Expert’s opinion on Irish potato farmers awareness and preferences towards climate smart agriculture practices attributes in Kenya; A conjoint analysis

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Abstract: Climate change is an environmental threat to all sectors, especially the agricultural sector around the globe. Climate Smart Agriculture (CSA) is one of the essential strategies to overcome low productivity, adaptation and mitigation problems in the face of global climate change challenges in developing countries including Kenya. Despite considerable efforts to improve adoption of CSA practices in Kenya, increasing awareness does not necessarily imply that farmers have access to innovative CSA practices preferred. There is no empirical evidence on how previous research adequately addressed how CSA attributes are compatible with Irish potato farmers’ awareness and preferences. A Delphi study was conducted to elicit information on farmers awareness and preference towards CSA practices and their pillar attributes from 22 experts from varied Irish potato and climate research organizations in Kenya. Descriptive statistics were used to analyse farmers awareness of CSA practices while conjoint experiment method was employed to identify the most preferred attributes of CSA pillars. The results showed that farmers were aware (76%) of the listed CSA practices even though the CSA practices uptake was

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PUBLIC INTEREST STATEMENT
The Climate Smart Agriculture (CSA) concept arises from the need to provide innovative solutions towards the complex and integrated goals of increasing yields, improving resilience and promoting low emissions in the agricultural sector. The awareness and preference of Irish potato farmers and experts’ opinions on different CSA practices and their pillar attributes being adopted highly affect upscaling of such practices and technologies. The variation in the implementation of such CSA practices is influenced by various determinants such as ecological differences and socio-economic factors of smallholder farmers. The expert opinion on farmer awareness and preferences on CSA have been studied before however, not specifically in Irish potato farming in Kenya. Hence, this conjoint analysis study adds to the knowledge gap on how farmer awareness and preferences affect adoption of selected CSA practices and the contribution of the CSA pillars to the current increasing climate adaptation concerns.
still low (40%). Furthermore, the findings indicated high adaptation, medium mitigation and high productivity were the most preferred CSA combination across the pillars by the farmers. Contrary to this low adaptation, low mitigation and low productivity were the least preferred CSA combination across the pillars. In addition, the result revealed that adaptation and mitigation were the most important factors that influence farmers preferences for CSA practices in Irish potato farming. Based on these findings, the study, therefore, calls for the need to set the level of priority towards climate change and adaptation and establish a solid strategy of creating awareness in the implementation of CSA practices. There is a need to plan for a coordinated and effective capacity-building effort focusing on CSA pillars tradeoffs.

Subjects: Agriculture & Environmental Sciences; Soil Sciences; Environmental Studies; Environmental Issues; Conservation - Environment Studies; Research Methods in Environmental Studies; Biodiversity & Conservation; Ecology - Environment Studies; Environmental Policy; Environmental Change & Pollution

Keywords: Climate Smart Agriculture; Conjoint Analysis; Preference; Adaptation; Mitigation; Irish Potato

1. Introduction

Irish potato (Solanum tuberosum L.) contributes to world food security and has a critical role to play in developing nations facing hunger. Irish potato is one of the roots and tuber crops that can help solve food insecurity and nutritional challenges in Africa (Liu et al., 2014). In Kenya, Irish potato value chain employs over 2.5 million Kenyans as market agents, transporters, vendors, processors and retailers (Okello et al., 2016). Despite the potential contribution of Irish potatoes, climate change is seen to affect Irish potato production around the globe. According to FAOSTAT (2019), the global production of Irish potato stands at 370.4 million tonnes with Africa and Kenya having a share of 26.5 million and 2 million tonnes respectively as in Table 1. Irish potato being a highly sensitive crop to weather conditions is projected to decrease by 22% in Sub-Saharan Africa (SSA) due to its susceptibility to both rainfall and temperature, leading to food insecurity (Spore, 2015 & Ndegwa et al., 2020). In Kenya, while

| Year | World Production (Million Tonnes) | World Acreage (Million ha) | Africa Production (Million Tonnes) | Africa Acreage (Million ha) | Kenya Production (Million Tonnes) | Kenya Acreage (Million ha) |
|------|----------------------------------|----------------------------|-----------------------------------|-----------------------------|---------------------------------|----------------------------|
| 2009 | 330.78                           | 18.58                      | 21.88                             | 1.70                        | 2.30                            | 0.12                       |
| 2010 | 328.66                           | 18.17                      | 24.98                             | 1.73                        | 2.73                            | 0.12                       |
| 2011 | 367.99                           | 18.70                      | 25.76                             | 1.82                        | 2.37                            | 0.12                       |
| 2012 | 361.05                           | 18.70                      | 27.76                             | 1.85                        | 2.92                            | 0.14                       |
| 2013 | 365.21                           | 18.51                      | 28.43                             | 1.90                        | 2.19                            | 0.15                       |
| 2014 | 370.01                           | 18.05                      | 24.23                             | 1.65                        | 1.63                            | 0.12                       |
| 2015 | 366.14                           | 18.07                      | 25.27                             | 1.69                        | 1.96                            | 0.13                       |
| 2016 | 354.19                           | 17.41                      | 23.24                             | 1.67                        | 1.34                            | 0.15                       |
| 2017 | 370.10                           | 17.44                      | 24.22                             | 1.69                        | 1.52                            | 0.19                       |
| 2018 | 365.32                           | 17.16                      | 25.40                             | 1.70                        | 1.87                            | 0.22                       |
| 2019 | 370.44                           | 17.34                      | 26.53                             | 1.76                        | 2.00                            | 0.21                       |

Source: FAOSTAT, 2019
Irish potato production has shown a relative decrease from 2.30 to 2.00 million tonnes, between 2009 and 2019 there has been an increase in acreage under production from 0.12 to 0.21 million hectares over the same period. The decrease in production despite increase in acreages have also been reported by (Wang’ombe & van Dijk, 2013) who found the decrease to be attributed to a non-linear relationship of the input variables used by smallholder farmers such as the use of certified seeds. Therefore, if interventions are not taken into account then this would lead to an increased trend of food insecurity associated with a decrease in land allocation for the cultivation of other crops.

Several studies in Africa (Fisher et al., 2015; Fosu-Mensah et al., 2012; Gnangle et al., 2012; Juana et al., 2013; Muzamhindo et al., 2015) have examined the effects of climate variability on agricultural production, food security and farmer livelihoods. The threat of climate change to agriculture, food security and livelihood places millions of people lives at stake across the world (Intergovernmental Panel Climate Change(IPCC), 2014; Khatri-chhetri et al., 2017). Responding to climate change is thus important for attaining food security. There are several potential adaptation options to reduce severe to moderate climatic risks in agriculture. Climate Smart Agriculture (CSA) is one of the suggested pathways to the improvement of food security in a changing climate (FAO, 2013; Hasan et al., 2018). In general, adaptation options that sustainably increase productivity, enhance resilience to climatic stresses, and reduce greenhouse gas emissions are known as climate-smart agricultural (CSA) technologies, practices and services (Foa, 2010; Khatri-chhetri et al., 2017). Existing literature shows that CSA practices can increase crop productivity and thus contribute to food security (Brüssow et al., 2017). At the same time, agricultural mitigation as a CSA pillar can minimize atmospheric greenhouse gas (GHG) concentrations and slow climate change itself (Verhagen et al., 2014; A. Wasse & Pauline, 2018). Schoofma et al. (2019) note that the promotion of CSA techniques to increase farmers resilience against climate change and improve their livelihoods is high on the international development agenda and aims to help achieve Sustainable Development Goals of food security (SDG 2) and climate resilience and mitigation (SDG 13). Thus, CSA has the potential to mitigate the negative effects of climate change and improve the efficiency of Irish potato production. Wekesa et al. (2018) note that CSA has been documented to register stable and higher yields and thus stable income from farming leading to high resilience in some regions of Kenya in comparison to conventional methods of production in agriculture. The 2017 Kenya Climate Smart Agriculture Strategy claims to guide a transformation of Kenya’s agricultural system through an integrated approach to agriculture, climate change, development, environment and food security (Failing, 2020).

Despite the various benefits of CSA practices, the current rate of adoption is fairly low among smallholder farmers in Kenya (Kurgat et al., 2020). Identification, prioritization and promotion of available CSA technologies considering local climatic risks and demand for technology are major challenges for scaling out CSA in diverse agro-ecological zones. However, finding optimal solutions in addressing climate change challenges in the implementation of CSA is also affected by different factors such as awareness, farmers preferences, socioeconomic characteristics, and prevailing climatic conditions (Musso et al., 2012). Furthermore, farmers preferences to CSA technologies are also linked and differ based on the benefits and cost of the CSA technologies (Khatri-chhetri et al., 2017). For example, application of weather smart information and technology would help in minimizing farming losses due to climate risk as it enhances proactive awareness and preparedness (Okonya et al., 2013). Probably, the ignored preferences are some of the socio-economic and policy trends exacerbating vulnerability of smallholder farmers and other marginalized communities to the impacts of climate change. (Musso et al., 2012). Thus, prioritization of the technologies used by farmers also has high implications in designing and implementing climate change adaptation practices. Further, awareness regarding the phenomenon of climate change and its adverse impacts is important for households and communities to cope with those impacts (Mustafa et al., 2019). Thus, through capacity building programs, information about CSA practices can help farmers identify efficiencies that lead to higher productivity and profitability, lower input costs and optimize fertilizer use.
Research has been done on climate change adaptation strategies, but little has been reported on awareness and preference of CSA attributes among Irish potato farmers especially in Kenya. Given the uncertainties of the multiple effects of climate change in agriculture, farmers and stakeholders must be constantly updated about the latest recommendations for each crop activity (De Sousa et al., 2018). The national development discourse emphasizes agriculture and food security, as demonstrated by Agriculture Sector Transformation and Growth Strategy (ASTGS) 2018–2030 (Boulanger et al., 2018). Further, to attain food self-sufficiency and equitable distribution of nutrients to all Kenyan citizens, the government of Kenya has developed the food security pillar under the “Big Four Agenda”. Under food security, the government has set up strategic interventions on expanding food production, which includes promoting Irish potato production. The government has identified Irish potato as one of the indigenous foods that can contribute towards diversification of the staple foods and boost the total volume of food production in the country (Laibuni et al., 2018). Building on this body of literature, the main objective of this study is to assess Irish potato farmers awareness of climate (CSA) practices and preferences of CSA attributes based on experts’ opinions. Our study contributes to the expert’s opinions about farmer’s preferences literature because to the best of our knowledge this is the first study to investigate expert’s opinions about Irish potato farmers preference on CSA practices using conjoint analysis in Kenya. This study is therefore designed to fill these knowledge gaps.

2. Methodology

2.1. Study area

This study assessed potato production in relation to climate change and CSA practices in Kenya. In Kenya, potatoes are mainly cultivated in the high-altitude areas (1,500–3,000 m above sea level), where Kenya’s main staple food maize has no comparative advantage (Muthoni & Nyamongo, 2009). Cultivation of potato is concentrated in highland areas from 1,200–3,000 m above sea level; where over 70% of potato is cultivated above 2,100 m above sea level. The major potato growing areas also experience an average minimum temperature of 8°C and an average maximum temperature of 23°C (Muthoni et al., 2017).

Rain is one of the most important determinants of agricultural production. The ideal ecological conditions for the production of Irish potatoes are areas receiving an average of 1125 mm/pa of rainfall (Muthoni et al., 2017). The existing two rainy seasons which determines potato production in Kenya are; the “short rains” which traditionally fall between October and February and; the “long rains” which fall between March and September. Generally, farmers grow potatoes twice a year, with a three-month interval between harvests. They plant for the short rains in October/November, for harvesting in January and February. Long rains planting is in March and April, with the crops harvested in July and August (Sinelle, 2018). Table 2 summarizes the schedule.

| Table 2. Irish potato cultivation schedule in Kenya |
|----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
|                | Jan     | Feb     | Mar     | Apr     | May     | Jun     | July    | Aug     | Sep     | Oct     | Nov     | Dec     |
| Short rains    | H**     | H**     |         |         |         |         |         | P**     | P**     |         |         |         |
| Long rains     | P**     | P**     |         |         | H**     |         |         | H**     |         |         |         |         |
| H**: Harvesting/ P**: Planting |

Irish potatoes are mainly grown by small-scale farmers, many of them women, although some larger-scale growers specialize in commercial production in Kenya (Janssens et al., 2013). Potato thus represents a cash crop for smallholder farmers and plays an important role in national food and nutrition security (Kaguongo et al., 2014).
2.2. Experts selection

The study employed the Delphi approach of exploring the expert’s opinions on farmer preferences of CSA practices since there was no consensus on the required number of participants (Roy et al., 2014). The Delphi method has been previously used in agriculture, technology and social changes (Brady, 2015; Brier et al., 2020; Eastwood & Dela Rue, 2017). The Delphi method utilizes group interactions for decision-making and can minimize the impact of dominant participants, while strengthening the groups reasoning through challenging respondent’s assumptions (Hasson & Keeney, 2011). The statistical sample consisted of 22 experts selected by the snowball sampling method. The study purposively sought individuals from academic, non-governmental organizations (NGOs) and government (Hsu & Sandford, 2007; Lee et al., 2015; Mohammadi et al., 2021). Purposive sampling involved identifying and selecting experts or groups of experts, especially competent or familiar with climate change and Irish potato value chain issues (Palinkas et al., 2015). The inclusion criteria for the experts included; i) experts with 10 years of relevant professional experience (ii) individuals who have been directly involved in Irish potato research, expansion, management and marketing for at least 5 years (iii) individuals who have been engaged or consulted for a minimum of 10 cumulative years in agricultural policy making in the potato value chain within the government or private sector.

2.3. Participating experts

A total of 28 CSA experts were contacted; however, 22 CSA experts responded to the invitation to join this study and completed the questionnaire and the interviews. However, six of the selected CSA experts declined, citing time constraints, resulting in a response rate of 78.6 %. The expert respondents came from different Non-Government Organizations (NGOs) and international research institutions such as Consultative Group for International Agricultural Research (CGIAR) (18%), Agrico East Africa Ltd (5%), International Potato Center (CIP) (5%), Netherlands Development Organization (SNV) (18%). The government institutions included the Ministry of Agriculture (MoA) (18%), National Potato Council of Kenya (NPCK) (18%), Kenya Plant Health Inspectorate Services (KEPHIS) (5%), Kenya Agricultural and Livestock Research Organization (KALRO) (5%) and Jomo Kenyatta University of Agriculture and Technology (JKUAT) (9%) with expert knowledge in the potato value chain and climate change. Figure 1 shows the distribution of experts from various institutions who were engaged during the process of data collection.

Figure 1. Experts’ distribution.

2.4. Delphi questionnaire structure

According to Roy et al. (2014), the Delphi method usually starts with an open-ended questionnaire. However, Kuo & Chen (2008) opines that the first round of the Delphi method should start with a literature review to adequately consider all of the issues that concern interviewees. The Delphi method has been used and its implementation in different fields was also developed for determining various factors in agricultural research (Rasouli et al., 2009). Correspondingly, this study carried out a review of the literature followed by conducting the Delphi survey to achieve expert consensus. Each round was based on the outcome of the preceding one.
In the first round of proofing, experts received a list of CSA adaptation strategies and attributes. The literature review drew the initial list of CSA adaptation strategies and experts were asked to make any adjustments to the initial list where necessary. The plan was for experts to make any adjustments proposed before evaluating the CSA adaption strategies.

Questionnaires were prepared in English language using Google forms and consisted of the following structure: (1) Professional activity and organization of the participants; (2) Awareness about climate change, its effects on farming and influence on the adoption of climate-smart practices (3) Opinions about farmers preference for CSA practices based on the attributes of the CSA pillars.

2.5. Conducting delphi survey
The online-based Delphi was adopted to improve the efficiency of the questionnaire by facilitating the process and saving time for the participants. The combination of the web-based survey platform and the questionnaire simplified the statistical analysis, avoiding the demands of paper-based surveys and limiting data entry and computing errors that are frequently reported in Delphi studies (Allen et al., 2019; Cam et al. 2002). The data collection process took place between September and October 2020 via email, Google forms, Zoom and telephone calls. Both qualitative and quantitative data were necessary because the objectives of the study required the acquisition of numerical data and preferences of CSA practices based on their attributes. Before the main interviews, questionnaires were pre-tested with three experts in September 2020 for clarity and editing. No major modifications were suggested; hence the three completed questionnaires were included in the analysis. Potential CSA experts were contacted and if they agreed to participate, detailed information about the study was provided and the questionnaires were sent via electronic mail.

One week after receipt of a questionnaire, the participants were asked to provide their feedbacks however, updates were sent to facilitate feedback from as many participants as possible. Extra time to complete a questionnaire was considered for some experts. Therefore, the realistic timeframe for the first round was 2 weeks and for the second round another 2 weeks. Experts’ interviews were conducted to provide the researcher with the knowledge of currently evolving new CSA strategies, their awareness and preferences for CSA practices. Experts also provided in-depth information on potential technical advances or activities, the effectiveness, economic performance, and the effect on CSA’s three pillars. Furthermore, it also helped where the required information was not found in any literature or other applicable sources. In general, expert elicitation was done through semi-structured questionnaires and interviews. This was to assess the subjective judgments of experts working in Kenya who were familiar with the subject on technical topics at a given point in time (Hagerman et al., 2010).

2.6. Data analysis
The qualitative information obtained from the telephone interviews were analyzed through content analysis. Quantitative information obtained from the expert’s survey were cleaned to ensure quality, coded and recorded in excel sheets then subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) version 26.

2.7. Conceptual framework
This conceptual framework is based on the understanding that different CSA strategies have been put forward to help farmers mitigate or adapt to climate change; the use of CSA practices has been recommended by research experts to help farmers adapt to climate change and variability. In this study, 19 different CSA practices identified were being used in potato farming in Kenya (Ogola & Ouko, 2021). The practices were identified from CSA strategies such as crop management practices, general field management practices, farm risk reduction practices, soil conservation practices, and information access practices. Awareness and preference of the attributes of these CSA practices by farmers based on the pillar performance influence their adoption and extent of use.
Figure 2 presents Irish potato CSA framework that integrates the preferences for its three pillars, including adaptation, mitigation and productivity based on their desirable outputs; increase in Irish potato yield, increase in Irish potato resilience and a reduction in GHGs emissions respectively.

Figure 2. Irish potato CSA conceptual framework.

2.8. Theoretical and empirical framework
This study uses conjoint analysis to elicit experts’ opinions on farmers preference for CSA attributes among Irish potato farmers. Conjoint analysis is a common method in marketing research but it has also become a tool in agricultural research (Steinke & van Etten, 2017). A three-step choice experiment design was adopted in this study. The steps included; specification of the model, development of a choice experiment survey and administering of the choice experiment. The attributes and attribute levels of the choice model were identified from the literature review and discussion with the experts. CSA pillars and their values were defined by the experts well in advance, being informed by the existing body of literature on climate smart agriculture, smallholder farmer’s vulnerability and preferences with regard to adapting to potential and current climate change impacts. The various combinations of the attribute/factor values yielded fictive combinations of the CSA strategy that were ranked by the experts about activities of smallholder farmers in Kenya.

| Table 3. Conjoint Plan | Pillar Productivity | Pillar Adaptation | Pillar mitigation |
|------------------------|---------------------|-------------------|------------------|
| Card ID | Low Productivity  | High Adaptation  | High mitigation |  
| 1 | Medium Productivity | Medium Adaptation  | Medium mitigation |  
| 2 | High Productivity | Low Adaptation | Low mitigation |  
| 3 | High Productivity | Medium Adaptation | Low mitigation |  
| 4 | Medium Productivity | Medium Adaptation | High mitigation |  
| 5 | High Productivity | Low Adaptation | Medium mitigation |  
| 6 | Medium Productivity | Medium Adaptation | Low mitigation |  
| 7 | Medium Productivity | Low Adaptation | High mitigation |  
| 8 | Medium Productivity | High Adaptation | Low mitigation |  
| 9 | High Productivity | Low Adaptation | High mitigation |  

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A full factorial experimental design that combined every level of each CSA attribute/factor with every level of all other attributes was used. The experiment was constructed with three attributes (n = 3, productivity, adaptation and mitigation) each of the three which had three levels (L = 3) as shown in Table 3. The attribute levels were as follows;

- Attribute 1: Productivity with high, medium and low levels
- Attribute 2: Adaptation with high, medium and low levels
- Attribute 3: Mitigation with high, medium and low levels

Therefore, the number of profiles (np) generated for a full factorial design was \( \text{Ln} = 9 \) profiles. Using conjoint analysis technique, metric partial utilities from the ranking results were derived, the summation of which resulted in metric total utilities.

All the attributes/factors were assumed to be discrete to indicate that the factor levels are categorical and no assumption was made about the relationship between the factor and the ranks.

Among various conjoint analysis methods, this study applied choice-based conjoint analysis. The choice-based conjoint analysis is based on two key economic theories; Lancaster’s consumer theory and McFadden random utility theory. Lancaster’s consumer theory states that a product’s value can be expressed as a sum of the utility for each attribute because the consumer’s utility is derived not from the product itself but the product’s attributes (Lancaster, 1966). The basic assumption in this study was borrowed from Mussa et al. (2012), that smallholder farmers choose the best bundle of CSA practices which maximizes their utility. Therefore, in this study, it is assumed that smallholder Irish potato farmers can rank their preferences logically and consistently within the limits of their budget and knowledge constraints (Veldhuizen et al., 2011). Basing on Train (2003), utility maximization gives the behavioural model of decision-making as represented in equation 1 where;

\[ U_i > U_j \Rightarrow i \forall j \in C \]  

This means that alternative \( i \) is chosen over any other alternative \( j \) only if it provides the highest utility. That is, if the utility of alternative \( i \) is greater than utility of all alternatives, \( j \). Alternative \( i \) will be preferred and chosen from the set of alternatives, \( C \).

\( \Rightarrow i \forall j \) means the alternative to the left is preferred to the alternative to the right, and \( \forall j \in C \); means all the cases \( j \), in the choice set \( C \). The probability that alternative \( i \) is chosen is depicted by equation 2.

\[ P_i = \Pr (V_i + \epsilon_i > V_j + \epsilon_j \forall j \neq i) \]  

Furthermore, the Random Utility Maximization (RUM) theory allowed researchers to include some uncertainty in the model as the utility is expressed in deterministic utility (\( V \)) and stochastic utility \( \epsilon \). RUM assumes that individual utility \( (U) \) is unknown but can be decomposed into observed or deterministic component \( (V) \) and an unobserved or stochastic component \( (\epsilon) \). Thus, for individual smallholder Irish potato farmer \( j \) in scenario \( i \), utility was expressed as; in equation 3.

\[ U_{ij} = V_{ij} + \epsilon_{ij} \]  

Following the estimation of the conjoint model, the importance of each attribute was computed. The relative importance of each attribute \( (i) \) is calculated in a two-step process. First, for each attribute, the highest and lowest part-worth for the attributes are determined. Then, the attribute part-worth range, consisting of the difference between the highest and lowest part-worth, is calculated. Next, the sum of the ranges overall attributes is computed. The relative importance of each attribute \( (i) \) to consumers is defined as in equation 4.
Relative importance = \frac{100 \times \text{range}(i)}{\sum \text{range}(i)} \quad (4)

The part-worth utility model is widely accepted due to flexibility to judge preferences for differences in the level of attributes and its easy interpretation as compared to ideal-point model and vector model (Rao, 2014)

3. Results and discussion

3.1. Awareness of climate change variability and its effect on Irish potato farming

With regard to awareness of climate change, 100% (n = 22) of the experts interviewed agreed that farmers perceived climate change and variability to be affecting Irish potato production in Kenya and thus they were aware of climate change. The views were attributed to the experts’ observations and various indicators reported by farmers in the past 10 years on climate change and variability. Some of the indicators of climate change listed by the CSA experts indicated that farmers experienced changes in rainfall patterns, floods, dry spells, and prolonged droughts coupled with increased temperatures, the emergence of pests and diseases, fragile agricultural lands and varietal turnovers. The findings are in line with previous studies (Muthoni et al., 2017; Macharia et al., 2012) who identified erratic and low rainfalls, frequent droughts and dust storms, low crop yields and high day and low nighttime temperature, pests’ emergence (aphids, potato tuber moth and leaf miners) and diseases such as late blight, bacterial wilt, and viruses as the leading indicators of climate change and variability in crop production.

Figure 3, illustrates that majority of the CSA experts (more than 55%) were in agreement that climate change’s impact increases chances of crop failure. The overall decline in crop yield (86%) leads to reduced incomes for the farmers and fluctuating prices affect the variable costs. The emergence of new strains of pests and diseases (91%) in potato farming results in reduced income due to heavy investment or over expenditure in farm inputs such as seed and pest control products. Moreover, the inability to plan farming activities (64%) resulted in farmers incurring losses through poor yields and delayed planting season for potato production. Lastly, erratic and low rainfall (68%) currently experienced in potato growing areas affects soil moisture leading to either flooding or wilting of crops respectively. The distribution of rainfall is an important factor in crop production; poor rainfall distribution leads to low yield, thereby reducing incomes for farmers. The weather changes within the seasons affect the production quantities translating to high market prices for consumers for 7 out of 12 months in a year.

![Figure 3. Effects of climate change on Irish potato farming.](image-url)
Asrat and Simane (2018) notes that adaptation to climate change is a two-step process requiring farmers to first perceive climate change and then respond to the changes in the second step. Subsequently, farmers who are aware of climate change, its causes and consequences are more likely to adopt adaptation measures and mitigation practices to cope with the adverse effects of climate change. These findings are supported by Adebayo et al. (2012) who observed that large majority of the respondents (about 96%) were aware of climate change, while only about 4% seemed not to be aware of climate change.

3.2. Awareness of climate smart agriculture practices
Irish potato farmers awareness of CSA practices is presented in Figure 4. On average, 76% of the experts indicated that farmers were aware of the listed CSA practices. However, there was a low uptake (averagely 40%) of the majority of CSA practices, except for farmer knowledge sharing (91%), membership to farmer association (82%), early land preparation (73%), changing planting dates (73%), use of organic fertilizer (64%) and use of improved crop varieties (55%). The experts were of the opinion that some of the exceptional CSA practices are not costly in implementation, some having preference advantages over other practices and those with less commitment from farmers would be practised more. The result is in line with the previous findings across SSA indicating a high level of awareness with low adoption of CSA practices due to various resource and infrastructural challenges (Nyasimi et al., 2017; World Bank & CIAT, 2015), with studies in Kenya showing that adoption of the CSA practices is increasing though the level still falls below 50% implementation on most of the practices investigated (Kurgat et al., 2020). The foregoing indicates the need to enhance awareness creation about CSA practices to improve adaptation planning and actions and avoid any negative climatic impacts on farmer’s livelihoods (Fadairo et al., 2020)

3.3. Adaptive CSA practices currently used by farmers versus preferred by the experts
The analysis on the frequency of the experts’ opinion on CSA practices currently used by farmers revealed that use of improved crop varieties (73%), irrigation (64%), efficient use of inorganic fertilizers (59%), early land preparations (50%) and changing planting dates (45%) were the most popular practices among Irish potato farmers. In contrast, minimum tillage, use of cover crops, use of live barriers, access to weather information, crop insurance, agroforestry, diversified crop production and access to market information were the least popular practised CSA practices among Irish potato farmers (Figure 5). The experts opined that these CSA practices were being used because of their perceived benefits that farmers were aware of and erratic climate variability in their production areas.
On the other hand, experts preferred improved varieties, efficient use of agrochemicals, early land preparation, diversified crop production efficient use of inorganic fertilizer as the most important CSA practices farmers should embrace for climate change adaptation. However, agroforestry, mulching, farmer knowledge sharing, use of live barriers, and cover crops were least preferred by experts.

Previous studies (Kimani & Bhardwaj, 2015; Mutunsa et al., 2017; Ndambiri et al., 2012) reported that farmers adopt different crop varieties, change of planting dates, crop diversification, changing land area under cultivation. Moreover, this also entailed increased use of irrigation, increased use of fertilizers and pesticides, increased use of soil and water conservation technologies, and mulching and manure adoption to adapt to CCV. Asayehegn et al. (2017) found that farmers who were aware of climate changes in the long term essentially changed the varieties depending on the expectation of the rainfall duration. According to Wassihun et al. (2019), production of potatoes using improved potato seeds is more efficient compared to using local seeds. This implies that the tendency for any potato producers to increase their production depend on the type and quality of seed available at the right time of sowing. This was confirmed by Wondwesen Shiferaw and T (2015) who found dissemination of improved seed potato varieties to the farmers is vital to increase the productivity of Irish potatoes. Farmers can increase crop yield and farm income under climatic stresses with the help of simple adaptation measures such as high-efficiency irrigation technologies (Imran et al., 2019) The use of inorganic fertilizer in the production of small-scale potatoes can increase soil water retention and increase production levels. Gebru et al. (2017) assessed production practices of smallholder potato farmers in Southern Ethiopia. The study found out that about 88.5% of the farmers used fertilizers for their potato farm and 97.7% of the farmers were aware of methods and time of application of inorganic fertilizer. Early land preparations reduce the risk of crop failures while changing planting dates reduces vulnerability of farmers during seasons of poor rain, drought, or other extreme events (Muthoni et al., 2017; Nyang’au et al., 2020). Furthermore, this study found out that farmers adjusted planting and harvesting time, fitting them with the onset and offset of rainfall and looked for alternative income sources such as mixed farming of crops and livestock. The finding of this study is in line with those of A. S. Wassie and Pauline (2020).

### 3.4. Conjoint results about farmers’ preferences for CSA attributes

#### 3.4.1. Utility estimates model

In Table 4, conjoint analysis results indicate that experts ranking on the attribute levels had different influences on Irish farmer’s preference for CSA practices. This highest utility value was obtained from high adaptation (1.089), followed by medium mitigation (0.444). The medium adaptation received
a utility value of 0.378 and high productivity and high mitigation received 0.189 and 0.161 utility values respectively. However, the highest disutility value was observed on low adaptation (~0.711), followed by low mitigation (~0.606). Low productivity and medium productivity received disutility values of ~0.311 and ~0.122. The higher the positive utility value, the higher the preference of the farmer to that particular level. Attributes levels that received negative utility value does not mean that the factor level was unattractive to the farmer, just that attribute levels that received positive utility values were better. The utilities are scaled to sum to zero within each attribute and therefore some of the utilities must receive negative values (Orme, 2002).

Table 4. Utility estimation of part-worth model

| Attribute Attribute Level | Utility Estimate | Std. Error | Relative Importance |
|---------------------------|-----------------|------------|---------------------|
| Productivity | Low Productivity | -0.311 | 0.402 | 14.925 |
| | Medium Productivity | -0.122 | 0.402 | |
| | High Productivity | 0.189 | 0.402 | |
| Adaptation | Low Adaptation | -0.711 | 0.402 | 53.731 |
| | Medium Adaptation | 0.378 | 0.402 | |
| | High Adaptation | 1.089 | 0.402 | |
| Mitigation | Low mitigation | -0.606 | 0.402 | 31.343 |
| | Medium mitigation | 0.444 | 0.402 | |
| | High mitigation | 0.161 | 0.402 | |
| (Constant) | | 4.456 | 0.285 | |

Adaptation is the most important attribute, having a value of 53.73 % followed by mitigation at 31.34%. Productivity was the least important factor for farmer’s preferences for CSA practises at 14.93%.

3.4.2. Model Fitness

The correlations coefficients indicate the validity of the empirical data generated by the conjoint analysis. The Pearson’s R correlation coefficient shows the correlation of observed preference scores versus the conjoint model estimated preference score; whereas Kendall’s tau correlation coefficient shows the discrepancy of the ranks between the predicted and actual profiles (Rao, 2014).

As shown in Table 5, both Pearson’s R (0.917) and Kendall’s tau (0.600) correlations were significant and the values high and moderate respectively, implying that the logic judgment made by the model was appropriate. This indicates that the model is well fitted to predict the respondents’ preferences for different attributes. This conforms with the “thumb rule” that these coefficients should always be very high. These findings are in line with the previous findings of CSA pillars preferences and model fit results among farmers (Mussa et al., 2012; Wassie, 2016; A. Wassie & Pauline, 2018).

Table 5. Correlations between observed and estimated preferences

| Model estimator | Correlation Coefficient | P-value |
|-----------------|------------------------|---------|
| Pearson’s R     | 0.917                  | 0.000   |
| Kendall’s tau   | 0.600                  | 0.013   |
4. Conclusion and recommendations
Climate change and variability influence Irish potato farming which in turn will threaten national food security. Climate change awareness thus affects the extent to which Irish potato farmers relate and prioritize climate change as a driver of change. The overall level of awareness of CSA practices among Irish farmers is high, suggesting that future work should focus on building on how farmers manage risks under the current climate, to then take into account climate change. Further, results indicated that there was a consensus among the experts on the effects of climate change and variability on Irish potato farming. An adjustment to the actual or expected changes in Irish potato production has to be, therefore, among priorities in policy decisions. Farmers’ awareness of adaptation options and willingness to take action are as important as policy decisions.

Expert opinions about Irish potato farmers preference for CSA attributes and practices were consistent with the findings in the part-worth model utility estimation. The conjoint analysis findings indicated high adaptation, medium mitigation and high productivity were the most preferred CSA combination across the pillars by the farmers. Contrary to this low adaptation, low mitigation and low productivity were the least preferred CSA combination across the pillars. In addition, the result revealed that adaptation and mitigation were the most important factors that influence farmers preferences for CSA practices in Irish potato farming. The results indicate that a trade-off in the three pillars of CSA is inevitable.

Overall, the outcomes of this research point out the need to clearly set the level of priority towards climate change and adaptation and establish a solid strategy of creating awareness as there exists a tradeoff between the various pillars of CSA and their corresponding practices. It is also imperative that there is a need to plan for a coordinated and effective capacity-building effort focusing on CSA pillars tradeoffs. There is further the need to implement Crops (Irish Potato) Regulations, 2019 of Kenya which spells out the need to use pest control products registered for use in the Irish potato production as a strategy preferred by experts in the efficient use of agrochemicals. This calls for participatory approaches that promote better decision-making to help bridge the gap between national and local level implementation. Along with scientific and technical knowledge, local knowledge is essential for successful adaptation. Adaptation to climate change in general begins the local level. Policy should therefore take local knowledge into account to ensure sustainable adaptation.

A limitation of this study is that we focused only on experts’ opinions and knowledge about farmer’s awareness of climate change and their preferences towards CSA practices based on the pillar attributes. We did not include the farmers directly in this study as it was impossible to work with them due to the COVID-19 pandemic outbreak and the subsequent restriction measures to contain its spread. However, future research can explore the level of awareness and preferences of CSA practices by including all the relevant stakeholders including farmers to validate the findings of this study. Further research can also explore the determinants of farmers awareness and preferences for the various CSA practices.

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