Research Article:

CLIMATE CHANGE PERCEPTION, AGRICULTURAL IMPACTS, AND ADAPTATION STRATEGIES: A CASE OF PALANTA, KALIKOT, NEPAL

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ABSTRACT
Climate change has emerged as a critical challenge for agriculture in Nepal, particularly in mountainous districts like Kalikot where livelihoods are highly climate-sensitive. This study aimed to examine the quantitative relationship between rainfall patterns, temperature changes, and the economic value of agricultural production, while also exploring farmers' adaptation practices and the role of agriculture in greenhouse gas (GHG) emissions mitigation. A stratified cluster sampling method was employed to select 30 households—10 each from low (1,000 masl), mid (1,700 masl), and high (2,200 masl) altitudes in Palanta, Kalikot—ensuring representation across ecological zones with homogeneous farming systems. Primary data were collected using face-to-face semi-structured questionnaires, complemented by focused group discussions. Multi-criteria analysis was applied to rank existing agricultural practices based on criteria such as net profit, resiliency, GHG emissions, workload on females and children, gender equality, social inclusion, institutional, and technological capacity. The findings revealed an overall economic decline of NPR 2,035.33 per household per annum in major agricultural and livestock components, reflecting a 9.7% reduction in rainfall and a 56.41% increase in the economic value of agricultural components over the past 42 years. Reduced rainfall was associated with decreased crop yields and livestock productivity, resulting in notable household-level economic losses. The study identified five top-ranked climate-smart practices: cultivation of drought-tolerant crops or varieties, promotion of fodder and forage, cultivation of high-yielding crops, beekeeping for forage, and tunnel farming. In conclusion, the research underscores the necessity of precise temporal and spatial understanding of climate-agriculture interactions and highlights the importance of integrating GHG emission considerations into future climate-resilient agricultural strategies.

Key words: Agricultural practices, climate change adaptation, livelihood strategies

INTRODUCTION
Climate change has emerged as a critical global challenge, impacting various sectors, with agriculture standing at the forefront of vulnerability. This research examines the complex details of "Farmers' Perception on Climate Change, Effect on Agriculture and Adaptation Practice in Kalikot, Nepal." The significance of agriculture as a cornerstone for livelihoods cannot be overstated, with 2.5 billion people globally relying on it (FAO, 2016). In South Asia, particularly in Nepal, where agriculture contributes around 23.95% to the gross domestic production (GDP) (NRB, 2022) and sustains over 60% of the population, understanding the implications of climate change on this sector is of paramount importance (Bastakoti & Doneys,

2020; Dahal & Khanal, 2010).

Kalikot District is one of the most climate-vulnerable district of Nepal. Characterized by steep topography, fragile soils, and highly rain-fed agricultural systems, Kalikot faces compounded risks of drought, erratic rainfall, and declining crop productivity. Despite these challenges, limited empirical research has explored how local farmers perceive climate change, how it affects their agricultural practices, and what adaptive measures are being adopted at the grassroots level. This gap in context-specific knowledge creates barriers for formulating effective adaptation policies and interventions suited to Kalikot's unique socio-ecological setting.

Agriculture's central role in the socio-economic fabric of Nepal is evident, providing employment for a substantial portion of the population and contributing significantly to GDP. The pursuit of sustainable agricultural growth is imperative for the nation's food security, poverty reduction, and overall development. However, this pursuit is hindered by escalating challenges posed by climate change, especially due to the country's insufficient irrigation infrastructure (MoE, 2010).

Nepal, ranked as the fourth most climate change vulnerable country, grapples with the immediate threat climate change poses to its agriculture and food systems (Thapa & Panthi, 2015). As climate patterns shift and extreme weather events become more frequent, the risks to national agriculture intensify, necessitating urgent and strategic interventions (MoE, 2010).

Agricultural activities contribute 10–12% of global greenhouse gas (GHG) emissions (Netz et al., 2007). Understanding agriculture's dual role—both as a victim of climate change and as a contributor to it—requires a broad perspective that encompasses entire food systems. The challenge lies in increasing agricultural productivity while minimizing emissions, underscoring the need for agricultural systems that ensure food security, adapt to climate change, and contribute to mitigation (Panthi, 2012).

Against this backdrop, this research addresses the limited understanding of farmers' experiential knowledge of climate change impacts and the effectiveness of their adaptation responses in Kalikot. While national-level assessments exist, there is a critical lack of micro-level data capturing farmers' experiences and adaptive capacities in marginalized regions. This study is justified because effective climate adaptation policies must be rooted in local realities, reflecting challenges and solutions identified by farming communities themselves.

The research aims to explore farmers' perceptions in Kalikot regarding climate change, its agricultural impacts, and the adaptation practices—such as altering crop varieties, adjusting farming schedules, and improving resource management—used in response to these challenges. By doing so, it seeks to contribute insights to the discourse on sustainable agriculture, resilience building—strengthening the capacity of farming systems and communities to absorb, recover from, and adapt to climate shocks and stresses—and climate change adaptation strategies at both local and global levels. The subsequent chapters will unfold the layers of this multifaceted inquiry, offering a comprehensive understanding of the relationship between farmers, climate change, and agricultural practices in Kalikot.

MATERIALS AND METHODS

The materials and methods employed in conducting the study is elucidated, outlining the primary information sources, tools utilized, and the sampling techniques applied.

Contextual Overview

Agriculture stands as the predominant occupation in the Karnali region, playing a pivotal role in ensuring food security and sustaining livelihoods. However, the economic landscape varies within the region, with the per capita income in Kalikot notably lower at $578.0 compared to the regional average of $806.0 (MoLMAC, 2019). A critical input in agricultural production, irrigation, is unevenly distributed, constituting 31.5% of cultivated land in the region but only 8.4% in Palanta Rural Municipality (MoLMAC, 2019; Palanta, 2020). Given these disparities, this study is focused specifically on Palanta, Kalikot, aiming to discern the intricate linkages between agriculture and climate change in this local context.

CLIMACT Prio Tool – Microsoft Excel

The CLIMACT Prio Tool, developed by the Institute of Housing and Urban Developing Studies at Erasmus University, Rotterdam, was employed as a quantitative instrument for the study. This Microsoft Excel-based tool underwent customization, adapting the scoring matrix, weights, and score range to align with the unique local context of Palanta, Kalikot. The rationale for selecting this tool lies in its flexibility and proven effectiveness in facilitating participatory, transparent prioritization of climate adaptation measures in resource-constrained and data-scarce environments. Given Kalikot's complex socio-ecological dynamics and the need for a tool that combines both quantitative rigor and community engagement, the CLIMACT Prio Tool provided an ideal balance between methodological robustness and practical applicability. We integrated focused group discussions (FGD) to set scores against different components, ensuring a nuanced and context-specific analysis; participants discussed each criterion in detail, reaching scores by group consensus. Where initial disagreements arose, additional discussion was facilitated until agreement was achieved. The Regional Urban Development Project (RUDP) / Institutional Development Consultants (IDC) / Performance Based Socio-Economic Development Project (PBSEDP) at Dhangadhi Sub-Metropolitan City has also developed similar types of criteria.

Household Survey

A stratified cluster sampling method was applied to select 30 households from different altitudes—low (1,000 masl), mid (1,700 masl), and high (2,200 masl)—in Palanta, Kalikot. Within each stratum, 10 households were selected using simple random sampling to minimize selection bias. Participation was ensured across gender and socio-economic groups to reflect the diverse impacts of climate change. The total sample size of 30 households, complemented by 2 FGDs with 15 participants each, is explicitly defined to avoid ambiguity.

The sample size of 30 households was determined based on practical considerations of their homogeneity in farming system, time and resources, aiming to achieve a manageable yet diverse representation across altitudes. While no formal statistical calculation was applied, a sample of this size is commonly used in exploratory field studies to provide indicative insights into community perceptions and experiences.

Face-to-face interviews were conducted using semi-structured questionnaires to gather information on various indicators of climate change. The respondents were queried about their experiences and perceptions concerning climate-related factors such as rainfall patterns, temperature variations, water availability, emergence of new weeds, new pest infestations, and agricultural production components—covering yields, pest/disease outbreaks, and crop failures. The questionnaires were piloted with seven households in the same area to enhance reliability and validity before full deployment. This approach facilitated a comprehensive comparison between the current situation and experiences dating back 42 years.

Focused Group Discussion (FGD)

To supplement the quantitative data, FGDs were conducted to identify major agricultural strengths in Palanta Rural Municipality. The discussion involved key stakeholders, including the executive body of Palanta, educators, representatives from local and international non-governmental organizations, media personnel, and other relevant stakeholders. Through collaborative dialogue, six criteria for evaluating profitable and non-profitable actions were developed. The participants assigned scores to each criterion, drawing from their diverse expertise and perspectives. For scoring climate change (CC) indicators—such as observed changes in rainfall, temperature, pest dynamics, crop productivity, and water availability—participants applied a 1 to 10 scale during FGDs, with each indicator discussed in depth and scores decided through consensus. This procedure ensured transparency and consistency in quantifying local perceptions of climate impacts.

The combined use of the CLIMACT Prio Tool, household surveys, and FGDs forms a robust methodology, allowing for a comprehensive exploration of the complex interplay between agriculture and climate change in Palanta, Kalikot. The criteria and their weight for climate-friendly agriculture practices is illustrated in Table 1.

Table 1. Criteria & weight for climate-friendly agriculture in Palanta rural municipality, Kalikot

Criteria set with minimum to maximum values	Weight (%)	Conversion factor	Score (range)
Net-profit (minimum: 1 & maximum: 10)	40	0.4	1- 10
Resiliency (minimum: 1 & maximum: 10)	30	0.3	1- 10
GHGs emissions (maximum: 1 & minimum: 10)	10	0.1	1- 10
Workload to female & children (maximum: 1 & minimum: 10)	10	0.1	1- 10
Inclusion (minimum: 1 & maximum: 10)	5	0.05	1- 10
Institution capacity to implement (minimum: 1 & maximum: 10)	5	0.05	1- 10

Source: Focus Group Discussion, 2020

Secondary Information

The foundational basis for this research rests on a meticulous collection of secondary information spanning 42 years, from 1979 to 2020. Weather data, a critical component of the study, were sourced from the Government of Nepal / Department of Hydrology and Meteorology (DHM) and yield data from Government of Nepal / Ministry of Agriculture and Livestock. The temporal scope of climatic dataset allows for a robust examination of long-term climate trends—annual, with a specific focus on rainfall and temperature patterns. Complementing this meteorological data, social information pertinent to the study area was extracted from the profile of Palanta Rural Municipality, Kalikot. This dual-sourced secondary information forms a comprehensive backdrop for understanding the climatic and socio-economic context of the region.

Statistical Analysis

The collected survey data, encompassing farmers' responses, FGD scores, and 42-years of weather data, were meticulously entered into a computerized system. Subsequent statistical analyses were conducted to discern meaningful insights and trends. Specifically, the focus was on rainfall and temperature patterns, as these variables play a pivotal role in shaping agricultural outcomes. To evaluate trends and quantify relationships between climate variables and agricultural outcomes, a simple linear regression model was applied. This model was selected due to its suitability in identifying directional trends and potential causative associations between climatic variables (rainfall, temperature) and agricultural production metrics, allowing the study to assess climate impact on farming productivity over time.

The statistical analysis culminated in the creation of tables, figures, and graphs, providing visual representations of the complex interplay between weather patterns and agricultural production. Notably, the mean values of rainfall and temperature over the 42-year period were derived from the nearest weather station, Dailekh. For data consistency, missing temperature records were interpolated, while missing rainfall data points were excluded. This comprehensive dataset, enriched by farmers' perspectives and FGD scores, serves as the foundation for evaluating the profound impact of weather on agriculture production and productivity in Kalikot.

RESULTS

Yearly Total Rainfall Trend

Through the analysis of 42-years of cumulative yearly rainfall data (1979-2020), the mean annual rainfall stands at 1,703.94 mm. A temporal disaggregation of this data further reveals distinct averages for specific periods: from 1979 to 1992, the average yearly rainfall is recorded at 1,801.96 mm; from 1993 to 2006, it diminishes to 1,685.46 mm/yr.; and from 2007 to 2020, it registers at 1,652.98 mm/yr (Fig. 1).

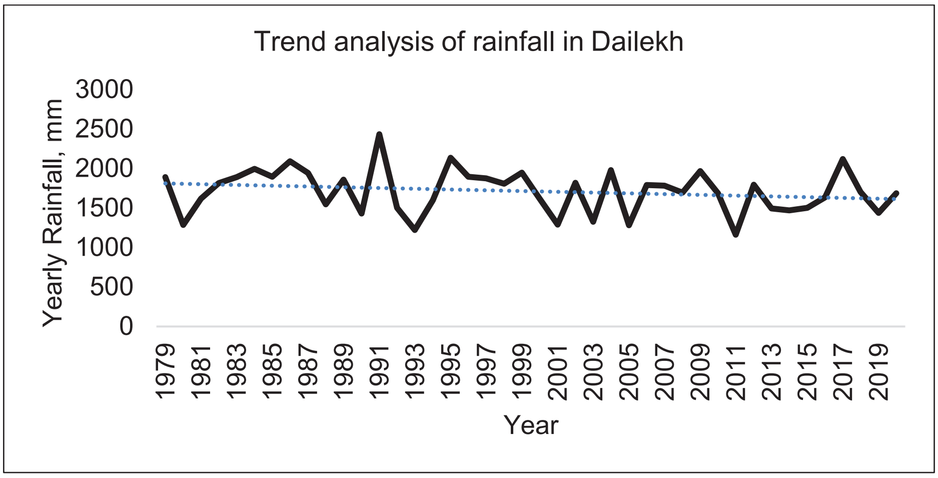

Fig. 1. Yearly rainfall trend of Dailekh, Nepal (Source: DHM, 2021)

The examination of a 42-year temporal span (1979–2020) in relation to annual average temperatures reveals that the average yearly maximum temperature (Tmax) manifests at 23.47°C, whereas the minimum temperature (Tmin) registers at 13.16°C (refer to Fig. 2).

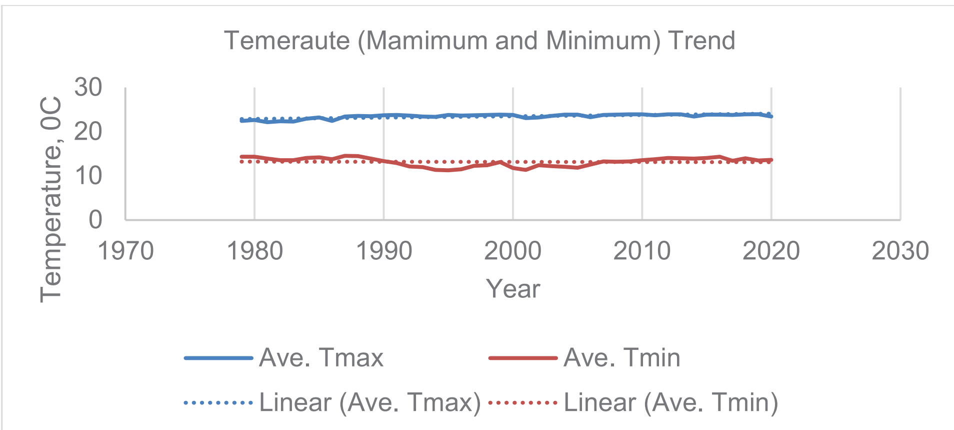

Fig. 2. Yearly temperature trend of Dailekh, Nepal (Source: DHM, 2021)

Indicators of Climate Change in Palanta, Kalikot

Community members articulated their experiences and perceptions concerning climate change indicators, drawing comparisons between current trends and those observed over the past four decades, as outlined in Table 2. Farmers reported a decrease in water levels (11.3%) and annual rainfall (9.7%), alongside increases in agricultural pests (3.2%), extreme cold events (3.2%), intense heat (1.6%), and the appearance of new weeds (1.6%) over the past 30-40 years.

Table 2. Climate change indicators in Palanta, Kalikot: respondent perceptions

	Strong hotness	Strong coldness	Annual rainfall	Amount of water in sources	New Weeds	Agricultural pests
Total Score	1	2	-6	-7	1	2
%	1.6	3.2	-9.7	-11.3	1.6	3.2

Source: Field Survey, 2021

Crop Components and Economic Values

The study reveals a decline in the productivity of major agricultural and livestock components in recent years. This decline is evident in the reduced number of *Apis cerana* F., beehives, cultivated areas of major cereals and pseudo cereals, chilly production, as well as the diminishing numbers of peach trees, buffalo, and cattle (Table 3). The overall economic value of these agricultural and livestock components has decreased by NPR 2,035.31 per household per annum.

However, farmers have shown a proactive response by cultivating new varieties of vegetables and fruits, such as broad leaf mustard, radish, tomato, onion, garlic, banana, cauliflower, cabbage, and apples. Notably, the performance of these newly introduced crops has exhibited positive outcomes.

Staple Foods, Spices and Vegetables. In contrast to the previous 42 years, the recent period has seen a 21.43% decline in the production of staple crops, spices, and fruits. Although the production of radish, onion, garlic, and tomato has increased, most other crops have declined. Consequently, the overall economic value of these components has decreased by 21.58%, amounting to a loss of NPR 262.03 per household per year (Table 3).

Table 3. Economic values of major agricultural commodities: 42-Year comparison in Palanta, Kalikot

Staple, spices & vegetables	Before 42 years		At present		Variation		Current rate (NPR/kg)	Value variation (NPR/kg)
	Area (ha)	Production (kg)	Area (ha)	Production (kg)	Area (ha)	Production (kg)		
Rice	4.4	6,660.0	4.2	5,940.0	-0.2	-720.0	36.0	-25,920.0
Wheat	4.8	6,680.0	4.4	5,550.0	-0.4	-1,130.0	36.0	-40,680.0
Maize	4.5	7,940.0	3.7	6,385.0	-0.8	-1,555.0	37.0	-57,535.0
Millet	2.2	2,410.0	2.0	1,870.0	-0.2	-540.0	43.0	-23,220.0
Karnali millets	2.3	2,410.0	0.7	640.0	-1.6	-1,770.0	36.0	-63,720.0
Beans	2.0	685.0	1.7	460.0	-0.3	-225.0	115.0	-25,875.0
Soybean	2.3	896.0	2.1	533.0	-0.2	-363.0	40.0	-14,520.0
Black-gram	0.8	346.0	0.6	111.0	-0.2	-235.0	60.0	-14,100.0
Radish	0.6	150.0	2.5	715.0	1.9	565.0	25.0	14,125.0
Potato	2.5	5,400.0	2.0	4,090.0	-0.5	-1,310.0	52.0	-68,120.0
Chilly	1.1	495.0	1.1	370.0	0.0	-125.0	260.0	-32,500.0
Onion	0.2	47.0	0.6	153.0	0.4	106.0	78.0	8,268.0

Garlic	0.1	18.0	0.3	58.0	0.2	40.0	420.0	16,800.0
Tomato	6.5	4.5	7.5	6.8	1.0	2.3	58.0	133.4
Cucumber	20.5	55.3	10.5	16.8	-10.0	-38.5	46.0	-1,771.0
Pumpkin	23.7	83.0	14.7	36.7	-9.0	-46.3	33.0	-1,527.9
Total	78.5	34,279.8	58.6	26,935.3	-19.9	-7,344.5		-330,162.5

Source: Field Survey, 2020

Fruits. Fruit production has declined by 19.17% in recent years compared to the previous 42-year period. Its economic contribution has also decreased, with a loss of NPR 0.84 per household per year (Table 4).

Table 4. Economic values of fruits: 42-Year comparison in Palanta, Kalikot

Fruits	Before 42 years		At present		Variation		Current rate (NPR/kg)	Annual value (NPR/kg)
	No. of plants	Production (kg)	No. of plants	Production (kg)	No. of plants	Production (kg)		
Peach	0.8	80.9	1.3	49.4	0.5	-31.5	52	-1638
Apple	0	0	4.4	20.6	4.4	20.6	56	1,153.6
Banana	2.9	1.7	1.8	1.1	-1.1	-0.6	100	-60
Citrus	0.4	11.3	0.4	4.8	0	-6.5	80	-520
Total	4.1	93.9	7.9	75.9	3.8	-18		-1,064.4

Source: Field Survey, 2020

Bee Keeping**.** The finding indicates that beehive numbers and honey production have declined by 69.77% and 85.71%, respectively, compared to the previous 42 years. The economic value has also dropped by NPR 8.29 per household per year (Table 5).

Table 5. Economic values of honey: 42-Year comparison in Palanta, Kalikot

Bees	Before 42 years		At present		Variations		Current rate (NPR/kg)	Annual value (NPR)
	No. of hives	Production (kg)	No. of hives	Production (kg)	No. of hives	Production (kg)		
A. cerana	4.3	12.6	1.3	1.8	-3	-10.8	967	-10,443.6
Total	4.3	12.6	1.3	1.8	-3	-10.8	967	-10,443.6

Source: Field Survey, 2020

Livestock Components and Economic Values

Livestock data show sharp declines in buffalo (80.63%), cattle (70.10%), and goat/sheep (70.72%) numbers, while chicken numbers increased by 106.67%. Milk production from buffaloes and cows fell by 82.71% and 69.25%, respectively. Sales and earnings from major livestock also dropped significantly, with buffalo, cattle, and goat/sheep earnings declining by 78.38%, 68.25%, and 64.14%. In contrast, poultry sales and earnings rose by 108.82% and 82.22%, though their overall economic impact remains minimal. The total economic value of livestock has decreased by NPR 1,764.15 per household per year, with goats showing the highest loss (NPR 981.43). A sample calculation for buffalo is shown in Table 6.

Table 6. Economic values of buffalo: 42-year comparison in Palanta, Kalikot

Livestock	Before 42 years		At present		Variation		Current rate (NPR/kg)	Annual value (NPR/kg)
	Total No.	Sell	Total No.	Sell	Total No.	Sell		
Buffalo, No.	55	11	9	3	-46	-8	34,500	-276,000.00
Yield, kg	0	6,200		1072		-5,128	80	-410,240.00
Total								-686,240.00
Variations per hh per year								544.63

Source: Field Survey, 2020

Livestock Production. The study indicates a 77.33% reduction in livestock production and a corresponding 77.75% decrease in its economic value, amounting to a loss of NPR 484.48 per household per year.

Table 7. Economic values of livestock yield: 42-year comparison in Palanta, Kalikot

Livestock	Before 42 years		At present		Variation		Current rate (NPR/kg)	Annual value (NPR)
	No. of animal	Yield, kg	No. of animal	Yield, kg	No. of animal	Yield, kg		
Buffalo	55	6,200	9	1,072	-46	-5,128	80	-410,240
Cattle	97	4,130	29	1,270	-68	-2,860	70	-200,200
Total	152	10,330	362	2,342	-624	-7,988	-	-610,440

Source: Field Survey, 2020

Livestock and Poultry Selling. The study findings demonstrate a notable contraction of 64.22% in the economic value associated with the annual selling of livestock and poultry in recent years, as compared to the preceding 42-year period. Moreover, an observed decline of NPR 1,279.68 per household per year underscores a diminishing economic value in the domain of livestock and poultry selling. Notably, among these, goat/sheep emerges as the most adversely impacted animal.

Table 8. Economic values of livestock and poultry selling: 42-year comparison in Palanta, Kalikot

Livestock and poultry	Before 42 years		At present		Variation		Current rate (NPR/kg)	Annual value (NPR)
	Total No.	Sell	Total No.	Sell	Total No.	Sell		
Buffalo	55	11	9	3	-46	-8	34,500	-276,000
Cattle/Ox	97	15	29	5	-68	-10	12,200	-122,000
Goat/Sheep	789	357	231	128	-558	-229	5,400	-1,236,600
Poultry	45	34	93	58	48	37	600	22,200
Total	986	417	362	194	-624	-223	-	-1,612,400

Source: Field Survey, 2020

Farmers' Perceptions on Rainfall and Economic Values of Agricultural Components

In the study area, key water sources for agriculture include rainfall, snow, dew, and irrigation, with only 8% of cultivated land irrigated (Palanta, 2020). A 9.7% rainfall decline over the past 40 years has led to an economic loss of NPR 2,035.33, despite an overall 56.41% increase in agricultural economic value.

Interestingly, despite this decline in rainfall, overall agricultural economic value showed a 56.41% increase, which may be attributed to factors such as the introduction of high-value crops, improved farming practices, or inflationary effects; however, this divergence warrants further investigation and may partly reflect an anomaly.

Table 9. Farmers perceptions on rainfall and economic value of agricultural components: 42-year comparison in Palanta, Kalikot

Components	Variations, 42-year comparison	
	Rainfall	Economic value of agricultural components
Variations	-9.7	56.41

Source: Field Survey, 2020

Association of Climatic Variables and the Production of Major Cereal Crops in Kalikot

The correlation between annual rainfall and major cereal crops is weak ($R^2 = 0.026$), explaining only 2.6% of yield variability. This suggests a limited linear relationship, with other factors likely influencing crop production. This implies that other factors—such as farming practices, seed quality, chemical fertilizers, pesticides, and seasonal timing—likely have a stronger influence on production outcomes.

Table 10. Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.162[a]	.026	.002	5517.82093

a. Predictors: (Constant), annual rainfall, mm

With an R^2 of 0.589, annual maximum temperature explains 58.9% of the variability in major cereal crop yields, indicating a relatively strong relationship, though a significant portion remains unexplained.

Table 11. Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.767[a]	.589	.578	3586.63901

a. Predictors: (Constant), average annual maximum temperature, °C

With an R^2 of 0.008, annual minimum temperature explains only 0.08% of the variability in crop yields, indicating a very weak relationship with production.

Table 12. Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.087[a]	.008	-.017	5570.43050

a. Predictors: (Constant), average annual minimum temperature, °C

Ranking of Agricultural Components

A ranking of 28 crop and livestock components identified the most sustainable agricultural options for Palanta. This evaluation, based on a scoring system encompassing economic, environmental, social, and technical criteria, provides a valuable measure of the agricultural system's efficiency and resilience. Beekeeping, especially when integrated with fruit and fodder plants, ranked highest, followed by crops like peach, apple, cucurbits, potato, chili, beans, maize, and goat. Components were evaluated on six parameters: Net Profit (40%), Resiliency (30%), Emissions (10%), Workload (10%), Inclusion (5%), and Capacity (5%) (Table 13, 14).

Beekeeping's top rank highlights its strong sustainability, while cattle, gourds, and buffalo ranked lower.

Table 13. Scoring on bee keeping (*Apis cerana*) in Palata, Kalikot

Scoring steps	Net profit	Resiliency	Emissions	Workload	Inclusion	Capacity	Total scores
Weight	40	30	10	10	5	5	100
Conversion factor	0.4	0.3	0.1	0.1	0.05	0.05	
Marks	3	3	1	-1	3	2	
Scores	1.2	0.9	0.1	-0.1	0.15	0.1	2.35

Source: Field Survey, 2020

The ranking results (Table 14) showed that beekeeping (*Apis cerana*) ranked highest due to its strong profitability, high resilience, low emissions, and positive contributions to social inclusion. Peach, apple, and staple vegetables such as potatoes and cucurbits also scored well, highlighting the potential of diversified horticulture to strengthen agricultural resilience in Palanta. By contrast, components such as cattle, gourds, and buffalo scored lower due to factors like lower profitability, greater sensitivity to climate variability, higher contribution of GHGs, and comparatively limited contributions to social inclusion and gender equity, and demands more institutional capacity. These results underscore the importance of aligning agricultural promotion with both environmental sustainability and socio-economic practicality to optimize resilience and impact.

Table 14. Assessment and ranking of climate-friendly agricultural components

Components	Net profit	Resiliency	Emissions	Workload	Inclusion	Capacity	Ranks
A. cerana	1.2	0.9	0.1	-0.1	0.15	0.1	1
Peach & apple	1.2	0.9	0.3	-0.3	0.15	0.05	2
Potato	1.2	0.9	0.1	-0.4	0.2	0.2	3
Cucurbits	1.2	0.9	0.1	-0.4	0.2	0.2	3
Chilly	1.2	0.9	0.1	-0.4	0.25	0.15	3
Beans	1.2	0.9	0.1	-0.4	0.25	0.05	6
Maize	1.2	0.9	0.1	-0.4	0.25	0.05	6
Goat	1.2	1.2	-0.3	-0.4	0.2	0.1	8
Wheat	1.2	0.9	0.1	-0.4	0.15	0.05	8
Tomato	1.6	0.3	0.1	-0.4	0.25	0.1	10
Soybean	0.4	0.9	0.3	-0.3	0.3	0.05	11
Rice	1.2	0.9	-0.5	-0.4	0.15	0.25	12
Millets	0.8	0.9	0.1	-0.6	0.3	0.05	13
Sheep	0.8	1.2	-0.3	-0.4	0.2	0.05	13
Blackgram	0.4	0.9	0.3	-0.4	0.25	0.05	15
Okra	1.2	0.3	0.1	-0.4	0.2	0.05	16
Citrus	0.8	0.3	0.1	0.1	0.05	0.05	17
Banana	0.4	0.6	0.2	0.1	0.05	0.05	17
Poultry	1.2	0.3	-0.2	-0.2	0.2	0.05	19
Onion	0.8	0.6	0.1	-0.4	0.2	0.05	19

Components	Net profit	Resiliency	Emissions	Workload	Inclusion	Capacity	Ranks
Garlic	0.8	0.6	0.1	-0.4	0.2	0.05	19
Radish	0.8	0.6	0.1	-0.4	0.2	0.05	19
Chirreeta	0.8	0.6	0.1	-0.4	0.15	0.05	23
Buffalo	1.2	0.3	-0.3	-0.4	0.1	0.2	24
BLM	0.8	0.6	0.1	-0.5	0.05	0.05	24
Brinjal	0.4	0.3	0.1	0.1	0.05	0.05	26
Gourds	0.4	0.6	0.1	-0.4	0.15	0.1	27
Cattle	0.4	0.9	-0.3	-0.4	0.2	0.15	27

Source: Field Survey, 2020

Note. Capacity: Institutional and Technological Capacity
Workload: Work Load to Female and Children
Emissions: Roles on GHGs emission

Climate Smart Agricultural Activities

The study (Table 15) underscored those interventions prioritizing drought-tolerant crops and their improved varieties, alongside the promotion of key fodder species such as Chinaberry and Napier, demonstrated the highest effectiveness in enhancing both economic and resilience outcomes. These practices not only improved net profitability but also contributed significantly to climate adaptability, securing top rankings. High-yielding crop varieties and strategies to bolster apiculture—through the cultivation of flowering plants for bee forage and infrastructural improvements—also showed substantial promise in improving livelihoods. Integrated approaches like tunnel farming, drip irrigation, and crop rotation further strengthened system resilience. Overall, the findings affirm that combining climate-smart agricultural technologies with training, insurance schemes, and ecosystem-based measures can meaningfully reduce climate vulnerability and improve the sustainability of farming systems in Palanta, Kalikot.

Table 15. Scoring and ranking of climate-friendly agricultural activities in Palanta, Kalikot

Activities	Net profit	Resiliency	Emissions	Workload	Inclusion	Capacity	Rank
Drought tolerant crops/ varieties	1.6	1.8	0.1	-0.2	0.1	0.15	1
Promotion of fodder/forage	2.4	0.6	0.4	-0.4	0.1	0.1	2
High yielding crops	2	0.9	0.1	-0.2	0.1	0.2	3
Bee forage	1.6	1.2	0.1	-0.1	0.2	0.05	4
Tunnel farming	2.4	0.6	0.1	-0.4	0.2	0.05	5
Drip irrigation	1.6	1.2	0.1	-0.3	0.25	0.05	6
Crop rotation	0.8	1.5	0.4	-0.2	0.15	0.2	7
Hive improvement	1.2	1.2	0.1	-0.1	0.2	0.05	8
Bee keeping training	1.2	1.2	0.1	-0.1	0.15	0.05	9
Inter/mix-cropping	0.8	1.5	0.4	-0.3	0.15	0.05	9
Agricultural insurance	0.8	1.2	0.1	0.1	0.15	0.05	11
Irrigation canal	1.2	0.9	0.1	-0.3	0.15	0.3	12
Bee keeping equipment	1.2	0.9	0.1	-0.1	0.15	0.1	12

Activities	Net profit	Resiliency	Emissions	Workload	Inclusion	Capacity	Rank
Local feed preparation	1.6	0.6	0.1	-0.1	0.1	0.05	12
FYM and/or compost	1.2	0.9	0.4	-0.6	0.15	0.25	15
Marketing infra-structures	1.2	0.9	0.1	-0.1	0.15	0.05	15
Breed improvements	1.6	0.3	0.1	-0.1	0.2	0.15	17
Shed/pen improvement	1.2	0.6	0.3	-0.1	0.15	0.05	18
Time adjustment	0.8	1.2	0.1	-0.3	0.15	0.25	18
Pest resistant varieties	0.8	1.2	0.1	-0.1	0.15	0.05	18
Frequent irrigation	1.2	0.9	0.1	-0.2	0.05	0.05	21
Access to service providers	1.2	0.9	-0.1	-0.1	0.15	0.05	21
Cold store	0.8	1.2	0.1	-0.2	0.05	0.05	23
Sprinklers	1.2	0.6	0.1	-0.2	0.2	0.05	24
Disaster control	0.8	0.9	0.2	-0.2	0.1	0.15	24
Fruit processing centers	1.6	0.9	-0.4	-0.3	0.1	0.05	24
Plantation	0.4	0.6	0.8	-0.2	0.15	0.2	24
Training	0.8	0.9	0.1	-0.2	0.2	0.05	28
IPM	0.8	0.9	0.1	-0.1	0.1	0.05	28
Lift irrigation	0.8	0.9	0.2	-0.2	0.05	0.05	30
Vigorous seeds, plants	0.8	0.6	0.1	-0.1	0.1	0.05	31
Pest control (chemical)	1.2	0.9	-0.6	-0.1	0.1	0.05	31
Bioengineering	0.4	0.3	0.7	-0.2	0.15	0.15	33
Seed bean	0.8	0.3	0.1	0.1	0.05	0.05	34

Source: Field Survey, 2020

DISCUSSION

Climate trends and local perceptions

According to the IPCC (2023), anthropogenic climate change has intensified across the biosphere, cryosphere, and hydrosphere, leading to a global increase in climate extremes. Our findings align with this global trend, as farmers in the study area reported increasing temperature, erratic rainfall patterns, and reduced snowfall. Quantitatively, an 8–9.7% decline in annual rainfall and snowfall was observed, with a 0.3°C per decade increase in maximum temperatures, consistent with broader South Asian warming patterns.

Community perceptions corroborated these data, noting reduced water availability from traditional sources and decreased snowfall at previously snow-prone areas. Such perceptual validation is critical in remote rural settings where formal climate data may be sparse, echoing the IPCC's emphasis on integrating local knowledge for climate assessments.

Impacts on crops

Rainfall variability and rising temperatures have significantly altered cropping patterns and yields. While the weak statistical correlation between rainfall and cereal production suggests complex causality, the strong linkage with Tmax highlights the role of heat stress on crop physiology. As observed in Pakistan and other South Asian nations (Rosenzweig et al., 1993), temperature increases can reduce yields by affecting flowering and grain filling phases.

In our study, farmers reported declines in traditional cereal and fruit productivity. However, the introduction of high-value crops (e.g., vegetables, cucurbits) has partly offset these losses. The altered cropping calendar—delayed planting and harvesting by ~1 month—illustrates adaptive shifts, though such changes also pose risks to yield stability and food security.

Impacts on livestock

Livestock productivity and associated economic value have also declined sharply—up to 84.7% in some cases—likely due to reduced water, forage availability, and increased disease incidence. This reflects similar findings in other mountainous regions where climate change disproportionately affects pasture-dependent systems. Farmers also reported increased pests and invasive species, further challenging both crop and animal health.

Adaptation strategies

Despite climatic adversity, certain adaptive measures have shown promise. Beekeeping emerged as a top-ranked agricultural component, reflecting its low water dependency and synergy with horticultural crops. Similarly, tunnel farming, drought-tolerant varieties, and water-saving technologies have contributed to resilience.

Interestingly, while rainfall decreased, the economic value from agriculture increased by 56.41%, suggesting either successful adaptation or external market/inflationary effects. This underscores the importance of non-climatic factors—like technology, inputs, and markets—in shaping livelihood outcomes, a finding echoed in Fischer et al. (2009).

The integration of gender equality and social inclusion (GESI) in adaptation measures further enhances their sustainability and scalability.

Implications for policy and future research

Aligning with IPCC recommendations, climate-smart agriculture should be central to adaptation and mitigation efforts. Measures like crop diversification, agroecological integration (e.g., bees with cucurbits and maize), and efficient livestock management can reduce emissions while enhancing productivity.

Future research should quantify the drivers of increased agricultural value amid declining rainfall and explore the thresholds of climate variability that rural systems can tolerate. Strengthening monitoring systems, knowledge-sharing platforms, and extension services will be essential to support climate-resilient development in vulnerable regions like ours.

CONCLUSION

Farmers and local policymakers in Palanta are aware of the challenges posed by drought, declining water availability, and increasing economic pressures on agriculture. While they have started adapting by changing crop varieties and planting schedules, there is still limited understanding of key factors such as profitability, resilience, greenhouse gas (GHG) emissions, labor demands, Gender Equality and Social Inclusion (GESI), and institutional capacity. This study highlights the strong potential of beekeeping when combined with fruit, fodder, and forage crops. Components such as peach, apple, cucurbits (cucumber and pumpkin), potato, chili, beans, maize, and goat have shown to be effective in improving resilience and productivity in the local context.

The results show that adopting climate-smart agricultural practices—such as drought-tolerant crops, high-yield varieties, improved fodder, efficient irrigation, and better beekeeping—can significantly strengthen Palanta's agricultural sector. To put these findings into practice, farmers should diversify their crops, adopt water-saving methods like drip irrigation, and join training programs focused on beekeeping and sustainable livestock management. Policymakers should support these efforts with subsidies, policies promoting drought-resilient farming, and inclusive insurance programs. Research institutions need to develop suitable crop varieties, assess climate risks, and create integrated farming approaches. Project implementers should work on building local capacity, organizing farmers, and ensuring GESI principles are central to all initiatives. Together, these actions can build a more resilient, inclusive, and sustainable agriculture system in Palanta.

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