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Impact of agribusiness value chain components on agribusiness performance and livelihood outcomes: An integrated analysis using porter's value chain and the sustainable livelihoods framework

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ABSTRACT

This research examines the influence of agricultural value chain elements on agribusiness performance and livelihood outcomes in Somalia, including Porter's Value Chain Analysis and the Sustainable Livelihoods Framework (SLF). It analyzes the impact of fundamental value chain components input supply, production, processing, and marketing on agribusiness performance and, subsequently, on livelihood outcomes such as income, food security, employment, and resilience. A quantitative methodology was employed, utilizing data collected from 400 agribusiness actors within Somalia's agricultural sector. Structural Equation Modeling (SEM) using SmartPLS was applied to explore the interrelationships among variables. The findings indicate that most value chain elements exert a significant positive influence on agribusiness performance; however, input supply was identified as a constraining factor due to inefficiencies. Agribusiness performance acts as a mediator linking value chain components to improved livelihood outcomes. The study provides actionable policy recommendations for vulnerable agricultural economies, emphasizing the need for improved infrastructure, better control of agricultural inputs and services, and conflict-sensitive strategies. This research presents an empirically validated model connecting value chain enhancement to sustainable livelihood improvements, offering valuable insights for policymakers, development partners, and practitioners aiming to strengthen agribusiness competitiveness and resilience in post-conflict and vulnerable rural areas.

Contribution/ Originality: This research uniquely integrates Porter's Value Chain with the Sustainable Livelihoods Framework to examine agriculture in a conflict-impacted economy. This study empirically examines agribusiness performance as a mediator between value chain components and livelihood outcomes, providing context-specific insights for Somalia's vulnerable agriculture sector, in contrast to previous studies.

1. INTRODUCTION

Historically, agriculture has been vital to social and economic stability in emerging countries, especially in rural regions where it offers the bulk of employment, food security, and income [1]. Enhancing agribusiness performance through agricultural value chains requires a comprehensive approach that addresses inefficiencies and fosters diversity. Improving value chains may provide smallholder farmers and other stakeholders with greater opportunities to achieve equitable profits from agricultural output [2]. An efficiently structured value chain enhances productivity, reduces post-harvest losses, and ensures increased earnings for distributors, processors, and farmers, thereby augmenting agricultural performance [3].

Efficient value chain integration enhances market accessibility, facilitates infrastructure investment, and fosters agricultural innovation, all of which bolster resilience [4]. Agriculture constitutes a significant component of Somalia's economy, providing employment for the majority of its population [5]. The Somali agricultural sector confronts significant obstacles, including inadequate infrastructure, insufficient financial resources, and frequent natural disasters that jeopardize its productivity and resilience [6]. Contextual characteristics underscore the urgent necessity to examine how enhancements in the agricultural value chain might mitigate these constraints, hence promoting agribusiness success and enhancing livelihood outcomes for smallholder farmers and rural communities [7].

The marketing component emphasizes the importance of market access, branding, and distribution channels in augmenting profitability and expanding market reach [8]. In Somalia, where many rural farmers lack access to formal markets and face high transportation costs, improving marketing and distribution is crucial for empowering smallholders to sell their products at competitive prices [9]. The contextual challenges underscore the imperative for a comprehensive strategy in agricultural performance that includes operational efficiency, market access, and infrastructure supportive of sustainable growth [10].

Porter [11] Value Chain Analysis and the Sustainable Livelihoods Framework (SLF) are two theoretical frameworks that offer a systematic way to assess agricultural value chains and underpin this study. Value Chain Analysis, a strategic instrument, was established by Porter [11] to examine an organization's internal operations and their role in attaining competitive advantage [12]. Porter outlined key activities, which include inbound logistics, operations, outbound logistics, marketing and sales, as well as support activities including the firm's infrastructure, human resources, technology, and procurement [13]. These activities collectively offer a conceptual framework that aids in comprehending the origins and mechanisms of value generation inside a corporation [14].

In agriculture, a value chain analysis may be utilized to evaluate all input suppliers, production, processing, marketing, and logistics that contribute to the efficiency and profitability of agricultural operations [7]. Porter's methodology has influenced the evaluation of competitive agribusinesses in developing nations, where resource scarcity and inadequate infrastructure can severely hinder productivity [15]. Traditional value chain evaluations often prioritize market competitiveness and company efficiency, sometimes neglecting the wider livelihood consequences for stakeholders. The five essential assets that constitute the cornerstone of the SLF are human, social, environmental, physical, and financial capital. Collectively, they enhance economic stability and resilience while fostering sustainable livelihoods [16].

Notwithstanding the robust theoretical underpinnings offered by Porter's Value Chain Analysis and the Sustainable Livelihoods Framework (SLF), a notable deficiency persists in the literature regarding its combined use in fragile and conflict-affected states such as Somalia. Current research on agricultural value chains (e.g., [8, 17]) predominantly examines stable ecosystems, assuming uninterrupted availability of inputs, operational markets, and strong institutional backing. These assumptions rarely apply in environments like Somalia, where agriculture operates amid persistent instability, resource shortages, market fragmentation, and infrastructural deterioration. Consequently, rural inhabitants remain highly vulnerable, and conventional value chain interventions often fail to produce significant improvements in livelihoods.

Furthermore, a significant portion of the existing literature regards agribusiness performance as a final objective, neglecting to examine its intermediary function in converting value chain enhancements into concrete lifestyle results. This limited perspective neglects the potential of performance to serve as a channel through which value chain components, including input supply, production, or marketing, influence wider livelihood metrics such as income, food security, employment, and resilience.

This study fills these gaps by using Porter's and SLF frameworks to examine both the direct impacts of value chain components and the mediating role of agribusiness performance in improving livelihood outcomes. This research applies the model to the Somali context an under-explored environment characterized by insecurity and institutional instability thereby enhancing the knowledge of value chain dynamics in fragile agricultural economies with contextual relevance and functional subtlety.

2. LITERATURE REVIEW

2.1. Introduction

Agriculture is crucial to Somalia's economy, and for most rural areas, it is either a source of cash or nutrition for the majority of the people. This study analyzes the effect of selected elements in agricultural value chains on performance and livelihood outcomes by applying an integrated approach using Porter's Value Chain Analysis and the Sustainable Livelihoods Framework. The value chain framework offers a systematic approach to analyze every stage of commercialization, identifying value-added activities and issues that need to be improved [18]. In agribusiness, the elements needed to create value are input supply, production, processing, marketing, and distribution. This, in turn, through optimization, enables an agribusiness to enhance its productivity and competitiveness, which ultimately increases revenue for stakeholders' improved welfare [19].

2.2. Components and Performance of the Agribusiness Value Chain

Porter's Value Chain Analysis is highly regarded for its ability to assess how specific business practices improve competitive advantage by generating value. [11]. In addition to ancillary activities such as firm infrastructure, human resources, technology, and procurement that provide indirect support, this model outlines five core activities necessary for the production of goods or services: inbound logistics, operations, outbound logistics, marketing and sales, and services [13]. Every activity has a significant impact on overall performance, but in agriculture, specific processes like input supply, production, and marketing can have a big impact on market access and profitability [16]. The quality and accessibility of resources such as seeds, fertilizer, and machinery are referred to as input supply in agriculture. Good inputs are essential for increasing yield and productivity, particularly for smallholders trying to increase outputs despite limited resources [20]. Resource management, technology integration, and efficient farming methods all improve output quality and productivity during the production stage [14]. Post-harvest processing operations, such as packaging and quality control, augment product value and enable smallholders to satisfy market norms, which are essential for accessing higher-value markets [3]. In Somalia, enhancing market access and logistical infrastructure provides an opportunity to improve agribusiness performance, allowing smallholders and local firms to participate more successfully [10]. Improved value chain efficiency strengthens the regional agriculture sector and fosters greater economic stability by increasing production, profitability, and market penetration.

Hypothesis 1: Enhanced components of the agricultural value chain (input supply, production, processing, marketing, and logistics) favorably influence overall agribusiness performance.

2.3. The Role of Agribusiness Performance as a Mediator

The impact of agribusiness success on the relationship between lifestyle outcomes and value chain components is dependent on performance indicators such as productivity, profitability, and market access. An optimized value chain improves performance by enhancing productive efficiency in production, reducing costs, and promoting quality, and consequently enhances profitability and access to markets [16]. Improved performance in agribusiness allows smallholders to achieve better yields, higher prices, and market access to become competitive players, thereby sustaining growth in developing countries [14]. Studies show that increases in productivity brought about by effective production and processing techniques significantly boost income and job growth in rural areas [8]. Market penetration in agribusiness refers to the ability to enter and remain present in new markets, demonstrating the company's potential for growth and competition. The relationship between operational efficiency from value chain activities and positive outcomes in terms of income, food security, and resilience is mediated by agribusiness performance [21].

Hypothesis 2: Improved agricultural performance mediates the association between value chain elements and enhanced livelihood outcomes.

2.4. The Influence of Agribusiness Value Chain on Livelihood Outcomes

Agribusiness value chains greatly enhance livelihoods through increased opportunities for income and reduced vulnerability, especially in rural areas of developing countries where agriculture is the main livelihood. The Sustainable Livelihoods Framework provides a way to analyze the contribution of agricultural value chains to livelihood improvement by assessing five important assets: human, social, natural, physical, and financial capital [22]. Access to such resources enables smallholders to increase production, be more responsive to market demand, and be better prepared against economic and environmental shocks. Value chain improvements have a direct impact on these livelihood outcomes [23]. The ability of households to obtain nutritious food is increased when agribusiness performance improves, resulting in higher revenue [24]. Agriculture's growth creates job opportunities, which promotes economic stability in rural regions [25]. Improving agricultural value chains is a calculated approach to raising household incomes, guaranteeing job stability, and enhancing community resilience in the Somali context, which is marked by pervasive poverty and food insecurity.

Hypothesis 3: Agribusiness performance exerts a favorable influence on livelihood outcomes, including income levels, food security, and resilience.

2.5. The Function of Livelihood Assets as a Mediator

The association between agricultural performance and livelihood outcomes is influenced by access to livelihood assets, such as human capital (education, skills), social capital (community networks), natural capital (land and water), physical capital (infrastructure, technology), and financial capital (credit, savings). Since these resources enable people to adjust and sustain their livelihoods in the face of changing circumstances, the SLF highlights their importance in reducing vulnerability and enhancing resilience [8]. The growth and sustainability of agribusiness depend heavily on labor productivity and efficiency, which are improved by human capital. Social capital supports business development and resilience in resource-constrained environments by improving networking and information exchange [26]. Smallholders in Somalia are unable to invest in improved inputs or technology because of the lack of financial services, making access to financial resources, including loans, crucial [10]. Agribusinesses may strengthen their operational base and improve household incomes, food security, and resilience by increasing access to these resources. As a result, livelihood assets act as a moderating factor to ensure that improvements in agricultural performance result in long-lasting benefits for industry participants [27].

Hypothesis 4: Access to livelihood assets mediates the link between agricultural performance and livelihood outcomes, with greater access resulting in improved results.

2.6. Obstacles in the Integration of Agribusiness Value Chains

Smallholder integration into agribusiness value chains presents a number of challenges despite its potential benefits. Value chain governance, which ensures that quality standards are followed and encourages cooperation among stakeholders, is often limited in developing countries, preventing smallholders from accessing markets [28]. Furthermore, the inclusion of value chain interventions is limited by the persistence of gender disparities in value chains, where women are underpaid and denied access to resources and decision-making opportunities [18]. Funding and market access are two additional challenges for smallholders. Due to limited resources and access to financing, many organizations find it difficult to meet value chain requirements for timely and high-quality delivery [29].

Somalia's underdeveloped financial system makes it difficult for smallholders to obtain funding for necessary technologies and inputs that meet value chain standards [30]. Addressing these challenges requires specific policies that provide smallholders with access to capital, infrastructure, and training opportunities.

2.7. Conclusion

This literature analysis highlights agribusiness value chains as critical catalysts for enhanced agricultural production and improved livelihood outcomes in Somalia. This study examines how the supply linkages of inputs, production, processing, marketing, and logistics influence agribusiness performance and subsequently affect income, food security, and resilience through the integration of Porter's Value Chain Analysis and the Sustainable Livelihoods Framework.

The findings suggest that better value chain components lead to increased productivity, profitability, and access to markets, and hence positively affect rural livelihoods. Second, it is assumed that agribusiness performance mediates partially between the efficiency of value chains and livelihood outcomes, thereby further reinforcing the necessity for optimization in operations and infrastructure. More importantly, livelihood assets human, social, natural, physical, and financial capital further reinforce the benefits accruing from improved agricultural performance. However, weak value chain governance, limited financial access, and gender disparities are some of the challenges facing smallholder integration into agribusiness markets. Such barriers need to be addressed through targeted policies and interventions that can help create an inclusive and resilient agribusiness sector for sustainable economic development in Somalia.

3. RESEARCH METHODOLOGY

3.1. Research Design

This study employed a quantitative research approach to empirically investigate the links among agricultural value chain components, agribusiness performance, and livelihood outcomes in Somalia. The research included Porter's Value Chain Framework and the Sustainable Livelihoods Framework (SLF) to evaluate both direct and mediated impacts of value chain optimization on agricultural performance and livelihood enhancement. A standardized, structured questionnaire was employed to gather data from diverse agriculture stakeholders, assuring uniformity and comparability across all variables and respondents.

3.2. Sample and Sampling Procedure

The target group comprised those engaged in Somalia's agriculture industry, especially farmers, input suppliers, processors, marketers, and logistics providers. A stratified random sampling method was employed to provide fair representation across the different stages of the agricultural value chain. Each stratum was defined based on members' roles within the value chain. A total of 400 respondents were selected, a sample size considered adequate for Structural Equation Modeling (SEM) as it meets the minimum threshold required for accurate estimation in complex models. This sampling method improved both the analytical strength and the applicability of the results throughout Somalia's varied agriculture sector.

3.3. Data Collection

Data were collected via a standardized self-administered questionnaire consisting of four primary components. The topics addressed include: (1) components of the value chain, encompassing input supply, production, processing, marketing, and logistics; (2) performance indicators for agribusiness, such as productivity, profitability, and market access; (3) livelihood outcomes, including income, employment, food security, and resilience; and (4) access to livelihood assets—human, natural, physical, social, and financial capital. Responses were quantified using a 5-point Likert scale, with 1 representing 'strongly disagree' and 5 denoting 'strongly agree.' The questionnaire underwent pretesting to ensure clarity and reliability prior to dissemination.

3.4. Data Analysis

The data analysis was performed in multiple steps. Initially, descriptive statistics were used to describe the sample's demographic characteristics, such as gender, age, education level, employment status, and income. Exploratory Factor Analysis (EFA) was employed to assess the dimensionality of the construct. The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity were used to ensure the sample size was adequate and that the factors could be grouped appropriately. Principal Component Analysis (PCA) with Varimax rotation was applied to identify components that aligned with the study's conceptual domains.

Afterward, SmartPLS 4 was used for Structural Equation Modeling (SEM). This method was chosen because it can handle complex models with a small number of samples and is robust enough to deal with data distributions that are not normal. We used Cronbach's alpha and Composite Reliability (CR) to assess the reliability of the measurement model, and Average Variance Extracted (AVE) to evaluate its convergent validity. The Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio confirmed the validity of the test. We examined the path coefficients, p-values, and R^2 values of the structural model to determine the strength and relevance of the hypothesized relationships. Multicollinearity was checked by analyzing the Variance Inflation Factor (VIF) values, which were all below acceptable thresholds.

3.5. Ethical Considerations

This study utilized people as subjects and followed ethical research rules very well. It was up to each participant whether or not to take part, and they all gave their informed consent before data collection. The process kept people's names and personal information private. The Institutional Review Board at SIMAD University approved this study from an ethical perspective. The study adhered to international standards for social science research involving people, which include respect, openness, and protecting the participants.

4. DATA ANALYSIS

4.1. Demographics

To understand how agricultural value chain components affect performance and livelihoods, it is vital to know the demographic features of the people involved. These insights help identify important trends, such as age distribution, gender roles, education levels, and income levels. Recognizing these patterns is essential for implementing effective interventions to improve agribusiness outcomes. Additionally, analyzing demographic patterns provides a comprehensive understanding of the social and economic conditions within the study area and how resources are distributed. This approach aligns with the research's purpose of integrating Porter's Value Chain framework with the Sustainable Livelihoods Framework.

Table 1. Demographic characteristics of study participants (N = 400).

Characteristics	Frequency (f)	Percent (%)
Age		
18-25	171	42.80
26-35	103	25.80
36-45	92	23.00
46-55	30	7.50
Above 56	4	1.00
Gender		
Male	348	87.00
Female	52	13.00
Education		
No formal education	200	50.00
Primary Education	126	31.50
Secondary Education	27	6.80
College diploma	7	1.80

Characteristics	Frequency (f)	Percent (%)
University Degree	40	10.00
Occupation		
Farming	268	67.00
Processing	71	17.80
Marketing	15	3.80
Logistics	46	11.50
Marital Status		
Single	27	6.80
Married	351	87.80
Divorced	16	4.00
Widowed	6	1.50
Experience		
Less than 1 year	18	4.50
1-3 years	196	49.00
4-6 years	170	42.50
More than 6 years	16	4.00
Household Size		
1-2 Members	29	7.30
3-5 Members	192	48.00
6-8 Members	166	41.50
More than 8 Members	13	3.30
Income Level		
Less than $100	15	3.80
$100-$500	210	52.50
$501-$1000	86	21.50
$1001-$2000	86	21.50
More than $2000	3	0.80
City		
Mogadishu	51	12.80
Afgoye	168	42.00
Balcad	127	31.80
Johar	35	8.80
Baladwayne	8	2.00
Others	11	2.80

The demographic analysis of the study in Table 1 provides important insights into the profiles of individuals engaged in agribusiness activities. Most participants (42.8%) fall within the 18-25 age group, highlighting the involvement of a younger population in the sector. Participants aged 26-35 also form a significant proportion (25.8%), while representation decreases substantially with age, with only 8.5% of participants over 45 years. This indicates a strong reliance on younger labor forces, potentially due to the physical demands of agribusiness activities or the migration of older individuals from the workforce. The sample is predominantly male, with men constituting 87% of respondents. Education levels among participants are notably low, with 50% lacking formal education and 31.5% having completed only primary education. Higher education attainment is rare, with just 1.8% holding a college diploma and 10% a university degree.

This analysis indicates that agribusiness tends to attract individuals with limited educational opportunities, potentially due to the sector's reliance on manual labor rather than technical skills. Regarding occupation, 67% of participants are involved in farming, highlighting its central role in the agribusiness value chain. Other roles, such as processing (17.8%), logistics (11.5%), and marketing (3.8%), are less represented, suggesting an uneven distribution across value chain activities. Most participants are married (87.8%), reflecting the social structure of the agribusiness workforce, where family support systems might play a vital role in sustaining livelihood activities. Household size is significant, with 48% of respondents living in households with 3-5 members, and 41.5% in households with 6-8 members. This indicates the prevalence of large families, which could influence labor contributions to agribusiness activities and income distribution. Income levels are generally modest, with 52.5% earning between $100-$500 and only 21.5% earning more than $500. The low income suggests limited profitability within agribusiness activities.

Geographically, the majority of participants are based in Afgoye (42%) and Balcad (31.8%), followed by Mogadishu (12.8%). It is also possible that this concentration in some cities is due to better agricultural opportunities or the availability of resources in those regions.

5. EXPLORATORY FACTOR ANALYSIS (EFA)

5.1. Rationale for Conducting the EFA

In this respect, the exploratory factor analysis was conducted to refine the dimensional structure of the components of the agribusiness value chain. Such analysis also serves as a method to ensure the validity of the derived constructs based on Porter's Value Chain Analysis. The identification of key underlying factors in the analysis helps narrow down specific points of intervention that may be required, such as improving the quality of input supplies, optimizing production efficiency, or enhancing marketing strategies [31]. The approach strengthens not only the conceptual framework of the study but also aligns the research findings with actionable insights into the improvement of agribusiness performance and livelihood outcomes.

Table 2. KMO and Bartlett's test for agribusiness value chain components.

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy.		**0.876**
Bartlett's test of sphericity	Approx. chi-square	2343.917
	df	105
	Sig.	0.000

5.2. EFA: Agribusiness Value Chain Components

Table 2 Kaiser-Meyer-Olkin: The KMO measure of sampling adequacy is 0.876. This indicates a strong suitability of the data for factor analysis. A KMO value above 0.8 is considered excellent, suggesting sufficient variable correlations to identify distinct factors. Bartlett's Test of Sphericity produced a significant result (Chi-Square = 2343.917, df = 105, $p < 0.001$), further confirming the appropriateness of the data for factor analysis.

This significant outcome indicates that the correlation matrix is not an identity matrix, meaning there are adequate interrelationships among variables to justify proceeding with exploratory factor analysis (EFA). The high KMO value and significant Bartlett's test imply that the selected variables effectively capture the dimensions of agribusiness value chain components. These results support the strength of the data and provide confidence in identifying latent constructs that contribute to agribusiness performance.

The communalities Table 3 provides insights into the proportion of variance in each variable that is explained by the factors extracted during the exploratory factor analysis. Initially, all variables have a value of 1.000, indicating that each variable is assumed to have complete variance at the start. However, after extraction, the communalities values reflect the extent to which each variable's variance is captured by the identified factors. The communalities range from 0.679 to 0.750, suggesting that a significant portion of the variance in each variable is explained by the extracted factors.

For the Input Supply variables (IS01, IS02, IS03), the communalities are high (0.743, 0.722, 0.730), indicating that factors such as the quality and availability of inputs are well represented. Similarly, the Production variables (Produc01, Produc02, Produc03) have communalities ranging from 0.708 to 0.749, which show that aspects such as production efficiency and resource utilization are effectively captured by the factors. In the Processing column, the communalities range between 0.680 and 0.735.

Table 3. Communalities for agribusiness value chain components.

Communalities		
	Initial	Extraction
IS01	1.000	0.743
IS02	1.000	0.722
IS03	1.000	0.730
Produc01	1.000	0.708
Produc02	1.000	0.749
Produc03	1.000	0.711
Proce01	1.000	0.735
Proce02	1.000	0.680
Proce03	1.000	0.702
Mark01	1.000	0.681
Mark02	1.000	0.721
Mark03	1.000	0.736
Logist01	1.000	0.750
Logist02	1.000	0.679
Logist03	1.000	0.689
Extraction method: Principal component analysis.		

Note: IS = Input Supply, Produc = Production, Proce = Processing, Mark = Marketing, Logist = Logistics and Distribution.

These figures show how much variance in post-harvest processing, value addition, and quality control is reflected in this factor structure.

The marketing variables also present high communalities, with Mark01, Mark02, and Mark03 oscillating between 0.681 and 0.736, thus supporting the fact that access to markets, branding, and pricing have been imperative in shaping the marketing component of the value chain. Not least, the logistics and distribution variables show the highest communalities, with Logist01, Logist02, and Logist03 varying between 0.679 and 0.750. The high communalities suggest that, overall, the factor analysis has effectively captured the underlying dimensions of the agribusiness value chain. The findings justify the extracted factors and confirm that the variables have appropriately represented the key components of agribusiness performance.

Table 4. Total variance explained for agribusiness value chain components.

Total variance explained									
	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
Component	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	5.575	37.165	37.165	5.575	37.165	37.165	2.177	14.515	14.515
2	1.516	10.107	47.272	1.516	10.107	47.272	2.152	14.346	28.862
3	1.409	9.393	56.665	1.409	9.393	56.665	2.147	14.311	43.173
4	1.225	8.165	64.830	1.225	8.165	64.830	2.134	14.226	57.399
5	1.010	6.734	71.564	1.010	6.734	71.564	2.125	14.165	71.564
6	0.539	3.593	75.158						
7	0.520	3.467	78.625						
8	0.481	3.208	81.833						
9	0.451	3.004	84.837						
10	0.434	2.894	87.731						
11	0.418	2.784	90.515						
12	0.387	2.578	93.094						
13	0.369	2.459	95.553						
14	0.340	2.269	97.822						
15	0.327	2.178	100.000						
Extraction method: Principal component analysis.									

In Table 4, eigenvalues, variance, and cumulative variance for the components extracted from the exploratory factor analysis are explained.

It provides insights into the amount of variance each component explains and helps in determining the optimal number of components to retain for further analysis.

The Initial Eigenvalues column shows that the first five components have eigenvalues greater than 1, indicating that each of these components explains more variance than a single variable would. The first component, with an eigenvalue of 5.575, explains 37.17% of the total variance, and cumulatively, the first two components account for 47.27%. This pattern continues across the first five components, which together explain 71.56% of the variance.

The Extraction Sums of Squared Loadings column confirms that the same five components explain most of the variance, with each component explaining a decreasing percentage of the total variance (from 37.17% for the first to 6.73% for the fifth). After the fifth component, the eigenvalues drop below 1, indicating that additional components contribute less to explaining the variance.

The Rotation Sums of Squared Loadings column shows the variance explained after rotating the factors to achieve a simpler, more interpretable structure. The first five components still explain most of the variance (71.56%), with the first component contributing 14.52% of the variance, the second 14.35%, and the third 14.31%. The variance continues to decline after the fifth component, with the cumulative variance reaching 71.56% at the fifth component. These results align with the Scree Plot (Figure 1).

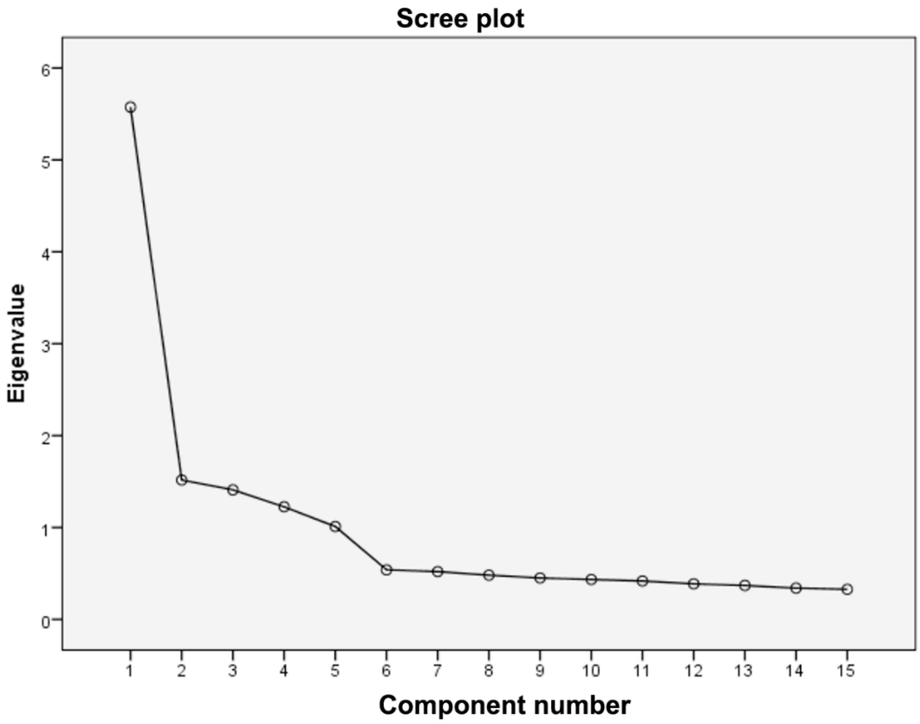

Figure 1. Scree plot of eigenvalues for agribusiness value chain components.

Figure 1 visually represents the eigenvalues of the components. In the scree plot, the steep drop-off after the fifth component indicates that components beyond the fifth contribute relatively little additional variance. This suggests that five factors are sufficient for capturing the key dimensions of the agribusiness value chain.

The Rotated Component Matrix in Table 5 provides insights into the structure of factors within the agribusiness value chain.The analysis employs Principal Component Analysis with Varimax rotation to identify five key components, each corresponding to different segments of the value chain. Production is strongly represented by Produc02 (.818), Produc01 (.801), and Produc03 (.783), indicating these variables are closely associated with this component. Logistics and distribution are reflected in Component 2, which includes Logist01 (.819), Logist03 (.799), and Logist02 (.769), highlighting logistical and distribution processes. Component 3 represents marketing, with high loadings for Mark02 (.802), Mark03 (.801), and Mark01 (.756), demonstrating a clear focus on marketing activities. Component 4 pertains to processing, with Proce01 at .814, Proce03 at .783, and Proce02 at .771, indicating significant value in the chain for processing activities. Finally, Component 5 covers input supply, with IS03 at .791, IS01 at .785, and IS02 at .779, which are critical for data and operations management. These elements illustrate how the agribusiness value chain is integrated yet segmented, providing a clear understanding of how various activities and processes are carried out and interconnected.

Table 5. Rotated component matrix for agribusiness value chain components.

Rotated component matrix[a]					
	Component				
	1	2	3	4	5
Produc02	0.818				
Produc01	0.801				
Produc03	0.783				
Logist01		0.819			
Logist03		0.799			
Logist02		0.769			
Mark02			0.802		
Mark03			0.801		
Mark01			0.756		
Proce01				0.814	
Proce03				0.783	
Proce02				0.771	
IS03					0.791
IS01					0.785
IS02					0.779
Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization.					

Note: a. Rotation converged in 6 iterations.
IS = Input Supply, Produc = Production, Proce = Processing, Mark = Marketing, Logist = Logistics and Distribution.

Table 6. KMO and Bartlett's test for agribusiness performance.

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy.		**0.831**
Bartlett's test of sphericity	Approx. chi-square	1317.720
	df	36
	Sig.	0.000

5.3. EFA: Agribusiness Performance

The results of the KMO Measure of Sampling Adequacy and Bartlett's Test of Sphericity for EFA on agribusiness performance are presented in Table 6. The KMO value is 0.831, indicating that an adequate sample size is available to conduct factor analysis with a high degree of inter-item correlations. Additionally, the result of Bartlett's Test of Sphericity was significant ($\chi^2 = 1317.720$, df = 36, $p < 0.001$), thus supporting that the correlation matrix is significantly different from an identity matrix. These findings validate the suitability of the dataset for conducting factor analysis.

Table 7. Communalities for agribusiness performance.

Communalities		
	Initial	Extraction
AG_Per_prod01	1.000	0.719
AG_Per_prod02	1.000	0.708
AG_Per_prod03	1.000	0.769
AG_Per_prof01	1.000	0.729
AG_Per_prof02	1.000	0.710
AG_Per_prof03	1.000	0.683
AG_Per_Mark01	1.000	0.697
AG_Per_Mark02	1.000	0.745
AG_Per_Mark03	1.000	0.680
Extraction method: Principal component analysis.		

Note: AG_Per_prod = Agribusiness Performance production, AG_Per_prof = Agribusiness Performance profitability, AG_Per_Mark = Agribusiness Performance Market Penetration.

Table 7 presents the communalities for the agribusiness performance indicators, derived using Principal Component Analysis. Initial communalities for all variables are 1.000, as expected. The extraction values range from 0.680 to 0.769, indicating the proportion of variance each variable shares with the extracted factors. Among the indicators, AG_Per_prod03 (production) shows the highest communality (0.769), suggesting it strongly aligns with the factors, while AG_Per_Mark03 (market penetration) has the lowest communality (0.680), indicating a slightly weaker representation. Overall, the high communalities across all variables reflect their relevance and contribution to the underlying factors of agribusiness performance.

Table 8. Total variance explained for agribusiness performance.

Total variance explained									
Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.903	43.366	43.366	3.903	43.366	43.366	2.202	24.465	24.465
2	1.366	15.180	58.546	1.366	15.180	58.546	2.122	23.579	48.044
3	1.171	13.016	71.562	1.171	13.016	71.562	2.117	23.518	71.562
4	0.495	5.496	77.059						
5	0.464	5.159	82.218						
6	0.459	5.097	87.315						
7	0.433	4.810	92.125						
8	0.377	4.194	96.319						
9	0.331	3.681	100.000						
Extraction method: Principal component analysis.									

Table 8 summarizes the total variance explained by the components in the analysis of agribusiness performance using Principal Component Analysis. The results indicate that three components have eigenvalues greater than 1, collectively accounting for 71.562% of the total variance. Component 1 explains 43.366% of the variance, followed by Component 2 at 15.180%, and Component 3 at 13.016%. After rotation, the variance is more evenly distributed, with Component 1 explaining 24.465%, Component 2 accounting for 23.579%, and Component 3 contributing 23.518%, while maintaining the cumulative variance at 71.562%. The scree plot (Figure 2) corroborates these findings, showing a clear inflection point after the third component, indicating the retention of three significant factors for further analysis. The remaining components explain minimal variance, as reflected by their eigenvalues below 1.

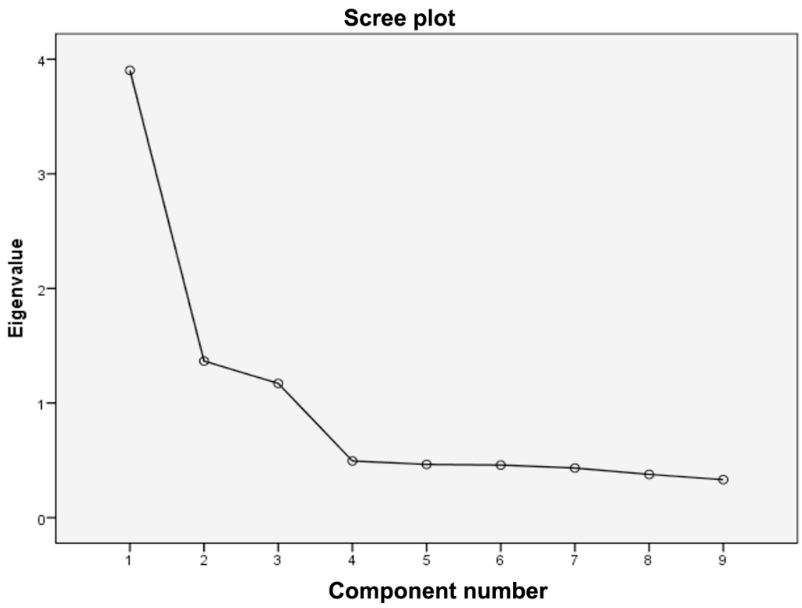

Figure 2. Scree plot of agribusiness performance components.

Figure 2 visually represents the eigenvalues of the components. In the scree plot, the steep drop-off after the third component indicates that components beyond the third contribute relatively little additional variance. This suggests that three factors are sufficient for capturing the key dimensions of agribusiness performance.

Table 9. Rotated component matrix for the agribusiness performance scale.

Rotated component matrix[a]			
	Component		
	1	2	3
AG_Per_prod03	0.852		
AG_Per_prod02	0.816		
AG_Per_prod01	0.804		
AG_Per_prof01		0.825	
AG_Per_prof02		0.802	
AG_Per_prof03		0.784	
AG_Per_Mark02			0.822
AG_Per_Mark03			0.791
AG_Per_Mark01			0.788
Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization.			

Note: a. Rotation converged in 5 iterations.
AG_Per_prod = Agribusiness Performance production, AG_Per_prof = Agribusiness Performance profitability, AG_Per_Mark = Agribusiness Performance Market Penetration.

Table 9 displays the rotated component matrix for the agribusiness performance variables, derived using Principal Component Analysis with Varimax rotation. The rotation achieved convergence in five iterations, resulting in a clear and interpretable factor structure. Component 1 is dominated by the production indicators, with high loadings for AG_Per_prod03 (0.852), AG_Per_prod02 (0.816), and AG_Per_prod01 (0.804). Component 2 captures the profitability indicators, with strong loadings for AG_Per_prof01 (0.825), AG_Per_prof02 (0.802), and AG_Per_prof03 (0.784). Component 3 reflects the market penetration indicators, characterized by high loadings for AG_Per_Mark02 (0.822), AG_Per_Mark03 (0.791), and AG_Per_Mark01 (0.788). The distinct loadings suggest that each component represents a unique dimension of agribusiness performance: production, profitability, and market penetration, respectively. This factor structure aligns with theoretical expectations and enhances the interpretability of the data.

Table 10. KMO and Bartlett's test for livelihood outcomes scale.

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy.		**0.831**
Bartlett's test of sphericity	Approx. chi-square	1733.979
	Df	66
	Sig.	0.000

5.4. EFA: Livelihood Outcomes

EFA for livelihood outcomes is supported by the results presented in Table 10. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy is 0.831, indicating that the sample size is adequate and the data are suitable for factor analysis. Additionally, Bartlett's Test of Sphericity yielded a significant result ($\chi^2 = 1733.979$, df = 66, $p < 0.001$), confirming that the correlation matrix is not an identity matrix. These findings validate the appropriateness of conducting factor analysis for the livelihood outcomes data.

Table 11. Communalities for livelihood outcomes scale.

Communalities		
	Initial	Extraction
IN_level01	1.000	0.749
IN_level02	1.000	0.700
IN_level03	1.000	0.707
Food_Sec01	1.000	0.703
Food_Sec02	1.000	0.680
Food_Sec03	1.000	0.694
Emplnt01	1.000	0.649
Emplnt02	1.000	0.721
Emplnt03	1.000	0.684
Resilience01	1.000	0.761
Resilience02	1.000	0.690
Resilience03	1.000	0.772
Extraction method: Principal component analysis.		

Note: IN_level = Income Levels, Food_Sec = Food Security, Emplnt = Employment.

Table 11 outlines the communalities for the livelihood outcomes indicators obtained through Principal Component Analysis. The initial communalities for all variables are set at 1.000, while the extraction values, ranging from 0.649 to 0.772, reflect the variance each variable shares with the extracted factors. Resilience03 exhibits the highest communality (0.772), indicating a strong association with the underlying factors, followed closely by Resilience01 (0.761). In contrast, Emplnt01 shows the lowest communality (0.649), suggesting a relatively weaker representation. Overall, the extracted communalities highlight the relevance of the variables, with all indicators demonstrating significant contributions to the latent factors of livelihood outcomes.

Table 12 provides the total variance explained by the components in the analysis of livelihood outcomes using Principal Component Analysis. Four components have eigenvalues greater than 1, collectively accounting for 70.922% of the total variance. Component 1 explains the largest portion, 35.844%, followed by Component 2 at 16.227%, Component 3 at 10.038%, and Component 4 at 8.814%. After rotation, the variance is more evenly distributed, with Components 1 through 4 explaining 18.407%, 17.921%, 17.322%, and 17.272%, respectively, while maintaining the cumulative variance of 70.922%.

Table 12. Total variance explained for livelihood outcomes scale.

Total variance explained									
Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	4.301	35.844	35.844	4.301	35.844	35.844	2.209	18.407	18.407
2	1.947	16.227	52.071	1.947	16.227	52.071	2.150	17.921	36.328
3	1.205	10.038	62.108	1.205	10.038	62.108	2.079	17.322	53.650
4	1.058	8.814	70.922	1.058	8.814	70.922	2.073	17.272	70.922
5	0.547	4.562	75.484						
6	0.533	4.444	79.928						
7	0.481	4.004	83.932						
8	0.450	3.754	87.686						
9	0.413	3.443	91.129						
10	0.401	3.338	94.468						
11	0.340	2.837	97.305						
12	0.323	2.695	100.000						
Extraction method: Principal component analysis.									

The scree plot (Figure 3) supports these findings, with a noticeable inflection point after the fourth component, justifying the retention of four factors. The remaining components account for minimal variance, with eigenvalues below 1, and are therefore excluded from further analysis. This distribution highlights the major dimensions contributing to livelihood outcomes.

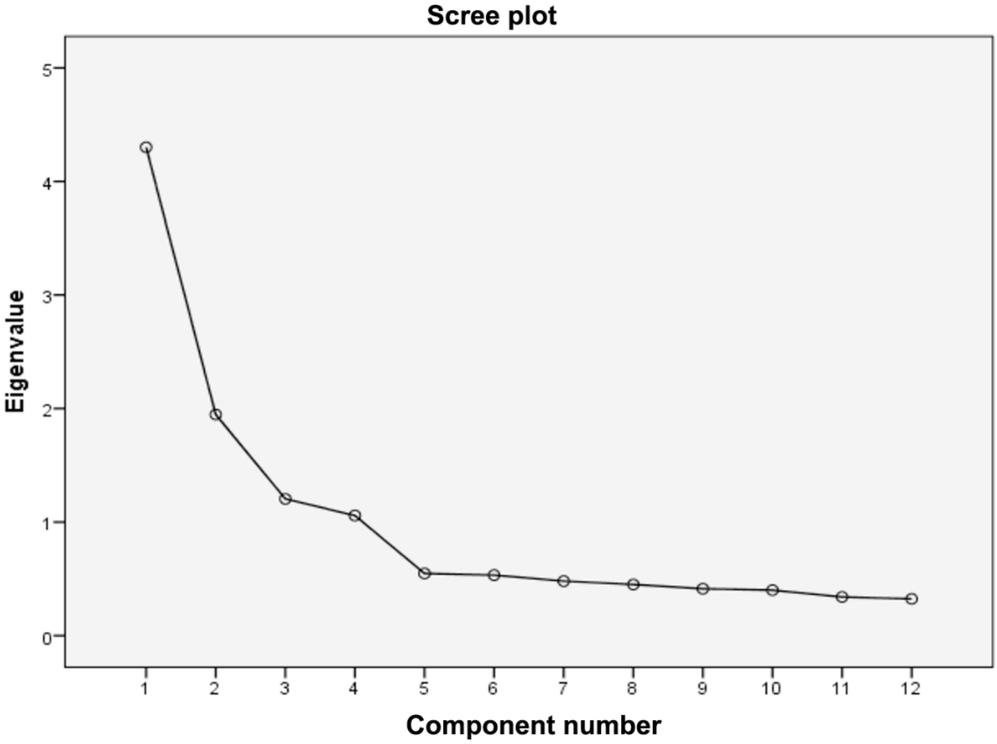

Figure 3. Scree Plot of livelihood outcomes scale's components.

Figure 3 visually represents the eigenvalues of the components. In the scree plot, the steep drop-off after the fourth component indicates that components beyond the fourth contribute relatively little additional variance. This suggests that four factors are sufficient for capturing the key dimensions of the livelihood outcomes.

Table 13. Rotated component matrix for livelihood outcomes scale's factors.

Rotated component matrix[a]				
	Component			
	1	**2**	**3**	**4**
Resilience01	0.846			
Resilience03	0.845			
Resilience02	0.753			
IN_level01		0.835		
IN_level02		0.802		
IN_level03		0.788		
Food_Sec01			0.815	
Food_Sec03			0.798	
Food_Sec02			0.748	
Emplnt02				0.836
Emplnt03				0.800
Emplnt01				0.763
Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization.				

Note: a. Rotation converged in 6 iterations.
IN_level = Income Levels, Food_Sec = Food Security, Emplnt = Employment.

Table 13 displays the rotated component matrix for livelihood outcomes, obtained through Principal Component Analysis with Varimax rotation, which converged in six iterations. Four distinct components emerged, each representing a key dimension of livelihood outcomes. Component 1 is characterized by high loadings from the resilience indicators, including Resilience01, Resilience03, and Resilience02, reflecting the resilience dimension. Component 2 is defined by income level indicators, with strong loadings for IN_level01, IN_level02, and IN_level03, highlighting income-related outcomes. Component 3 is associated with food security, with significant contributions from Food_Sec01, Food_Sec03, and Food_Sec02. Finally, Component 4 captures employment outcomes, indicated by high loadings for Emplnt02, Emplnt03, and Emplnt01. These results suggest that resilience, income levels, food security, and employment are the primary dimensions underlying livelihood outcomes.

Table 14. KMO and Bartlett's test for livelihood assets scale.

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy.		**0.855**
Bartlett's test of sphericity	Approx. chi-square	2157.819
	df	105
	Sig.	0.000

5.5. EFA: Livelihood Assets

EFA for livelihood assets is supported by the results presented in Table 14. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.855, indicating that the sample size is highly suitable for factor analysis. Additionally, Bartlett's test of sphericity produced a significant result ($\chi^2 = 2157.819$, df = 105, $p < 0.001$), confirming that the correlation matrix is not an identity matrix. These findings validate the dataset's appropriateness for conducting factor analysis on livelihood assets.

Table 15. Communalities for livelihood assets scale.

Communalities		
	Initial	**Extraction**
HC01	1.000	0.648
HC02	1.000	0.717
HC03	1.000	0.689
SC01	1.000	0.719
SC02	1.000	0.721
SC03	1.000	0.669
NC01	1.000	0.734
NC02	1.000	0.753
NC03	1.000	0.735
PC01	1.000	0.708
PC02	1.000	0.689
PC03	1.000	0.718
FC01	1.000	0.702
FC02	1.000	0.709
FC03	1.000	0.694
Extraction method: Principal component analysis.		

Note: HC = Human Capital, SC = Social Capital, NC = Natural Capital, PC = Physical Capital = PC, FC = Financial Capital.

Table 15 presents the communalities for the livelihood assets indicators obtained through Principal Component Analysis. The initial communalities for all variables are set at 1.000, representing the total variance of each variable before extraction. The extraction values, which reflect the proportion of variance each variable shares with the extracted factors, range from 0.648 to 0.753. NC02 (Natural Capital) has the highest communality (0.753), indicating it strongly aligns with the underlying factors, while HC01 (Human Capital) shows the lowest communality (0.648), suggesting a relatively weaker representation. Overall, the communalities suggest that the variables related to human, social, natural, physical, and financial capital all contribute significantly to the underlying factors of livelihood assets, with most variables showing strong correlations.

Table 16. Total variance explained for livelihood assets scale.

Total variance explained									
	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
Component	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	5.110	34.070	34.070	5.110	34.070	34.070	2.231	14.874	14.874
2	1.636	10.904	44.974	1.636	10.904	44.974	2.128	14.189	29.062
3	1.410	9.398	54.372	1.410	9.398	54.372	2.106	14.039	43.101
4	1.293	8.622	62.993	1.293	8.622	62.993	2.082	13.880	56.981
5	1.156	7.709	70.702	1.156	7.709	70.702	2.058	13.721	70.702
6	0.552	3.678	74.380						
7	0.532	3.544	77.925						
8	0.509	3.391	81.315						
9	0.479	3.196	84.512						
10	0.454	3.027	87.538						
11	0.408	2.723	90.261						
12	0.385	2.570	92.831						
13	0.380	2.535	95.366						
14	0.357	2.377	97.743						
15	0.339	2.257	100.000						
Extraction method: Principal component analysis.									

Table 16 presents the total variance explained by the components in the analysis of livelihood assets using Principal Component Analysis. The results show that five components have eigenvalues greater than 1, together accounting for 70.702% of the total variance. Component 1 explains the largest portion, 34.070%, followed by Component 2 at 10.904%, Component 3 at 9.398%, Component 4 at 8.622%, and Component 5 at 7.709%. After rotation, the variance is more evenly distributed across the components, with Component 1 contributing 14.874%, Component 2 explaining 14.189%, Component 3 contributing 14.039%, Component 4 at 13.880%, and Component 5 at 13.721%, while maintaining a cumulative variance of 70.702%. The scree plot (Figure 4) supports these findings, showing a distinct inflection point after the fifth component, which justifies retaining five components for further analysis. The remaining components explain smaller portions of the variance, with eigenvalues below 1, and are thus excluded from further consideration. This distribution suggests that the five components represent the primary factors underlying livelihood assets.

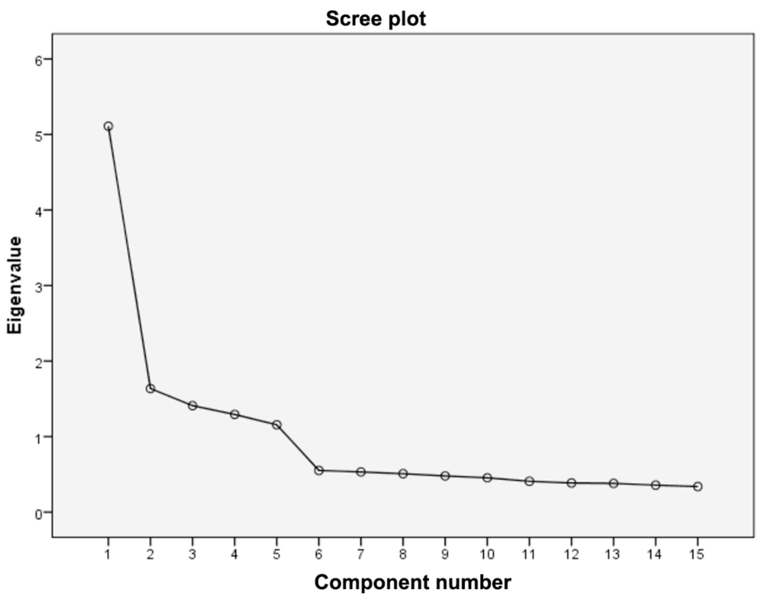

Figure 4. Scree plot for livelihood assets scale's components.

Figure 4 visually represents the eigenvalues of the components. In the scree plot, the steep drop-off after the fifth component indicates that components beyond the 5th contribute relatively little additional variance. This suggests that five factors are sufficient for capturing the key dimensions of livelihood assets.

Table 17. Rotated component matrix for livelihood assets scale.

Rotated component matrix[a]					
	Component				
	1	2	3	4	5
NC02	0.825				
NC03	0.824				
NC01	0.819				
PC01		0.806			
PC03		0.793			
PC02		0.789			
SC02			0.807		
SC01			0.802		
SC03			0.779		
FC03				0.803	
FC02				0.788	
FC01				0.784	
HC02					0.806
HC03					0.790
HC01					0.753
Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization.					

Note: a. Rotation converged in 6 iterations.
HC = Human Capital, SC = Social Capital, NC = Natural Capital, PC = Physical Capital = PC, FC = Financial Capital.

In Table 17, PCA reveals five distinct components representing different dimensions of livelihood assets. Component 1 is predominantly characterized by indicators of Natural Capital, such as land and environmental assets. The high loadings on NC02, NC03, and NC01 suggest that natural resources form a significant aspect of this component. Component 2 is defined by indicators of Physical Capital, with strong loadings on PC01, PC03, and PC02. This reflects the importance of tangible productive assets in shaping livelihood outcomes. Component 3 is primarily associated with Social Capital. The high loadings on SC02, SC01, and SC03 highlight the critical role of social capital relationships in supporting livelihoods. Component 4 captures Financial Capital, with significant contributions from FC03, FC02, and FC01. Component 5 is linked to Human Capital, with loadings from HC02, HC03, and HC01.

6. RELIABILITY AND DESCRIPTIVES

6.1. Rationale for Analysis

It is of utmost importance that Cronbach's alpha be applied when assessing the internal consistency of the scales and subscales. In general, values higher than 0.70 reflect acceptable reliability, while those found in this analysis range from a low of 0.77 to a high of 0.82, well above the threshold, which suggests that these scales are reliable and can confidently be used in further analyses.

Furthermore, the consistent means, which range between 3.07 and 3.14, indicate that agreement from the participants on the questionnaire items is quite high; thus, a factor indicating that the scales accurately represent the constructs being measured. The moderate ranges further suggest that responses are not concentrated on one side of the scale, a factor indicative of variability in perceptions across participants [31, 32]. Consequently, this set of results provides considerable support for the measurement scales used in the present study with respect to their reliability and validity.

Table 18. Psychometric properties of scales and subscales.

Scales	M	Range	Cronbach's α
Agribusiness value chain			
Input supply	3.07	3.06-3.08	0.81
Production	3.07	3.06-3.08	0.81
Processing	3.08	3.07-3.09	0.79
Marketing	3.08	3.06-3.09	0.80
Logistics and distribution	3.07	3.07-3.08	0.79
Agribusiness performance			
Productivity	3.09	3.08-3.10	0.82
Profitability	3.08	3.07-3.10	0.79
Market penetration	3.07	3.06-3.09	0.79
Livelihood outcomes			
Income level	3.09	3.08-3.11	0.80
Food security	3.07	3.05-3.09	0.77
Employment	3.14	3.13-3.14	0.77
Resilience	3.08	3.07-3.10	0.82
Livelihood assets			
Human capital	3.09	3.07-3.11	0.77
Social capital	3.07	3.06-3.08	0.78
Natural capital	3.10	3.09-3.11	0.82
Physical capital	3.08	3.08-3.09	0.79
Financial capital	3.07	3.06-3.08	0.78

As it appears in Table 18, the internal consistencies of these subscales under the Agribusiness Value Chain range from 0.79 to 0.81 of Cronbach's α. The mean values for input supply, production, processing, marketing, and logistics and distribution fall within the range 3.07 to 3.08, implying that there is a moderately high consensus on the perceived effectiveness of those components in agribusiness. High Cronbach's α values provide evidence that items within scales correlate highly. Thus, the scale satisfies the reliability criteria of the construct measured. Subsequently, Agribusiness Performance Scales and their subscales, comprising Productivity, Profitability, and Market Penetration, also show strong reliability; Cronbach's α values range from 0.79 to 0.82. The mean values of these subscales range from 3.07 to 3.10, which suggests that respondents generally perceive agribusiness performance in terms of productivity, profitability, and market reach to be moderately positive. The consistency across these measures further supports the strength of the scales used to assess performance outcomes. Similarly, Livelihood Outcomes Scales and their subscales (Income Level, Food Security, Employment, and Resilience) show similarly strong reliability, with Cronbach's α values between 0.77 and 0.82. Mean values for these scales range from 3.07 to 3.14, reflecting a positive outlook on livelihood outcomes among participants. These values suggest that respondents generally perceive these outcomes (such as income, food security, and employment) as being moderately favorable. The high Cronbach's α values indicate that the scales reliably measure these important livelihood indicators. The Livelihood Assets Scales and subscales (Human Capital, Social Capital, Natural Capital, Physical Capital, and Financial Capital) have Cronbach's α values ranging from 0.77 to 0.82. The mean values for these subscales range from 3.07 to 3.10, indicating moderate agreement among participants regarding the availability and quality of these livelihood assets.

Stage 3: SEM Analysis in SmartPLS for Measurement and Structural Models.

The use of Structural Equation Modeling through SmartPLS.4 was occasioned by the increasing need to analyze possibly complex relationships among latent constructs [33] such as agribusiness value chain components, agribusiness performance, livelihood outcomes, and livelihood assets while ensuring that the rigor and reliability of the results are maintained. According to Ringle et al. [34], SEM allows for the testing of the dual approach: on one hand, verification of the measurement model to ensure latent variables are adequately represented by their observed indicators and, on the other hand, assessment of the structural model to test the set of hypothesized pathways and interactions among these constructs.

More specifically, SmartPLS was chosen because it allows handling complex models, which include both reflective and formative constructs, is strong on issues like small sample sizes, and tolerates non-normal data distributions [34, 35]. These features rendered it particularly suitable for this study's context, whereby an understanding of direct, indirect, and mediating effects was central. The SEM, therefore, offers a comprehensive framework to validate theoretical assumptions, measure construct reliability and validity, and explore the interplay between agribusiness performance and livelihood outcomes.

6.2. Measurement Model

In a measurement model, the relationship between each construct and its respective indicators is specified to allow the researcher to assess the reliability and validity of these constructs before testing the structural relationships among such constructs [31]. For the current study, the measurement model is presented in Figure 5.

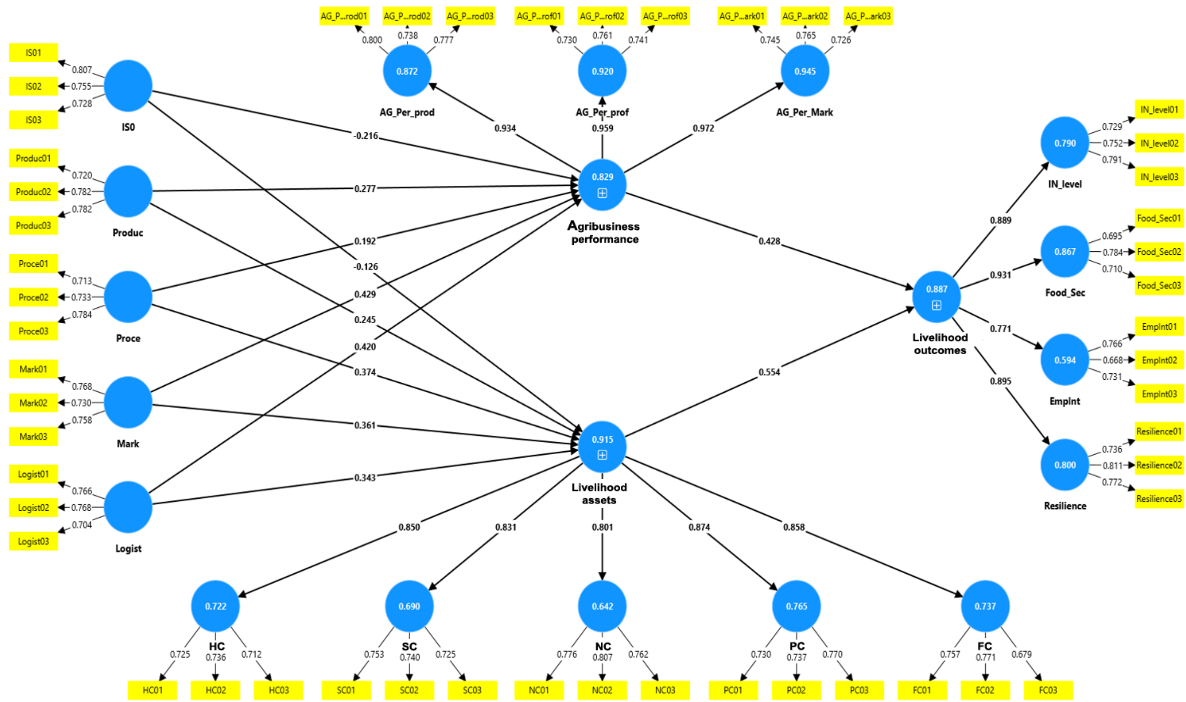

Figure 5. Measurement model.

6.3. Collinearity Statistics (VIF)

VIF values in Table 19 indicate that there is low to medium collinearity across the variables, well below the common threshold of 5. Hence, there are very minimal multicollinearity concerns in this model.

Table 19. Collinearity statistics (VIF).

Variables	Variance inflation factor (VIF)
AG_Per_Mark01	1.641
AG_Per_Mark02	1.768
AG_Per_Mark03	1.645
AG_Per_prod01	1.909
AG_Per_prod02	1.686
AG_Per_prod03	2.027
AG_Per_prof01	1.749
AG_Per_prof02	1.691
AG_Per_prof03	1.603
Emplnt01	1.635
Emplnt02	1.638
Emplnt02	1.677
Emplnt03	1.570
FC01	1.659
FC02	1.643
FC03	1.629

Variables	Variance inflation factor (VIF)
Food_Sec01	1.544
Food_Sec02	1.637
Food_Sec03	1.655
HC01	1.503
HC02	1.735
HC03	1.656
IN_level01	1.800
IN_level02	1.668
IN_level03	1.845
IS01	1.789
IS02	1.705
IS03	1.777
Logist01	1.815
Logist02	1.630
Logist03	1.600
Mark01	1.635
Mark02	1.687
Mark03	1.780
NC01	1.942
NC02	2.026
NC03	1.851
PC01	1.680
PC02	1.603
PC03	1.710
Proce01	1.727
Proce02	1.609
Proce03	1.636
Produc01	1.664
Produc02	1.866
Produc03	1.731
Resilience01	1.940
Resilience02	1.688
Resilience03	2.020
SC01	1.699
SC02	1.698
SC03	1.608

Note: IS = Input supply, Produc = Production, Proce = Processing, Mark = Marketing, Logist = Logistics and DistributionAG_Per_prod = Agribusiness Performance production, AG_Per_prof = Agribusiness Performance profitability, AG_Per_Mark = Agribusiness performance market penetration, IN_level = Income levels, Food_Sec = Food security, Emplnt = Employment, HC = Human capital, SC = Social capital, NC = Natural capital, PC = Physical capital = PC, FC = Financial capital.

In Table 19, the highest VIF values are observed in variables such as "NC02" (2.026) and "Resilience03" (2.020), while the lowest VIF values are found in variables like "HC01" (1.503) and "Food_Sec01" (1.544). These values demonstrate that, although some collinearity exists, it remains within acceptable limits, supporting the stability and reliability of the model. The consistent range of VIF values indicates that none of the variables exhibit excessive redundancy, making them suitable for further analysis in regression models.

6.4. Convergent Validity

6.4.1. Agribusiness Value Chain Components

The Average Variance Extracted (AVE) values for each construct—Input Supply (0.584), Production (0.580), Processing (0.553), Marketing (0.566), and Logistics and Distribution (0.557)—all exceed the 0.5 threshold, indicating that each construct accounts for over 50% of the variance in its respective indicators (IS01, IS02, IS03 for Input Supply; Produc01, Produc02, Produc03 for Production; Proce01, Proce02, Proce03 for Processing; Mark01, Mark02, Mark03 for Marketing; and Logist01, Logist02, Logist03 for Logistics and Distribution). This supports adequate convergent validity (see Table 20).

6.4.2. Agribusiness Performance

Convergent Validity: The Average Variance Extracted (AVE) values for each construct, Productivity (0.596), Profitability (0.554), and Market Penetration (0.556), all exceed the minimum threshold of 0.5. This indicates that each construct captures more than 50% of the variance in its indicators, confirming adequate convergent validity for these constructs (see Table 21).

6.4.3. Livelihood Outcomes

The Average Variance Extracted (AVE) values for each construct meet or exceed the 0.5 threshold, indicating adequate convergent validity. Income Levels (0.574), Food Security (0.534), Employment (0.522), and Resilience (0.599) each capture more than 50% of the variance from their indicators. This means that each construct explains a satisfactory amount of variance from its associated items (see Table 22).

6.4.4. Access to Livelihood Assets

Each construct has an Average Variance Extracted (AVE) above the 0.5 threshold, demonstrating adequate convergent validity. Specifically, Human Capital has an AVE of 0.524, Social Capital 0.547, Natural Capital 0.612, Physical Capital 0.557, and Financial Capital 0.543. These values indicate that each construct explains over 50% of the variance in its indicators, showing that the constructs capture a meaningful portion of the variance from their items (see Table 23).

6.5. Construct Validity

6.5.1. Agribusiness Value Chain Components

Each construct meets the reliability criteria with Cronbach's Alpha and Composite Reliability values above 0.7. Specifically, Input Supply (Cronbach's Alpha = 0.808, Composite Reliability = 0.808), Production (0.805, 0.806), Processing (0.788, 0.788), Marketing (0.797, 0.797), and Logistics and Distribution (0.790, 0.791) show high internal consistency, confirming that the items within each construct consistently measure the intended construct (see Table 20).

6.5.2. Agribusiness Performance

The Cronbach's Alpha and Composite Reliability scores are above 0.7 for all constructs, indicating good internal consistency. Specifically, Productivity has Cronbach's Alpha = 0.815 and Composite Reliability = 0.816; Profitability has 0.788 and 0.788; and Market Penetration has 0.789 and 0.790. These values confirm that the items within each construct reliably measure the respective construct (see Table 21).

6.5.3. Livelihood Outcomes

Each construct has strong internal consistency, with Cronbach's Alpha and Composite Reliability scores above 0.7. Specifically, Income Levels have Cronbach's Alpha = 0.802 and Composite Reliability = 0.802; Food Security has 0.773 and 0.774; Employment has 0.767 and 0.766; and Resilience has 0.818 and 0.817. These values indicate that the items within each construct consistently measure the intended concept, supporting their reliability (see Table 22).

6.5.4. Access to Livelihood Assets

The Cronbach's Alpha and Composite Reliability scores for each construct are above 0.7, which confirms strong internal consistency. Human Capital has Cronbach's Alpha = 0.768 and Composite Reliability = 0.768; Social Capital 0.783 and 0.783; Natural Capital 0.825 and 0.825; Physical Capital 0.790 and 0.790; and Financial Capital 0.780 and 0.780. These values reflect reliable measurement, showing that the indicators within each construct consistently represent the underlying concept (see Table 23).

6.6. Construct Reliability

6.6.1. Agribusiness Value Chain Components

The outer loadings for each item within the constructs are all above 0.7, supporting that each indicator is a good measure of its respective construct. For example, IS01 (0.807), IS02 (0.755), IS03 (0.728) for Input Supply, Produc01 (0.720), Produc02 (0.782), Produc03 (0.782) for Production, and similar high loadings for Proce01, Proce02, Proce03 in Processing, Mark01, Mark02, Mark03 in Marketing, and Logist01, Logist02, Logist03 in Logistics and Distribution indicate that the indicators align well with their respective constructs (see Table 20).

6.6.2. Agribusiness Performance

The outer loadings for all items are above 0.7, which supports that each indicator is a strong measure of its construct. For Productivity, items AG_Per_prod01 (0.800), AG_Per_prod02 (0.738), and AG_Per_prod03 (0.777) show high loadings, indicating that these items align well with the Productivity construct. Similarly, AG_Per_prof01 (0.730), AG_Per_prof02 (0.761), and AG_Per_prof03 (0.741) for Profitability, and AG_Per_Mark01 (0.745), AG_Per_Mark02 (0.765), and AG_Per_Mark03 (0.726) for Market Penetration, all demonstrate strong alignment with their respective constructs (see Table 21).

6.6.3. Livelihood Outcomes

The outer loadings for the indicators are generally strong, mostly above 0.7, supporting each indicator's alignment with its respective construct. For Income Levels, the items IN_level01 (0.729), IN_level02 (0.752), and IN_level03 (0.791) demonstrate strong loadings. For Food Security, items Food_Sec01 (0.695), Food_Sec02 (0.784), and Food_Sec03 (0.710) also support the construct, though Food_Sec01 is slightly below 0.7. For Employment, items Emplnt01 (0.766), Emplnt02 (0.668), and Emplnt03 (0.731) show acceptable loadings, although Emplnt02 is slightly lower. Lastly, for Resilience, Resilience01 (0.736), Resilience02 (0.811), and Resilience03 (0.772) confirm strong alignment with their construct (see Table 22).

6.6.4. Access to Livelihood Assets

Outer loadings for most indicators are above the preferred threshold of 0.7, supporting construct validity for each variable. For Human Capital, the items HC01 (0.725), HC02 (0.736), and HC03 (0.712) align well with the construct. Social Capital items SC01 (0.753), SC02 (0.740), and SC03 (0.725) similarly show strong alignment. Natural Capital exhibits the strongest loadings, with NC01 (0.776), NC02 (0.807), and NC03 (0.762), reflecting its high internal coherence. Physical Capital loadings are also high, with PC01 (0.730), PC02 (0.737), and PC03 (0.770). Finally, Financial Capital items, FC01 (0.757), FC02 (0.771), and FC03 (0.679), mostly support the construct, though FC03 is slightly below 0.7 (see Table 23).

Table 20. Outer loadings, construct reliability, and validity of agribusiness value chain components.

Scale	Outer loading	Cronbach's alpha	Composite reliability	AVE
Input supply		0.808	0.808	0.584
IS01	0.807			
IS02	0.755			
IS03	0.728			
Production		0.805	0.806	0.580
Produc01	0.720			
Produc02	0.782			
Produc03	0.782			
Processing		0.788	0.788	0.553
Proce01	0.713			
Proce02	0.733			
Proce03	0.784			
Marketing		0.797	0.797	0.566

Scale	Outer loading	Cronbach's alpha	Composite reliability	AVE
Mark01	0.768			
Mark02	0.730			
Mark03	0.758			
Logistics and distribution		0.790	0.791	0.557
Logist01	0.766			
Logist02	0.768			
Logist03	0.704			

Table 21. Outer loadings and construct reliability and validity of agribusiness performance.

Scale	Outer loading	Cronbach's alpha	Composite reliability	AVE
Productivity		0.815	0.816	0.596
AG_Per_prod01	0.800			
AG_Per_prod02	0.738			
AG_Per_prod03	0.777			
Profitability		0.788	0.788	0.554
AG_Per_prof01	0.730			
AG_Per_prof02	0.761			
AG_Per_prof03	0.741			
Market Penetration		0.789	0.790	0.556
AG_Per_Mark01	0.745			
AG_Per_Mark02	0.765			
AG_Per_Mark03	0.726			

Table 22. Outer loadings and construct reliability and validity of livelihood outcomes.

Scale	Outer loading	Cronbach's alpha	Composite reliability	AVE
Income Levels		0.802	0.802	0.574
IN_level01	0.729			
IN_level02	0.752			
IN_level03	0.791			
Food Security		0.773	0.774	0.534
Food_Sec01	0.695			
Food_Sec02	0.784			
Food_Sec03	0.710			
Employment		0.767	0.766	0.522
Emplnt01	0.766			
Emplnt02	0.668			
Emplnt03	0.731			
Resilience		0.818	0.817	0.599
Resilience01	0.736			
Resilience02	0.811			
Resilience03	0.772			

Table 23. Outer loadings and construct reliability and validity of access to livelihood assets.

Scale	Outer loading	Cronbach's alpha	Composite reliability	AVE
Human capital		0.768	0.768	0.524
HC01	0.725			
HC02	0.736			
HC03	0.712			
Social capital		0.783	0.783	0.547
SC01	0.753			
SC02	0.740			
SC03	0.725			
Natural capital		0.825	0.825	0.612
NC01	0.776			
NC02	0.807			
NC03	0.762			
Physical capital		0.790	0.790	0.557
PC01	0.730			

Scale	Outer loading	Cronbach's alpha	Composite reliability	AVE
PC02	0.737			
PC03	0.770			
Financial capital		0.780	0.780	0.543
FC01	0.757			
FC02	0.771			
FC03	0.679			

6.6.5. R Square

The results in Table 24 show high R-square values for the outcome variables, indicating that the model explains a significant proportion of variance in Agribusiness Performance, Livelihood Assets, and Livelihood Outcomes.

Table 24. R square.

Outcome variables	R2	R2 adjusted
Agribusiness performance	0.829	0.827
Livelihood assets	0.915	0.914
Livelihood outcomes	0.887	0.887

In Table 24, Agribusiness Performance: With an R-square of 0.829 and an adjusted R-square of 0.827, approximately 82.9% of the variance in agribusiness performance is explained by the independent variables in the model. This suggests a strong model fit and implies that the selected predictors are highly effective in accounting for variations in agribusiness performance. For the livelihood assets, the R-square of 0.915 and adjusted R-square of 0.914 indicate that 91.5% of the variance in livelihood assets is captured by the model. This exceptionally high R-square value suggests a robust model fit, with the independent variables explaining almost all the variance in livelihood assets. For the livelihood outcomes, with an R-square and adjusted R-square both at 0.887, the model accounts for 88.7% of the variance in livelihood outcomes.

This indicates that the model is highly effective in predicting livelihood outcomes, providing a strong fit for the data. The high R-square and adjusted R-square values across all three outcome variables demonstrate that the model has strong explanatory power for Agribusiness Performance, Livelihood Assets, and Livelihood Outcomes, underscoring its effectiveness in capturing the key determinants of these outcomes.

6.7. Discriminant Validity

6.7.1. Heterotrait-Monotrait Ratio (HTMT) - Matrix

The Heterotrait-Monotrait (HTMT) ratio matrix in Table 25 indicates satisfactory discriminant validity among the constructs in the model. HTMT values below 0.85 are typically considered acceptable, and most pairs of constructs in this matrix fall within this range, suggesting that the constructs are distinct from one another. For instance, low HTMT values, such as those between AG_Per_Mark and NC (0.187) and between AG_Per_prod and NC (0.284), confirm a strong level of distinction among these constructs. Additionally, some pairs exhibit moderate values, such as AG_Per_Mark with Food_Sec (0.607) and Logist with PC (0.536), which are still below the threshold, indicating acceptable discriminant validity. A few pairs, such as Logist with AG_Per_prod (0.763) and PC with Mark (0.771), have higher values close to the threshold, suggesting a moderate level of association but still remaining distinguishable. Overall, these HTMT results support that the constructs are sufficiently differentiated, confirming satisfactory discriminant validity across the model without problematic overlap.

Table 25. Heterotrait-monotrait ratio (HTMT) - matrix.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. AG_Per_Mark																	
2. AG_Per_prod	0.516																
3. AG_Per_prof	0.567	0.473															
4. Emplnt	0.558	0.469	0.320														
5. FC	0.540	0.555	0.611	0.361													
6. Food_Sec	0.607	0.403	0.697	0.332	0.499												
7. HC	0.373	0.407	0.489	0.340	0.488	0.403											
8. IN_level	0.532	0.459	0.631	0.547	0.609	0.418	0.361										
9. IS0	0.313	0.412	0.431	0.317	0.500	0.583	0.196	0.456									
10. Logist	0.478	0.763	0.584	0.416	0.715	0.402	0.619	0.557	0.436								
11. Mark	0.605	0.697	0.477	0.338	0.631	0.438	0.500	0.471	0.602	0.532							
12. NC	0.187	0.284	0.255	0.179	0.484	0.549	0.415	0.388	0.374	0.373	0.340						
13. PC	0.485	0.716	0.559	0.452	0.454	0.651	0.444	0.417	0.641	0.536	0.771	0.455					
14. Proce	0.367	0.487	0.617	0.433	0.702	0.699	0.318	0.692	0.546	0.513	0.441	0.504	0.636				
15. Produc	0.413	0.521	0.586	0.379	0.603	0.489	0.475	0.452	0.559	0.409	0.497	0.312	0.623	0.494			
16. Resilience	0.514	0.482	0.583	0.262	0.657	0.633	0.396	0.396	0.423	0.451	0.677	0.422	0.705	0.517	0.399		
17. SC	0.558	0.602	0.603	0.373	0.381	0.733	0.522	0.575	0.358	0.566	0.470	0.361	0.494	0.576	0.435	0.462	

Note: IS = Input Supply, Produc = Production, Proce = Processing, Mark = Marketing, Logist = Logistics and DistributionAG_Per_prod = Agribusiness performance production, AG_Per_prof = Agribusiness Performance profitability, AG_Per_Mark = Agribusiness performance Market penetration, IN_level = Income levels, Food_Sec = Food security, Emplnt = Employment, HC = Human capital, SC = Social capital, NC = Natural capital, PC = Physical Capital = PC, FC = Financial capital.

Table 26. Fornell-Larcker criterion.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. AG_Per_Mark	0.745																
2. AG_Per_prod	0.516	0.772															
3. AG_Per_prof	0.567	0.474	0.744														
4. Emplnt	0.558	0.471	0.322	0.723													
5. FC	0.542	0.557	0.612	0.365	0.737												
6. Food_Sec	0.609	0.404	0.698	0.333	0.499	0.730											
7. HC	0.373	0.410	0.489	0.340	0.487	0.403	0.724										
8. IN_level	0.533	0.460	0.632	0.549	0.605	0.419	0.361	0.758									
9. IS0	0.314	0.414	0.429	0.321	0.500	0.579	0.196	0.455	0.764								
10. Logist	0.479	0.761	0.586	0.419	0.715	0.404	0.618	0.557	0.436	0.747							
11. Mark	0.604	0.698	0.476	0.339	0.631	0.439	0.501	0.471	0.603	0.532	0.752						
12. NC	0.188	0.282	0.256	0.183	0.483	0.546	0.415	0.388	0.374	0.372	0.340	0.782					
13. PC	0.485	0.716	0.559	0.450	0.456	0.650	0.443	0.418	0.642	0.535	0.771	0.455	0.746				
14. Proce	0.369	0.487	0.617	0.434	0.701	0.700	0.317	0.693	0.543	0.513	0.443	0.504	0.638	0.744			
15. Produc	0.414	0.521	0.586	0.380	0.604	0.488	0.475	0.453	0.558	0.410	0.496	0.312	0.622	0.494	0.762		
16. Resilience	0.516	0.482	0.585	0.267	0.658	0.636	0.395	0.397	0.423	0.452	0.678	0.422	0.706	0.516	0.400	0.774	
17. SC	0.557	0.602	0.602	0.375	0.383	0.733	0.521	0.576	0.357	0.565	0.470	0.360	0.495	0.576	0.435	0.463	0.739

Note: IS = Input Supply, Produc = Production, Proce = Processing, Mark = Marketing, Logist = Logistics and DistributionAG_Per_prod = Agribusiness Performance production, AG_Per_prof = Agribusiness Performance profitability, AG_Per_Mark = Agribusiness performance Market penetration, IN_level = Income levels, Food_Sec = Food security, Emplnt = Employment, HC = Human capital, SC = Social capital, NC = Natural capital, PC = Physical capital = PC, FC = Financial capital.

6.7.2. Fornell-Larcker Criterion

Table 26 provides evidence of strong discriminant validity among the constructs. Each diagonal value in the matrix, representing the square root of the Average Variance Extracted (AVE) for each construct (e.g., AG_Per_Mark at 0.745, AG_Per_prod at 0.772, Food_Sec at 0.730), is higher than the off-diagonal correlations with other constructs. It indicates that each construct shares more variance with its own indicators than with those of other constructs, confirming that they are distinct from one another. For instance, AG_Per_prod has a diagonal value of 0.772, which is greater than its correlations with AG_Per_Mark (0.516) and FC (0.557), highlighting that AG_Per_prod is uniquely capturing its own indicators rather than overlapping with others. Additionally, constructs like NC (0.782) and SC (0.739) demonstrate similar results, with diagonal values consistently higher than off-diagonal correlations, underscoring that each construct represents a separate conceptual element. Overall, the Fornell-Larcker criterion supports that each construct is distinct within the model, confirming strong discriminant validity and indicating a robust model structure.

6.8. Structural Model

A structural model in research, particularly in Structural Equation Modeling (SEM), represents the hypothesized relationships between latent constructs (variables that aren't directly measured but are inferred from other observed variables). This model is used to test and validate theories by examining how well the data supports hypothesized paths and interactions between these constructs [34]. The structural model is shown in Figure 6.

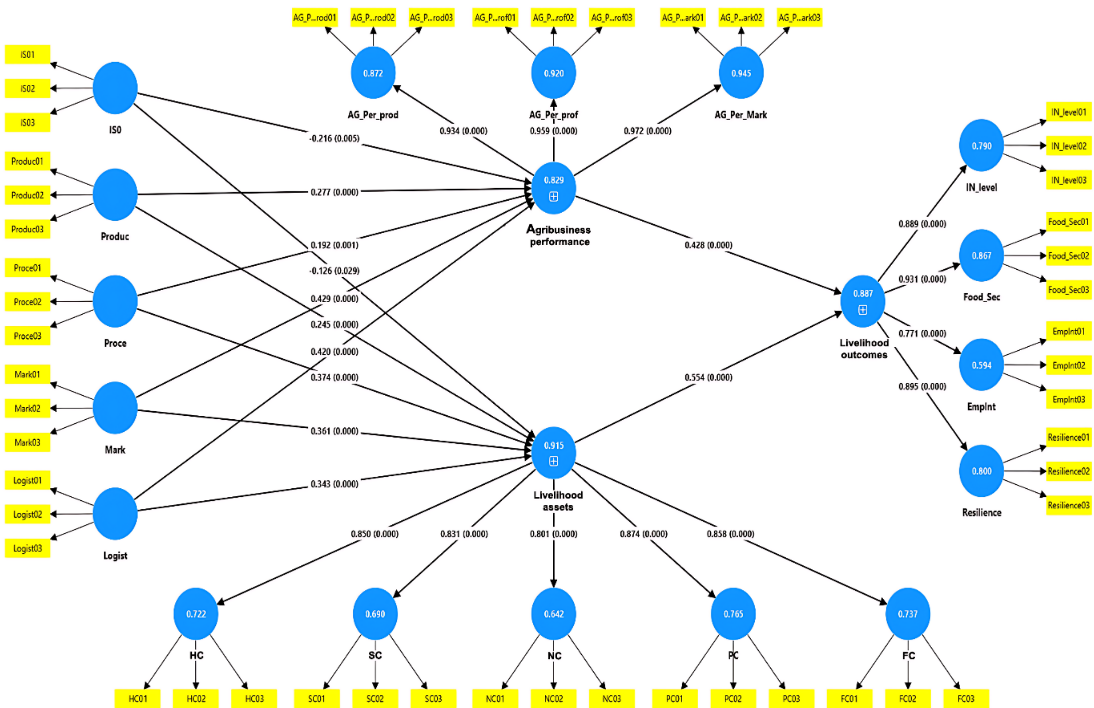

Figure 6. Structural model.

6.9. Direct Effects

The direct effects in Table 27 reveal the relationships between various agribusiness components, livelihood assets, and livelihood outcomes, demonstrating significant positive impacts across most paths. For Agribusiness Performance, production, processing, marketing, and logistics each positively contribute, with marketing (0.429) and logistics (0.420) showing the strongest effects, indicating the critical role of market strategies and efficient logistics in boosting performance. Interestingly, input supply has a slight negative effect (-0.216) on agribusiness performance, possibly due to inefficiencies associated with high input levels.

When examining Livelihood Assets, processing (0.374), marketing (0.361), and logistics (0.343) demonstrate substantial positive impacts, indicating that value-added processing, access to markets, and strong distribution networks are essential in strengthening household resources. Production also positively influences livelihood assets (0.245), whereas input supply again shows a minor negative effect (-0.126), suggesting that excessive inputs might not directly enhance household assets.

For Livelihood Outcomes, agribusiness performance (0.428) positively affects outcomes such as income and food security, showing that high-performing agribusiness activities benefit households directly. Likewise, livelihood assets have a substantial impact on outcomes (0.554), emphasizing that access to resources like financial capital and infrastructure leads to improved household welfare and resilience. Overall, the results underscore the importance of effective agribusiness practices, market access, and resource availability in enhancing agribusiness success and improving livelihood outcomes, while also highlighting areas where resource management could be optimized.

Table 27. Direct effects.

Direct path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Input supply -> Agribusiness performance	-0.216	-0.222	0.077	2.812	0.005
Production -> Agribusiness performance	0.277	0.279	0.062	4.471	0.000
Processing -> Agribusiness performance	0.192	0.192	0.060	3.180	0.001
Marketing -> Agribusiness performance	0.429	0.434	0.071	6.040	0.000
Logistics and distribution -> Agribusiness performance	0.420	0.420	0.061	6.837	0.000
Agribusiness performance -> Livelihood outcomes	0.428	0.427	0.085	5.057	0.000
Input supply -> Livelihood assets	-0.126	-0.128	0.058	2.180	0.029
Processing -> Livelihood assets	0.374	0.377	0.050	7.436	0.000
Production -> Livelihood assets	0.245	0.243	0.050	4.881	0.000
Marketing -> Livelihood assets	0.361	0.364	0.054	6.650	0.000
Logistics and distribution -> Livelihood assets	0.343	0.341	0.050	6.866	0.000
Livelihood assets -> Livelihood outcomes	0.554	0.555	0.083	6.641	0.000

6.10. Indirect Effects

The indirect effects in Table 28 highlight how Agribusiness Performance and Livelihood Assets mediate the impact of agribusiness components on Livelihood Outcomes, revealing a nuanced picture of these relationships. Both marketing and logistics exhibit strong positive indirect effects on livelihood outcomes through agribusiness performance (0.184 and 0.180, respectively) and livelihood assets (0.200 and 0.190, respectively), underscoring their central role in enhancing household welfare and resilience. Production and processing also demonstrate positive indirect effects, where improvements in these areas indirectly benefit livelihood outcomes by strengthening both performance and assets. For example, processing activities contribute positively (0.082 through performance and 0.207 through assets), suggesting that value addition can significantly boost household resources. Interestingly, input supply has a slight negative indirect impact on livelihood outcomes both through agribusiness performance (-0.093) and livelihood assets (-0.070), indicating that excessive reliance on inputs may not translate effectively into improved household outcomes. These results underscore the importance of efficient logistics, effective marketing, and robust production and processing practices for maximizing positive impacts on livelihood, while also highlighting that optimized resource management in input supply is essential to avoid potential inefficiencies.

Table 28. Indirect effects.

Indirect path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Input supply -> Agribusiness performance -> Livelihood outcomes	-0.093	-0.094	0.036	2.556	0.011
Production -> Agribusiness performance -> Livelihood outcomes	0.118	0.119	0.034	3.457	0.001
Processing -> Agribusiness performance -> Livelihood outcomes	0.082	0.083	0.033	2.476	0.013
Marketing -> Agribusiness performance -> Livelihood outcomes	0.184	0.185	0.047	3.913	0.000
Logistics -> Agribusiness performance -> Livelihood outcomes	0.180	0.178	0.041	4.375	0.000
Input supply -> Livelihood assets -> Livelihood outcomes	-0.070	-0.071	0.034	2.058	0.040
Production -> Livelihood assets -> Livelihood outcomes	0.135	0.134	0.033	4.158	0.000
Processing -> Livelihood assets -> Livelihood outcomes	0.207	0.210	0.047	4.422	0.000
Marketing -> Livelihood assets -> Livelihood outcomes	0.200	0.202	0.044	4.559	0.000
Logistics -> Livelihood assets -> Livelihood outcomes	0.190	0.188	0.037	5.096	0.000

6.11. Hypotheses Testing

Hypothesis 1: Improved agribusiness value chain components (input supply, production, processing, marketing, and logistics) positively impact overall agribusiness performance.

The results confirm Hypothesis 1, as each value chain component, except input supply, positively and significantly impacts agribusiness performance. Production (0.277), processing (0.192), marketing (0.429), and logistics (0.420) all show strong positive effects on performance, with marketing and logistics having the most substantial impacts. However, input supply has a slight negative effect (-0.216), indicating that excessive or inefficient input usage may not contribute positively to performance and may even hinder it. Status: Partially Accepted

Hypothesis 2: Enhanced agribusiness performance mediates the relationship between value chain components and improved livelihood outcomes.

The indirect effects support Hypothesis 2 by demonstrating that agribusiness performance mediates the impact of value chain components (input supply, production, processing, marketing, and logistics) on livelihood outcomes. For example, marketing (0.184) and logistics (0.180) have strong positive indirect effects on livelihood outcomes through agribusiness performance, highlighting that improvements in these areas enhance performance, which, in turn, benefits household welfare. The negative indirect effect for input supply (-0.093) through performance suggests that inefficiencies in inputs might indirectly reduce livelihood outcomes, emphasizing the importance of balanced resource utilization. Status: Accepted

Hypothesis 3: Agribusiness performance positively impacts livelihood outcomes, such as income levels, food security, and resilience.

The direct effect of agribusiness performance on livelihood outcomes (0.428) confirms Hypothesis 3. This positive and statistically significant impact demonstrates that improved agribusiness performance enhances livelihood outcomes, supporting higher income levels, better food security, and greater resilience among households engaged in agribusiness activities. Status: Accepted

Hypothesis 4: Access to livelihood assets mediates the relationship between agribusiness performance and livelihood outcomes, where greater access leads to better outcomes.

The indirect effects provide strong support for Hypothesis 4, as access to livelihood assets significantly mediates the relationship between agribusiness performance and livelihood outcomes. For example, production (0.135), processing (0.207), marketing (0.200), and logistics (0.190) all positively impact livelihood outcomes indirectly through livelihood assets, confirming that increased access to resources such as financial capital, infrastructure, and social networks enhances household welfare and resilience. This mediation underscores the importance of resource access in translating agribusiness performance gains into meaningful livelihood improvements.

7. DISCUSSION OF THE RESULT

This study uncovered numerous significant findings about the interconnections among agriculture value chain elements, agribusiness performance, livelihood assets, and livelihood outcomes within the Somali setting. Production, marketing, processing, and logistics were determined to favorably impact agribusiness performance, with marketing and logistics exhibiting the most significant benefits. This result shows how important it is to connect manufacturing to market access and ensure that distribution channels are quick, reliable, and accessible. Notably, input supply had a slight negative effect on agricultural performance, which suggests that resources were not being used or distributed efficiently. This conclusion might indicate that the Somali agribusiness ecosystem faces challenges, such as difficulty in obtaining high-quality inputs, improper use of inputs, or insufficient funding, leading to suboptimal results.

Agribusiness performance is seen as an important link between value chain elements and livelihood outcomes, demonstrating the importance of combining operational efficiency with social and economic benefits. The mediating function indicates that improvements in the value chain, such as better production methods, enhanced marketing, and more efficient transportation, do not directly lead to better lives but influence the overall performance of agriculture. This relationship underscores the necessity of taking targeted steps to improve performance metrics like productivity, profitability, and market penetration to achieve greater social and economic benefits.

One important finding is that livelihood assets have a significant effect on livelihood outcomes. Human, social, natural, physical, and financial capital all contribute to improving aspects such as stable income, food security, and job opportunities. The results indicate that households need access to these resources and the ability to utilize them effectively to translate better agricultural performance into tangible benefits. This discovery underscores the importance of having a comprehensive rural development plan that combines agricultural improvements with efforts to facilitate access to essential resources for livelihoods.

Efficient and productive agricultural operations are directly connected to better living conditions, which demonstrates the importance of these factors for rural development. This direct correlation highlights that agriculture is a vital component in maintaining a stable and resilient economy, especially in unstable regions. Agribusinesses can increase profitability and generate more employment opportunities by addressing issues within the value chain and enhancing efficiency. This, in turn, supports the stability and strength of families and communities. The results indicate that agriculture serves dual purposes: as an economic enterprise and a social enterprise. Its impacts extend beyond the business sector and positively influence society as a whole.

In Somalia, where agriculture is a main source of revenue and resilience despite political and social turmoil, these findings are even more important. Making agribusinesses work better and enhancing parts of the value chain might make a significant difference in people's lives, especially for smallholder farmers and others who live in rural areas. Because marketing and logistics have such a substantial effect on agricultural success, it is important to have policies and activities that make markets more accessible and improve distribution networks. The minimal negative effect of input supply highlights the importance of improving resource management to reduce waste and ensure that inputs positively impact overall performance.

The role of agribusiness performance as a mediator demonstrates how the parts of the value chain are interconnected and how they influence society and the economy. This finding indicates that improving operational efficiency is not only a business strategy but also a crucial means to achieve broader development goals such as reducing poverty and ensuring food security. The significant impact of livelihood assets highlights that for sustainable growth, individuals need better access to resources, including improved infrastructure, increased financial services, and higher education. These results emphasize the necessity of developing solutions that address both operational and resource-related challenges to fully realize agriculture's potential as a driver of social and economic progress.

The study's contributions are also placed in the context of the current body of research. Combining Porter's Value Chain Analysis with the Sustainable Livelihoods Framework provides a strong theoretical basis for understanding how agricultural operations and livelihoods influence each other simultaneously. The results align with other research emphasizing the importance of optimizing the value chain [15] and how resources can enhance resilience. This study adds to existing research by demonstrating how agricultural performance can serve as an intermediary and offers new insights into transforming operational gains into social and economic benefits.

The negative impacts of input supply go against what most people think, which is that inputs are always beneficial. This gap may be due to factors that are specific to Somalia, such as high input prices, inefficient distribution, or insufficient spending on other parts of the value chain that might help. These results show how important it is to tailor agricultural policy to the specific needs of each area so that interventions are appropriate to the situation and address the root causes of inefficiency.

This research makes a significant contribution to the literature by providing real-world examples of how the Somali agriculture industry functions and how different parts of the value chain influence performance and livelihoods. It offers policymakers, practitioners, and researchers valuable insights into improving farming practices, increasing resource accessibility, and enhancing community resilience. However, the study has several limitations. The cross-sectional methodology complicates establishing causality, and the diverse range of locations limits the generalizability of the findings to other contexts. Future research should employ longitudinal approaches to examine how relationships between these variables evolve over time. Additionally, investigating how technological advancements, gender roles, and government policies impact agricultural optimization would provide a more comprehensive understanding of the sector's potential.

By overcoming these constraints and expanding upon the findings of this study, subsequent research can enhance the evidence base for formulating sustainable agriculture strategies in fragile and conflict-affected areas. This study provides a robust foundation for these initiatives, emphasizing the transformative capacity of agriculture in improving economic performance and social resilience.

8. CONCLUSION

The study offers critical insights into the complex interlinkages between the elements of an agricultural value chain, agribusiness performance, livelihood assets, and livelihood outcomes in the Somali context. It shows that value chain elements such as production, processing, marketing, and transportation have a strong positive impact on agricultural performance, which in turn mediates the relationship between enhanced livelihood outcomes like income, food security, and resilience. Furthermore, access to livelihood assets, including human, social, and financial capital, adds to these desired benefits, aligning agricultural wealth with socio-economic wealth. Porter's Value Chain Analysis and the Sustainable Lives Framework integrated into this research provide an integrated method that considers both operational and resource-oriented factors to better rural lives. The research hypotheses were largely affirmed. The building blocks of the agribusiness value chain had a positive impact on performance, with the only exception being input supply, which had a marginal negative impact, possibly due to inefficiencies or situational factors. Agribusiness performance was established as a significant mediator connecting improvements in operations to better livelihood outcomes. Livelihood assets were found to moderate the link between agricultural performance and outcomes, highlighting their central role in ensuring sustainable development. The results corroborate the interrelated nature of resource- and operations-based development in agriculture.

8.1. Implications for Policy

The results provide policy practitioners with actionable recommendations to guide policymakers striving to enhance rural development and resilience:

- Improving Market Access and Distribution Networks: Investments in infrastructure that can enhance market access and facilitate logistics, including roads, warehousing, and transport networks, can significantly enhance agricultural performance and, consequently, livelihoods.
- Resource Management Policies: Maximizing the supply system of inputs to achieve maximum resource use efficiency, minimize costs, and enhance input quality should be the decision of policymakers. Subsidization or incentives for improved-quality inputs and capacity building on proper usage can enhance inefficiencies.
- Development of Livelihood Assets: The upgrading of access to livelihood assets is a priority. Education, access to finance, and community-based support systems policies can enhance resilience and raise the socio-economic value of agriculture.
- Support for Fragile Environments: In conflict-affected areas, such as Somalia, specialized solutions are required to respond to distinctive challenges, such as security issues, weak infrastructure, and market instability. A collective effort by governments, NGOs, and the private sector can help build resilience within agricultural systems.

8.2. Practical Implications

The research presents several practical suggestions to agricultural stakeholders.

- Capacity Building: Training programs for farmers and agribusiness operators in effective production practices, marketing techniques, and logistics management can increase performance and profitability.
- Use of Technology: Adoption of technology-facilitated solutions for market connectivity, resource management, and supply chain optimization can improve operational efficiency and market access.
- Community-Based Strategies: Agribusinesses must interact with local communities proactively to enhance access to resources and resilience. Cooperatives can aggregate resources to realize economies of scale in purchasing inputs and marketing.
- Value Addition and Diversification: Promoting value-added processing, including packaging and quality control, can enhance product marketability and increase income opportunities for smallholder farmers.

This study points to the transformational potential of optimizing agriculture in vulnerable and resource-poor contexts. Through efficiency correction in value chain segments, improved livelihood assets access, and operational effectiveness, stakeholders are able to derive enormous socio-economic gains for rural populations. These outcomes offer a manual for policymakers and practitioners wishing to harness the resilience and sustainable development potential of agriculture as a strategy for better livelihoods and stability in adversity.

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Institutional Review Board Statement: This study was approved by the Institutional Review Board of SIMAD University, Somalia, under protocol number EC000146, dated November,2024. Informed verbal consent was obtained from all participants prior to data collection, and all responses were anonymized to protect participant confidentiality. The study was conducted in accordance with institutional ethical standards and international research guidelines
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
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