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Global Value Chains and the Uptake of Innovative Technology in Vanilla Production among Women Smallholder Farmers in Bukoba Rural District, Tanzania

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Abstract: *This study looked at how women smallholder farmers' involvement in the global value chain fosters innovation in vanilla production. The study concentrated on the importance of vanilla associations, the adoption of innovative vanilla production technology, and the obstacles preventing women producers from participating in global value chains. Additionally, the study uses a cross-sectional, quantitative research design, collecting data through a survey. Moreover, the multistage cluster sampling technique was used; focusing on women's involvement in agricultural cooperatives and wards with notable vanilla output. Descriptive statistics and multiple linear regression were therefore used in the data analysis. The results showed that pollination technology (25.1%) and farm preparation technology were the most often adopted technologies (24.4%). These findings show that women who grow vanilla are primarily implementing useful farm-level innovations that directly raise crop quality and yield. With a standardized regression coefficient of β =.194, p =.005, the regression results further demonstrated that pollination had a positive and statistically significant impact on innovation. This implies that better pollination techniques are crucial to fostering innovation in the production of vanilla. The substantial effect of vanilla association, recorded (β = .248, p = .003), which provided additional support for the findings. This suggests that vanilla associations provide farmers with production knowledge, where pollination technology demonstrates a positive innovation spillover effect, showing that global value chain participation can enhance farmers' innovation when supported by local institutional linkages. However, 33.9% of barriers to women vanilla growers' participation in global value chains were due to lack of training.*

Keywords*: Global Value Chain, Technology Adoption, Innovation, Small-holder, Women Farmers*

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1. Introduction

Developed and developing nations' economy Global value chains (GVCs) account for 70% of global trade, greatly impacting the dynamics of globalization and stimulating innovation by 5% (Cigna & Gunnella, 2022; OECD, 2022; Rub´ınov´, 2021). GVC as collaborative web of production among nations have transformed how things are made, and now many businesses including vanilla smallholder women farmers (VSWF) don't make everything within their own limits. Instead, they split up tasks and send them to different places and people where

they can be done best, often through offshoring (Ambos *et al*., 2021; Fernandez-stark & Gereffi, 2019b; Sébastien Miroudot and Håkan Nordström, 2019).

Additionally, in the 20th century, agricultural global value chains (AGVCs) have grown fast and reshaping the global production of food through their ability to coordinate and spread innovative technologies among local producers. For instance, it has enabled VSWF to focus on areas of comparative advantage and facilitate broader dissemination of innovation activities (Cigna & Gunnella, 2022; Fieldsend *et al*., 2021; Sunghun Lim, 2021). Hence, worldwide the leading center for vanilla plantation and export are Mexico, Indonesia, India, and other countries in the United States, (Chambers *et al*., 2019), which implies the ability to focus on areas of competitive advantages facilitate innovative ability of producers such as VSWF (Rasib *et al.*, 2021).

The perspective of GVCs in Africa situated it in upstream flow of value chain as they export commodities as an inputs to the other manufacturing nations (Cigna & Gunnella, 2022). According to Avenyo *et al*., (2022), GVCs have increased African firms' potential for innovation through the dissemination of innovative technologies and information. Despite this affiliation up to date evidence is limited on how GVCs contribute to innovation in Agricultural sector in Africa since the level of productivity is low (Steffens *et al*., 2020), also, (Deng, 2020; Okpoko *et al*., 2022), reported technological innovation as one of the barrier for growth of the agriculture and food industry. As a result an insight related to how vanilla smallholder women farmers obtain innovation from GVCs is also limited due to a weak coordination of actors along the value chain. Although GVCs, have shaped many sectors including agriculture where innovative technology from effective producers and buyer can be obtained domestically which stimulate product innovation, and process innovation for smallholder as well as optimal cost consideration which make Madagascar to be the global center for vanilla production (Şerbănel, 2021; Shriver, 2020; Ahmad *et al.*, 2017)

In Tanzania, GVCs intervention in agriculture innovation is motivated by the fact that 70% of Tanzanians depend on agriculture and related value chains and most of them are smallholders who produce variety of cash crops such as vanilla (WB, 2019; Mufuruki *et al*., 2017). For that case GVCs facilitate agricultural innovation where a number of agricultural frameworks such as agriculture sector development strategy (ii) and the national five-years development plan (phase II) have been developed to ensure revitalization of agriculture sector and reduction of postharvest losses (URT, 2021; WB, 2019). According to Thomas & Makundi, (2020) GVCs have imbedded innovation on production of horticulture crops that include vanilla where smallholder get access to market information and new farming technologies. Also, (Magesa *et al*., 2019, 2020), reported diffusion of agricultural market information facilitate best farming practices.

Despite government initiatives, the agriculture sector—including vanilla production—continues to highlight the need for technological advancements and stronger connections to regional and international agricultural value chains (BoT, 2021; Finance, 2021; URT, 2021; WB, 2019). As a result, smallholder farmer are vulnerable to limitation of innovation such as new farming technology, and advanced storage facilities which this is justified by postharvest losses in agriculture which account for 40% of harvested crops in which vanilla is branded (Maziku, 2019). Therefore, this infers that 100% of harvested crops, 40% of them do not meet market standards due to outdated farming technology and storage facilities. Though scholars proposed study on the Innovation System (IS) and lens of GVC (Jurowetzki *et al*., 2018; Lema *et al*., 2018; Montalbano *et al*., 2018;) , studies on GVCs and agriculture innovation as well as related value chain are available (Avenyo et al., 2022; Deng, 2020; Sunghun Lim, 2021; Thomas & Makundi, 2020), however, (Rodriguez, 2018) opened that most AGVCs have isolated smallholder farmers. On that view, still there is a knowledge gap on global value chains and the uptake of innovative technology in vanilla production among women smallholder farmers.

Therefore, this research intends to contribute on the body of knowledge by discover the given research questions:

RQ1: To what extent global value chain (GVC) has influenced application of innovative technologies in vanilla production among women smallholder farmers?

RQ2: What challenges within global value chain (GVC) that hinder the adoption of innovative technologies in vanilla production among women smallholder farmers?

This study is important to all parties concerned on global production networks, smallholder farmers, policy-maker and general public because value chains, which begin with research and development, are essential components of the quickly evolving industrial landscape of today.

2. Literature Review

2.1 Theoretical Literature Review

The study is guided by the interactive model of innovation, rooted in Schumpeter's perspective on innovation and further developed by scholars like (Nelson, 1993; Roy Rothwell & Walter Zegveld, 1985). This model views innovation as a collaborative process involving internal, external, national, and regional innovation systems. Rothwell and Zegveld's interactive model, developed in the 1970s or 1980s, elucidates how innovations are acquired through channels such as

training, technology, trade networks, and firm capabilities (Maxim Kotsemir, 2013; Rothwell, 1992, 1994).

The study underscores the importance of interactive innovation for smallholder women farmers, emphasizing the role of knowledge and technology spillovers in fostering innovation within the global value chain (GVC) by providing flexibility in farming practices (Schmidt *et al*., 2022; Ambos *et al*., 2021; Keresztes & Endresz, 2020; Gaddefors *et al*., 2019). It highlights the necessity of interconnectedness between actors to facilitate innovations like adoption of new farming technology (Fieldsend *et al*., 2021), which aligning with the study's focus on assessing how the GVC stimulate the uptake of innovative technology in vanilla production among smallholder women farmers. In essence, the study bridges the interactive model of innovation with GVC dynamics, illustrating how innovative technology contribute to innovation in the agricultural sector.

2.2 Empirical Literature Review

2.2.1 Global Value Chain and Innovation in Farming.

The idea behind Global Value Chains (GVCs) is to maximize the value of services offered to clients while reducing production costs by shifting manufacturing activities to regions with effective production systems and resources. GVCs in agriculture highlight the value of co-creation by fostering relationships between farmers that improve the sharing of cutting-edge technology and skills among farmers. These relationships encourage negotiation about production sharing, which eventually leads to more productive and efficient agricultural technology (Avenyo *et al*., 2022; Rodriguez, 2018). In the other hand GVCs contributed to innovative farming since innovation is defined as farmer's ability to create new or improved product and apply new approach by using newly introduced technology from counter parts. For this reason firms as well as VSWF participate in GVC strive to increase innovation capacity in order for them to reach global markets (Avenyo *et al*., 2022; Barmuta et al., 2022;; Reddy *et al*., 2021; Keresztes & Endresz, 2020).

2.2.2 Global Value Chain and Application of Innovative Technology.

According to the literature, GVC participation influences the spread of new technology in a variety of activities, depending on the type of firm where the activity is carried out. Additionally, it has been mentioned that the emerging GVC in production may result in the adoption of new technology that enhances functional upgrading and entails a shift to new and higher-valued-added activities throughout the chain by the small firms that are involved in niche markets (Geneva, 2022). In that case, since part of innovation for producers (VSWF) is the increase of productivity and product quality to achieve international certification criteria, the introduction of innovative technology in cultivation also helps to upgrade processes while involving producers such as vanilla smallholder women farmers in the value chain.

In a study of GVC and innovation among producers of avocado (Thomas & Makundi, 2020), it was pointed out that smallholder farmers involved in GVC have acquired new and improved farming technologies and knowledge, such as minimal use of chemical fertilizers and pesticides, through the use of natural fertilizer. Furthermore, farmers obtained innovation in production related to the production of organic avocados, resulting in an increase in productivity and quality of production, which secured the farmer's position in global markets. Similarly, (Valdes et al., 2023) support this finding that certified seeds and record keeping were among of the technology adopted in horticulture cultivation. Though the study was specific to avocado farmers, the findings of this study are relevant for the current study, which focused on exploring GVC and innovation in vanilla smallholder women farmers since the study was conducted in Tanzania and in the horticulture categories where vanilla is included. Moreover, they might offer strategies for preventing supply chain disruption, which could have an impact on all steps of the vanilla production value chain, including producers, processors, distributors, and final consumers.

Likewise, a study of Technology and smallholder farmers attachment in GVC revealed that farmers participation on GVC have revolutionize the value chain capability trough adoption of new technology in production. The newly introduced technology boosted farmers bargaining capability in the global supply chain since farmers have earn innovative advantage of capturing new markets of their product (Kos & Kloppenburg, 2019). Also, (Digdoyo & Budiansyah, 2017) support this finding that the application of new technology in the production of vanilla, particularly processing technology like incubation and extraction techniques, has increased the value added to exported vanilla. In addition, It was then confirmed by (Alfredi, 2021), who revealed that vanilla association help farmers embrace cutting-edge agricultural technology, including using natural pesticides and planting vanilla by combining it with other crops to improve organic vanilla, which in turn gives farmers access to international markets. Also, (Steffens *et al*., 2020), innovative technology like processing and storage superbugs reduces post-harvest losses. The reviewed results had a significant impact on the current research because they showed that for VSWF to obtain global competitive advantage through value-adding activities, must engage in GVCs. In doing so, they are able to obtain appropriate innovative technologies that supported their efforts.

In addition, a study of GVC and firms productivity revealed GVCs has promoted the higher rate of innovation to firms by being enhancing better product standards, and more efficient labor costs, which together

help bring about technological progress in the company (Ledezma & Villavicencio, 2024). The results of this study align with the current research, as they are based on two-way traders, making them relevant for vanilla producers involved in export activities.

2.2.3 Barriers in the Adoption of Innovative Technology

The functionality of GVC framework for producers depends on global and local factors which means producers' innovation development such as adoption of new or improved technology is influenced by the location, capacity for upgrading, and structure of the production stages in GVC. Moreover, under GVCs the higher value generated is affected by the migration capacity of firms' and likewise to agricultural perspective that including vanilla value chain performance is influence by the adoption of technology (Valdes *et al*., 2023; Buciuni & Pisano, 2021; Fernandez-stark & Gereffi, 2019). Similarly, once global agricultural production revived agriculture innovation, GVCs changed the agriculture value chain. It is now no more a one-country function but rather involves connections between other countries. These changes have therefore presented challenges for agricultural innovation, including improving the sustainability of agricultural production and the supply of agricultural products, as well as managing global agricultural production networks from a global viewpoint (Yang, X., & Liu, 2022). Therefore, it is crucial for this study to addressed this shortcoming by utilize input-output structure (global factors) to identify challenges associated with GVCs on the aspect of technology adoption for VSWF.

Figure 1: Input-output structure flow

Source: (Fernandez-stark & Gereffi, 2019a; Gereffi & Fernandez-stark, 2016; Karina Fernandez-Stark Penny Bamber Gary Gereffi Contributing, 2011)

Additionally, a study on coconuts from Fiji and the difficulties faced by producers in participating in GVC revealed that a barrier affecting smallholder farmers' ability to adopt new technologies is the interruption of communication flow throughout the coconut value chain that start from inputs acquisition to output generation. It was discovered that communication flow presented information, and human resources with capabilities, and training sessions related to new farming technologies were the main problems. Nonetheless, among the important respondents who were interviewed were women, and they disclosed that one of their concerns was the absence of a farmers' organization that organized women for activities related to the value addition of coconuts (Lin, 2020). According to this perspective, the results are important for the current investigation since they reveal the GVC's attitude and the difficulties that farmers faced during the intervention.

Furthermore, Alfredi, (2021) discovered export market for vanilla farmers is affect by production and market challenges. The study found that limited availability of certified seeds, theft of vanilla cuttings, and inadequate knowledge of fertilization, storage, and curing training, made it difficult for vanilla farmers to access the worldwide market, which in turn led to a limited uptake of novel technology. The results of this study support the assertion that producers participating in GVC are not connected to vanilla processors on international marketplaces, which imposes limitations such as certificate requirements, reactive orders, price volatility, and an unstable market.

2.2.4 Conceptual Framework

The conceptual framework provides a brief example that illustrates the connection between GVCs and the spread of innovation to producers, particularly smallholder women farmers who grow vanilla. In this study, GVC was the independent variable, production innovation was the dependent variable, and vanilla association was the intervening variable. Accordingly, in order to guarantee both process and product improvement, vanilla associations should connect VSWF with existing GVCs so that they can learn and apply emerging GVCs in the production of vanilla, such as the application of natural fertilizer, farm preparation techniques, pollination, pest management, and record management.

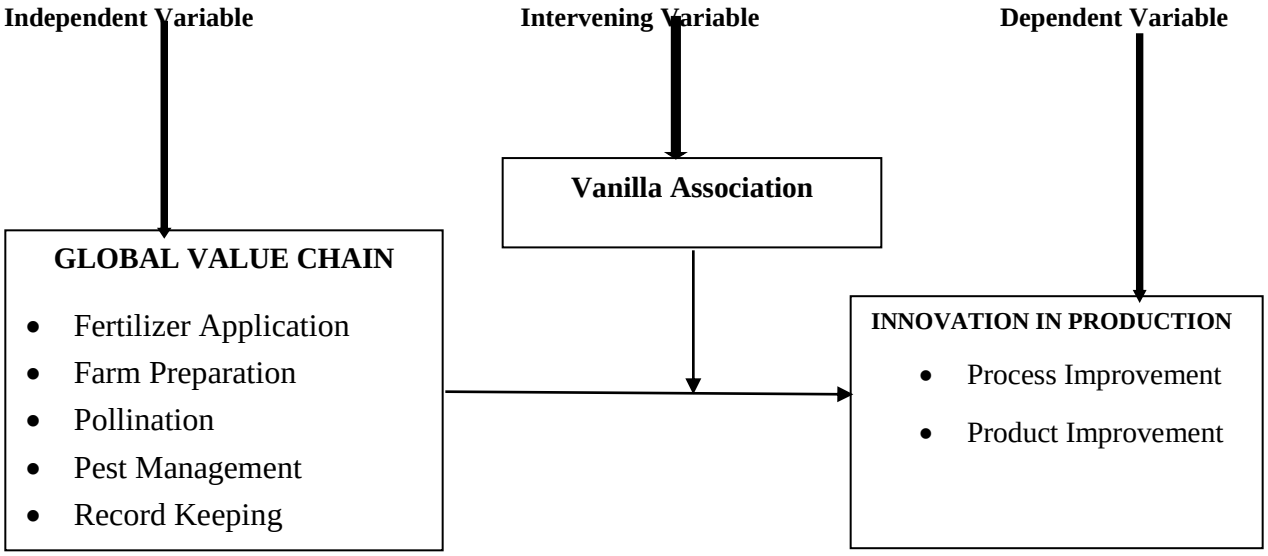

Figure 2: Conceptual Framework

Source: Own construction, (2025)

3. Methodology

3.1 Study Area and Target Population

The study was carried out in Tanzania's Bukoba rural district, which is a prominent hub for vanilla farming over the region and it had large number of farmers who are engaged on GVC. The target population for the study were all women smallholders who are registered under MAYAWA co-operative and agents of vanilla associations who were involved in the vanilla value chain. Women smallholder farmers were chosen as the focus of this study because, although they represent only 22% of vanilla farmers in the area, they play a crucial role in essential processes like pollination. Despite their contribution and knowledge within the global value chain (GVC), they face unique challenges that limit their participation. Studying this group allows us to assess both the extent of their involvement and the specific obstacles they encounter within the GVC. Understanding these barriers is vital for promoting a more inclusive and effective value chain, especially considering the potential for increased productivity and economic empowerment if more women participate actively in vanilla production. Additionally, as farmer associations support smallholder farmers in the production and marketing of produce as well as in the adoption of modern agricultural technologies, agents from those associations were also involved. Moreover, vanilla crop was used as it is a cash crop that is quickly integrated within GVC; meanwhile, a challenge of low productivity is still prevailing. (Yao, 2023; Israel *et al*., 2022; Sisifa, 2021; Gerald, 2020).

3.2 Research Design and Approach

Furthermore, the study deployed a cross-sectional research design since it enables collection of information from various respondent groups at one time. The adoption of novel technology acquired from GVC was assessed through the application of a quantitative approach, which allowed for collection of quantitative information in order to assess the how GVC has enhanced the uptake of innovative technology in production process. Correspondingly, data were gathered through the use survey method in which tool for data collection were structured questionnaire since result from questionnaire survey can easy be quantified (Flick, 2020; Thakur, 2021).

3.3 Sample and Sample Process

The sampling technique employed to select a sample of smallholder women farmers was multistage-cluster sampling, conducted in three stages. Initially, Bukoba rural district was purposefully chosen due to its prominence as the primary agricultural hub in the Kagera region for vanilla production since vanilla contribute 62% of household annual income of farmer. Subsequently, the district was subdivided into wards; Kasharu, Maruku, and Nyakato were specifically chosen to represent other women small-scale farmers in the district. These wards were selected because they provide a global market network for women smallholder producers, with a significant number of vanilla farmers being members of MAYAWA, which facilitates access to technical support for adopting and utilizing new farming technologies.

Within each ward, the villages were further divided. Stratified random sampling was employed to select sections of the villages to participate in the study. Villages were stratified based on productivity and the registration

of village women farmers under MAYAWA, ensuring homogeneity among the selected villages. The villages selected from the wards were Maruku (comprising Maruku and Bukairuka villages), Nyakato (consisting of Kiilima and Ibosa villages), and Kasharu (encompassing Kasharu and Butainamwa villages) (Gerald, 2020; Muzanila & Assenga, 2022).

Stratification of women who cultivate vanilla in each village was undertaken to determine the sample size. Subsequently, the census approach was utilized to identify all participants within the sample size in each village. Key informants from each village were then randomly selected with the assistance of local administration.

3.4 Sample Size

According to Gerald, (2020) the selected village had 414 total population of vanilla farmers, whereby 22% are women which means women who crop vanilla were 92. The study's focus is on women vanilla farmers specifically because, as the statistic indicates, they represent a minority in this sector. Therefore, the intent is to investigate the extent of involvement and unique challenges that may limit wider participation among women in vanilla farming. Understanding these factors could provide insights into how to increase women's involvement in vanilla production and enhance their economic opportunities in agriculture. Hence, distribution of sample size was done using a formula introduced by Kothari (2015).

$$n = \frac{Z^2.p.q.N}{e^2(N-1)+Z^2.p.q}$$

$$n = \frac{1.96^2 \times 0.5 \times (1-0.5) \times 92}{0.05^2(92-1)+1.96^2 \times 0.5 \times (1-0.5)} = 75$$

Where:

p – stands for sample proportion, q = 1 – p; thus, to have an assurance on the adequacy of sample the study opt to use 0.5.

e – is the precision level, where the study used +/- 5%.

Z– is the confidence level, where a study used 1.96 for the purpose of obtain a 95% confidence level.

N- total population

n – Size for sample size

Consequently, the study considered 75 sample size for vanilla smallholder women farmers to be representative of the population. However, 83 informants were choosen, of whom 75 were women smallholders and 8 others were key informants.

Besides, sample size for proposed stratum was determined by following formula Kothari (2015).

$$nape = n\left(N_{1,n} \middle| N\right)$$

Where

n.p–Number of elements selected from the stratum, *n* – Sample size, N_1- proportion of the population and *N* – total population.

The study accepted 1: 2: 3 as a proportion of the investigation in three cases: $N_{1\ldots n}$= 1, 2, and 3

Therefore, $n.p = 75\left\lfloor\frac{1}{6}\right\rfloor$----*n* , and so far, the proportion of sample size in each stratum was given in Table 1 below.

Table 1: Sample Frame (n = 83) as of, Kasharu, Maruku, and Nyakato wards

Villages	Women Smallholder	Associations' Agents	Sample Size
Kasharu, Butainamwa	12	2	14
Maruku , Bukairuk	38	3	41
Kiliima , Ibosa	25	3	28
Total	75	8	83

Source: (Gerald, 2020)

3.5 Ethical Consideration

Throughout the whole research procedure, the study adhered to ethical standards. Before taking part, respondents were made aware of the study's objectives, and their involvement was entirely voluntary. The

information provided by female vanilla farmers was used exclusively for academic purposes, and their privacy and confidentiality were safeguarded. Additionally, the study made sure that participants were neither harmed or under duress while data was being collected. The appropriate authorities granted permission, and local leaders, farmer organizations, and all study participants were respected

3.6 Data Analysis

The Statistical Package for Social Sciences (SPSS) version 25 was used to statistically test the acquired data using both descriptive and inferential statistics. Measures like percentages, frequency, mean, graphs, and charts were used in descriptive statistics to describe the variables seen in the field. The degree to which GVC's indicators—such as fertilizer application, farm preparation, pollination, pest management, recordkeeping, and vanilla associations—illustrate process and product improvements was also demonstrated using a multiple linear regression model. Survey instruments used to gather data were evaluated for accuracy in measuring the study's variables in order to validate the data. Additionally, test-retest reliability was used to verify data dependability by giving a subset of respondents the identical survey instrument again in a brief amount of time.

The summary below shows multiple linear regression model summary equation.

IP =

$$\beta_0 + \beta_1 FA + \beta_2 FP + \beta_3 POL + \beta_4 PM + \beta_5 RK + \beta_6 VA + e \text{----------(1)}$$

Where by:

IP = Innovation in Production

FA = Fertilizer Application

FP = Farm Preparation

POL = Pollination

PM = Pest Management

RK = Record Keeping

VA = Vanilla Association

3.7 Reliability Test

Cronbach's Alpha was used to assess the research instrument's dependability. According to the findings, every construct had Cronbach's Alpha values higher than the allowable cutoff of.70. Fertilizer application, farm preparation, pollination, pest management, record keeping, and vanilla association were all measured using questionnaire items that were found to be internally consistent and reliable for additional research (Green, 2014; Mashenene, 2019).

Table 2: Cronbach's Alpha per Dimension

Construct	Number of Items	Cronbach's Alpha	Interpretation
Fertilizer Application	4	.782	Acceptable reliability
Farm Preparation	4	.801	Good reliability
Pollination	4	.824	Good reliability
Pest Management	4	.776	Acceptable reliability
Record Keeping	4	.741	Acceptable reliability
Vanilla Association	5	.836	Good reliability
Innovation	5	.849	Good reliability
Overall Scale	30	.872	Good reliability

Source: Survey data, (2025)

4. Results and Discussion

4.1 Demographic Information

The analysis demonstrated that 52.9% of respondents were VSWF aged range between 36-45yrs, while minimum participation was 7.1% for women aged above 60yrs. Also, 61.4% were married women farmers and the least participation was 7.1% divorced women farmers. About 67.1% of respondents had the primary level of education, while few 5.7% had university education. This implies that the vanilla GVC and adoption of innovation technology in farming practices is influenced by women with the active age in which marital status has a greater percentage for them to participate in cash crop production and adoption of new farming technology in order to earn higher yield since married household depend on each other for household supply. Consequently, women with the higher level of education were not interested with the agricultural activities. These findings aligned with those of Abdalla, (2021); and Gerald, (2020), who opened that most of vanilla and cash crop growers were energetic onces, in which support from both husband and fiwes had a positive impact of productivity regardless that most of farmers had a primary education. Simillarly, Alejandro Lavopa, (2018); and Lorenz & Kraemer-mbula, (2022), supported that education is indispensable tool in innovation stages if it reaches a right people. In this view it can be argued that education on the context of technology adoption has stronger relationship with the domestic value added and in one-way influences disseminations of the innovative technology introduced by GVC.

4.2 Global Value Chain and Adoption of Innovative Technology

This section report varied findings on application and adoption of innovative technology in vanilla cultivation. Furthermore, the investigation inquires the awareness and the extent of adoption of innovative technology as one of the way agricultural GVC is altered to obtained value added processes and products.

Table 3: Vanilla Women Farmers' Awareness of and Adoption of Innovative Technology (n=70)

Variables	Parameters	Frequency (n=70)	Percent (n=100)
Knowledge of Innovative Technology	Yes	68	97.1
	No	2	2.9
Adoption of Technology in the Previous Crop Season	Yes	63	90.0
	No	7	10.0

Source: Survey data (2025)

In the table 3 above findings demonstrated that 97.1% of VSWF were well informed with the innovative technology applied on the cultivation of vanilla as well as vanilla global value chain in the export markets, while 2.9% were not aware. Additionally, 90% of them adopted innovative technology that boosted value added produce as well as market penetration, while 7% did not adopt new production technology.

Table 4: Technology Adoption Rates and Share (Multiple Responses N=70 , Percent n=100)

		Responses		
Characteristics	Variables	N	Percent	Percent of Cases
Innovative Technology Adopted[a]	Fertilizer application	60	22.1%	85.7%
	Farm preparation	66	24.4%	94.3%
	Pollination	68	25.1%	97.1%
	Paste management	66	24.4%	94.3%
	Record keeping	11	4.1%	15.7%

a. Dichotomy group tabulated at value 1.

Source: Survey data (2025)

This means that substantial portion of VSWF have fused and are aware of innovative agricultural technology brought by GVC, and producers may expand vanilla productivity by incorporate technological equipment into their farming activities. Besides, these outcomes highlight the interactive model, emphasizing that technology spillover is essential for fostering innovation. Effective innovation starts from the organization's own context to regional context since practically farmers were exposed to external innovations through global networks. These findings concur with those of Marhaeni, (2019), that 61% to 80% of the respondents who produce vanilla had good productivity as a result of technology adoption. Likewise, Lorenz & Kraemer-mbula, (2022), opened that the first step in adopting technology is being aware of it. Therefore, it is argued that the nation's openness to new technology strength the ability of GVCs to contribute on producing quality and certified vanilla that fits for standards of the global markets. As a matter of fact that GVCs involves transfer of technology, knowledge, and practices across different production phases, farmers' willingness and aptitude on technologies adoption are essential for any advances that may be made inside the GVC.

In addition, the research questions aim to provide an understanding of the technology that has been accepted and to infer the participants' comprehension of this novel technology adoption. Table 4 presents the research results on the adoption of innovative technology.

Accordingly, Table 4 above's findings show that women farmers stated that pollination processes—which accounted for 68 respondents, 25.1% of the responses—were the most often used innovative technologies. These were followed by farm preparation and paste control which accounted for 66 respondents, 24.4% of the responses, fertilizer application which accounted for 60 respondents, 22.1% of the responses, and a few respondents mentioned record-keeping which accounted for 11 respondents, 4.1 percent of responses. This, imply a difference in the application of cutting-edge technology, which could have a major impact on supply chain value addition. In this regard for smallholder women farmers to increase innovation in vanilla production, the pertinent technologies are: farm preparation, pollination, fertilizer application, and paste management. Therefore, this data supports the interaction model's commonly held theory that technology acts as a significant stimulant. These

results corroborated those of Yao, (2023); Alfredi, (2021), who discovered that essential technological improvements in vanilla production that producers dealt with in a workday per activity included manual pollination, pruning, fertilizing, and disease management. Additionally, Thomas & Makundi (2020) found that the majority of producers of spices prepared their farms by plantation, fertilization, and irrigation. Despite these technological advancements, Yao (2023) pointed out that vanilla growers have also adopted other cutting-edge methods like inspecting and eliminating sick plants, managing shoots, keeping weeds out of mulch, composting, and trimming. Information from a survey indicates that GVC has used technology to enable small producers to participate in the vanilla value chain in a variety of ways, including source traceability system.

Moreover, the inquires for vanilla productivity based on applicable technology was among of paramount attribute of the study so as to elucidate the extent to which GVCs embark production activities in agriculture. Figure 2 below presented findings of vanilla Productivity and quality in relation to technology adopted.

Figure 3: Respondents' Opinions Regarding the Quality and Use of Technology in Vanilla Production

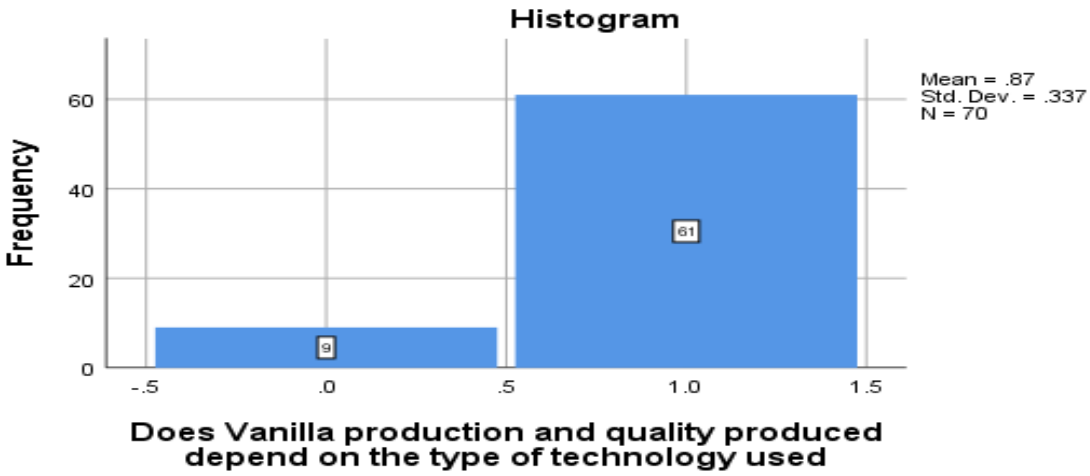

Figure 3: Respondents' Opinions Regarding the Quality and Use of Technology in Vanilla Production

Source: Survey data (2025)

According to Figure 2's findings, 61 respondents, with a mean of 0.87 replies, indicated that most respondents generally agreed that technology has an impact on the quality and production of vanilla. Also, the standard deviation of 0.337, indicate that there is some variation in responses, but most respondents are clustered around the mean. This implies that approximately 87% respondents agree that the type of technology used significantly affects vanilla production and quality. Thus, improving technology in vanilla farming could positively influence outcomes in terms of production and quality. As a result, this outcome validates the existing interactive theory that technology enhances producers' capacities in a manner appropriate to their innovation environment. This result align with those of Marhaeni (2019) finding that technology increased vanilla productivity. In this way, it can be argued that GVC has a larger percentage of improved quality and productivity for vanilla grown by smallholder women farmers.

4.3 Regression Findings on GVC and Innovation Technology in Vanilla

4.3.1 Multicollinearity Test

In this study inter-correlation of indicators of independent variable was tested using multicollinearity test. The test was done prior to interpreting the regression coefficients, so as to ensure credibility of the regression results.

Table 6: Multicollinearity Test for GVC Indicators

Predictor Variable	1/VIF	VIF
Fertilizer Application	.642	1.558
Farm Preparation	.681	1.468
Pollination	.604	1.655
Pest Management	.717	1.395
Record Keeping	.756	1.323
Vanilla Association	.593	1.686

Source: Survey data, (2025)

Table 6's results revealed that the multicollinearity test was statistically acceptable since every indicator had variance inflation factors that were larger than 0.1 and smaller than 10. The results showed that all predictor variables had tolerance values (1/VIF) more than 0.1 and VIF values less than 5. According to Geofrey Shahanga & Momole Kasambala, (2023) and Shrestha, (2020) a minimal VIF number indicates no collinearity, while a VIF of $1 < VIF < 5$ indicates moderate correlation of variables. As a result, in this study all indicators of the independent variable were sufficiently independent from one another and fit in the regression model, indicating that there was no strong collinearity of the independent variables.

4.3.2 Model Fit

Table 7: Regression Model Summary and Model Fit Indicator

Model	R	R Square	Adjusted R Square	F-statistic	Sig. / p-value
1	.721	.520	.503	30.417	.000

a. Predictors: (constant), b1Fertilizerapplication, b2Farmpreparation, b3Pollination, b4Pestmanegement, b5Recordkeeping, b6Vanillaassociation
Source: Field survey data, (2025)

Additionally, the results of the multiple linear regression model test are shown in Table 7 above. To find the association between the variables Global Value Chain and Production Innovation, the study used the model summary test for correlation coefficient R, whereby $R = 0.721$ and $R^2 = 0.520$ indicate a good association between the GVC and innovation, according to the statistical test. The results suggest that the vanilla association and GVC indicators together account for 52.0% of the variation in innovation among VSWF in Bukoba Rural District. Consequently, other factors not included in the model could account for the remaining 48.0%. Furthermore, an adjusted $R^2 = 0.503$ shows that the independent variables continued to account for 50.3% of the variation in innovation even when the number of predictors in the model was changed. This demonstrates that the model's ability to explain innovation to smallholder women farmers was reasonable. These results are consistent with those of (Avenyo *et al*., 2022; Hoang *et al*., 2026; Vu *et al*., 2024) who found that involvement in GVC can enhance innovation in processes and products, particularly in areas with robust local innovation support networks. Thus far, the results of this study are pertinent since the Vanilla Association serves as a local innovation support framework that provides VSWF with access to new technologies, market information, training, and knowledge.

4.3.3 Global Value Chain and Innovation in Production of Vanilla.

Table 8: Results on Innovation among Women Smallholder Vanilla Farmers in Bukoba Rural District

Predictor Variables	Unstandardized Coefficient (B)	Standard Error	Standardized Beta (β)	t-value	p-value	Significance
Constant	.462	.087		5.310	.000	***
Fertilizer Application	.143	.052	.176	2.750	.008	**
Farm Preparation	.126	.048	.161	2.630	.011	**
Pollination	.171	.058	.194	2.950	.005	**
Pest Management	.102	.047	.128	2.170	.034	*
Record Keeping	.057	.041	.072	1.390	.169	Ns
Vanilla Association	.220	.073	.248	3.010	.003	**

Significance levels: ***p < .001; **p < .01; *p < .05; ns = not significant

First, Table 8 showed the coefficient of the independent variable, Global Value Chain, which includes aspects of record keeping, pest control, pollination, fertilizer application, farm preparation, and the intervening variable, vanilla association. The study's results showed that fertilizer application had a statistically significant positive link with innovation in vanilla production, with a regression coefficient of (β =.176, p =.008). This suggests that because VSWF uses an innovative approach, adding one unit of organic fertilizer enhances the likelihood of improving soil fertility and the grade of vanilla produced by 0.176. Accordingly, this conclusion implies that the use of organic fertilizer in the cultivation of vanilla is not only a production process but also a component of agricultural innovation since it calls for enhanced knowledge brought in by local innovators that enhance soil fertility. The findings are consistent with those of (Chambers et al., 2019; Gerald, 2020; Kaiser & Burger, 2022; Smith, 2024), who found that applying natural fertilizer was one of the cutting-edge technologies used to add value, particularly in crop quality in agricultural systems, primarily in the cultivation of horticultural crops like fruits, vegetables, and vanilla.

The findings for farm preparation also showed a statistically significant positive correlation with innovation, with a regression value of (β =.161, p =.011). An increase of one unit in farm preparation increases the possibility of higher innovation among VSWF by 0.161 because better and proper farm preparation helps farmers manage the farm, prepare the soil, and create favorable conditions for vanilla growth. Additionally, because vanilla requires careful management from planting to harvesting, the results suggests that farm preparation is critical in the context of vanilla cultivation and innovation spillover. This finding is supported by (Kaiser & Burger, 2022; Thomas & Makundi, 2020) who also revealed that GVCs have brought about innovation in agriculture, empowering farmers through seminars and efforts to prepare farms to support the application of organic fertilizers like compost and boost horticultural production yield.

In line with this, pollination demonstrated a statistically significant beneficial impact on innovation in vanilla farming, with a regression coefficient of (β =.194, p =.005). According to this perspective, an increase of one unit in acceptable pollination techniques raises the probability of more innovation by 0.194, particularly in vanilla yield and quality. Hence, the study's findings opened that pollination practice is strongly reasonable to innovation because vanilla productivity depends heavily on successful hand pollination skills obtained from training and seminars given by local innovator like vanilla associations. These results are in line with those of H. Ahmad *et al*., (2020) who found that, when done correctly during blooming, pollination is the most significant factor contributing to enhanced quality in vanilla farming.

Despite these results, paste management had a regression coefficient of (β =.128, p =.034), indicating a favorable impact on innovation in vanilla cultivation. These results showed that an increase in a paste management unit influences innovation by 0.128, particularly in the quality of vanilla produced. These results imply that using better

management techniques boosts market value and productivity. These findings are consistent with those of Yao, (2023) who similarly found that value addition and vanilla production entailed teaching vanilla growers how to deal with pests and other diseases.

Overall, with all the efforts made by VSWF to grasp numerous innovations brought by GVC, the importance of local innovators like farmers' associations cannot be foregone. In this study, the regression coefficient of (β =.248, p = .003), vanilla associations were found to have positive effects on innovations spill over, specifically for VSWF. According to these results, women who participate in vanilla associations were more likely to be creative farmers by 0.248 per unit. Thus far, it can be said that vanilla associations are crucial forums for input access, market access, information sharing, and training. In reality, a farmer who is a member of an active vanilla association might have better access to customers, quality standards, technical guidance, and possibilities for shared learning. As a result, vanilla association can be viewed as a crucial intervening variable that facilitates the evolution of farming operations. These findings align with those of (Elder & Sarmiento, 2024; Thomas & Makundi, 2020; Yao, 2023) of also, revealed that local innovators like farmers associations had a significant impact on diffusion of innovation as the offer training, and other technical support to farmers.

4.4 Global Value Chain's Challenges and Adoption of innovative technologies

Table 5: Challenges Hindering Adoption of Innovative Technology (Multiple Responses n=70, Percent n=100

		Responses		
Variables	Parameters	F	Percent	Percent of Cases
Challenges in GVCs[a]	Inability to Access the Market	60	32.7%	84.9%
	Lack of awareness on packaging and storage	61	31.3%	88.0%
	Lack of trainings in using the technology	64	33.9%	91.4%
	Lack competition	3	1.6%	4.3%
	Restrictive regulations	1	0.5%	1.4%
Total		189	100.0%	270.0%

As evidenced by the multiple responses provided by respondents, Table 5 above reveals that the main reasons given by 64 (33.9%) smallholder women farmers for not using innovative technology in the production and value addition of vanilla and affect their GVCs participation are lack of training in using such technology, 61 (31.3%) lack of awareness regarding packaging and storage, and 60 (32.7%) difficulty accessing the market, while 3 (1.6%) respondents cited lack of competition in the market. This suggests that smallholder women farmers' main challenges to innovatively integrating into the GVC include a lack of technical expertise, a lack of knowledge about embedded technology in product packaging and storage, and restricted access to the global market. Furthermore, these results are consistent with the interaction theory. These findings are in line with those of Abhishek (2019), who found that the barriers to small producers' participation in the GVC were their ignorance of value addition and their unfamiliarity with the necessary conditions to enter the international market. Similarly, Lorenz & Kraemer-Mbula (2022) contend that businesses' ability to function in a market that is conducive to the adoption of cutting-edge technologies is hampered by a lack of skills and competencies to accept and apply technology. Wherein, Yao (2023) argued that among the benefits received by vanilla farmers in GVC were knowledge, and learning skills, these suggest that effective GVC intervention in agriculture must be started with the farmers' willingness, and learning programs. Therefore, it is argued that within the global value chain (GVC) trade facilitation is considered an essential strategy for VSWF, as it helps address multiple challenges such as commercialization, transportation difficulties, access to market information, technology adoption, and capacity building.

5. Conclusion and Recommendations

5.1 Conclusion

The results indicate that GVCs play a vital role in boosting the adoption of innovative technology to enhance vanilla production among smallholder women farmers. High awareness (97.1%) and adoption rates (90%) of new technology highlight its positive impact on production practices, particularly pollination techniques, farm preparation, and paste control. However, the lack of training in using innovative technology (91.4%) remains a significant barrier to fully leveraging its benefits. Overall, technology-driven innovation significantly boosts both yield and quality in vanilla production.

5.2 Recommendations

The study recommends that:

1. Practical training programs for women vanilla farmers be strengthened by government agencies, development partners, buyers, and vanilla associations. These programs should focus on pollination, farm preparation, pest management, quality control, and market standards.

2. Additionally, vanilla associations should be empowered to offer ongoing technical support, access to reliable information, and market linkages, to vanilla small-holder women farmers.

3. In order for women to gain more from innovation, increased productivity, and access to international markets, stakeholders should also encourage women to participate in decision-making inside vanilla value chains.

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