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MICRO-LEVEL ANALYSIS OF CLIMATE-INDUCED DISASTERS AND THEIR IMPACT ON AGRICULTURE IN IDUKKI DISTRICT, KERALA

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ABSTRACT

The impact of disasters due to the occurrence of climate change created disturbance in the nook and corner of our fragile ecosystem. This study analysed its objectives with the micro level focus on three villages (Kanjikuzhi, Konnathady, and Rajakkad), which are highly vulnerable to climate change-induced by natural disasters in the agriculture sector in Idukki district of Kerala. The study employed a mixed-methods approach. Using a three-stage sampling procedure that combined primary and secondary data gathered through an interview schedule with 312 interviewees and the agricultural office of the Idukki district during 2025. To compare the pre- and post-disaster conditions of the agriculture sector, a paired t-test was applied. For the analysis of the loss of crop in three different villages under the district, MANOVA and Fisher's LSD, Post Hoc test was used in this study. It is found that 100 per cent of farmers were affected by the disaster. Among them, 84.3 per cent experienced crop losses, with cocoa at 5.4 per cent, cardamom at 34.9 per cent, nutmeg at 12.5 per cent, and pepper at 31.41 per cent being significantly impacted. As these crops were the primary source of income for farmers in the study area, the impact of disasters was highly felt in the study area. It also revealed that 38.5 per cent of farmers faced psychological difficulties and challenges. The environmental analysis revealed that the decline in soil and water quality led to a reduction in yield in the study area. The deterioration in water and soil quality, with of crop loss, particularly in cardamom ($\bar{x}$ = 8.1891) (σ = 26.91214) and pepper ($\bar{x}$ =57.6474) (σ =75.26432) across villages was observed. The MANOVA test results highlighted that independent factors, such as soil quality (.003), water quality (.324), fertility (.008), and rainfall (.000), significantly influenced crop losses in the selected sample study villages. But, only 10.26 per cent of farmers received financial assistance from the government, highlighting a gap between the losses incurred and the compensation provided in the study area. A comprehensive comparison through the post hoc test showed that Rajakkad village experienced the highest crop loss, particularly in cardamom production (= 13.6065). Furthermore, the analysis of primary and secondary data revealed that, year by year, the farming community suffered from agricultural vulnerability due to the impact of the disaster. The study recommends targeted compensation, climate-resilient farming practices, crop insurance, and environmentally friendly land use to strengthen the region's agricultural resilience and aid recovery.

(Keywords: Climate change, disaster, crop loss, government intervention)

INTRODUCTION

Natural disaster is a phenomenon that affects living and non-living things in the environment. Development activities since 1800 have caused environmental damage and threatened human existence (Anonymous,2023). The impacts of climate change are already evident, as witnessed in the increased severity and frequency of natural disasters (Venu,2022). The ongoing changes occurring daily lead to significant environmental issues and damage. Moreover, it creates a risk to biodiversity as well as flora and fauna. The growing population and shortage of resources were among the reasons for this crisis. ''Human wants are unlimited; the resources are limited.'' Over-exploitation and misuse of natural resources were other threatening reasons behind the environmental vulnerability and risk (Anonymous,2024). In the mid-19th century, due to overpopulation, people began to settle near hilly regions and forests. Idukki and Wayanad districts are highly dense with forest and the Western Ghats. The people who have started their lives here have agriculture as their main occupation. The geographical and favourable weather conditions make for better yield production in spices like cardamom, pepper, etc. Moreover, the dynamic

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nature of soil and crop, which plays a better role for sustainable agricultural practice, directly influences crop productivity and environmental protection (Bhartendu *et al.*, 2023). In Kerala, the years 2018, 2019, and 2020 continuously suffered extreme rainfall, resulting in massive landslides and floods over the region of Idukki. More than 60 people died, and 2.34 lakh houses were destroyed (Anonymous, 2022; Anonymous,2018). As a result, 88 per cent of the damages reported from the agriculture sector (Boopathi and Rehman, 2023). Based on the gross state value, the addition stated that 5.42 per cent of the contribution was received from the agriculture sector (Boopathi and Rehman, 2022). During that time of increasing demand for cardamom production with low supply of power, evidence of the influence of the agricultural economy is seen in the regions. Low supply of cardamom, which created a high demand for the crop for export in 2018, compared to 2019, the cardamom price quickly surged (Elizabeth *et al.*,2020). Furthermore, socio-economic and income disparities among farmers were another reason driving the decline in crop production (Sha Hussain *et al.*, 2023).

In this context, the study focused on the impact of the agricultural sector in three different villages of the Idukki district in Kerala. Primarily, the study explains the (i) trends in the financial loss across the different years, and (ii) evaluates the pre- and post-condition of agricultural environmental quality, (iii) analyses the agricultural crop loss in different villages, and (iv) studies the effectiveness of government intervention in the impact of climate change in the agricultural sector. Through these objectives, the crisis and challenges are clearly defined, in addition to the agricultural vulnerability of the Idukki district. Moreover, the study sought to find the answers to the following questions.

i) What kind of adaptation and mitigation measures do farmers use to reduce the climate impact?

ii) Is there any incidence of depeasantisation or migration activities in the study area?

MATERIALS AND METHODS

Research design

The present study incorporates three stages of sampling methods. According to historical data and professional judgement, the taluks most susceptible to the effects of disasters were chosen. Along with that, villages that had the greatest impact on the agriculture sector were chosen within the taluks using purposive sampling methods during the year 2025. Subsequently, within each village, a stratified random sampling method was used to select the respondents from three distinct working age groups, such as 18-30 years, 31-54 years, and above 54 years, aligning with the International Labour Standard. This stratification ensures the comprehensive analysis of the impact on different age groups. This also ensures a diverse range of perspectives on the impact of disaster. The third stage random sampling technique was used to select the sample in the above-mentioned category of age group. In the selected age group, the respondents were randomly selected mainly on the basis that their primary occupation should be agriculture. Finally, a total of 312 sample farmers from the Kanjikuzhi, Konnathady and Rajakkad villages were chosen.

Data collection

The study was designed with a well-strengthened interview schedule. The disaster-affected farmers, who have less than 1 acre of land,were selected as the sample for the study and primary data were collected from them. The secondary data were collected from the District Agriculture Office of Idukki district and the District Disaster Management Authority of Idukki.

Tools and techniques

Through the step-by-step process, the study solves the problems. In the initial stage of the study, the pre- and post-condition of the agricultural attributes, like water, soil and fertility of land, were compared and solved through the paired t-test model.

$$\mathbf{t} = \frac{\bar{\mathbf{d}}}{\mathbf{sd}/\sqrt{\mathbf{n}}}$$

Where the $\bar{d}$ is the difference between the paired observations, *Sd* is the standard deviation difference, and n is the number of pairs. In the above equation, variables are assigned as (1 = yes and 0 = no). A value of 1 indicates that the agriculture supporting factors have changed due to the impact of climate change or disaster; 0 means no change.

In the second stage, the study employed multivariate analysis of variance MANOVA to examine whether there is a significant difference in crop loss patterns across the different villages, over the change of climate.

$$\mathbf{Y_i = \mu + X_i\beta + e_i}$$

In the above equation, Y_i represents the dependent variable for the i^{th} observation; therefore

$$Yi = [Y_1, Y_2, Y_3, Y_4]$$

μ is the grand vector for each dependent variable (crop loss) across all villages. Xi is the vector for all independent variables (villages), β is the coefficient of each dependent variable (crop loss), ei is the error term.

In the final stage, post hoc test was applied to determine which village significantly differs in terms of the dependent variable (crop loss).

$$\mathbf{t} = \frac{\bar{\mathbf{x}}_\mathbf{t} - \bar{\mathbf{x}}_\mathbf{j}}{\sqrt{\frac{\mathbf{2s^2}}{\mathbf{n}}}}$$

Therefore $\bar{x}_i$ $\bar{x}_j$ is the mean of the dependent variable *i* and village *j*, s^2 is the pooled variable, n is the sample size, t is the test statistic, which means the difference between ($\bar{x}_i - \bar{x}_j$) is away from the zero.

Hypotheses

a) H_0 There is no change in the water, soil quality and fertility before and after the disaster

H_1 There is a change in the water, soil quality and fertility before and after the disaster

b) H_0 There is no difference in the crop loss across the villages by the effect of climate change

H_1 There is a difference in the crop loss across the villages by the effect of climate change.

RESULTS AND DISCUSSION

Table 1 illustrates the impact of disasters on the agricultural sector in Idukki district from 2018 to 2023. The period from 2018 to 2019 stands out as the most challenging period for the study district. During this time, the State recorded 1701.4 mm of normal rainfall, while actual rainfall reached 2394.1 mm. The district-wide report indicates that Idukki experienced an unusually high rainfall rate of 92 per cent (Lina,2022). Normal rainfall was 1851.7 mm, whereas the actual figure was 3555.5 mm (Sankar,2018; Sudheer *et al.*,2019). The heavy rainfall led to several landslides, isolating the district. The Debris slide and Debris flow were the most frequent landslide occurrences in the study region (Sheelu, 2021). The area that was severely affected faced substantial financial losses and a high number of impacted farmers, prompting a sustainable relief effort. In subsequent years, the study area recorded rainfall in this manner (2019 - 1187.62 mm, 2020-1307.16 mm, 2021-1473.87 mm, 2022-1598.32 mm). The agriculture industry suffered significant losses as a result of ongoing damages and disruptions, while government subsidies for the 2018–2019 period only accounted for 39 per cent of the overall loss. Moreover, many residents of the district derived a significant portion of their livelihood from agriculture, particularly in the production of spices, but the challenges from climate change were a threat to the farmers who primarily depended on agriculture as their main source of income. Over, the data revealed not only the continuation of vulnerability but also there was a gap between the government compensation and crop loss, which further exacerbates their recovery challenges.

Table 2 presents the devastating impact of disasters on the agricultural sector. It was found that 100 per cent of farmers were affected by the disaster's impact in the study area. Within that, 84.3 per cent meet crop loss. Of the total farming community cultivated land, while 97.8 per cent of them cultivated their own land, and the remaining around two per cent of the farmers cultivated the leased land. This suggests that the majority of the affected people had direct ownership of the land. Cardamom, pepper,cocoa and nutmeg were the major crops cultivated in the study area. In these areas, the majority of people produce spice products due to the climate conditions and the presence of lateritic soil, which supports the growth of spice production. The impact of a disaster not only affects the financial condition of an individual farmer but also causes mental disturbance among the farming community. Around 78.2 per cent of respondents reported that after the disaster there were changes that happened in the land use pattern, which directly influenced the further farming of crops. The respondent reported income losses from crops during the field visit, with cardamom at 34.9 per cent, pepper at 31.41 per cent, nutmeg at 12.5 per cent, and cocoa at 5.45 per cent, all being significantly affected. These crops were the primary source of income for the farming households in the study area, which constituted 84 per cent of cardamom, 65.7 per cent of pepper, 46 per cent of cocoa and 30.1 per cent of nutmeg, which played a crucial role in their livelihood.

This overlap between damaged crops and major income sources indicated a high level of economic disturbance among the respondents. The multi-dimensional impact of disaster creates multiple types of loss in these villages. But it was the damage caused by the agricultural damage that had left them most mentally damaged. 38.5 per cent suffered from the damages caused by crop failure, which caused them financial and psychological problem. Damages to agricultural infrastructure caused an increase in the financial vulnerability among the respondents. Here, 64.1 per cent reported that the destruction of the irrigation system disrupted their agricultural activities, which also limits the ability to resume cultivation aftermath of the disaster. Despite these damages, only 10.26 per cent of the respondents reported receiving government assistance. It's pointing out the gap between the institutional support and the compensation mechanism. The continued rainfall and its impact consequently created economic and environmental suffocation, also created an unsuitable situation for further cultivation or farming.

Table 3 presents the results of a paired sample t-test model used to assess the changes in environmental factors such as water quality, soil quality, and soil fertility before and after the disaster in the study area. The results emphasised that water quality significantly declined after the disaster, with $p<0.001$ and a mean difference of 0.4391, indicating a notable deterioration. Similarly, soil quality also showed a significant decline post-disaster, where $t(311) = -34.066$, $p < 0.001$, with a mean difference of -1.36859, indicating that such degradation of soil condition occurred after the disaster. Conversely, soil fertility increased significantly after the disaster, with $t(311) = 4.56$, $p<.001$, and a mean difference of 0.3654. Based on the results and discussion of Table 3. Hence null hypothesis get rejected ($H_0: \mu_i \neq \mu_J$) and the alternative hypothesis was accepted. ($H_1: \mu_i = \mu_J$)

This result indicates that both water and soil quality after the disaster significantly worsened. The substantial decline of water quality refers to residents' perception that the water source was much more polluted, which may be attributed to the influx of mud, debris and organic waste into the river and water bodies. The contamination of water bodies due to pollution which created a shortage of drinking water, and also for the agricultural sector, especially for water-sensitive crops like cardamom. As a result, there was a drastic decline in the crop yield, moreover caused by crop diseases. The degradation of soil quality refers to the top layer of the fertile soil being washed away, which contains most nutrients and organic matter needed for the crops. With the absence of nutrients, poor soil, crop yields fall. The farmer may overuse the chemical fertilisers to compensate for the increased production. But the change in fertility of the soil was temporary due to the nutrient-rich sedimentation deposited, making it almost vulnerable to the fluctuation of crops like pepper, cocoa and nutmeg. Overall, this unpredictability created difficulty in crop planning. The 2018-19 landslide and flood in the study area caused a decline in the agrarian economy, especially the spices production. The lack of supply of cardamom during these environmental challenges in the upcoming years had been increased the value of cardamom products. According to the market situation, during the above-mentioned period, the price kg^{-1} of cardamom was Rs. 4,000 to 5,000. Out of 40000 cardamom families in Idukki district, almost 60 per cent lost their crops. Also, the farmers added that the yield of the field had declined by 100 kilograms ha^{-1}. Similarly, the growth rate of the crop was stunted, which created financial distress among the farming households.

Table 4 investigates how various ecological factors, such as rainfall, soil quality, fertility, and water quality, respond to crop loss in the study region. Multivariate tests like Pillai's Trace, Wilks' Lambda, Hotelling's Trace, Roy's, and Largest Root were employed to strengthen the relationship between the independent and dependent variables. The results show that, following climate change, soil quality, fertility, and water quality declined, leading to reduced production and damage to yields. Roy's largest root (p = .003*, p = 000*) strongly supports this. Changes in soil quality significantly affect crop loss in the region, as it will influence root development and nutrient uptake. Similarly, soil infertility also contributes to crop loss among farmers. The highest F value was 5.247, with a p value of .000, underscoring the significance of the findings. Correspondingly, the heavy impact of rainfall caused the crop loss. The excessive and continuous rainfall caused landslides and soil erosion in slope areas. The rainfall was an important climatic factor, also showed the significant influence (p = 0.008, .009) on the dependent variable. This significant result indicates that a high rate of rainfall, which determines the devastating landslide and creates changes in the soil and water quality.

Rainfall, soil fertility, water quality, and other environmental variables had a significant impact on landslide-prone areas. There was a close relationship between these factors. Rainfall aggravates soil deterioration, which in turn impacts soil fertility and can make crop stress situations worse. The hills and slope areas were particularly vulnerable to improper land use and environmental activities during periods of excessive rainfall, which led to natural disasters in those areas. However, the pollution results in poor water quality and several harms to the agricultural industry. The significance of integrating rainfall was highlighted by its dual role as a direct and indirect driver of crop loss. Significant crop damage can result from excessive rainfall in several ways, including direct physical effects like waterlogging, root damage, and delayed planting, as well as indirect effects like nutrient leaching, increased disease susceptibility, and unfavourable interactions with soil drainage and climate conditions (Yan Li, *et al*, 2019).

Table 5 presents the results of multiple comparisons from post hoc tests concerning crop losses across the villages (Rajakkad, Kanjikuzhi, Konnathady). The loss of cocoa was significantly higher in village Kanjikuzhi than in Konnathady, with a mean of 32.82 and p =.024,95, 95% confidence level, but a significant difference between Konnathady and Rajakkad was reflected (p =.918). In the case of nutmeg, there was also a significant difference compared to Kanjikuzhi and Rajakkad (p=.304). The significant value across the village in the case of loss of nutmeg showed a uniformity in nature. Similarly, there was a statistically significant difference between the Kanjikuzhi and Rajakkad. With a high rate of cardamom loss reported in the Rajakkad, where the mean value was 13.61 (p = .006), for Kanjikuzhi and Konnathady (p =.054), for Konnathady and Rajakkad (p =.124). Correspondingly, loss of pepper showed (p =.725) in the Kanjikuzhi and Rajakkad, and p = .516 showed in Konnathady and Rajakkad villages. Therefore, the null hypothesis is rejected ($H_0 : \mu_i \neq \mu_J$) and the alternative hypothesis is accepted. ($H_1 : \mu_i = \mu_J$)

According to the data, there was notable decline in cocoa and cardamom in a particular village. The losses of pepper and nutmeg remained statistically consistent. According to the village Kanjikuzhi, the rate of cocoa loss was higher than that of Rajakkad and Konnathady. Agricultural vulnerability resulted from crop loss due to soil shifting and sensitive moisture. In a similar vein, village Rajakkad lost more cardamom than Konnathady and Kanjikuzhi. Disasters occurred as a result of the cardamom plantation's increased resilience. Root damage and a fungal outbreak in the yield were induced by heavy rainfall. It is suggested that Rajakkad is one of the district's peak areas based on its geographic location. The elevation above sea level is about 2001 feet. Heavy rainfall harms the ecology and makes living circumstances miserable for the residents, even though the foggy weather and slope areas offer a better platform for cardamom development and plantations. According to the researcher's primary survey report, man-made activities increase the likelihood of natural disasters. For instance, within a 10-kilometre radius of one of the landslide-prone locations, there were various human activities such as quarries, land cutting, and unpermitted construction activities that disturbed the soil structure. Last but not least, the monsoon's intense rainfall caused landslides, soil erosion, and soil piping. Presently, the hazardous exploitation of human activities affected practically the whole high range, not just one location.

The study underlined the diversity of socio-economic, environmental, and psychological damages affected by the farming community in the Idukki district, particularly in three disaster-prone villages. The findings confirmed that disasters, particularly landslides, significantly deteriorated soil and water quality. Additionally, the results of MANOVA highlighted that many ecological elements react to crop loss in the study region. Finally, from the Post Hoc test, it is also evident that there was a disproportionality among the impacted crops across the villages. The study found that there was a significant disparity between government compensation and losses brought on by the effects of disasters.

Hence, the study calls for urgent policy reforms that include the government ensuring the success of their programme in the agricultural sector related to compensation for disaster management and to encourage the small and marginal farmers for the reproduction of the agriculture sector. There is a need to promote an eco-friendly agricultural environment in the disaster-prone areas and to increase crop insurance as a favour to farmers. There is also a need of the hour to conduct awareness programs for mitigation measures. Moreover, the government should reduce the gap between the crop loss and reimbursement. Encouraging farmers to move from high-risk locations to safer ones so they may continue farming without giving up their livelihoods is crucial for facilitating a steady reduction in vulnerability. By putting these changes into place, the government can rebuild public institutions' credibility while simultaneously bolstering the agricultural community's resilience throughout the villages.

Table 1. Impact summary of the agriculture sector in Idukki (2018-2023)

Year	Affected area (As per FIR)	Financial Loss (As per FIR)	Affected farmers	Sanctioned amount (As per FIR)
2018-2019	11579.415	652662950	36888	255205661
2019-2020	1968.26	5370.12	4823	19232436
2020-2021	15065.13	36877.58	8159	4519433
2021-2022	3011.69	28335.82	3953	21181551
2022-2023	686.18	2381.01	2254	8018756

Sources: Secondary data, Agriculture office, Idukki district, Thodupuzha.

Table 2. Socio-economic damages due to the disaster in agriculture

Variables and their attributes		F	Per cent
The devastating impact	Affected farmers	312	100%
	Crop loss, (yes)	263	84.3%
	Crop loss (no)	49	22.8%
	Own land	305	97.8%
	Rent	7	2.2%
Loss of income from the crops due to the landslide	Loss of income from Coco	17	5.45%
	Loss of income from Cardamom	109	34.9%
	Loss of income, Nutmeg	39	12.5%
	Loss of income from Pepper	98	31.41%
	Changes in the land pattern (yes)	244	78.2%
Kind of loss made psychological stress	Employment loss	36	11.5%
	Property loss	45	14.5%
	Agriculture loss	120	38.5%
Damages in the agriculture sector	Household loss	111	35.6%
	Fully damaged	190	60.9%
	Partially damaged	58	18.6%
	Slightly damaged	68	20.5%
A significant source of income from the crops	Coco	145	46%
	Pepper	205	65.7%
	Cardamom	262	84%
	Nutmeg	94	30.1%
Damage to Irrigation Systems in Agriculture	Yes	200	64.1%
	No	112	35.1%
Government assistance received for the agricultural loss	Yes	32	10.26%
	No	280	89.74%

Sources: The author's assessment is derived from data obtained through field surveys., N =312

Table 3. Pre- and post-disaster conditions of the agricultural environment

Df	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T		Sig
Water quality before and after the landslide	-.43910	.56376	.03192	-.50190	-.37630	-13.758	311	.000***
Soil quality before and after the landslide	-1.36859	.70963	.04017	-1.44764	-1.28954	-34.066	311	.000***
Fertility before and after the landslide	.36538	1.38706	.07853	.21087	.51990	4.653	311	.000***

Sources: The author's assessment is derived from data obtained through field surveys., N =312
*** significant at 1% level

Table 4. Multivariate tests of crop loss

Independent variable		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Soil quality	Pillai's Trace	.060	2.375	8.000	614.000	.016**	.030
	Wilks' Lambda	.940	2.384	8.000	614.000	.016**	.030
	Hotelling's Trace	.063	2.394	8.000	612.000	.015**	.030
	Roy's Largest Root	.053	4.078	4.000	307.000	.003***	.050
Water quality	Pillai's Trace	.017	.639	8.000	614.000	.745*	.008
	Wilks' Lambda	.984	.639	8.000	612.000	.746*	.008
	Hotelling's Trace	.017	.638	8.000	610.000	.746*	.008
	Roy's Largest Root	.015	1.170	4.000	307.000	.324*	.005
Fertility	Pillai's Trace	.065	2.570	8.000	614.000	.009***	.032
	Wilks' Lambda	.935	2.603	8.000	612.000	.008***	.033
	Hotelling's Trace	.069	2.637	8.000	610.000	.008***	.033
	Roy's Largest Root	.068	5.247	4.000	307.000	.000***	.064
Rainfall	Pillai's Trace	.065	2.570	8.000	614.000	.009***	.032
	Wilks' Lambda	.935	2.603	8.000	612.000	.008***	.033
	Hotelling's Trace	.069	2.637	8.000	610.000	.008***	.033
	Roy's Largest Root	.068	5.247	4.000	307.000	.000***	.064

Sources: The author's assessment is derived from data obtained through field surveys., N =312,*** significant at 1% level, ** significant at 5% level, * significant at 10% level

Table 5. Multiple comparisons post hoc test in Kanjikuzhi, Konnathady, and Rajakkad villages

Dependent Variable	(I) Name of the village	(J) Name of the village	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Loss of quantity of cocoa	Kanjikkuzhi	Konnathady	32.8209*	10.75631	.002***	11.6561	53.9858
		Rajakkad	34.2288*	15.09415	.024**	4.5284	63.9291
	Konnathady	Kanjikkuzhi	-32.8209*	10.75631	.002***	-53.9858	-11.6561
		Rajakkad	1.4078	13.63087	.918*	-25.4133	28.2289
	Rajakkad	Kanjikkuzhi	-34.2288*	15.09415	.024**	-63.9291	-4.5284
		Konnathady	-1.4078	13.63087	.918*	-28.2289	25.4133
Loss of nutmeg quantity	Kanjikkuzhi	Konnathady	1.8697	3.29606	.571*	-4.6158	8.3553
		Rajakkad	4.7634	4.62530	.304*	-4.3377	13.8645
	Konnathady	Kanjikkuzhi	-1.8697	3.29606	.571*	-8.3553	4.6158
		Rajakkad	2.8937	4.17691	.489*	-5.3251	11.1124
	Rajakkad	Kanjikkuzhi	-4.7634	4.62530	.304*	-13.8645	4.3377

		Konnathady	-2.8937	4.17691	.489*	-11.1124	5.3251
Loss of cardamom quantity	Kanjikkuzhi	Konnathady	-6.7616	3.50129	.054**	-13.6510	.1278
		Rajakkad	-13.6065*	4.91330	.006**	-23.2743	-3.9388
	Konnathady	Kanjikkuzhi	6.7616	3.50129	.054**	-.1278	13.6510
		Rajakkad	-6.8449	4.43699	.124*	-15.5755	1.8856
	Rajakkad	Kanjikkuzhi	13.6065*	4.91330	.006***	3.9388	23.2743
		Konnathady	6.8449	4.43699	.124*	-1.8856	15.5755
Loss of pepper quantity	Kanjikkuzhi	Konnathady	-3.2672	9.91251	.742*	-22.7718	16.2373
		Rajakkad	4.8915	13.91006	.725*	-22.4789	32.2619
	Konnathady	Kanjikkuzhi	3.2672	9.91251	.742*	-16.2373	22.7718
		Rajakkad	8.1587	12.56157	.516*	-16.5583	32.8758
	Rajakkad	Kanjikkuzhi	-4.8915	13.91006	.725*	-32.2619	22.4789
		Konnathady	-8.1587	12.56157	.516*	-32.8758	16.5583

The error term is Mean Square (Error) = 5693.066
*** significant at 1% level, ** significant at 5% level, * significant at 10% level,
Sources: The author's assessment is derived from data obtained through field surveys., N =312

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