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Systematic Literature Review on Evaluation of Quality Management Practices in Palm Oil Supply Chain: The Case of Upstream

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Abstract. Malaysia and Indonesia are classified among the world’s leading producers and exporters of palm oil. In previous findings, the palm oil industry is linked together from upstream to downstream and consists of four sub-sectors which are growers, millers, refiners, and oleo chemicals. There are various quality management practices that are currently being implemented in palm oil industry. This research attempts to identify the current quality management practices in palm oil upstream supply chain and to develop an instrument to produce quality palm oil in upstream sector. This paper presents a systematic review on quality management practices in upstream sector and the final selection comprehends 32 articles selected and comprehensively analyzed to assess quality management practices in upstream processes of palm oil supply chain. This study adds value to the current knowledge by extending organizational readiness theories. This study is relevant, practical, and useful to both practitioners and academics by providing a holistic implementation roadmap for the upstream chain to guide the managers to implement quality management practices at the organisational level.

1. Introduction
Palm oil industry are linked to each other from upstream to downstream and consists of four sub-sectors which are growers, millers, refiners, and oleo chemicals [1]. Upstream industry consists of growers sector who is involved in the cultivation of oil palm such as smallholders and large plantations. The activity involved at this stage includes nursery establishment, planting of oil palm trees and production of fresh fruit bunches (FFB). The trees will bear fruit after 3 years and able to give productivity up to 25 years and it produce continuously, where the fruit bunches will be harvested every few weeks. The fresh fruit bunches (FFB) will then be taken to mill, where oil will be extracted with pressure and steam that produces Crude Palm Oil (CPO) and also Palm Kernel Oil (PKO) [2]. Midstream involve the millers alone.

Whereas for downstream industry, it consists of oleochemicals and refiners sectors such as palm kernel crushers, palm oil refiners, palm-based edible products manufacturers, specialty fats producers and oleochemical producers [1]. The extracted oil is taken from the mill to refineries to be refined into primary palm oil fractions such as stearin and olein [2]. The refined oil are then transported to downstream ingredients manufacturers of consumers goods who might further process it into more complex fractions which then be sold to retailers or consumers.
Hence, in order for these firms to operate efficiently along their supply chain, they need a better approach in their supply chain management (SCM). Figure 1 illustrates the value chain in this industry.

![Figure 1. Process Flow of Oil Palm Upstream Sector](image)

Based on above supply chain provided by [3], activities exist at upstream sectors that mainly affects the palm oil is planting, harvesting, loading and delivery to the mill and after received at mill it undergoes sterilization, threshing and stripping of fruitlets and finally extracted to produce crude palm oil (CPO) and palm kernel oil (PKO). According to [4], the main practice that is being referred by organizations involved in Palm Oil Supply Chain is the Codes of Practice for the Oil Palm Supply Chain (COPS). This is due to ensure that Sustainable Palm Oil is produced to meet requirement of quality palm oil, environmental protection and food safety [5].

The main objective of this research is to propose a research framework to investigate quality management practices for upstream supply chain in the palm oil industry. The scope of the study will only review the literature. The paper investigates the constructs of quality management practices for upstream chain in palm oil industry. The rest of the paper is organized as follows. The subsequent section summarized related literature, which is followed by the proposed framework to investigate key quality management practices in palm oil industry. Next, the research methodology been discussed. The final section presents the conclusion and the further study.
2. Methodology
This research is an exploratory in nature. Thus, it can be inferred that this study is a revelatory to the understanding of a phenomenon or problem. The method being used in this research is Systematic Literature Review (SLR). A systematic literature review is a method involving identify, evaluate and interpret all available research which is relevant to a particular research question, topic area, or situation of interest. Systematic review is a method of literature review which adopt a series of steps to ensure the appropriate transparency is brought in the process of analyzing lots of paper. It suggests that there are four phases needed to prove this research is relevant which is: planning, sampling, analysis and reporting [6].

The quality of a journal is reflected by its indexation value. Compared to non-indexed journals, indexed journals are considered to have higher scientific quality. Many popular indexation services have been developed over the past few years. These include Google Scholar, Science direct, SCOPUS, Scimago and much more database. There are many article databases containing millions of journals with various ratings so to ensure that only relevant journals were used in this paper, the journal’s index used as references is checked through these indexation service provider.

Indexing helps the journal to achieve its main purpose of being accessible to a wide audience. A journal’s reputation will be improved and referred as a reliable source of high quality information in one’s field if it widely accessible. Searching through database is the first activity researchers will do as part of their research process, and mainly they will look forward to retrieve it from established and well-known databases. Thus, being indexed in a popular database in a particular field will help increase a journal’s readership.

Jorge Hirsch proposed a research performance indicator known as The Hirsch index, or h index. Hirsch’s index is an original and simple new measure that incorporates both quantity and visibility of publications [7]. According to [8], an h index of 20 after 20 years of scientific activity indicates a successful scientist, an h index of 40 after 20 years of scientific activity indicates outstanding scientists, likely to be found only at the top universities or major research laboratories, and an h index of 60 after 20 years, or 90 after 30 years characterizes truly unique individuals.

Building a search string by determining identifying the keywords is the first search strategy for SLR. It is the most important step as the database will determines which papers to be retrieved just by using the keywords. Following relevant works in the field of oil palm upstream [3], six key processes were selected for this review. Hence, the author considered the oil palm upstream process consists of nursery, land clearing and preparation, planting, harvesting, loading and delivery to mill.

![Figure 2. SLR Articles Screening Process](image_url)
The sources were identified from various databases and a number of 472 articles were retrieved. The criteria is further screened by removing duplicate articles which reduces the number of articles into 390. After title screening, the articles were further narrowed to 233 and further narrowed into 150 after the abstract were screened. This number includes articles discussing about QMP, SCM, GAP, and other main practices and management system exists in the oil palm upstream supply chain area. Figure 2 shows the flow of article screening process that were being conducted.

Non-indexed journals are also used as one of the information sources relates to literature published in journals that are not being indexed on major bibliographic databases such as SCOPUS, Google Scholar and Science direct. Non-indexed journals were not being used as primary source in this research as it is only being used as side-reference to support the primary data from indexed articles.

3. Results

Oil palm involves a lot of process in its supply chain and to assess its quality management practices, each process that directly leads to the formation of the palm oil itself needs to be identified. This process were identified by reading journals, SOP’s of big companies and Codes of Agricultural Practices (MPOB).

From extensive readings of past papers, it can be observed that there are only a limited number of journals about management of oil palm upstream activities that were found relevant with this study. In addition, there are very limited number of journals exists regarding quality management in palm oil upstream process.

Other findings is that even if there are good quality journals, lots of them are outdated and thus it needs to be excluded from this research’s journal database management system. After screening of journals, the data were then critically analysed to extract only good management practices to be taken as a criteria, and from those criteria a checklist of upstream process in palm oil supply chain.

From the literature review, the process involved in oil palm upstream supply chain were simplified as in Figure 3. Those process were the main activity that were operating daily in an estate. The process begins with nursery establishment as the seedlings were grown in this process. Land clearing, land preparation and planting also linked to nursery where it involves only during replanting process after oil palm reach economics life of 25 years. Other operations were conducted daily from these main operations, there are sub-activity exists which contributes direct and indirect effects towards the product of oil palm which is the FFB itself.

Table 1 lists all the articles reviewed which were relevant with each sub-process involved in the oil palm upstream process. Some of the articles explain about more than one process in the oil palm upstream activity.
Table 1. Articles Review

| Articles Theme                  | Source                      |
|--------------------------------|-----------------------------|
| FFB post-harvest handling      | [9, 10]                     |
| Transport of FFB               | [11, 12]                    |
| FFB characteristics            | [13, 14, 15, 16]            |
| FFB quality assessment         | [17, 18, 19, 20, 21]        |
| FFB ripeness assessment        | [22, 23, 24]                |
| Harvesting round management    | [25, 26]                    |
| Weed management                | [27, 28]                    |
| Fertilizer management          | [29, 30, 31, 32, 33]        |
| Planting material              | [34, 35]                    |
| Land selection                 | [36, 37, 38]                |

3.1. FFB post-harvest handling

According to [40], first process to be supervised is the post harvesting handling where harvester should handle the oil palm FFB with care after the FFB being harvested because the FFB could easily become damaged and bruised if it is not handled properly. All FFB and LF were collected from the palm base should be delivered free from any contamination of ground debris and stones to the collection points at the road side with minimum damage, delay, contamination and being sent to the mill together with harvested bunches. In other study by [9], in order to resist quality reduction it is recommended that FFB should be handled carefully. High impact when dropping and throwing the fruit by the harvester and fruit loader should be avoided. Meanwhile, the fruit collector and transporter should try to reduce the friction and bump among the fruit.

3.2. Transport of FFB

A study by [11] suggest that to reduce bruising during transportation of FFB to mill is by taking sterilizer cages to the field for immediate sterilisation process. For process of transport of FFB to the mill, harvested bunches should be transported by lorry, tractor-drawn trailers or rail cages. According to [12], they also states that the FFB and LF should be sent to the mill preferably within 24 hours after harvesting. Transport should be arranged in such a way that the FFB do not become contaminated with undesirable substances and quality is preserved. The general requirement is that the compartments should be dedicated to FFB, free from previous load residues, free from odour of previous loads, mineral oil and is dry. This should be checked before each consignment. The result of the cleaning actions should be checked visually and recorded. Another aspect to be prevented during transport is the penetration of rainwater and splash water. Even if the load compartments are empty, it needs to be covered in order to prevent rain penetration and contamination from bird droppings. In case of road transport, the outside of the means of transport including the chassis should be free from visible traces of previous cargoes [12].

3.3. FFB characteristics

A study by [13] states that a ripe FFB should have an OER higher than 21% and the FFA content less than 5%. The OC and FFA level are determined through analysis at the chemical laboratory [13]. The FFA level determines the quality of palm oil, because high presence of FFA leads to production of poor quality of oil [17]. The temperature and moisture content influences FFB physical and mechanical properties [39]. Previous studies also shows that the FFA content and oil quality will slowly be reduced if there was no immediate heating step taken [15]. A study was also found that a damaged FFB causes the lipase enzymes to be rapidly hydrolysed, contamination of FFB by microorganisms and FFA development on the FFB [16].
3.4. FFB quality assessment
According to [17], the FFB quality can be determined by it ripeness, FFA and OC level. To ensure quality FFB is graded physically right before it passes through process of oil extraction and current FFB quality assessment is very time consuming and prone to errors and inconsistencies [18].

The storage time of damaged oil palm fruits is also a major problem that could activate the lipase enzymes and eventually reduce the oil quality where a study proves that the length of the storage periods showed significant correlation with the FFA release rate within a 2 hour storage period [40].

3.5. FFB ripeness assessment
In practice, manual ripeness assessment is carried out by visual inspection [17]. The FFB colour varies from very dark purple for unripe to orange for ripe bunch. To harvest, the bunch ripeness needs to be analysed first. To determine the ripeness of bunch on a tree, observing the number of loose fruits on the ground is one of the method [24]. Another way to determine the ripeness is based on observing different colour intensities of FFB by referring to the colour ripening index. Using this index, a ripe bunch could be differentiated from other FFB categories such as the black bunches, under ripe bunches, empty bunches and rotten bunches. According to indicator used, purplish black indicates an unripe bunches, reddish black indicates an under ripe bunches, red indicates a ripe bunches, and reddish orange indicates an overripe bunches. Another method available to determine the ripeness according to [41] is by measuring the fruit firmness using penetrometer based on colour, shape and feature. Other than that, measuring level of chemical type and parameters are also related to ripeness such as spectral image analysis and pH value.

3.6. Harvesting round management
According to study by [26], Plantations Company usually have harvesting round of 7-day, 10-day or 14-day interval while smallholders usually having harvesting intervals of 14 or 15-day sometimes up to 30 days. Having a shorter period of harvesting interval is important as they proved that the yield increase at 5–20% when reducing length of harvesting round from 14 to 10 days. Another study by [25] that were more focused on smallholders further proven the above research findings where it shows that harvesting once a month predicted the lowest yields in smallholder oil palm plantations. They find that short harvesting intervals around 7–10 days helps to improve fresh fruit bunch productivity of oil palm crops.

3.7. Weed management
Based on study by [28], weeds affect crop production and the importance of managing weeds is usually ignored by farmers and government officials. The effects of weeds on oil palm are difficult to be expressed due to their long economic life up to 20-30 years. The researchers reported that because of strong competition from weeds, yield losses in oil palm plantations are up 6% to 20%. Oil palm growers normally assume that weeds can easily be controlled by herbicides or mechanically. This misinterpretation prevents effective weed management. Overall, chemical control has been widely used as a weed management tool for oil palm sectors. There have been issues where the application of herbicide mainly affects the main crop being grown which is the oil palm itself. A findings from [27] proved the issue to be wrong based on their research data regarding the FFB amount per plant and the number of fronds for each plant. The results shows that as long as the herbicides used in the research such as glufosinate ammonium, paraquat, and glyphosate were not sprayed directly at the plant, they had no adverse effect on the vegetative growth of the oil palm.

3.8. Fertilizer management
A study by [29] states that the fertilizer input on oil palm is very much needed to sustain high yields and usually contributes to 40–65% of total upkeep costs of the field. For a duration of 25 years, fertilizer management within a plantation requires an annual plan for 25–30 hectare of each block. A specific fertilizer sequence is received by each block and each were different from the others. On a
multiannual period, blocks may receive only mineral fertilizers, only organic fertilizers or they receive both mineral and organic fertilizer but alternately or known as mixed fertilizer sequence. Based on study by [33], N, P and K nutrient elements is one of the main factor that affect in oil palm seedlings and also mature palm growth and development that resulted from better nutrient management. Fertilizer application practice were conducted to ensure the growing plant get all the required nutrients for optimum growth. The most important nutrient element in terms of plant growth, carbohydrate content and physiology is Nitrogen [30]. Phosphorus is the second most important nutrient for plants that are needed for energy transfer and storage and low availability of phosphorus is a limiting factor to plant growth [31]. Potassium is the third important nutrient that needed for maintaining osmotic balance, phloem transport, and photosynthesis [32].

3.9. Planting material
Current issue arising is the yields of oil palm reached a stagnant level due to unimproved planting materials being used in the field [34]. They suggest that to improve productivity, generation of superior populations is much needed. This is vital to develop an elite planting material to be used for breeding purposes and as potential genetic resource. However, we need to estimate heritability among the fresh fruit bunch yield traits of different breeding populations because high heritability estimates resulting high genetic advance for FFB yield. At the end of the process of choosing a right planting material, the number of bunches (BN) and average bunch weight (ABW), is a major outcome that will be gained [35].

3.10. Land selection
To start an oil palm plantations it is good to begin with the selection of appropriate land or soil, to determine the land potential that can be developed to obtain the proper management of oil palm fruit productivity [36]. Oil palm can grow, develop and produce as expected when the available soil water is even and sufficient with areas of rainfall 2000-2500 m / year and dry months less than one month per year [38]. The temperature should be around 22°C to 33 °C with relative humidity more than 85% [37].
Based on the results obtained (Figure 4), the sector with the highest number of articles is fertilizer management and FFB quality assessment. This might due to the importance and direct effect of such factors towards the oil palm quality itself.

4. Results
To date, no instruments have been successfully produced and published to the public to assist oil palm growers to track down their quality management practices. So the best way to solve this problem is to produce such instrument and this paper had systematically reviewed past papers, extract key information and use them as a criterion in producing an instrument for assessing quality palm oil in the form of checklists. A checklist a simple standardized list of the required steps developed for a repetitive task to reduce mistakes that might cause its quality to deteriorate. Using checklists helps supervisors to do it right every time, and ensures they did not forget anything throughout the supply chain. Academically, this study proposes the set of constructs for studying quality management practices in palm oil industry. The framework is expected to be investigated in palm oil organisation in Malaysia.

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