

Research materials for Simulation model for a sustainable food supply chain in a developing country

Step 1: Literature review

The systematic literature review conducted for this study followed the five-step process guidelines in Saunders et al. (2016: 108). These are 1) developing the review questions, 2) identifying the research area and generating a comprehensive list of potentially relevant research studies, 3) selecting and evaluating relevant research studies by explicit inclusion and exclusion checklists to assess research relevance initially by title and abstract and then by reading the full text of those not excluded, 4) analysing and synthesising the relevant research studies, and 5) reporting the results.

1.1. Developing the review questions

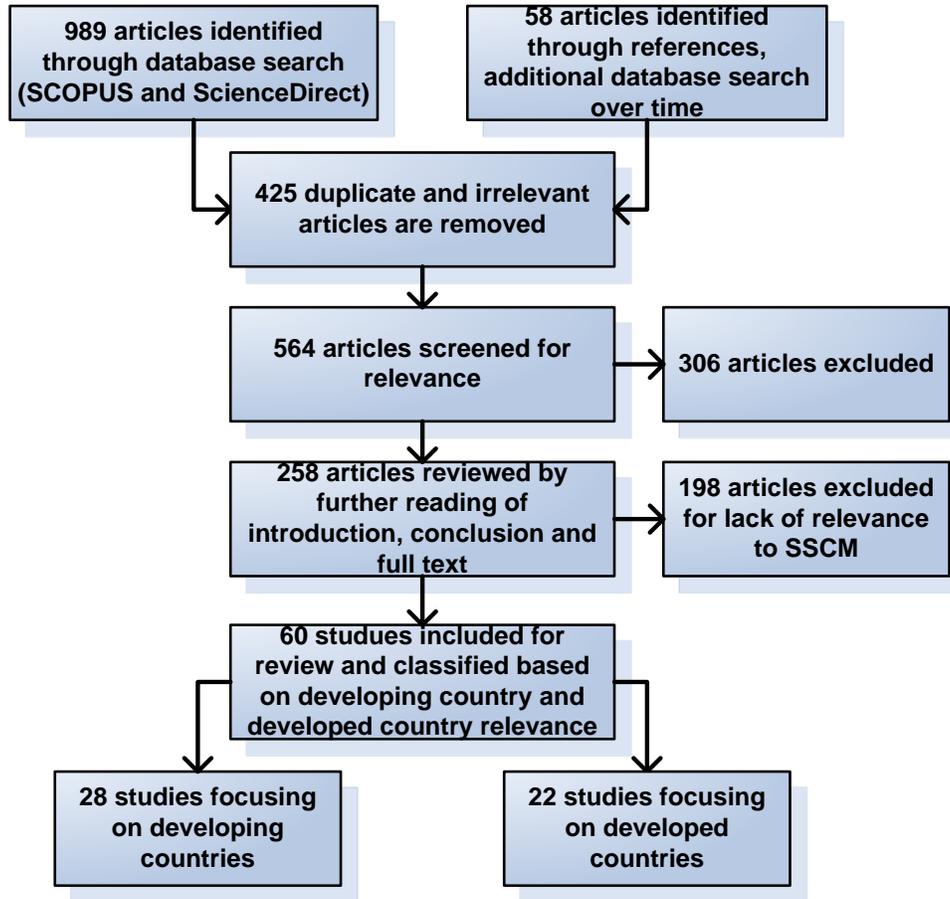
The review questions were developed as part of a PhD study and formed chapter 1. It involved preliminary informal interviews with several supply chain participants and policy makers and observation of the processes to get an overview of the current situation in the food cold supply chains. Notes on the challenges were taken and literature was searched to see the current research in the area.

1.2. Selecting and evaluating relevant research studies

Delimitation of the literature search was done through the use of keywords of the relevant constructs of the research questions: SSCM, and later, when specific categories of key SSCM elements were identified, the perishability and CC configurations, the food SCM and the application in developed and developing countries were included. Initially, papers published in the period ranging from 2001 to February 2021 were searched. This starting point was selected to cover the period within which issues of sustainability in perishable food management have progressively taken prominence. The search was initially performed on the SCOPUS and ScienceDirect databases using the following generic keyword strings:

1. ('supply chain*' OR 'value chain*' OR '*logistic*' OR '**demand* chain*') AND
2. ('sustainab*' OR 'green*' OR 'environment*' OR 'social*' OR 'economic*') AND
3. ('food' OR 'edible' OR 'agri*') AND
4. ('cold * chain*' OR 'perishable' OR 'short life' OR 'fruit*' OR 'vegetable' OR 'flower*' OR 'fresh') AND
5. ('developing*' OR '*nation*' OR '*developed*' OR 'underdeveloped*' OR 'non-industrial*')

An in-depth review using Atlas.ti 23 software resulted in a list of 60 articles that were more aligned to the subject. References from the filtered articles were used to find other relevant papers and as time lapsed, the databases were checked for more articles beyond the initial search period which led to 58 more articles reviewed (Figure 1).



Source: Author created

Figure 1: Literature search process map

1.3. Survey questionnaire

The following comprehensive questionnaire was used to get data from the participants. The questionnaire was developed based on the main CFs identified in the literature review and demographic data elements. The final questionnaire was a result of several refinements after trial surveys with sample participants and suggestions from experts in the field. The questionnaire used a four-point Likert scale with low, average, high and not applicable as selection options.

SECTION 1:

Introduction and demographic information

Please note that NA = Not applicable

Code	Type of Participant (Please select applicable)	1. Farmer	2. Transporter	3. Intermediary	4. Retailer	5. Other (specify)
A1.						
A2.	Location (district):					

A3.	Date (DD.MM. YYYY):	Start time:	End time:
A4.	Gender of participant:	Male	Female
A5.	Job category in Organisation/ Firm/Company/Farm:	Management or Owner	Operations
A6.	Work experience in this field: (Years):	1 - 5	6 - 10
A7.	Average size of Farm (Ha) (<i>not applicable (NA) if not a farm</i>):		

The following questions relate to your organisation. Please respond on areas that apply to your operations.

Code		1. Harvesting	2. Grading	3. Storage	4. Transporting	5. Retail	6 Other (Specify)
A8.	What operations do you do? (Tick applicable)						
A9.	How often do you perform your operation in a month?						
A10.	How much volume do you handle in a month (Kg)?						
A11.	Number of workers that provide the service						
A12.	Ideal number of workers required to provide the service						
A13.	Your monthly expenditure to provide service (Kwacha):						
A14.	The value of the product (Kwacha)						
A15.	How long does the activity take in hours						
A16.	At what temperature do you perform the operation?						
A17.	Which category is your supplier? (Select the applicable)	1. Farmer	2. Intermediary	3. Transporter	4. Retailer	5 Other (specify)	NA
A18.	To whom do you supply? (Select the applicable)		2. Intermediary	3. Transporter	4. Retailer	5 Other (specify)	NA

Rate of loss and waste

Please rate the amount of product loss and waste you experience during the operation(s) applicable to you.

NA = not applicable

Code	Operation	Amount lost/wasted (kg)	Scale			
			Low (1)	Average (2)	High (3)	NA
B1.	Harvesting					
B2.	Transferring					
B3.	Grading					
B4.	Storage					
B5.	Transportation					
B6.	Retailing					

B7.	How do you dispose of the wasted or lost bananas?	1. Landfill	2. Animal feed	3. Land application	4. Litter	5. Not harvested	4. Other (Specify)
B8.	Cost of disposal method (s) above (Malawi kwacha:)						
B9.	Do you try to reduce the waste or loss?					Yes (1)	No (0)
B10.	If Yes in above, please explain						
Comment:							

Product Management practice

How do you ensure the bananas are managed properly? Select all applicable.

1. Using refrigeration	2. Harvesting at right temperature	3. Harvesting at proper maturity stage	4. Using refrigerated Truck/Van	5. Transporting at right temperature	6. Using Proper packaging	7. Using proper storage	8. Grading	9. Other (please specify)
Comment:								

Production/Service Efficiency

Part 1: Quantitative

Code		Amount in Malawi Kwacha
D1.	What is your annual investment in relation to the banana business?	
D2.	What is your annual gross profit in relation to banana business?	
D3.	What are your annual expenses related to banana business?	
Comment:		
Code	Specific for transporting function	Response
D4.	What is the typical distance to the market (kilometre)	
D5.	How many types of transport do you use in one run? (e.g., if oxcart and truck = 2)	
D6.	How long does it take to load into the transport carrier? (In hour units)	
D7.	How long does it take to offload from the transport carrier? (In hour units)	
D8.	Cost of loading (Malawi Kwacha)	
D9.	Cost of unloading in (Malawi Kwacha)	
D10.	How long does it take to travel to the market?	
Comment:		

Part 2: Qualitative

Please rate the measures of Production Efficiency for your operations. NA = not applicable

Code		Scale			
		Low (1)	Average (2)	High (3)	NA
D11.	Return on investment				
D12.	Profit				
D13.	Delivery performance				
D14.	The ability to minimise distribution cost				
D15.	The ability to minimise storage cost				
D16.	The probability that product is accepted by customer				
D17.	The ability to reduce product waste and loss				
D18.	The ability to reduce waste of other resources (please specify)				
Comment:					

Innovation Capacity

Please rate the measures of Innovation Capacity in your operations. NA = not applicable

Code		Scale			
		Low (1)	Average (2)	High (3)	NA
E1.	Level of your external collaboration with partners regarding new ideas				
E2.	Your flexibility in marketing				
E3.	Promotion of your product/service				
E4.	Product pricing				
E5.	Product display				
E6.	Product disposal				
E7.	Other (specify and rate)				
Comment:					

Strategic capacity

Part 1: Measures of Strategic Capacity related to your operations.

F1.	Do you have the following goals or plans related to the banana business operation? Write Yes (1) or No (0)				
1. Financial	2. Production/ Service provision	3. Marketing	4. Market linking or access	5. Technology	6. Human Resource
Comment:					

Part 2: Please rate the measures of Strategic Capacity for your operations related to bananas. NA = not applicable

Code		Scale			
		Low (1)	Average (2)	High (3)	NA
F2.	Level of visibility in the whole supply chain				
F3.	Existing production or service capacity				
F4.	Existing communication capacity and infrastructure				
F5.	Existing storage capacity				
F6.	Existing transport infrastructure				
F7.	The overall effect of the states above on your operations. (<i>Select high if negative effect or low if positive effect</i>)				
Comment:					

Vertical Collaboration

Part 1: Please rate the measures of collaboration with your intermediaries. NA = not applicable

Code		Scale

		Low (1)	Average (2)	High (3)	NA
G1.	Trust in information acquisition from firms in the same business as you				
G2.	Level of knowledge dissemination among intermediaries				
G3.	Shared interpretation/decision making in business situation among intermediaries				
G4.	Sharing of organisation memory with intermediaries				
G5.	Alignment of incentives with intermediaries				
G6.	Strategic alliance with intermediaries				
G7.	Collaborative new innovative ideas and practices among intermediaries				
Comment:					

Part 2: Qualitative data

Code		Yes (1)	No (0)
G8.	Do you have permanent relationship with your intermediaries?		
		Written (1)	Verbal (2)
G9.	If yes, what is the nature of the relationship		
G10.	Any reason for the type of relationship?		
Comment:			

Horizontal Collaboration

Part 1: Please rate the following measures of Collaboration with your suppliers and customers. NA = not available

Code		Scale			
		Low (1)	Average (2)	High (3)	NA
H1.	Trust in information acquisition from your suppliers or customers				
H2.	Level of knowledge dissemination with your suppliers or customers				
H3.	Shared interpretation/decision making in business situation with suppliers or customers				
H4.	Sharing of organisation memory with suppliers or customers				
H5.	Alignment of incentives with suppliers or customers				
H6.	Strategic alliance with suppliers or customers				
H7.	Collaborative new innovative ideas and practices with suppliers or customers				

Part 2: Qualitative data

Code		Yes (1)	No (0)
H8.	Do you have permanent relationship with your suppliers or customers?		
		Written (1)	Verbal (2)
H9.	If yes, what is the nature of the relationship do you have?		
H10.	Any reason for the type of relationship?		
Comment:			

Knowledge and Skills

Please answer the following question on measures of SC Knowledge and Skills related to your operations.

I1.	Do you or other workers here have the skills and knowledge for managing the banana business in the following areas? Please write Yes (1) or No (0)				
	1. Supply Chain Management	2. Marketing and/or market linking	3. Communication channels or tools	4. Technologies for operation	5. Necessary infrastructure
I2.	What is the shelf life of bananas (in days)?				

Governance Support

J1.	Are there governance support tools or measures related to your operations in the following? Yes (1) or No (2)			
	1. National regulations and guidelines	2. International regulations and guidelines	3. Self-Regulation measures (Internal)	4. Self-Regulation (External)
J2.	Is there enforcement of the following in your firm?			
	1. Accountability	2. Justice	3. Social responsibility	4. Autonomy
Comment:				

Evaluation of barriers

Please rate the following factors associated with your operations. NA = not applicable

Code		Scale			
		Low (1)	Average (2)	High (3)	NA
K1.	The ability to manage uncertainty in the supply chain				
K2.	The ability to manage complexity of the supply chain				
K3.	The ability to manage risks associated with the banana business (e.g., risk of making losses)				
K4.	The standard of the work conditions				
K5.	The measures in place for health and safety associated with working in the banana sector				
K6.	Availability of water resources				
K7.	Availability of land resources				
K8.	The demand for the banana product				
K9.	The availability of Government support				
K10.	The availability of support from NGO or other donors				
K11.	The availability of competent workforce				
K12.	The level of capacity building				
K13.	The ability to deal with many middlemen (intermediaries) existing in the supply chain				
K14.	The ability to manage transportation and many transport iterations				

Code		Scale			
		Low (1)	Average (2)	High (3)	NA
K15.	The ability to manage customer requirements/expectations				
K16.	The availability of communication infrastructure and tools				
Comment:					

1.4. Data analysis

Exploratory factor analysis (EFA) and principal component analysis (PCA) were used to extract factors from the data collected. Only the items considered to have acceptable variability were maintained for the next step in the EFA. The final list of variable for analysis and the communality values are shown in the table 1

Table 1: Communalities for variables

Item	Extraction	Item	Extraction
Alignment of incentives with vertical firms	0.794	Management of risk is the SC	0.807
Availability of land resources	0.823	Management of the complexity of the SC	0.661
Availability of water resources	0.878	Management of transport and transport iterations	0.615
Capacity building	0.721	Management of uncertainty in the SC	0.738
Capacity in communication tools and infrastructure	0.685	Managing customer expectations	0.814
Capacity of existing storage	0.622	Measures for health and safety	0.722
Collaborative new innovative ideas with horizontal firms	0.799	Minimising distribution cost	0.803
Collaborative new innovative ideas with vertical firms	0.598	Minimising storage cost	0.747
Communication infrastructure and tools	0.805	NGO support	0.729
Competent workforce/labour	0.710	Probability of customer acceptance of product	0.705
Dealing with many intermediaries in the existing SC	0.789	Reduction of product waste and loss	0.714
Existing transport infrastructure	0.698	Service delivery performance	0.653
External collaboration with partners on new ideas	0.723	Shared interpretation/decision-making among vertical firms	0.779
Flexibility in marketing	0.691	Sharing of organisation memory with vertical firms	0.701
Government support	0.653	Standard of work conditions	0.756
Innovation capacity in product display	0.750	Strategic alliance with vertical firms	0.741
Innovation capacity in product disposal	0.671	Strategic capacity in existing production/service	0.653
Innovation capacity in product pricing	0.777	The overall effect of the state of operations	0.514
Innovation capacity in the promotion of product/service	0.743	Trust in information acquisition from horizontal firms	0.830
Knowledge dissemination among vertical firms	0.746	Trust in information acquisition from vertical firms	0.736
Knowledge dissemination with horizontal firms	0.837	Visibility in the whole SC	0.772
Level of demand for bananas	0.574		

Source: Authors' creation

The factor items converging in components were evaluated for internal consistency using Cronbach's alpha, a statistical measure to assess the internal consistency or reliability of a test or scale (Bujang *et al.*, 2018). A Cronbach's alpha score of over 0.7. is preferred (Taber, 2018). The scores in each component (Table 2) are higher than 0.7 suggesting a high average correlation between items in the components and hence, greater reliability.

Table 2: Rotated component matrix for items and Cronbach's alpha scores

Item description	Component					Cronbach's alpha score
	1	2	3	4	5	
Capacity building	0.782					0.945
Communication infrastructure and tools	0.792					
Competent workforce/labour	0.796					
Dealing with many intermediaries in existing SC	0.801					
Innovation capacity in the promotion of product/service	0.764					
Management of risk in the SC	0.862					
Management of the complexity of the SC	0.776					
Management of uncertainty in SC	0.838					
Managing customer expectations	0.832					
Standard of work conditions	0.769					
Alignment of incentives with vertical firms		0.862				0.925
Collaborative new innovative ideas with vertical firms		0.721				
Knowledge dissemination among vertical firms		0.809				
Shared interpretation/decision-making among vertical firms		0.838				
Sharing of organisation memory with vertical firms		0.774				
Strategic alliance with vertical firms		0.823				
Trust in information acquisition from vertical firms		0.806				
Collaborative new innovative ideas with horizontal firms			0.851			0.927
Knowledge dissemination with horizontal firms			0.923			
Trust in information acquisition from horizontal firms			0.913			
Capacity of communication tools and infrastructure				0.785		0.763
External collaboration with partners on new ideas				0.553		
Flexibility in marketing				0.817		
Visibility in the whole SC				0.728		
Availability of land resources					0.880	0.799
Availability of water resources					0.911	
Measures for health and safety					0.648	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalisation.

Rotation converged in 5 iterations.

The sustainability status of the researched banana SCs was assessed using the median and modal responses in the factor items loading in each component (Table 3).

Table 3: Status of researched banana SC by modal and median score

Factor	Item name	Valid	Median	Mode	Std. deviation
Governance Strategy	Capacity building	353	2.0	2	0.592
	Communication infrastructure and tools	353	2.0	2	0.599
	Competent workforce/labour	352	2.0	2	0.585
	Dealing with many intermediaries in the existing SC	348	2.0	2	0.583
	Innovation capacity in the promotion of product/service	353	2.0	2	0.691
	Management of complexity of the SC	353	2.0	2	0.649
	Management of risk in the SC	353	2.0	2	0.636
	Management of uncertainty in SC	353	2.0	2	0.609
	Managing customer expectations	346	2.0	2	0.644
	Standard of work conditions	352	2.0	2	0.566
Vertical Collaboration	Alignment of incentives with vertical firms	350	3.0	3	0.518
	Collaborative new innovative ideas with vertical firms	351	2.0	2	0.516

Factor	Item name	Valid	Median	Mode	Std. deviation
	Knowledge dissemination among vertical firms	347	3.0	3	0.512
	Shared interpretation/decision-making among vertical firms	351	3.0	3	0.523
	Sharing of organisation memory with vertical firms	350	2.0	2	0.544
	Strategic alliance with vertical firms	350	3.0	3	0.539
	Trust in information acquisition from vertical firms	349	3.0	3	0.500
Horizontal Collaboration	Collaborative new innovative ideas with horizontal firms	351	2.0	2	0.758
	Knowledge dissemination with horizontal firms	352	3.0	3	0.777
	Sharing of organisation memory with horizontal firms	352	2.0	2	0.793
	Trust in information acquisition from horizontal firms	352	3.0	3	0.783
Efficiency	Capacity in communication tools and infrastructure	352	3.0	3	0.654
	External collaboration with partners on new ideas	353	3.0	3	0.723
	Flexibility in marketing	353	3.0	4	0.929
	Visibility in the whole SC	350	3.0	3	0.782
Resilience	Availability of land resources	350	2.0	3	0.803
	Availability of water resources	352	2.5	2	0.834
	Measures for health and safety	349	3.0	2	0.612

Source: Authors' calculation

1.5. Simulation process

A selection of questions from the questionnaire were adapted to get the following information

- Total production cost defined as the costs associated with processing services, specifically banana transport from a farm to the customer's location
- Labour resources to run a process
- The time taken from harvesting to completion of sales at the case study company, including waiting time
- Total demand
- The shelf-life of the product determined by subtracting processing and transport time from the difference between the harvest day and the last day of marketable quality.
- The total number of products that exited the system to be available for customers.
- The total weight of products that left the system and were available for customers.
- The Wastage determined by subtracting the total harvested from the throughput.

The variables were programmed into Arena simulation software 2022 version.