Research Article

Drivers of Crop Diversification: Understanding the Global and South Asian Shift from Cotton to Competing Crops

Shahbaz Sharif Wahla [1], Burhan Ahmad [1,*], M. Amjed Iqbal [2,*], Hammad Badar [1]
[1] Institute of Business Management Sciences, University of Agriculture Faisalabad, Pakistan
[2] Institute of Agricultural and Resource Economics, University of Agriculture Faisalabad, Pakistan

*Corresponding Email:
nmbuaf@gmail.com
amjed.iqbal@uaf.edu.pk

Abstract
The cotton industry, which has traditionally served as one of the key drivers of economic growth in Asia, Africa, and Latin America, is currently undergoing a radical structural change. Cotton production has been falling in key areas like Pakistan, India, China, and parts of sub-Saharan Africa for the last 20 years. Instead, farmers are shifting their focus to growing other crops such as soybeans, pulses, and fruits and vegetables. This change is a good illustration of the complexity in relationships between economic, environmental, and institutional determinants. This review aims to synthesize global and South Asian research to identify the key factors driving the decline of cotton agriculture and the resulting migration of people. It explores how volatile commodity prices, changing climatic patterns, pest resistance, rising input prices, and evolving policy processes interact to shape decisions made by farmers. The analysis also explains the consequences of these changes to the rural economic systems, the sustainability of agro-ecological practices, and food security in general. In the end, it highlights potential research and policy pathways that may improve the resilience and competitiveness of cotton and alternative agricultural systems.
Keywords: Crop diversification, Cotton, South Asia, Climate change, Agricultural policy, Market dynamics, Sustainability.

Introduction

Cotton, or 'white gold', has provided a major source of agricultural income for more than two centuries. Cotton pioneered international trade and was the source of livelihood for peasants in large numbers. Cotton has continued to this day as one of the highest-earning cash crops in many developing countries. Its contribution is not confined to bringing much-needed foreign exchange revenue but also employment (Ashraf et al., 2014). Since the beginning of the 2000s, the area of cotton cultivation has begun to decline in several major cotton-producing countries. Farmers are replacing their fields with pulses, oilseeds, and cereals. According to them, these are more reliable crops than cotton, which faces significant variation and where input prices are rising sky-high (Das et al., 2023). What is important here is not the simple substitution from one crop to another, but reflects deeper structural changes occurring within agri-food systems.

Sarkar et al. (2024) observed that smallholder farmers were increasingly moving to stable income and reduced financial risk crops because cotton prices fluctuated and input costs were continuing to rise. Environmental stresses, such as irregular rainfall, drought, and pest attacks, are increasingly harming cotton production. In semi-arid regions of India, Pakistan, and Africa, where cotton depends on rain, these problems make growing cotton unreliable and unprofitable (Zerssa et al., 2021). In this regard, the change can be both positive and negative towards sustainability.

Having a diverse range of crops can boost food security and help farmers manage risks. But if cotton production slows down, it will negatively impact the textile industry and limit job creation in rural communities. Consequently, policymakers now find themselves in a fine balancing act; they must remain true to their diversification agenda in the economy, and on the other hand, be quite committed to the sustainability of the traditional cash crops.

The main objectives of this review are as follows:

1. To synthesize the main factors influencing the global and South Asian shift from cotton to competing crops.

2. To compare international experiences and patterns of diversification within similar agro-ecological and institutional contexts.

3. To outline policy implications and research directions that ensure the sustainable production of cotton.

Through an inter-, multi-and transdisciplinary approach including economics, agronomy, climate and policy studies this review contributes to the wider debate on agricultural transformation. Providing a broader framework for understanding drivers of change in cotton-based farming systems, the intention is to address global changes as well local developments in South Asia.

Methodology of Literature Review

In order to guarantee thorough coverage and a critical synthesis of the body of existing literature, this study uses a systematic review methodology. The method consists of three primary steps: thematic synthesis, screening and inclusion, and literature identification (Snyder, 2019).

Literature Identification

The Scopus, Web of Science, and Google Scholar databases were used to find peer-reviewed papers, policy documents, and reports released between 2000 and 2025. Cotton acreage decline, crop diversification, agricultural transformation, South Asia, climate change, and cotton, and competing crops were among the search terms used. To capture current policy perspectives, additional literature was consulted, including reports from the World Bank and the FAO (FAO, 2022).

Screening and Inclusion Criteria

A study was considered if it (a) offered conceptual or empirical analyses of cotton production trends or diversification, (b) concentrated on South Asia or similar developing regions, and (c) addressed at least one driver among institutional, climatic, technological, or economic factors. Eighty-two studies in all satisfied the inclusion requirements. Exclusion criteria were used for papers that were strictly technical or very localized, with no wider implications.

Thematic Synthesis

The selected literature was categorized into five thematic domains:

1. Economic and Market Factors — price volatility, profitability, input costs, and trade dynamics.

2. Climatic and Environmental Factors — temperature stress, rainfall variability, water scarcity, and pest outbreaks.

3. Technological and Agronomic Factors — innovations in seeds, mechanization, and pest management.

4. Institutional and Policy Factors — subsidies, trade policies, and governance mechanisms.

5. Socio-demographic and Labor Factors — migration, aging farmers, and gender participation.

This thematic framework led to the synthesis of the findings across contexts. The similarities and regional differences in the theme of diversification driving factors were determined by looking at each theme through a comparative lens. The method is particularly suitable to interdisciplinary sustainability reviews as the method does not emphasise aggregation but analytical depth (Tranfield et al., 2003).

Overview of Cotton Production Trends

Cotton is a fiber crop that is still economically significant in over 75 countries of the world. In the past 20 years, genetic and technological innovations have not been effective because there has been a steady reduction in acreage of cotton across the world (ICAC, 2023). The productivity level stabilized between 2000 and 2022 as a result of climatic and pest outbreaks, and the area in the world under cotton cultivation dropped to approximately 31 million hectares (USDA, 2023).

There has been some change especially in South Asia that possesses nearly 45 percent of the world cotton land. China, Pakistan and India remain the largest manufacturers of cotton in the world however their acreage has declined due to a number of interrelationship variables. The area of cotton production in Pakistan reduced by over a third, falling to less than 2.1 million hectares in 2023-24, down 3.2 million hectares in 2004-05 (GoP, 2024). On the same note, in India, farmers are moving towards more lucrative crops like soybean, maize and pulses, so cotton is losing share to these crops in the gross cropped acreage (Das et al., 2023).

The reduced productivity of cotton is explainable by a number of interdepending factors, including the pests, including the pink bollworm in Bt cotton, the environmental degradation, and the prices of inputs (ICAC, 2023). In addition, competition with synthetic fibers in the world textile market has also eliminated long-term demand, making the cotton-based value chains less profitable (Su et al., 2025).

Policy wise, the lack of policy confidence in cotton farming in the state has been worsened since progressive erosion of input subsidies, lack of adequate investment in extension services and uncertainty over support prices have resulted in the lack of confidence amongst farmers in cotton farming in the state. The 2010s reforms of the policies exposed growers to increased price risks, resulting in faster diversification to food crops in China, where state-based procurement had been used to shield farmers against market risks (Li et al., 2020).

A combination of these complexities makes cotton a worse choice than more resilient and market-receptive crops. The factors that contribute to the shift are discussed in the sections that follow and analyze the dimensions of economics, the environment, technology, institutions, and socio-demographics.

Factors Responsible for the Shift from Cotton to Competing Crops

A combination of these complexities makes cotton a worse choice than more resilient and market-receptive crops. The factors that contribute to the shift are discussed in the sections that follow and analyze the dimensions of economics, the environment, technology, institutions, and socio-demographics.

Economic and Market Factors

Profitability is also one of the leading factors in crop selection. The price of cotton production has been increasing, although the output prices remain fluctuating, which is in many ways because of higher spending on fertilizers, pesticides, and irrigation (Das et al., 2023). The cost of cotton production in Pakistan and India has almost doubled within the last decade, but the returns per hectare have not increased or even decreased (GoP, 2024).

Cotton prices are highly affected by international market forces and regulations that affect the production of cotton in the global market. An example of this is that the volatility of prices triggered by the 2018-19 trade tensions between the U.S and China, led to the pivoting of many farmers to more stable domestic produce like pulses and maize (FAO, 2022). The opaque market mechanisms and delayed payment of procurement increase the financial risks of smallholders (Sarkar et al., 2024).

On the other hand, crops such as maize and soy beans use less time to complete its cash cycles, value addition and are also demanded domestically hence leading to a faster cash cycle. Therefore, diversification is not only a strategy of production adjustment but a logical adjustment strategy in the economy (Ashraf et al., 2024).

Climatic and Environmental Factors

The climate variability has also had a significant impact on cotton cultivation practices, especially in semi-arid areas where the practice has been limited by temperature stress and water supply. The extreme responsiveness

of cotton to heat, lack of water has made its growth more complex in case of frequent droughts and irregular rainfalls (Zerssa et al., 2021).

The reliability of yield in South Asia has been impaired due to irregular patterns of monsoons and high rates of evapotranspiration. Empirical research in Sindh province of Pakistan and Maharashtra in India suggests that with each 1 o C higher than the optimal temperature range, cotton production decreases by 5-7 percent (ICAC, 2023). Simultaneously with it, the overuse of pesticides has upset the ecological balance, and the result is the degradation of the soil and resistance of pests (Qureshi et al., 2023).

Competing crops, including oilseeds and pulses, are, on the other hand, more economically and environmentally desirable because of their cheaper inputs and the ability to adapt better to changing rainfall patterns. Therefore, climatic stress serves as a pull factor for more resilient crops and a push factor that drives cotton production towards the downward direction.

Technological and Agronomic Factors

The stagnation in technology noted in the cotton sector is also seen to be on a comparative basis with the rapid development of the alternative crop systems. Despite the fact that the first introduction of Bt cotton improved crop production and reduced pesticide spending (Su et al., 2025), it is not as effective as it was initially because resistance has already been developed and there are few varieties.

The lack of transgenic cultivars adapted to regions, as well as the lack of proper mechanisms to certify seeds, has also limited productivity in other countries, including Pakistan and India (Das et al., 2023). At the same time, rival crops have enjoyed massive research-and-development investment, excellent seed technology, and mechanization plans to suit the smallholders (Ashraf et al., 2024).

Besides, the complex pest management needs and long growth cycle make cotton less appealing to modern technologies in precision agriculture, digital advisory services, and electronic extension services, which appeal to short-cycle crops that can be easily incorporated into new digital value chains.

Institutional and Policy Factors

The institutional weaknesses and unstable policy regimes have facilitated the process of taking cotton to other crops. Cotton-producing farmers in most of the emerging economies are not given incentives and supportive programs that would help them to stay afloat in the market, and this is also maintained by policy systems which have focused on staple crops like wheat and rice (FAO, 2022).

 The deregulation of support prices, cutbacks in subsidies, and limited access to cheap credit have destroyed profitability in cotton (GOP, 2024). There is also a lack of innovation and resiliency, which is due to the lack of extension services and the decrease in funding of research (Zhou et al., 2020).

On the contrary, the public-private alliances and state-supported diversification programs on oilseeds and pulses have given farmers other sources of income. In turn, the market liberation and the construction of the institutional capacities are the crucial instruments of guiding crop selection.

Socio-Demographic and Labor Factors

The availability of rural labor has been changing according to the socioeconomic forces of urbanization, labor migration, and generational changes. The manual labor that is involved in planting and cultivation processes of cotton has been aggravated by the loss of opportunities of off-farm jobs and exodus of youth in the countryside (Sarkar et al., 2024).

The issue of gender has also affected cotton agriculture. Women, who have traditionally played an important role in cotton production, are moving outwards and show an increasing trend in their work on other activities with higher values (Ashraf et al., 2024). Economic viability of smallholders has declined because of the shortage of labor and wage inflation, which makes mechanized substitutes (rice and maize) relatively more desirable (Zerssa et al., 2021).

These demographic and labor market factors have increased the rate at which there has been a shift towards

crops that are more mechanization and less labor-intensive.

Empirical Insights from Punjab's Cotton–Competing Crop Transition

The prime example of market and environmental forces in South Asia that have transformed the areas is the replacement of cotton by alternative crops in Southern Punjab, Pakistan. Empirical researches in Vehari, Lodhran, and Multan reveal that the farmers are being shifted towards more profitable and stable products that include wheat, maize, and sugarcane because of the pressure of insects, low quality of fiber and unstable profits (Shahbaz et al., 2017). Such replacements have lower production risk, better liquidity in the market, and lower dependency on management that requires pesticides, unlike cotton that had a central position in the history of the textile industry in Pakistan (Hussain et al. 2022).

Socioeconomic variables also determine the crop switching behaviour. Small plot, financially endowed, or more extension-linked farmers tend to abandon cotton more than others who enjoy diversified wealth or contract relations with ginning businesses (Alam, 2025). Perceived risk, relative price advantage, and the history of losses caused by pests all play a significant role in causing a change in crops, as theorized by the theory of planned behaviour (TPB) analysis (Damalas et al., 2021). On the other hand, this shift can be addressed through the timely supply of inputs, high-quality institutional support, and the availability of high-quality varieties of cotton. Ashraf et al. (2024) indicate that in the event that the input costs increase at a higher rate than the farm-gate returns, policy uncertainty and fluctuating procurement prices further discourage the farmers from carrying on with cotton farming.

The future of cotton is not only socially and environmentally detrimental, but also economically detrimental. Switching to maize brings new pest-disease relationships, whereas water-intensive substitutes like sugarcane will only contribute to the depletion of groundwater. Since the cotton hand-picking offers seasonal wages that are more inaccessible to the mechanized system, the role of labor has changed for women as well (Naz et al., 2025). Although diversification might seem economically viable, it can actually increase weaknesses instead of reducing them, hence the necessity of systemic strategies that inject gender, economic, and agronomic dimensions into policy frameworks.

Comparative Evidence from Other Cropping Systems and Countries

The cotton production in Pakistan has declined in the same way as other emerging agricultural economies have experienced similar changes. A productivity revolution introduced in the early 2000s in India was the adoption of Bt cotton. However, as indicated by recent studies in Telangana and Maharashtra, yield has stagnated and pests have returned, alongside an increase in costs, thus the shift to horticulture, soybean, and pigeon peas (Najork et al., 2022). However, the Xinjiang region in China is an example of how technology and collective governance can stabilize agriculture; in this case, cotton sustainability is maintained by massive mechanization and a blockchain-based traceability system that connects farm-level data to export markets (Li et al., 2025).

Decreased production of cotton in Sub-Saharan Africa, especially in Burkina Faso and Tanzania, can be mostly explained by the disintegration of institutions, the lack of access to input credit, and the drop in global prices, as opposed to insect pressure (Staritz & Tröster, 2015). Equally, in Egypt, climate change and water shortage are forcing farmers to adopt high-value or short-term crops, thus changing the cotton-rice relationship. Comparative studies have shown that the agroecology of the place, governance systems, and exposure to the international market have overall impacts that affect cotton paths. Due to the combined economy consisting of textile-agriculture, the experience in Pakistan is also unique since the shifts in crops have macroeconomic implications that far surpass the farm-level giggles (Tasneem & Khan, 2024).

The cross-commodity analyses add another level of comparative evidence. Empirical studies of South Asian rice wheat systems have also shown that long-term monocropping in the regimes of input-intensive agriculture results in reduced soil fertility and profitability (Hossain et al., 2021). Resource efficiency and resilience are often promoted by diversification into high-value vegetables, oilseeds or pulses; an example is

the use of short-duration pulses, such as in rice rotations in Bangladesh, where this practice has led to improved nitrogen balance and a reduction in the use of synthetic fertilizers (Sarkar et al., 2024). Such models can be useful in Pakistan, where the success of developing chickpea and mungbean in previously fallow areas under cotton is already proving to have water conservation and soil health-restoring potential (Khan et al., 2025).

The impact of institutional innovations can also be identified with the help of a comparative approach. With the help of FPOs and online platforms, Indian farmers have regained their entry into the premium cotton markets. However, similar changes in Pakistan are prevented by poor contract execution, disjointed supply chains, and a lack of changes in the seed industry (Ashraf et al., 2024). Risk-sharing arrangements and facilitating institutions are therefore as essential as technological interventions to the sustainability of cotton.

Policy Implications and Future Research Directions

The decline in cotton production in Southern Punjab needs to be mitigated or reversed through a complete integrative amalgamation of institutional, technological, and policy measures. First and foremost, to rebuild the trust of growers, the price signals of inputs and outputs have to be stabilized through the introduction of clear market information systems and sound procurement channels. Export bans and input subsidies are volatile, and they undermine long-term decision-making. In this line, policymakers must focus on price-stabilizing tools to protect producers against shocks, which may be on the digital warehouse receipt system and hedging (Samaratunga et al., 2019).

Second, it is mandatory that institutional reforms be carried out. A way of overcoming the gap between innovation and innovation in agricultural sector with the industrial need is by re-energising the Pakistan Central Cotton Committee (PCCC) and enhancing the connection between the textile exporters, the ginners, and the provincial research centres. The Aegean cotton belts in Turkey and Xinjiang, China have demonstrated that it is important to have public-/private-partnership (PPP) and collaborative investments in research and development in order to remain competitive (Li et al., 2025).

Similarly, best practices unique to the area in the integrated management of pests and nutrients can be spread by improving extension services via ICT-based advisory services. Third, the diversification must be planned rather than done indiscriminately. It would be possible to encourage intentional diversification by policymakers, such as establishing oilseeds and pulses as rotational complements and not cotton substitutes. This would maintain the fertility of the soil, lessen the carry-over of the insects, and replace imported food oils. The existing incentive systems might be re-oriented to enable sustainable diversification by using specific initiatives, such as guaranteed procurement of legumes, low-interest financing of drip irrigation, and pulse-seeds input vouchers (Khan et al., 2025).

Longitudinal studies of crop profitability, water use, and environmental effects in competing commodities should be the priority of future research. The combination of remote sensing data and farm surveys can contribute to the spatial understanding of the processes that led to the decline of cotton. Displacement of women labor in non-cotton systems has not been well documented, which explains the need to have gender disaggregated assessments. Additionally, the creation of sustainable cotton and post-cotton contracts in Pakistan requires interdisciplinary paradigms that can combine economics, climate science, and institutional studies.

Conclusions

The decline in cotton production in Asia and Africa, particularly in Southern Punjab, is an indication of a more fundamental structural change in the Pakistani agricultural economy, and not a simple sectoral alteration. The rational reactions of farmers to a set of regional institutional, environmental, and economic pressures are manifested in the change of crops to wheat, maize, sugarcane, and pulses. Despite the steady returns and the availability of a stable market, the profitability of cotton has gone down because of insect pressures, the high cost of inputs, and policy discrepancies. This unplanned diversification, however, develops ecological and social trade-offs, such as soil erosion, groundwater depletion, and seasonal employment opportunities for

women will be eroded. The sustainability of cotton depends on the synergistic system consisting of institutions, technology, and incentives, as demonstrated by the comparative analysis between South Asia, China, and Africa. The countries that have been able to compete effectively, such as China and Turkey, do so by means of mechanization, collaborative governance, and transparency in the market information systems. By contrast, India and Pakistan are becoming stagnant or falling behind, with most of the country as smallholders and with disjointed public research. Such findings point to the need to address the urgency in terms of Pakistan reinvesting in cotton research, rejuvenating the seed sector, and enforcing digital traceability in order to reestablish consumer trust in the quality assurance.

The shift in the policy reforms to include the integrated risk-management/diversification frameworks should be done over adaptive subsidies. They include planned pulse-based rotational, ICT-facilitated extension services and price stabilization systems that together enhance the resilience of the farms and bolster national food security goals. Context-specific and gender-responsible, and climate-smart initiatives, including supporting women-owned micro-enterprises in seed production or value-added cotton by-products, can be used to enable the recovery of displaced livelihoods. Lastly, to close the gaps in available information, which impedes the evidence-based decision-making process, long-term research partnerships between academic institutions, governmental agencies, and agribusinesses are essential.

References

Alam, J. S. (2025). Climate change and agriculture in Pakistan: Impacts and adaptation strategies (Doctoral dissertation, University of Reading). https://centaur.reading.ac.uk/124161/ .

Ashraf, S., Ch, K. M., Ashraf, I., & Akbar, N. (2024). A phenomenological inquiry into farmers' experiences growing cotton in Punjab, Pakistan. Scientific reports, 14(1), 13846.

Damalas, C. A. (2021). Farmers' intention to reduce pesticide use: The role of perceived risk of loss in the model of the planned behavior theory. Environmental Science and Pollution Research, 28(26), 35278-35285.

Das, T. K., Kumar, S., Das, A., Ansari, M. A., Raj, R., & Ghosh, S. (2023). Sustainable production systems. In Trajectory of 75 years of Indian Agriculture after Independence (pp. 541-575). Singapore: Springer Nature Singapore.

FAO. (2022). The State of Food and Agriculture 2022: Leveraging automation in agriculture for transforming agrifood systems. Food and Agriculture Organization of the United Nations - FAO, Rome, Italy.

GoP. (2024). Pakistan Economic Survey 2023–24. Ministry of Finance, Government of Pakistan.

Hossain, A., Sarkar, S., Rahman, M. A., Bhatt, R., Garai, S., Saha, S., & Meena, R. S. (2021). Ecological intensification for sustainable agriculture in South Asia. In Ecological intensification of natural resources for sustainable agriculture (pp. 171-213). Singapore: Springer Singapore. https://doi.org/10.1007/978-981-33-4203-3_6.

Hussain, A., Akhtar, W., & Jabbar, A. (2022). Risk management for small farmers in Pakistan: A review. Pakistan Journal of Agricultural Sciences, 59, 2.

ICAC. (2023). Cotton: World statistics and outlook 2023. International Cotton Advisory Committee.

Khan, S. A., Zubair, H., Rathnayake, I., Abeysekara, I., Korai, P. K., Mumtaz, H., & Kamran, M. (2025). Pulses Based Cropping System under Changing Climate in Pakistan. Dialogue Social Science Review (DSSR), 3(2), 342-377.

Li, F., Kojima, D., & Tang, Z. (2025). Speciality Agri-production How to Achieve Quilty Improvement through Digitalization like Xinjing Cotton. https://ageconsearch.umn.edu/record/356770/.

Najork, K., Friedrich, J., & Keck, M. (2022). Bt cotton, pink bollworm, and the political economy of sociobiological obsolescence: insights from Telangana, India. Agriculture and Human Values, 39(3), 1007-1026.

Naz, F., Abedullah, & Rola-Rubzen, M. F. (2025). Analysis of Gender-Inclusive Rural Transformation and

Policies in Pakistan. Asia & the Pacific Policy Studies, 12(2), e70023.

Qureshi, S. H., Khan, D. M., & Bukhari, S. Z. A. (2023). Intelligent resistant source detection against stalk rot disease of maize using deep learning technique. SABRAO J. Breed. Genet, 55(6), 1972-1983.

Samaratunga, P., Punjabi, M., Karmacharya, B., & Balakrishnan, U. (2019). Agricultural pricing and procurement policies in South Asia. Gates Open Res, 3(665), 665.

Sarkar, S., Brahmachari, K., Gaydon, D. S., Dhar, A., Dey, S., & Mainuddin, M. (2024). Options for Intensification of Cropping System in Coastal Saline Ecosystem: Inclusion of Grain Legumes in Rice-Based Cropping System. Soil Systems, 8(3), 90.

Shahbaz, P., Boz, I., & Haq, S. U. (2017). Determinants of crop diversification in mixed cropping zone of Punjab Pakistan. Direct Research Journal Agricultural Food Science, 5(11), 360- 366.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research, 104, 333-339.

Staritz, C., & Tröster, B. (2015). Cotton-based development in Sub-Saharan Africa? Global commodity chains, national market structure and development outcomes in Burkina Faso, Mozambique and Tanzania (No. 54). ÖFSE Working Paper. https://www.econstor.eu/handle/10419/113284.

Su, Y., Wei, X., Wang, Z., Gao, L., & Zhang, Z. (2025). Cotton production in the Yellow River Basin of China: reforming cropping systems for ecological, economic stability and sustainable production. Frontiers in Sustainable Food Systems, 9, 1615566.

Tasneem, F., & Khan, M. A. (2024). Growth and structural transformation–Options for Pakistan. Research in Globalization, 8, 100190.

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. British journal of management, 14(3), 207-222.

USDA. (2023). Cotton: World markets and trade. United States Department of Agriculture, Foreign Agricultural Service.

Zerssa, G., Feyssa, D., Kim, D. G., & Eichler-Löbermann, B. (2021). Challenges of smallholder farming in Ethiopia and opportunities by adopting climate-smart agriculture. Agriculture, 11(3), 192.