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The Application of Lean Six-Sigma in Food Security and Food Safety: A LSS strategy for Small Holder Farmers

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Abstract

Purpose: The purpose of this study is to urge smallholder farmers and regional food production companies of developing nations, with particular focus on SHF's to increase their food production by switching to LSS (Lean Six Sigma) tools to ensure optimal production, improved storage and handling of food quality.

Design: The paper describes outcomes of a rigorous analysis based on the identified common issues with farm management and present an idea of improving the quality of farm management and food security. Tasks include drafting a strategy plan to increase food production and minimize waste by implementing LSS tools, starting from a smallholder farmer level of production.

Methodology: The paper would provide systematic and structured literature review of the analyses of the research findings on Lean six sigma and food security and safety. The approach would be to connect the concept of LSS tools and food security to achieve effective farm management.

Findings: The research model is based on achieving food security based on improved crop storage and production operations by using Six Sigma principles for crop production and post-harvest handling.

Originality and Value: According to a report by ACIAR (Australian center for international agricultural research) in 2014, the world would be required to increase food production by 70% in order to feed the growing population by the year 2050. Developed nations are at primary risk due to their dependency on developing nations for production supply chains. The research findings of this paper will help concerned authorities and individuals in understanding how LSS may be applied to meet global needs of increasing food production. Unlike past works, this paper will provide a review of possible implementation of LSS tools in food security, safety and handling of food quality.

Practical implications: The paper will provide an effective framework to establish a set of tools from Lean Six-Sigma (LSS) that can be used by the smallholder farmers to improve their crop production strategy for increased production. The managers of the small scale food production units can also utilize this framework to switch to Lean Six-Sigma strategy for better food production, storage and handling.

Keywords: Lean Six Sigma, Food security, Food Production, Post-Harvest Handling, Farm management

Introduction

Lean six-sigma is defined as a collection of effective tools and techniques aimed at minimizing the waste generation and establishment of a continuous improvement plan to ensure the consistency of a process. Some of the basic principles of Lean Six Sigma includes performance improvement through data based decision making, conducting effective root cause analyses and implementing plans for control and sustainability for improvement, right at the value creation level (Zhang, Q., Irfan, M., Khattak, M.A.O., Zhu, X. and Hassan, M., 2012). The major underlying concept of Lean six sigma is to identify the value and non-value added steps within a given process. This can be achieved using LSS tool of VSM's (or Value stream mapping) which helps in formation of a basic skeleton of the given process (Pepper, M.P. and Spedding, T.A., 2010). Similarly other tools like DMAIC, 5S, 5 Whys, AD's etc. can be used to identify and fix the different types of issues which are most commonly observed in the poor farm management systems

The paper would take a quick look on the condition of smallholder farmers in Colombia where the issue of farm management and forced child labor has been in practice since long period of time (Rochin, R.I., 1977). This has since resulted in a bigger issue of having food insecurities at both internal and external areas. The internal areas in particular are associated with the food insecurity within the households which has in turn caused food insecurities on external areas as well due to lack of effective farm management system (Burkhardsmeier, B., Rhodes, E., Girard, A.W., Yount, K.M. and Hines, D., 2017).

The objective would be to analyze the field of Lean six sigma and issues with farm management (particularly with food insecurity in Colombia) separately and then using a Venn diagram connect the dots as to what could be the future of adopting more of lean thinking in improving farm management system. The ISO 9001:2000 standard provides an effective quality management system to improve crop production processes and therefore would be used in this paper to obtain certain specific areas where the LSS tools could be applied (ISO, B., 2000. 9001: 2008).

This study would therefore provide an effective framework about effectiveness of the application of LSS tools and techniques for optimal food production, post-harvest handling in order to ensure food safety and food security. This was started by utilization of idea generation methods for design changes in real world. Idea generated through brainstorming and ideation process was done. Starting with user requirements, a point of view (POV) was adopted for feasibility, scope of the study and smallholder farmer needs. The result of this was a focus on smallholder farmers particularly in developing nations (Mentzer, N., Farrington, S. and Tennenhouse, J., 2015).

According to a report by ACIAR (ACIAR, 2014), the world would be required to increase its food production by 70% in order to feed the growing population by the year 2050. In particular, agriculture production is crucial to Columbia as a percent of GDP. As a consequence of civil war, Columbia has suffered from child and informal

labor in food production. We hypothesize that supporting smallholder farmers (SHF) through LSS technique adoption would support food security and mitigate child and informal labor.

The paper will discuss an approach adopted by researchers at Cornell University's nutrition management department who developed a model for implementation of nutrition planning management in dairy farming. Narrowing the scope of this research to Colombian SHF's this study will take the POV of the farmer conditions struggling to achieve desired quality of life standards, as defined by WHO's food security definition and safety conditions of tough farming conditions. For example, Tylutki, T.P., Fox, D.G. and McMahon, M., 2004 (2004) noted improved food safety and security of farmers and support an improved general farm management environment by LSS techniques applications, such as control plans. Control plans adopted would therefore support the consistency and agility in the production process. (Tylutki, T.P., Fox, D.G. and McMahon, M., 2004).

This paper, however, was limited to the small-scale farmers like mostly prevalent in Columbia. These types of farmers are not particularly limited to a certain growing region but are characterized by low incomes regionally. Every farmer who faces food insecurity with limited means may employ child and informal labor. The SHE needs for an established production management system to attain sustainability in livelihoods is paramount.

This study followed the following processes: (1) a review of current literature to understand and explore potential LSS applications for more effective farm management via tools and techniques. (2) Discuss results of this exploratory analysis and propositions of future field work, incorporating quantitative and qualitative techniques.

Literature review

Food security among Columbian farmers is based upon sweat and toil. Lacking access to modern techniques and operation techniques results in a significant informal and child labor. The failure of food security may be described as a failure of the smallholder farmers in achieving effective farm management. Farm management typically means how effectively a small farmer is able to maintain the budgeting, food production, food distribution, food maintenance, storage and mitigation. (Kay, R.D., Edwards, W.M. and Duffy, P.A., 1994). The primary purpose for a farmer to have sustainable food security and farm management supports this premise. To be effective, SHF's must ensure consistent and predictable production, quality post-harvest handling, including timely delivery of commodities to meet supply chain demands, at the nutritional target value of the food products. According to ISO 9001:2000

Smallholder farms

Small farms in general are more productive and resourceful in terms of crop growth, via providing essential nutritional requirements to promote production. (Altieri, M.A.,

2009). Small farms play a crucial role in supplying food for domestic markets and employment for the low-income families. SHF's are one of the major contributing factors to the overall economic development of the nation. Therefore, it is indeed essential to support a significant social group division to overcome the challenges of the food insecure through establishment of more effective plans for farm management. (Minot, N., 1986)

Issues with SHF management

Major issues faced by the current SHFs significantly contributes towards the worsening of the economic life conditions, which both financially and morally hampers farmers, especially in employment. This leads to the poor deployment of the farm management factors, which in turn increases SHF food security concerns, creating a malicious cycle. The systematic review produced results among African SHF's. As per the Young African leaders Initiative Network (2017) the following factors were identified to be the challenging factors for the farmers in achieving the effective farm management practices:

- A. Working with smallholders: A typical small farmer operates its food supply with small time contracts. These contractors then sell the food products to local companies. In this context, healthy engagement of the relationship between the farmers and contractors for secure and timely delivery of commodities is crucial to customer satisfaction. Customer dissatisfaction often leads to conditions where the farmers (typically poor) are susceptible to market conditions.
- B. Quality strategy: It is important for the SHFs to know about the current and varying market demands and understand commodity pricing. Growers must be aware of the quality of food they are producing and customer needs. The failure to achieve a quality criterion often leads to a situation where the SHF is either forced to compromise on the quality for the sake of meeting demand or compromise on the selling price if the right quality is not produced.
- C. Logistics, transport and storage: Due to limited access to the high-end infrastructure areas, small farmers often face trouble with proper crop storage. It is important for the farmers to be well aware of market demands and possible supply chain disruption of routing and timeliness for logistics to minimize food waste. In case of any delays, a backup plan must be well planned to give the SHF agility. Failures to do so may result in loss of food quantity and poor post-harvest management, eventually leading to nutritional loss.
- D. Modern farming methods: finally, modern deployment of operational techniques, to support technology adoption would offer better farming techniques through quality assurance and control for better farm management.

With rising populations and increasing food needs, it is important to understand that adoption of new ideas could may ease pressure, regionally and globally. For Colombians, social compliance has been the primary mitigation principle in reducing improper sweat and toil. Rather, a course of action that is based upon quality

management, and in particular, the principles of LSS, to support SHF's is worthy of attention (Rochin, R.I., 1977).

Lean Six Sigma

Lean six-sigma is defined as a set of system tools and methodologies implemented in a given environment to ensure continuous improvement with a process focus for stability and consistency. From the systematic review above, an effort that takes advantage of LSS as applied to farm management for food security is viable. (Zhang, Q., Irfan, M., Khattak, M.A.O., Zhu, X. and Hassan, M., 2012). As per an article (Van Iwaarden, J., van der Wiele, T., Dale, B., Williams, R., & Bertsch, B. 2008) the application of Lean six sigma varies greatly from organization to organization. It may be used as a more of general philosophy approach or as a statistical tool. Irrespective of the organization it was noted by same article that LSS requires a high level of organizational strategy as well involvement of the high management level. According to an article (upkar, R.S., Lande, M.S. and Jawalekar, S.B., 2016), there are typically 8 commonly observed wastes observed in any kind of organization which needs to be immediately addressed before controlling the process. As seen in Figure 2 the common types of wastes are due to inventory, talent, waiting, motion, defects, transportation, over processing and overproduction.



Figure 1: Common wastes identified by lean six sigma (Upkar, R.S., Lande, M.S. and Jawalekar, S.B., 2016)

Lean six sigma, Food security and Farm management

The synthesis of the systematic review is also vetted in the literature. In terms of managing improved crop storage, food production, and managing logistics, with a customer focus, and align with LSS principles. The techniques of LSS such as FMEA (Failure mode effect analyses), RCA, SIPOC and CAPA, and control plans, may be implemented in the field to support a more effective crop production plan. (Zhang, Q., Irfan, M., Khattak, M. A. O., Zhu, X., & Hassan, M., 2012). To analyze this further, the researchers note that these techniques have not been deployed in a systematic

manner. For instance, root cause analysis, utilizing a Fishbone diagram from FMEA priorities of failure modes, and confirmed with change techniques, embedded in control plans, may benefit SHF's that have little capitalization but improved understanding of operations with a LSS focus on the process approach. Combining the concepts from LSS strategy and farm management, a light of hope can be seen to establish a lean thinking environment within the agricultural field. The Colombian farmers can therefore switch to this LSS thinking to organize the farm activities and attain a complete QMS (Quality management system) to maintain the consistency and look for more improvements.

Methodology

A systematic literature review was conducted of existing sources of the food security and farm management, along with LSS. Exploration of a relationship of food security and farm management presents a practical view for LSS and food security to achieve effective farm management. According to Okoli and Schabram (2010), the systematic literature review refers to a set of procedures and techniques to study and analyze the existing sources of literature available for the given topic and present a concrete discussion and analyses by implementing some other tools and techniques. Rigorous analyses of the research topic noted above generate more literature review for in depth analyses. The association of the LSS and food security was additionally explored utilizing ideation tools, including brainstorming methods by the research team, with regard these concepts. Brainstorming and ideation are two effective tools that can be deployed in almost any field to generate a set of collective ideas by examining the occurrences and the events of personal life experiences and involuntary observations we make on day to day basis. (Mentzer, N., Farrington, S. and Tennenhouse, J., 2015). Early results note that a control plan is viable.

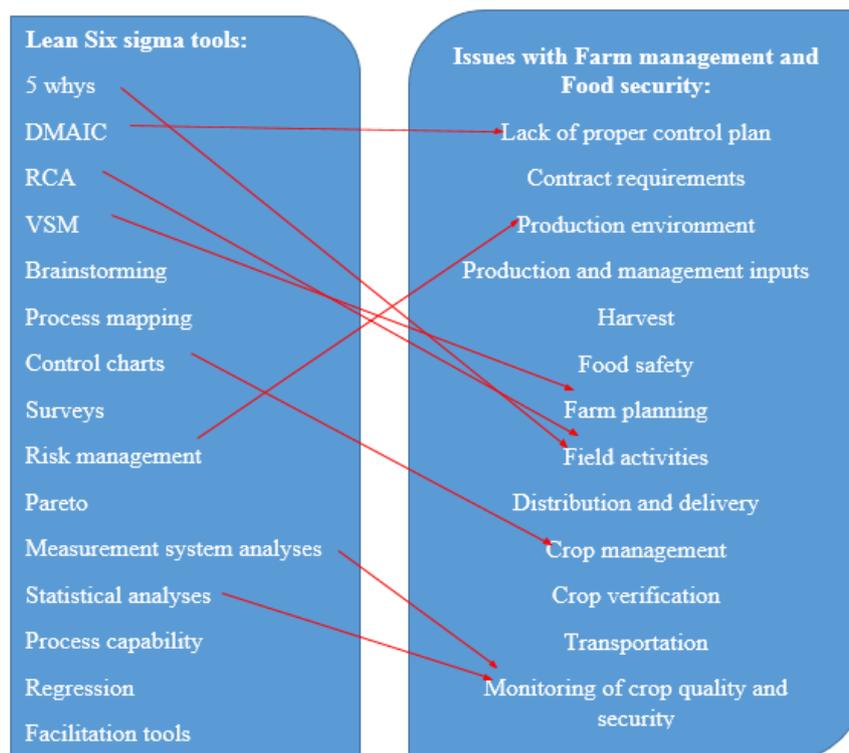


Figure 2: Framework for the Lean six sigma tools and issues with Farm management (Hahn, G.J., Hill, W.J., Hoerl, R.W. and Zinkgraf, S.A., 1999), (ISO, B., 2000. 9001: 2008)

The framework provided in Figure 2, depicts that there could be a possible relationship within the elements of LSS tools and the issues with farm management and food security. In other words the common issues in farm management and food security (ISO, B., 2000. 9001: 2008) could be addressed using some common LSS tools (Hahn, G.J., Hill, W.J., Hoerl, R.W. and Zinkgraf, S.A., 1999). In order to use the tools more effectively it would be important for the GB's and BB's (green belts and the black belts) to first identify and note the important data points addressing the optimal food production. The limits for the optimal production and allowed wastage should be well known before the application of LSS tools. The purpose here would be to apply the tools of LSS to ensure the food production and storage has the minimal wastage and the production is consistent with the market demand.

The concept of '5 Whys' and RCA analysis (Myszewski, J.M., 2013.) could be possibly used to eliminate the quality losses that are caused due to the poor quality of the equipments. This would be used to identify the possible root causes responsible for the poor quality in farm machinery. The control charts (Goh, T.N. and Xie, M., 2003) could prove to be vital tools while dealing with the supervision of crop management and verification purposes. As per the article (Goh, T.N. and Xie, M., 2003), the control charts can be generated to determine the viable control limits of the crop production and storage. A simplified version can therefore help the farmers to keep a proper control check over the crops being produced over the duration of the time. The process capability analyses (Kwak, Y.H. and Anbari, F.T., 2006) is possibly one best tool to ensure the crop production meets the required demands. The VSM's and process mapping techniques can be used to identify the value added and non-value added

steps in the farming process to ensure there is no wastage during the production process. The Pareto analysis (Karuppusami, G. and Gandhinathan, R., 2006) can help the GB's and BB's to identify the issues with most severe and frequent impacts and accordingly proceed for the improvement purposes. This would also help to achieve a total quality management system (Karuppusami, G. and Gandhinathan, R., 2006) if implemented appropriately. The concepts of risk management and the risk mitigation (Chiarini, A., 2012) can be used to identify the possible risks in the production processes and provide an effective LSS strategy to identify and address the possible risks that may be encountered in the food production process. This method of risk management analyses is quite favorite for health care and drug industries where risk management is one of the most important factor to consider. Such LSS tools can therefore significantly contribute to the betterment of the farm management system and food security.

Limitations and Future work

The research paper comprises a brief research case study of depicting a possibility of implementing the lean six-sigma thinking to achieve farm management. The paper provides an incentive to help the farm management organizations to switch to the idea of using LSS tools in achieving effective farm management and food security. The framework for implementing LSS tools, in order to address the issues of farm management and food security, are a result of research and ideation process and does not provide a measurable outcome. The implementation of LSS tools in food security and farm management would require lots of work to train and convince the farmers to switch to more lean thinking. The agricultural organizations therefore would play a major role to achieve this target. The next steps would be to conduct field research and obtain consensus as to what could be the possibility in real life to implement the LSS tools and drive effective farm management.

Conclusion

In conclusion, from the systematic review, analysis, and discussion, there has been little research done in this area. While LSS, food insecurity, and farm management have been thoroughly studied, these have not been systematically explored. While there have been a few studies that discussed applications of quality tools, as noted above, issue of food security is a grand challenge, which are difficult to achieve at global level.

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