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Drivers and socioeconomic factors influencing individual and household adaptation to climate change: A case study of residents of Leeds, UK

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The dynamic nature of human adaptation and coping strategies to climate change continues to arouse the interest of environmental researchers. This study contributed to this growing area of research by examining the drivers and some socioeconomic factors influencing individual and household adaptation to climate change. Data were collected through household surveys and in-depth interviews. Descriptive statistics, binomial logistic regression, multiple regression analysis, and content/discourse analysis were employed to analyse data collected. The study result shows that the majority of the respondents adopt low cost and low skill coping responses against cold spell. The comfort of the household was found to be the key driver of adaptation to cold spell. Meanwhile, government support and having previous experience of flooding increases the chances of households adopting flood defense measures. The result further shows that house type ($p<0.01$), house ownership ($p<0.01$), and income ($p<0.05$) were significant factors affecting the level of adaptation strategies adopted. Age, gender, and education were found not to be significant in affecting the level of adaptation strategies adopted. The study recommended that government support as well as improvement in some socioeconomic factors like income level and educational level will increase individual and household resilience against climate change.

Key words: Climate change, adaptation drivers, protection motivation, coping responses, individual and household, UK.

INTRODUCTION

In recent years, climate change adaptation (CCA) has become the watch word in many international organizations and development agencies- such as the United Nations (UN), the Economic Co-operation and Development (OECD), etc. The focus on CCA reached a high point perhaps with the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1988, and the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 (Mitchell and Tanner, 2006). These global environmental agencies,

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undoubtedly, emerged because of the need to chart a course on how the human society can cope and adapt to the vagaries of weather caused by the unprecedented rate of increase in climate change (CC) in recent human history (IPCC, 2001; UNFCCC, 1992). Accordingly, concerted efforts have been made, and researches conducted, on how to improve societal adaptive capacities (Conde et al., 2007). However, according to Porter et al. (2014), most of these efforts and researches have focused on public and private organizations with little attention to individual and household adaptation. Although climate change is a global phenomenon, its impacts are felt at the household and individual level. The UK has experienced several impacts of climate change in the recent past that necessitates individual responses. For instance, in 2013, The Climate Reality Project reported that UK and most countries in mainland Europe witnessed one of the highest heat waves in its history. This extreme climatic event which happens to be the hottest summer recorded in the last 500 years led to the death of many, with UK alone recording more than 2,000 casualties. A post assessment of this tragic event shows that individuals were not sufficiently prepared to positively respond to such extreme climatic event ((Herring et al., 2016). Another extreme climatic event in the UK that requires individual adaptation is the problem of flooding. Environmental reports in the UK show that flooding risk is on the increase (Alexander et al., 2016). In 2015, Leeds City in the UK experienced one of its highest and widespread flooding ever recorded, with a devastating effect on lives, homes, and businesses. Again, such common extreme climatic event requires adequate adaptation responses from individuals and households. An empirical examination of the proximate and underlying drivers of individual and household adaptation is the focus of this study. This is because, the little available literature on individual and household adaptation has been more theoretical, with limited empirical evidence to support a more general and representative data on individual and household engagement in CCA (Porter et al., 2014).

In the UK, progress has been made to engage the government, the public and private business companies in CCA policies. What remains is to take a step further to engage individuals and households as well (Tompkins and Adger, 2003). Available literature suggests that building CCA capacity at the individual and household levels will improve UK's resilience to CC (Shaw et al., 2007). While the roles and importance of individuals and households has been recognised in UK's Climate Impacts Programme (UKCP), empirical evidence on the key drivers, and the influence of socioeconomic factors in CCA is largely absent in the literature. This partly suggests why CCA studies grounded in UK have failed to provide solutions to major impacts of CC frequently experienced in the UK- such as cold spells and flooding. Hence the needs to critically examine the drivers and socioeconomic factors influencing individual and household adaptation suggest a critical research agenda for UK.

According to Gawel et al. (2012), drivers of CCA are incentives that motivate individuals to respond to climatic risks. Porter et al. (2014) identified three drivers of household adaptation in the UK. These include; previous exposure to extreme weather, social acceptability, and long-term financial reward. For instance, Walker et al. (2011) and Whitmarsh (2008) found that individual households in UK who have experienced flooding show more willingness to adopt flood defense measures than households that have not experienced flooding. Furthermore, Porter et al. (2014), Stenek et al. (2013), Fankhauser and Burton (2011), and Kunreuther and Kerjan (2009) all posit that individuals and households would be more willing to adapt if they perceive the long term financial benefit of adaptation. Additionally, Grothmann and Patt (2003), in trying to find out why some individuals have more adaptive capacity than others, identified "self- motivation" and desire for comfort as another major drivers of adaptation that have been neglected in literature. They showed that often at times, people are self -motivated to take precautionary measures to protect themselves against climatic risks, as well as install adaptation features that will make their houses more comfortable, without necessarily having an external motivation.

Agrawal (2008) argues that if adaptation to CC is to help the most vulnerable social groups, then it must involve individuals at the local level, and its effectiveness depends (among other things) on building individual capacities, and understanding the key drivers and socioeconomic factors influencing their choices of adaptation strategies. UKCIP (2004) noted that CCA do not take place in isolation, it happens within the context of society, shaped by socioeconomic scenarios. Hence, capacity to adapt will be influenced by socioeconomic factors. Understanding socioeconomic variables that influence level of adaptation will therefore provide policy makers with background information about the capacity of individuals and households to build resilience to CC (Smit et al., 2007).

In the light of the above, Porter et al. (2014) classified CCA into low cost-and-low skill adaptation measures called coping responses,- meant to manage short-term climatic stimuli such as cold spells. They include mostly behavioral adjustments such as change of clothing, use of heater during winter, installing of double-glazed windows to cushion extreme colds, etc. The other class of adaptation is the more technical and financially demanding measures usually associated with adaptation with flooding. They include removing tarmac/pavement and replacing with soil/trees, taking flood insurance policy, sealing entry points to prevent water coming into the house, etc.

This study asks; do socioeconomic factors influence

the level of CCA, and what are the key drivers that motivate the adoption of various coping responses and adaptation features/strategies against cold spells and flooding? The overarching aim is to derive context-specific evidence on the drivers and socioeconomic factors influencing individual and household adaptations, using residents of Leeds as a case study. Specifically, the study seeks to: i) identify coping responses and adaptation features/strategies adopted by residents of Leeds against cold spells and flooding, ii) identify the proximate and underlying drivers of individual and household adaptation, and iii) determine socioeconomic factors affecting level of adaptation to CC.

THEORETICAL AND EMPIRICAL BACKGROUND

This section presents a review of two major issues: first, it provides the theoretical underpinnings of the study; and secondly, it explores empirical literature regarding climate change adaptation and adaptation drivers. These two reviews provide a conceptual background for the study.

Motivation and behaviour theories

Addressing the global challenges of climate change adaptation all relate back to individual behaviour and responses towards the environment. Human behaviour is notoriously complex and motivation for behaviour is multifaceted (Kissinger et al., 2012). In the context of climate change adaptation, several theories have been propounded to explain the motivating drivers of choosing one adaptation strategy or the other. Some of these theories have attempted to answer questions such as; how can individuals be motivated towards pro-environmental behaviour in terms of choosing the right adaptation options? What are the different strategies to influence pro environmental behavioural change?

From the wealth of several theories attempting to explain the drivers and motivations for climate change adaptation behaviour, we selected two that are most relevant to individual and household adaptation. These include the Protection Motivation Theory (PMT) and the Theory of Planned Behaviour (TPB). These are theories that link one's belief and eventual behaviours towards an issue. They are adapted to examine the role of information and environmental awareness, social interactions, and personal perceptions in influencing individual's adoption of coping/adaptation strategies thus, making them the most relevant for the study in examining the motivating drivers of climate change adaptation among individuals and households.

Protection motivation theory

Propounded by Rogers in 1975, this theory was originally proposed to understand fear appeals and its coping strategies (Rogers, 1975). However, in 1983 the theory was expanded to explain the concept of persuasive communication and how people behave and cope during stressful conditions (Rogers, 1983). The core assumption of the theory is that people will normally protect themselves against four perceptions: perceived probability of the occurrence of a threatening event or vulnerability; perceived severity of such a threatening event; perceived self -efficacy in managing such a threatening event; and finally perceived efficacy of recommended preventive measures (Rogers, 1983).

This theory aptly fits into explanations around how people respond to climate change threats and coping strategies against such threats. This is because the protection motivation theory anchors on two factors: threat appraisal and coping appraisal. In the climate change discourse, the threat appraisal assesses the severity of the climate change event and its adverse impacts. It takes care of the first two perceptions that people will normally protect themselves against – perceived occurrence/vulnerability and perceived severity of such occurrence. Here, the theory posits that self defence against potential threats is the motivation for certain behavioural responses. The coping appraisal on the other hand assesses how individuals respond to such situations. In this case, it assesses the last two individual's perceptions of self-efficacy and recommended efficacy of preventive measures. Self- efficacy is the belief in one's ability to cope with threatening climatic events and successfully execute recommended adaptation options (Prentice-Dunn et al., 2009). This implies that it is more likely that an individual will positively respond to or adopt coping strategies if he believes that he has the capacity and resources to execute such a coping strategy. This relates directly with the perceived resilience level of individuals against climatic threats. It also implies that costly coping strategies are less likely to be adopted by individuals. Another factor that will influence adoption of a coping strategy is the individual's expectancy and belief in the effectiveness of a recommended coping strategy to remove a climatic threat. Therefore, the PMT is one model that could be adopted to explain why individuals accept or reject some coping/adaptation strategies (Herath and Rao, 2009). It goes further to suggest ways through which negative response/behaviour towards climate change adaptation could be changed. One of such ways is the role of education and motivation in changing peoples' attitude towards climate change adaptation (Ifinedo, 2012).

Theory of planned behaviour

The Theory of Planned Behaviour (TPB) proposed by Icek Ajzen is a modification and improvement of the Theory of Reasoned Action (TRA) – which postulates that

an individual's behaviour is usually influenced not only by his pre-existing attitudes, but also by the expected potential outcome of his behaviour (Ajzen, 1991; Ajzen and Fishbein, 1980). As an extension of the TRA, TBP, in addition to attitudes and expected behavioural outcomes incorporates perceived behavioural control (rational thinking) as factors that govern individual's considerations, which in turn influence their choices, decisions, behavioural intentions, and behaviour. The core assumption of the theory is that individual's personal attitude, subjective norms, and perceived behavioural control all come together to shape an individual's intentions and final behaviour (Ajzen and Fishbein, 1980).

According to the theory, individual's attitudes will usually be influenced by cognitive beliefs which in turn affects one's intention to act or not to act. Where the outcomes of such intentions are favourably perceived, it will most likely lead to positive behaviour and increased likelihood of actual performance. This suggests a nexus between attitudes, intentions and behaviour. Some environmental scholars have hinged on this to posit that most pro- environmental behaviours are as a result of self- motivation (internal factors) that results from one's perceived benefit of adopting one adaptation strategy or not (Grothmann and Patt, 2003).

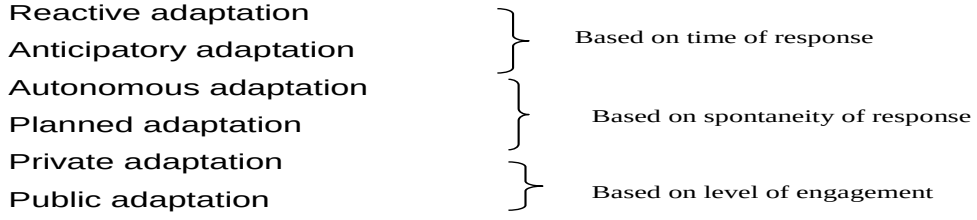
In a similar manner, intentions and final behaviour are not only products of beliefs and attitudes but also influenced by subjective norms. This is against the backdrop that man is a social being and thus, his behaviour and actions will be influenced by the beliefs and actions of others. This suggests that in a situation where the general society demonstrates a favourable response towards an issue, individuals are most likely to key it to the societal thinking and consequently develop a similar positive behaviour towards such an issue. This could further explain the upsurge of positive interests about climate change adaptation in the society today. Many people are gradually becoming interested in climate change adaptation as a result of public awareness campaign and global interest on the matter (Ford et al., 2011; Wolf et al., 2010; Parry et al., 2009).

The third distinguishing component of the TPB is the perceived behavioural control which influences one's intentions and behaviour. This has to do with one's perceived ability to actually perform or engage in a particular behaviour. Available literature on TPB shows that this perception is divided into internal and external control factors. The internal controls relates to how an individual perceives himself as being in control of a specific behaviour. Such level of control, according to Jackson (2005), is usually influenced by the sufficiency of the resources available to him such as skills, finance, and knowledge, in addition to the amount of sacrifice or discipline he is willing to make in performing the behavior. The level of climate change knowledge and awareness, together with the amount of information availability about a particular adaptation strategy comes to play here in determining adaptation responses and drivers. Modern proponents of this theory have however acknowledged that the link between information availability, intention to act and final behaviour is not very straightforward; there are other intervening factors between awareness, intention and behaviour (Kaiser et al., 2010; Jackson, 2005; Kollmuss and Agyeman, 2002). For example, level of understanding a particular adaptation strategy will ultimately influence final behaviour in adoption. External controls on the other hand more or less mirror the influence of subjective norms. It relates to how societal perceptions, acceptance or approval of behaviour will influence individual's action towards such behaviour. For example, if one's family and/or friends approve or are practicing a particular adaptation strategy, it may boost an individual's intention to adopt such strategy. In addition to societal perception, time is another factor that will impact behavioural control. The following section explores relevant empirical evidences on individual and household adaptation and adaptation drivers to climate change.

Empirical evidence on what we know about types and drivers of individual and household adaptation to climate change

Types of climate change adaptation

Available literature identifies different types of adaptation. According to Carter et al. (1994), there are many factors that determine how adaptation is classified. These factors include; time of response, spontaneity of response, and level of engagement (Porter et al*.,* 2014; IPCC, 2001; Smit et al., 2000; Burton, 2000). Based on these factors, the following adaptation types were identified:



IPCC (2001) defined reactive adaptation as any adaptation that takes place after the impacts of CC have

been observed. Porter et al. (2014) noted that most individual and household adaptation types in the UK fall within this category. This assertion was supported by New et al. (2011) and Ford et al. (2011) who found out that most households in UK only adopted some flood defence measures after experiencing flooding. On the other hand, anticipatory adaptations are adaptations that require more proactive approach such as construction of storage reservoirs to guard against flooding (IPCC, 2001). Harvatt et al. (2011) disclosed that most UK residents are not sensitive to this type of adaptation. It was discovered that reactive adaptation has a direct link with "private adaptation" type which is any adaptation initiated by individuals (IPCC, 2001). However, private and reactive response actions are grossly inadequate to manage more complex and serious climate risks (Niemeyer et al., 2005).

Autonomous adaptation which does not require any conscious planning (IPCC, 2001) is more common in responding to 'short term' climatic stimuli (example cold spells, heat stress) among individual households (Harvatt et al. 2011). This is what Porter et al. (2014) termed "*Coping responses*". According to them, coping responses are less expensive actions to manage short-term climatic stimuli. They include mostly behavioral adjustments such as change of clothing, use of heater during winter, installing of double-glazed windows to cushion extreme colds etc. (Porter et al., 2014). Planned adaptation on the other hand requires premeditated deliberate strategy to respond to climatic stimuli (IPCC, 2001). Harvatt et al. (2011) linked this type of adaptation to 'long term' climatic risks such as flooding. Porter et al. (2014) noted that adaptations of this type are more costly, more challenging, and more complex, requiring greater technical investments. Unfortunately, Porter et al. (2014), Harvatt et al. (2011), and Paavola and Adger (2005) revealed that most individual/households in UK are not willing to respond to this type of adaptation without any form of government support. This implies that planned adaptation is related to public adaptation, which are adaptations normally initiated by the government.

Drivers of climate change adaptation

Drivers of climate change adaptation are incentives that motivate individuals to respond to climatic risks (Gawel et al., 2012). Porter et al. (2014) identified three drivers of household adaptation in the UK. These include; previous exposure to extreme weather, social acceptability, and long-term financial reward". The paper explained that individual households who have experienced any form of environmental disaster are more likely to respond to climatic stimuli more than those that have not. This finding was supported by Walker et al. (2011) and Whitmarsh (2008) who noted that individual households in UK who have experienced flooding show more willingness to adopt flood defence measures than households that have not experienced flooding.

On the issue of social acceptability as a driver of adaptation, there are supporting and opposing evidences. For example, Adger (2003) demonstrated that in the events of extreme cold weather, social acceptable measures could influence households' choice of adaptation. This assertion was reinforced by Kent et al. (2013) who noted that during winter, it is a common practice in UK for people to turn on the heater to keep the house warm for visitors. However, Wolf et al. (2010) provided contrary evidence with the claim that social acceptability could worsen vulnerability, especially in the event of hot weather. They supported their claim with the finding that most elderly people in UK did not consider heat wave as a serious climatic risk that requires adaptation, as such, they perceived social acceptable measures such as social bonding/networks as a detrimental measure that could exacerbate vulnerability. This argument seems to suggest that while social acceptable measures may be useful in influencing adaptation options against extreme cold weather, it may be less functional in building coping strategies against extreme hot weather.

Concerning the third driver of adaptation, Porter et al.(2014) and Kunreuther and Kerjan (2009) noted that individuals and households would be more willing to adapt if they perceive the long term financial benefit of adaptation. According to Stenek et al. (2013), house owners in UK who have either taken flood insurance policies or install flood preventive features are those who believe that in the long run, these features will pay off by reducing their costs of adapting to climate change consequences such as flooding. This, according to Fankhauser and Burton (2011), are individuals who believe that it is cheaper to take preventive measures than to pay for havocs of climatic risks. There are other drivers of adaptation that have not been explored very well in the literature. For instance, Grothmann and Patt (2003), in trying to find out why some individuals have more adaptive capacity than others, identified "self-motivation" and "perceived ability" as another major driver of adaptation that have been neglected in literature. They showed that often at times, people are self- motivated to take precautionary measures to protect themselves against climatic risks, without necessarily having an external motivation.

METHODOLOGY

Sampling procedure and data collection

The study area is Leeds, UK, which has experienced some extreme climatic events like flooding, cold spell, and heat waves in the recent past. The study engaged a mixed methods approach where quantitative method (survey) was combined with context specific qualitative method (in-depth interviews). Both methods have their strengths and weaknesses. While the quantitative method is very

Table 1. Sample distribution.

England population (census)	Study sample (%)	Number of persons interviewed	
Gender			
49.1% males	50	245 persons	
50.9% females	50	245 persons	
Age			**For in-depth interview**
49% 18 – 44 years old	50	245 persons	5 persons
31% 45 – 64 years old	30	147 persons	5 persons
20% 65 or over years old	20	98 persons	5 persons

useful in generalising results, it tends to oversimplify reality. The qualitative method on the other hand is very apt in critically analysing reality through the provision of "deep and rich observational" data, but however lacks the quality of generalisability (O'Leary, 2005). Thus, the mixed method approach was employed to help overcome the weaknesses of the two whilst drawing on their strengths.

For quantitative method, semi-structure questionnaires were administered to 490 individuals/households to elicit data on coping responses and adaptation features/strategies, socioeconomic characteristics, and drivers of CC adaptation. Non-probability (quota) sampling was employed based on the England population distribution. The quota was based on two observed characteristics of the population– gender and age according to the England population census (Table1). The individuals within these groups were interviewed until the quota was met. The quota approach was employed in this study because it ensured that the individuals interviewed were fairly distributed among the study population in order to enhance unbiased representation of the perceptions and experiences across various groups (O'Leary, 2005).

The quantitative survey data were complemented with 15 in-depth interviews selected from the 490 sampled respondents using quota sampling (5 from each of the 3 age category in Table 1). The discussions were organised using an interview guide which was structured to elicit information about the individual/household's adaptive measures and motivations for such actions. Specifically, the in-depth interview served triangulation purpose by deepening the understanding about drivers of CCA and unpacking the reasons/motivations behind their choices of adaptation measures. In other words, in-depth interview aimed to improve the reliability of the quantitative model on drivers of CCA.

Data analysis

The choice of analytical tools was guided by the specific objectives and the nature of data collected. Data on adopted coping responses and adaptation strategies in objective one were analysed using descriptive statistics of frequency and percentages. A combination of binomial logistic regression (BLR) and content/discourse analysis were employed to analyse the proximate and underlying drivers of individual and household adaptation in objective two. Multiple linear regression analysis was employed to determine socioeconomic factors affecting level CCA in objective three.

Model specification

Binomial logistic regression

BLR was employed to ascertain the factors that drive the adoption of three most popular adaptation strategies against cold spells and flooding. BLR was employed because it is widely used where the dependent variable is a dichotomous (or dummy variable) with two possible outcomes. The regression model predicted the logit, that is, the natural log of the odds of adopting one adaptation strategy (yes) or not (No). The model can be represented as follows:

$$\ln(\text{ODDS}) = \left[\frac{\hat{Y}}{1-\hat{Y}}\right] = a + bx_1 + bx_2 + bx_3 + bx_4 + bx_5 \quad (1)$$

Where $\hat{Y}$ is the predicted probability of adopting an adaptation feature, which is coded 1 for Yes. $1-\hat{Y}$ is the predicted probability of not adopting a particular adaptation strategy, coded 0 for No. 'a' is the constant, 'b' is the coefficient of predictor variables, while 'X_1 – X_5' represents our predictor variables, in this case, drivers of CCA (that is, to save cost, comfort, protect environment, government support, and previous experience respectively).

All the assumptions for BLR were also met. For instance, the dependent variables (that is, adaptation features) are measured in dichotomous scale (yes or no), and are mutually exclusive. Again, there was no continuous variable among the independent variables. So the assumption of linear relationship between any continuous independent variables and the logit transformation of the dependent variable was not violated. To find the parameter estimates for the model, a BLR was ran for each of the selected adaptation strategies, and the exponential of coefficient of the drivers were extracted from the result tables titled 'variables in the equation' and presented in Appendix Table 2.

The exponential of coefficient Exp (B) in a BLR can be interpreted in terms of the odd ration. When the odd ratio is >1, the probability of the event occurring with unit increase in the independent variable is higher than at the original value of independent variable. On the other hand, when the odd ratio is <1, the probability of the event occurring with unit increase in the independent variable is lower than at the original value of independent variable (Schüppert, 2009).

Multiple linear regression analysis

A number of modifications and tests were carried out to ensure that data satisfy certain assumptions for linear regression. First, data on the level of adaptation (dependent variable, Y) was converted from categorical to continuous variables, by adding up the number of adaptation features adopted by each respondent. Secondly, to ensure the validity of the regression result, test for normality was carried out to assess the normality of the distribution of the data as

well as other key assumptions. The kolmogorov-smirnov statistics (0.170) shows a non-significant value of 0.1300 (p-value > 0.05) which indicates that the data are normally distributed (Appendix Table 3). This was further confirmed by the scatterplot which shows a fairly clear linear relationship and histogram which followed a normal distribution (Appendix Figures 1 and 2 respectively). The function for the multiple linear regression analysis can be represented as follows:

$$Y= B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + e \quad (2)$$

Where: Y = Dependent variable (level of adaptation strategies adopted), B_0 = Intercept, B_1-B_n = Coefficient of explanatory variables, (X_1-X_n) = Socioeconomic factors, X_1 = age of the respondent (years), X_2 = annual gross income (the midpoint of each income category for each respondent was calculated, £GBP), X_3 = education level of the respondent, X_4 = gender (Male or female), X_5 = Children (Yes or No), X_6 = Household type, X_7= Household ownership, X_8 = years lived in home, e = stochastic error term.

RESULTS AND DISCUSSION

Coping responses and adaptation measures against cold spells and flooding

Adapting to climate change requires some low-cost and low-skill measures, as well as some high-cost and technical skill measures. Various coping responses and adaptation features/strategies adopted by residents of Leeds against cold spells and flooding were investigated. The extent to which each these adaptation options were adopted in the study area is presented in Table 1. The result in Appendix Table 1 shows that majority of the respondents easily adopt low cost and low skill coping responses against cold spell. For instance, 81.6% would wear heavier clothes during cold weather while about 78.8% would keep the house warm by turning on the heater. These coping responses fall under what Porter et al. (2014) classified as coping responses. They are behavioral adjustments that require no premeditated plan; they occur spontaneously, and often take place after the impact of climate change has been experienced. This finding also agrees with Ford et al. (2011) who found that coping response actions against extreme weather events are common among UK households, and often require no government intervention to occur.

Furthermore, the adoption of some adaptation features against cold spell, such as double (or triple) glazing (90.2%), loft insulation (58.8%) show an appreciable amount of popularity among the respondents. However, the use of wood-burning stove as an adaptation measure against cold is not popular in the area. This could be attributed to the difficulty and inconvenience in sourcing, storing, and putting the wood into the chamber. Nevertheless, some previous studies have found that the use of wood-burning stove, apart from being a cheaper heating source, is also an eco-friendly strategy of adapting to cold spells (Leslie et al., 2012; Houck and Tiegs, 1988). Although burning of wood releases carbondioxide into the air, it actually balances the carbon cycle, because the same wood absorbed carbon from the air to grow. In contrast, man-made heating machines emit and keep a lot of carbon dioxide into the air with no absorption pathway. This suggests that although the use of wood-burning stove is unpopular in the area, it presents a relatively cheaper and eco-friendly adaptation measure that can be exploited to adapt to cold spells.

A further study of Appendix Table 1 also reveals that when it comes to more technical, financially demanding, and anticipatory adaptation measures against flooding, the percentage adoption falls drastically. For instance, while about 90.2% of the respondents installed or are willing to install double/triple glazing window in the building as an adaption measure against cold spell, only about 3.1% are willing to remove tarmac/pavement and replace with soil/tree as an adaptation measure against flooding. This is coherent with previous findings from Harvatt et al. (2011) who found that most households in UK are not sensitive to anticipatory adaptation measures-usually associated with adaptation to flooding. In addition, the poor adoption or willingness to adopt flooding adaptation measures may not be unconnected with the findings from Porter et al. (2014), Harvatt et al. (2011), and Paavola and Adger (2005) who noted that most individuals and households in UK may not respond to adaptation against flooding without any form of government support. It can therefore be concluded from the analysis of coping responses and adaptation measures against cold spells and flooding that, while individuals and households can autonomously adapt to cold spells, some form of incentives and support may be needed to build resilience against flooding at the individual and household level.

Drivers of individual and household adaptation

From Appendix Table 2, the odds of installing double glazing (0.206), loft insulation (0.320), and cavity insulation (0.342) are lower for those who consider saving cost in the long run as a driver of adaptation to cold spell. In other words, those who consider cost as a driver of adaptation against cold spell are 79.4, 68.0, and 65.8% less likely to double glaze, loft insulate, and install cavity insulation respectively in their houses than those who do not consider cost as a driver. This implies that cost consideration was not found to be a major driver of adaptation against cold spell in the study area. This result contradicts the findings of Porter et al. (2014) and Kunreuther and Kerjan (2009) who noted that individuals and households would be more willing to adapt if they perceive the long term financial benefit of adaptation. The same could be interpreted for other drivers such as; protecting the environment, and government support-whose odd values are less than 1. The only driver of

adaptation against cold spell that significantly influences adoption of double glazing (1.242), loft insulation (1.553), and cavity insulation (1.442) is comfort of the house, whose odd values are greater than 1.

These findings imply that most individuals and households protect themselves against cold spells primarily to make their houses more comfortable. It has been reported in the literature that people are often self-motivated to take precautionary measures to protect themselves against climatic risks, without necessarily having an external motivation (Grothmann and Patt, 2003). During the in-depth interview, comfort was also found to be the underlying reason why people adapt to cold spells. As one of the respondents puts it; "*I want to be comfortable in my house, and I will do anything to keep my house warm during winter. I have never considered cost, or the environment as a reason for installing some of the features you mentioned. I also don't think I need the government to keep my house warm, they have bigger functions to do in the society…*" (An elderly male resident in Leeds, age 68 years).

Concerning adaptation against flooding, the result shows that receiving government support, and having previous experience of flooding whether in the house or elsewhere, all of which have odd values greater than 1, will increase the chances of adopting flood defence measures such as removing tarmac, taking flood insurance, and moving electricity fixtures up wall. Porter et al*.* (2014), Walker et al*.* (2011) and Whitmarsh (2008) also made similar observations when they identified previous exposure to environmental disasters, and some form of government support as major drivers of CCA.

Socioeconomic factors affecting level of adoption of adaptation strategies

Ordinary least square multiple linear regressions analysis was employed to determine socioeconomic factors affecting level of adoption of adaptation strategies. The result of the analysis is presented in Appendix Table 4. The result shows that house type and house ownership were significant at 1% level of significance, while income was significant at 5% level of significance, indicating that these variables affect the level of adaptation strategies adopted in the study area. The coefficient values in Appendix Table 4 also shows that for a unit increase in the house type and house ownership, the model predicts that the level of adaptation will increase by 0.168 and 0.180 respectively, holding all other independent variables constant. These partly imply that individuals who own their house tend to adopt more adaptation strategies than those individuals living in rented apartments. In line with the protection motivation theory, this finding confirms that individuals will normally protect themselves and their property against perceived probability of the occurrence of a threatening event or vulnerability, perceived severity of such a threatening event, and perceived self- efficacy in managing such a threatening event. Thus, house owners are more motivated to adopt more adaptation strategies as a protective measure against their property more than tenants who have little stake or self-interest in the building.

Similarly, the type of house one lives in is likely to affect one's level of adoption of adaptation strategies. We found from our observation and interaction with respondents that individuals living in bungalows tend to adopt more adaptation strategies. This might not be unconnected with the relatively high income level of such households as against individuals living in terraced houses who mostly fall under low/middle income class (Department for Communities and Local Government, 2010; Burrows, 2003). This finding further relates with the significance of income level in affecting the level of adoption of adaptation strategies. Several authors have found that individuals with higher income are more likely to adopt more adaptation strategies, especially the more technical and financially demanding, adaptation measures (Feng et al., 2017; Mabe et al., 2014; Uddin et al., 2014). Overall, the significant relationship of these socioeconomic factors confirms the findings of Smit et al. (2007) who noted that socioeconomic status is an important factor which affects respondents' behaviour and attitudes towards CCA. Improvement in some socioeconomic status such as income will therefore increase individuals' and households' resilience to CC.

Conclusion

Understanding the key drivers and socioeconomic factors influencing individual and household adaptation is a step in the right direction towards strengthening UK's resilience to CC. From the results of the study, it is obvious that government support is needed as a vital driver to increase individual and household resilience to long-term climatic risks such as flooding. Improvement in the socioeconomic status of individuals and households are also needed to strengthen CCA at the individual and household level. This, however, does not mean that socioeconomic variables and drivers identified in this study are the only factors needed to enhance individual and household engagement in CCA. More pragmatic research is recommended to further identify and/or confirm other factors, as well as barriers to CCA not covered in this study.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Appendix Table 1. Summary descriptive statistics for coping responses and adaptation measures against cold spells and flooding.

Adaptation measures	Frequency	Percentage
Low-cost and low-skill coping responses against cold spell		
Wear extra and heavier clothes		
Yes	400.0	81.6
No	90.0	18.4
Turn up or keep on for longer the heating		
Yes	386.0	78.8
No	104.0	21.2
Have more hot meals and drinks		
Yes	272.0	55.5
No	218.0	44.5
Use draft excluders		
Yes	121.0	24.7
No	369.0	75.3
Adaptation features against cold spell		
Double (or triple) glazing		
Yes	442	90.2
No	48	9.8
Loft insulation		
Yes	288	58.8
No	202	41.2
Cavity wall insulation		
Yes	217	44.3
No	273	55.7
Wood burning stove		
Yes	42	8.6
No	448	91.4
More technical and High-cost adaptation against flooding		
Removed tarmac/pavement and replaced with soil/trees		
Yes	15	3.1
No	475	96.9
Take flood insurance policy		
Yes	49	10.0
No	441	90.0
Move electricity fixtures up the wall		
Yes	16	3.3
No	474	96.7
Seal entry points to prevent water coming into the house		
Yes	38	7.8
No	452	92.2
Water-proof external walls and doors for lower ground floor		
Yes	24	4.9
No	466	95.1
Subscribed to the Environment Agency flood warning service		
Yes	21	4.3
No	469	95.7
Source: Field survey, 2016.		

Source: Field survey, 2016.

Appendix Table 2. Summary Exponential of coefficient [Exp (B)] of drivers of individual and household adaptation.

Drivers	Double (triple) gazing	Loft insulation	Cavity insulation	Remove tarmac	Flood insurance	Move electricity fixtures
To save cost in the long run	0.206 (-79.4)	0.320 (-68.0)	0.342 (-65.8)	-	-	-
Comfort of the house	1.242 (24.2)	1.553 (55.3)	1.442 (44.2)	-	-	-
To protect the environment	0.998 (-0.2)	0.698 (-30.2)	0.122 (-87.8)	-	-	-
Government support	0.999 (-0.1)	0.640 (-36.0)	0.210 (-79.0)	1.001 (0.1)	1.758 (75.8)	0.990 (-1.0)
Experience flooding in house	-	-	-	1.999 (99.9)	1.246 (24.6)	1.150 (15.0)
Experience flooding elsewhere	-	-	-	1.606 (60.6)	1.245(24.5)	1.150(15.0)

The figures in bracket are probability percentage derived by: Exp (B) * 100 – 100.

Appendix Table 3. Normality test result.

Tests of normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Level_of_adoption_of_adaptation_strategies	0.170	490	0.130	0.965	490	0.1300

a. Lilliefors Significance Correction.

Appendix Table 4. Multiple regression analysis result on the socioeconomic factors affecting level of adoption of adaptation strategies.

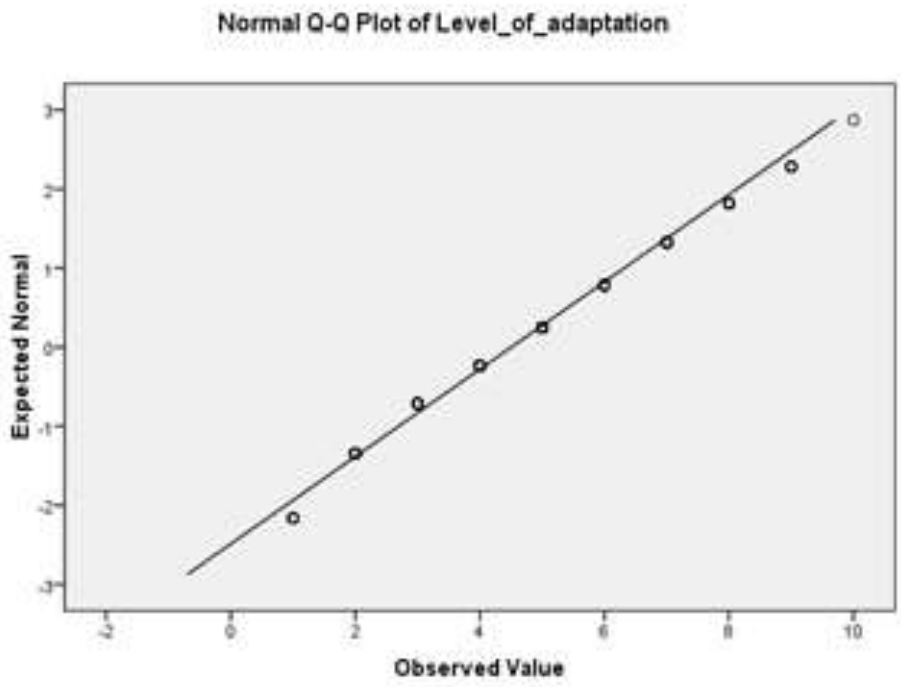
Model summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.423[a]	0.179	0.165	1.654

a. Predictors: (Constant), Children, Age, Gender, Income, Education, House_Type, House_Ownership, Years_lived_in_home

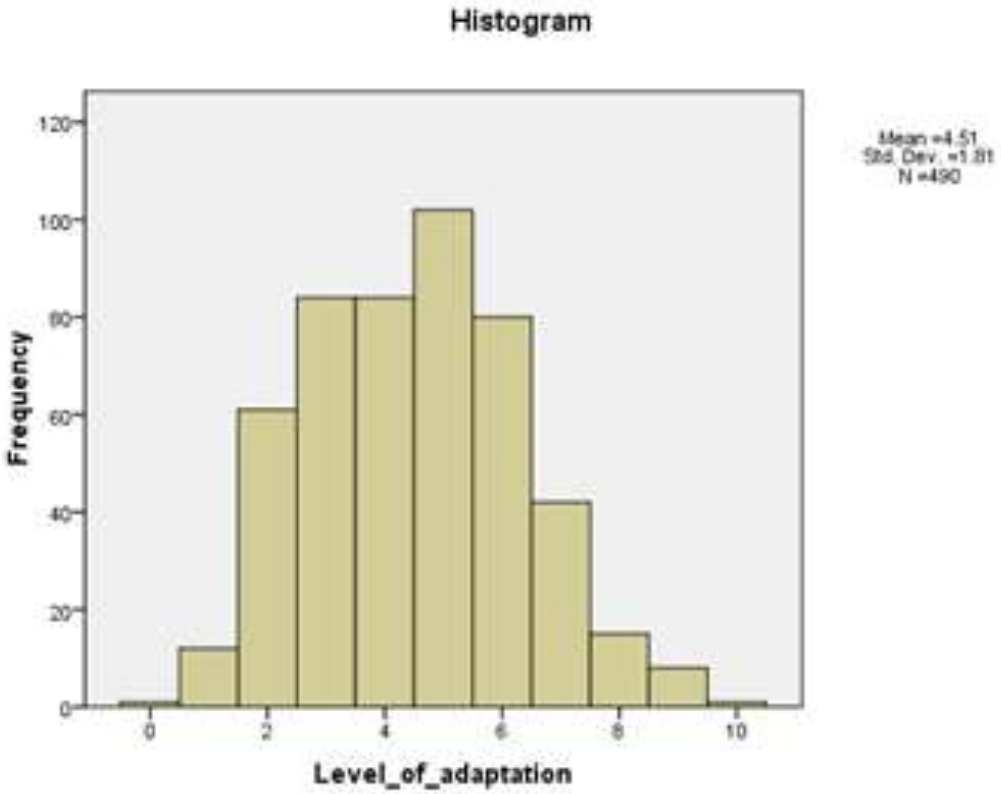
ANOVA[b]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	287.050	8	35.881	13.120	0.000[a]
	Residual	1315.432	481	2.735		
	Total	1602.482	489			

a. Predictors: (Constant), Children, Age, Gender, Income, Education, House_Type, House_Ownership, Years_lived_in_home, b. Dependent Variable: Level_of_adoption_of_adaptation_strategies

Coefficients[a]						
Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.318	0.398		5.831	0.000
	Age	0.003	0.006	0.031	0.540	0.589
	Education	0.107	0.063	0.077	1.691	0.091
	Income	0.090	0.031	0.135	2.880	0.004
	Gender	0.054	0.150	0.015	0.359	0.720
	House_Type	0.210	0.061	0.168	3.460	0.001
	House_Ownership	0.653	0.199	0.180	3.287	0.001
	Years_lived_in_home	0.011	0.008	0.074	1.332	0.183
	Children	0.108	0.174	0.026	0.624	0.533



Appendix Figure 1. Scatterplot result for normality test confirmation.



Appendix Figure 2. Histogram result for normality test confirmation.