ISSN:2656-4270 (Online) 1410-4466 (Print)
Accredited by Ministry of Education, Culture, Research, and Technology with the ranking of Sinta (S3) SK NO.164/E/KPT/2021, 27th December 2021

Buletin Penelitian Sosial Ekonomi Pertanian Fakultas Pertanian Universitas Haluoleo
2025:27(2):109-118
https://ejournal.agribisnis.uho.ac.id/index.php/sosek
doi: https://doi.org/10.37149/bpsosek.v27i2.1831

LIVELIHOOD RISK ADAPTATION AMONG LOCAL MAIZE FARMERS IN GULUK-GULUK MADURA INDONESIA (A PLS-SEM Approach)

Anisah[1*)], Cepryana Sathalica Widyananda[1)], Tirta Yoga[2)]

[1]Madura University Indonesia
[2]Tribhuwana Tunggadewi University Indonesia

Corresponding author: anisah@unira.ac.id

To cite this article:
Anisah, A., Widyananda, C. S., & Yoga, T. (2025). Livelihood Risk Adaptation Among Local Maize Farmers in Guluk-Guluk Madura Indonesia (A PLS-SEM Approach). *Buletin Penelitian Sosial Ekonomi Pertanian Fakultas Pertanian Universitas Haluoleo*, *27*(2). https://doi.org/10.37149/bpsosek.v27i2.1831

Received: February 15, 2025**; Accepted:** November 22, 2025**; Published:** November 24, 2025

ABSTRACT

Local maize serves as a vital source of both food security and household income across various regions of Indonesia, particularly in Sumenep, Madura. However, efforts to sustain agricultural livelihoods are increasingly challenged by a range of risks. One of the most pressing issues is the growing prevalence of hybrid maize cultivation in Madura, which has adversely affected local farmers who continue to grow traditional maize varieties to meet their subsistence needs. Given these challenges, farmers need to develop and implement strategic responses by leveraging their available livelihood assets in order to mitigate risks and adopt adaptation strategies suited to their specific context. This study aims to develop a risk management and adaptation framework for maize farmers in the Guluk-Guluk area of Madura, taking into account their livelihood assets. The research was conducted in Guluk-Guluk, a location purposively selected based on regional differences in maize productivity. The study took place from October 2023 to March 2024 and involved 51 local maize farmers selected via random sampling with a 1% margin of error. The study assessed several forms of farmers' resources, including labor capacity, material assets, community networks, environmental conditions, and economic means, along with their adjustment practices, such as diversifying activities and modifying planting timelines. Risk variables included technological and natural risks. Data were analyzed using the Partial Least Squares-Structural Equation Modeling (PLS-SEM) method. The findings indicate that the resources supporting farmers' livelihoods play a meaningful and beneficial role in shaping how corn growers in the area manage risks and adjust their practices. The findings also indicate that the most commonly adopted adaptation strategy is diversification. Technological risk emerged as the most significant risk faced by farmers, while financial capital was found to be the most influential asset in supporting risk response and adaptation efforts.

Keywords: adaptation strategy; local maize; PLS-SEM.

INTRODUCTION

Maize is a vital commodity in Indonesia, serving as food, a raw material for the food and feed industries, and a source of bioenergy (Visković et al., 2024). It plays a strategic role in agricultural and economic development, as its widespread cultivation can significantly increase farmers' incomes (Hasna & Supyandi, 2021; Lun et al., 2024). The strategic role of maize in Indonesia's agriculture and economy was evident throughout 2023. Maize production in Indonesia reached 14.46 million tons. Nationally, East Java Province was the leading producer of maize, accounting for 30.63% of the country's total maize production that year.

East Java is the main center of maize production in Indonesia (Heryanto et al., 2024), accounting for 30.4% of total production, followed by Central Java (15.9%) and other areas such as Lampung, South Sulawesi, and North Sumatra (Safruddin et al., 2023). In Madura, most cultivated corn (>90%) is local, whereas in East Java, superior and hybrid varieties dominate (>70%) (Amzeri, 2018).

Sumenep Regency, located on Madura Island, is a leading maize-producing region in Indonesia, offering farmers opportunities to enhance their cultivation techniques (Salsadyra et al., 2022). From 2020 to 2024, Sumenep recorded the highest maize output among Madura's four regencies, producing 325,326 tons in 2024, significantly more than Pamekasan (87,668 tons), Sampang (92,242 tons), and Bangkalan (132,602 tons). This is mainly due to its high land suitability for maize, covering 55.8% of its total area (67,772.7 ha) (Syahrial & Susanto, 2024). Maize is a staple food in Madura, especially in Sumenep, where traditional dishes like maize rice are widely consumed and culturally significant. The practice of eating maize has been passed down through generations.

Guluk-Guluk District, a key maize center in East Java, is known for its superior local variety. In 2019, its local maize yielded 2.552 tons/ha over 1,427 hectares, the highest among Sumenep's 27 sub-districts (Department of Food Crops Agriculture, Horticulture, and Plantation, Sumenep Regency, 2020). Although traditional varieties mature faster, they lag behind hybrid varieties in yield and plant morphology (Windra Sukma, 2018). Hybrid maize in Guluk-Guluk reached 4.953 tons/ha in 2019, almost double the yield of local varieties, driven by growing national demand and efforts to increase productivity.

Most residents of Guluk-Guluk Village grow local maize, which yields less than hybrid varieties. The push for hybrid maize in Madura poses significant challenges, including market competition, pest and disease outbreaks, falling prices due to overproduction, and limited access to technology and information. Small landholdings further limit farmers' ability to rely solely on local maize. As a result, many farmers adopt adaptation strategies, using their available resources to sustain their livelihoods.

A considerable body of research has examined how agricultural producers respond to climate-related threats to maintain their livelihoods. For example, Peng et al. (2020) used a logit model to analyze farmers' adaptation in Chongqing, China. Similarly, Turasih & M Kolopaking (2016) examined adaptation strategies among upland farmers in the Dieng Highlands, Banjarnegara District. However, there has been limited research on the development of adaptation strategies among small-scale farmers facing technological risks, particularly those arising from the recent trend of hybrid maize adoption. This is especially true for local maize farmers who continue to cultivate traditional maize varieties. In Guluk-Guluk, farmers have adopted a distinctive adaptation strategy by integrating indigenous knowledge, such as sensory perception, generational experience, and local skills, with modern knowledge obtained through the media and farmer groups. This integration is reflected in their diversification strategy: growing hybrid maize alongside local maize. While local maize has a longer harvest cycle, it is more resilient to extreme weather conditions. This approach offers new insights and contributions to the discourse on smallholder adaptation in Indonesia, which have not been addressed in previous studies. The forward looking actions taken by these growers in turning potential threats into adaptive practices offer important insights for other small scale producers facing environmental pressures.

The difference between this research and previous research is that it analyzes risk and adaptation strategies based on livelihood assets using the SEM-PLS method, enabling in-depth analysis of each variable indicator's influence. This research provides implications for farmers and the government, especially in the Guluk-Guluk District, with a recommendation for appropriate adaptation strategies for farmers who continue to plant local maize despite changing trends in the initiation of hybrid maize planting, by controlling the most dominant livelihood assets. Therefore, this research seeks to develop strategies that help farmers reduce risks and adapt to changing conditions by leveraging the resources available to maize producers in the Guluk-Guluk region of Madura.

MATERIALS AND METHODS

The group of individuals considered for this research consisted of corn producers residing in the Guluk-Guluk area. The sample in Guluk-Guluk village, where the local maize farmers numbered 106, was selected using a random sampling method because the population was homogeneous. There will be 51 maize farmers' samples, selected using the Slovin formula, with a 1% margin of error. This research was conducted from October 2023 to March 2024. Data collection activities were conducted through interviews, participant observation, and documentation. The study is quantitative in character. To determine SEM using variance-based estimation in SmartPLS 2.0, they estimate SEM via PLS-SEM (Partial Least Squares Structural Equation Modeling) (Marliati, 2020; Marliati, 2020; Marliati, 2020). The use of PLS-SEM is justified by its ability to be applied in studies with a comparatively small sample size (Kock, 2018). The minimum acceptable is 30-100 (Kock and Hadaya, 2018). The structural model and measurements were evaluated in a computational procedure over several iterations. The measurement model (outer model) incorporating reflective indicators was assessed by examining the convergent validity of the indicators, with loadings of 0.50 or higher indicating a valid indicator. A t-test was used, with significance determined by the t-value exceeding the critical value of 1.96 (0.05), to evaluate the reliability of the research construct as acceptable. Table 1 contains the concepts, dimensions, variables, and their measures.

Table 1. Indicators and description of livelihood assets, livelihood risks, and adaptation strategies

Concept	Variables	Indicators
Livelihood Assets (X)	Human Capital (X1)	Education Level (X1.1) Training Skills (X1.2) Labor (X1.3)
	Social Capital (X2)	Trust (X2.1) Relatives and friends (X2.2) Organization/Group Membership (X2.3)
	Natural Capital (X3)	Land area (X3.1) Local maize area (X3.2) Climate (X3.3)
	Physical Capital (X4)	Facilities and infrastructure (X4.1) Property (X4.2)
	Financial Capital (X5)	Income (X5.1) Financial support (X5.2) Savings (X5.3)
Livelihood Risk (Y1)	Natural risk (Y1.1) Technology risk (Y1.2)	Climate Price and sales
Adaptation Strategy (Y2)	Change planting date (Y2.1) Diversification (Y2.2)	Planting season Planting hybrid maize

Source: Primary Data Processed, 2024

RESULTS AND DISCUSSION

Respondent Characteristics

The characteristics of the respondents indicate that the majority of local maize farmers are male (66.67%) and have an elementary school education level (39.26%), while only 9.80% hold a bachelor's degree. Most farmers are between 40 and 59 years old (72.54%) and support three family members (47.05%). In terms of income, the largest group earns between IDR 1,000,000-1,999,000 per month (39.26%), followed by those earning IDR 100,000–999,000 and IDR 2,000,000-2,999,000, each accounting for 29.41%. Higher-income farmers generally have larger planting areas or additional employment.

Based on farming experience, 41.18% of farmers have been cultivating local maize for 20–29 years, while only 3.92% have 40–50 years of experience. The majority of farmers produce between 500-999 kg of local maize per harvest (41.18%), which aligns with the dominant planting area of 0.25–0.49 ha owned by 66.67% of respondents. Conversely, only 7.84% of farmers produce 2,000–2,499 kg, and just 3.92% cultivate nearly 1.5 ha. Overall, local maize farming areas tend to be relatively small compared to hybrid corn cultivation.

Risk-oriented and resource-driven approaches employed by community-based corn producers

The livelihood assets of local maize farmers are quantified using five indicators: human capital (X.1), social capital (X.2), natural capital (X.3), and physical capital (X. 4). X 4), and financial capital (X.5). At the same time, the indicators of the livelihood risk (Y1) are natural risk (Y1.1), market risk (Y1.2), technology risk (Y1.3), and policy risk (Y1.4). Other indicators of the adaptation strategy (Y2) are adaptation strategies to change the planting date (Y2.1) and diversification (hybrid). As shown in Figure 1, the structural model depicts the relationships among livelihood assets (X), livelihood risk (Y1), and adaptation strategy (Y2).

Evaluation of Index Criteria for the Suitability of the Structural Model (Evaluation of the Measurement Model): Reliability and validity indicators are the first steps to assess whether the indicators are well captured by the latent constructs (Wong, 2019). This study begins with an evaluation of reflective measures using convergent validity. The assessment process considers convergent validity by analyzing the Loading Factor, Average Variance Extracted (AVE), and Composite Reliability.

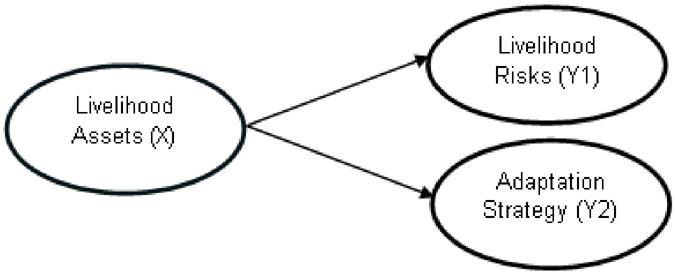

Figure 1. Structural model of the effect of assets on risk and adaptation strategies

An iterative test was performed using SmartPLS 2 software to obtain a fit index and develop risk-reduction and adjustment strategies for small-scale corn growers, considering their livelihoods. The assessment findings on the conceptual framework's validity, presented in Table 2, indicate that 1 of 20 elements has a loading factor below 0.5. Elements with a loading factor below this threshold were removed from the study framework, while the rest were retained because their external loading values exceeded 0.5.

Table 2. Evaluation of measurement model (loading factor, AVE, and composite reliability)

Construct	Indicators/ Items	Loading Factor (≥ 0.5)	AVE (≥ 0.5)	Composite Reliability (≥ 0.7)	Criteria
Human Capital	X1.1 X1.2 X1.3	0.914273 0.801452 0.912383	0.770221	0.909253	Valid and Reliable
Social Capital	X2.1 X2.2 X2.3	0.814015 0.762118 0.714046	0.584435	0.807953	Valid and Reliable
Natural Capital	X3.1 X3.2 X3.3	0.782143 0.758640 0.818979	0.619336	0.829819	Valid and Reliable
Physical Capital	X4.1 X4.2	0.975904 0.976189	0.952666	0.975759	Valid and Reliable
Financial Capital	X5.1 X5.2	1.000000 1.000000	1.000000	1.000000	Valid and Reliable
Livelihood Risk	Y1.1 Y1.2 Y1.3 Y1.4	0.916176 0.892620 0.916176 0.869010	0.807676	0.943790	Valid and Reliable
Adaptation Strategy	Y2.1 Y2.2	0.758187 0.851484	0.649937	0.787271	Valid and Reliable

Source: Primary Data Processed, 2024

Table 2 shows that all construct indicators have an outer loading value above 0.5, indicating that the measurement meets the criteria for convergent validity. Also, the square root of the _Average Variance Extracted (AVE) is more than 0.5, which further indicates validity. The results of the reliability test also indicate a degree of consistency, as the composite reliability exceeds 0.7. So, it can be assumed that this model is valid and reliable. (Hair et al., 2021).

a. Model Structural Assessment

The correlation test analysis between these latent variables is illustrated in the path diagram from the SmartPLS analysis results, using a reflective indicator model in the final stage. Reflective model indicators are generally seen as variables that reveal (reflected), are seen, or are reflected in latent variables so that the indicators are reflective (Solimun et al., 2017). The causal relationship from the latent variable to the indicator ensures that removing a single indicator does not alter the meaning or significance of the measured variable. Thus, the assessment of the structural model hypothesis is tested through path coefficient analysis and R-square (R2) from blindfolding results for the reflective model (Wati, 2018). To clarify further, the relationship between these latent variables can be described as shown in Table 3.

Table 3. Results of hypothesis tests on the influence of livelihood assets on adaptation strategies and risks

Model Construct	Coefficient	T-Statistic	Result	R-Square
X (Livelihood Assets) → Y1 (Livelihood Risks)	0.424189	4.704790	Significant	0.180
X (Livelihood Assets) → Y2 (Adaptation Strategy)	0.258611	2.076140	Significant	0.060
X → X.1 Human Capital	0.492349	4.836412	Significant	
X → X.2 Social Capital	0.750064	13.708913	Significant	
X → X.3 Natural Capital	0.841947	16.512246	Significant	
X → X.4 Physical Capital	0.607584	4.766423	Significant	
X → X.5 Financial Capital	0.891656	40.756701	Significant	

Source: Primary Data Processed, 2024
Significant at the 5% level, the value of the t-table at the 5% level = 1.96

b. Determination of R Square (R^2)

R-squared (R^2) is used to assess the goodness-of-fit of a structural model. The worth of this evaluation is employed to observe the degree of impact of the independent latent variable on the dependent latent variable. According to the calculation algorithm (the magnitude of each indicator's influence), the R2 for livelihood risk is 0.172, indicating that the exogenous variable of livelihood assets can explain 17.2% of the variation in livelihood risk (Y1), and the remaining variables are affected by non-research variables. The correlation between the livelihood assets as an exogenous variable and the adaptation strategy (Y2)1 is 0.065, indicating that the effects of the livelihood assets can be explained by 6.5 percent, with the remaining explained by the other variables outside the research model.

c. T-Statistical Testing Results

The outcome of hypothesis testing will be determined by comparing the t-value with the critical t-value from the t-table. When the t-value exceeds the t-table value (1.96 at the 5 percent significance level), the relationship between the latent variables is considered significant and may be further investigated. In detail, the dominant indicators are exogenous variables for livelihood assets and endogenous variables for livelihood risk (Y1) and adaptation strategy (Y2), as shown in Figure 2 below.

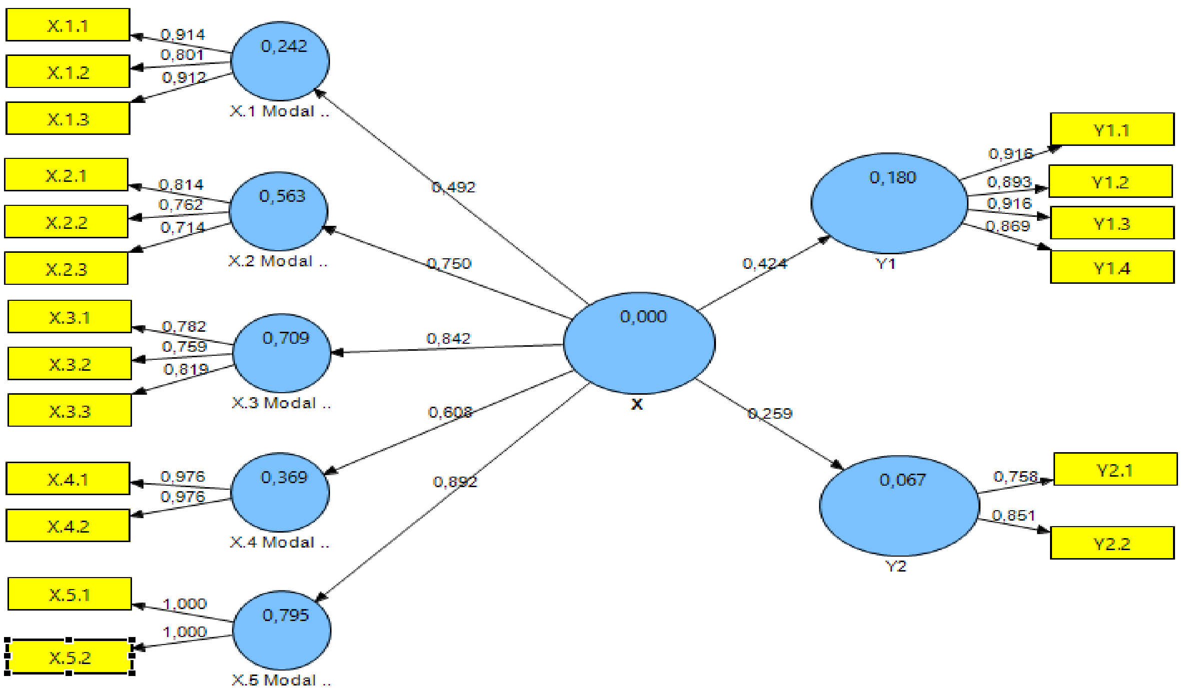

Figure 2. Magnitude of Hypothesis Testing Results of the Influence of Livelihood Assets On Adaptation Strategies And Risk Strategies (Measurement Model PLS Algorithm). Source: Primary Data Processed, 2024

In total, the livelihood assets of farmers have a positive influence on both livelihood risks and local maize farmers' adaptation strategies. Livelihood risks are positively and significantly influenced by livelihood assets, with a value of 0.414 and a significance value of 4.428, which is greater than 1.96. Livelihood assets have a positive and significant influence on the adaptation strategy, as indicated by a significance value of 0.255, which is less than 1.96. Therefore, livelihood assets help farmers overcome risks and adopt the right adaptation strategy in the face of change (Kuang et al., 2020). (2017) stated that farmers' resource management is essential to helping them implement effective response measures to minimize economic uncertainties, such as environmental, commercial, technological, and regulatory challenges. Furthermore, analyzing resource ownership among farmers helps policymakers and experts assess the extent of necessary assistance to reduce vulnerabilities.

After conducting the Algorithm (seeing the significance value of each variable and indicator) as seen in Figure 2 above, the following statement is obtained:

1. Financial Capital

The most dominant indicator in reflecting the exogenous variable of livelihood assets (X) is X.5 (financial capital), with a value of 0.894, indicating that financial capital contributes 0.894 to the adoption of adaptation strategies and the overcoming of risks. As Paul et al. (2020) stated, choosing a means of earning a living is primarily determined by the economic resources available to a family. Monetary assets are essential in supporting the survival of mobile farmers in Jhumias, a region in India. Based on the findings, short-term livelihood assets, such as financial capital, are beneficial for farmers in overcoming livelihood risks and in deciding which adaptation strategies to adopt. This finding is also consistent with (2022), who found that financial capital positively affects self-sufficiency in rice production in Indonesia.

You et al.,(2019) further emphasizes that access to financial capital can improve household welfare, which positively correlates with higher income. Local maize farmers need financial support to increase income and to plant hybrid maize, either simultaneously or alternately with local maize cultivation. Hybrid maize seeds are not stored like local maize. Instead, farmers have to buy them at agro centers at approximately Rp 75,000/kg to Rp. 120,000/kg. With comparatively lower incomes, local maize farmers also need additional financial support. Financial asset indicators also help improve the quality of maize production by reducing livelihood risks (natural and market risks).

2. Natural Capital

The second most dominant indicator is natural capital (X.3), reflecting the exogenous variable of livelihood assets with a value of 0.843, indicating that natural capital contributes 0.843 to adopting adaptation strategies and overcoming risks. Natural capital significantly affects livelihood risks and adaptation strategies. Good climatic conditions will reduce vulnerability to natural, market, technological, and policy risks. Besides, implementing an adaptation strategy through diversification and changing planting dates also requires a supportive climate. Based on the research by Sedi et al. (2024) on the factors influencing Nigerian farmers' decisions to cultivate hybrid corn from a gender perspective, the study found that most male farmers preferred hybrid corn due to its higher yields and greater tolerance to unpredictable climate conditions. Farmers' land area also determines the adoption of strategies. The wider the land owned by the farmers, the wider the planting area for local maize farmers, or even farmers can plant hybrid maize and local maize simultaneously. In line with Shinbrot et al. (2019), natural capital supports farmers to adapt by diversifying crops - other than coffee - in Mexico. Additionally, natural capital is directly used in the production of goods and supports sustainable livelihoods (Ibrahim et al., 2018).

3. Social Capital

The third most dominant indicator in reflecting the exogenous variable of livelihood assets is social capital (X.2), with a value of 0.748, indicating that social capital contributes 0.748 to the adoption of adaptation strategies and the overcoming of risks. In the short term, social capital is a less dominant livelihood asset than others, as it is not simply an outcome but an ongoing process. Unlike tangible assets, social capital is continuously developed and accumulated over time. In that regard, it has not immediately influenced the adoption of strategies or livelihood risks. However, in the long run, social capital helps mitigate livelihood risks in adaptation strategies by fostering a system of mutual trust through cooperation. Farmers can help each other collectively deal with risks, specifically by adopting appropriate strategies that increase income without reducing food requirements.

The next social capital is mainly based on the idea that beliefs, norms, and informal networks hold that social relations are abundant resources that will never be exhausted when used. Frequent use of social capital enhances its quality (Fathy, 2019). A study by Liu et al. (2018) found that different community-based resources positively influence how economic resources are allocated within families that engage in farming. However, their empirical study of China has shown that communal networks do not strongly influence farmers' decisions about how to earn income. This explains why it is essential to use both quantitative and qualitative analyses of societal determinants in analyzing agricultural livelihoods.

Social capital refers to the ways households interact with the social environment, including other communities. It is said to increase trust and reduce the costs of collaboration (Su et al., 2024). Ma et al. (2018) also assert that assets, especially social assets owned by farmers, are vital for income growth. One of the underlying causes of poverty among low-income individuals is a deficit of livelihood capital, which entails social assets and access to information. According to Kuang et al. (2020), social capital plays a significant role in supporting farmers' livelihoods in Rugou, China.

4. Physical Capital

Physical capital (X.4) is the fourth most dominant measure of livelihood assets, with a value of 0.606, indicating that it plays a role of 0.606 in the adoption of adaptation strategies and the overcoming of risks. Physical capital is limited in the form of farmers' livelihood assets, given the conditions within the field. Most of the farmers were simply owners of hoes and sickles, with the farms' assets being the motorized vehicles. It follows that physical capital has a relatively small effect on minimizing livelihood risks and on adaptation strategies. Liu et al. (2018) explain that the more physical capital, the higher the likelihood of them carrying on farming (rural households). Unlike Dang et al. (2020), physical capital does not play a positive role in the sustainability of the livelihoods of the Loess highlanders in China following an ecological restoration project or the conversion of agricultural land to forest.

5. Human Capital

The lowest-value contributor to wrong livelihood assets is human capital (X.1), with a value of 0.496, indicating that human capital contributes 0.496 towards adaptation strategies and risk mitigation. There is a lack of training ability of local maize farmers in the field. The local government does not provide farmers with the necessary training. Farmer groups in certain hamlets are not performing their functions well; they perform well only at one time. A small proportion of farmers are not well educated, and not all of them engage in farming activities on their own; instead, they depend on their neighbors. Others opted out of their village to live better lives. Hence, the input of human capital into livelihood assets is minimal, as are the impacts on the farmer's livelihood risks and adaptation strategies.

Human capital helps reduce poverty levels because access to human resources can bolster household earnings (Kamaruddin and Baharuddin, 2015). Meanwhile, regarding food consumption, it is clarified that the availability of human assets grows and sustains household food consumption (Parmawati et al., 2018). Besides that, access to human assets is also highlighted, as it provides households with power and facilitates welfare improvement (Sulemana et al., 2019). The use of human capital is the least contribution to this study, whereas in Kasim et al. (2017), the human capital is the contributing Factor with the highest contribution to the welfare of farmer households in Nigeria.

6. Livelihood Risk

The indicator of technological risk and natural risk with the highest value of 0.915 is the most overwhelming in reflecting the endogenous variable livelihood risk (Y1). Based on field findings, technology and natural risks are the most significant sources of impact on farms. The phenomenon of hybrid maize is a threat and a new trend for maize farmers, who have to adjust to it. As described in the first research objective, the introduction of hybrid maize led to increased volatility in maize prices. Introduce new maize crop pests and diseases, in general, and jeopardize food availability for farmers whose staple food is local maize. According to the farmers, technological risks are among the livelihood risks they face. By that, the proper utilization of livelihood assets would empower farmers to make informed decisions about agricultural production, thereby diminishing their vulnerability to livelihood risks (García de Jalón et al., 2018).

7. Adaptation Strategy

The most dominant indicator in reflecting the endogenous variable of adaptation strategy (Y2) is the diversification (hybrid) adaptation strategy, with a contribution value of 0.852. Based on the collected facts, many farmers have implemented diversification strategies, namely planting hybrid and local maize. The hope is that it can generate higher income from hybrid maize sales while simultaneously meeting food needs. In line with the research by (2023) on the impact of adopting hybrid maize and rice crops on the income and food security of smallholder households in Bihar and Uttar Pradesh, India, the study found that hybrid maize significantly increased farmers' income and food security compared to hybrid rice. Unlike the adaptation strategy of changing the planting date with a value of 0.767, farmers plant local maize in the second planting season to avoid unsupportive wind conditions in MT 1. In the first planting season, farmers plant hybrid maize to increase income, while food needs are met with the residue of stored local maize from the previous year. As in Peng et al. (2020), the most common strategies for farmers to deal with changing trends, disaster hazards, and climate change are diversification, adjusting planting dates, and adjusting crop varieties, which are the most dominant adaptation strategies, followed by area-wide agricultural patterns and switching to other professions. Compared with this research, the strategy of adjusting plant varieties to natural disasters used by developing countries in China can also be an additional strategy, but not the primary one, for farmers in Guluk-Guluk because the geographical location and natural disasters differ between the two. Not maximizing livelihood assets as support in adopting strategies to be more optimal in dealing with natural disasters faced by farmers in the Chinese highlands. Therefore, this study can provide a broader view of the supporting factors for easier, more efficient adaptation strategies based on farmers' ownership of assets in other areas.

CONCLUSIONS AND SUGGESTIONS

The conclusion of this study indicates that the adaptation strategy employed by farmers to address technological risks is diversification, with financial assets being the most dominant supporting Factor. Based on this conclusion, to optimize policy implementation, the government should provide effective financial services, such as term savings managed by farmer groups, to manage farmers' financial assets better. However, this study has limitations, as it only focuses on one area in Madura. Therefore, future research should expand the study area to enable a more comprehensive comparison of results. Further in-depth research is also necessary to strengthen the findings.

REFERENCES

Achmad, B., Sanudin, Siarudin, M., Widiyanto, A., Diniyati, D., Sudomo, A., Hani, A., Fauziyah, E., Suhaendah, E., Widyaningsih, T. S., Handayani, W., Maharani, D., Suhartono, Palmolina, M., Swestiani, D., Budi Santoso Sulistiadi, H., Winara, A., Nur, Y. H., Diana, M., ... Ruswandi, A. (2022). Traditional Subsistence Farming of Smallholder Agroforestry Systems in Indonesia: A Review. *Sustainability*, *14*(14), 8631. https://doi.org/10.3390/su14148631

Amzeri, A. (2018). Tinjauan Perkembangan Pertanian Jagung di Madura dan Alternatif Pengolahan Menjadi Biomaterial. *Rekayasa*, *11*(1). https://doi.org/10.21107/rekayasa.v11i1.4127

Dang, X., Gao, S., Tao, R., Liu, G., Xia, Z., Fan, L., & Bi, W. (2020). Do environmental conservation programs contribute to sustainable livelihoods? Evidence from China's grain-for-green program in northern Shaanxi province. *Science of the Total Environment*, *719*. https://doi.org/10.1016/j.scitotenv.2020.137436

Fathy, R. (2019). Modal Sosial: Konsep, Inklusivitas dan Pemberdayaan Masyarakat. *Jurnal Pemikiran Sosiologi*, *6*(1). https://doi.org/10.22146/jps.v6i1.47463

García de Jalón, S., Iglesias, A., & Neumann, M. B. (2018). Responses of sub-Saharan smallholders to climate change: Strategies and drivers of adaptation. *Environmental Science and Policy*, *90*. https://doi.org/10.1016/j.envsci.2018.09.013

Hair, J. F., Jr., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2021). A primer on partial least squares structural equations modeling (PLS-SEM). Sage Publications. *Journal of Tourism Research*, *6*(2).

Hasna, M., & Supyandi, D. (2021). Partisipasi Petani Dalam Program Pengembangan Jagung Hibrida (Suatu Kasus Pada Kelompoktani Di Desa Mulyasari Kecamatan Mande Kabupaten Cianjur). *Mimbar Agribisnis: Jurnal Pemikiran Masyarakat Ilmiah Berwawasan Agribisnis*, *7*(1). https://doi.org/10.25157/ma.v7i1.4555

Heryanto, A. Y., Kristanti, N. E., & Widodo, K. H. (2024). An Analysis of Logistic Cost Structure in Corn Commodity Supply Chain (Zea Mays L) in East Java Using Activity-Based Costing (ABC) Method. *Emerging Advances in Integrated Technology*, *5*(2), 45–52. https://doi.org/https://doi.org/10.30880/emait.2024.05.02.004

Ibrahim, A. Z., Hassan, K. H., Kamaruddin, R., & Anuar, A. R. (2018). The Level of Livelihood Assets Ownership Among Vulnerability Groups in East Coast of Malaysia. *European Journal of Sustainable Development*, *7*(3). https://doi.org/10.14207/ejsd.2018.v7n3p157

Kamaruddin, R., & Baharuddin, A. H. (2015). The importance of good aquaculture practices in improving fish farmers' income: A case of Malaysia. *International Journal of Social Economics*, *42*(12). https://doi.org/10.1108/IJSE-02-2014-0028

Kasim, Y., Zubir Ibrahim, A., Binti, B., Din, H., Shafie, G., & School Of Government, G. (2017). Understanding the Effect of Access To Livelihood Assets and Government Intervention on Poverty Reduction: A Partial Least Squares Approach. *International Journal of Emerging Trends in Engineering and Development Issue*, *7*(7), 123–138. https://doi.org/https://doi.org/10.17632/IJETED/JULY2017/0011

Kock, N. (2018). Minimum sample size estimation in PLS-SEM: An application in tourism and hospitality research. In *Applying Partial Least Squares in Tourism and Hospitality Research*. https://doi.org/10.1108/978-1-78756-699-620181001

Kock, N., & Hadaya, P. (2018). Minimum sample size estimation in PLS-SEM: The inverse square root and gamma-exponential methods. *Information Systems Journal*, *28*(1). https://doi.org/10.1111/isj.12131

Kuang, F., Jin, J., He, R., Ning, J., & Wan, X. (2020). Farmers' livelihood risks, livelihood assets, and adaptation strategies in Rugao City, China. *Journal of Environmental Management*, *264*. https://doi.org/10.1016/j.jenvman.2020.110463

Liu, Z., Chen, Q., & Xie, H. (2018). Influence of farmers' livelihood assets on livelihood strategies in the western mountainous area of China. *Sustainability (Switzerland)*, *10*(3). https://doi.org/10.3390/su10030875

Lun, R., Liu, W., Li, G., & Luo, Q. (2024). Does Digital Agricultural Technology Extension Service Enhance Sustainable Food Production? Evidence from Maize Farmers in China. *Agriculture (Switzerland)*, *14*(2). https://doi.org/10.3390/agriculture14020292

Ma, J., Zhang, J., Li, L., Zeng, Z., Sun, J., Zhou, Q. (Bill), & Zhang, Y. (2018). Study on livelihood asset-based spatial differentiation of income in natural tourism communities. *Sustainability (Switzerland)*, *10*(2). https://doi.org/10.3390/su10020353

Marliati. (2020). Factors influencing the entrepreneurial behavior of street vendors (A case in Pekanbaru City, Riau Province). *Agraris*, *6*(2). https://doi.org/10.18196/agr.6297

Parmawati, R., Soemarno, S., Maryunani, M., & Kurnianto, A. S. (2018). Analysis Of Poverty In Forest Surrounding Communities By Sustainable Livelihood Approach. *Jurnal Antropologi: Isu-Isu Sosial Budaya*, *20*(1). https://doi.org/10.25077/jantro.v20.n1.p1-15.2018

Paul, S., Das, T. K., Pharung, R., Ray, S., Mridha, N., Kalita, N., Ralte, V., Borthakur, S., Burman, R. R., Tripathi, A. K., & Singh, A. K. (2020). Development of an indicator-based composite measure to assess livelihood sustainability of shifting cultivation-dependent ethnic minorities in the disadvantaged Northeastern region of India. *Ecological Indicators*, *110*. https://doi.org/10.1016/j.ecolind.2019.105934

Peng, L., Tan, J., Deng, W., & Liu, Y. (2017). Understanding the resilience of different farming strategies in coping with geo-hazards: A case study in Chongqing, China. *International Journal of Environmental Research and Public Health*, *4*(7), 123–138. https://doi.org/https://doi.org/10.17632/IJETED/JULY2017/0011

Safruddin, S., Sitopu, J. W., Manurung, A. A., Satria, I., & Wanto, A. (2023). Pengelompokkan Produksi Tanaman Jagung di Sumatera Utara Menggunakan Algoritma K-Medoids. *JURNAL MEDIA INFORMATIKA BUDIDARMA*, *7*(1). https://doi.org/10.30865/mib.v7i1.5562

Salsadyra, V. D., Nugroho, T. R. D. A., & Sugiarti, T. (2022). Female Farmworkers' Participation in the Cultivation of Madurese Local Maize at Pakaan Laok Village. *Agriecobis : Journal of Agricultural Socioeconomics and Business*, *5*(02). https://doi.org/10.22219/agriecobis.v5i02.20311

Sedi, M., Akinola, A. A., Obunyali, C. O., Adebayo, M. A., Muungani, D., Mazambani, I., & Oikeh, S. O. (2024). Hybrid Maize Adoption Determinants in Northern Nigeria : A Gendered Perspective. *International Journal of Agriculture and Technology*, *4*(1), 1–9. https://doi.org/https://doi.org/10.33425/2770-2928.1021

Shinbrot, X. A., Jones, K. W., Rivera-Castañeda, A., López-Báez, W., & Ojima, D. S. (2019). Smallholder Farmer Adoption of Climate-Related Adaptation Strategies: The Importance of Vulnerability Context, Livelihood Assets, and Climate Perceptions. *Environmental Management*, *63*(5). https://doi.org/10.1007/s00267-019-01152-z

Solimun, Fernandes, A. A. R., & Nurjannah. (2017). Metode Statistika Multivariat Pemodelan Persamaan Struktural (SEM) Pendekatan WarpPLS. In *UB Press* (Cetakan Ke). UB Press. https://books.google.co.id/books?id=GrRVDwAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

Su, Y., Zhang, S., Li, Y., & Yu, H. (2024). How does social capital promote consumer participation in food safety governance? Evidence from online food consumers in China. *Humanities and Social Sciences Communications*, *11*(1). https://doi.org/10.1057/s41599-024-02890-0

Sulemana, M., Malongza, B. F. I., & Abdulai, M. (2019). Assessment of the Livelihood Empowerment Against Poverty programme in Karaga district, Ghana. *Development in Practice*, *29*(4). https://doi.org/10.1080/09614524.2018.1551859

Syahrial, R., & Susanto, H. (2024). A Strategic Model To Fulfill The Food Security of Farming Families Who Maintain The Culture of Growing Local Madurese Maize. *Agricultural Science*, *8*(1), 93–111. https://doi.org/https://doi.org/10.55173/agriscience.v8i1.153

Tripathi, A., Sardar, S., & Shyam, H. S. (2023). Hybrid crops, income, and food security of smallholder families: Empirical evidence from poor states of India. *Technological Forecasting and Social Change*, *191*. https://doi.org/10.1016/j.techfore.2023.122532

Turasih, & M Kolopaking, L. (2016). Strategi Adaptasi Perubahan Iklim Pada Petani Dataran Tinggi (Studi Petani di Dataran Tinggi Dieng, Kabupaten Banjarnegara). *Sodality: Jurnal Sosiologi Pedesaan*, *4*(1). https://doi.org/10.22500/sodality.v4i1.14408

Udoh, E. J., Akpan, S. B., & Uko, E. F. (2017). Assessment of Sustainable Livelihood Assets of Farming Households in Akwa Ibom State, Nigeria. *Journal of Sustainable Development*, *10*(4). https://doi.org/10.5539/jsd.v10n4p83

Visković, J., Dunđerski, D., Adamović, B., Jaćimović, G., Latković, D., & Vojnović, Đ. (2024). Toward an Environmentally Friendly Future: An Overview of Biofuels from Corn and Potential Alternatives in Hemp and Cucurbits. *Agronomy*, *14*(6). https://doi.org/10.3390/agronomy14061195

Wati, L. N. (2018). *Metodologi Penelitian Terapan, Aplikasi SPSS, EVIEWS, Smart PLS dan AMOS*. Pustaka Amri.

Windra sukma, K. perdana. (2018). Pertumbuhan dan Produksi Jagung Lokal, Hibrida dan Komposit Di Pamekasan Madura. *Jurnal Agrosains: Karya Kreatif Dan Inovatif*, *4*(2). https://doi.org/10.31102/agrosains.2017.4.2.34-38

Wong. (2019). Mastering Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS in 38 Hours. *Syria Studies*, *7*(1).

You, H., Hu, X., Bie, C., & Zhou, D. (2019). Impact of livelihood assets on farmland-transferred households' willingness to urbanize and policy implications for farmland transfer: Evidence from Zhejiang, China. *Discrete Dynamics in Nature and Society*, *2019*. https://doi.org/10.1155/2019/9631701