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Effect of perception on adoption of climate-smart agricultural practices in Irish potato farming: A case of Ainabkoi, Uasin Gishu County, Kenya

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Abstract

Perception of climate change has been one of the important factors that enables or hinders the adoption of climate-smart agricultural practices (CSAPs) among farmers worldwide. Nevertheless, little in-depth analysis and information exist in Kenya on how Irish potato farmers perception influence their adoption to CSAPs. It is crucial to understand how farmers perceive the various practices to create successful approaches for encouraging the implementation of CSAPs among farmers. The focus of this article is to investigate perception aspects that influence the adoption of CSAPs among Irish potato farmers in Ainabkoi, Uasin Gishu County, Kenya. In a population of 1500 Irish potato farmers, a random sample of 196 farmers were interviewed. Descriptive statistics was used to analyze farmers' benefits, sustainability, and effectiveness perception aspects. SPSS version 28, and Stata version 17 software, were employed for econometric analysis. The investigation involved employing a principal component analysis (PCA) model. The results of PCA analysis show that the benefits aspect rotated factor loadings explained 96.09% of the total variance, sustainability explained 93.61%, and effectiveness accounted for 94.43%. The study recommends that policymakers and extension services focus on increasing farmers' awareness concerning the benefits of embracing climate-smart practices in boosting productivity and food security.

Keywords: Climate-Smart Agricultural Practices; Perception; Climate Change; Adaptation Strategies; Potato Farmers; Adoption

1. Introduction

The perception toward CSAPs among farmers in sub-Saharan Africa has emerged as a crucial factor influencing the adoption adaptation strategies [1]. Farmers assess and implement these practices as beneficiaries of agricultural innovations based on the perceived benefits they offer [2]. The adoption decisions of farmers are driven by their preferences for options that can mitigate climate change-induced risks, such as droughts and floods, or those that enhance productivity and income [3]. Notably, innovations can provide these benefits individually or through multiple advantages derived from a single intervention [4].

Adopting CSAPs benefits farmers through increased agricultural productivity. It offers strategies to mitigate and adapt to the changes in climate, which are the leading solutions [5]. The activities and motivations for effective climate-smart practices are an excellent response to the Sustainable Development Goals (SDGs) number 2 and 13 on boosting productivity and adapting to climate change, respectively [6]. In recent years, farmers have embraced usage of CSAPs as a unique opportunity for achieving food security, climate change adaptation, and mitigation goals [10]. Adopting climate-smart agricultural practices is common in various enterprises such as maize, beans, tea, and Irish potatoes [7].

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Despite the growing recognition of the importance of CSAPs in addressing the challenges posed by climate change, there is a notable gap in understanding the specific factors that hinder the adoption of these practices among Irish potato farmers in Ainabkoi, Uasin Gishu County [8]. Existing studies on CSAP adoption in agriculture have primarily focused on broader regional or national contexts, with limited attention given to the unique characteristics and constraints farmers face at the local level [9]. By narrowing the scope of the investigation to the specific context of Ainabkoi, this study seeks to fill this crucial knowledge gap by providing context-specific insights into the perception aspects of barriers and opportunities associated with the adoption of CSAPs in Irish potato production [10].

Various strategies to promote Irish potato farming and yields in Uasin Gishu County involve using multiple methods, including providing high-quality seeds, agroforestry, and the growth of short-cycle and drought-tolerant potato varieties [11]. The potato industry's stakeholders have also created and promoted CSAPs to modify potato production to address climate change. Climate change adoption is therefore essential to cope with the inherent challenges hampering food productivity while trying to encourage Irish potato farming [12]. Therefore, farmers need education on climate issues related to potato farming and the best approaches to adopt [13].

Perceptions are crucial in shaping the adoption of climate-smart agricultural practices among Irish potato farmers. Farmers' perceptions regarding the benefits, profitability, costs, impact, and risks associated with these practices can significantly influence their decision to adopt them. Positive perceptions regarding the benefits of climate-smart practices, such as increased productivity, improved food security, and enhanced resilience to climate change, can motivate adoption [14]. Farmers who perceive climate-smart practices as profitable and economically beneficial are likelier to embrace them, as they are potential pathways to increased yields and income generation [15]. There is a need to draw well-defined conclusions on how smallholder farmers perceptions influence the adoption of climate-smart practices.

2. Methodology

The study was conducted in Ainabkoi, Uasin Gishu County, Kenya. It is situated between longitudes 34° 50 East and 35° 37 West and latitudes 0° 03 South and 0° 55 North. This region exhibits substantial variations in altitude, with elevations ranging from 1500 m to 2100 m above sea level. Ainabkoi holds prominence as a hub for Irish potato production, making it one of the key economic activities within the area. The fertile land and favorable climatic conditions have contributed to the success and productivity of potato farming in this region. The sample size was computed using a formula described by [16] to obtain 196 potato-producing households chosen using a simple random sample method. A survey questionnaire was used to collect data from the households. A cluster sampling procedure was employed to examine the effects of perception on Irish potato production in Ainabkoi, Uasin Gishu. The population of potato farmers in the Ainabkoi sub-county was divided into clusters based on geographical or administrative boundaries, such as wards.

Data analysis involved two main approaches: descriptive statistics and econometric models, with the support of SPSS and Stata statistical tools. Descriptive statistics provided valuable insights into the central tendencies, variability, and proportions of farmers' attitudes toward CSAPs and their adoption rates. On the other hand, applying econometric models allowed for examining correlations between different variables and identifying key factors influencing the adoption of CSAPs among farmers in the study area. Combining these analytical methodologies, the study achieved a comprehensive and rigorous understanding of the factors shaping farmers' perceptions and behaviors regarding adopting CSAPs. This enhanced knowledge is crucial for developing targeted interventions and policies to promote the region's widespread adoption of climate-smart agricultural practices.

2.1. Econometric Model Specification.

Principal Component Analysis (PCA), a multivariate statistical technique, was used to reduce the dimensionality of a dataset while retaining as much variation as possible. In determining the effect of farmers' perception on adopting Climate-smart Agricultural Practices in Irish Potato Production in Ainabkoi, Uasin Gishu County, PCA model identified the most important perception element influencing farmers' adoption of climate-smart practices. The following steps were followed while analyzing data using this model:

Standardization of the data: For each variable x, its standardized value z was calculated by subtracting the variable's mean from x and dividing the result by the variable's standard deviation.

$$z = \frac{(X - mean\ (X))}{sd(X)} \quad \ldots\ldots (1)$$

Calculation of the covariance matrix *S* of the standardized variables. The covariance matrix is an n x n matrix where n is the number of variables in the data set.

$S = cov(z)$ …….. (2)

Calculate the eigenvalues and eigenvectors of the covariance matrix *S*. The eigenvalues are the variances of the principal components, and the eigenvectors are the coefficients of the principal components.

$[V, D] = eig(S)$ …….. (3)

Where:

V is an n x n matrix whose columns are the eigenvectors of *S*, and *D* is an n x n matrix whose diagonal entries are the eigenvalues of *S*.

Sorting of the eigenvectors in descending order of their corresponding eigenvalues. This gives the order of importance of the principal components. Then, calculating the principal components *PC* by multiplying the standardized variables *z* by the matrix of sorted eigenvectors *V* was done.

$PC = z \times V$ …….. (4)

The Interpretations of results follow where the loadings of the variables on the principal components were analyzed to identify the most important factors that influence the adoption of climate-smart agricultural practices. The loadings are the correlations between the variables and the principal components. The correlation between the principal components and the adoption of climate-smart agricultural practices was calculated to determine the effect of farmers' perceptions on the adoption of climate-smart agricultural practices. The existence of the different perceptions on climate-smart strategies, such as crop rotation, adopting enhanced Irish potato varieties, and agroforestry management approaches, was analyzed. Factor analysis ranked farmers' opinions and the criteria they used to decide whether to implement climate-smart farming practices on a 5-point Likert scale. When choosing to implement a climate-smart agriculture practice, the perceptions of farmers analyzed include perceived benefits and effectiveness, awareness and information on the climate-smart practices, and financial accessibility criteria.

3. Results

3.1. Descriptive Statistics of the Perceptions of Climate-smart Practices

This study tried to understand descriptive statistics on the perception of the respondents on the impact of farmers' perception on adopting CSAPs in Irish potato production in Ainabkoi, Uasin Gishu County, allowing us to understand the overall perception and the variation in responses. The study employed a five-point Likert scale with minimum and maximum values of 1-5, respectively, where the value reflected (1= strongly agree,2=agree somewhat, 3=neutral, 4= disagree somewhat, 5= strongly disagree) while investigating several key aspects of farmer's perception, grouped into benefits, sustainability, and effectiveness. The mean values indicate the average perception score for each aspect. Higher mean values suggest a more positive perception of the corresponding aspect (Table 1).

The results indicate that respondents perceive CSAPs as positively enhancing various aspects of potato farming. They perceive CSAPs positively impacting enhanced productivity, increased yields, improved soil health, and reduced water usage. Additionally, respondents believe that CSAPs effectively manage pests and diseases, improve income and financial benefits, and promote diversification of crops and income sources on potato farms. Furthermore, the findings reveal that respondents recognize the role of CSAPs in promoting long-term sustainability and resilience in potato farming. They also view CSAPs as environmentally friendly, promoting biodiversity and preserving land quality for future generations. The participants positively perceive CSAPs' effectiveness in adapting to local climate and soil conditions. They also believe that CSAPs are instrumental in mitigating the adverse effects of extreme weather events, reducing greenhouse gas emissions, and ensuring overall success and stability in Irish potato farming operations.

Table 1 Summary statistics for the aspects used to measure perception.

Variable name	Observations	Mean	SD	Min	Max
Enhanced potato productivity	196	1.964	0.799	1	3
Increased yields	196	1.980	0.771	1	3
Soil health improvement	196	1.954	0.760	1	3
Water usage reduction	196	1.944	0.811	1	3
Pest and disease management	196	1.949	0.809	1	3
Income Improvement	196	1.948	0.809	1	3
Crop diversification	196	1.955	0.806	1	3
Increased farm efficiency	196	2.061	0.801	1	3
Resource conservation	196	1.947	0.809	1	3
Emission reduction	196	1.923	0.797	1	3
Long-term sustainability	196	1.944	0.811	1	3
Environment friendly	196	1.959	0.803	1	3
Biodiversity promotion	196	1.954	0.806	1	3
Land quality preservation	196	1.964	0.800	1	3
Effective in local conditions	196	1.959	0.803	1	3
Mitigating extreme events	196	1.943	0.792	1	3
Adapting to climate conditions	196	1.984	0.774	1	3
Success and stability	196	1.959	0.790	1	3
Positive outcomes	196	1.989	0.771	1	3
Practical and feasible	196	1.964	0.793	1	3
Effective on profitability	196	1.954	0.786	1	3

Note: SD= Standard Deviation, Min= Minimum, Max= Maximum

3.2. Principal Component Analysis of Farmers' CSAPs

3.2.1. Perception of Benefits of CSAPs

The factor loadings represent the correlation between the observed variables (perception questions) and the underlying factor (Benefits of CSAPs). Higher factor loadings indicate a stronger association between the variable and the factor. The findings indicate that all variables have high factor loadings (ranging from 0.947 to 0.995), suggesting they are strongly related to the Benefits factor (Table 2). The uniqueness values represent the unique variance not explained by the common factor. Low uniqueness values indicate that the variance in the variables was attributed to the underlying factor. In this case, the uniqueness values are low, suggesting that the Benefits factor explains a significant portion of the variance in the perception questions. The Kaiser-Meyer-Olkin Measure (KMO) measure assessed the adequacy of the data for factor analysis, with a value close to 1 indicating the well-suitability of data for factor analysis. In this study, the KMO values for all variables were high, ranging from 0.849 to 0.983, and the overall KMO is 0.926, indicating that the data was highly suitable for factor analysis (Table 2). The scale reliability coefficient (alpha) assesses the internal consistency or reliability of the scale constructed from the perception questions, with a value close to 1 indicating good internal consistency. In this analysis, the scale reliability coefficient is 0.993, which was high, suggesting excellent reliability and consistency of the perception questions in measuring the Benefits of CSAPs [17].

Table 2 Factor Loadings, Unique Variances, Kaiser-Meyer-Olkin Measure, and Alpha Values

Variable	Factor1	Uniqueness	KMO
Enhanced potato productivity	0.982	0.036	0.969
Increased yields	0.963	0.073	0.958
Soil health improvement	0.947	0.104	0.983
Water usage reduction	0.995	0.011	0.849
Pest and disease management	0.990	0.019	0.945
Income Improvement	0.994	0.013	0.874
Crop diversification	0.991	0.019	0.928
Overall KMO			0.926
Alpha			0.993

Note: KMO= Kaiser-Meyer-Olkin measure of sampling adequacy

The rotated factor loadings after applying varimax rotation indicated that the single factor retained had a high variance (6.72604), explaining about 96.09% of the total variance (Table 3). The high proportion suggested that the Benefits factor adequately captured the common variance shared by the perception questions.

Table 3 Rotated factor loadings (pattern matrix) and unique variances

Factor	Variance	Difference	Proportion	Cumulative
Factor1	6.726	.	0.961	0.961

The sum of Benefits CSAPs represented each respondent's composite score for the Benefits aspect of CSAPs. The mean value of 2.660 indicated a positive perception overall, as it falls between the scale's minimum and maximum range of -1.227 to 1.339 (Table 4).

Table 4 Summary of benefits of CSAPs

Variable	Observations	Mean	SD	Min	Max
Benefits of CSAPs	196	2.660	1	-1.227	1.339

3.2.2. Perception of Sustainability of CSAPs

Table 5 Factor Loadings, Unique Variances, Kaiser-Meyer-Olkin Measure, and Alpha Values

Variable	Factor1	Uniqueness	KMO
Increased farm efficiency	0.869	0.243	0.985
Resource conservation	0.991	0.018	0.947
Emission reduction	0.959	0.080	0.977
Long-term sustainability	0.993	0.014	0.881
Environment friendly	0.984	0.032	0.924
Biodiversity promotion	0.989	0.022	0.952
Land quality preservation	0.981	0.038	0.962
Overall KMO			0.944
Alpha			0.988

Note: KMO= Kaiser-Meyer-Olkin measure of sampling adequacy

The results show that all perception questions have high factor loadings, ranging from 0.869 to 0.993 (Table 6). This suggests that the questions are well-represented by the Sustainability factor. Additionally, the uniqueness values indicate the amount of variance in each perception question that was not explained by the common factor. Lower uniqueness values indicate a better fit for the factor. Here, most uniqueness values are low, suggesting a good fit. In this analysis, the KMO values range from 0.881 to 0.985 for individual variables, and the overall KMO value is 0.944, which indicates that the data is suitable for factor analysis (Table 5). Scale reliability coefficient, also known as Cronbach's alpha, assesses the internal consistency and reliability of the scale. The value of 0.988 is close to 1, indicating high reliability and consistency among the perception questions related to Sustainability (Table 5).

The rotated factor loadings, in this case, have a high cumulative proportion of 0.936 for Factor 1 (Table 6). This indicates that Factor 1 explains a significant portion of the variance in the perception questions related to Sustainability.

Table 6 Rotated factor loadings (pattern matrix) and unique variances

Factor	Variance	Difference	Proportion	Cumulative
Factor1	6.552	.	0.936	0.936

The mean value of 1.620 suggests a neutral response, and the standard deviation of 1 indicates variability in the responses. The minimum and maximum values of -1.237 and 1.331, respectively, indicate that respondents have different perceptions of the Sustainability of CSAPs (Table 7).

Table 7 Summary statistics of sustainability of CSAPs

Variable	Observations	Mean	SD	Min	Max
Benefits of CSAPs	196	1.620	1	-1.237	1.331

3.2.3. Perception of Effectiveness of CSAPs

Effective in Local Conditions variable has a high factor loading of 0.983, suggesting that respondents strongly associate CSAPs with their adaptability and suitability to local farming conditions. Mitigating Extreme Events, 0.973, adapting to climate conditions, 0.961, and success and stability, 0.976. Respondents associate CSAPs with positive outcomes, as reflected by a factor loading of 0.956. Practical and Feasible 0.974, respondents find CSAPs practical and feasible to incorporate into existing farming techniques. Effective on Profitability 0.979 suggests that respondents believe CSAPs positively impact the profitability of farms (Table 8).

Table 8 Factor Loadings, Unique Variances, Kaiser-Meyer-Olkin Measure, and Alpha Values

Variable	Factor1	Uniqueness	KMO
Effective in local conditions	0.983	0.034	0.919
Mitigating extreme events	0.973	0.053	0.930
Adapting to climate conditions	0.961	0.076	0.970
Success and stability	0.976	0.048	0.958
Positive outcomes	0.956	0.087	0.982
Practical and feasible	0.974	0.051	0.947
Effective on profitability	0.979	0.041	0.941
Overall KMO			0.949
Alpha			0.990

Note: KMO= Kaiser-Meyer-Olkin measure of sampling adequacy

An overall KMO value of 0.949 indicates that the data is highly suitable for the factor analysis, as it exceeds the recommended threshold of 0.5 (Table 8). The Scale Reliability Coefficient of 0.990 suggests high internal consistency, indicating that the variables in the scale reliably measure the same construct (Table 8).

The analysis reveals that Factor 1 explains 94.43% of the total variance in the perceptions of CSAPs' effectiveness (Table 9).

Table 9 Rotated factor loadings (pattern matrix)

Factor	Variance	Difference	Proportion	Cumulative
Factor1	6.610	.	0.944	0.944

The mean value for the variable effectiveness of CSAPs was 8.020. This exceedingly small mean suggests that, on average, participants rated the effectiveness of CSAPs close to zero. However, it is essential to note that the mean value, in this case, is negligible due to its small magnitude. The standard deviation (SD) of 1 indicates that the responses vary across the participants. The minimum perception score is -1.262, suggesting that participants may hold a negative view of the effectiveness of CSAPs. On the other hand, the maximum perception score is 1.352, indicating that participants may have a highly positive perception of CSAPs' effectiveness (Table 10).

Table 10 Summary of the effectiveness of CSAPs

Variable	Observations	Mean	SD	Min	Max
Effectiveness of CSAPs	196	8.020	1	-1.262	1.352

4. Discussion

The findings reveal that respondents perceive CSAPs as positively enhancing various aspects of potato farming. They recognize the potential benefits of CSAPs, such as enhanced productivity, increased yields, improved soil health, and reduced water usage. Additionally, the respondents believe that CSAPs positively impact pest and disease management, leading to improved income and financial benefits and promoting crop diversification on potato farms. The study also shows that respondents acknowledge the role of CSAPs in promoting long-term sustainability and resilience in potato farming, considering them environmentally friendly, contributing to biodiversity promotion, and preserving land quality for future generations. These findings are consistent with the [18] study conducted in sub-Saharan Africa and Ethiopia, which revealed that farmers perceived that adopting CSAPs could enhance climate change adaptation and resilience by improving soil fertility and reducing soil erosion. This also aligns with those of [19], which highlighted the positive effects of soil management, composting, and agroforestry on soil health.

Regarding the effectiveness of CSAPs, the factor loadings indicate strong associations between the perception questions and the underlying factor of effectiveness. Respondents particularly view CSAPs as practical and feasible to integrate into existing farming techniques while also positively impacting the profitability of their farms. These findings suggest that farmers perceive CSAPs as suitable for local conditions and effective in mitigating extreme weather events, adapting to climate conditions, and ensuring success and stability in Irish potato farming operations. The high factor loadings in the Principal Component Analysis (PCA) of the perception questions related to benefits, sustainability, and effectiveness indicate that the factors adequately capture the data variance, supporting the findings' validity and reliability. Moreover, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy demonstrates that the data used for the factor analysis are well-suited, as all KMO values exceed the recommended threshold. This diversity of perspectives is crucial when developing strategies and interventions to promote the adoption of CSAPs. Understanding the factors contributing to farmers' positive perceptions can help tailor communication and extension programs to address concerns, build trust, and encourage wider adoption of sustainable agricultural practices.

5. Conclusion

Farmers' perceptions play a role in influencing the adoption of CSAPs. Through a comprehensive investigation of farmers' perceptions towards various CSAP innovations, this research has provided valuable insights into the factors that facilitate or hinder the uptake of these practices. The findings demonstrate that farmers' perception of CSA

innovations significantly varies across agroecosystems, which was attributed to varying climatic conditions, resource availability, and socio-economic factors. This suggests the importance of considering context-specific approaches while promoting the adoption of CSA practices to ensure their effectiveness and sustainability. Positive perceptions of CSAPs have been strongly associated with enhanced food security and climate change adaptation. Farmers who recognize the benefits of CSAPs, such as increased productivity, improved soil fertility, and reduced agricultural vulnerability to climate change, are more inclined to adopt innovative approaches like improved variety selection, crop residue management, and agroforestry.

Furthermore, the study reveals that adopting CSAPs for climate change mitigation was hindered by a lack of awareness of the potential benefits, particularly in agroforestry practices. Bridging this perception gap through targeted awareness campaigns and extension services could unlock agroforestry's significant climate mitigation potential, contributing to overall sustainability efforts. It is evident from the results that farmers' perception of the benefits and relevance of CSAPs is a critical driver of their decision-making process. As such, efforts to encourage the adoption of CSAPs should beaccompanied by initiatives that promote positive perceptions among farmers, highlight the tangible benefits, and address potential misconceptions or barriers.

Recommendation

A targeted approach to extension services is crucial, tailoring awareness campaigns to the specific needs of farmers in different value chains. A good policy should also be adopted to foster successful adoption, offering comprehensive packages of CSAPs rather than isolated practices. Also, providing targeted training and support in key practices such as agroforestry, compost making, and crop residue management can empower farmers to implement climate-smart practices effectively. Furthermore, public awareness campaigns by governments and non-governmental organizations are essential to promote the understanding and benefits of CSAPs. Lastly, further research, including exploratory factor analysis, can deepen our understanding of farmers' perceptions and the factors influencing CSA innovations adoption, aiding future interventions and policy development in the region. Implementing these recommendations can pave the way for enhanced agricultural productivity, climate resilience, and sustainable development within the Irish potato farming communities of Ainabkoi.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to disclosed.

Statement of informed consent

The study ensured that all participants provided written informed consent, and relevant documents were obtained accordingly. In cases where verbal consent was obtained, the reasons for opting for verbal consent were thoroughly documented and can be made available upon request.

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