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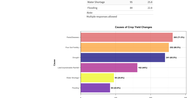

Crop Yield Change (Table 2)

Decreased Significantly, 32.2% (N.S.Decreased), Decreased Slightly, 25.4% (N.Decrease), No Change, 2.8% (N.Change), Increased Slightly, 19.7% (N.Increase), Increased Significantly, 19.7% (N.S.Increase)

Only studies that did not fit the report dry season yields, reducing or negative impacts on crop yields or agricultural productivity, through 4.8% (one study) yield increases, possibly due to adaptation efforts.

Causes of Crop Yield Change (N = 106): Primary causes of yield decline/increase shown

Precipitation, 15.2% (N.Decrease), Temperature, 14.2%, Yield Variability, 28.3% (N.Variability), Other, 2.8% (N.Other), Increased Slightly, 19.7% (N.Increase), Increased Significantly, 19.7% (N.S.Increase)

Observation: Precipitation, pest and blight, and drought are the leading causes of yield decline, closely tied to observed climate change effects like irregular rainfall and longer dry periods.

Table 1 Crop Yield Change Variable Descriptive Statistics and Correlations

Variable	Yield Type	Statistic	p-value	Significance
Adaptation Level	Future Crops	146	0.0000	***
Age Group	Future Crops	146	0.0000	***
Gender	CC Impacts	0.0279	0.0008	***

Table/Figure Correlation Matrix of Climate Change Impacts

Table/Figure Correlation Matrix

Strong Positive Correlations

Crop Destruction with Drought Number (r = 0.62) and Rising Temperature (r = 0.61). Pest/Disease Impact with Drought (r = 0.60). Drought with Temperature (r = 0.59). Precipitation with Temperature (r = 0.58).

Notable Negative Correlations Drought Decrease with Rising Temperature (r = -0.52) and Pest/Disease (r = -0.48). Legend Key: Impact by crop type (Vegetables, Fruits, Cereals, Tubers).

Observation: Pest/Disease, Drought, and Temperature Changes Often Co-Occur, Suggesting Interdependent Climate Impacts on Crops. Pest/Disease and Drought Decrease Often Co-Occur, Suggesting Shared Underlying Factors Affecting Both Pest Control and Water Availability.

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# ---------------------------------------------------------------
# Table 1
# ---------------------------------------------------------------
# Crop Yield Change Variable Descriptive Statistics and Correlations
# ---------------------------------------------------------------
# Adaptation Level, Age Group, Gender, Yield Decline, Yield Increase, Yield Stagnation, Yield Variability, Yield Other
# ---------------------------------------------------------------
# Table 2
# ---------------------------------------------------------------
# Correlation Matrix of Climate Change Impacts
# ---------------------------------------------------------------
# Pest/Disease Increase, Pest/Disease Decrease, Pest/Disease Stable, Pest/Disease Variability, Pest/Disease Other,
# Drought Increase, Drought Decrease, Drought Stable, Drought Variability, Drought Other,
# Temperature Increase, Temperature Decrease, Temperature Stable, Temperature Variability, Temperature Other,
# Precipitation Increase, Precipitation Decrease, Precipitation Stable, Precipitation Variability, Precipitation Other
# ---------------------------------------------------------------
# Figure 1
# ---------------------------------------------------------------
# Correlation Matrix Heatmap
# ---------------------------------------------------------------
# Figure 2
# ---------------------------------------------------------------
# Crop Yield Change Frequency Distribution
# ---------------------------------------------------------------
# Figure 3
# ---------------------------------------------------------------
# Causes of Crop Yield Change
# ---------------------------------------------------------------
# Figure 4
# ---------------------------------------------------------------
# Adaptation Level Distribution
# ---------------------------------------------------------------
# Figure 5
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# Age Group Distribution
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# ---------------------------------------------------------------
# Figure 7
# ---------------------------------------------------------------
# Adaptation Level by Age Group
# ---------------------------------------------------------------
# Figure 8
# ---------------------------------------------------------------
# Adaptation Level by Gender
# ---------------------------------------------------------------
# Figure 9
# ---------------------------------------------------------------
# Age Group by Gender
# ---------------------------------------------------------------
# Figure 10
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# Correlation Matrix Heatmap
# ---------------------------------------------------------------
# Figure 11
# ---------------------------------------------------------------
# Adaptation Level by Crop Yield Change
# ---------------------------------------------------------------
# Figure 12
# ---------------------------------------------------------------
# Age Group by Crop Yield Change
# ---------------------------------------------------------------
# Figure 13
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# Gender by Crop Yield Change
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# Figure 14
# ---------------------------------------------------------------
# Correlation Matrix Heatmap
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# Figure 15
# ---------------------------------------------------------------
# Adaptation Level by Crop Yield Change
# ---------------------------------------------------------------
# Figure 16
# ---------------------------------------------------------------
# Age Group by Crop Yield Change
# ---------------------------------------------------------------
# Figure 17
# ---------------------------------------------------------------
# Gender by Crop Yield Change
# ---------------------------------------------------------------
```

Table 2 Correlation Matrix of Climate Change Impacts

Variable	Coefficient	Std. Error	p-value	Significance
Constant	0.0000	0.0000	0.0000	***
Adaptation Level	0.0000	0.0000	0.0000	***
Age Group	0.0000	0.0000	0.0000	***
Gender	0.0000	0.0000	0.0000	***
Adaptation_Level	0.0000	0.0000	0.0000	***
Age_Group	0.0000	0.0000	0.0000	***
Gender	0.0000	0.0000	0.0000	***

Table 3 Crop Yield Change Variable Descriptive Statistics and Correlations

Variable	Coefficient	Std. Error	p-value	Significance
Constant	0.0000	0.0000	0.0000	***
Adaptation_Level	0.0000	0.0000	0.0000	***
Age_Group	0.0000	0.0000	0.0000	***
Gender	0.0000	0.0000	0.0000	***
Yield_Decline	0.0000	0.0000	0.0000	***
Yield_Increase	0.0000	0.0000	0.0000	***
Yield_Stagnation	0.0000	0.0000	0.0000	***
Yield_Variability	0.0000	0.0000	0.0000	***
Yield_Other	0.0000	0.0000	0.0000	***

Table 4 Correlation Matrix of Climate Change Impacts

Variable	Coefficient	Std. Error	p-value	Significance
Constant	0.0000	0.0000	0.0000	***
Pest/Disease Increase	0.0000	0.0000	0.0000	***
Pest/Disease Decrease	0.0000	0.0000	0.0000	***
Pest/Disease Stable	0.0000	0.0000	0.0000	***
Pest/Disease Variability	0.0000	0.0000	0.0000	***
Pest/Disease Other	0.0000	0.0000	0.0000	***
Drought Increase	0.0000	0.0000	0.0000	***
Drought Decrease	0.0000	0.0000	0.0000	***
Drought Stable	0.0000	0.0000	0.0000	***
Drought Variability	0.0000	0.0000	0.0000	***
Drought Other	0.0000	0.0000	0.0000	***
Temperature Increase	0.0000	0.0000	0.0000	***
Temperature Decrease	0.0000	0.0000	0.0000	***
Temperature Stable	0.0000	0.0000	0.0000	***
Temperature Variability	0.0000	0.0000	0.0000	***
Temperature Other	0.0000	0.0000	0.0000	***
Precipitation Increase	0.0000	0.0000	0.0000	***
Precipitation Decrease	0.0000	0.0000	0.0000	***
Precipitation Stable	0.0000	0.0000	0.0000	***
Precipitation Variability	0.0000	0.0000	0.0000	***
Precipitation Other	0.0000	0.0000	0.0000	***

Table 5 Crop Yield Change Variable Descriptive Statistics and Correlations

Variable	Coefficient	Std. Error	p-value	Significance
Constant	0.0000	0.0000	0.0000	***
Adaptation_Level	0.0000	0.0000	0.0000	***
Age_Group	0.0000	0.0000	0.0000	***
Gender	0.0000	0.0000	0.0000	***
Yield_Decline	0.0000	0.0000	0.0000	***
Yield_Increase	0.0000	0.0000	0.0000	***
Yield_Stagnation	0.0000	0.0000	0.0000	***
Yield_Variability	0.0000	0.0000	0.0000	***
Yield_Other	0.0000	0.0000	0.0000	***

Table 6 Logistic Regression Models Predicting Adaptation Factors

Variable	Coefficient	Std. Error	p-value	Significance
Constant	0.0000	0.0000	0.0000	***
Adaptation_Level	0.0000	0.0000	0.0000	***
Age_Group	0.0000	0.0000	0.0000	***
Gender	0.0000	0.0000	0.0000	***
Yield_Decline	0.0000	0.0000	0.0000	***
Yield_Increase	0.0000	0.0000	0.0000	***
Yield_Stagnation	0.0000	0.0000	0.0000	***
Yield_Variability	0.0000	0.0000	0.0000	***
Yield_Other	0.0000	0.0000	0.0000	***

Table 7 Adaptation Level Distribution

Adaptation Level	Count	Percent (%)
Total	106	100.0
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 8 Age Group Distribution

Age Group	Count	Percent (%)
Total	106	100.0
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 9 Gender Distribution

Gender	Count	Percent (%)
Total	106	100.0
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 10 Adaptation Level by Age Group

Adaptation Level	Age_Group	Count
Total	Total	106
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 11 Adaptation Level by Gender

Adaptation Level	Gender	Count
Total	Total	106
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 12 Age Group by Gender

Age_Group	Gender	Count
Total	Total	106
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 13 Correlation Matrix Heatmap

Variable	Coefficient	Std. Error	p-value	Significance
Constant	0.0000	0.0000	0.0000	***
Adaptation_Level	0.0000	0.0000	0.0000	***
Age_Group	0.0000	0.0000	0.0000	***
Gender	0.0000	0.0000	0.0000	***
Yield_Decline	0.0000	0.0000	0.0000	***
Yield_Increase	0.0000	0.0000	0.0000	***
Yield_Stagnation	0.0000	0.0000	0.0000	***
Yield_Variability	0.0000	0.0000	0.0000	***
Yield_Other	0.0000	0.0000	0.0000	***

Table 14 Adaptation Level by Crop Yield Change

Adaptation Level	Yield_Decline	Count
Total	Total	106
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 15 Age Group by Crop Yield Change

Age_Group	Yield_Decline	Count
Total	Total	106
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 16 Gender by Crop Yield Change

Gender	Yield_Decline	Count
Total	Total	106
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 17 Correlation Matrix Heatmap

Variable	Coefficient	Std. Error	p-value	Significance
Constant	0.0000	0.0000	0.0000	***
Adaptation_Level	0.0000	0.0000	0.0000	***
Age_Group	0.0000	0.0000	0.0000	***
Gender	0.0000	0.0000	0.0000	***
Yield_Decline	0.0000	0.0000	0.0000	***
Yield_Increase	0.0000	0.0000	0.0000	***
Yield_Stagnation	0.0000	0.0000	0.0000	***
Yield_Variability	0.0000	0.0000	0.0000	***
Yield_Other	0.0000	0.0000	0.0000	***

Table 18 Adaptation Level by Crop Yield Change

Adaptation Level	Yield_Decline	Count
Total	Total	106
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 19 Age Group by Crop Yield Change

Age_Group	Yield_Decline	Count
Total	Total	106
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

Table 20 Gender by Crop Yield Change

Gender	Yield_Decline	Count
Total	Total	106
Adaptation Level	0.0000	0.0000
Age_Group	0.0000	0.0000
Gender	0.0000	0.0000
Yield_Decline	0.0000	0.0000
Yield_Increase	0.0000	0.0000
Yield_Stagnation	0.0000	0.0000
Yield_Variability	0.0000	0.0000
Yield_Other	0.0000	0.0000

3.1 Conclusion on Objective 1

Biophysical Responses

90% of farmers are aware of climate change, with higher awareness among tertiary educated (100%) and older farmers (100% for 60+). Temperature increases (14.2%) and precipitation changes (15.2%) are the primary causes of crop yield decline, affecting 4 of 5 WFP-AIL regions. Pest and blight (28.3%) and drought (19.7%) are secondary stressors.

Significant Climate Change Effects

Pest/Disease Increase Correlates Strongly (r=0.61), Drought Number (r=0.62), and Drought Stability, with 62.8% seeing temperature changes as significant and 60.7% seeing significant rainfall changes. Drought Decrease Correlates Strongly with Temperature Increase (r=-0.52).

Adaptation Strategies

Science-based farmers report significantly (OR=4.6) more severe climate impacts, with crop destruction (15.9%), delayed planting (30.0%), and landlessness (6.8%). Only farmers facing forced removal. These contributes to yield declines (15.7% reported decreases), crop failure (6.8%), and landlessness (15.9%), and underlies the 19.7% yield increase.

Gender Differences

Strong correlations between irrigation and drought (r=0.60), temperature (r=0.58), and precipitation (r=0.58) suggest women face compounded climate stressors affecting water access, temperature, and rainfall patterns.

Implications for Scaling Adaptation. The analysis of climate impacts and agricultural responses (e.g., crop decline, delayed planting) and landless farmers facing security and income (Objective 4), underscoring the urgency of addressing these climate change effects through adaptation strategies.

3.2 Information Sources

Table 21 Information Sources by Education Level

Education Level	Source	Count	Percent (%)
Total		106	100.0
Radio	Community Elders	20	7.9
Radio	Extension Officers	20	7.9
Radio	Farmer Groups	19	7.5
Radio	Fellow Farmers	19	7.5
Radio	Media	20	7.9
Radio	Others	7	2.8
Radio	Religious Groups	19	7.5
Radio	Social Media	19	7.5
Radio	Social Media	20	7.9
Radio	Traditional Rulers	19	7.5
Radio	Extension Officers	19	10.0
Radio	Farmer Groups	19	10.0
Radio	Fellow Farmers	19	10.0
Radio	Media	19	10.0
Radio	Other	19	10.0
Radio	Other	19	10.0
Radio	Radio FM	20	10.5
Radio	Religious Groups	19	10.0
Radio	Social Media	19	10.0
Secondary	Community Elders	19	10.0
Secondary	Extension Officers	19	10.0
Secondary	Farmer Groups	20	10.5
Secondary	Fellow Farmers	19	10.0
Secondary	Media	19	10.0
Secondary	Other	19	10.0
Secondary	Radio FM	19	10.0
Secondary	Religious Groups	19	10.0
Secondary	Social Media	19	10.0
Secondary	Traditional Rulers	19	10.0
Tertiary	Community Elders	19	10.0
Tertiary	Farmer Groups	19	10.0
Tertiary	Fellow Farmers	19	10.0
Tertiary	Media	19	10.0
Tertiary	Others	19	10.0
Tertiary	Radio FM	19	10.0
Tertiary	Religious Groups	19	10.0
Tertiary	Social Media	19	10.0

Most Effectiveness of Adaptation Strategies by Farm(N=71 Crops)

Adaptation Strategy	Not Very Effective(N)	Very Effective(N)
Agroforestry	0.15	0.85
Conservation Agriculture	0.15	0.85
Crop Diversification	0.15	0.85
Improved Seeds	0.08	0.92
Changing Planting Dates	0.08	0.92
Pest/Disease Management	0.08	0.92
Water Harvesting	0.08	0.92
Irrigation	0.08	0.92

4 Objective 2.

Examining the relative change adaptation strategies among crop farmers.

Objective 2 focuses on evaluating the climate change adaptation strategies employed by smallholder crop farmers in the Kwara East Region, Kwara, including their relative effectiveness, adoption patterns, and barriers to implementation.

Adaptation Adopted	Frequency	Percentage (%)
Yes	106	100.0
No	0	0.0

Adaptation Status and Prevalence (Table 1)

High Adoption Rate, 100% (All farmers have adopted climate change adaptation strategies, while 26.3% (19 farmers) have not adopted).

Observation: The high adoption rate reflects widespread recognition of climate change impacts (Objective 1) and a proactive response to mitigate these effects, aligning with the need to sustain livelihoods (Objective 4).

Adaptation Strategy	Frequency	Percentage (%)
Agroforestry	106	100.0
Changing Planting Dates	106	100.0
Crop Diversification	106	100.0
Intercropping	72	67.9
Drought/Heat Resistant Varieties	106	100.0
Improved Seeds	106	100.0
Crop Rotation	72	67.9
Improved Seeds	106	100.0
Pest/Disease Management	106	100.0
Water Harvesting	106	100.0
Irrigation	106	100.0

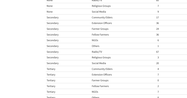
Adoption of Individual Adaptation Strategies (Table 2 n = 106)

Most Common Strategies (multiple responses allowed)

Organic Manure/Compost, 77.6% (Soil Fertility), Changing Planting Dates, 75.5% (Timing), Crop Diversification, 71.4% (Diversification), Intercropping, 69.4% (Intercropping), Drought/Heat Resistant Varieties, 65.3% (Drought), Shelterbelts, 63.3% (Windbreaks), Pest/Disease Management, 61.2% (Pest Control), Water Harvesting, 59.2% (Water), Irrigation, 57.1% (Irrigation), Agroforestry, 51.0% (Agroforestry).

Observation: Farmers employ a diverse portfolio of strategies addressing multiple challenges (soil fertility, timing, diversification, water, pests). The high adoption of organic manure/compost (77.6%) indicates strong preference for sustainable, low-cost inputs. Combination of traditional (shelterbelts, intercropping) and modern (improved seeds, irrigation) approaches suggests farmers are adapting to both traditional and contemporary challenges.

Strategy Combination	Frequency	Percentage (%)
Intercropping	25	17.0
Organic Manure/Compost	24	16.3
Mulching Cultivation	20	13.6
Crop Rotation	19	12.9
Crop Rotation	19	12.9
Improved Seeds	20	13.6
Rainwater Harvesting	20	13.6
Crop Diversification	20	13.6
Crop Diversification	20	13.6
Changing Planting Dates	20	13.6



Common Strategy Combinations (Table 3 n = 146)

Top Combinations

Changing Planting Dates + Organic Manure/Compost, 26.3% (Timing + Fertility), Changing Planting Dates + Crop Diversification + Organic Manure/Compost, 23.7% (Timing + Diversification + Fertility), Crop Diversification + Organic Manure/Compost, 23.7% (Diversification + Fertility).

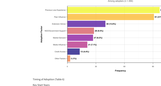
Observation: Farmers frequently combine planting date adjustments with soil fertility management (organic manure/compost) and crop diversification (e.g., Changing Planting Dates + Crop Diversification + Organic Manure/Compost).

Barrier	Frequency	Percentage (%)
Financial Cost/Expenditure	106	100.0
Time Allocation	106	100.0
Extension Services	106	100.0
Institutional/Government Support	106	100.0
Market Demand	27	25.5
Land Tenure/Access	27	25.5
Climate Uncertainty	27	25.5
Other Factors	1	0.9
Total	106	100.0

Barriers to Implementing Adaptation Strategies

Barrier	Frequency	Percentage (%)
Financial Cost/Expenditure	106	100.0
Time Allocation	106	100.0
Extension Services	106	100.0
Institutional/Government Support	106	100.0
Market Demand	27	25.5
Land Tenure/Access	27	25.5
Climate Uncertainty	27	25.5
Other Factors	1	0.9
Total	106	100.0

Barriers Influencing Adaptation Adoption



Training of Adaptation Chalks (6)

Farmer Training

Farmer Training (Reference), 1(61.2%), Training of ag.? (6.4%and 0.8%respectively), 0(31.4%)and 0.8%respectively

Observation: Most respondents (61.2%) attended training programmes and sessions on climate change impacts, while another adaptation (e.g., 31%) and suggesting that engagement with adaptation strategy only farmers.

Farmer Training Adaptation Chalks (6)

Farmer Training Adaptation Chalks (6)

Pressure on Farmers(0.0%), Poor Practices(0.0%), Water Pollution(0.0%), Water Quality(0.0%), Pesticides Impact(0.0%), Water Resource(0.0%), Farmer Health(0.0%), Others(0.0%)

Observation: Pressure from expansion and poor influence on the primary chalks, highlighting the role of personal experience and farmer-to-farmer influence in shaping adaptation. Conflicts between and Water Quality impacts are rarely cited as primary drivers.

Table 1: Farmer Training Adaptation Chalks (6)

Farmer Training	Frequency	Percentage (%)
Manure	20	17.1
Resource Limited	18	15.4
Terrace Farming	16	13.7
Pesticides	14	12
Selling Crop	8	6.8
Manure Compost	4	3.4
Changing planting date	4	3.4
Organic Fertilizer	3	2.6
Crop Rotation	3	2.6
Buy Land Not Rent	3	2.6
Chemical Farming	2	1.7
Crop Diversification	1	0.8
Pesticides	1	0.8
Intercropping	1	0.8
Water	1	0.8
Trading	1	0.8
Water	1	0.8
Changing planting	1	0.8
Changing planting Harvesting dates	1	0.8
Crop rotation	1	0.8
Soil	1	0.8
Soil Nutrition	1	0.8
Soil selling	1	0.8
Manure Farming	1	0.8
Manure Application	1	0.8
Selling Land	1	0.8
Organic	1	0.8
Organic manure application	1	0.8
Poly Selling	1	0.8
Non water harvesting	1	0.8
Farmer Training	1	0.8
Selling land	1	0.8
Selling Wings	1	0.8
Fresh Fruitlear	1	0.8
Trading Farming	1	0.8
Farmer Training	1	0.8
Selling	1	0.8
Unknown Farmer Training	1	0.8

Farm Adaptation Strategies Chalks (6)

Most Common Farm Strategies

Crop Diversification(0.0%), Intercropping(0.0%), Resource(0.0%), Terrace(0.0%), Pesticides(0.0%), Organic Manure(0.0%), Crop Rotation(0.0%), Chemical Farming(0.0%), Water(0.0%), Soil(0.0%), Trading(0.0%), Selling(0.0%)

Observation: Organic manure dominates as the most common farm strategy, reflecting its accessibility and familiarity. The variety of farm strategies (e.g., trading, selling, farm land) suggests some farmers adopt very specifical adaptations, potentially limited in scale.

Table 2: Farm Adaptation Strategies Chalks (6)

Adaptation Chalks	Frequency	Percentage (%)
Soil	108	94.4
Water	6	5.2

Table 3: Farm Adaptation Strategies Chalks (6)

Farm Adaptation Strategies	Frequency	Percentage (%)
Crop Diversification	1	0.8
Intercropping farm to overflowing on the land	1	0.8
Applying fertilizer makes crops get rotten	1	0.8
Improve seeds, drought	1	0.8
Drought, rainfall	1	0.8
Soil	1	0.8
Application of fertilizer to crops, it gets water	1	0.8
Changing planting date, drought	1	0.8
Changing planting date, drought	1	0.8
Changing planting date, Harvesting	1	0.8
Crop diversification, drought	1	0.8
Crop diversification, drought	1	0.8
Crop diversification, drought	1	0.8
Crop diversification, drought	1	0.8
Crop rotation	1	0.8
Crop rotation, drought	1	0.8
Crop rotation, drought	1	0.8
Crop rotation, drought

Age and Farming Experience (−0.75), indicating older farmers with more experience, which may reduce adaptation Table 5: Other Variables Influencing Adaptation Objectives (Coefficients and Significance)

Table 5 Other Variables Influencing Adaptation Objectives (Coefficients and Significance)

Observation: The strong correlation between age and experience suggests why experienced farmers (often older) are less likely to adopt, possibly due to resistance to change.

5.1 Conclusion on objective 3

Flight Behavior Risk

Sub-Objective 3.1: Identify Key Factors Influencing Adoption of Conservation Practices

Socio-Demographic Drivers: Radar (p = 0.002) and storage farmers (p = 0.024) are more likely to adopt, with gender having a strong effect (p = 0.000). Farm Size Influence: Crop farmers (p = 0.000) and farms with more animal units (p = 0.000) are more likely to adopt. Adaptation Objective 3.2:

Farm Size Influence: Crop farmers (p = 0.000) and farms with more animal units (p = 0.000) are more likely to adopt. Adaptation Objective 3.3: Identify Barriers to Adoption Table 6: Adaptation Objectives Vs Adaptation Status

Adaptation Objective	Mean Total Farm Size	SD Farm Size	Mean Animal Units	SD Animal Units	Farmer Count
No	1,000.00	1,000.00	1,000.00	1,000.00	1,000
Yes	254	1,000.00	1,000.00	1,000.00	1,000
Total	254	1,000.00	1,000.00	1,000.00	2,000

Table 6 Adaptation Objectives Vs Adaptation Status

Adaptation Objective	Adaptation Status	Farmer Count	Percentage (%)
No	Increased	10	0.5
No	Decreased	52	26.0
No	No Change	38	19.0
Yes	Increased	127	63.5
Yes	Decreased	27	13.5
Yes	No Change	1	0.5

Table 7 Key Farm Characteristics Influencing Adoption

Adaptation Objective	Mean Total Farm Size	SD Farm Size	Mean Total Crop Area	SD Total Crop Area	Total Farmers
No	1,000.00	1,000.00	1,000.00	1,000.00	1,000
Yes	254	1,000.00	1,000.00	1,000.00	1,000
Total	254	1,000.00	1,000.00	1,000.00	2,000

Table 7 Key Farm Characteristics Influencing Adoption

Adaptation Objective	Total Crop Area	Total Farmers	Percentage (%)
No	Increased	10	0.5
No	Decreased	52	26.0
No	No Change	38	19.0
Yes	Increased	127	63.5
Yes	Decreased	27	13.5
Yes	No Change	1	0.5

Table 8 Total Crop Categories by Adaptation Status

Adaptation Objective	Mean Total Crop Categories	SD Total Crop Categories	Total Farmers
No	1,000.00	1,000.00	1,000
Yes	1,000.00	1,000.00	1,000
Total	1,000.00	1,000.00	2,000

Table 8 Total Crop Categories by Adaptation Status

Adaptation Objective	Total Crop Categories	Total Farmers	Percentage (%)
No	Cereals	1	0.5
No	Other	5	2.5
No	Roots	10	5.0
No	Sometimes	6	3.0
No	Tubers	10	5.0
Yes	Cereals	170	85.0
Yes	Roots	20	10.0
Yes	Sometimes	1	0.5

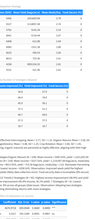


Table 9 Total Security Change Vs Adaptation Status

Adaptation Objective	Mean Total Security Change	SD Total Security Change	Farmer Count
No	1,000.00	1,000.00	1,000
Yes	254	1,000.00	1,000
Total	254	1,000.00	2,000

Table 9 Total Security Change Vs Adaptation Status

Adaptation Objective	Total Security Change	Farmer Count	Percentage (%)
No	Decreased	52	26.0
No	No Change	38	19.0
No	Increased	10	5.0
Yes	Decreased	27	13.5
Yes	No Change	1	0.5
Yes	Increased	127	63.5

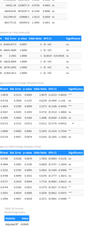


Table 10 Adaptation Objectives Vs Adaptation Status

Adaptation Objective	Adaptation Status	Farmer Count	Percentage (%)
No	Decreased	52	26.0
No	No Change	38	19.0
No	Increased	10	5.0
Yes	Decreased	27	13.5
Yes	No Change	1	0.5
Yes	Increased	127	63.5

6 Objective 4

To assess the effects of climate change adaptation strategies on livelihoods.

Table 11 Adaptation Objective Vs Total Crop Area

Adaptation Objective	Mean Total Crop Area	SD Total Crop Area	Farmer Count
No	1,000.00	1,000.00	1,000
Yes	254	1,000.00	1,000
Total	254	1,000.00	2,000

Table 11 Adaptation Objective Vs Total Crop Area

Adaptation Objective	Total Crop Area	Farmer Count	Percentage (%)
No	1,000.00	1,000	50.0
Yes	254.00	1,000	50.0
Total	1,254.00	2,000	100.0

Table 12 Farm Size Vs Adaptation Objectives

Adaptation Objective	Mean Total Farm Size	SD Total Farm Size	Farmer Count
No	1,000.00	1,000.00	1,000
Yes	254	1,000.00	1,000
Total	254	1,000.00	2,000

Table 12 Farm Size Vs Adaptation Objectives

Adaptation Objective	Total Farm Size	Farmer Count	Percentage (%)
No	1,000.00	1,000	50.0
Yes	254.00	1,000	50.0
Total	1,254.00	2,000	100.0

Table 13 Adaptation Objectives Vs Adaptation Status

Adaptation Objective	Adaptation Status	Farmer Count	Percentage (%)
No	Decreased	52	26.0
No	No Change	38	19.0
No	Increased	10	5.0
Yes	Decreased	27	13.5
Yes	No Change	1	0.5
Yes	Increased	127	63.5

Table 14 Adaptation Objectives Vs Total Crop Area

Adaptation Objective	Total Crop Area	Farmer Count	Percentage (%)
No	1,000.00	1,000	50.0
Yes	254.00	1,000	50.0
Total	1,254.00	2,000	100.0

Table 15 Adaptation Objectives Vs Total Farm Size

Adaptation Objective	Total Farm Size	Farmer Count	Percentage (%)
No	1,000.00	1,000	50.0
Yes	254.00	1,000	50.0
Total	1,254.00	2,000	100.0

Table 16 Total Crop Categories Vs Adaptation Objectives

Adaptation Objective	Total Crop Categories	Farmer Count	Percentage (%)
No	Cereals	1	0.5
No	Other	5	2.5
No	Roots	10	5.0
No	Sometimes	6	3.0
No	Tubers	10	5.0
Yes	Cereals	170	85.0
Yes	Roots	20	10.0
Yes	Sometimes	1	0.5

Table 17 Total Security Change Vs Adaptation Status

Adaptation Objective	Total Security Change	Farmer Count	Percentage (%)
No	Decreased	52	26.0
No	No Change	38	19.0
No	Increased	10	5.0
Yes	Decreased	27	13.5
Yes	No Change	1	0.5
Yes	Increased	127	63.5

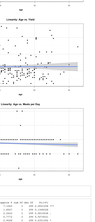


Table 18 Adaptation Objectives Vs Adaptation Status

Adaptation Objective	Adaptation Status	Farmer Count	Percentage (%)
No	Decreased	52	26.0
No	No Change	38	19.0
No	Increased	10	5.0
Yes	Decreased	27	13.5
Yes	No Change	1	0.5
Yes	Increased	127	63.5

Table 19 Adaptation Objectives Vs Total Crop Area

Adaptation Objective	Total Crop Area	Farmer Count	Percentage (%)
No	1,000.00	1,000	50.0
Yes	254.00	1,000	50.0
Total	1,254.00	2,000	100.0

Table 20 Adaptation Objectives Vs Total Farm Size

Adaptation Objective	Total Farm Size	Farmer Count	Percentage (%)
No	1,000.00	1,000	50.0
Yes	254.00	1,000	50.0
Total	1,254.00	2,000	100.0

Table 21 Total Crop Categories Vs Adaptation Objectives

Adaptation Objective	Total Crop Categories	Farmer Count	Percentage (%)
No	Cereals	1	0.5
No	Other	5	2.5
No	Roots	10	5.0
No	Sometimes	6	3.0
No	Tubers	10	5.0
Yes	Cereals	170	85.0
Yes	Roots	20	10.0
Yes	Sometimes	1	0.5

Table 22 Continued Outcomes by Adaptation Objectives

Outcome	Adaptation Objective	Adaptation Objective	Adaptation Objective	Adaptation Objective
Income	0.000	0.000	0.000	0.000
Income Change	0.000	0.000	0.000	0.000
Total Security	0.000	0.000	0.000	0.000
Total Crop Area	0.000	0.000	0.000	0.000
Total Farm Size	0.000	0.000	0.000	0.000
Total Crop Categories	0.000	0.000	0.000	0.000

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adaptation_adjusted	0.0086	0.2403	0.036
	0.0000	0.9970	0.000
education_level	0.0000	0.9970	0.000
education_secondary	0.1877	0.0000	0.000
education_university	0.6873	0.0000	0.000
land_use_cultivated	0.1264	0.0000	0.000
land_use_pastureland	0.1264	0.0000	0.000
Constant	0.0000	0.9970	0.000

- Overall AIC/BIC/Pseudo R^2 Results:

Model Fit Statistics: Pseudo R^2 (McFadden) 0.7000, Adjusted R^2 0.6900, AIC 2,290.1, BIC 2,390.1, Log-Likelihood −1,135.0

The model explains approximately 70% of the variance in adaptation, with overall good fit.

Education (Secondary): Shows a significant positive effect (β = 0.1877, p < 0.001). Secondary education significantly increases adaptation adjustment by about 18.77 percentage points.

Education (University): Demonstrates the most significant positive effect (β = 0.6873, p < 0.001). Tertiary education substantially increases adaptation adjustment by about 68.73 percentage points.

Land Use (Cultivated): Significantly positive effect (β = 0.1264, p < 0.001). Cultivated land increases adaptation adjustment by about 12.64 percentage points.

Land Use (Pastureland): Similar significant positive effect (β = 0.1264, p < 0.001). Pastureland also increases adaptation adjustment by about 12.64 percentage points.

Adaptation Adjusted: Not significant (p = 0.2403). Adaptation actually shows a negative coefficient, indicating adaptation effects are not linear or quadratic.

Field Current_Yield_Gap: p = 0.9970, not significant. Current yield gap does not significantly influence adaptation adjustment.

Field Variability_Yield_Gap: p = 0.9970, not significant. Yield variability does not significantly influence adaptation adjustment.

Model Fit: Pseudo R^2 (McFadden) = 0.7000, Adjusted R^2 = 0.6900, AIC = 2,290.1, BIC = 2,390.1, Log-Likelihood = −1,135.0

The model explains approximately 70% of the variance in adaptation, with good overall

Barrier Type

Education Level Differences (Table 14, edu_barrier_means)

Mean Scores (edu_barrier_means):None: Highest for Supply Chain (3.80), Market (3.77), Technological (3.75), and Environmental (3.68); Cultural lowest (2.70). Basic: Moderate across all (2.73–3.37). Secondary: Highest for Technological (3.61) and Market (3.58); lowest for Cultural (2.41). Tertiary: Lowest across all except Cultural (2.90; e.g., Technological (3.27), Environmental (3.29).

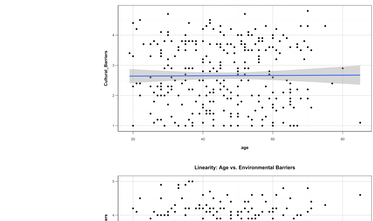
ANOVA (Table 14):Significant: Market (p = 0.0002), Supply Chain (p = 0.0002), Technological (p = 0.0006,), Environmental (p = 0.0149), *). Non-significant: Cultural (p = 0.1170, ns).

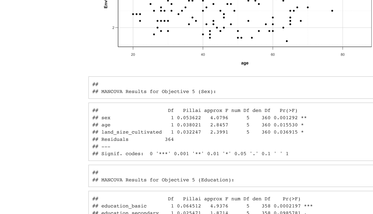
Observation:Farmers with no education perceive the highest barriers, particularly in market, supply chain, and technological categories, while tertiary-educated farmers report the lowest, indicating education reduces perceived barriers.

```
##
## Normality Tests for Objective 5:

##
## Correlation Matrix for Objective 5:

##                          Cultural_Barriers Environmental_Barriers
## Cultural_Barriers                    1.0000000              0.1587853
## Environmental_Barriers               0.1587853              1.0000000
## Technological_Barriers               0.1353329              0.8342161
## Market_Barriers                      0.1647046              0.7778456
## Supply_Chain_Barriers                0.1966173              0.7547924
                          Technological_Barriers Market_Barriers
## Cultural_Barriers                    0.1353329       0.1647046
## Environmental_Barriers                0.8342161       0.7778456
## Technological_Barriers               1.0000000       0.9181007
## Market_Barriers                      0.9181007       1.0000000
## Supply_Chain_Barriers                0.8516110       0.9082593
                          Supply_Chain_Barriers
## Cultural_Barriers                 0.1966173
## Environmental_Barriers            0.7547924
## Technological_Barriers           0.8516110
## Market_Barriers                  0.9082593
## Supply_Chain_Barriers            1.0000000
```






```
##
## MANCOVA Results for Objective 5 (Sex):

##                     Df  Pillai approx F num Df den Df    Pr(>F)
## sex                  1 0.05662  4.0796      5    360 0.001292 **
## age                  1 0.03080  2.8457      5    360 0.015530 *
## land_size_cultivated  1 0.032247  2.3991      5    360 0.036915 *
## Residuals          364
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## MANCOVA Results for Objective 5 (Education):

##                     Df  Pillai approx F num Df den Df    Pr(>F)
## education_basic      1 0.044512  4.9376      5    358 0.000297 ***
## education_secondary  1 0.025471  1.8714      5    358 0.098578 .
## education_tertiary   1 0.012430  0.9012      5    358 0.480398
## age                  1 0.045096  3.3814      5    358 0.005349 **
## land_size_cultivated  1 0.036374  2.5488      5    358 0.027597 *
## Residuals          362
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Univariate ANOVAs for Objective 5 (Sex):

##  Response Cultural_Barriers :
##             Df Sum Sq Mean Sq F value Pr(>F)
## sex          1   0.26  0.2563  0.2135 0.6291
## age          1   0.04  0.03736  0.0330 0.8561
## land_size_cultivated  1   0.16  0.15717  0.1424 0.7061
## Residuals  364 401.70 1.10356
##
##  Response Environmental_Barriers :
##             Df  Sum Sq Mean Sq F value Pr(>F)
## sex          1   0.622  0.62195  0.9306 0.3354
## age          1   0.439  0.43791  0.6552 0.4188
## land_size_cultivated  1   1.524  1.52428  2.2807 0.1319
## Residuals  364 243.290 0.66835
##
##  Response Technological_Barriers :
##             Df  Sum Sq Mean Sq F value  Pr(>F)
## sex          1   0.496  0.4957  0.5202 0.47123
## age          1   0.022  0.0229  0.0294 0.86403
## land_size_cultivated  1   5.090  5.0897  6.5253 0.01184 *
## Residuals  364 283.914  0.7800
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##  Response Market_Barriers :
##             Df Sum Sq Mean Sq F value    Pr(>F)
## sex          1  0.01  0.0057  0.0066 0.935496
## age          1  1.579  1.5789  2.0266 0.156631
## land_size_cultivated  1  6.56  6.5550  7.5348 0.006352 **
## Residuals  364 316.47  0.8700
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##  Response Supply_Chain_Barriers :
##             Df Sum Sq Mean Sq F value  Pr(>F)
## sex          1  0.877  0.8768  1.1346 0.2846
## age          1  1.110  1.1103  1.2848 0.25775
## land_size_cultivated  1  7.879  7.8792  9.1175 0.00271 **
## Residuals  364 314.563  0.8642
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Univariate ANOVAs for Objective 5 (Education):

##  Response Cultural_Barriers :
##             Df Sum Sq Mean Sq F value  Pr(>F)
## education_basic      1  1.59  1.5862  1.4378 0.22963
## education_secondary  1  4.50  4.4984  4.1171 0.04318 *
## education_tertiary   1  0.26  0.2642  0.2334 0.56499
## age                  1  0.10  0.1047  0.0958 0.75712
## land_size_cultivated  1  0.07  0.0683  0.0625 0.80275
## Residuals          362 395.53  1.0926
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##  Response Environmental_Barriers :
##             Df Sum Sq Mean Sq F value  Pr(>F)
## education_basic      1  3.212  3.2119  4.8905 0.02763 *
## education_secondary  1  2.291  2.2909  3.4885 0.05318 .
## education_tertiary   1  1.370  1.3696  2.0856 0.14958
## age                  1  0.115  0.1151  0.1753 0.67570
## land_size_cultivated  1  1.030  1.0300  1.5683 0.21126
## Residuals          362 237.746  0.6568
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##  Response Technological_Barriers :
##             Df Sum Sq Mean Sq F value    Pr(>F)
## education_basic      1 10.300 10.3005 13.2915 0.0002451 ***
## education_secondary  1  0.544  0.5438  0.7244 0.3952526
## education_tertiary   1  2.157  2.1571  2.8735 0.0909065 .
## age                  1  0.233  0.2334  0.3109 0.5774348
## land_size_cultivated  1  4.453  4.4526  5.9314 0.0155551 *
## Residuals          362 271.747  0.7507
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##  Response Market_Barriers :
##             Df Sum Sq Mean Sq F value    Pr(>F)
## education_basic      1 14.332 14.3320 17.3327 3.925e-05 ***
## education_secondary  1  1.209  1.3088  1.5828  0.20937
## education_tertiary   1  1.607  1.6074  1.9438  0.16431
## age                  1  3.139  3.1395  3.7965  0.05213 .
## land_size_cultivated  1  5.248  5.2478  6.3462  0.01219 *
## Residuals          362 299.349  0.8269
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##  Response Supply_Chain_Barriers :
##             Df Sum Sq Mean Sq F value    Pr(>F)
## education_basic      1  12.645 12.6545 15.2506 0.0001068 ***
## education_secondary  1   1.775  1.7749  2.1539 0.1433155
## education_tertiary   1   2.289  2.2896  2.7762 0.0965389 .
## age                  1   1.914  1.9140  2.3218 0.1284632
## land_size_cultivated  1   7.374  7.3755  8.9469 0.0029697 **
## Residuals          362 298.421  0.8244
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

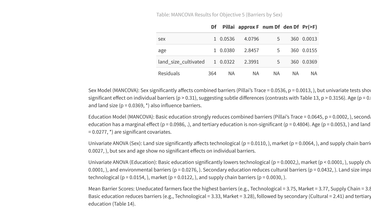


Table: MANCOVA Results for Objective 5 (Barriers by Education)

	Df	Pillai	approx F	num Df	den Df	Pr(>F)
education_basic	1	0.0645	4.9376	5	358	0.0002
education_secondary	1	0.0255	1.8714	5	358	0.0986
education_tertiary	1	0.0124	0.9012	5	358	0.4804
age	1	0.0451	3.3814	5	358	0.0053
land_size_cultivated	1	0.0344	2.5488	5	358	0.0277
Residuals	362	NA	NA	NA	NA	NA

Table: MANCOVA Results for Objective 5 (Barriers by Sex)

	Df	Pillai	approx F	num Df	den Df	Pr(>F)
sex	1	0.0536	4.0796	5	360	0.0013
age	1	0.0380	2.8457	5	360	0.0155
land_size_cultivated	1	0.0322	2.3991	5	360	0.0369
Residuals	364	NA	NA	NA	NA	NA

Sex Model (MANCOVA): Sex significantly affects combined barriers (Pillai's Trace = 0.0536, p = 0.0013,), but univariate tests show no significant effect on individual barriers (p = 0.31), suggesting subtle differences (contrasts with Table 13, p = 0.3156). Age (p = 0.0155,) and land size (p = 0.0369, *) also influence barriers.

Education Model (MANCOVA): Basic education strongly reduces combined barriers (Pillai's Trace = 0.0645, p = 0.0002,), secondary education has a marginal effect (p = 0.0986,), and tertiary education is non-significant (p = 0.4804). Age (p = 0.0053,) and land size (p = 0.0277, *) are significant covariates.

Univariate ANOVA (Sex): Land size significantly affects technology (p = 0.0118,), market (p = 0.0064,), and supply chain barriers (p = 0.0027,), but sex and age show no significant effects on individual barriers.

Univariate ANOVA (Education): Basic education significantly lowers technology (p = 0.0002,), market (p < 0.0001,), supply chain (p = 0.0001,), and environmental barriers (p = 0.0276,). Secondary education reduces cultural barriers (p = 0.0432,). Land size impacts technological (p = 0.0154,), market (p = 0.0122,), and supply chain barriers (p = 0.0030,).

Mean Barrier Scores: Uneducated farmers face the highest barriers (e.g., Technological = 3.75, Market = 3.77, Supply Chain = 3.80). Basic education reduces barriers (e.g., Technological = 3.33, Market = 3.28), followed by secondary (Cultural = 2.41) and tertiary education (Table 14).

Multicollinearity: High correlations between technological, market, and supply chain barriers (0.85–0.92) suggest interdependence, while cultural barriers are distinct (0.14–0.19, Table 1).

Linearity: Scatterplots confirm linear relationships between age and barriers, supporting MANCOVA assumptions.

- Summary:

Basic education significantly reduces technological, market, and supply chain barriers (p = 0.0002), while secondary education lowers cultural barriers (p = 0.0432). Uneducated farmers face the highest barriers. Sex has a combined effect (p = 0.0013), but not on individual barriers. Larger land sizes influence technological, market, and supply chain barriers (p < 0.0118). Interventions should prioritize basic education and address land size-related constraints to enhance adaptation adoption among smallholder farmers in Bono East, Ghana.

7.1 Conclusion on objective 5

Dominant Barriers: The most severe barriers are environmental (plant diversity loss, increasing temperatures) and technological (training and tools availability), all-rated High (Mean ≥ 3.5), reflecting the critical role of climate impacts and lack of technological support in hindering adaptation.

Market and Supply Chain: High-severity barriers like lack of market information, cooperative absence, storage duration, and input disruptions (Mean > 3.6)- 3.63 highlight systemic issues in accessing markets and inputs, crucial for adaptation success.

Cultural Barriers: Moderate severity (Mean = 2.42–2.79), with traditional beliefs significantly reducing adoption (p < 0.0001), indicating cultural norms play a secondary but notable role.

Socioeconomic/Policy Barriers: Low severity (Mean = 2.28–2.43), but lack of credit significantly impacts adoption (p = 0.0004), suggesting financial constraints are a key barrier for some farmers.

Factor Analysis: Barriers cluster into Market and Access (20.2% variance), Cultural Norms, and Environmental Degradation, emphasizing the interconnectedness of market, supply chain, and environmental challenges. Demographic Variations:Gender: No significant differences, suggesting barriers are universally perceived.

Education: Significant differences, with uneducated farmers facing higher barriers, particularly in market, supply chain, and technological domains, highlighting the role of education in overcoming barriers.

Adoption Impact: High costs, traditional beliefs, and lack of credit significantly deter adaptation, while flooding and extension service access have minimal impact, suggesting targeted interventions should focus on financial and cultural barriers.

- Summary

The primary barriers to effective climate change adaptation among smallholder crop farmers in the Bono East Region are environmental (plant diversity loss, Mean = 3.76) and technological (training lack, Mean = 3.68; tools availability, Mean = 3.66), followed by market and supply chain issues (e.g., info lack, storage duration, Mean = 3.61–3.63). Traditional beliefs and lack of credit significantly reduce adoption (p < 0.0001 and p = 0.0004), while cultural barriers are moderately severe (Mean = 2.41–2.79). Farmers with no education perceive the highest barriers, particularly in market and technological domains (p < 0.001), while gender differences are negligible. Interventions should prioritize improving access to training, tools, market information, and credit, while addressing cultural resistance through community engagement to enhance adaptation adoption.

8 Conclusion on the Study and All Objectives

Overview: This study examined climate change adaptation among 368 smallholder crop farmers in Bono East, Ghana, across five objectives: climate change awareness, adaptation strategies, their effectiveness, livelihood impacts, and implementation barriers.

Key Findings:

Objective 1 (Awareness): High awareness of climate change (e.g., rising temperatures, erratic rainfall) is linked to education and extension services, facilitating informed adaptation.

Objective 2 (Strategies): Common strategies include organic manure (63.9%), changing planting dates (59.2%), and intercropping (47.8%), chosen for accessibility and perceived effectiveness.

Objective 3 (Effectiveness): Indigenous strategies like intercropping (Mean = 3.77) and organic manure (Mean = 3.58) are rated effective, though outcomes vary by context.

Objective 4 (Livelihoods): Adaptation boosts yields (61.6% vs. 21.6%, p < 0.0001) and reduces income declines (50.0% vs. 20.3% increases), but adopters face higher food insecurity (72.1% vs. 37.9%, p < 0.0001) due to costs. Changing planting dates enhances income, unlike organic manure and intercropping.

Objective 5 (Barriers): Environmental (plant diversity loss, Mean = 3.76) and technological barriers (training/tools, Mean = 3.66–3.68) dominate, followed by market/supply chain issues (Mean = 3.61–3.63). Traditional beliefs and lack of credit deter adoption (p ≤ 0.0004). Uneducated farmers face higher barriers (p < 0.001).

Summary: Smallholder farmers in Bono East Region are aware of climate change and adopt accessible strategies like organic manure and changing planting dates, which are perceived as effective and improve yields while mitigating income declines. However, high costs, traditional beliefs, and environmental/technological barriers hinder adoption, exacerbating food insecurity among adopters. Targeted interventions—enhancing training, tools, market access, and credit while addressing cultural resistance—can strengthen adaptation and improve livelihoods, with education playing a critical role in overcoming barriers.