



Value Chain Analysis of Maize in Bhaktapur District, Nepal: Structure, Participants, and Constraints

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Abstract

Background: Value chain participants play a vital role in ensuring the smooth flow of agri-food products to meet consumer demand without compromising safety and quality. Understanding the structure, relationships, and challenges within the maize value chain is essential for improving productivity and market efficiency.

Purpose: This study aims to analyze the maize value chain in Bhaktapur District, identifying its structure, major participants, key relationships, and the constraints faced by stakeholders.

Design/Methodology/Approach: The study follows an exploratory research paradigm using value chain analysis theory. Quantitative data were collected from 350 participants in Bhaktapur District, Nepal, using a structured questionnaire via KOBO Toolbox. Purposive sampling was applied, and data were analyzed descriptively and inferentially using ordered logistic regression with STATA and Excel.

Findings: Results indicate a conventional arrangement of the maize value chain with limited innovative connections. Farmers' knowledge of value addition is positively and significantly associated with their education level, the size of maize cultivation land, and their autonomy in setting selling prices. Key challenges include limited market knowledge and the unavailability of quality inputs.

Conclusion: Enhancing value addition requires interventions to improve market information flows among traders, strengthen input supply systems through governmental and non-governmental support, and promote sales via organized channels. Supportive strategies include farmer education and expanding maize cultivation areas. The study offers insights into policy and practice to improve the maize value chain through refined extension services, capacity-building programs, and better information dissemination. This is a novel study with no potential conflict of interest.

Key words: Value Chain Analysis, Farmer, Traders, Value addition, Ordered logistic Model



1. Introduction

The agri-food value chain includes the overall chain of processes needed to transport agricultural products through the process of starting to be produced to their end-users and includes the physical transformation and producer services as part of the process (Zhao et al., 2019). This system is also necessary to satisfy the demand of consumers and be sure of the safety and quality of products that each member involved in the circulation process has a critical role to play. The value chain framework provides numerous points of entrance and connection through which companies with small and medium scale can struggle with the market restrictions of the traditional market (Moura & Saroli, 2021). It eases the process of value addition because products pass by different processing units and actors within the supply chain. Centralized vegetable packhouses are some of the strategies that are currently being adopted by many countries to boost the income of farmers (Roux et al., 2018), and the increase in integration of technology to improve supply chain management (Kittipanya-ngam and Tan, 2020). There are also productivity issues in certain geographical areas like smallholders in Malawi where outputs are restricted due to low soil fertility, low fertilizer application and reliance on rainfall (Mango et al., 2018). Such government programs as Malawi Farm Input Subsidy Program (FISP) have contributed to the increased productivity of maize (Nkhoma, 2018). Beyond, Brazilian agriculture has been developed enhanced crop treatments, hybrid and genetically modified seeds and access to new territories (Klein and Luna, 2022), whereas in Argentina, systems based on state control have been established to regulate the process of growing grain and commercializing it in the wake of trade liberalization (Alvarez et al., 2020). Digitalization is changing the supply chain around the world, and the major companies are embracing robotics and artificial intelligence to carry out procurement, invoicing, and customer service functions, among others (Schniederjans et al., 2020). South Asian agriculture is also very sensitive to climate change, and it is predicted that it will reduce considerably in production of maize (Aryal et al., 2020; Grote et al., 2021).

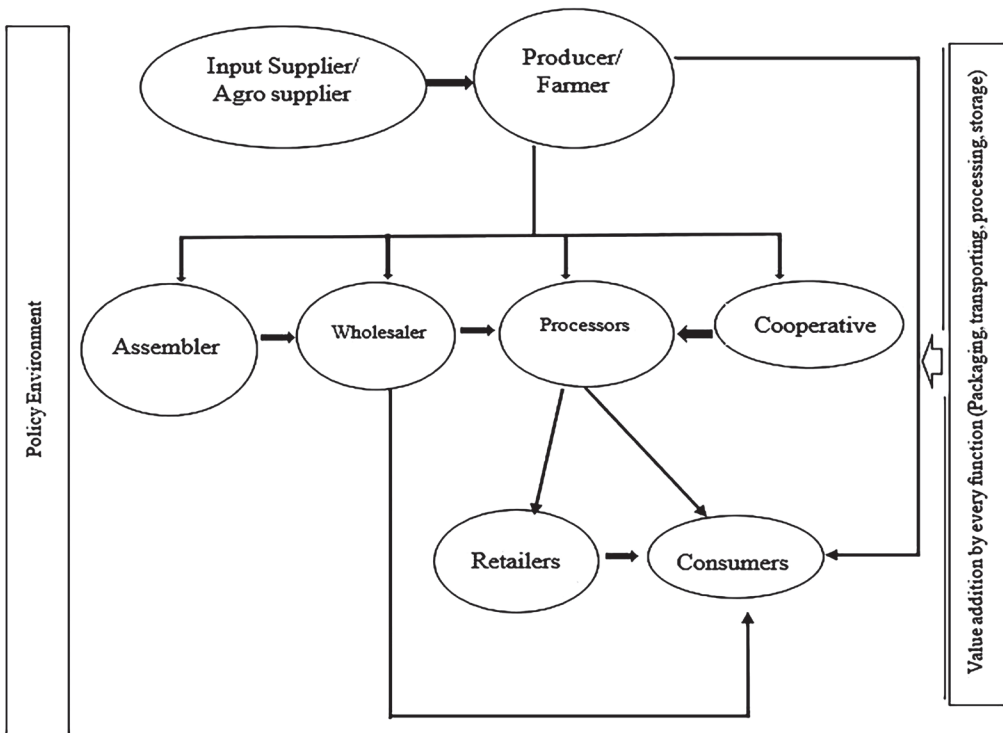
The process of assimilating smallholders into organized markets frequently includes the cooperation in the form of cooperatives that carry out the aggregation of products and training of farmers (Sánchez-Galvana et al., 2019). Countries like India are introducing technologies like blockchain, which can improve traceability and food safety, but the adoption has certain barriers such as regulatory gaps and the problem of stakeholder trust (Yadav et al., 2020). Wider issues within the food supply chains are inadequate environmental enforcement, absence of market pressure, and poor cooperation among the chain participants (Farooque et al., 2019). Nepal has been focused on value chain development with its Agriculture Development Strategy and has created the Value Chain Development Program (VADEP) to empower crops, livestock, fisheries, and forestry (Sharma, 2019). It is stated that Nepal has potential in the off-season production of vegetables, but the lack of inputs, accessibility of harvesting points, lack of market information and ineffective post-harvest management are barriers to its expansion (Sharma, 2020). On the whole, the agri-food value chains promotion is bound to improve the competitiveness of agriculture on both the national and international markets and to earn more value-added in the countries of production. These chains also need to be reinforced by establishing good supply relationships with the farmers, including contract farming, technical capacity to create value chains, and a product of the correct quality, as frequently as possible.

2. Conceptual Framework

This study examined a few research papers, including Mapanga et al. (2017) and Sims and Kienzle (2016), under the value chain theory. These models include the Generic value chain analysis framework, vertical value chain, Porters five force model, value chain framework in network structure and business model development. Value Chain Analysis (VCA) is one of the methods applied in the process of attaining cooperative resource distribution and management within and between firms to enhance overall competitiveness of the chain (Uddin and Akhter, 2019). VCA is applied to evaluate the economy of a chain and is aimed at aligning the value of customers with chain efficiency by analyzing information and resource flow and linkages that support products. In addition the agricultural supply chain reflects

the parties including: the input (fertilizer, seeds, wrapping), farm production, processing (turning the agricultural raw materials into one or more finished products by drying, canning, and freezing or any other form of processing), domestic and foreign logistics. On the same note, Porter's model emphasizes the five forces in an industry (buyers, suppliers, new entrants, substitution, and rivalry) which influence one another. The overall power of the five forces defines the capability of a company to compete within a sector (Baxter, 2019). Conversely, the value chain Framework model on Network Structure dimensions, vertical and horizontal value chain displays the agricultural product flow within the upstream and forward stream. The vertical dimension shows the way the products and services flow out of the primary producer to the end consumer (i.e., the value chain or supply chain). The horizontal dimension displays the relationships between actors within the same chain (Gaitan-Cremaschi et al., 2019). In addition, Ros-Tonen et al. (2019) define a business model as inclusive when it involves the involvement of smallholders into the markets, which enhances the development and performance of the supply chain relationships, and coordination among the supply chain actors, to achieve a win-win scenario by both smallholders and buyers. The business model works under the stakeholders include value proposition, value architecture, and financing mechanism that defines how the benefit of the product or service will be provided, experienced, and acquired (Asikin et al., 2020).

Figure 1: Conceptual Framework



Source: Adopted from KE & Molaba (2016)

3. Research Methods

Study area, population and sampling

This study was done in the Bhaktapur District, which is a historically and culturally important region in the Kathmandu Valley in Nepal. The district is between 85° 21' - 85°31' E longitude 27° 36' - 27° 44' N north latitude and has an area of approximately 6.9 km and an average elevation of 1,400m above sea level and is located approximately 12 km east of Kathmandu (Silwal et al., 2021). Administratively, the

Bhaktapur District is made up of four municipalities of Bhaktapur, Changunarayan, Suryabinayak, and Madhyapur Thimi. The study area was chosen to be Bhaktapur since it has intensive agricultural features. It has been noted to be the top producer of agricultural goods in the three districts of the Kathmandu Valley, and there also exists a significant and growing pattern toward commercial and intensive vegetable production (Thapa et al., 2021). Furthermore, 11,106 hectares is an area that can be utilized as a farmland out of the total areas comprising the district, 11,900 hectares, and once again, highlighting its applicability and appropriateness to the current research (Sharma et al., 2020).

Sampling data collection and analysis

This paper employed a quantitative-method design to holistically examine the maize value chain in Bhaktapur District. The method of purposive sampling was applied to choose the study location and respondents, as there is no single farmer registry and the agricultural intensity of the area is well known (Thapa et al., 2021; Sharma et al., 2021). In the municipalities, the wards that had a high density of maize farmers were identified by local agricultural offices. Farming households were considered as a standard finite population formula (Daniel, 1999), whereby the sample size was 403 households. Surveys were conducted among 350 households that had a representative sample based on the homogeneity of the population after considering the logistical factor. Primary data were used through structured questionnaires undertaken face-to-face using KOBO Toolbox. In the case of other value chain actors (e.g., traders, input suppliers), snowball sampling and semi-structured interviews were conducted. Descriptive and inferential statistics (ordered logistic regression) in STATA and Excel were used to analyze the quantitative data. These findings were contextualized with the help of qualitative data from key informants and focus groups that were used to inform the value chain mapping. Pre-testing of the instruments, training of the enumerators, and triangulation of the data sources were also methodological rigor.

4. Results

Socio-Demographic Characteristics (Farmers)

Table 1: Socio-Demographic Characteristics of Farmers

Title	Category	Number	Percentage (%)
Gender	Male	183	52.29
	Female	167	47.71
Age	Below 30	35	10
	30-40	142	40.57
	40-50	108	30.86
	50 and above	65	18.57
Marital Status	Married	303	86.57
	Single	40	11.43
	Widowed	7	2
Study Area (Municipality)	Bhaktapur Municipality	164	46.86
	Suryabinayak Municipality	12	3.43
	Changunarayan Municipality	174	49.71
Family Size	Below 5	47	13.43
	5-10	252	72
	10 and above	51	14.57

Education Level	Illiterate	57	16.29
	Primary Level.	48	13.71
	Lower Secondary Level	64	18.29
	SLC/SEE	74	21.14
	+2 Level	57	16.29
	Bachelor	48	13.71
	Master and above	2	0.57
Family Type	Nuclear	107	30.57
	Joint	215	61.43
	Extended	28	8
Farming Experience	Below 5	33	9.43
	5-15	187	53.43
	15-25	65	18.57
	25 and above	65	18.57
Source of Income	Sale of crops	122	34.86
	Sale of livestock	39	11.14
	Off-farm income	183	52.29
	Others	6	1.71
Occupation beside maize production	Agriculture	59	16.86
	Service	77	22
	Business	137	39.14
	Government Employment	5	1.43
	Remittance	4	1.14
	Other (Specify)	21	6
Decision on production	HH Head	208	59.43
	Father	73	20.86
	Mother	69	19.71

The socio-demographic characteristics of the respondents show a fairly balanced gender distribution among the 350 participants, with 183 males (52.29%) and 167 females (47.71%) involved in maize-related activities. In terms of age, the majority of respondents fall within the 30–40 years age group (40.57%), followed by 40–50 years (30.86%), indicating that most participants are in their economically active and productive years. A smaller proportion of respondents are below 30 years (10%), while 18.57% are aged 50 years and above. Regarding marital status, most respondents are married (86.57%), while 11.43% are single and 2% are widowed, suggesting that the farming activities are largely undertaken by family-based households.

With respect to the study area, respondents are mainly from Changunarayan Municipality (49.71%) and Bhaktapur Municipality (46.86%), whereas only 3.43% belong to Suryabinayak Municipality. The analysis of family size indicates that the majority of households (72%) have 5–10 family members, while 13.43% have fewer than five members and 14.57% have more than ten members, reflecting relatively large household structures typical of rural farming communities. In terms of education level, respondents have

varied educational backgrounds: 21.14% completed SLC/SEE, 18.29% studied up to lower secondary level, 16.29% are illiterate, and another 16.29% completed +2 level. Smaller proportions completed primary education (13.71%), bachelor’s degree (13.71%), and only 0.57% attained master’s level or higher.

Regarding family type, the majority of respondents live in joint families (61.43%), followed by nuclear families (30.57%), while 8% belong to extended families. In terms of farming experience, most respondents (53.43%) have 5–15 years of experience, while 18.57% each have 15–25 years and more than 25 years of experience, and only 9.43% have less than five years of experience. Looking at the source of income, more than half of the respondents (52.29%) rely primarily on off-farm income, while 34.86% depend on the sale of crops, 11.14% on livestock sales, and 1.71% on other sources.

When considering occupations besides maize production, 39.14% of respondents are involved in business, 22% in service jobs, and 16.86% in agriculture-related activities, while smaller proportions work in government employment (1.43%), rely on remittance (1.14%), or are involved in other occupations (6%). Finally, regarding decision-making in maize production, most decisions are made by the household head (59.43%), followed by the father (20.86%) and the mother (19.71%), indicating that agricultural decision-making is largely concentrated within the household leadership structure.

Source: Field Study

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
AwarenessL~1	350	0.9457	0.5077	0	2
Gender_	350	0.5229	0.5002	0	1
Age_	350	40.02	9.0416	25	66
Marital_St~	350	0.8657	0.3414	0	1
Size_of_fam_	350	7.4857	2.4829	3	16
Edu_Lvl_	350	0.8371	0.3698	0	1
Farming_exp	350	12.3886	8.8995	2	37
offfarm_in~	350	0.5229	0.5002	0	1
Deci_taker~	350	0.5943	0.4917	0	1
Training_	350	0.0657	0.2481	0	1
Area_allo_~	350	0.9463	0.5072	0.3	3
Input_cost_	350	755.6571	391.8014	250	2100
Sell_to_Cons_	350	0.6257	0.4846	0	1
Sell_to_coop_	350	0.0171	0.13	0	1
Storage_	350	37.7743	18.2718	2	200
mkt_place_	350	0.8114	0.3917	0	1
Produc_dec~	350	0.4143	0.4933	0	1
Nego_with_pro_	350	0.4829	0.5004	0	1
Mkt_info_~p_	350	0.1829	0.3871	0	1
Mkt_info_~d_	350	0.8914	0.3115	0	1
Input_loc_~	350	0.5086	0.5006	0	1
Input_Gos_	350	0.0114	0.1064	0	1

Farming Experience	5.22	2.28	0.1917	0.8083
Off-farm Income	1.42	1.19	0.7062	0.2938
Decision Taker on Production	1.4	1.18	0.7144	0.2856
Training	1.14	1.07	0.8781	0.1219
Area Allocated for Maize	2.23	1.49	0.4478	0.5522
Input Cost	1.72	1.31	0.5826	0.4174
Sell to Consumer	1.17	1.08	0.8527	0.1473
Sell to Cooperative	1.21	1.1	0.8293	0.1707
Storage	1.39	1.18	0.7209	0.2791
Market Place	1.28	1.13	0.7835	0.2165
Producer Decision on Price	1.47	1.21	0.6816	0.3184
Negotiation with Trader	1.49	1.22	0.6719	0.3281
Market Information from Cooperative	1.29	1.14	0.776	0.224
Market Information from Trader	1.26	1.12	0.7921	0.2079
Input Location Availability	1.13	1.06	0.8818	0.1182
Input from Government	1.08	1.04	0.9224	0.0776

Heteroscedasticity

Heteroscedasticity refers data having uneven variance across predictor variables. The value of heteroscedasticity must be greater than 0.05 (O. K. & O. A., 2020). Otherwise, robust regression needs to run for further analysis.

Table 19: Heteroscedasticity Test

. hetttest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of AwarenessLevel

chi2(1) = 0.84

Prob > chi2 = 0.3594

Looking at hetttest, the value for model is prob>chi2 = 0.3594, implying that the dataset does not have a heteroscedasticity problem.

Logistic Regression Analysis

The result in annex II shows that the value LR chi² (21) is 104.01 which explains that our model is fit and we can go ahead. Likewise, the value pf pseudo R² is 0.1988 which indicates that the independent variables undertaken for the study are explained dependent variable by 19.88%. It is very good in terms of logistic regression. Likewise, log likelihood is -209.64378. In the table shown in Annex II, there are altogether five significant variables under the 95% confidence interval, namely, area allocated for maize production, storage, producers decide price during sell, inputs from locally available, inputs from GOs/NGOs/INGOs.

Table 5: Final Regression

VARIABLES	(1)	(2)	(3)
	logit coeff	odds ratio	marginal effect
AwarenessLevel			
Gender_	-0.187 (0.272)	0.829 (0.226)	0.0193 (0.0281)
Age_	0.00642 (0.0326)	1.006 (0.0328)	-0.000663 (0.00336)
Marital_Status_	0.180 (0.416)	1.197 (0.498)	-0.0186 (0.0429)
Size_of_fam	0.00169 (0.0615)	1.002 (0.0616)	-0.000175 (0.00636)
Edu_Lvl_	0.919* (0.552)	2.507* (1.384)	0.0949* (0.0569)
Farming_exp_	-0.00443 (0.0351)	0.996 (0.0349)	0.000458 (0.00362)
offfarm_income_	-0.282 (0.318)	0.755 (0.240)	0.0291 (0.0329)
Deci_taker_on_produc_	0.208 (0.313)	1.232 (0.386)	-0.0215 (0.0324)
Training_	-0.177 (0.549)	0.838 (0.460)	0.0183 (0.0567)
Area_allo_for_mai_	1.817*** (0.386)	6.151*** (2.373)	0.188*** (0.0423)
Input_cost	0.000216 (0.000439)	1.000 (0.000439)	-2.23e-05 (4.53e-05)
Sell_to_Consumer	-0.531* (0.298)	0.588* (0.175)	0.0549* (0.0308)
Sell_to_cooperative	-1.115 (1.073)	0.328 (0.352)	0.115 (0.110)
Storage_	-0.0285*** (0.00954)	0.972*** (0.00927)	0.00294*** (0.000951)
mkt_place_	0.0905 (0.379)	1.095 (0.415)	-0.00935 (0.0392)

Produc_decision_pri_	0.641**	1.898**	-0.0662**
	(0.321)	(0.608)	(0.0332)
Nego_with_protrad_	0.446	1.563	-0.0461
	(0.316)	(0.494)	(0.0325)
Mkt_info_from_Coop_	0.387	1.473	-0.0400
	(0.390)	(0.574)	(0.0403)
Mkt_info_from_trad_	-0.801*	0.449*	0.0827*
	(0.473)	(0.212)	(0.0489)
Input_loc_avai_	0.686**	1.985**	-0.0708**
	(0.275)	(0.546)	(0.0285)
Input_Gos_	-2.418**	0.0891**	0.250**
	(1.219)	(0.109)	(0.124)
Constant cut1	-0.478	0.620	
	(1.474)	(0.914)	
Constant cut2	4.506***	90.52***	
	(1.508)	(136.5)	
Observations	350	350	350

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

In this study, eight factors have been identified that have a significant impact on the maize value addition among farmers with different levels of statistical significance. The 10% mark of education level, directly selling to consumers, and market information of traders are significant. The 5 percent level is important in determining whether the producer will make decisions based on price, use of local sources, and development organizations (GOs/NGOs/INGOs). The strongest factors, which are significant at the 1% level, are area dedicated to maize and storage. Coefficient (Model 1) analysis shows that education, area allocated, producer price decision and local inputs are positively correlated with value addition. On the other hand, there is a negative correlation between selling to consumers, storage, market information provided by the traders and the inputs provided by NGOs. These effects are measured using odds ratios (Model 2). As an example, education level has a one-unit higher value addition odds ratio of 2.5, whereas area allocated has the odds ratio of 6.2. Conversely, other aspects such as NGO inputs significantly decrease the odds (0.089), meaning that there is a strong negative relationship. Lastly, model 3 is the estimation of change in probability using marginal effects. Training farmers raises the chances of value addition by 9.5 percent and raises cultivated area by 18.8 percent. It is interesting to notice that two variables, which are positively correlated as producer price decision and local inputs are negatively correlated and suggests that their effect on changing the probability between outcome categories is not straight forward. In a nutshell, the important positive drivers include farm scale (size), human capital (education), and some sources of inputs, and the market channels/information sources may determine the discouragement and re-alignment of value-addition activities.

5. Discussion

The survey revealed that a bit more males participated, and the majority of the participants were between 30 and 40 years, which is like previous studies that reported that most of the farmers were male and the average age of the farmers was approximately 40 years (Adu et al., 2021; Shee et al., 2019). This is a relatively productive workforce, and age is also a key factor in determining technology uptake. The mean number of members in most families was 5-10 with joint family systems the production decisions made by the household heads implying that experience comes to play in farm management (Shee et al., 2019). This is however unlike evidence that younger household heads tend to be more sensitive to adoption of innovation (Wiredu et al., 2009). Although the role of training in increasing agricultural productivity has been realized to be of significance (Ayele et al., 2021), the majority of the respondents indicated that they rarely access extension services, as well as formal training. Small-scale, low-input, and rainfed production are the main features of maize production, and the lack of irrigation infrastructure limits maize production (Bajracharya et al., 2016). Without adequate public or privately installed irrigation funding, farmers use irrigation systems operated locally with limited management. The positive and significant relationship between education and the practice of awareness and value addition among farmers confirmed the research results that formal education increases their participation in the market and availability of technological information (Ayele et al., 2021). Maize production was also positively significant ($p < 0.01$) and it implied that it was scale effect on output (Daly et al., 2016). Conversely, consumer-to-consumer direct sales and the lack of storage infrastructure adversely impacted value addition, which were low market linkage and loan small sizes (Shee et al., 2019; Wilson and Lewis, 2017). Value addition was generally accessible, but capitalized by high interest rates and low loan amounts. Better results were observed in farmers who had more control in price setting when selling their produce ($p < 0.05$) which highlights the significance of the bargaining power and market knowledge (Bloom & Hinrichs, 2011). The traders were the main source of market information because there were no formal information systems as it has been observed by Mazhar et al. (2019). Increasing the contribution of the government input support and encouraging value chain integration would help to increase productivity, value addition as well as the socio-economic status of the farmers.

6. Conclusions,

This paper examined maize value chain in the Bhaktapur District in Nepal, with the identification of important determinants of awareness of value addition of smallholder farmers. The results show the chain is quite traditional and has minimal innovative connections. The ordered logistic regression suggests that the level of education of the farmer, area that is used in growing maize and the autonomy of the producer in determining the prices of the sales are important positive predictors of value addition awareness. On the other hand, direct consumer sales, poor storage infrastructure, as well as excess dependence on the traders in market intelligence will greatly lower the value addition potential. The findings highlight that the key factors to improve the chain performance are human capital, scale of production, and market empowerment, whereas market access fragmentation and losses after harvest are the most significant limitations. The policy interventions should therefore focus on enhancement of extension services to enhance education and technical capacity of the farmers. Efforts towards establishing a formal system of market information, storage facilities, etc., will be necessary to minimize post-harvest losses and the reliance on intermediaries. Additionally, the bargaining power might be boosted by supporting farmer cooperatives and by making credit more affordable and thus economies of scale. Further studies are needed to extend this study to other geographical settings and crop systems in future to confirm the applicability of these determinants. Long-term research on the effectiveness of individual interventions, including digital market platforms or better storage technologies, would be helpful in creating better and more sustainable agricultural value chain development programs.

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