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RESEARCH PAPER

Risks in the Sri Lankan Banana Supply Chain: Analysis through an Interpretive Structural Modeling

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المخاطر في سلسلة توريد الموز السريلانكي: التحليل من خلال النمذجة الهيكلية التفسيرية

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Abstract. Although banana is an important fruit in Sri Lanka that gives a good income to farmers. Researchers have indicated that the majority of the crop is damaged from the farm gate to the consumer table. Accordingly, this research was addressed 'to find the risks of the banana supply chain in Sri Lanka. The Interpretive Structural Modeling (ISM) approach was used in this research to find the risks in the banana supply chain of Sri Lanka. According to the literature survey and data analysis, several risks such as human and personal, production, financial, land prices, biological and environmental, information, political, weather-related, management and operational, agricultural policy, logistics and infrastructure, country's economic cycle, price or market and input risks can be encountered in the banana supply chain. These risks were categorized into different levels according to the influence they provide to the supply chain. Identifying these risks on a hierarchical model was significant to the administrators, managers and farmers to minimize them effectively to manage the supply chain. The analysis in this study further indicated that production, financial, biological and environmental, weather-related events, political situations, and logistics and infrastructure were the most significant risks. Dealing with these risks can minimize the effect of other risks, improve the income of the farmers and maximize consumer choice.

Keywords: Agriculture, Banana, Interpretive Structural Modeling (ISM), Risks, Sri Lanka, Supply Chain.

الملخص: على الرغم من أن الموز يعتبر فاكهة مهمة في سريلانكا حيث يوفر دخلاً جيدًا للمزارعين، إلا أن الباحثين أشاروا إلى أن غالبية المحصول يبدأ بالتلف منذ خروجه من بوابة المزرعة وحتى طاولة المستهلك. وفقًا لذلك، تناول هذا البحث مخاطر سلسلة توريد الموز في سريلانكا. في هذا البحث تم استخدام نهج النمذجة الهيكلية التفسيرية (ISM) للعثور على المخاطر في سلسلة توريد الموز في سريلانكا. وفقًا للمصادر العلمية وتحليل البيانات، هناك العديد من المخاطر مثل المخاطر البشرية والشخصية والإنتاجية والمالية وأسعار الأراضي والمخاطر البيولوجية والبيئية والمعلوماتية والسياسية والمخاطر المتعلقة بالطقس والإدارة والتشغيل والسياسة الزراعية واللوجستيات والبنية التحتية والدورة الاقتصادية للبلد و مخاطر الأسعار أو السوق كل هذه المدخلات يمكن مواجهتها في سلسلة توريد الموز. تم تصنيف هذه المخاطر إلى مستويات مختلفة وفقًا للتأثير الذي تحدثه في سلسلة التوريد. إن تحديد هذه المخاطر على نموذج هرمي سيكون مهمًا للمسؤولين والمديرين والمزارعين لتقليل هذه المخاطر بشكل فعال ولإدارة سلسلة التوريد. وقد أشارت نتائج هذه الدراسة إلى أن الإنتاج، والأحداث المالية والبيولوجية والبيئية، والأحداث المتعلقة بالطقس، والأوضاع السياسية، والخدمات اللوجستية والبنية التحتية كانت من أهم المخاطر. إن التعامل مع هذه المخاطر قد يؤدي إلى تقليل تأثير المخاطر الأخرى، وتحسين دخل المزارعين وزيادة خيارات المستهلك.

الكلمات المفتاحية: الزراعة ، الموز ، النمذجة الهيكلية التفسيرية (ISM) ، المخاطر ، سريلانكا ، سلسلة التوريد.

Introduction

Banana (*Musa acuminata* L.) is one of the favourite fruit crops grown in Sri Lanka covering an area of 72,010 hectares with an annual average production of 864,120 tons (AgStat, 2019). It is also known as one of the staple foods that helps the food security of many tropical countries (Ghag & Ganapathi, 2017). Out of the 1000 varieties available around the world, Sri Lanka grows 29 of these varieties (Ratnasinghe, 2003). These are mainly divided into four main groups namely; Sour, Seeni, Kolikuttu and Anmalu (AgStat, 2018). Sri Lanka is geographically located in a favourable position to grow banana. Additionally, the soil and other climatic conditions are also useful to the growth of the crop (Perming, 2013). Due to these facts, there is a potential to increase the harvest and income of farmers. However, irrigation problems, weather patterns, cost of inputs, pests and diseases, political impacts, and climate changes, are seen as the crucial impediments to planting and growing banana in Sri Lanka (Perming, 2013).

There is always a struggle among farmers to continue agriculture due to the low income. Due to the shorter yield time, low cost of replanting and low overheads, more farmers grow banana as perennial crop (Arvanitoyannis and Mavromatis, 2009). Although, there is a

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relatively higher turnaround of income from planting banana, full benefit of the yield is not received by farmers due to various problems in the supply chain.

The yield of Sri Lankan banana has increased without a major increase in the harvested area. Although the prices of the various crops of banana have increased from 20 to 30 per cent from 2016 to 2017, the wholesale prices have only increased from 10 to 20 per cent (AgStat, 2018) during the same period. This indicates that there is a decrease of profit from farmer to wholesaler. Researchers have indicated that the state of the insubstantial and non-standard transportation methods from each point in the supply chain have made a significant quantity of the crop being perished during transportation (Wasala et al., 2014).

The supply chain always encourages a system-wide approach that helps identify the commonalities and the differences in separate segments (King and Venturini, 2014). As described by Jaffee, et al. (2010), banana supply chain in Sri Lanka also covers various activities, such as raw materials with equipment and technology; production methodology adopted for harvesting. In addition, post harvesting methods such as re-plantation and crop rotation; processing the harvest by diversifying the product range; promoting the product by carrying out marketing campaigns; and distribution of the products throughout the country to the consumers affected the supply chain. There is a physical financial information flow occurs in this supply chain as in the case of others (Partane et al., 2020).

The major attraction of growing banana to the farmers is the economic gain. A shorter life cycle and ease of planting also contribute to the growth (Kudagamage et al., 2002). However, 30% of the crop is damaged during the journey from the 'farm to fork' (Ekanayake and Bandara, 2002). Researchers indicated that improper handling, bad packaging, and excess use of pesticides, mechanical damage and various other problems throughout the supply chain as the reasons for this loss (Hathurusinghe et al., 2012). Additionally, the involvement of middle vendor by double handling the product contributes to these post-harvest losses and reduces the level of profits of farmers. Although there was no increase in the cultivated land, crop yield has increased between 2014 and 2017 (IndexMundi, 2020; AgStat, 2018). Due to the various factors, the advantage of production growth has not reached farmers (Ratnasinghe, 2003). Additionally, the relationship between income and profitability depends on the cost of cultivation. Such a decreasing trend in profitability may have various associated reasons. Having an effective supply will leverage the firms and improve profitability (Salvia, 2020). This research, therefore, was focused on identifying the risks that affect the banana supply chain to propose strategies to minimize such risks that would contribute to increase the profit of the sector.

Many programs have been launched by the governmental and non-governmental sector to reduce the negative effects on banana supply chains. There has been previous research conducted to find the effectiveness of the banana industry (Ekanayake and Bandara, 2002), factors affecting the transport chain (Abeysekera & Abeysekera, 2008), methods of increasing the yield (Ekanayake and Bandara, 2002), supply chain issues (Sarananda, 1999) and packaging (Wilson, 1996) of banana in Sri Lanka. The risk will restrict the efficient function of the supply chains (Crouhy et al., 2006). A large number of risks have been studied by previous researchers concerning agriculture supply chains (Jaffee et al., 2010). Managing these risks is also necessary to increase efficiency and effectiveness. However, in this research, we considered the factors with a holistic view of the supply chain.

Although different types of risks are agreed upon by different researchers, they may differ from situation, sector, time and type of operation (Crouhy et al., 2006). Risk management is also a prominent factor in agriculture (Jaffee et al., 2010). Although the concept of risk management in agriculture is less-known in Sri Lanka, it is being practiced in other regions. Risk management in the agriculture supply chain can also be explained as "managing the most demanding events" (Jaffee, et al., 2010) that negatively affect the financial and information flows in the supply chain. It is difficult to mitigate all the risks to the lowest level. However, trying to minimize such risks will positively affect the collective impact of the whole supply chain (Hathurusinghe et al., 2012). It did not mention what risks are the most significant in banana supply chains. A holistic approach to agricultural supply chain risks is not deemed practical due to the diverse nature of each crop and the other aspects such as region and country that may affect the supply chain (Dolgui, et al., 2020). The situation is the same with Sri Lankan banana industry.

Thus, the main objective of this study was to identify the risks in the banana supply chain of Sri Lanka and rank them according to their severity. These findings will enable the regulators to mitigate them depending on the impact of each risk. We used Interpretive Structural Modeling (ISM) to analyze the data. Subsequently, this research will enable administrators and farmers to minimize the likelihood and the consequences of risks in the banana industry. This will enable a smoother efficient flow of product, finances and information. This is the intial study carried out to find the risks in the banana supply chain in Sri Lanka. Additionally, initial study to apply ISM in the Sri Lankan banana industry. Thus, this research can open a new paradigm in the agriculture supply chain of Sri Lanka.

Methodology

In this study, firstly we researched journal articles to find various risks in the banana industry as published by

the previous researchers. Number of journal sites were used for this search. Accordingly, we found 312 articles with the term 'agriculture supply chain' and 'risks' in the publication title. Thereafter, this search was further refined to find the words 'agriculture', 'risk' and 'banana industry' in the abstract and/or key words of each article; 21 articles qualified the criteria. Having gone through the articles, it was revealed that 8 of those 21 articles do not contain any direct relevance to agricultural risk in the banana industry. Finally, we established 16 risks that have a relationship to 'agriculture risks' and 'banana industry' and thirteen articles was finally selected.

Secondly, we discussed the existence of these 16 risks in the Sri Lankan banana industry with a randomly selected sample of government agriculture officers, farmers and vendors. The sample consisted of 10 government agriculture officers, 30 small, medium and large scale farmers and 15 vendors. We requested the sample to rank the risks according to their knowledge and experience. The sample represented all banana growing districts in Sri Lanka.

Thirdly, we introduced Interpretive Structural Modeling (ISM) as the principal method of data analysis in this research. Accordingly, we provided these initially agreed 16 risks to a focus group consisted of six academics and administrators in the field of agriculture. Considering the socio-economic conditions as well as with relevance to the banana industry in Sri Lanka, the focus group agreed on fourteen most relevant risks that are suitable to the Sri Lankan banana supply chain. The focus group decided to drop Marketing Risk since it is already including in the Price or Market Risk. Additionally, Institutional Risk was also dropped since it is already a part of Management & Operational Risk. Consequently, the following fourteen risks were considered for the ISM analysis considering their relevance to the Sri Lankan economic and agricultural situation: (i) Human & Personal Risk, (ii) Production Risk, (iii) Financial Risks, (iv) Risk of Increase In Land Prices, (v) Biological & Environmental Risk, (vi) Information Risk, (vii) Political Risk, (viii) Weather-Related Risks, (ix) Management & Operational Risk, (x) Agricultural Policy Risk, (xi) Logistics & Infrastructure Risk, (xii) Country's Economic Cycle, (xiii) Price or Market Risk, and (xiv) Input Risk.

We use ISM to study the hierarchy of these risks. This method enables to convert poorly expressed models to more detailed and defined models that can be further tested with the use of data. ISM can also be used for many other purposes, such as finding the interrelationships among variables, to identify and rank the variables, ease of educating the public and critically analyse the results for improvements (Sushil, 2012) However, the interrelationship of the factors can be considered as the most important (Attri et al., 2013). The method is interpretive since the judgment of a group decides the relationship among different variables. Modelling methodology in ISM facilitates to develop a diagraph that showed the direction and order in the variables (Attri et al., 2013). ISM has several advantages as an analysis tool. All possible pairwise elements are selected through a literature survey was further purified by the respondents' recommendations. The use of such transitive inferences can reduce the required rational queries making the process efficient (Sushil, 2012). ISM also helped to record complex issues efficiently and systematically. The structural model generated through ISM graphically presented a complex problem. This graphical representation could depict the problem where interdisciplinary and interpersonal communication can be effectively. Thenceforth, ISM served as a tool to develop a deeper understanding when identifying, analyzing and taking actions to each element (Kumar et al., 2018).

Every effort was made to reduce the negative effects of ISM in this research. As having a larger number of variables may increase the complexity of methodology, this research was only considered the most significant risks factors in the banana supply chain with the assistance of expert opinion. Discussions were carried out among the researchers and the focus group on the driving and the dependence power effect variables. ISM was used across many research fields such as information technology (Pfohl et al., 2011), supply chain (Khan and Rahman, 2017), agriculture (Gardas et al., 2017), and quality management (Muruganantham et al., 2018). Risk identifications and analysis was the core of these research. Thus, it was proved that ISM was a realistic analysis tool in identifying risks. Although agricultural risks was identified in previous research (Gardas et al., 2017; Sudarshan et al., 2013), there is a deficiency of literature on banana supply chains, particularly in the Asian region. This research deemed significant considering factors, such as the income of banana farmers, nutritious value in the food, improvement of export income and diversification of the agricultural sector in Sri Lanka. Steps were taken according to the ISM methodology when developing and identifying the risks to the banana supply chain.

Step One - Listing of Variables

Most of the research published in various sources was discussed and the variables that relate to the banana supply chain were indicated in Table 1.

Step Two - Establishing a Contextual Relationship among Variables

Contextual and pairwise relationship among variables were identified in this step. The consultation and assistance of an expert panel consisted of researchers, academics and practitioners were used initially to nominate the variables and to find the pairwise relationship among them whilst removing the transitive links. As indicated previously, the opinion of experts from various spheres in the agricultural field was used to identify the relationship of these risks to one another. Afterwards, this appropriate relationship and significance were further

Table 1. Structural self-interaction matrix (SSIM) of the causal factors of Risks in Banana Supply Chain: Source Research data

			Variable *j*												
		Risk Parameter	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Variable *i*	1	Human & Personal Risk	X	V	V	A	A	O	O	O	V	A	X	A	A	-
	2	Production Risk	V	V	V	A	V	V	V	V	O	V	O	A	-	
	3	Financial Risks	V	V	V	O	V	V	V	A	V	V	V	-		
	4	Risk of Increase in Land Prices	X	V	V	A	A	V	A	O	V	A	-			
	5	Biological and Environmental Risk	V	V	V	O	V	V	X	O	-	-				
	6	Information Risk	A	A	V	A	A	X	A	-						
	7	Political Risk	V	V	V	O	V	V	O							
	8	Weather-Related Risks	V	V	V	O	V	V	-							
	9	Management & Operational Risk	A	A	A	O	O	-								
	10	Agricultural Policy Risk	V	V	V	A	-									
	11	Logistics & Infrastructure Risk	V	O	V	-										
	12	Country's Economic Cycle	A	A	-											
	13	Price or Market Risk	A	-												
	14	Input Risk	-													

Note. Where the driver is V= element i will help to achieve element j
Where the driver is A= element j will help to achieve element i
Where the driver is X=element i and j will achieve each other
Where the driver is O= i and j are unrelated
Accordingly, the decision of the expert panel was considered to develop the SSIM in table 2.

examined. The relationship among variables was shown in the SSIM as below:
V= *i* will achieve *j*.
A= *j* will achieve *i*.
X= *i* and j will achieve each other.
O= *i* and *j* are unrelated.

where *i* and *j* are variables in the banana supply chain and Ψ indicates the relationship among the variables. Structural Self Interaction Matrix (SSIM) is a comparison that was based on pairwise relationships. Thus, SSIM was obtained by asking a question of whether *'variable i'* influenced the *'variable j'*. This was described in Figure 1.

Step Three - Structural Self Interaction Matrix (SSIM) Development

$$\begin{array}{c} \\ \text{SSIM} = \\ \\ \end{array} \begin{array}{c} \begin{array}{cccccc} \alpha_1 & \alpha_2 & \ldots & \ldots & \alpha_n \end{array} \\ \begin{bmatrix} \alpha_1 & 0 & \Psi_{12} & \ldots & \ldots & \Psi 1n \\ \alpha_2 & \Psi_{21} & 0 & \ldots & \ldots & \Psi 2n \\ . & . & . & . & & . \\ . & . & . & . & & . \\ . & . & . & & . & . \\ . & . & . & & . & . \\ . & . & . & & & . \\ . & . & . & & & . \\ \alpha_m & \Psi m1 & \Psi m2 & \ldots & \ldots & 0 \end{bmatrix} \end{array}$$

Figure 1. Structural Self Interaction Matrix (SSIM).

Table 2. Initial Binary Reachability Matrix:

Parameter		Variable *j*													
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Variable *i*	1	1	0	0	1	0	1	0	0	0	0	0	1	1	1
	2	1	1	0	0	1	0	1	1	1	1	0	1	1	1
	3	1	1	1	1	1	1	1	1	1	1	1	0	1	1
	4	1	0	0	1	0	1	0	0	1	0	0	1	1	1
	5	1	0	0	1	1	1	0	1	1	1	0	1	1	1
	6	0	0	0	0	0	1	0	0	1	0	0	1	0	0
	7	0	0	0	1	0	0	1	0	1	1	0	1	1	1
	8	0	0	0	1	1	1	0	1	1	1	0	1	1	1
	9	0	0	0	0	0	1	0	0	1	0	0	0	0	0
	10	1	0	0	1	0	1	0	0	0	1	0	1	1	1
	11	1	1	0	1	0	1	0	0	0	1	1	1	0	1
	12	0	0	0	0	0	0	0	0	1	0	0	1	0	0
	13	0	0	0	0	0	1	0	0	1	0	0	1	1	0
	14	1	0	0	1	0	1	0	0	1	0	0	1	1	1

Source – Survey data

SSIM was established for all variables to identify the pairwise relationship for the research area of the banana supply chain of Sri Lanka.

Step Four - Initial Binary Reachability Matrix (IBRM) Development

The previously created SSIM reachability matrix was used to form the IRM, and this was also further analysed for transitivity. Transitivity was an assumption that defined the relationship among factors such as if 'A' was related to 'B' and also 'B' was related to 'C' then we hypothesized that 'A' was also related to 'C'. The SSIM developed in the previous step was converted to a binary matrix. The V, A, X, and O was converted to 1's and 0's. IBRM is presented in Table 2. The 1's and 0's were replaced according to the following rule:

- If i,j entry is V then it becomes a 1 and the corresponding j, i entry be a 0.
- If i, j entry is A then it becomes a 0 and the corresponding j, i entry be a1.
- If i, j entry is X then it becomes a 1 and the corresponding j, i entry also be a 1.
- If i, j entry is O then it becomes a 0 and the corresponding j, i entry also be a 0.

Step Five- Developing a Final Reachability Matrix (FRM)

After considering the transitivity as indicated in Step Four, FRM was developed. The FRM was developed by considering transitivity. Accordingly, the reachability matrix's transitivity was analysed with equations 1 and 2 according to Huang et al. (2005):

i. RM = SSIM+U1
ii. RM*= RMX= RMX+1 +1,X> 12

According to the above equation, U is the unit of matrix and X indicates the power. Also RM* is the reachability matrix. Boolean multiplication and addition system was used (Lin et al., 2010) in determining the transitivity values.

This suggests us: 1.1=1;1+1= 1;1.0= 0;1+0= 0+1= 1;1.0 = 0.1 = 0.

Step Six - Carrying out Level Partitions

Level partitions were checked to identify the rank of each element. Reachability and the antecedent sets were used to identify such hierarchy. Reachability and antecedent sets were found from the FRM as used to develop the level partitions. These assisted to identify the elements in a ranked pattern (Suhil, 2012). This can be expressed as:

$$R(D_i)= R(D_i) \cap A(D_i)$$

Accordingly, D_i is element and all the other elements that help to attain, $R(D_i)$ is reachability set with the element as well as all other elements that help to attain it, and $A(D_i)$ is antecedent set that consists of the subjective element and all other elements to achieve it.

Step Seven – Creating a Diagraph

A direct graph (diagraph) was created using the final reachability to present the relationship among variables. Previously, different levels of drivers in the banana supply chain were identified to develop a diagraph.

Step Eight - MICMAC Analysis

Impact Matrix Cross-Reference Multiplication Applied to a Classification (MICMAC) analysis was performed to find the driving and dependence power of each variable.

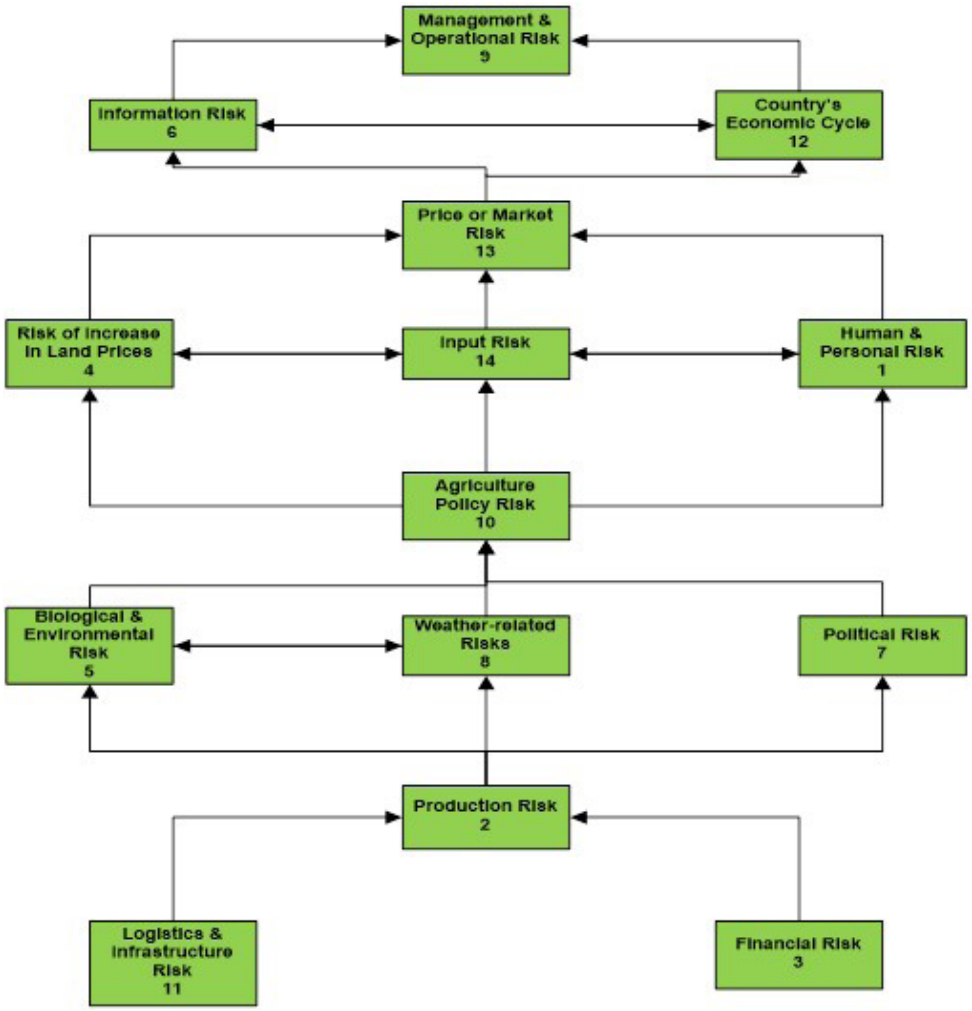

Figure 2. ISM model for Banana Supply Chain Risks.

Results and Discussion

As described previously, several risks related to the banana supply chain from the 'farm to fork' was explored in this research. Identifying such risks can enable us to undertake the most vital risk that can have a trickledown effect to minimize other related risks. Such action can, therefore, reduce the cost and effort of tackling each risk independently. This can create a cost and benefit advantage for the farmers and vendors as well as the government to attain an effective banana supply chain in Sri Lanka. All such risks researched previously were selected by the expert panel and these were used in this research.

Types of Risk

Risk of Country's Economic Cycle

Domestic crop production can be greatly influenced the economic cycle and governmental policies to promote agriculture. Research has showed that the economic crisis can positively affect agriculture since more people can turn to agriculture due to increasing unemployment (Ogboru et al., 2018). Moreover, the elasticity variance of agriculture was low during different economic periods from a recession to an expansion (Contre and Goldin, 1990). However, the sustainability of agriculture has a concern on economic, social and ecological sustainability (Ghag and Ganapathi, 2017).

Price or Market Risk: Due to the nature of demand and supply pattern in agriculture, there is always a risk involved in market price. However, the price or market risk can vary from product to product (Rosch, 2018). Banana being a short-term crop and can help the subsistence farmers in Sri Lanka, since there is always a price variation. From 2015 - Jan 2019 monthly banana prices have increased by 65% (IndexMundi, 2020). This did not consider the monthly variations that were almost 15% in the year 2017 (for Ambul only) (CBSL, 2018).

Risk of Increase in Land Price: Land prices in the Co-

lombo district have increased by 18% compared to 2017 (CBSL, 2019). Central Bank (2019), report further indicates that 'three sub-indices of Land Price Index, namely 'residential, commercial and industrial have contributed' to this increase. It can be claimed that this has a trickle-down effect on the increase in land prices in other districts. Growth in population and improvement of roads and infrastructure has also contributed to this de-urbanization (Rosch, 2019: Ogboru, et al., 2018). As a result, harvesting of banana did not increase from 2014 to 2017 (AgStat, 2018).

Input Risk: Banana farmers face a shortage of approved tissue cultured nursery plants due to minimum research carried out in Sri Lanka (Perming, 2013). The situation about the labor, pesticides and the special planting and yielding equipment were also the same (Hanson et al., 2004). Researchers indicated that 2% of the yield was damaged due to bad handling at the farm gate since the right equipment was not available (Wasala et al., 2014). Moreover, most of the banana plantations on the Island were organic (Sarananda, 1999), thus required knowledge and the inputs to develop popular organic farming were also in short supply.

Biological and Environmental Risk: Researchers have classified biological and environmental risks in agriculture to two areas namely, dependent and independent from the business activities (Zakharchenko, 2017). The growth of agriculture including farming and animal husbandry harms the environment (Jaffee et al., 2010). Heavy use of fertilizer can deteriorate the quality of the topsoil and deplete the groundwater sources (Zakharchenko, 2017). Since the farmers lack knowledge on scientifically grounded crop rotation methods, problem of soil and groundwater contamination has worsened. Also, the continuously deteriorating environment due to deforestation and extreme climatic conditions can be negatively contributed. Although, there was much less use of fertilizer in the banana plantations in Sri Lanka (Sarananda, 1999), other factors did not affect biological and environmental risk.

Logistics and Infrastructure Risk

Climacteric and the perishable nature of banana make them highly vulnerable to postharvest losses (Wasala et al., 2014). The available transportation and storage conditions can also deteriorate the situation further. As indicated in Figure 2, banana supply chain in Sri Lanka has many transportation loops and storage points. This can make it vulnerable to more postharvest losses during transit and it was calculated that this loss amounts to 30% of the yield (Ekanayake and Bandara, 2002).

Political Risk: To develop an efficient and resilient agriculture mechanism in any country, innovative experimentation and research are needed (Bennett et al., 2014). Also, there should be a 'holding hands' approach between the farmers and the authorities to develop a winning supply chain. Since all governmental issues are politically driven, it is difficult to have the expected sustainability in agriculture (Ghag and Ganapathi, 2017). This has a direct impact on the agriculture policy risk that can be discussed next. However, other factors are influenced by political risks, such as land availability, supply chain effectivity and agricultural decentralization (Dolgui et al., 2020). These can be influenced by the prevailing political regime. Such short-termism approach of the politicians had negatively influenced the agriculture industry including the banana supply chain (Contre and Goldin, 1990). Considering the influence that the political risk can bring to the banana supply chain (Ekanayake and Bandara, 2002), it can be included as a major risk.

Agricultural Policy Risk: As described previously, the government agricultural mechanism can waste resources and efforts in practices that are ineffective and does not provide adequate opportunities for innovation (De Silva and Kawasaki, 2018). As a reason, the farming community is unable to reap the benefits of such governmental efforts. Presently, it is provided by the local agricultural advisers and this does not have an end to end process where a crop can be looked after by the governmental mechanism from seed to yield (Abeysekera and Abeysekera, 2008). Additionally, the policy of various governments changed time to time ad these could also slow down the growth.

Weather-related Risk: Agriculture contributes 7.5% of the total GDP of Sri Lanka in the year 2018 (CBSL, 2019). That said, there is a correlation between weather-related activities and agriculture productivity (De Silva and Kawasaki, 2018). Natural disasters are increasing due to climate change. Therefore, whenever there is a climatic change, there is a risk of the banana crop being damaged.

Financial Risk: Managing the costs incurred through planting to consumption, availability of various financing methods, and the knowledge of the farmers to manage the cash flows are known as the highest risks in agriculture (Komarek et al., 2020). There is a lack of knowledge in cash flow management throughout the farming communities of Sri Lanka (Kiriveldeniya and Rosairo, 2020) Since there is a shortage of awareness in sound financial control due to the illiteracy of the farming communities (Wanigasundera and Atapattu, 2019), objective nature of farming could not be achieved. Whilst the fact that the role of the government to improve the financial acumen of the farmers are not being negated, there is still much the farming communities can also do in reducing the financial risk by way of cooperatives and other cartels (Kiriveldeniya and Rosairo, 2020).

Production Risk: Production risk involves all the risk factors that help production from inputs, process, weather, biological and environmental factors (Shahzad and Abdulai, 2019). Although some of these risks were discussed previously, we highlighted production risk also as a separate risk phenomenon due to the significance. Since there are other contributory factors such as pests, disease and machinery efficiency and these did

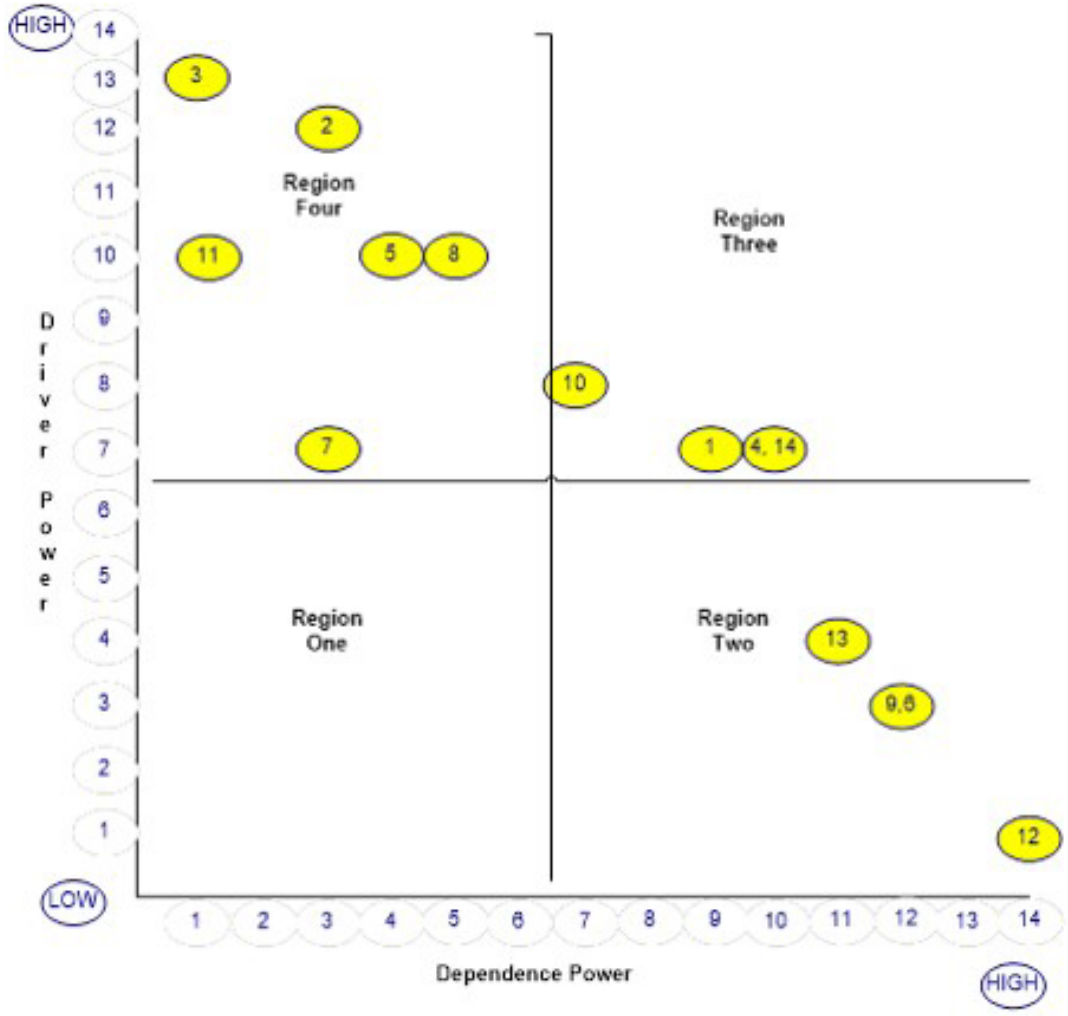

Figure 3. MICMAC Analysis Diagram, Banana Supply Chain Risks.

not include previously. The food and Agriculture Organisation (FAO) of the United Nations have claimed that there is "20 to 40 percent of crops that are lost due to pest" (FAO, 2020). These pest problems have affected the food security of various countries. Although there are no statistical data, this must-have affected the Sri Lankan Agriculture sector too. The recent locust attacks on the plantations in Kurunagala District in Sri Lanka can be one of the examples (Shivantha, 2020).

Human and Personal Risk: There are various human and personnel risks that the agriculture industry faces every day in Sri Lanka (CBSL, 2019). Among them a scarcity of labor force (Karunagoda, 2004), inadequate health and safety systems (Weerasinghe et al., 2020), non-effective training to farmers including the partners of the banana supply chain (Kiriveldeniya and Rosairo, 2020), non-availability of pension schemes (Perera and Weerakkody, 2018) and ill health among farming communities (DCS, 2017) are the most aggravating factors that affect human and personal health.

Operational Risk: Operational risk is defined as something that might happen and its effect(s) on the achievement of objectives (ISO, 2018). When considering the banana supply chain, there may be numerous objectives including growth, expansion profitability and resilience. The Ministry of Agriculture has laid down policy objectives and road maps for the whole industry. However, there is a lack of proactive planning to have a first and second-line defense model to minimize or to eradicate the consequences and likelihoods of problems that may encounter when reaching these strategic objectives (Nisansala et al., 2020). Additionally, the changes in the policy and political environment can also affect the drive towards the set strategic objective.

Information Risk: Information has become a significant requirement in our everyday life. Thenceforth, it is also vital to the development of the banana supply chain (Bo et al., 2014). Accordingly, the right mandate and

Table 3. Final Binary Reachability Matrix: Source – Survey data.

	Drivers	Variable *j*															
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Driving Power**	**Rank**
	Human & Personal Risk	1	0	0	1	0	1	0	0	1#	0	0	1	1	1	7	V
1	*Production Risk*	1	1	0	1#	1	1#	1	1	1	1	0	1	1	1	12	II
2	*Financial Risks*	1	1	1	1	1	1	1	1	1	1	0	1	1	1	13	I
3	*Risk of Increase in Land Prices*	1	0	0	1	0	1	0	0	1	0	0	1	1	1	7	V
4	*Biological & Environmental Risk*	1	0	0	1	1	1	0	1	1	1	0	1	1	1	10	III
5	*Information Risk*	0	0	0	0	0	1	0	0	1	0	0	1	0	0	3	VII
6	*Political Risk*	0	0	0	1	0	0	1	0	1	1	1	1	1	0	7	V
7	*Weather- Related Risks*	1#	0	0	1	1	1	0	1	1	1	0	1	1	1	10	III
8	*Management & Operational Risk*	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	VIII
9	*Agricultural Policy Risk*	1	0	0	1	0	1	0	0	1#	1	0	1	1	1	8	IV
10	*Logistics & Infrastructure Risk*	1	1	0	1	0	1	0	1#	0	1	1	1	1#	1	10	III
11	*Country's Economic Cycle*	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	VIII
12	*Price or Market Risk*	0	0	0	0	0	1	0	0	1	0	0	1	1	0	4	VI
13	*Input Risk*	1	0	0	1	0	1	0	0	1	0	0	1	1	1	7	V
14	**Dependence Power**	9	3	1	10	4	12	3	5	13	7	1	13	11	10		
	Rank	V	IX	X	IV	VIII	II	X	VII	I	VI	X	I	III	IV		

Note. 1# entries indicate the transitivity

infrastructure were set by the authorities to have a free flow of supply chain-wide information availability. The banana supply chain can achieve many advantages by effectively employing costly inputs (Dolgui et al., 2020). Even though, the government has taken several steps there are still gaps in the system. Lack of knowledge and the ability of the farmers, lack of information sources, unreceptive attitude of the authorities and slow flow of information are some problems, and these have to be resolved to have a sound information regime (Gardas et al., 2017). Considering the impact that information has on the development of the banana supply chain, information risk can be judged as risk as identified in this research.

The final Binary Reachability Matrix is presented in Table 3. According to the results, financial risks takes the highest rank of the set of drivers followed by production risks. This implies that policy-level initiatives must be in place to reduce both financial and production risks as a priority. The third rank is taken by biological and environmental risks that should be handled separately. When the dependence power is examined the top rank is taken by price or market risks. This signals that price regulation and access to market price and market place timely may help reduce such dependency.

Models

The results of Level Partitions are presented in Table 4. Thus, the element which has the highest number of intersections and antecedents were considered as the first level partition. This application was continued until all variables were removed. These partitions were then used to develop the diagraph and the ISM model at the later stage. Thenceforth, the FRM achieved is shown in Table 4 indicating the driving and dependence power as well as the transitivity of the banana supply chain risks in Sri Lanka. This further indicates the role of financial risks and logistic and infrastructure risks in the overall context of the banana supply chain in Sri Lanka.

Results of diagraph and formation of ISM-based model shows the graphical representation of the relationships of the elements according to different hierarchy. According to the diagraph, it can be seen that "Logistics & Infrastructure risk (Driver 11)" and "Financial risks (Driver 3)" can be considered as the most significant risks to affect the others in the banana supply chain. Therefore, these risks need to be dealt with at the outset. However, management and operational risk are at the top of the diagraph. This indicates that treating this risk can greatly influence all the other risks. Accordingly, the final model of the diagraph after removing the transitivity is presented in Figure 2.

Results of MICMAC analysis helps to understand the driving and dependence power of the risks in the banana supply chain. There are four groups in this analysis. Namely, autonomous, dependent, linkage and independent. These were also numbered as region one to four respectively in Figure 3 (Kumar et al., 2018).

There were no risks in the banana supply chain that falls into the autonomous region which is also called region one. The dependence cluster which is named as region two had Information risk (6)," "country's economic cycle (12)," "price or market risk (13)," and "management & operational risk (9)". These risks had high dependence and low driving power. The region three (linkage) had, "human & personal risk (1)," "risk of an increase in land prices (4)," "input risk (14)," and "agriculture policy risk (10)". This indicates that action taken to minimize these risks can affect other risks.

Risks such as "production risk (2)," "financial risk (3)," "biological & environmental risk (5)," "weather-related risks (8)," "political risk (7)," and "logistics infrastructure

Table 4. Drivers to Risks in Banana Supply Chain Partition.

Drivers(Di)	Reachability R(Di)	Antecedent A(Di)	Intersection R(Di) ∩ A(Di)
Level I			
1	1,4,6,9,12,14	1,2,3,4,5,8,10,11,14	1,4,14
2	1,2,4,5,6,7,8,9,10,12,13,14	2,3,11	2
3	1,2,3,4,5,6,7,8,9,10,12,13,14	3	3
4	1,4,6,9,12,13,14	1,2,3,4,5,7,8,10,11,14	1,4,14
5	1,4,5,6,8,9,10,12,13,14	2,3,5,8	5,8
6	6,9,12	1,2,3,4,5,6,8,9,10,11,13,14	6,9
7	4,7,9,10,12,13,14	2,3,5,7	7
8	1,4,5,6,8,9,10,12,13,14	2,3,5,8,11	5,8
9	6,9	1,2,3,4,5,6,7,8,9,10,13,14	6,9
10	1,4,6,9,10,12,13,14	2,3,5,7,8,10,11	10
11	1,2,4,6,8,10,11,12,13,14	7,11	11
12	9,12	1,2,3,4,5,6,7,8,10,11,12,13,14	12
13	6,9,12,13	1,2,3,4,5,7,8,10,11,13,14	13
14	1,4,6,9,12,13,14	1,2,3,4,5,7,8,10,11,14	1,4,14
Level II			
1	1,4,6,13,14	1,2,3,4,5,8,10,11,14	1,4,14
2	1,2,4,5,6,7,8,10,13,14	2,3,11	2
3	1,2,3,4,5,6,7,8,10,13,14	3	3
4	1,4,6,13,14	1,2,3,4,5,7,8,10,11,14	1,4,14
5	1,4,5,6,8,10,13,14	2,3,5,8	5,8
6	6	1,2,3,4,5,6,8,9,10,11,13,14	6
7	4,7,10,13,14	2,3,5,7	7
8	1,4,5,6,8,10,13,14	2,3,5,8,11	5,8
10	1,4,6,10,13,14	2,3,5,7,8,10,11	10
11	1,2,4,6,8,10,11,13,14	7,11	11
12	12	1,2,3,4,5,6,7,8,10,11,12,13,14	12
13	6,13	1,2,3,4,5,7,8,10,11,13,14	13
14	1,4,6,13,14	1,2,3,4,5,7,8,10,11,14	1,4,14
Level III			
1	1,4,13,14	1,2,3,4,5,8,10,11,14	1,4,14
2	1,2,4,5,7,8,10,13,14	2,3,11	2
3	1,2,3,4,5,7,8,10,13,14	3	3
4	1,4,13,14	1,2,3,4,5,7,8,10,11,14	1,4,14
5	1,4,5,8,10,13,14	2,3,5,8	5,8
7	4,7,10,13,14	2,3,5,7	7
8	1,4,5,8,10,13,14	2,3,5,8,11	5,8
10	1,4,10,13,14	2,3,5,7,8,10,11	10
11	1,2,4,8,10,11,13,14	7,11	11
13	13	1,2,3,4,5,7,8,10,11,13,14	13
14	1,4,13,14	1,2,3,4,5,7,8,10,11,14	1,4,14
Level IV			
1	1,4,14	1,2,3,4,5,8,10,11,14	1,4,14
2	1,2,4,5,7,8,10,14	2,3,11	2
3	1,2,3,4,5,7,8,10,14	3	3
4	1,4,14	1,2,3,4,5,7,8,10,11,14	1,4,14
5	1,4,5,8,10,14	2,3,5,8	5,8
7	4,7,10,14	2,3,5,7	7
8	1,4,5,8,10,14	2,3,5,8,11	5,8
10	1,4,10,14	2,3,5,7,8,10,11	10
11	1,2,4,8,10,11,14	7,11	11
14	1,4,14	1,2,3,4,5,7,8,10,11,14	1,4,14

Level V			
2	2,5,7,8,10	2,3,11	2
3	2,3,5,7,8,10	3	3
5	5,8,10	2,3,5,8	5,8
7	7,10	2,3,5,7	7
8	5,8,10	2,3,5,8,11	5,8
10	10	2,3,5,7,8,10,11	10
11	2,8,10,11	7,11	11
Level VI			
2	2,5,7,8	2,3,11	2
3	2,3,5,7,8	3	3
5	5,8	2,3,5,8	5,8
7	7	2,3,5,7	7
8	5,8	2,3,5,8,11	5,8
11	2,8,11	7,11	11
Level VII			
2	2	2,3,11	2
3	2,3	3	3
11	2,11	7,11	11
Level VIII			
3	3	3	3
11	11	7,11	11

risk (11)" fell into region four (also known as an independent). These risks therefore considered as the most significant risks in the banana supply chain since they drive the other risks. This phenomenon was also evident in the ISM model in Figure 2 where these risks were in the lower layers of the risk model.

We consider that this would help the administrators to take necessary measures to minimize the risks in the banana supply chain. It shall be emphasized that administrators, practitioners and farmers must take the required action to reduce these risks to improve the banana supply chain and increase the profit as well as the benefits to the customers. Also, the structural model we introduced can show the hierarchy of action needed to improve the performances of the banana by undertaking each risk considering the interrelationship among each risk as shown in Figure 3. Since there were no risks that fall into 'region one', none of the risks shown in the research can be disconnected. Therefore, the authorities should look into all risks that are identified from a holistic point of view. Additionally, the risks that are in 'region three' are high independence and driver power, therefore minimizing these risks can reduce the effect on them as well as the other risks such as the ones in 'region two' which can be influenced by them. Additionally, the risks that are in 'region four' of the MICMAC analysis diagram lie on the lower part of the ISM model (Figure 3). Therefore, minimizing such as production risk (2), logistics & infrastructure risks (11) and the financial risk (3), affect the whole banana supply chain. Moreover, administrators and managers can minimize these risks as the basis of all other risks.

This research explored the risks that are in the Sri Lankan banana supply chain. However, there were some limitations encountered during the research due to time and financial restraints. Accordingly, we could not compare the results of ISM against other available models such as Structural Equation Modeling (SEM), Pareto analysis or Failure Mode and Effects Analysis (FMEA). Additionally, there may be other risks that affect the banana supply chain. We call for future research in these areas. Although this research was only towards the banana supply chain, this model could be applied to other areas in agriculture in Sri Lanka as well as in other regions. Finally, we hope that the productive potential of the banana supply chain can be increased by minimizing these risks.

Conclusion

This study was initiated to find the risks that are available in the Sri Lankan banana supply chain. Accordingly, various agricultural risks were found through a literature survey and these were forwarded to a randomly selected sample of farmers, vendors and government-appointed agricultural officers. These represented all banana growing districts of Sri Lanka. Once the sample agreement was obtained, these risks were presented to a focus group to carry out the pairwise relationship among them whilst removing the transitive links. Afterwards, the data were analyzed through ISM according to their driving and dependence power. It was revealed that four risks are more significant than others. Minimizing or eradicating these four risks can influence other risks.

The administrators can take necessary action to discuss a methodology to minimize them throughout the supply chain. This study is significant to Sri Lankan banana supply chain since there is a 30% wastage of the crop from 'farm to fork'. This was the initial study carried out in Sri Lanka regarding agriculture using ISM methodology. This study can also be used in other countries in the region with the necessary adaptations.

References

Abeysekera T, Abeysekera S. (2008). Alternative supply chain management practices and the performance of marketing channels in fresh fruit and vegetable marketing in Sri Lanka, http://www.fao.org (accessed 27 October 2019).

AgStat. 2018. Centre, Socio-Economics and Planning, Peradeniya - Kandy Sri Lanka: Department of Agriculture, https://www.doa.gov.lk (accessed 12 April 2020).

AgStat. 2019. Centre, Socio-Economics and Planning, Peradeniya - Kandy Sri Lanka: Department of Agriculture, https://www.doa.gov.lk (accessed 28 February 2021).

Arvanitoyannis I, Mavromatis, A. (2009). Banana cultivars, cultivation practices, and physicochemical properties. Critical Review in Food Science and Nutrition 49: 113-135.

Attri R, Dev N, Sharma V. (2013). Interpretive structural modelling (ISM) approach: An overview. Research Journal of Management Sciences 2(2): 3-8.

Bennett E, Carpenter S, Gordon J, Ramankut N. (2014). Toward a More Resilient Agriculture. The Solutions Journal 5(5): 65-75.

Bo Y, Ping S, De-long D. (2014). Risk Assessment and Control of Agricultural Supply Chain on the Internet of Things. Journal of Industrial Engineering and Engineering Management 2014(03): 10-23.

CBSL. 2018. Monthly Price Bulletin, Colombo: Central Bank of Sri Lanka, https://www.cbsl.gov.lk (accessed 10 June 2020).

CBSL. 2019. Annual Report, Colombo: Central Bank of Sri Lanka, https://www.cbsl.gov.lk (accessed 3 may 2020).

Contre F, Goldin I. (1990). Agriculture and The Economic Cycle: An Economic and Econometric Analysis with Special Reference to Brazil, Brasília: OECD Development Centre. https://www.oecd.org (accessed 3 May 2020).

Crouhy M, Galai D, Mark R. (2006). The Essentials of Risk Management. McGraw Hill, New York.

DCS (2017). Agricultural Household Survey, Colombo: Department of Census and Statistics Sri Lanka, http://www.statistics.gov.lk (accessed 3 may 2020).

De Silva M, Kawasaki A. (2018). Socioeconomic vulnerability to disaster risk: A case study of flood and drought impact in a rural Sri Lankan community. Ecological Economics 152: 131-140.

Dolgui A, Ivanov D, Rozhkov M. (2020). Does the ripple effect influence the bullwhip effect? An integrated analysis of structural and operational dynamics in the supply chain. International Journal of Production Research 58(5): 1285-1301.

Ekanayake S, Bandara L. (2002). Development of banana leather. Annals of the Sri Lanka Department of Agriculture 4: 353-358.

FAO, 2020. Food and Agriculture Organization, http://www.fao.org (accessed 15 June 2020].

Gardas BB, Raut RD, Narkhede B. (2017). Modelling causal factors of post-harvesting losses in vegetable and fruit supply chain: An Indian perspective. Renewable and Sustainable Energy Reviews 80: 1355-1371.

Ghag S, Ganapathi T. (2017). Genetically modified bananas: To mitigate food security concerns. Scientia Horticulture 214(1): 91-98.

Hanson J, Dismukes R, Chambers W, Greene C, Kremen A. (2004). Risk and risk management in organic agriculture: Views of organic farmers. Renewable Agriculture and Food Systems 19(4): 218–227.

Hathurusinghe C, Vidanapathirana R, Rambukwella R, Somaratne T. (2012). A Study on Value Chain of Pineapple and Banana in Sri Lanka. (accessed 4 October 2018).

Huang J, Tzeng G, Ong C. (2005). Multidimensional data in multidimensional scaling using the analytic network process. Pattern Recognition Letters 26(6): 755–767.

IndexMundi. (2020). IndexMundi. https://www.indexmundi.com (accessed 9 June 2020).

ISO (2018). ISO 31000. Geneva, Switzerland: BSI Standards Limited.

Jaffee S, Siegel P, Andrews C. (2010). Rapid Agricultural Supply Chain Risk Assessment: A Conceptual Framework. The World Bank, World Bank. http://documents1.worldbank.org (accessed 6 July 2020).

Karunagoda K. (2004). Changes in labor market and domestic agriculture. Sri Lankan Journal of Agricultural Economics 6(1): 83-97.

Khan I, Rahman Z. (2017). Brand experience anatomy in hotels: An interpretive structural modeling Approach. Cornell Hospitality Quarterly 58(2): 165-178.

King R, Venturini L. (2014). Demand for quality drives changes in food supply chains, Chicago: Economic Research Service/USDA, Chicago (accessed 20 July 2020).

Kiriveldeniya K, Rosario H. (2020). Value chain actors, farm-gate price and farmer loyalty in strategic vertical coordination in the maize out-grower farming in Sri Lanka. The Journal of Agricultural Sciences - Sri Lanka 15(2): 154-172.

Komarek A, Pinto A, Smith V. (2020). A review of types of risks in agriculture: What we know and what we need to know. Agricultural Systems 178: 1-18.

Kudagamage C, Chandrasiri G, Razmy A. (2002). Analysis of long-term trends in the banana sector of Sri Lanka,

Annals of Sri Lanka. Annals of the Sri Lanka Department of Agriculture 4: 21-32.

Kumar P, Ahmed F, Singh R, Sinha P. (2018). Determination of hierarchical relationships among sustainable development goals using interpretive structural modelling. Environment, Development and Sustainability 20(5): 2119–2137.

Lin Y, Lin C, Yu H, Tzeng G. (2010). A novel hybrid MCDM approach for outsourcing vendor selection: A case study for a semiconductor company in Taiwan. Expert Systems with Applications 37(7): 4796-4804.

Muruganantham G, Vinodh S, Arun CS, Ramesh K. (2018). Application of interpretive structural modelling for analysing barriers to total quality management practices implementation in the automotive sector. Total Quality Management & Business Excellence 29(5-6): 524-545.

Nisansala W, Abeysingha N, Islam A, Bandara A. (2020). Recent rainfall trend over Sri Lanka 1987–2017. International Journal of Climatology 40(7): 3417-3435.

Ogboru I, Abdulmalik F, Park I. (2018). Government expenditure on agriculture and its impact on unemployment reduction in Nigeria: 1999 –2015. International Journal of Economics, Commerce and Management 6(3): 1-25.

Partane J, Kohtamäki M, Patel P, Parida, V. (2020). Supply chain ambidexterity and manufacturing SME performance: The moderating roles of network capability and strategic information flow. International Journal of Production Economics 221: 1-10.

Perera E, Weerakkody W. (2018). Determinants of Post-Retirement Employment in Sri Lanka. Kelaniya Journal of Management 7(2): 38-53.

Perming E. (2013). Paddy and banana cultivation in Sri Lanka - A study analysing the farmers' constraints in agriculture with a focus on Sooriyawewa D.S. division, Lund Sweden: Department of Physical Geography and Ecosystem Science Physical Geography and Ecosystems Analysis Lund University Sölvegatan.

Pfohl HC, Gallus P, Thomas D. (2011). Interpretive structural modelling of supply chain risks. International Journal of Physical Distribution & Logistics Management 41(9): 839-859.

Ratnasinghe G. (2003). Present status and future research need on banana nematodes in Sri Lanka. In Training Workshop on Enhancing Capacity for Nematode Management on Small-scale Banana Cropping Systems, Laguna, Philippines: INIBAP-AP, Los Baños.

Rosch S. (2018). United States Department of Agriculture-Economic Research Service. https://www.ers.usda.gov (accessed 9 October 2018).

Rosch S. (2019). United States Department of Agriculture Economic Research Service. https://www.ers.usda.gov (accessed 8 June 2020).

Salvia L. (2020). The restructuring of Italian agriculture and its impact upon capital-labour relations: Labour contracting and exploitation in the fresh fruit and vegetable supply chain of the Lazio Region, Central Italy. Agrarian Change 20(1): 98-112.

Sarananda K. (1999). Country paper - Sri Lanka, Report of the APO Seminar on Appropriate Postharvest Technologies for Horticultural Crops in Asia. Bangkok-Thailand, 230-236.

Shahzad M, Abdulai A. (2019). Production risk management in agriculture and farm performance in rural Pakistan: Role of adaptation to climate change. Agricultural & Applied Economics Association Annual Meeting, Atlanta, GA.

Shivantha K. (2020). Sri Lanka Mirror. https://srilankamirror.com (accessed 13 July 2020).

Sudarshan GM, Anand B, Sudulaimuttu MB. (2013). Marketing & post-harvest losses in fruits: Its implications on availability and economy-A study on pomegranate in Karnataka. International Journal of Management and Social Sciences 2(7): 34-43.

Sushil M. (2012). Interpreting the interpretive structural model. Global Journal of Flexible Systems Management 13(2): 87-106.

Wanigasundera W, Atapattu N. (2019). Extension reforms in Sri Lanka: lessons and policy options. In: Extension reforms in Sri Lanka: lessons and policy options. Babu S, Joshi P. eds. Academic Press, Washington DC, p. 79-98.

Wasala W, Dharmasena D, Disanayaka T. (2012). Physical characteristics and mechanical properties three commercially grown banana cultivars in Sri Lanka. Tropical Agricultural Research 24(1): 42-53.

Wasala W. (2014). Postharvest losses, current issues and demand for postharvest technologies for loss management in the main banana supply chains in Sri Lanka. Journal of Postharvest Technology 2(1): 80-87.

Weerasinghe W, Rajapaksha E, Gunawardena W, Samarakone T. (2020). Relationship between management practices and calf welfare in mid-country dairy farms in Sri Lanka. Tropical Agricultural Research 31(1): 103-113.

Wilson N. (1996). Supply chain management: a case study of a dedicated supply chain for bananas in the UK grocery market. Supply Chain Management: An International Journal 1(2): 28-35.

Zakharchenko O. 2017. Ecological risks in agriculture: Problem-oriented approach. Business, Management and Accounting 3(1): 12-18.