5S’s.

Japanese	Translated	English	Definition
Seiri	Organize	Sort	Eliminate whatever is not needed by seoarating needed tools, parts, and intructions from unneeded materials
Seito	Orderliness	Set in order	Organize whatever remains by neatly arranging and identifying parts for ease of use
Seiso	Cleanliness	Shine	Clean the work area by conducting a cleanup campaign
Seiketsu	Standardize	Standardize	Schedule regular cleaning and maintenance by conducting seiri, seiton daily
Shitsuke	Discipline	Sustain	Make 5S a way of life by forming the habit of always following the first 4 S

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The literature highlights about 5-S and that an implementation of 5-S will enhance organizational efficiencies and improve overall performance of workers in the workplace. Sii (2004) also mentions that 5-S is a fusion of art and science of suiting or fitting the working areas to the employees. It is a method which is utilised for cultivating, maintaining and establishing a quality working environment in an organization. 5S actually originates from the acronym of five Japanese words seiri; seiton; seiso; seiketsu; and shitsuke. By translating into English, seiri means sort; seiton means straighten; seiso means shine; seiketsu means standardize and shitsuke means sustain (Agrahari et al, 2015).

E. Ergonomics in the Workplace

Sii (2004) explains that ergonomics is the study and design of working environments such as machinery control rooms, process design, plant layout and their components, work practices and work procedures for the benefit of the worker`s efficiency, effectiveness, health, comfort and safety. Cormick and Saunders (1993) states that "Ergonomics applies information about human behaviour, abilities and limitations and other characteristics to the design of tools, machines, tasks, jobs and environments for productive, safe, comfortable and effective human use." According to International Ergonomics Association (2015), ergonomics or human factors is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

Ergonomics applies information about human behavior, abilities and limitations and other characteristics to the design of jobs, tools, machines, tasks, and environments for productive, safe, comfortable and effective human use. The goal for the design of workplaces is to design for as many people as possible and to have an understanding of the Ergonomic principles of posture and movement which play a central role in the provision of a safe, healthy and comfortable work environment

Health and Safety Executive (2013) has briefly discussed a range of factors that need to be taken into consideration to assess ergonomics or human factors at work. The factors include: the job or task being completed; the physical and psychological characteristics of an individual; and the social environment and organisation.

Fernandez (1995) has outlined the advantages of applying ergonomic principles in the workplace, including its compliance with the Occupational Safety and Health Administration (OSHA) standards; productivity is increased; health and safety of workers is improved; job satisfaction is improved; work quality is enhanced; workers` morale is improved; worker turnover rate is decreased; lost time at work is reduced; workers` compensation claims are lowered; and absenteeism rate is reduced. Ergonomic principles offer possibilities to optimise jobs or tasks in the work area.

F. Time and Motion Study

Time-and-motion study, in the evaluation of industrial performance, analysis of the time spent in going through the different motions of a job or series of jobs. Time-and-motion studies were first instituted in offices and factories in the United States in the early 20th century.

The time and motion study consists of two components – time study by Frederick Taylor and motion study by Frank B. and Lillian M. Gilbreth. Taylor began time studies in the 1880s to determine the duration of particular tasks occurring under specific conditions. The time study was a component of the scientific management theory. Taylor's approach focused on reducing time wastage for maximum efficiency.

Motion study by the Gilbreths evaluated movements and how they can improve work methods. Frank and Lilian Gilbreth pursued the motion study in a bid to expound on scientific management. The Gilbreths included several variables while studying how to increase efficiency. Some of them are health, skills, habits, temperament and nutrition. In the book Gilbreth and Gilbreth, the two experts explain that motion study looks at the fatigue that workers experience then finds ways to eliminate it. They recommended solutions like rest-recovery periods, chairs and workbenches.

Implementation of the scientific management theory was one of the first instances that process improvement and process management were treated as a scientific problem.

Muhamad and Mahmood (2005) highlight that time and motion study can eliminate the unnecessary work and design the most effective as well as suitable methods to specified individuals while performing their tasks. In the authors` point of view, it also offers the methods of how to measure work so that a productivity index for an individual, a group of employees, a department or for an entire organisation can be determined. The study conducted by the authors concludes that implementation of time and motion study can enhance or increase productivity, quality improvement, job efficiency and operation time per part is reduced.

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Niebel (1988) states that time and motion study provide actual or real challenges. Industries with capable and competent engineers, industrial relations personnel, business administrators, supervisors with specialised training and psychologists conducting time and motion study methods are able to face the competition or challenges and are better equipped to perform effectively and profitably.
Bon and Daim (2010) stress that time and motion study is a method to determine the actual time required to complete a task. The author also highlights that by stating the time standard for the manpower process, the production rate in a rice-based company in Sabah has increased and the cost has been reduced at the same time. This case supports the view that time and motion study can be applied in an agricultural-based industry in order to improve productivity with less time needed and with a lower cost of production.

III. RESEARCH FRAMEWORK AND METHODOLOGY

2K5S is a noble operational framework designed by the researchers with the purpose of providing a practical approach for continuous improvement for operational processes. 2K stands for Kaizen and Kaikaku and 5S stands for Japanese 5S housekeeping principles. Therefore, 2K5S is an integration of Kaizen, Kaikaku and 5S concept, which is to be implemented in a series of case studies conducted in a pineapple farm. The farm is located in the central region of Sarawak, Malaysia. The main objective is to explore into the practicality and effectiveness of applying 2K5S to an agriculture-based organisation. In this paper, various tools and methods such as direct observation method, time-motion study and ergonomics study are employed to determine the effectiveness of implementing 2K5S in a pineapple farm. The aspect of ergonomics in the workplace is taken into consideration such as the level of occupational health and safety of workers will be identified and assessed based on the guidelines regarding the ergonomics risk assessment provided by Department of Occupational Safety and Health (DOSH, 2017). The proposed 2K5S operational framework model will be used as the basic framework of this research study. Figure 3 illustrates the proposed 2K5S operational framework model.

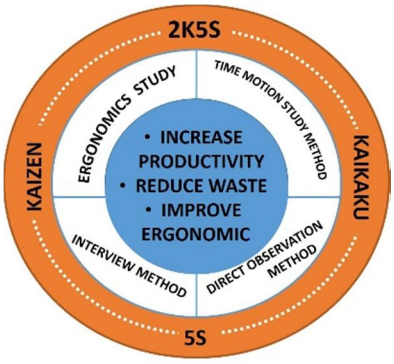

Figure 3: Proposed 2K5S Operational Framework Model

In the early part of the study, a series of site visit to the collaborator's farm is conducted to identify the existing problems encountered and the waste generated in the farm operations. Case study method is employed in this study through observation or direct observation of the working process and structured personal interviews with the management personnel and employees in the farm. Questionnaires are also distributed to the management team and employees to understand their awareness of quality and productivity. This step is helpful to the researchers in identifying the problems in the farm operations and looking for opportunities for improvement.
After identifying the operational short-comings and their related possible causes, a few sessions of in-house training concerning quality and productivity are provided to the operators and supervisors. Then the project of implementation of 2K5S operational framework to the farm operations is communicated among the operators and supervisors with the full support from the top management. The techniques or tools such as time and motion study method, and ergonomics in the workplace are also introduced to the workforce. The workers and supervisors are equipped with the knowledge in ergonomics principles in the workplace through in-house workshop. For time and motion study method, a stopwatch is used. These suggested techniques are essential in providing measurement of the operational performance, which are crucial in suggesting potential solutions to overcome the existing problem.
After implementing 2K5S to the farm operations, the results in term of organization performance such as productivity, waste elimination will be assessed or evaluated. This is to determine whether 2K5S operational framework can be fully utilised in improving the productivity in the field of agricultural sectors.

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A. Case Study Method

Yin (2009) has defined case study as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. Several methods and tools which are frequently used to gather data from a number of units by a direct observer can be utilized to conduct case study. The data collection result will not be influenced by any experimental control or manipulations (Meredith, 1988).

The case study can be conducted either in a qualitative or quantitative approach. The purpose is to fully understand the phenomenon that has been studied in a real-life situation, in which the research is the implementation and assessment of the 2K5S operational framework in a pineapple farm. Besides, it is crucial to ensure that the accumulation of multiple entities as supporting evidences to make sure that the data gathered are correct and trustable (Meredith, 1988). Thus, observation and personal interviews methods are required to carry out in order to ensure the validity and truthfulness of data obtained.

According to Meredith (1988), the case study method has several disadvantages, for instance, the requirements that are required to carry out the method such as the time usage, cost, access to information obstacles and the need for utilising several methods and entities for surveying. Hence, these disadvantages must be considered before carrying out the observation study and personal interview.

B. Observation/Direct Observation Method

Robson (2002) has defined observation as a natural and obvious technique to examine the real-world context. Effectiveness is the major benefit of direct observation as the only requirement is to observe and listen with no questions are required when carrying out observation. Nevertheless, the researcher needs to be concerned about the risk of interpreting a condition or situation in the wrong manner. Observation method can be supportive in complementing and setting data in perspective. The evidence that obtained via observation method is often useful in providing additional information (Yin, 2009). In this research project, direct observation method is favourably preferred especially during conducting personal interviews. This is because direct observation is used to analyse and substantiate or justify the interviews. Impressions and insights of the interviewee during the interviews will only be captured directly by observation on the spot. Furthermore, the observation obtained contributes towards a deeper understanding to the research study particularly when visiting the collaborator's farm, the existing or current problems present in the farm can be identified through observation. The researcher should observe the overall working process in the farm and it is necessary to record every detail from the beginning until the end of the operational processes based on direct observation.

C. Stopwatch Time Study

Stopwatch time study is also required during direct observation since the function of stopwatch is to measure work. Bon and Daim (2010) points out that time study using stopwatch can determine the policy guidance for future improvements. In addition, this method is used to analyse the efficiency and effectiveness of qualified workers in carrying out specific task in terms of time. It also measures the time needed to complete the work process (Bon and Daim, 2010).

D. Interviews Method

Interviews are widely utilized as a research method (Robson, 2011). There are three categories of interviews which are structured, semi-structured and unstructured. In this research, a structured personal interview method is more preferable than others in order to obtain more in-depth answers from the interviewee or respondents. Otterlei and Myrold (2012) claim that the advantages of using structured personal interview are that the reactions that respondents might have can be observed by the interviewer and also the respondents can be convinced by the interviewer to answer all the questions. This further secures that the respondents are able to understand the questions and thus misunderstandings can be avoided throughout the structured personal interview session.

E. Ergonomic Hazards

Hamid et al. (2018) stated that an ergonomic hazard is a physical factor within the working environment that give harmful effect to the musculoskeletal system which include repetitive movement, manual handling, workplace layout design, poor body posture and uncomfortable workstation height. Ergonomic issues also relate to the equipment or tools used, noise, lighting and workspaces. The researcher concerns on these ergonomic issues among the workers in the companies under study as the past studies indicated that work performance and productivity of the employees will decrease if they suffer from ergonomic health risk. Hence, the researcher suggests to consider ergonomics principle in the workplace as one of the main components included in 2K5S Operational Framework.

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The researcher plans to conduct interview with the workers of the agricultural farm in order to investigate the ergonomics hazards within the workplace. The initial ergonomics risk assessment (ERA) sheet will be prepared based on the guidelines provided by Department of Occupational Safety and Health Malaysia (2017) and distributed to the workers during interview session. All the results obtained will be tabulated and discussed. The appropriate ways proposed to solve the ergonomics hazards within the work place will be outlined as well once the interview is conducted.

F. Problems Identified

Every kaizen program proposed is aimed to save cost and reduce waste found within the organisation. There are a few problems identified during a series of site visit to the pineapple farm in the early phase of this study. Four main operational problems that significantly challenged the farm's operational viability are discussed here.

1) *Weeding*: One of the most common problems found is weeding as shown in Figure 4. Weeding has to be carried out manually as mechanical aim will cause damage to the pineapple plants which are cultivated close to each other. Using of herbicide is avoided as it is not environmental-friendly and herbicide can cause damage to the leaves of the plant too. Moreover, weeding has to be done frequently which is at least once every two months. It takes a worker at least ten days to complete an acre of land. A worker`s daily wage is RM50. Every round of weeding requires RM500 per worker. Meanwhile, pineapples require 10 months to flowering which indicates that it needs five rounds of weeding. Thus, the labour cost to do weeding is RM2500/acre.

Figure 4: Growth of weeds around pineapples

Figure 5: Poor drainage system

2) *Drainage:* Pineapple is highly sensitive to water stagnation and high moisture content in the planting bed. Thus, it is vital to provide a good drainage system. According to the data retrieved from Department of Drainage and Irrigation Sarawak, Sibu has a high average rainfall days per year. The highest rainfall days is about 20 days and the least is about 12 days in a month. Therefore, the humidity level is always high and water stagnation is hard to prevent especially in peat soil region. Based on the initial observation made by the researcher during site visits, there is poor drainage along every row of pineapple plant cultivated as shown in Figure 5. This would greatly slow down the growth of the crops and hence the productivity of the pineapple crop is seriously jeopardized.
3) *Land Preparation for Pineapple Farming:* Before planting, the weeds, pebbles and unwanted material should be removed from the planting field. The land is ploughed before planting followed by levelling. The land should be ploughed several times as the soil attains fine tilth and also smooth texture. After ploughing and levelling, the planting holes are prepared and each planting hole should be about 15 to 25 cm deep. All the above jobs are done manually before introducing 2K5S approach. There are several operational constraints observed by the researcher. The main constraints are time consuming and labour intensive. For instance, it takes two labours one month to complete all the tasks required for one acre of planting ground. For the labour cost of RM50 per person per day, it costs about RM3000 per month. Since the work done by labour manually, the planting field is not uniformly ploughed. The levelling is also difficult to reach optimum level to provide good drainage capacity as no planting bed in prepared.
4) *Planting of Pineapple Manually:* The researchers observed that to plant one pineapple would take a worker five minutes which include to dig a planting hole of around 15 to 25cm depth with a stick, then place the sucker in the planting hole and backfill the hole with soil. Since the plants of pineapple have shallow roots, the roots are prone to the lodging. If plants get lodged during the development of fruit, then it will result the uneven fruit development and also the irregular growth.

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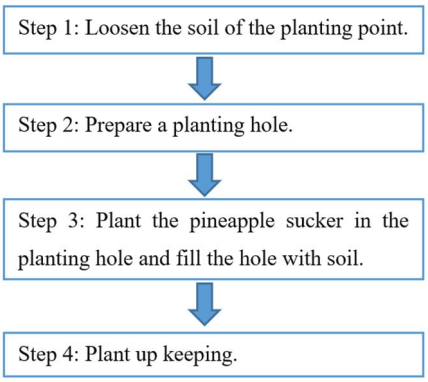

Figure 6: Planting pineapple process

G. Proposed 2K5S Approaches

In order to solve the problem identified in the farm operations, the novel 2K5S Operational Framework is implemented to improve the farm operational processes. The project of implementation of 2K5S is carried out in a few stages with specific programs over a period of 1 year (due to the outspread of Covid-19, the whole exercise took more than one and hail year to complete).

2K5S Program 1: The first 2K5S program proposed is to apply Kaizen approach in introducing one small step of improvement at one time. In this kaizen program the use of planting bed with drainage on both side of the bed is introduced. In addition, PVC sheet is also introduced to cover the top of the planting bed before planting. This is to prevent weed from growing on the bed and save the labour cost for weeding throughout the pineapple life cycle. The cost of PVC sheet is estimated RM400 for an acre of land and this can reduce 84% of the labour cost needed in carrying out weeding which incurred RM2500/acre. Figure 7 shows the illustration of the planting bed with drainage and PVC sheets.

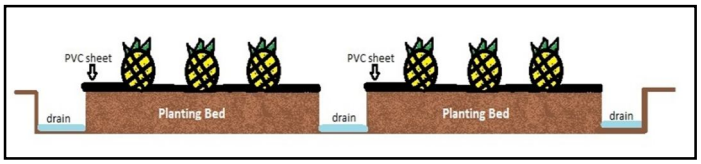

Figure 7: Illustration of the planting bed with drainage and PVC sheets

There are multiple advantages observed through this kaizen program used in 2K5S approach. No weeding and application of herbicide are needed throughout the whole farm; good drainage system developed to ensure healthier growth of the pineapple crops and also provide convenient way of application of fertilizer by using PVC tubes. These positive outcomes not only improve the productivity of the operations, they enhanced the quality of the crop and they are all environmentally friendly too.

2K5S Program 2: The second 2K5S program proposed is to apply Kaikaku concept in introducing intermediate improvement in term of utilizing a new technology to the current operations. The main objective of this program is to improve land preparation, especially improvement of soil quality of the planting beds because this new approach will ensure that soil on the planting beds is thoroughly and evenly ploughed. This will provide adequate oxygen to the roots of pineapple suckers and also prevent access water from being locked up in the planting beds. Since the planting ground is not ploughed uniformly as it is carried out by labour manually before. The use of a Kubota, a mini farm excavator under Kaikaku program provides an incremental innovative structural change to the overall operational practice. By using a Kubota mini farm excavator, it takes ten days to complete the jobs mentioned earlier including preparation of planting beds and drainage at the same time. Consequently, the time and labour cost needed for land preparation as well as pre-planting preparation would be greatly reduced. This provided a leap to the operations.

2K5S Program 3: The third 2K5S program proposed is to introduce kaizen and 5S principles to improve the planting performance of workers qualitatively and quantitatively and reduce the worker`s tiredness which may decrease the work performance and at the same time to improve workers' occupational health and safety level. A new worker deployment for planting is proposed. Two workers for planting instead of one as more hand make the work lighter and faster. One worker is assigned to prepare planting holes while another worker is assigned to put the pineapple sucker into the planting holes and backfill them with soil. This is to ensure good anchorage obtained and it takes less than two minutes to plant one pineapple. Moreover, based on the ergonomics principles in the workplace, the workers` frequency of kneeling down and stand up is greatly reduced and hence this will significantly reduce the chance of injuries to the workers` back and knee. Their work performance is thus believed to be enhanced.

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IV. RESULTS AND DISCUSSION

Case studies are conducted based on one acre of pineapple farming operations. Before the initiation of this research study, pineapple plants are planted directly on the ground without planting beds and proper drainage provided. In this study, the new planting pattern is designed in such a way that there are 38 rows of planting bed in one acre of farmland and each planting row accommodates 320 plants.

Two scenarios are designed for on-site case study purpose. Scenario 1: Before implementation of 2K5S methods and Scenario 2: After implementation of 2K5S.

The farming tasks are broken down into work elements for ease of monitoring and data measurement. The workers` performance is rated based on the rating factor in which the researcher compares the performance of workers under observation to the Normal Performance. The average time, cycle time, normal time (Nt) and standard time (St) are computed based on the formula listed below. A stopwatch is used to record time taken to complete each task for each scenario. All the on-site data is collected and recorded for further evaluation.

Time and motion study method is used to identify the best sequence of motions for maximizing efficiency and productivity. The data collected before and after the implementation of 2K5S approaches will be compared and analysed to validate the effectiveness of the 2K5S approaches in the agriculture field particularly pineapple farming. The following formulas are applied in the calculation of the data collected. The formulas used are retrieved from the book "Motion and Time Study Improving Productivity". Marvin, E and David, L (1994) stress that the standard time is validated by comparing with the standard for similar jobs, evaluating the credibility of the ratings subjectively as well as monitoring the work performance against the standard.

Formulas:

$$\text{Rating Factor (RF)} = \frac{Observed\ Performance}{Normal\ Performance} \quad (1)$$

Normal Time = (elemental average time) (rating factor) or Nt =(t) (RF) (2)

Standard Time = (observed time) (rating factor) + (observed time) (rating factor) (PFD allowance) or St = Nt (1 + PFD allowance) where PFD allowance refers to Personal, Fatigue and Delay allowance (3)

A. Scenario A

In this scenario, the researchers observed and recorded the time required to do each detailed element of the basic pineapple planting operation before implementation of any Kaizen, Kaikaku or 5S approaches. The four basic pineapple planting operational processes is depicted in Figure 8. Then, the pineapple planting operational processes are further broken down into nine work elements as shown in Table 1.

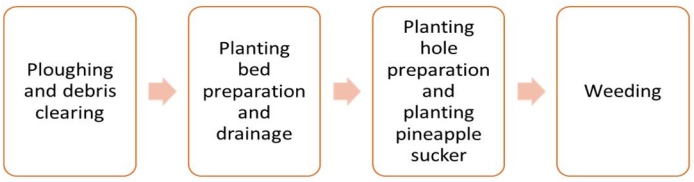

Figure 8: Flow chart for basic pineapple operational processes

Table 1: Scenario 1: Work Elements of Pineapple Planting Operation before Implementation of 2K5S Approaches

Operational Process	Work Element(s)
(1) Ploughing and debris clearing	Element A: Ploughing process Element B: Debris clearing
(2) Planting bed preparation and drainage	Element C: Heap up the soil Element D: Make drainage
(3) Planting hole preparation and planting pineapple sucker	Element E: Dig hole Element F: Put pineapple sucker into the hole Element G: Backfill the soil
(4) Weeding	Element H: Hand pulling Element I: Using sickle to cut weed

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Furthermore, time and motion study is a sampling process, thus large number of readings would be taken so that the results will be representative of the operation being measured and higher accuracy may be obtained. Experience have shown that 95% confidence level and ± 5% accuracy is sufficient for the study. From engineering statistics, for this situation, number of cycles to be timed can be found by using the following formula (Marvin, E and David, L, 1994):

$$N` = \{\frac{40N\sqrt{\frac{N\Sigma X^2-(\Sigma X)^2}{N(N-1)}}}{\Sigma X}\}^2 \quad (4)$$

N`=Required number of observations to predict the operation time within 95% confidence level and ± 5% accuracy.
X=Each stopwatch reading
ΣX =Summation of individual readings
ΣX^2 = Summation of Squares of each reading
The data is collected for ten cycles with different number of workers involved. Time taken to complete each work element is recorded and the normal time as well as the standard time are calculated and tabulated. Rating factor and PFD allowance are determined after discussion between the management team of the company under study with the reference to Westinghouse rating factor and allowance factor systems (Barnes,1977). For this case study, PFD allowance is set as 30% as the workers are required to work under sun and rain for eight hours per day. Table 2 shows the results of normal time, standard time and number of cycles required for one worker involved. The number of cycles obtained for each work element is in between two to eight cycles. Hence, taking ten sets of data is considered precise and appropriate for this case study. Table 3 indicates the results of calculated normal time and standard time to complete one planting operation under different number of workers involved. From the results obtained, the normal time and standard time are both greatly decreased with the number of workers increased in each particular work element.

Table 2: Results of Calculated Normal Time, Standard Time and Number of Cycle for One Worker

Element	Average Time (min)	Rating factor	Normal Time (min)	Standard time (min)	No of cycle
A	219	1.04	228	296	2
B	140	1.17	163	212	2
C	127	1.06	134	174	2
D	136	1.13	154	200	2
E	132	1.10	145	188	3
F	129	1.08	139	181	3
G	118	0.98	115	150	2
H	185	1.03	190	247	2
I	157	1.05	165	214	8

Table 3: Results of Normal and Standard Time Required to Complete Whole Planting Process before 2K5S

	Before implementation of 2K5S	
Condition	Nt (min)	St(min)
One worker involved	1433	1863
Two workers involved	733	953
Three workers involved	498	648

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B. Scenario B

In this scenario, the outcomes of implementing 2K5S operational framework are observed and highlighted. In order to implement 2K5S to the farm operations, the operational processes are redesigned and each process is further broken down into new work elements to ensure each work element is standardized. Work elements for each operational process before and after implementing 2K5S is depicted in Table 4. According to the results obtained after implementing 2K5S approaches, the standard time required to complete one cycle of planting process is reduced approximately 62.5% which means that the overall productivity and the workers` performance are enhanced. Figure 9 shows the comparison of standard time required before and after implementation of 2K5S.

Table 4: Work Elements of Pineapple Planting Process Before & After Implementing 2K5S

Operational Process	Work Element(s)	
	Before 2K5S	After 2K5S
(1) Ploughing and debris clearing	Element A: Ploughing process Element B: Debris clearing	Element A2: Use Kubota Mini Farm Excavator to complete Operational process 1
(2) Preparation of planting beds and drainage	Element C: Heap up the soil Element D: Make drainage	Element B2: Use Kubota Mini Farm Excavator to complete Operational process 2
(3) Preparation of planting hole and planting pineapple sucker	Element E: Dig hole Element F: Put pineapple sucker into the hole Element G: Backfill the soil	Element C2: Put PVC sheet Element D2: Use hole puncher to make hole on the PVC sheet Element E2: Put pineapple sucker into the hole Element F2: Backfill the soil
(4) Weeding & farm upkeeping	Element H: Hand pulling Element I: Using sickle to cut weed	No weeding required as placement of PVC sheet inhibits the growth of weed.

Table 5: Results of Normal and Standard Time Required to Complete Whole Planting Process after Implementing 2K5S

	After implementation of 2K5S	
Condition	Nt (min)	St(min)
One worker involved	360	468
Two workers involved	244	316
Three workers involved	188	243

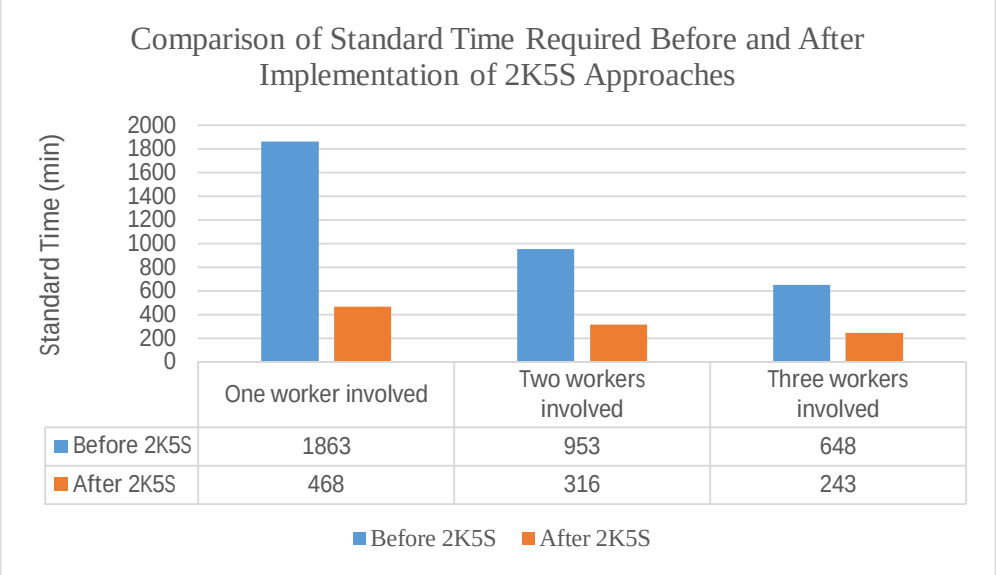

Figure 9: Comparison of Standard Time Required Before and After Implementation of 2K5S Approaches.

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Figure 10: Use of Kubota mini farm excavator

Figure 11: Modified planting beds after 2K5S

V. CONCLUSION

2K5S is a novel operational quality and productivity enhancement framework, an integration of Kaizen, Kaikaku and 5S principles adopted from Japanese manufacturing and quality management, is equally practical and effective to be applied in agricultural sectors. The most important findings discovered from this research study are that improvements in workers' productivity, effectiveness in completing tasks, improved in occupational health and safety as well as reduce wastes generation. The results indicate that 2K5S operational framework can be a powerful approach used for continuous improvements in terms of operational productivity and quality of an agricultural organisation. An integration of kaizen, kaikaku and 5S principles used in 2K5S approaches is a synthesis of continuous improvement in small steps, an introduction of a new technology or method with intermediate capital investment and Japanese 5S housekeeping solutions, in the end with big result. Do it at the farming site, technical issues or other operational related issues but with the full participation of employees from each level starting from the farm operators to the top management. Other tools or techniques used in quality and productivity in manufacturing sectors for operational enhancement could possibly be applicable to agricultural sector too.

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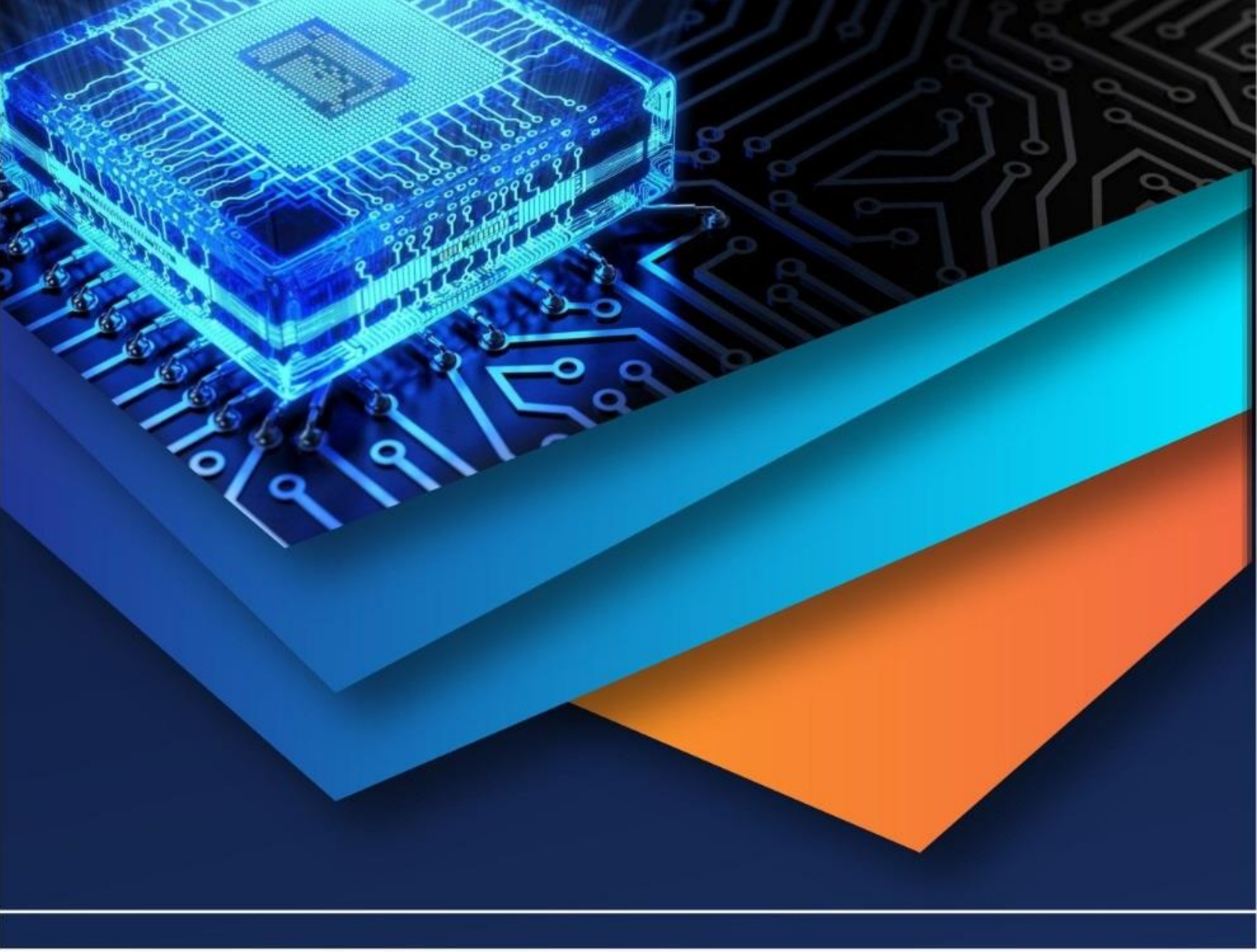

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