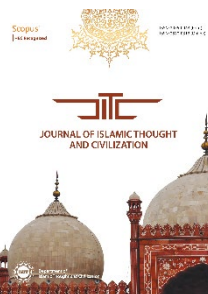
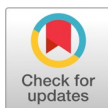


Journal of Islamic Thought and Civilization (JITC)

Volume 15 Issue 2, Fall 2025

ISSN(P): 2075-0943 ISSN(E): 2520-0313

Homepage: <https://journals.umt.edu.pk/index.php/JITC>



- Title:** Reviving Agricultural Finance via Islamic Contracts: Promoting Risk Management, Economic Empowerment, and Social Justice
- Author (s):** Mohamed Nafeel Mahboob^{1,2}, Fadillah Mansor¹, and Azian Bin Madun¹
- Affiliation (s):** ¹Universiti Malaya, Kuala Lumpur, Malaysia
²Bait Al-Mashura Finance Consultations Doha, Qatar
- DOI:** <https://doi.org/10.32350/jitc.152.05>
- History:** Received: November 12, 2024, Revised: May 23, 2025, Accepted: May 26, 2025,
Published: October 10, 2025
- Citation:** Mahboob, Mohamed Nafeel., Fadillah Mansor, and Azian Bin Madun. “Reviving Agricultural Finance via Islamic Contracts: Promoting Risk Management, Economic Empowerment, and Social Justice.” *Journal of Islamic Thought and Civilization* 15, no. 2 (2025): 72–95. <https://doi.org/10.32350/jitc.152.05>
- Copyright:** © The Authors
- Licensing:**  This article is open access and is distributed under the terms of [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/)
- Conflict of Interest:** Author(s) declared no conflict of interest



A publication of

Department of Islamic Thought and Civilization, School of Social Science and Humanities
University of Management and Technology, Lahore, Pakistan

Reviving Agricultural Finance via Islamic Contracts: Promoting Risk Management, Economic Empowerment, and Social Justice

Mohamed Nafeel Mahboob 

Jabatan Pengurusan dan Kewangan Islam,
Academy of Islamic Studies,
Universiti Malaya, Kuala Lumpur,
Malaysia

Bait Al-Mashura Finance Consultations,
Doha, Qatar

Fadillah Mansor 

Azian Bin Madun 

Jabatan Pengurusan dan Kewangan Islam,
Academy of Islamic Studies,
Universiti Malaya, Kuala Lumpur,
Malaysia

Abstract

Islamic finance provides a diverse range of contracts and concessions to address the financial needs of farmers. However, most Islamic financial institutions remain reluctant to fund agricultural projects despite having excess liquidity, primarily due to perceived financial risks, high uncertainty (*Gharar*), and limited risk-sharing mechanisms. As a result, many Muslim farmers struggle to access financing, confronting multiple challenges, such as high interest rates, stringent collateral requirements, and ethical or religious constraints. This paper examines the financial risks, uncertainties, and unique risks of selected Islamic agricultural finance contracts, namely *Salam*, *Muzara'ah*, and *Musaqah*. This study utilizes qualitative content analysis to examine the primary Islamic sources, the holy *Qur'an*, *Hadith*, classical jurisprudence, and *Hadith* commentaries. Indicatively, to define agricultural financing contracts, this study analyzes their structural features, establishes their permissibility, and assesses the implications of *Gharar* in the agricultural field. The findings suggest that integrating Islamic financial instruments with social finance mechanisms, such as combining *Salam* contracts with *Zakah* funds or implementing *Muzara'ah* and *Musaqah Sukūk*, can enhance financial inclusion, stabilize farmers' incomes, manage price volatility, and reduce wealth disparities. By promoting fair, risk-sharing financial models, these instruments enhance economic empowerment, social justice, and sustainable agricultural finance. Future research should pilot-test these contracts to refine their practical applications and offer innovative financial solutions for agricultural communities worldwide.

Keywords: agriculture, *Gharar*, *Musaqah*, *Muzara'ah*, risk management, *Salam*, *Sukūk*, religious studies and Islamic finance

Introduction

In risk, the distribution of results is known statistically through experience or a priori, whereas in uncertainty, it is impossible to quantify probabilities. Risk is the situation in which the distribution of results is known statistically through experience or a priori, whereas uncertainty is the situation where it is impossible to quantify probabilities; thus, imperfect information about the outcome of an

*Correspondence concerning this article should be addressed to Fadillah Mansor, Associate Professor, Jabatan Pengurusan dan Kewangan Islam, Academy of Islamic Studies, Universiti Malaya, Kuala Lumpur, Malaysia at fadillah@um.edu.my

action and probabilities-based actions are highlighted.¹ Harwood *et al.* discussed risk as an uncertainty that affects an individual's welfare and is frequently linked to adversities and losses.² Hence, it is the uncertainty that matters with the possibility of adverse events or losses: possible loss of money, potential harm to health, effects to resources, such as water, credit, and others. Uncertainty does not always imply complex situations only; however, it remains integral to understanding risk in complex situations. Risk embodies the potential adversity or failure that involves an individual's resilience and decision-making strategies in an unknown risk-centered situation.³

Hardaker interpreted risk in three different ways: (1) the chances of a negative result, (2) the variability of results (i.e. unstable outcome), and (3) the uncertainty of results.⁴ According to Bouslama and Lahrichi, despite the apparent ambiguity in the definition of the term risk, risk situations can be characterized by identifying different future situations and assigning them a probability of occurrence. In the case of uncertainty because of the complexity or opacity of a situation, the future of such a situation is unknown.⁵

The close term that stands for risk and uncertainty found in Islamic finance is *Gharar* which stems from the root term *Gharrara* and *Taghreer*. It means to put oneself in danger or risk and to expose someone, their money, or their property to destruction without even knowing it. The definitions of Muslim jurists for *Gharar* conclude in the following directions. The first definition limits *Gharar* to events whose occurrence is unknown, thus excluding unknown *Gharar* elements. For example, the definition of Ibn al-Abideen defines *Gharar* as doubt about the existence of the item being sold. Consequently, the second definition limits *Gharar* to the unknown, i.e., excluding something doubtful to happen from *Gharar*, whereas the third definition (of Ibn Hazm) combines the previous directions and makes *Gharar* comprehensive about the known and the unlikely.⁶ For example, Sarkhasi's definition of *Gharar* defines *Gharar* as something the outcome of which is hidden, and it is the opinion of most jurists. This definition was preferred and chosen by the award-winning expert scholar in *Gharar* related studies, the Late Professor Al-Dhareer, over other definitions because it contains all the jurisprudential particles discussed by the jurists under *Gharar*.⁷

Even though the holy *Qur'an* does not explicitly mention the term *Gharar*, it implicitly prohibits transactions that involve *Gharar* through verses emphasizing justice, transparency, clarity, fairness, and mutual consent in financial transactions. These verses have vividly and implicitly prohibited

¹Adam. M. Komarek, Alessandro De Pinto, and Vincent H. Smith, "A Review of Types of Risks in Agriculture: What We Know and What We Need to Know," *Agricultural Systems* 178 (2020): 102738, <https://doi.org/10.1016/j.agsy.2019.102738>; Joy Harwood et al., *Managing Risk in Farming: Concepts, Research, and Analysis* (Washington DC: U.S. Department of Agriculture, 1999).

²Harwood et al., *Managing Risk in Farming*.

³Kim Morgan et al., *Farm Financial Risk Management: Overview of Financial Systems for New and Beginning Farmers* (Virginia State University, 2016), <https://www.pubs.ext.vt.edu/AAEC/AAEC-114/AAEC-114.html>.

⁴John Brian Hardaker, *Some Issues in Dealing with Risk in Agriculture* (Working Paper, University of New England Graduate School of Agricultural and Resource Economics, Australia, 2000), accessed August 1, 2021, <http://www.une.edu.au/febl/EconStud/wps.htm>.

⁵Ghassen Bouslama, and Younes Lahrichi, "Uncertainty and Risk Management from Islamic Perspective," *Research in International Business and Finance* 39, (2017): 718–726, <https://doi.org/10.1016/j.ribaf.2015.11.018>.

⁶Siddiq Mohammad Al-Ameen Al-Dhareer, *Al-Gharar in Contracts and Its Effects on Contemporary Transactions* (Jeddah: Islamic Research and Training Institute, 1997), 10.

⁷*Ibid.*, 10.

contracts involving *Gharar*.⁸ “The Prophet (pbuh) forbade the sale of *Gharar*.”⁹ According to Imam Nawawi, the above hadīth, which is narrated by many of his companions, applies as the principle for *Gharar* in contracts.¹⁰ The hadīth gives three important determinations: prohibition of the sale of *Gharar*, the lifting of the sale of *Gharar* and all sales with *Gharar* are subject to prohibition and repeal.

Various methodologies can classify risks in agriculture and, from different perspectives; by its sources, probability of occurrence, and severity and correlation are three major methods found in the literature. Regarding sources of risks, there are five fundamental sources of risks faced by farmers: financial issues, production or yield, market or price, institutional policies and regulations, and human behaviors and errors (idiosyncratic). By the probability of occurrence, risk occurs at three layers: micro or individual farm level, meso or farm group level, and macro-level. Concerning the level of correlation, risks can be unique or completely independent at the micro-level, covariant at the meso-level, or perfectly correlated or systemic at the macro-level.¹¹

The central focus of this paper is to examine financial risks, specifically credit and market-oriented risks. Although the lack of funds and capital is among the major problems facing the agricultural sector,¹² when analyzing the financial risks in agriculture, financial risks commonly arise from the sources of production, such as exposure to extreme weather and disease shocks, from the need and the way farmers obtain capital and finance their farming activities and business operations. Thus, maintaining adequate cash flow levels to ensure the repayment of debt and other financial obligations and securing necessary loans for farming activities are vital to farming activity.

However, borrowing money introduces several risk factors, such as variability or volatility in borrowing rates, which can negatively affect borrowers' ability to borrow and their capacity to repay the capital. For instance, the default rate on leveraged loans in the United States recently reached to 7.2% in the 12 months leading up to October 2024, marking the highest rate since 2020. Elevated interest rates account for this surge in defaults, increasing borrowing costs and straining borrowers'

⁸See for instance, al-Baqarah 2:188 which implies the prohibition of transactions involving ambiguity, uncertainty, fraud, or deception, as such practices lead to unjust consumption of wealth; al-Nisa' 4:29 which highlights the importance of mutual consent and clarity in trade, prohibiting transactions that involve deception, ambiguity, or uncertainty (*Gharar*); and al-Ma'idah 5:90 which prohibits gambling (Maysir), which shares similarities with *Gharar* by involving uncertainty, chance, and speculation.

⁹Sulaymān ibn al-Ash'ath Abu Dawood, *Sunan Abī Da'ūd*, ed. Muḥammad Muḥyī al-Dīn 'Abd al-Ḥamīd (Beirut, Saīda: Al Maktabah Al Asriya, 1392 AH), hadīth no. 3376; Ahmad bin Al Shuaib Al Nasaci, *Al Sunan Al Kubra*, ed. Hasan & Abdul Mohsin Al Turki Al Shalbi (Beirut: Al Risala, 2001), hadīth no. 4626 and 4518; Muslim ibn al-Hajjaj, *Saheeh Muslim*, ed. Muhammad Fuad Abdul Baqi (Beirut: Dar Ihya' Al Thurath Al Arabi, 1388 AH), hadīth no. 1513 and Abu Isa Mohammad Ibn 'Eisa al-Thirmidhi, *Sunan Al Thirmidhi*, ed. Ahmad Muhammad Shakir and Muhammad Fuad Abdul Baqi (Egypt: Mustafa Al Babi Al Halabi, 1975), hadīth no. 1274.

¹⁰Al-Dhareer, *Al-Gharar in Contracts and Its Effects on Contemporary Transactions*, 9.

¹¹Klaus Maurer, “Where is the Risk? Is Agricultural Banking Really More Difficult than Other Sectors?” in Kohn, D. (Ed.), *Finance for Food: Towards New Agricultural and Rural Finance*, (Berlin, Heidelberg: Springer, 2014); Harwood et al., *Managing Risk in Farming*.

¹²Ahamad Faosiy Ogunbado, and Umar Ahmed, “Bay' Salam as an Islamic Financial Alternative for Agricultural Sustainability in Nigeria,” *Journal of Islamic Economics Banking and Finance* 11, (2015): 63–75, <https://dx.doi.org/10.12816/0024789>.

repayment capacity.¹³ Such challenges can lead lenders to become reluctant to extend credit or to impose stricter credit terms, thus making conditions unfavorable, particularly for farmers. Moreover, volatility in borrowing costs may lead to insufficient cash reserves or credit availability for production, potential loan recalls by lenders, adverse changes in exchange rates, and increased risks of insolvency or bankruptcy.¹⁴

Internal and external factors influence farm financial risks. Internal factors include, for instance, the creditworthiness of the farmers, cashflows, and management and control of the farm assets, uncontrolled family expenses and inadequate reserve of cash or credit for production, and unable to maintain capital equity from going bankrupt. External factors, for instance, include macroeconomic factors, such as farm regulations, supply and demand trends in the global markets, changes in financial markets, potential loan calls by lenders, adverse changes in the exchange rates, (price) risks, increased input costs, and changes in market values of collaterals that could ultimately affect the farmer's ability to maintain a profitable farming activity or farming enterprise.¹⁵

This paper advances existing research by moving beyond theoretical discussions and proposing practical Islamic financial solutions for agricultural financing, integrating Islamic social finance mechanisms with commercial models, and introducing innovative instruments. Embedded risk-sharing mechanisms in the selected Islamic finance contracts effectively addressed inherent agricultural risks and uncertainties (*Gharar*), thereby, promoting financial stability, economic empowerment, and social justice. Nevertheless, Islamic financial institutions, despite having excess liquidity, are hesitant to finance agricultural projects because of perceived financial risks. Consequently, there is a significant need for sustainable, *Shari'ah*-compliant financial solutions to address the financing gaps faced by Muslim farmers who cannot access conventional finance because of multiple hurdles, including high interest rates, stringent collateral requirements, and ethical and religious considerations. The research focuses on the under-explored feasibility and practical effectiveness of Islamic agricultural finance contracts and innovative financial instruments therein, with an aim to evaluate the permissibility, practicality, and risk mitigation capabilities of these contracts, comparing their effectiveness against conventional interest-based agricultural financing. Additionally, the study emphasizes how integrating Islamic financial instruments like *Salam* contracts with *Zakah* funds and implementing *Muzara'ah* and *Musaqah Sukuk* can support farmers' financial inclusion, sustainable income generation, and poverty alleviation. Furthermore, these Islamic contracts mitigate agricultural risks by stabilizing farmers' incomes, managing price volatility, and equitably distributing financial risks between landowners and farmers. Finally, the study highlights social justice by promoting fair financial practices, eliminating exploitative elements such as *Riba* and *Gharar*, supporting marginalized agricultural communities, and reducing economic disparities through equitable wealth distribution.

¹³Alan Livsey, and Harriet Clarfelt, "Defaults on Leveraged Loans Soar to Highest Rate in 4 years," *www.ft.com, The Financial Times Limited*, December 24, 2024, accessed March 8, 2025, <https://www.ft.com/content/e6ba508c-4612-4b4a-9a6b-ecde6fc91c12>.

¹⁴Sarah A. Drollette, "Managing Financial Risk in Agriculture," (Utah State, USA: Department of Applied Economics, Utah State University Extension, 2009), accessed December 14, 2021, <https://extension.usu.edu/apec/files/uploads/agribusiness-and-food/risk-management/risk-management-factsheets/Managing-Financial-Risk.pdf>; Satit Aditto, Christopher Gan, and Gilbert V. Nartea, "Sources of Risk and Risk Management Strategies: the Case of Smallholder Farmers in a Developing Economy," in *Risk Management - Current Issues and Challenges*, ed. Nerija Banaitiene (Intech Open, 2012), 449–474; Harwood et al., *Managing Risk in Farming*.

¹⁵Morgan et al. "Farm Financial Risk Management: Overview of Financial Systems for New and Beginning Farmers".

2. Literature Review

Farmers in developed countries face risks of market price volatility and loss of profit, organizations' stress level and poor decision making skills of the farm managers, weakness in the government monitoring mechanisms of the farm credit programs, excessive credits, swings in asset values,¹⁶ overconcentration on the problems of farm entities while neglecting the problems of farm people,¹⁷ conflicts on common agricultural fund management issues,¹⁸ effects of racial and gender bias on loan terms.¹⁹ Similarly farm firms have been facing many risks including crop price volatility, inconsistent crop yields, unpredictable costs of fertilizer, financial constraints in meeting the cash flow needs of farm operations and changes in the market value of farmlands²⁰ because of various reasons, including weather affects.²¹ As for financial institutions, they get affected by production risks, unfavorable government policies, loss of collateral values, legal risks, demographic risks of grey hair syndrome and unfavorable interest rates, etc.²² Researchers have found various approaches to risk management tools in the literature. Livestock Risk Protection (LRP) insurance,²³ a Sustainable Supply Chain model of contract combinations,²⁴ AgriStability to reduce the Business Risk of

¹⁶Jeremy Michael Gregory Cole, "Behavioural Determinants of the Adoption of Financial Price Risk Management Tools by Wheat Farmers in England," (PhD diss., The University of Reading, 2014).

¹⁷Nigel Purves, Scott James Niblock and Keith Sloan, "On the Relationship between Financial and non-Financial Factors," *Agricultural Finance Review* 75, no. 2 (2015): 282–300, <https://doi.org/10.1108/AFR-04-2014-0007>; Edward I. Reinsel, "Off-Farm Income of People Involved in Farming," *Journal of Agricultural and Applied Economics* 2, no. 1 (2015): 115–119, <https://doi.org/10.1017/S0081305200009900>.

¹⁸Gabriel Popescu et al. "The Financial Relationships between Farmers, Credit Institutions and Public Authorities - Short Review," *Ekonomika Poljoprivrede* 65, no. 1 (2018): 427–436, <https://doi.org/10.5937/ekoPolj1801427P>.

¹⁹Cesar L. Escalante et al. "Looking Beyond Farm Loan Approval Decisions: Loan Pricing and Nonpricing Terms for Socially Disadvantaged Farm Borrowers," *Journal of Agricultural and Applied Economics* 50, no. 1 (2018): 129–148, <https://doi.org/10.1017/aae.2017.25>; Chandra K. Dhakal, Cesar L. Escalante, and Charles Dodson, "Heterogeneity of Farm Loan Packaging Term Decisions: A Finite Mixture Approach," *Applied Economics Letters* 26, no. 18 (2019): 1528–1532, <https://doi.org/10.1080/13504851.2019.1584360>.

²⁰Shasha Li, "Financial Stress Test under Multiple Risks for Representative Farms of Central Illinois," (Master's Thesis, Purdue University, 2012), Purdue e-Pubs (AA11535051).

²¹Meagan G. Merritt et al., "Probability of Receiving an Indemnity Payment from Feeder Cattle Livestock Risk Protection Insurance," *Journal of Agricultural and Applied Economics* 49, no.3 (2017): 363–381, <https://doi.org/10.1017/aae.2016.44>.

²²Eric A. DeVuyst, et al., "Sources of Institutional Financial Risks in Agriculture," *Risk Education Publication Series*, Southern Risk Management Education Center, University of Arkansas System, (2013), accessed August 8, 2021. <https://www.uaex.edu/publications/PDF/srme01fs.pdf>.

²³Meagan G. Merritt et al., "Probability of Receiving an Indemnity Payment from Feeder Cattle Livestock Risk Protection Insurance".

²⁴Joshua R. Yoder et al., "Risk Versus Reward, a Financial Analysis of Alternative Contract Specifications for the Miscanthus Lignocellulosic Supply Chain," *Bioenergy Research* 8, (2015): 644–656, <https://doi.org/10.1007/s12155-014-9548-z>.

farmers,²⁵ and Diversification of activities by farm and off-farm sectors by rural households²⁶ are some examples proposed in developed countries.

A large body of work pertaining to the developing countries focuses extensively on conditions that limit and/or bar access to credit, such as unpleasant weather and socio-economic factors including literacy, experience, awareness of weather risks factors, income level and distance to financial institutions, etc.²⁷ Moreover, unfavorable government policies related to agricultural trade and the economic welfare of farmers lead them to be depressed with price distortions, import and export risks, and other crucial factors.²⁸ Microfinance institutions' operations in developing countries are challenged by inefficient policies, weak economic foundations of rural agricultural resources, poor agricultural infrastructure problems, less capital, poor management systems, and very relaxed government policies.²⁹

Many strategies have been proposed to deal with the financial risks pertaining to the developing world. For example, Shee *et al.* developed and piloted a credit model linked with Insurance for Kenya.³⁰ Römer and Musshoff studied the application of microfinance credit- scoring models to

²⁵Nicoleta Uzea et al. "Farm Support Payments and Risk Balancing: Implications for Financial Riskiness of Canadian Farms," *Canadian Journal of Agricultural Economics* 62, No. 4 (2014): 595–618, <https://doi.org/10.1111/cjag.12043>.

²⁶Jan Falkowski, Maciej Jakubowski, and Paweł Strawiński, "Returns From Income Strategies in Rural Poland," *Economics of Transition and Institutional Change* 22, no. 1 (2013): 139-178. <https://doi.org/10.1111/ecot.12032>.

²⁷Apurba Shee, Calum G. Turvey, and Liangzhi You, "Design and Rating of Risk-Contingent Credit for Balancing Business and Financial Risks for Kenyan Farmers," *Applied Economics* 51, no. 50 (2019): 5447–5465, <https://doi.org/10.1080/00036846.2019.1613502>; Yahuza Salisu, Ahmed Ibrahim Mohammed, and Anas Muhammad Yakub, "The Mediating Effect of Murabahah Financing on the Relationship between Farm Land, Farm Infrastructure and Agricultural Output in Nigeria," *International Journal of Management Research and Reviews* 7, no. 12 (2017): 1080–1089. <https://www.proquest.com/scholarly-journals/mediating-effect-murabahah-finance-on/docview/1992208983/se-2>; Diana Fletschner, Catherine Guirkingner, and Steve Boucher, "Risk, Credit Constraints and Financial Efficiency in Peruvian Agriculture," *The Journal of Development Studies* 46, no. 6 (2010): 981–1002, <https://doi.org/10.1080/00220380903104974>; Chandra S. Kumar, Calum G. Turvey, and Jaclyn D. Kropp, "The Impact of Credit Constraints on Farm Households: Survey Results from India and China," *Applied Economic Perspectives and Policy* 35, no. 3 (2013): 508-527, <https://doi.org/10.1093/aep/ppt002>; Shahab E. Saqib et al. "Factors Influencing Farmers' Adoption of Agricultural Credit as a Risk Management Strategy: The Case of Pakistan," *International Journal of Disaster Risk Reduction* 17, (2016): 67–76, <https://doi.org/10.1016/j.ijdrr.2016.03.008>.

²⁸Kym Anderson, "Agricultural Price Distortions: Trends and Volatility, Past, and Prospective," *Agricultural Economics* 44, no. 1 (2013): 163–171, <https://doi.org/10.1111/agec.12060>; Parmod Kumar Singhal, and Vivek Mittal, "PMFBY - A Financial Inclusion Initiative for Farmers Development," *International Journal of Business Ethics in Developing Economies* 6, no. 2 (2017): 39–43.

²⁹Mohammad Obaidullah, "Enhancing Food Security with Islamic Microfinance: Insights from Some Recent Experiments," *Agricultural Finance Review* 75, no. 2 (2015): 142–168, <https://doi.org/10.1108/AFR-11-2014-0033>.

³⁰Shee, Turvey, and You, "Design and Rating of Risk-Contingent Credit for Balancing Business and Financial Risks for Kenyan Farmers".

contribute to credit scoring accuracy in Madagascar.³¹ Duguma proposed engaging in farming activities with low-risk and guiding farm households to make informed decisions based on their risk tolerance while emphasizing the need to select appropriate risk management tools, such as selecting of crops based on their resilience, as identified in the Ethiopian context.³² Among the literary works found pertaining to Bangladesh, the proposal for complementary technological and financial innovative solutions for managing weather-related risks like weather-related insurance products and rice varieties that withstand water stress by Ward *et al.*, is significant.³³

Existing research on Islamic agricultural finance contracts, such as *Muzara'ah*, and *Musaqah*, has mostly focused on their practical applications, community benefits and economic welfare.³⁴ However, scholars have paid limited explicit attention to addressing financial risk, particularly managing the inherent uncertainty (*Gharar*) in these contracts. Recent literature addressing *Salam* financing has begun to fill this gap by explicitly discussing financial risks and their management through innovative hybrid models combining commercial and social financing. For instance, Kurniati *et al.* explicitly proposed the hybrid *Salam* model integrating *Wakalah* and *Shirkah* contracts to mitigate the inherent risks associated with traditional *Salam* financing, especially in volatile market conditions, such as those experienced during the COVID-19 pandemic.³⁵ Similarly, Majid proposes the *Salam-Muzara'ah* linked *Waqf* model, combining commercial and social Islamic finance mechanisms to mitigate risks associated with agriculture financing, addressing issues of limited capital and idle land use simultaneously.³⁶ However, discussions specifically targeting *Gharar* and financial risk mitigation within *Muzara'ah*, *Musaqah* and *Salam* contracts themselves remain relatively underexplored.

³¹Ulf Romer, and Oliver Musshoff, "Can Agricultural Credit Scoring for Microfinance Institutions be Implemented and Improved by Weather Data?" *Agricultural Finance Review* 78 (2018): 83–97, <https://doi.org/10.1108/AFR-11-2016-0082>.

³²Ashenafi Duguma, "The Role of Agricultural Cooperatives in Risk Management and Impact on Farm Income: Evidence from Southern Ethiopia," *International Journal of Economic Behavior and Organization* 4, no.4, (2016): 39–67, <https://doi.org/10.11648/j.ijebo.20160404.11>.

³³Patrick S. Ward *et al.*, "Demand for Complementary Financial and Technological Tools for Managing Drought Risk: Evidence from Rice Farmers in Bangladesh" (Paper presented at the *Agricultural and Applied Economics Association 2015 Joint Annual Meeting*, San Francisco, CA, July 26–28, 2015), International Food Policy Research Institute.

³⁴Khalishah Ulfah, and Muryani Aarsal, "Muzara'ah Contract of Farmer Perspective," *International Economics and Business Conference*, 1 no. 1 (2023): 235–240, <https://jurnal.amertainstitute.com/index.php/IECON/article/view/57>; Maulidah Narastri, "Muzara'ah in Efforts for Economic Prosperity: Between Patterns of Behavior, Improvements and Demands," *International Conference on Economic Business Management, and Accounting* 2, 474–480, <https://conference.untag-sby.ac.id/index.php/icoema/article/view/3028>; Mustika Lestrai Ramadani, Siti Kholis Napsiah, and Muhammad Nur Iqbal, "Muzara'ah, Musaqah And Mugharasah Contracts In Fiqh Muamalah," *Jurnal Multidisiplin Sahombu* 5, no. 1 (2025): 89–101; Eka Nurhalimatus Sifa, and Sudarso Kaderi Wiryono, "How Does Salam Financing Affect Farmers' Income? A System Dynamics Approach," *Journal of Islamic Accounting and Business Research* 15, no. 1 (2024): 119–135. <https://doi.org/10.1108/JIABR-02-2022-0042>.

³⁵Kurniati, Sunuwati, Muhammad Majdy Amiruddin, and Abdul Syatar, "Bay Al Salam as Financing Alternative During Pandemic Outbreak: A Proposal to Indonesia," *Academy of Entrepreneurship Journal* 27, no. 5S (2021): 1–7, <http://repository.uin-alauddin.ac.id/id/eprint/19738>.

³⁶Rifaldi Majid, "Designing Salam-Muzara'ah Linked Waqf to Financing Agricultural Sector," *Journal of Islamic Monetary Economics and Finance* 7, No.3 (2021): 503–526, <https://doi.org/10.21098/jimf.v7i3.1309>.

To address this gap and enrich the discussion, this paper undertakes an analysis of the *Sharī'ah* principles underlying the permissibility of selected Islamic agricultural finance contracts, *Salam*, *Muzara'ah*, and *Musaqah*. Specifically, by examining the foundational sources of *Sharī'ah* and the jurisprudential perspectives provided by Islamic scholars to better understand the theoretical and practical implications of these contracts. By focusing on these dimensions, this study aims to highlight both the need and the potential approaches for a more comprehensive management of financial risks within Islamic agricultural finance, thus rendering the identified research gap more substantial and accountable.

3. Research Methodology

This paper's objectives necessitated a data collection strategy centered on acquiring primary and secondary data, with a content analysis as the primary research technique. The primary data from the fundamental sources of the Holy Qur'ān and classical Hadīth and some jurisprudence books and hadīth commentary books, such as Al Bassam³⁷ and Al-Dhareer³⁸ were used. These sources were used to define the contracts, analyze their features, extract the proofs of their permissibility and related issues as well and analyze the texts related to *Gharar* that have come in connection with agriculture whether as *Salam*, or *Muzara'ah*, or *Musaqah* or any other forms of contracting.

The systematic review and synthesis of results from earlier studies to uncover patterns and insights relevant to the current research led to the adoption of content analysis. The significance of content analysis lies in its ability to provide a rigorous and structured approach to analyzing large volumes of qualitative data from various sources. By combining results from various studies, content analysis helps to identify consistent trends, contradictions, and gaps in existing literature, thereby offering a more comprehensive understanding of the topic. This method not only enhances the reliability of the research by triangulating data from different studies but also contributes to the practical applications.³⁹

This paper also examined various data, both in theoretical and empirical forms, collected for content analysis. The other secondary sources include books, journal articles, conference proceedings, and online sources related to uncertainty, risks and financial risks in agriculture, uncertainty and risk aspects of *Salam*, *Muzara'ah* and *Musaqah* contracts by coding and classifying them to derive the understandings of the approaches toward risk, uncertainty, risk taking, the permissibility of risk and uncertainty, their implications, risk and financial risk aspects of the contracts. The paper uses a qualitative approach, since no mathematical or statistical figures were used, in which the description of risk and uncertainty, its management from conventional and Islamic perspectives are discussed, together with the models for managing agricultural financial risk by farmers, farm firms and farm related financial institutions, representing both conventional and Islamic, are explored. This analysis highlights the advantages of Islamic models over conventional ones.

³⁷Abdullah Al-Bassam, *Tawdheeh Al Ahkam Min Al Buloogh Al Maram*, [Clarification of the provisions of Bulugh al-Maram] (Makkah: Maktaba Al Asadi, 1423 AH).

³⁸Siddiq Mohammad Al-Ameen Al-Dhareer, "al-Salam wa-Taṭbīqātuḥu al-Mu'āṣirah," [*Salam* and its Contemporary Practices], *Majallat Mujamma' Al Fiqh Al Islami Al Duwali* [Journal of the OIC Fiqh Academy] 9, (1991), <https://al-maktaba.org/book/8356/17703>. Accessed 17 July 2021; Al-Dhareer, *Al-Gharar in Contracts and Its Effects on Contemporary Transactions*.

³⁹Krippendorff, Klaus, *Content Analysis: An Introduction to Its Methodology*, 4th ed. (Los Angeles: SAGE Publications, 2018).

4. Results and Discussion

Islam encourages participation in agricultural activities and offers many contracts and options based on sharing risks, which can provide effective risk management strategies. Although most of the Islamic banks hold excess liquidity, however, they fail to implement *Shari'ah* compliant agricultural financial instruments to park funds for agricultural projects. Islamic agricultural finance contracts, which are particularly important sources for funding farmers in Islamic finance on both the small and large scales, allow these funds to be used to finance agricultural enterprises with higher profit-sharing than conventional agricultural loans. Therefore, Islamic finance contracts can play a vital role in enhancing risk management capabilities for financial institutions that provide agricultural finance globally. To build on this argument, the following sections will be elaborating on the potential application of the contracts of *Salam*, *Muzara'ah*, and *Musaqah* in the agriculture sector, supported by illustrations.

4.1. Innovative Application of *Salam* Contract

If *Salam*-based products are developed with innovation, the perceived risks can be mitigated. The classic form of *Salam* with innovation can be used to boost agricultural productivity, farmers' income, their standards of living, food security and exports, all of which benefit the country's economy and provide sustainability. Other benefits of *Salam* include financing without middlemen, price stabilization against seasonal price fluctuations and price protection against market price drops, promoting large-scale agriculture, providing an alternative loan choice to conventional financial institutions, protecting farmers from adversities and marketing expenses, providing hedging opportunities for buyer and seller, while protecting against revenue risk and price-indexed debts among other advantages. Concessions given by *Shari'ah* in *Salam* contract aimed to satisfy the economic and social needs of the poor, small and medium producers in the economy and being responsible for its growth.⁴⁰

4.1.1. *Zakah* Linked *Salam* Contract for Agriculture

Salam could also be used by linking *Zakah*'s funds into the process. Hossain *et al.*,⁴¹ in Bangladesh, provided a strategy as illustrated in (figure 1) to link *Zakah* with *Salam* contract. This suggested that a food bank will be set up with pooled *Zakah* funds for serving vulnerable people who will get food vouchers. The local smallholder farmers are engaged with the food bank to deliver target agricultural yields in the future. Through institutional demand, this strategy provides an opportunity to source food at a fair price, open doors to new markets, and provide smallholder farmers with a secure income.

⁴⁰Aishath Muneeza, Nik Nurul Atiqah Nik Yusuf, and Rusni Hassan, "The Possibility of Application of *Salam* in Malaysian Islamic Banking System," *Humanomics* 27, (2011): 138–147, <https://doi.org/10.1108/08288661111135135>.

⁴¹Ishrat Hossain *et al.*, "Support for Smallholder Farmers through Islamic Instruments: The Case of Bangladesh and Lessons for Nigeria," *International Journal of Islamic and Middle Eastern Finance and Management* 12, no. 2 (2019): 154–168, <https://doi.org/10.1108/IMEFM-11-2018-0371>.

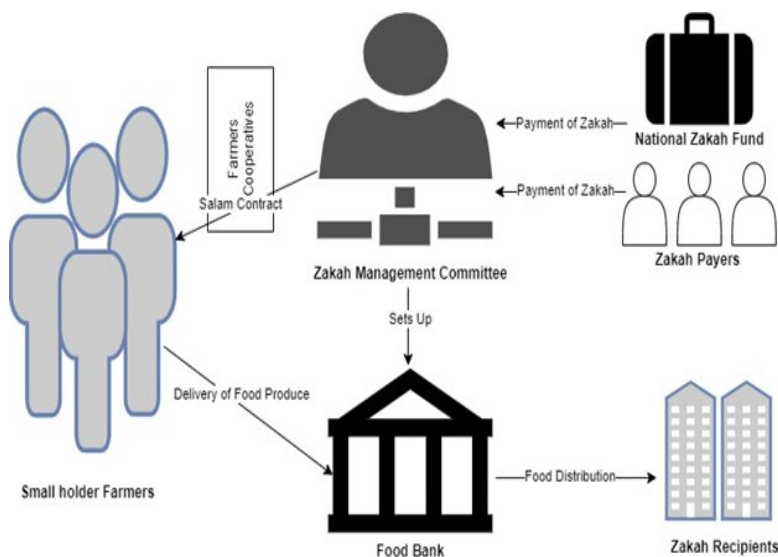


Figure 1. *Zakah Linked Salam Contract* (authors' own illustration based on the work of Hossain et. al.⁴²)

4.1.2. Parallel *Salam* Contract via Banks

Alternatively, for managing the suspected commodity risk faced by financial institutions, parallel *Salam* could be an important strategy. A bank enters into two separate contracts of *Salam* contracts: one with the farmer (seller) and another with the commodity buyer, who will purchase the object from the bank, thus playing the intermediary role between the two parties. Contracts with both parties must be completely independent of one another. Kaleem and Abdul Wajid⁴³ introduced three different models for *Salam* contract as given in figures 2-4, where the bank provides credit to the farmers under the first *Salam* contract, while bringing in a middleman (Model 1) or a mill (Model 2)

⁴²Ibid.

⁴³Ahmad Kaleem, and Rana Abdul Wajid, "Application of Islamic Banking Instrument (Bai *Salam*) for Agriculture Financing in Pakistan," *British Food Journal* 111, no. 3 (2009): 275–292. <https://doi.org/10.1108/00070700910941471>.

or a subsidiary firm (Model 3) to ensure the marketability of crops and execute the second *Salam* contract.

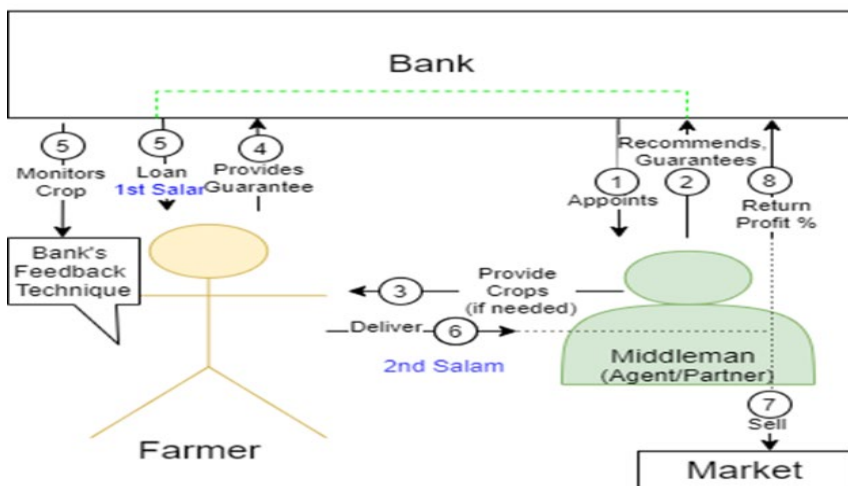


Figure 2. Functionality Model 1 of *Salam* and Parallel *Salam* (authors' own illustration based on the work of Ahmad Kaleem and Rana Abdul Wajid⁴⁴)

Nevertheless, the practical application of *Salam* and Parallel *Salam* contracts in modern times presented multiple challenges and issues. It includes the second buyer purchasing an object whose price has been paid but has not been delivered yet to the seller (i.e., bank for example). This constitutes a fundamental violation of *Shari'ah*, i.e., the nature of the transaction in *Salam* is a debt because the seller is obliged to deliver the commodity in the future, which creates a debt on their part, thus it is executed under the primary concessions applicable to *Salam*.

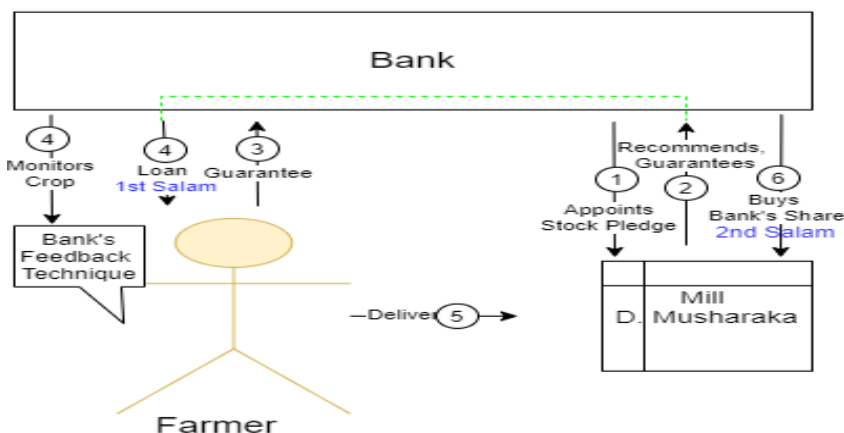


Figure 3. Functionality Model 2 of *Salam* and Parallel *Salam* (authors' own illustration based on the work of Ahmad Kaleem and Rana Abdul Wajid⁴⁵)

⁴⁴Ibid.

⁴⁵Ibid.

A parallel *Salam* contract could add to another controversy if the seller of the first *Salam* probably fails to deliver as promised. It is possible that the original buyer/bank could not deliver the commodities as agreed under the parallel *Salam* contract, contributing to the dispute and causing the legal bottleneck. However, this can be resolved by guarantees and collateral in place taken from and on behalf of the seller.

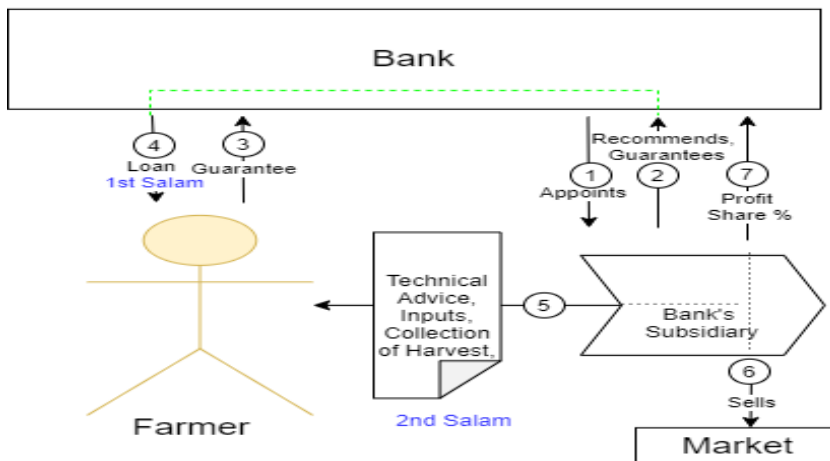


Figure 4. Functionality Model 3 of *Salam* and Parallel *Salam* (authors' own illustration based on the work of Ahmad Kaleem and Rana Abdul Wajid⁴⁶)

There is also another perceived problem with Parallel *Salam* that it could be easily turned into a promissory note produced from a single transaction and traded by different parties on different contract terms. Thus, the first seller (i.e., farmer) receives a disadvantageous financial position because a lower starting price would be required to be tradable with profits in the transaction that follows. Frequently, the farmer receives a guaranteed price that is much less than the prevailing market rate, perhaps in order to get financing from the bank, which prevents him from negotiating, resulting in the exploitation of the first seller and a complete nullification of *Shari'ah* law's purposes regarding *Salam* sale. Muslim economists argue this practice is similar to the interest-based loan because it compensates for time value of money and losses to the farmer because of advance prices. In spite of the fact that *Shari'ah* permits advance payments at a lower price than the current market price, a price risk management solution called *Band al Ihsan*⁴⁷ developed in Sudan, has been known to be effective in protecting and compensating both the banks and the farmers in cases of price fluctuations beyond certain threshold, either upwards or downwards.

Also, the current generation of Islamic financial institutions might not have adequate resources to participate in the commodities market, as there are very few or no commodity markets in most Islamic countries, whereas non-Islamic countries have standardized markets for commodities, which could disadvantage financiers who would have to compete with experienced middlemen, and with producers in order to trade commodities. Therefore, standardization and competitive disadvantage of

⁴⁶Ibid.

⁴⁷Adam B. Elhiraika, *On the Experience of Islamic Agricultural Finance in Sudan: Challenges and Sustainability* (Jeddah, KSA: Islamic Development Bank, 2003); Khalid M Mustafa Aburaida, "Rural Finance as a Mechanism for Poverty Alleviation in Sudan with an Emphasis on *Salam* Mode." *European Scientific Journal* 7, no. 26 (2014): 157–166.

the bank (buyer) over the middlemen in the Bai *Salam* contract poses a challenge to the sale, pricing, and marketability of commodities in the contract.⁴⁸

4.2. Innovative Application of *Muzara'ah* and *Musaqah* Contracts Integrated with *Sukūk*

Sukūk is more sophisticated and standardized instrument proposed to financing agriculture. It can provide a fixed rate of return and regular payments in order to provide the working capital, necessary property, plant and equipment and instruments required by agricultural units. AAOIFI has approved and issued several methods for *Sukūk* in its standard No. 17 including *Salam* (3/3), *Muzara'ah* (3/7) and *Musaqah* (3/8) related *Sukūk* for trading and investing.⁴⁹

Muzara'ah and *Musaqah* contracts have been categorized as forms of partnership contracts in farming for sharing agricultural product and loss (aPLS).⁵⁰ In *Musaqah* a share of what the trees produce is given, while in *Muzara'ah* a share of whole crops/plantation is the subject of the agreement. It is allowed to mix and match between *Musaqah* and *Muzara'ah* contracts. However, it is necessary to agree and include a term in the contracts of *Musaqah* and *Muzara'ah*.⁵¹ As such the following section will focus on the practical application of *Sukūk* in both *Muzara'ah* and *Musaqah* contracts.

4.2.1. *Muzara'ah Sukūk* (Farm-letting *Sukūk*)

Despite the *Muzara'ah* contract has been known as “a type of partnership contract where one party gives another a piece of agricultural farmland for a defined period so that he can work on it, and then the harvest is shared among them according to the conditions of the agreement”, however, the integration of *Sukūk* differs from the classical *Muzara'ah* contract. The operation model of *Muzara'ah Sukūk* is given in (figure 5).

⁴⁸Alagabi Abdghaffar Adedapo et al., “Bai *Salam* in the Light of Contemporary Application: Issues, Challenges and Recommendation,” (Paper presented at *Islamic Business Management Conference (IBMC)*, (Kuala Lumpur, August 18–19 2014). <https://www.researchgate.net/publication/318317523>.

⁴⁹AAOIFI, *Shari'ah Standards* (Bahrain, 2017). <https://aaoifi.com/shariah-standards-3/?lang=en>.

⁵⁰Muhammad Hakimi Mohd Shafiai, and Mohammed Rizki Moi, “Financial Problems Among Farmers in Malaysia: Islamic Agricultural Finance as a Possible Solution,” *Asian Social Science* 11, No. 4, (2015): 1-16, <http://dx.doi.org/10.5539/ass.v11n4p1>.

⁵¹Al-Bassam, *Tawdheeh Al Ahkam Min Al Buloogh Al Maram* [Clarification of the provisions of Bulugh al-Maram].

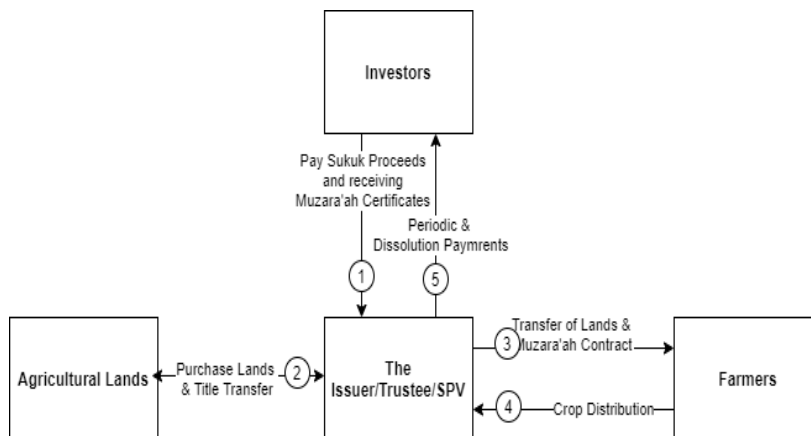


Figure 5. Operating Model of *Muzara'ah Sukūk* (authors' own illustration based on the data from the website <https://www.Sukūk.ir>⁵²)

The issuer of *Muzara'ah Sukūk* transfers the *Sukūk* and collects the money paid by the *Sukūk* owners (investors), then uses this fund to purchase agricultural land. On behalf of the investors, it then transfers these lands to farmers who work on them under the *Muzara'ah* contract, and at the end of the cultivation year, the crop will be distributed. In *Muzara'ah Sukūk*, the owners play the role of landowners, the issuer plays the function of attorney for the owners, and the farmers play the role of an agent in *Muzara'ah* contract. *Muzara'ah Sukūk* is deeds of joint ownership of certain agricultural lands by *Sukūk*-owners. This facilitates the enhancement of agricultural land, especially in the poor region, by taking uncertainty problems into account, which would create job opportunities and economic development. These alternatives are valuable in such regions where traditional financing may not be accessible.⁵³

4.2.2. *Musaqah Sukūk*

Musaqah Sukūk operates slightly differently from *Muzara'ah Sukūk*, and the operational flow is given in (figure 6). First, the *Sukūk* issuer transfers the *Sukūk* and collects the money paid by the *Sukūk* applicants, using this money to buy agriculture fields. The fields are subsequently given to farmers on behalf of the *Sukūk* owners, based on the *Musaqah* contract, to work on the lands, and later, the crop will be distributed.

⁵²Central Asset Management Capital Market, "Muzara'ah Sukuk (Farm-letting Sukūk)," accessed January 11, 2025, <https://www.sukuk.ir/sukuk/types-of-sukuk/farm-papers/>.

⁵³AAOIFI, *Shari'ah Standards* (Bahrain, 2017), <https://aaoifi.com/shariah-standards-3/?lang=en>; Central Asset Management Capital Market, "Muzara'ah Sukuk (Farm-letting Sukūk)," accessed January 11, 2025, <https://www.sukuk.ir/sukuk/types-of-sukuk/farm-papers/>.

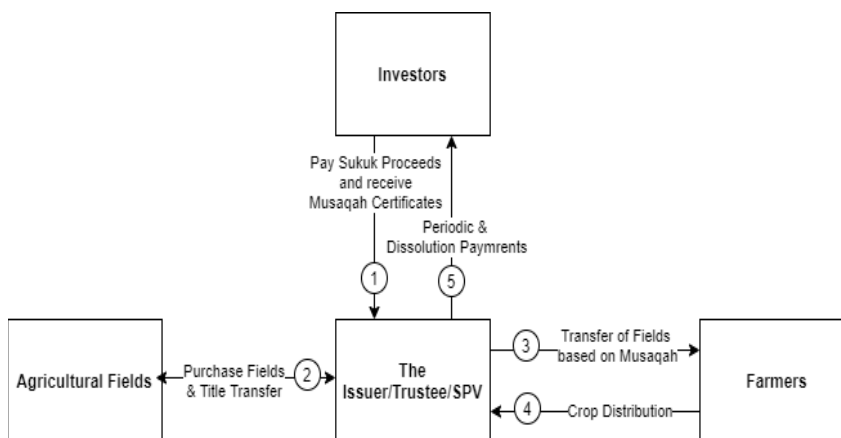


Figure 6. Operating Model of *Musaqa Sukuk* (authors' own illustration based on the data from the website <https://www.suku.ir>⁵⁴)

In the *Musaqa Sukuk*, the owners function as landowners, the issuer as an attorney, and the farmer as an agent in the *Musaqa* contract. The deeds of joint ownership of particular cultivated fields by *Sukuk*-owners are known as *Musaqa Sukuk*. This *Sukuk* also allows a *Shari'ah*-compliant and sustainable source of finance to the agriculture industry.⁵⁵ Especially looking into countries where farmers cannot operate because of financial constraints corresponding to the COVID-19 impact, the *Musaqa Sukuk* would help the farmers restart their operation by going into joint ownership of the fields and sharing the business risk. Therefore, the *Sukuk* could be used just more than uplifting the agriculture sector; however, helping the country depending on the primary sector to revive their economy in a sustainable mechanism in line with the Islamic principles and teachings.

5. Discussions

Islamic *Shari'ah* prohibits any transaction that involves interest, falsifying, speculation, fraud, risks or uncertainties that are unmanageable (*Gharar*), hegemony, greed, exploitation, unfairness, and the unjust taking of other people's money. Another significant feature of the Islamic financial system is that assets must back all funds issued.⁵⁶ Although multiple problems cause devastation in the agricultural sector, the financial problem is significant and leads to other issues. Thus, a solution for lack of funds could control other issues. The availability of adequate funding sources, for example, can contribute to the recovery of the agricultural sector, including modernization of agricultural machinery, improvement of processing and storage facilities, and other agricultural infrastructure.

In line with the findings of this study, two applications of *Salam* contract have been explained in the previous section. Undoubtedly, the issues related to capital and funds can be solved through the sale of *Salam*, which was practiced by the farmers in Madinah during the early Islamic era. Since

⁵⁴Central Asset Management Capital Market, "Musaqa Sukuk (Irrigation Sukuk)," accessed January 11, 2025, <https://www.sukuk.ir/sukuk/types-of-sukuk/employment-papers/>.

⁵⁵Ibid.

⁵⁶Rohana Othman et al., "Islamic banking: The Firewall against the Global Financial Crisis," *Journal of Applied Business Research* 28, no. 1 (2012): 9–14. <https://doi.org/10.19030/jabr.v28i1.6679>.

the commodity risk has been a key obstacle in implementing *Salam* based financing, a Parallel *Salam* sale with a commodity dealer or a third party can be used to mitigate the commodity risk of financier.

Salam financing constitutes many risk mitigating techniques in agriculture and agricultural financing. It saves from interest risk being an alternative instrument for interest bearing loans; thus, *Shari'ah* compliance is maintained by individuals and institutions. It also helps mitigate market risk, price risks and revenue or income risk saving farmers from adversity, additional marketing expenses and price volatility by giving stability in price and in income with the direct involvement of the financier, whether as an investor, or as a buyer or as a fund provider, farmers can avoid middlemen risk as well through *Salam* financing.

Financial contracts embedded with *Gharar*, and uncertainty are subject to specific considerations regarding the level of *Gharar* and uncertainty therein. The permissibility or tolerance of uncertainty and risk in the contracts and/or the prohibition of the same are determined by the level of *Gharar* contained thereupon.

In *Salam* sales, moving the price to an unknown date or selling an item that is unlikely to exist when due are relevant examples of a major *Gharar*. However, suppose there exists a legitimate need, whether public, private, or personal, for such a contract of major *Gharar*, while all other legitimate means to reach the need are obstructed. In that case, the *Gharar* is tolerated, and the contract shall not be considered as prohibited because of major *Gharar*. *Salam* contracts are permitted, because the farmer needs them, despite the *Gharar* in it, according to the opinion of most jurists. This demonstrates that the *Shari'ah*'s aim of meeting the economic and social needs of the poor, thereby ensuring the prevalence of social justice.

However, it is noteworthy that the *Salam* sale contract in agriculture has not been permitted in *Shari'ah* with a free hand. A farmer cannot sell all that his land or tree will produce neither before planting, nor after planting but before harvesting and becoming fit for sale, neither conditional sale on getting harvest, nor confirmed sale with guaranteed crop regardless of the status of its harvest. These forms of sales are prohibited in Islamic jurisprudence.

Some of them have no room for scholars to maneuver because of clear *Shari'ah* prohibitions (e.g. hadith that forbids selling fruit before it becomes good⁵⁷ besides the general prohibition of *Gharar* that is present in both cases referred above; when conditional sale the quantity of a sold item is not known, when the confirmed sale, existence of the sold item is doubtful and *Gharar* (uncertainty) in its quantity if exists. Unlike selling something that may or may not be available in the future, selling an item which will be most likely to exist according to customs and practices is acceptable in *Shari'ah*, where *Salam* sale is applicable.

The sale of objects that may or may not exist in future is non-permissible. However, this can be permitted exceptionally within narrow limits and if there was any hardship and embarrassment in the postponement of such sale until the existence of those things or their existence becomes more real. For example, sale of what has not appeared yet from the melon etc., with what has already appeared in good condition.⁵⁸ Hence, it is understood that the notion of necessity leads to tolerance even with some major risks and permissibility, which means Islam encourages taking and managing risks rather than avoiding risks.

While scholars agree that the small *Gharar* is negligible and the large *Gharar* is forbidden, they disagree on the status of the medium level *Gharar* and its effect on relatively large transactions. Sale

⁵⁷Ibn 'Umar reported that Allah's Messenger (pbuh) forbade the sale of fruits until they were clearly in good condition, he forbade it both to the seller and to the buyer (*Sahih Muslim*, Book 10 (KITAB AL-BUYU'), Number 3665)

⁵⁸Al-Dhareer, *Al-Gharar in Contracts and Its Effects on Contemporary Transactions*.

of what lies on the ground, sale of plants that are there one after another, *Muzara'ah* and *Musaqah* contracts are examples. The part of the harvest received by the landowner in these contracts cannot be predetermined. Therefore, these types of *Gharar* are treated as non-avoidable.⁵⁹

There are many precedents in *Shari'ah* law showing tolerance with *Gharar* when prioritizing farmers' needs. Permissibility of *Ariyyah*⁶⁰ Sale as an exemption from the prohibited transaction of *Muzabanah*⁶¹, permissibility to give fruits as gift before it becomes ripen, permissibility to make a will for the fruits while on the tree (the bequest of the non-existent), overall negligibility of *Gharar* in non-commutative or voluntary contracts, which is not permitted in commutative or exchange contracts according to all jurists, are further examples.

Apparently, the exemption of *Ariyyah* came solely for prioritizing the needs of poor farmers, the owners of *Ariyyah* those who do not have anything to buy fresh dates, neither gold nor silver, other than dry dates. *Gharar* is forgiven because there is a genuine need to sell. All jurists agree that the effect of *Gharar* in non-commutative contracts, such as gift, is less than its effect in commutative contracts; however, they differ in the extent of this effect. The Shafi'is hold the strictest opinion on the impact of *Gharar* on contracts. In contrast, the Malikis are the most lenient in the impact of *Gharar* on contracts, which is the most correct approach according to Al-Dhareer.⁶²

Hence, Islamic law has offered a clear boundary between the prohibition of *Gharar* versus tolerance of *Gharar* and a clear understanding of the *Sharī'ah*'s perception in offering certain exceptions to the prohibition of *Gharar* or risks in contracts. Some contracts have been allowed because of their *Gharar* embedded nature. In contrast, other contracts have been allowed based on need and necessity arising from such contracts. Contracts that have been embedded with *Gharar* and allowed when such permission does not harm either of the parties. *Muzara'ah* and *Musaqah* contracts are good examples of this category where one party owns the land, and others cultivate or irrigate in exchange for a part of the harvest. This part cannot be predetermined.

On the other hand, exceptions arise from the need or necessity open some rooms for scholars to maneuver based on *Shari'ah* principles of "easing" or "avoiding difficulty", even to the extent of tolerating excessive *Gharar*, without invalidating such contracts.⁶³ Examples include *Salam* and other agricultural financing precedents. By granting concessions in the *Salam* contract, *Sharī'ah* aims to satisfy the economic and social needs of the poor, small, and medium producers, promoting inclusive economic growth. *Zakah*-linked *Salam* contracts, for instance, play a crucial role in uplifting marginalized communities by providing financial support to needy farmers, thereby contributing to social welfare. Similarly, *Muzara'ah* and *Musaqah* contracts embody Islamic

⁵⁹Al-Dhareer, *Al-Gharar in Contracts and Its Effects on Contemporary Transactions*; Ghassen Bouslama and Younes Lahrichi, "Uncertainty and Risk Management from Islamic Perspective".

⁶⁰This is a sale by which some trees in the garden that are dedicated for the use of poor. *Ariyya* Sale of a tree or two in which case the members of a poor farmer's family can get fresh dates for eating against the dry dates that they own is permitted exceptionally, provided that it does not exceed five *wasags* (i.e., 645kg), which he can sell to whomever he wants, to anyone who eats it fresh and to others. This is called *Ariyyah* or *Araya* sale.

⁶¹*Muzabanah* refers to the prohibition of selling fresh dates on palm trees, the prohibition of selling grapes in the vineyard for raisins, and the prohibition of selling crops before they are harvested. The reason for the prohibition in *ribawi* items, i.e., items sold by weight and measure, is the inequality and *gharar*, and in other than *ribawi* items the *gharar* arises as a result of not being able to verify the amount sold.

⁶²Al-Dhareer, *Al-Gharar in Contracts and Its Effects on Contemporary Transactions*.

⁶³Ghassen Bouslama and Younes Lahrichi, "Uncertainty and Risk Management from Islamic Perspective".

principles of social justice through equitable wealth distribution and cooperative agricultural development. The inherent risk-sharing nature of these contracts protects small farmers from financial uncertainties, preventing them from disproportionate burdens and reducing economic disparities. Islamic finance institutions, therefore, should actively utilize *Salam*, *Muzara'ah*, and *Musaqah*-based products to protect vulnerable farming communities.⁶⁴

6. Conclusion

The current research investigates the feasibility and effectiveness of Islamic agricultural finance contracts and innovative financial instruments. It highlights how Islamic finance caters for risk sharing, financial inclusion, and economic sustainability in agriculture. Additionally, this study highlighted the traditional *Salam* contracts, which help to mitigate agricultural risks and enhance food security, while innovative adaptations, such as *Zakah*-linked and Parallel *Salam* models, provide fair pricing, stabilize farmers' income, and expand market access. These innovations also manage commodity risks for financial institutions by ensuring crop marketability. Furthermore, *Muzara'ah* and *Musaqah* contracts facilitate equitable risk-sharing between landowners and farmers. Thus, showcasing that integrating these contracts with *Sukūk* can further drive agricultural development, employment, and sustainable finance, particularly benefiting vulnerable and crisis-prone regions.

6.1. Further Research Implications

To address critical financial gaps in agriculture, policymakers and financial institutions must facilitate the adoption of *Salam*, *Muzara'ah* and *Musaqah* contracts, which enhance income stability, manage risks, and promote ethical financial practices. These instruments align with faith-based principles while supporting resilience and growth for the agricultural sector.

Islamic finance embraces a pragmatic risk-tolerance approach, prioritizing economic and social necessities. The principle of necessity, allows contracts like *Salam* despite their inherent *Gharar* (uncertainty), highlights the value of proactively taking and managing risks rather than merely avoiding or transferring them, to support farmers' needs. Similarly, *Muzara'ah* and *Musaqah* contracts accept manageable uncertainties, underscoring Islam's emphasis on balancing risk mitigation with social justice and economic equity. Historical precedents in Islamic jurisprudence, such as the *Ariyyah* contract, further illustrate the Islamic legal tradition's adaptability in serving the genuine interests and welfare of vulnerable groups, particularly farmers and the economically disadvantaged. Moreover, from a theoretical perspective, Islamic jurisprudence schools' leniency toward specific risk-embedded contracts contributes to a richer, adaptable legal framework, emphasizing the necessity of balancing risk mitigation with the broader goals of social justice and economic equity.

However, this research was only limited to qualitative content analysis, which constrains its ability to provide empirical validation of the proposed financial models. Therefore, future research should explore the piloting of Islamic agricultural finance contracts in countries like Sri Lanka, where such facilities are either unavailable or inaccessible because of strict credit requirements. Studies could focus on innovative financing models that incorporate concessions and exemptions for uncertainty and risk, ensuring compliance with Islamic principles. Additionally, further research should assess the practicality of *Zakah*-linked *Salam* contracts, *Muzara'ah Sukūk*, and *Musaqah Sukūk* through quantitative studies with industry practitioners. Investigating the role of *Waqf* in agricultural finance can also be considered addressing farmers' financial challenges, mitigate high-interest and collateral issues, and provide a sustainable mechanism for the economically

⁶⁴Adedapo et al., "Bai Salam in the Light of Contemporary Application: Issues, Challenges and Recommendation".

disadvantaged. A study on generating Waqf for agricultural causes could further enhance its applicability.

Thus, a strategic adoption of Islamic financial instruments can strengthen agricultural resilience, support vulnerable farming communities, and promote sustainable and inclusive economic growth.

Author Contribution

Mohamed Nafeel Mahboob: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Resources Visualization, Writing Original Draft. **Fadillah Mansor:** Funding Acquisition, Data Curation, Project Administration, Supervision, Validation, Writing-review & Editing. **Azian Bin Madun:** Funding Acquisition, Resources Supervision, Validation, Writing-review & Editing.

Conflict of Interest

The author has absolutely no financial or non-financial conflict of interest regarding the subject matter or material discussed in this manuscript.

Data Availability Statement

The data associated with this paper is available from the authors upon request.

Funding Details

This research is associated with Universiti Malaya (UM) research projects, APIUM Research PV039-2024 and RMF0039-2021.

Generative AI Disclosure Statement

The authors did not use any type of generative AI software for this research.

Bibliography

AAOIFI. *Shari'ah Standards*. Bahrain, 2017. <https://aaoifi.com/shariah-standards-3/?lang=en>.

Abu Dawood, Sulaymān ibn al-Ash'ath. *Sunan Abī Da'ūd* [Abu Dawood's Collection of Sayings and Deeds of Prophet Muhammad (pbuh)]. Edited by Muḥammad Muhyī al-Dīn 'Abd al-Ḥamīd (Beirut, Saīda: Al Maktabah Al Asriya, 1392 AH), <https://al-maktaba.org/book/33759/4843>. Accessed 15 December 2021.

Aburaida, Khalid M. Mustafa. "Rural Finance as a Mechanism for Poverty Alleviation in Sudan with an Emphasis on *Salam* Mode." *European Scientific Journal* 7, no.26 (2014): 157–166.

Adedapo, Alagabi Abdghaffar, Abubakar Tabiu, Ladan Sahnun, Hamid Mohsin Jada, Ehsan Saeed Yaqoot, Hadiza Garba Isah, and Alagabi Modinat Remi, "Bai Salam in the Light of Contemporary Application: Issues, Challenges and Recommendations." Paper presented at *Islamic Business Management Conference (IBMC)*, Kuala Lumpur, August 18-19, 2014. <https://www.researchgate.net/publication/318317523>.

Aditto, Satit, Christopher Gan, and Gilbert V. Nartea. "Sources of Risk and Risk Management Strategies: the Case of Smallholder Farmers in a Developing Economy." In *Risk Management - Current Issues and Challenges*. Edited by Nerija Banaitiene. Intech Open, 2012.

Anderson, Kym. "Agricultural Price Distortions: Trends and Volatility, Past, and Prospective." *Agricultural Economics* 44, no. 1 (2013): 163-171. <https://doi.org/10.1111/agec.12060>.

Al-Bassam, Abdullah. *Tawdīh al-Aḥkām min Bulūgh al-Marām* [Clarification of the Provisions of Bulugh al-Maram]. Makkah: Maktaba Al Asadi, 1423 AH.

- Bouslama, Ghassen., and Younes Lahrichi. "Uncertainty and Risk Management from Islamic Perspective." *Research in International Business and Finance* 39, (2017): 718-726. <https://doi.org/10.1016/j.ribaf.2015.11.018>.
- Central Asset Management Capital Market. "Muzara'a Sukūk (Farm-letting Sukūk)." Accessed January 11, 2025, <https://www.Sukūk.ir/Sukūk/types-of-Sukūk/farm-papers/>.
- Central Asset Management Capital Market. "Musaqah Sukūk (Irrigation Sukūk)." Accessed January 11, 2025, <https://www.Sukūk.ir/Sukūk/types-of-Sukūk/employment-papers/>.
- Cole, Jeremy Michael Gregory. "Behavioural Determinants of the Adoption of Financial Price Risk Management Tools by Wheat Farmers in England." Ph.D. diss., The University of Reading, 2014, <https://centaur.reading.ac.uk/66398/>.
- DeVuyst, Eric A., Cesar L. Escalante, Jaclyn D. Kropp, Rodney Jones, and Phil Kenkel. "Sources of Institutional Financial Risks in Agriculture." *Risk Education Publication Series*. Southern Risk Management Education Center, University of Arkansas System, (2013). Accessed August 8, 2021, <https://www.uaex.edu/publications/PDF/srme01fs.pdf>.
- Dhakal, Chandra K., Cesar L. Escalante, and Charles Dodson. "Heterogeneity of Farm Loan Packaging Term Decisions: A Finite Mixture Approach." *Applied Economics Letters* 26, no. 18 (2019): 1528–1532, <https://doi.org/10.1080/13504851.2019.1584360>.
- Al-Dhareer, Siddiq Mohammad Al-Ameen. "al-Salam wa-Taṭbīqātuḥu al-Mu'āshirah." [Salam and its Contemporary Practices]. *Majallat Mujamma' Al Fiqh Al Islami Al Duwali* [Journal of the OIC Fiqh Academy] 9, (1991), <https://al-maktaba.org/book/8356/17703>.
- Al-Dhareer, Siddiq Mohammad Al-Ameen. *Al-Gharar in Contracts and Its Effects on Contemporary Transactions*. Jeddah: Islamic Research and Training Institute, 1999.
- Drollette, Sarah A. "Managing Financial Risk in Agriculture." Utah State, USA: Department of Applied Economics, Utah State University Extension, 2009. Accessed December 14, 2021, <https://extension.usu.edu/apec/files/uploads/agribusiness-and-food/risk-management/risk-management-factsheets/Managing-Financial-Risk.pdf>.
- Duguma, Ashenafi. "The Role of Agricultural Cooperatives in Risk Management and Impact on Farm Income: Evidence from Southern Ethiopia." *International Journal of Economic Behavior and Organization* 4, no. 4 (2016): 28–39, <https://doi.org/10.11648/j.ijebo.20160404.11>.
- Elhiraika, Adam B. *On the Experience of Islamic Agricultural Finance in Sudan: Challenges and Sustainability*. Jeddah, KSA: Islamic Development Bank, 2003.
- Escalante, Cesar L., Adenola Osinubi, Charles Dodson, and Carmina E. Taylor. "Looking Beyond Farm Loan Approval Decisions: Loan Pricing and Nonpricing Terms for Socially Disadvantaged Farm Borrowers." *Journal of Agricultural and Applied Economics* 50, no. 1 (2018): 129–148, <https://doi.org/10.1017/aae.2017.25>.
- Fałkowski, Jan., Maciej Jakubowski, and Paweł Strawiński. "Returns From Income Strategies in Rural Poland." *Economics of Transition and Institutional Change* 22, no.1 (2013): 139–178, <https://doi.org/10.1111/ecot.12032>.
- Fletschner, Diana, Catherine Guirking, and Steve Boucher. "Risk, Credit Constraints and Financial Efficiency in Peruvian Agriculture." *The Journal of Development Studies* 46, no. 6 (2010): 981–1002, <https://doi.org/10.1080/00220380903104974>.

- Hardaker, John Brian. "Some Issues in Dealing with Risk in Agriculture." *Working Paper*, University of New England Graduate School of Agricultural and Resource Economics, Australia, (2000). Accessed August 1, 2021, <http://www.une.edu.au/febl/EconStud/wps.htm>.
- Harwood, Joy, Richard Heifner, Keith Coble, Janet Perry, and Agapi Somwaru. "Managing Risk in Farming: Concepts, Research, and Analysis." *Agricultural Economic Report No. 774*. Washington DC: U.S. Department of Agriculture, 1999.
- Hossain, Ishrat, Aliyu Dahiru Muhammad, Binta Tijjani Jibril, Simeon Kaitibie. "Support for Smallholder Farmers through Islamic Instruments: The Case of Bangladesh and Lessons for Nigeria." *International Journal of Islamic and Middle Eastern Finance and Management* 12, no. 2 (2019): 154–168, <https://doi.org/10.1108/IMEFM-11-2018-0371>.
- Ibn Al Hajjaj, Muslim. *Sahih Muslim* [Muslim's Authentic Collections of the Sunnah of the Prophet (pbuh)]. Edited by Muhammad Fuad Abdul Baqi. Beirut: Dar Ihya' Al Thurath Al Arabi, 1388 AH), <https://al-maktaba.org/book/33760>. Accessed 7 September 2021.
- Kaleem, Ahmad., and Rana Abdul Wajid. "Application of Islamic Banking Instrument (Bai Salam) for Agriculture Financing in Pakistan." *British Food Journal* 111, no. 3 (2009): 275–292, <https://doi.org/10.1108/00070700910941471>.
- Klapper, Leora., Dorothe Singer, Saniya Ansar, and Jake Hess. *Financial Risk Management in Agriculture: Analyzing Data from a New Module of the Global Findex Database*. Washington DC: The World Bank, 2019.
- Komarek, Adam. M., Alessandro De Pinto, and Vincent H. Smith. "A Review of Types of Risks in Agriculture: What We Know and What We Need to Know." *Agricultural Systems* 178 (2020): 102738, <https://doi.org/10.1016/j.agsy.2019.102738>.
- Klaus, Krippendorff. "Content Analysis: An Introduction to Its Methodology." 4th ed., Los Angeles: SAGE Publications, 2018.
- Kumar, Chandra S., Calum G. Turvey, and Jaclyn D. Kropp, "The Impact of Credit Constraints on Farm Households: Survey Results from India and China." *Applied Economic Perspectives and Policy* 35, no. 3 (2013): 508-527, <https://doi.org/10.1093/aep/ppt002>.
- Kurniati, Sunuwati, Muhammad Majdy Amiruddin, and Abdul Syatar, "Bay Al Salam as Financing Alternative During Pandemic Outbreak: A Proposal to Indonesia," *Academy of Entrepreneurship Journal* 27, no 5S: (2021): 1–7. <http://repositori.uin-alauddin.ac.id/id/eprint/19738>.
- Li, Shasha. "Financial Stress Test Under Multiple Risks for Representative Farms of Central Illinois." Master's Thesis, Purdue University, 2012. Purdue e-Pubs (AAI1535051).
- Livsey, Alan, and Harriet Clarfelt. "Defaults on Leveraged Loans Soar to Highest Rate in 4 Years." www.ft.com, *The Financial Times Limited*, December 24, 2024. accessed March 8, 2025. <https://www.ft.com/content/e6ba508c-4612-4b4a-9a6b-ecde6fc91c12>.
- Majid, Rifaldi. "Designing Salam-Muzara'ah Linked Waqf to Financing Agricultural Sector." *Journal of Islamic Monetary Economics and Finance* 7, no. 3 (2021): 503–526, <https://doi.org/10.21098/jimf.v7i3.1309>.
- Maurer, Klaus. "Where Is the Risk? Is Agricultural Banking Really More Difficult than Other Sectors?" In *Finance for Food: Towards New Agricultural and Rural Finance*, edited by Doris Köhn. Berlin, Heidelberg: Springer, 2014, https://doi.org/10.1007/978-3-642-54034-9_7.

- Merritt, Meagan G., Andrew P. Griffith, Christopher N. Boyer, and Karen E. Lewis. "Probability of Receiving an Indemnity Payment from Feeder Cattle Livestock Risk Protection Insurance." *Journal of Agricultural and Applied Economics* 49, no. 3 (2017): 363–381, <https://doi.org/10.1017/aae.2016.44>.
- Morgan, Kim., Peter Callan, Allyssa Mark, Kim Niewolny, Theresa Nartea, Kelli Scott, and Jim Hilleary. "Farm Financial Risk Management: Overview of Financial Systems for New and Beginning Farmers." *Verginia State University*, 2016. <https://www.pubs.ext.vt.edu/AAEC/AAEC-114/AAEC-114.html>.
- Muneeza, Aishath., Nik Nurul Atiqah Nik Yusuf, and Rusni Hassan. "The Possibility of Application of *Salam* in Malaysian Islamic Banking System." *Humanomics* 27, no. 2 (2011): 138–147, <https://doi.org/10.1108/0828866111135135>.
- Narastri, Maulidah. "Muzara'ah in Efforts for Economic Prosperity: Between Patterns of Behavior, Improvements and Demands." (Paper presented at *International Conference on Economic Business Management, and Accounting (ICOEMA)*, 2, 474-480. Universitas 17 Agustus 1945. Surabaya, 2023, <https://conference.untag-sby.ac.id/index.php/icoema/article/view/3028>.
- Al Nasaei, Ahmad bin Al Shuaib. *Al Sunan Al Kubra* [Al Nasaei's Collection of Sayings and Deeds of Prophet Muhammad (pbuh)]. Edited by Hasan & Abdul Mohsin Al Turki Al Shalbi, 2001, (Beirut: Al Risala, 2001), Accessed December 15, 2021, <https://al-maktaba.org/book/33867/8601>.
- Obaidullah, Mohammad. "Enhancing Food Security with Islamic Microfinance: Insights from Some Recent Experiments." *Agricultural Finance Review* 75, no. 2 (2015): 142-168. <https://doi.org/10.1108/AFR-11-2014-0033>.
- Ogunbado, Ahamad Faosiy., and Umar Ahmed. "Bay' *Salam* as an Islamic Financial Alternative for Agricultural Sustainability in Nigeria." *Journal of Islamic Economics Banking and Finance* 11, (2015): 63–75, <https://dx.doi.org/10.12816/0024789>.
- Othman, Rohana., Nooraslinda Abdul Aris, Rafidah Mohd Azli, and Roshayani Arshad, "Islamic Banking: The Firewall Against the Global Financial Crisis." *Journal of Applied Business Research* 28, no. 1 (2012): 9–14, <https://doi.org/10.19030/jabr.v28i1.6679>.
- Popescu, Gabriel., Alina Zaharia, Daniela Mihai, and Roxana Chiocaru. "The Financial Relationships between Farmers, Credit Institutions and Public Authorities - Short Review." *Ekonomika Poljoprivrede* 65, no. 1 (2018): 427–436, <https://doi.org/10.5937/ekoPolj1801427P>.
- Purves, Nigel, Scott James Niblock, and Keith Sloan. "On the Relationship between Financial and Non-Financial Factors." *Agricultural Finance Review* 75, no. 2 (2015): 282-300. <https://doi.org/10.1108/AFR-04-2014-0007>.
- Ramadani, Mustika Lestrai, Siti Kholis Napsiah, and Muhammad Nur Iqbal. "Muzara'ah, Musaqoh And Mugharasah Contracts in Fiqh Muamalah." *Jurnal Multidisiplin Sahombu* 5, no 1 (2025): 89–101.
- Reinsel, Edward I. "Off-Farm Income of People Involved in Farming." *Journal of Agricultural and Applied Economics* 2, no. 1 (2015): 115–119, <https://doi.org/10.1017/S0081305200009900>.
- Romer, Ulf, and Oliver Musshoff. "Can Agricultural Credit Scoring for Microfinance Institutions Be Implemented and Improved by Weather Data?" *Agricultural Finance Review* 78, no. 1 (2018): 83–97, <https://doi.org/10.1108/AFR-11-2016-0082>

- Salisu, Yahuza, Ahmed Ibrahim Mohammed, and Anas Muhammad Yakub. "The Mediating Effect of Murabahah Financing on the Relationship between Farm Land, Farm Infrastructure and Agricultural Output in Nigeria." *International Journal of Management Research and Reviews* 7, no. 12, (2017): 1080–1089, <https://www.proquest.com/scholarly-journals/mediating-effect-murabahah-finance-on/docview/1992208983/se-2?accountid=28930>
- Saqib, Shahab E., Mokbul Morshed Ahmad, Sanaullah Panezai, and Ubaid Ali. "Factors Influencing Farmers' Adoption of Agricultural Credit as a Risk Management Strategy: The Case of Pakistan." *International Journal of Disaster Risk Reduction* 17, (2016): 67–76, <https://doi.org/10.1016/j.ijdrr.2016.03.008>.
- Shafiai, Muhammad Hakimi Mohd., and Mohammed Rizki Moi. "Financial Problems Among Farmers in Malaysia: Islamic Agricultural Finance as a Possible Solution." *Asian Social Science* 11, no. 4 (2015): 1–16. <http://dx.doi.org/10.5539/ass.v11n4p1>.
- Shee, Apurba, Calum G. Turvey, and Liangzhi You. "Design and Rating of Risk-Contingent Credit for Balancing Business and Financial Risks for Kenyan Farmers." *Applied Economics* 51, no. 50 (2019): 5447–5465, <https://doi.org/10.1080/00036846.2019.1613502>.
- Sifa, Eka Nurhalimatus., and Sudarso Kaderi Wiryono. "How does Salam Financing Affect Farmers' Income? A System Dynamics Approach." *Journal of Islamic Accounting and Business Research* 15, no. 1 (2024): 119–135, <https://doi.org/10.1108/JIABR-02-2022-0042>.
- Singhal, Parmod Kumar, and Vivek Mittal. "PMFBY - A Financial Inclusion Initiative for Farmers Development." *International Journal of Business Ethics in Developing Economies* 6, no. 2 (2017): 39–43.
- Al Thirmithi, Abu 'Eisa Mohammad Ibn 'Eisa. *Sunan Al Thirmidhi* [Al Thirmithi's Collection of Sayings and Deeds of Prophet Muhammad (pbuh)]. Edited by Ahmad Muhammad Shakir and Muhammad Fuad Abdul Baqi, (Egypt: Mustafa Al Babi Al Halabi, 1975), Accessed December 15, 2021, <https://al-maktaba.org/book/33754/2138>.
- Ulfah, Khalishah, and Muryani Arsal. "Muzara'ah Contract of Farmer Perspective." Paper presented at *International Economics and Business Conference* 1, no. 1 (2023): 235-240. <https://jurnal.amertainstitute.com/index.php/IECON/article/view/57>.
- Uzea, Nicoleta., Kenneth Poon, David Sparling, and Alfons Weersink. "Farm Support Payments and Risk Balancing: Implications for Financial Riskiness of Canadian Farms." *Canadian Journal of Agricultural Economics* 62, no. 4 (2014): 595-618, <https://doi.org/10.1111/cjag.12043>.
- Ward, Patrick S., David J. Spielman, David L. Ortega, Neha Kumar, and Sumedha Minocha. "Demand for Complementary Financial and Technological Tools for Managing Drought Risk: Evidence from Rice Farmers in Bangladesh." Paper presented at the Agricultural and Applied Economics Association & Western Agricultural Economics Association Joint Annual Meeting, San Francisco, CA, July 26–28, 2015. Washington, DC: International Food Policy Research Institute..
- Yoder, Joshua R., Corinne Alexander, Rastislav Ivanic, Stephanie Rosch, Wallace Tyner, and Steven Y. Wu. "Risk Versus Reward, a Financial Analysis of Alternative Contract Specifications for the Miscanthus Lignocellulosic Supply Chain." *Bioenergy Research* 8, (2015): 644–656. <https://doi.org/10.1007/s12155-014-9548-z>.