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Humanitarian Food Logistics: Optimizing the Inventory Model of Corn Soya Blend (CSB) and Deterioration Rate by the World Food Program (WFP) Under the Conflict and Insurgency Controlled Areas

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Abstract:

The paper carefully examines malnutrition food supplements, the corn soya blend (CSB) distribution among children, and breastfeeding mothers in areas engulfed by conflict attacks. The vulnerable situation created by the Boko Haram Jihadists cannot be easily quantified or overemphasized. The deterioration rate of corn soya blend (CSB) is high due to the impact of climate, temperature, and storage facility. This situation also leads to a substantial rise in holding and ordering costs and the safety of WFP humanitarian workers, CBS consignments, and other essential items is crucial. This study attempts to develop an optimized inventory model for the distribution of corn soya blend (CSB) to enhance the performance of the WFP. An inventory model is developed to identify the optimality, a numerical analysis is conducted to assess the model's effectiveness, and a sensitivity analysis is performed to evaluate how changes in key parameters affect the optimal solution. This analysis helps demonstrate the model's reliability and highlights which parameters are most influential to the objective. The model can assist relief organizations in efficiently managing the distribution of supplies to conflict-controlled areas.

Keywords: Humanitarian, Logistics, CSB, WFP, Inventory management, Deterioration, Insurgency.

1. INTRODUCTION

The corn soya blend (CSB) is simply recognized as fortified blended food which is accepted and used all over the world. These food supplements called corn soya blend (CSB) are regarded as a ‘super cereal’ by the World Food Program (WFP) because of their rich contents of vitamins and nutrition values. The CSB is a pre-cooked food that consists of a mixture of corn and soya along with a small percentage of vitamins of international standard produced in powder form and can be conveniently consumed in the form of porridge/gruel/balls/ along with the African staple foods. The product can be effectively used to fight malnutrition as well as during emergency food substitutes during hunger and relief operations in conflicts, wars, disasters, and draught regions. The World Food Program (WFP), the largest nongovernmental organization focused on global humanitarian efforts, plays a leadership role in delivering relief and food aid to regions affected by conflicts and insurgency attacks. In 2020/21, the ongoing effects of the COVID-19 pandemic, combined with intensifying conflicts involving Boko Haram terrorists and rising global living costs, resulted in high records of hunger and malnutrition in the northeastern states of Nigeria. In areas where the World Food Program (WFP) operated, acute levels of malnutrition nearly doubled compared to prepandemic levels, because of conflicts and attacks from Boko Haram terrorists which have adversely affected and disrupted the supply chain, and food procurement costs. Despite these challenges, progress was made in advancing United Nations development system reforms aimed at helping the children and breastfeeding mothers of various internally displaced persons (IDPs) who are facing hunger and malnutrition. The violent sectarian group popularly called the Jihadist Boko Haram terrorists began its conflict with Nigerian security forces in early 2004. This conflict traced its roots to a dispute over fishing rights in a pond in Kanamma a village in Yobe state, Nigeria, shortly after the September 11, 2001, attacks on the World Trade Center. These events raised global concerns about insecurity and terrorism, particularly in democratic nations. The resulting instability, alongside other forms of socio-political unrest, contributed to the growth of insurgency attacks and organized crime in Nigeria, including the rise of Boko Haram. Over the past decade, Nigeria has faced severe challenges from Boko Haram insurgents, whose actions have devastated the northeastern region.

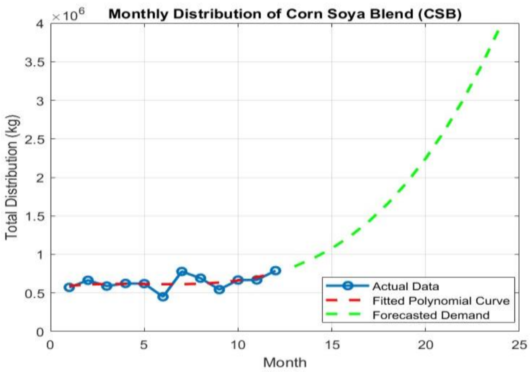
In this context, inventory management refers to the identification of defects, spoilage, damage, and expiration of corn soya blend (CSB) during both initial inspection and distribution of goods, products, and any raw materials meant for vulnerable children and breastfeeding mothers living in internally displaced persons (IDPs) camps affected by the Boko Haram insurgent attacks. This includes determining the economic order quantity (EOQ) for critical items, optimizing warehouse operations, and ensuring the timely distribution of supplies. Key considerations involve deciding when to reorder, how much to order, and how to minimize costs while ensuring effective and efficient food distribution to those in need. The importance of effective inventory management has spurred extensive research into models that address key challenges. These include EOQ models for temperature-sensitive and perishable items, strategies for managing imperfect quality, and policies for inventory control under conditions such as payment delays or inspection requirements. Researchers have also developed models that incorporate factors like price-dependent demand, preservation technologies, and competitive dynamics in global markets. Such insights are invaluable for optimizing inventory systems, particularly for organizations like the World Food Program (WFP), which operate in complex and high-stakes environments, temperature-sensitive and perishable items, strategies for managing imperfect quality, and inventory control policies in situations such as payment delays or inspection requirements. Researchers have also developed models that account for factors like price-dependent demand, preservation technologies, and competitive dynamics in global markets. These insights are essential for optimizing inventory systems, especially for organizations like the World Food Program (WFP), which operate in complex and high-stakes environments. Deterioration is defined as the loss of original value due to decay, spoilage, or degradation of goods during storage, mishandling during distribution, or damage of sacks in the process of distribution and on so many factors such as light, oxygen, moisture, microorganisms, and temperature, presents a significant challenge in inventory management and after initial inspections of goods such as corn soya blend (CSB), grains, rice, beans, etc. Also, the simple definition of deterioration in the context of medicine refers to biodegradation or pharmaceutical products and chemical companies as the expiration of overtime or loss of their value over time, while foodstuffs like corn soya blend (CSB), or wheat soya blend (WSB), grains, beans and rice suffer quality degradation during extended storage. Effectively managing the perishability of these items is crucial for developing reliable inventory policies. The demand forecasting method uses trend patterns of data collected from the field to predict future demand inventory. (Banomyong, Varadejsatitwong and Oloruntoba, 2019) A systematic review of humanitarian operations, humanitarian logistics and humanitarian supply chain performance literature 2005 to 2016. (Shrivastav and Bag, 2024) Humanitarian implementation plan (hip) strategic humanitarian supply chain and logistics. (Marciniak and Sienkiewicz-Małyjurek, 2022) Humanitarian supply chain – a bibliometric analysis and scientific landscape. (Behl and Dutta, 2019) Humanitarian supply chain management: a thematic literature review and future directions of research. (Costa, Campos and Bandeira, 2012) Supply chains in humanitarian operations: Cases and Analysis. (SINGH and KUMAR, 2018) Optimal ordering and replenishment policies for deteriorating items having a fixed expiry date with price and credit period sensitive demand under trade credit. (Yang *et al.*, 2024) An EOQ model for temperature-sensitive deteriorating items in cold chain operations. (Sindhuja and Arathi, 2023) An inventory model for deteriorating products under preservation technology with time-dependent quality demand. (Ferreira, Arruda and Marujo, 2018) Inventory management of perishable items in long-term humanitarian operations using Markov decision processes. (Sahoo *et al.*, 2021) Inventory management and its impact on the firm performance. (Paciarotti, Piotrowicz and Fenton, 2021) Humanitarian logistics and supply chain standards. Literature review and view from practice. (Priyadharshini, Jayasankari and Uthayakumar, 2024) Optimal inventory policies for deteriorating items with expiration dates and dynamic demand under two-level trade credit. (Buba M.T. Hambagda, 2024) Humanitarian food logistics: An inventory model for World Food Program (WFP) operations in Boko Haram-Controlled areas. (Jaggi and Singh, 2020) Inventory relief chain model with deterioration and disposal of relief commodity. (Gautam *et al.*, 2024) Investigating the impact of inflation on inventory systems: Time-Dependent quadratic demand, Time-Variable deterioration, and Shortage. (Önal, Kundakcioglu and Jain, 2020) An EOQ model with deteriorating items and self-selection constraints. (Zhong, Xu and Wang, 2017) Food supply chain management: systems, implementations, and future research. (Massimiliano, 2006) Inventory control policies for humanitarian logistics supply chain. (Rodman, 2004) Supply chain management in humanitarian relief logistics. (Tiwari *et al.*, 2018) Retailer’s optimal ordering policy for deteriorating items under order-size dependent trade credit and complete backlogging. (Mahato and Mahata, 2021) Optimal inventory policies for deteriorating items with expiration dates and dynamic demand under two-level trade credit. (Jaggi and Mittal, 2012) Retailer Ordering Policy for Deteriorating Items with Initial Inspection and Allowable Shortage Under the Condition of Permissible Delay in Payments. (Analysis, 2017) An inventory model for variable deteriorating pharmaceutical items with time-dependent demand and time-dependent holding cost under trade credit in healthcare industries. (Swami *et al.*, 2015) An inventory model for decaying items with Multivariate demand and variable holding cost under the facility of trade credit. (Jaggi and Verma, 2009) Retailer’s ordering policy for deteriorating items in a supply chain with varying deterioration rates. (Shah, Pareek and Sangal, 2016) Deteriorating Inventory model under permissible Delay in Payments and fuzzy environment. (R. Uthayakumar and A. Ruba Priyadharshini, 2024) Optimal strategy on inventory model under permissible delay in payments and return policy for deteriorating items with shortages. The research work focused on the humanitarian logistics supply chain with safety in warehouses. In real life, actual situations may vary with increasing or decreasing demand due to the time and nature of the disaster. Researchers' efforts have been made in the development of decision models related to problems in supply chains. In support of these models, they have been integrated with decision support systems and optimization of these models, the researchers aim is to introduce or demonstrate how mathematical analysis can be applied to develop optimal strategies for managing inventory systems. Once products deteriorate due to climate, temperature, spoilage, etc customer interest declines, prompting sellers to reduce prices before the product's shelf life expires. The goal is to create a reliable and cost-effective inventory model using data gathered from wholesale companies. A comprehensive inventory model has been developed that focuses on the actual monthly demand pattern. Additionally, a deteriorating inventory model for WFP foodstuffs has been proposed, incorporating a price-dependent demand rate and a time-proportional deterioration rate. The numerical solution indicated that the cost of military escort transportation is relatively high. This research aims to incorporate the military escort transportation cost and enhance the existing EOQ model for deteriorating items, while forecasting the monthly demand of internally displaced persons (IDPs), assuming a nonlinear demand. The structure of the paper is as follows: an abstract, followed by a combined introduction and literature review. Section 2 covers the model formulations, while Section 3 elaborates on the model. Sections 4 and 5 present the numerical solutions and sensitivity analysis of key parameters. Section 6 concludes the study.

2. MODEL FORMULATION

The data was obtained from a reliable desk staff of the World Food Program (WFP) and the auxiliary or ad-hoc staff in charge of the distribution of 1.5kg of corn soya blend (CSB) malnutrition food supplements to vulnerable children and breastfeeding mothers. The demand forecast is based on the data obtained. `

Distribution of Corn Soya Blend (CSB) Malnutrition Food Supplements for Breastfeeding Mothers and Children below 5 years of 1.5kg to each beneficiary from January 2020 to December 2020 Under the World Food Program (WFP).

MONTH	Total number of beneficiary	1.5kg Corn Soya Blend (CSB) for each person	Day 1 Distribution	Day 2 Distribution
Jan 2020	231,746	347,619	225,900	121,719
Feb 2020	258,002	387,003	278,642	108,361
March, 2020	257,379	386,063	204,610	181,453
April, 2020	244,022	366,033	258,880	107,153
May,2020	254,041	381,062	240,070	140,992
June, 2020	264,126	296,189	156,135	140,054
July, 2020	309,306	463,959	315,490	148,469
Aug 2020	303,818	455,727	236,978	218,749
Sept 2020	245,456	368,184	176,728	191,456
Oct 2020	273,559	410,339	258,513	151,826
Nov 2020	279,173	418,760	251,256	167,504
Dec, 2020	301,270	451,905	338,930	112,975



2.1. Notations and Assumptions

Retailer ordering policy and the deteriorating rates of inventory management of beans foodstuff distributions to internally displaced persons (IDPs) in the World Food Program (WFP) under the impact of Boko Haram terrorist-controlled areas.

2.1.1. Notations.

S/No.	Notations
C_p	It is considered as the purchasing cost per unit.
C_h	It is considered as holding cost per unit, per unit of time.
A	It is considered as ordering cost per cycle.
$S(t)$	It is considered an inventory level at any time.
T	It is considered as the length of each cycle (decision variable)
δ	It is considered a Deterioration rate constant and high
Do	It is considered as deterioration value per order per cycle.
SS	It is considered a safety stock.
TC	It is considered as the total inventory cost.
S_0	It is considered as the total ordered quantity.
Z	is the service level factor (1.65% for 95% $service$ $level.$)
σ_L	is the lead time demand variability (10% if monthly demand).
D	It is considered as demand rate $at^2 + bt + c$
Mf	It is considered as military escort logistics cost per unit per cycle.

2.1.2 Assumptions

(1). The lead time is negligible or merely zero.

(2). Shortage and back ordering are not allowed in this model.

(3). Replenishment is instantaneous.

(4). The time horizon of the inventory system is infinite.

(5). Deteriorated products are not replaceable or repairable.

3. MODEL DEVELOPMENT

In the current inventory system, $S(t)$ are stock level of corn soya blend (CSB) by the World Food Program (WFP) relief malnutrition food supplements for distribution, and the demand rate D, where T is the length of each cycle. We denote φ as the defective, spoiled, or damaged items during storage time. Figure II illustrates the behavior of inventory management.

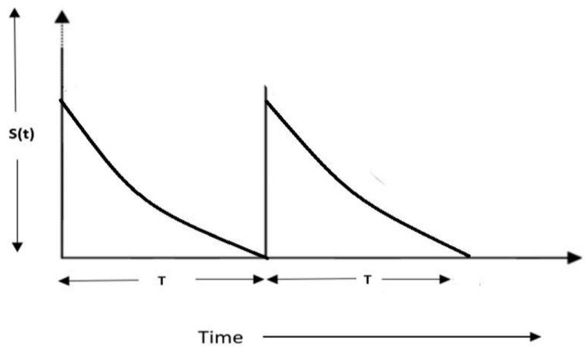


Figure II: Inventory Level at time t.

$$\frac{dI(t)}{dt} + \delta . S(\mathrm{t}) = -(at^3 + bt^2 + ct + d) \qquad 0 \leq t \leq T \qquad (1)$$

With boundary condition $S(0) = S_0 \, and \, S(T) = 0$

The solutions to equation (1) are obtained below.

$$S(t) = (\frac{-d\delta^3+C\delta^2-2b\delta+6a^2}{\delta^4} + \frac{t^2(3a-b\delta)}{\delta^2} - \frac{t^3a}{\delta} - \frac{t(c\delta^2-2b\delta+6a)}{\delta^3} - e^{\delta(T-t)}\left(\frac{-d\delta^3+C\delta^2-2b\delta+6a^2}{\delta^4} + \frac{T^2(3a-c\delta)}{\delta^2} - \frac{t^3a}{\delta} - \frac{T(c\delta^2-2b\delta+6a)}{\delta^3}\right) \quad (2)$$

Total Purchase Cost CP $= C_pS(0)$

$$CP = C_p\,(\frac{-d\delta^3+C\delta^2-2b\delta+6a^2}{\delta^4} - e^{\delta T}\left(\frac{-d\delta^3+C\delta^2-2b\delta+6a^2}{\delta^4} + \frac{T^2(3a-c\delta)}{\delta^2} - \frac{t^3a}{\delta} - \frac{T(c\delta^2-2b\delta+6a)}{\delta^3}\right)\ldots (3)$$

Total Deterioration Cost $DO = C_pD_0 = C_p\left(S(0) - \int_0^T D(t)dt\right)$

$$Do = C_p\left\{\frac{-d\delta^3+C\delta^2-2b\delta+6a^2}{\delta^4} - e^{\delta T}\left(\frac{-d\delta^3+C\delta^2-2b\delta+6a^2}{\delta^4} + \frac{T^2(3a-c\delta)}{\delta^2} - \frac{t^3a}{\delta} - \frac{T(c\delta^2-2b\delta+6a)}{\delta^3}\right) - \frac{T^4a}{4} - \frac{T^3b}{3} - \frac{T^2c}{2} - T.d\right\} \quad (4)$$

Ordering Cost CO$= \frac{A}{T}$

Inventory holding cost $CH = C_h\int_0^T S(t)dt.$

$$CH = \frac{-C_h}{12\delta^5}\{12b\delta(1-e^{\delta T}) - 72Ta\delta e^{\delta T} - 12c\delta^2 + (12c+24Tb+36T^2a)\delta^2e^{\delta T} + 12d\delta^3 - (12d+12Tc-12T^3a+12T^2b)\delta^2e^{\delta T} + (3T^4a-4T^3b+6T^2c+12Td)\delta^4\}$$
(5)

Military Escorts transportation $MF = M_fS_0$

$$MF = Mf(\frac{-d\delta^3+C\delta^2-2b\delta+6a^2}{\delta^4} - e^{\delta T}\left(\frac{-d\delta^3+C\delta^2-2b\delta+6a^2}{\delta^4} + \frac{T^2(3a-c\delta)}{\delta^2} - \frac{t^3a}{\delta} - \frac{T(c\delta^2-2b\delta+6a)}{\delta^3}\right)\ldots (6)$$

Safety Stock cost $SS = LC_hZ$.Type equation here.

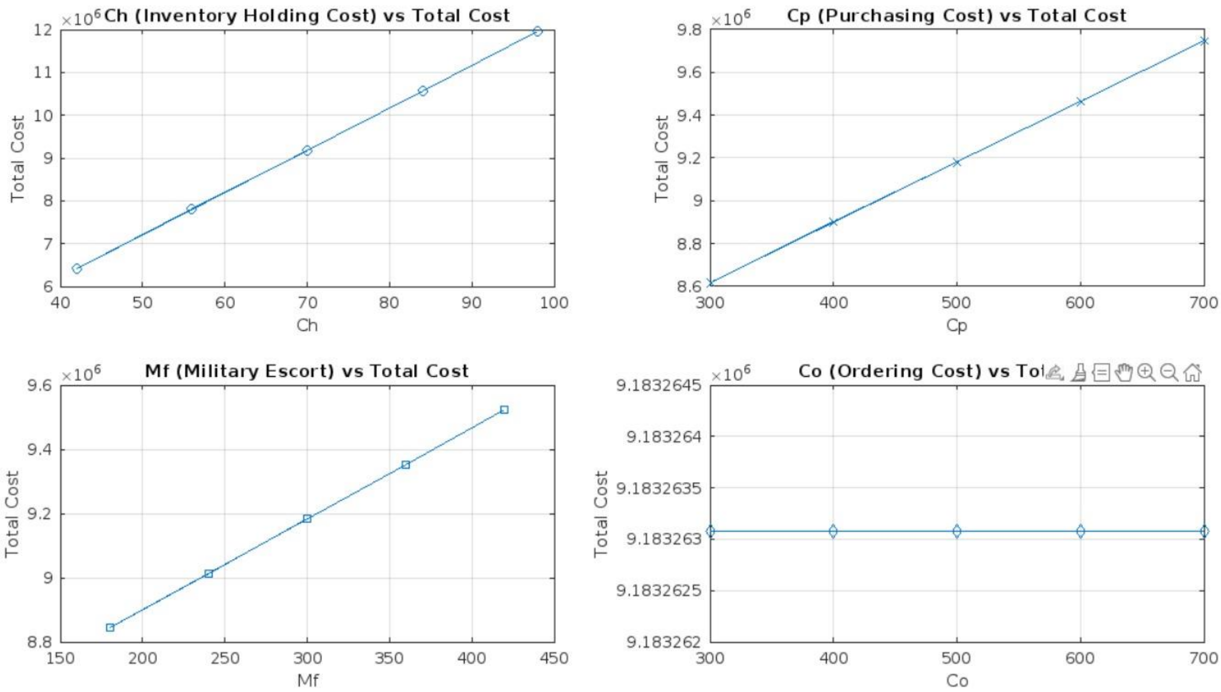
$TC(0,T)$ = Ordering Cost + Purchase Cost + Holding Cost + Deterioration Cost + Military Escorts Transportation Cost + Safety Stock Cost

$$TC(T) = \frac{1}{T}\{CO + CH + CP + DO + MF + SS\}$$

Hence, the total cost for the World Food Program (WFP) per cycle unit.

$$TC(0,T) = \frac{1}{T}\left\{Co - Cp\left\{Td + \frac{T^4a}{4} + \frac{T^3b}{3} + \frac{T^2c}{3} - \frac{-d\delta^3+c\delta^2-2b\delta+6a}{\delta^4} + e^{\delta T}(\frac{-d\delta^3+c\delta^2-2b\delta+6a}{\delta^4} + \frac{T^2(3a-b\delta)}{\delta^2} - \frac{T^3a}{\delta} - \frac{T(c\delta^2-2b\delta+6a)}{\delta^3}))\right. + (Cp+Mf)\left\{\frac{-d\delta^3+c\delta^2-2b\delta+6a}{\delta^4} - e^{\delta T}(\frac{-d\delta^3+c\delta^2-2b\delta+6a}{\delta^4} + \frac{T^2(3a-b\delta)}{\delta^2} - \frac{T^3a}{\delta} - \frac{T(c\delta^2-2b\delta+6a)}{\delta^3}\right\} + LC_hZ.\right\} \quad (7)$$

4. GRAPHICAL SOLUTIONS.



5. NUMERICAL SOLUTIONS.

The following parameters to do our numerical solutions.

C_h=70; a = 503.02; b = 7670.21; c = 36161.09; d=565048.64; δ=0.005; C_p=500; M_f=300; C_0=500; Z=1.15; L=0.15*d;

	%	T	T in Days	TC	Total Inventory
C_h	-40%	0.0050	0.1501	6414709.7571	180.9658
	-20%	0.0050	0.1501	7798986.4144	180.9658
	70	0.0050	0.1501	9183263.0717	180.9658
	+20%	0.0050	0.1501	10567548.4529	180.9658
	+40%	0.0050	0.1500	11949317.1066	180.9074
C_p	-40%	0.0050	0.1501	8617722.6854	180.9658
	-20%	0.0050	0.1501	8900489.2436	180.9658
	2500	0.0050	0.1501	9183263.0717	180.9658
	+20%	0.0050	0.1501	9466036.8999	180.9658
	+40%	0.0050	0.1501	9748810.7280	180.9658
M_f	-40%	0.0050	0.1501	8844066.0838	180.9658
	-20%	0.0050	0.1501	9013660.9428	180.9658
	300	0.0050	0.1501	9183263.0717	180.9658
	+20%	0.0050	0.1501	9352865.2006	180.9658
	+40%	0.0050	0.1501	9522467.3296	180.9658
C_0	-40%	0.0050	0.1501	9183263.0717	180.9658
	-20%	0.0050	0.1501	9183263.0717	180.9658
	500	0.0050	0.1501	9183263.0717	180.9658
	+20%	0.0050	0.1501	9183263.0717	180.9658
	+40%	0.0050	0.1501	9183263.0717	180.9658

6. CONCLUSION.

In this paper, we develop an inventory model of corn soya blend (CSB) distribution template by the World Food Program (WFP) in areas formerly under the control of terrorists in northeastern Nigeria. The model also considered the monthly forecast, procurement, and instantaneous replenishment to determine the required level of inventory management needed to satisfy the future demands of malnutrition children and breastfeeding mothers in various internally displaced persons (IDPs) camps. We provided numerical illustrations with some parameters and also carried out sensitivity analysis of several associated variables. Key findings include the following.

The impact of $C_p,\ C_h\ and\ M_f$ at $-40\%, -20\%$ led to a simultaneous decrease on TC without any effect on the total inventory, While C_o at $-40\%, -20\%$ on is static without any corresponding changes.

The impact of $C_p,\ C_h\ and\ M_f$ at $+20\%, +40\%$ led to simultaneous increase on TC and with stable and a static level of total inventory C_o without any effect.

The impact of parameters $\delta = 0.005$ having minimal influence. Effective management of and δ is essential for optimizing inventory performance.

REFERENCES.

[1] Analysis, A. (2017) ‘an Inventory Model for Variable Deteriorating’, 4(4), pp. 533–549.

[2] Banomyong, R., Varadejsatitwong, P. and Oloruntoba, R. (2019) ‘A systematic review of humanitarian operations, humanitarian logistics and humanitarian supply chain performance literature 2005 to 2016’, Annals of Operations Research, 283(1–2), pp. 71–86. Available at: https://doi.org/10.1007/s10479-017-2549-5.

[3] Behl, A. and Dutta, P. (2019) ‘Humanitarian supply chain management: a thematic literature review and future directions of research’, Annals of Operations Research, 283(1–2), pp. 1001–1044. Available at: https://doi.org/10.1007/s10479-018-2806-2.

[4] Buba M.T. Hambagda (2024) ‘Humanitarian Food Logistics: An Inventory Model for World Food Program (WFP) Operations in Boko Haram-Controlled Areas’, Communications on Applied Nonlinear Analysis, 31(6s), pp. 380–387. Available at: https://doi.org/10.52783/cana.v31.1230.

[5] Costa, S.R.A. da, Campos, V.B.G. and Bandeira, R.A. de M. (2012) ‘Supply Chains in Humanitarian Operations: Cases and Analysis’, Procedia - Social and Behavioral Sciences, 54, pp. 598–607. Available at: https://doi.org/10.1016/j.sbspro.2012.09.777.

[6] Ferreira, G.O., Arruda, E.F. and Marujo, L.G. (2018) ‘Inventory management of perishable items in long-term humanitarian operations using Markov Decision Processes’, International Journal of Disaster Risk Reduction, 31(May), pp. 460–469. Available at: https://doi.org/10.1016/j.ijdrr.2018.05.010.

[7] Gautam, R. et al. (2024) ‘Investigating The Impact of Inflation on Inventory Systems : Time- Dependent Quadratic Demand , Time-Variable Deterioration , and Shortage’, 31(7), pp. 660–669.

[8] Jaggi, C.K. and Mittal, M. (2012) ‘Retailer Ordering Policy for Deteriorating Items with Initial Inspection and Allowable Shortage Under the Condition of Permissible Delay in Payments’, International Journal of Applied Industrial Engineering, 1(1), pp. 64–79. Available at: https://doi.org/10.4018/ijaie.2012010106.

[9] Jaggi, C.K. and Singh, J. (2020) ‘Inventory relief chain model with deterioration and disposal of relief commodity’, Yugoslav Journal of Operations Research, 30(4), pp. 525–542. Available at: https://doi.org/10.2298/YJOR190310009J.

[10] Jaggi, C.K. and Verma, M. (2009) ‘Retailer’s ordering policy for deteriorating items in a supply chain with varying deterioration rates’, International Journal of Advanced Operations Management, 1(2/3), p. 250. Available at: https://doi.org/10.1504/ijaom.2009.030675.

[11] Mahato, C. and Mahata, G.C. (2021) ‘Optimal inventory policies for deteriorating items with expiration date and dynamic demand under two-level trade credit’, Opsearch, 58(4), pp. 994–1017. Available at: https://doi.org/10.1007/s12597-021-00507-7.

[12] Marciniak, D. and Sienkiewicz-Małyjurek, K. (2022) ‘Humanitarian Supply Chain – a Bibliometric Analysis’,

Organization and Management, 1(57). Available at: https://doi.org/10.29119/1899-6116.2022.57.5.
[13] Massimiliano, M. (2006) 'Inventory Control Policies for Humanitarian Logistics Supply Chain', (September 2009).
[14] Önal, M., Kundakcioglu, O.E. and Jain, S. (2020) 'An EOQ model with deteriorating items and self-selection constraints', Optimization Letters, 14(6), pp. 1491–1518. Available at: https://doi.org/10.1007/s11590-020-01566-3.
[15] Paciarotti, C., Piotrowicz, W.D. and Fenton, G. (2021) 'Humanitarian logistics and supply chain standards. Literature review and view from practice', Journal of Humanitarian Logistics and Supply Chain Management, 11(3), pp. 550–573. Available at: https://doi.org/10.1108/JHLSCM-11-2020-0101.
[16] Priyadharshini, A.R., Jayasankari, C. and Uthayakumar, R. (2024) 'Impact of Learning on Ordering Policy for Deteriorating Imperfect Quality Items with Promotion Dependent Demand, Partial Trade-Credit and Shortages', Indian Journal Of Science And Technology, 17(SPI1), pp. 21–33. Available at: https://doi.org/10.17485/ijst/v17sp1.143.
[17] R. Uthayakumar and A. Ruba Priyadharshini (2024) 'Optimal strategy on inventory model under permissible delay in payments and return policy for deteriorating items with shortages', Malaya Journal of Matematik, 12(01), pp. 71–84. Available at: https://doi.org/10.26637/mjm1201/006.
[18] Rodman, W.K. (2004) 'Supply Chain Management in Humanitarian Relief Logistics S'. Available at: https://scholar.afit.edu/etd/4012.
[19] Sahoo, A. et al. (2021) 'Inventory Management and Performance of Manufacturing Firms', International Journal of Value Chain Management, 12(2), p. 1. Available at: https://doi.org/10.1504/ijvcm.2021.10033598.
[20] Shah, N.H., Pareek, S. and Sangal, I. (2016) 'Deteriorating Inventory Model under Permissible Delay in Payments and Fuzzy Environment', pp. 77–99. Available at: https://doi.org/10.4018/978-1-4666-9888-8.ch005.
[21] Shrivastav, S.K. and Bag, S. (2024) 'Humanitarian supply chain management in the digital age: a hybrid review using published literature and social media data', Benchmarking, 31(7), pp. 2267–2301. Available at: https://doi.org/10.1108/BIJ-04-2023-0273.
[22] Sindhuja, S. and Arathi, P. (2023) 'An inventory model for deteriorating products under preservation technology with time-dependent quality demand', Cogent Engineering, 10(1), pp. 1–25. Available at: https://doi.org/10.1080/23311916.2023.2176968.
[23] SINGH, D. and KUMAR, N. (2018) 'Optimal Ordering and Replenishment Policies for Deteriorating Items Having a Fixed Expiry Date with Price and Credit Period Sensitive Demand under Trade Credit', Journal of Ultra Scientist of Physical Sciences Section A, 30(01), pp. 8–19. Available at: https://doi.org/10.22147/jusps-a/300102.
[24] Swami, A. et al. (2015) 'Inventory Model for Decaying Items with Multivariate Demand and Variable Holding Cost under the Facility of Trade-Credit', International Journal of Computer Applications, 113(11), pp. 18–28. Available at: https://doi.org/10.5120/19871-1858.
[25] Tiwari, S. et al. (2018) 'Accepted Manuscript'.
[26] Yang, M.F. et al. (2024) 'An EOQ Model for Temperature-Sensitive Deteriorating Items in Cold Chain Operations', Mathematics, 12(5), pp. 1–15. Available at: https://doi.org/10.3390/math12050775.
[27] Zhong, R., Xu, X. and Wang, L. (2017) 'Food supply chain management: systems, implementations, and future research', Industrial Management and Data Systems, 117(9), pp. 2085–2114. Available at: https://doi.org/10.1108/IMDS-09-2016-0391.