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Willingness to pay for climate change
adaptation in developing countries**

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Are we willing to give what it takes? Willingness to pay for climate change adaptation in developing countries

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Abstract

Climate change adaptation is gaining traction as a necessary policy alongside mitigation, particularly for developing countries, many of which lack the resources to adapt. However, funding for developing country adaptation remains woefully inadequate. This paper identifies the burden of responsibility that individuals in the UK are willing to incur in support of adaptation projects in developing countries. Results from a nationally representative survey indicate that UK residents are willing to contribute £27 per year (or a median of £6 per year) towards developing country adaptation (US\$30 and \$7 using the World Bank's purchasing power conversion factors). This represents less than one third of the back-of-the-envelope \$100-140 per capita per year that the authors estimate would be needed to raise the \$70-100bn per year recommended by the World Bank to fund developing country adaptation. Regressions indicate that WTP is driven mostly by a combination of beliefs and perceptions about one's own knowledge levels, rather than actual knowledge of climate change. We conclude that, to engage the many different audiences that make up the 'public', communication efforts must move beyond the simple provision of information and instead, connect with people's existing values and beliefs.

Key words: climate change adaptation, contingent valuation, developing country, environmental economics, development aid/assistance

1. Introduction

Until fairly recently, the policy of adaptation to climate change was largely considered ethically suspect, and side-lined in favour of its more noble cousin, mitigation (Pielke, Prins, Rayner & Sarewitz, 2007; Tol, 2005). However, as climate-related risks have become more certain and real, adaptation has gained acceptance as a realistic and necessary policy alongside mitigation (Pielke et al., 2007) a fact particularly highlighted in the recent IPCC report (IPCC, 2014). Adaptation is particularly relevant for developing countries, particularly those in the ‘low-income’ bracket¹, many of which lack the institutional, financial and technological capacity to adapt to climate change (Barr, Fankhauser & Hamilton, 2010; Fankhauser & McDermott, 2014). There is widespread recognition that long-term adaptation processes, involving planning, regulation, infrastructure development, and development of increasingly accurate climate forecasts will be essential for vulnerable populations and ecosystems in these countries to become more resilient to climate-change impacts (Fankhauser & Burton, 2011; Adger, Lorenzoni & O'Brien, 2009; Smith et al., 2011) and thus avoid deeper entrenchment in poverty (Tanner and Mitchell, 2008).

However, adaptation requires resources. Despite some examples of successful adaptation actions implemented in a number of less-developed country contexts, these represent a small fraction of the adaptation projects needed for these countries to withstand the impacts of climate change (Berrang-Ford, Ford & Paterson, 2011; Mertz, Halsnæs, Olesen & Rasmussen, 2009).

There are a range of global estimates of the costs of adaptation in developing countries (World Bank, 2010; UNFCCC, 2008; UNDP, 2007; Stern, 2007; Oxfam, 2007), with values ranging from \$4-37 bn/yr (Stern, 2007), through \$28–67 bn/yr (UNFCCC, 2008), to \$86-109 bn/yr (UNDP, 2007). The most recent study, carried out by the World Bank (2010), estimates that \$70-100 billion/year will be needed by 2050 for developing countries to adapt. These are arguably the most robust estimates to date (Barr, Fankhauser & Hamilton, 2010; Chambwera et al., 2014; Smith et al., 2011), so we will use them here as indicative of the required adaptation funding for developing countries.

¹ The term ‘developing’ is used by the World Bank to denote both low-income and lower-middle-income countries (see: <http://data.worldbank.org/about/country-and-lending-groups>)

If vulnerable communities in developing countries are to adapt, then the most likely source of funding for these endeavours will be the international community, via institutions such as the World Bank, Global Environmental Fund, or the recently established Green Climate Fund. However, as noted in the IPCC 2014 report (Chambwera et al., 2014), adaptation investment is currently several orders of magnitude lower than needed to meet adaptation requirements in developing countries. Compared to the figures summarized above, actual expenditures range from an estimated \$244 million in 2011 (Elbehri, Genest & Burfisher, 2011) to \$316 million in 2013 (Caravani, Barnard, Nakhlooda & Schalatek, 2013).

The question is: who will pay, and how much? There is much debate over this issue (Bowen, 2011; Khan & Roberts, 2013; Smith et al., 2011). It is recognized that a combination of sources of revenue will be required including private sources (Bowen, 2011; Khan & Roberts, 2013). However, until the question of distribution of responsibility is resolved, country-level pledges are likely to remain the principal source of revenue for such investments. A substantial fraction of adaptation funding will therefore ultimately come from individuals in developed countries via taxes (see Supplementary Information section 1 for discussion). Consequently, we consider it a valuable exercise to identify the burden of responsibility that individuals in developed countries may be prepared to incur to support developing country adaptation. To do this, the present study identifies individual preferences for adaptation projects in developing countries. We use a contingent valuation survey (Bateman et al., 2002) to elicit willingness to pay (WTP) extra taxes amongst U.K. residents for various sectoral adaptation policies aimed in particular at vulnerable communities in developing countries. There have been a number of studies examining WTP for mitigation activities (e.g. Carlsson et al., 2012; Akter & Bennett, 2011). However, to the best of our knowledge, the present study represents the first attempt to identify WTP for adaptation projects in developing countries.

A back-of-the-envelope estimate of the annual tax per capita that would be needed to raise the \$70-100bn in funds for developing country adaptation indicates that each individual of adult age in industrialised nations would need to pay about \$100-140 per year to support this endeavour (see Supplementary Information section 1 for estimation process). This is comparable to personal expenditures on postage stamps in the UK (£148 per person per year (ONS, 2012)). Our results however suggest that WTP falls far below this estimate. Consider furthermore that the UK's total contribution between 2003 and 2013 towards adaptation financing for developing countries comes to about US\$600m (Caravani et al., 2013), crudely

equivalent to about US\$12/year per UK adult. This approximate measure of ‘revealed preference’ for developing country adaptation is half the size of our WTP estimates, and less than one-fifth of the approximate per capita funding required (as noted above). These results are sobering to say the least.

2. Method

2.1 Survey design

This study uses a contingent valuation survey (Bateman et al., 2002) that collected data on UK residents’ willingness to pay for adaptation projects with a focus on developing countries. The survey elicited respondents’ knowledge, beliefs and attitudes towards climate change, followed by the valuation scenario and the payment question. The valuation scenario consisted of extensive information about climate change causes, impacts, and adaptation (see Supplementary Information for full valuation scenario). We emphasise throughout that the impacts of climate change will be borne mostly by developing countries. For example, the section explaining adaptation to climate change states that:

“Meanwhile, some countries are already suffering from the impacts of climate change - in particular developing countries. According to the World Health Organisation, climate change is directly responsible for 150,000 deaths a year, and this figure is rising. Countries such as these will need to implement adaptation strategies – human interventions to help adapt to the impacts of climate change that are already happening. Adaptation strategies can range from the testing and introduction of new and more resilient crop varieties, to the construction of seawalls and storm surge barriers to protect people and property from flooding. Climate change adaptation is especially important in developing countries since those countries are predicted to bear the brunt of the effects of climate change.”

After reading the information, respondents were asked if they were willing to support a proposed global climate change adaptation program (which we termed the ‘Worldwide Adaptation Fund’ (WAF)) encompassing a series of sector-targeted programmes (Nature & the Environment, Agriculture, Human Health, and the Built Environment). The scenario was worded as follows:

“Suppose there was a Worldwide Adaptation Fund - an international institution responsible for overseeing the implementation and management of Adaptation Programmes across the globe. These Adaptation Programmes would be designed to alleviate the negative impacts of climate change on nature and the environment, agriculture, human health and the built environment. Funding for these Adaptation Programmes would come from all individual countries as a percentage of their GDP. This means that everyone would have to pay a little more income tax.”

The particular sectoral programmes were selected on the basis of a review of key adaptation at sectors in developing countries (World Bank, 2010), in addition to one ‘Built Environment’ programme which was included for completeness and to comply with the focus of the project funding (see Acknowledgements).

Respondents were then given the option of: 1) contributing a lump sum to the Worldwide Adaptation Fund (WAF), which would allocate the funds amongst the individual sector programs according to need; 2) contributing individual amounts to individual sector programs if they preferred, or 3) contributing nothing. Those who indicated a positive WTP, were asked to select their preferred contribution in terms of annual household taxes using a payment ladder approach (Bateman et al., 2002), in which respondents are presented with a series of amounts that increase in regular increments (up to a maximum value of £750 per year for each of the sectoral adaptation programmes, and £2000 per year for the overall programme)². Valuations of the various sectoral programmes were carried out simultaneously and could be changed during the valuation process. A “total” box at the bottom of the page tallied the sum of the individual payments as they were being proposed so that respondents could keep an eye on their total WTP. See Figure 1 for the valuation questions (the payment ladders can be found in Supplementary Information section 3).

² We note that the WTP scenario was presented in terms of annual payments over an indefinite period of time, whereas the World Bank estimates refer to specific financial requirements up until 2050. As adaptation efforts provide an on-going stream of annual benefits, on-going annual payments are the most appropriate payment schedule to use (Egan et al, 2015). Had we specified a payment time horizon of 2050 we would have had to justify why the duration of the payments did not match the duration of the benefits. It is possible that some individuals would have responded differently had we provided the information in terms of a specific end date of 2050 for payments. However, this is unlikely given that 35 years is a long term horizon and an annual payment for 35 years is not, in all likelihood, going to be perceived to be very different from an indefinite horizon.

Before stating their values, respondents were reminded to consider all other relevant substitutes, including other development and aid goals. We also included a paragraph emphasising the trustworthiness, transparency and accountability of the Worldwide Adaptation Fund (WAF), as lack of trust accounted for a major number of protest responses in the pilot surveys (n=50). Finally, we emphasized that the programmes were of greatest relevance to the developing world:

“Also, remember that the impacts of climate change will mostly affect people in the developing world and future generations.” (emphasis included in scenario)

Reasons for payment/non-payment were elicited after the valuation section (see Supplementary Table 1). The entire valuation scenario is included in the Supplementary Information Valuation Scenario.

2.2 Comment on survey versions





There were two versions of the survey as per a methodological test which aimed to explore the influence on WTP of different information treatments. One set of surveys (n=491) presented respondents with neutral and unbiased information about climate change and adaptation; this was the standard CV survey. The second set of surveys (n=575) included information that was designed to be ‘persuasive’, involving stronger, more emotive wording on the first page and no reminders of substitutes (see Supplementary Information section 2). Both surveys were identical in all other respects. Overall, we found that our information treatment had very little impact on stated contributions: mean WTP of treated respondents (£28.15; s.d. 94.17) was marginally, but not significantly higher ($p=0.5360$), than that of respondents who received the standard survey (£24.99; s.d. 55.56). Given that our main interest in this paper is in presenting estimates of mean WTP, and given the lack of influence of our treatment on this measure, we opted to present results from both survey versions together. All regressions include a VERSION dummy to control for influences on WTP.

Figure 1 | Valuation Question


Please select your preferred option:

	Tick one only	
a. I prefer to contribute towards one or more of the separate Adaptation Programmes	<input type="checkbox"/>	GO TO A
b. I prefer to contribute an overall amount towards the Worldwide Adaptation Fund, who will allocate the money amongst the different adaptation programmes according to need	<input type="checkbox"/>	GO TO B
c. I don't want to contribute towards climate change adaptation	<input type="checkbox"/>	SKIP A & B

A. Please choose the amount(s) that best represent the maximum you would be willing to pay, as an increase in household income tax, from the drop-down lists.

Adaptation Programme	Your money will go towards:	CHOOSE THE <u>MAXIMUM</u> AMOUNT YOU ARE WILLING TO CONTRIBUTE as an <u>increase in household tax</u>
Nature & the Environment 	<ul style="list-style-type: none"> ✓ Development of more protected areas & corridors linking these ✓ Improved wildlife disease surveillance & control ✓ Increased control of wildfires & floods 	DROP-DOWN LIST
Agriculture 	<ul style="list-style-type: none"> ✓ Development & use of different crop varieties ✓ Soil management & erosion control e.g. planting more trees ✓ Crop relocation if necessary 	DROP-DOWN LIST
Health 	<ul style="list-style-type: none"> ✓ Building & staffing of health centres ✓ Development of heat-health action plans ✓ Improved disease surveillance & control 	DROP-DOWN LIST
Built Environment 	<ul style="list-style-type: none"> ✓ Protection of built cultural heritage i.e. castles, churches & other cultural sites ✓ Building seawalls & storm surge barriers ✓ Restoration & rebuilding of damaged assets 	DROP-DOWN LIST
This is the total amount you would be prepared to pay:		TOTAL (CONFIGURATOR)

B. Please choose the amount that best represents the maximum you would be willing to pay, as an increase in household income tax, from the drop-down list.

Worldwide Adaptation Fund 	You can contribute an <u>overall amount</u> to the Worldwide Adaptation Fund, and <u>they will allocate the money</u> amongst the different Adaptation Programmes according to need.	DROP-DOWN LIST
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2.3 Data Collection

A total of 1,066 online surveys were completed by a panel of UK residents between September and December 2012. The average completion time was 15 minutes. A quota sampling procedure was used to achieve representativeness across gender, age and income, although representativeness was not fully achieved (Table 1) with regards to age due to a programming error in the quota sampling procedure. As a result all results presented in the paper are weighted to account for this discrepancy between sample and population age³.

3. Study Findings

3.1 Descriptive statistics

Key sample characteristics are summarized in Table 1 and compared to UK population statistics (source of UK population statistics is ONS Census 2011, unless otherwise specified). Results show that self-reported knowledge about climate change, and awareness that carbon dioxide emissions are its main cause, are not high.

³ Probability (also known as ‘sample’) weights were applied using the ‘pweights’ command in Stata, which adjusts each sample observation according to its probability of being observed in the population. Age statistics for the UK were obtained from the 2011 Census.

Table 1: Socio-economic characteristics, knowledge and attitudes towards climate change

Variable name	Description	Respondents (n=1,066)	UK population (n=63.2m)
Income	Gross annual household income (mean £) taken as mid interval of income levels	36,045 ^a	36,130 ^b
Female	(1=female, 0=male)	0.50	0.51
Age	(median years) ^c	45.0 ^c	39.9 ^e
Education	Respondent has university degree or professional qualification (1=yes, 0=no)	0.34	0.30 ^f
Know_selfreport	Self-reported measure of knowledge about climate change (scale 1-5, where 1=very low knowledge and 5=very knowledgeable)	3.20	n/d
Know-CO2	Awareness that CO2 is the main cause of climate change (1=yes, 0=no)	0.34	n/d
CC_causenature	“Climate change is happening and is caused by nature” (1=agree, 0=don’t agree)	0.31	n/d
CC_nothappen	“Climate change is not happening” (1=agree, 0=don’t agree)	0.01	0.07 ^g
CC_dontknow	Respondent does not have existing ‘belief’ about climate change existence/ causes (1=no belief, 0=belief)	0.24	
Alreadydecided	“I already knew before this survey whether I would support adaptation to climate change” (1=agree, 0=don’t agree)	0.32	n/d
Environment_publicfunds	1=respondent selected ‘environment’ as one of the top 3 areas in which more public funds should be spent, 0=did not select ‘environment’	0.24	n/d
Reduce_energy	“I have reduced my energy use specifically for environmental reasons” (1=agree, 0=don’t agree)	0.53	n/d
Member_envorg	Respondent is member of environmental organization (1=yes, 0=no)	0.11	n/d

^a The highest level in the survey (“over £150,000 per year”) was given a value of £175,000 per year.

^b Mean income data is for 2010. The statistic given is gross household income per head (GDHI). We convert this value (£15,709) to mean income per household for comparability to our summary statistics by multiplying GDHI per head by the average of 2.3 people per household.

^c We report the median age for comparability with the Census data (which only provides medians)

^d The highest level in the survey (“over 75 years old”) was given a value of 80 years of age.

^e Median sample age is significantly higher ($p=0.0002$) than UK population median. As noted in the main text (Section 2.4), all results are therefore weighted to account for this discrepancy between sample and population age.

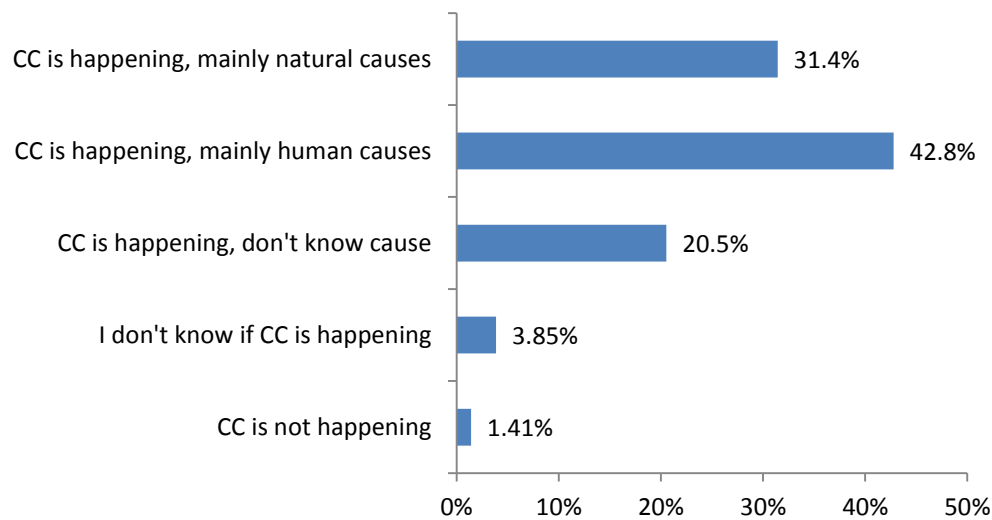
^f Data on education levels are available only for individuals of working age (males aged 16 to 64 and females aged 16 to 59).

^g Source UK population data for this variable: YouGov (2014). However, as noted in the main text, comparisons between our data and that of the YouGov survey must be made with caution given different question structuring.

In addition, respondents were asked to indicate their agreement with one of five statements regarding their thoughts about climate change. Fig 2 shows the distribution of responses. If we compare climate change beliefs amongst our sample with those of the UK population as gathered via a YouGov survey⁴ (YouGov, 2013), it appears that our sample is significantly less convinced that climate change is caused by human activity (43%) compared to the YouGov sample (sample size n=1956 adults) (53%). In addition, only 1.4% of our sample does not agree that climate change is even happening, whereas this figure is closer to 7% among the YouGov sample, and the difference is statistically significant (p=0.001). However, we note that comparability between our sample and the YouGov study with regards to this measure is somewhat limited due to the fact that we structured our question differently: the YouGov survey asks respondents to indicate agreement with one of *four* statements: 1. humans cause climate change, 2. humans don't cause climate change, 3. climate change isn't happening, 4. I don't know. However, as can be noted in Fig 2, we presented respondents with five statements, and the percentage choosing the additional statement ("Climate change is happening, but I don't know what the cause is") is rather high at 21%. If our results are in any way indicative of the opinions of the UK public, then about one fifth of the population in the YouGov survey are selecting a statement that does not fully capture their thinking. We cannot ascertain which alternative category they would select, and therefore comparisons between our survey and the YouGov survey must be made with caution.

⁴ UK data for this question is only available from 2013. Prior to this date, the question was worded in terms of 'warming', as opposed to 'climate change'. For example, the question "Do you think the climate is changing as a result of human activity?" used to be phrased, "Do you think the world *is becoming warmer* as a result of human activity?" Results between questions types are very different: in 2013, when the 'climate change' frame was used for the first time as a comparison with the 'warming' frame, results were as follows: 39% (53%) believed human activity is making the world warmer (changing the world's climate); 16% (26%) believed the world is becoming warmer (the climate is changing) but NOT due to human activity. (Source: www.yougov.com).

Figure 2 | Personal belief about climate change (CC) (% respondents who chose statement). Total sample size=1,066.



3.2 Willingness to Pay towards adaptation programmes

As noted in Section 2.1, respondents were asked to indicate whether they were interested in contributing in annual tax increases to support a global climate change adaptation program. They were given the option of: 1) contributing a lump sum to the Worldwide Adaptation Fund (WAF), which would allocate the funds amongst the individual sector programs according to need; 2) contributing individual amounts to individual sector programs if they preferred, or 3) contributing nothing (see Supplementary Information Valuation Scenario for wording of scenario and question). Fig 3 shows the distribution of responses.

Our results show that almost half (45.7%; n=487) of the 1,066 surveyed respondents were not willing to contribute towards adaptation. Reasons for zero contributions (Supplementary Table 1) were analysed to help identify non-valid 'protest' responses, which do not reflect true WTP for the good being valued but rather, indicate a rejection of the some aspect of the valuation scenario, such as the payment method (e.g. 'Governments should pay for this' 'I would prefer to make an individual voluntary donation'). Evidence of objection to the method of payment used can often be found in CV surveys, particularly when using tax-based payment methods (Champ and Bishop, 2001; Atkinson, Morse-Jones, Mourato & Provins 2012). Inspection of the zero WTP responses indicate that 76% (n=370) are 'valid' representations of value (as opposed to protests against the contingent scenario). All data reported from here on exclude the non-valid protest values.

Figure 3 | Number of respondents choosing different contribution options (e.g. n=169 chose to contribute towards individual sector adaptation programs). Total sample size=1,066

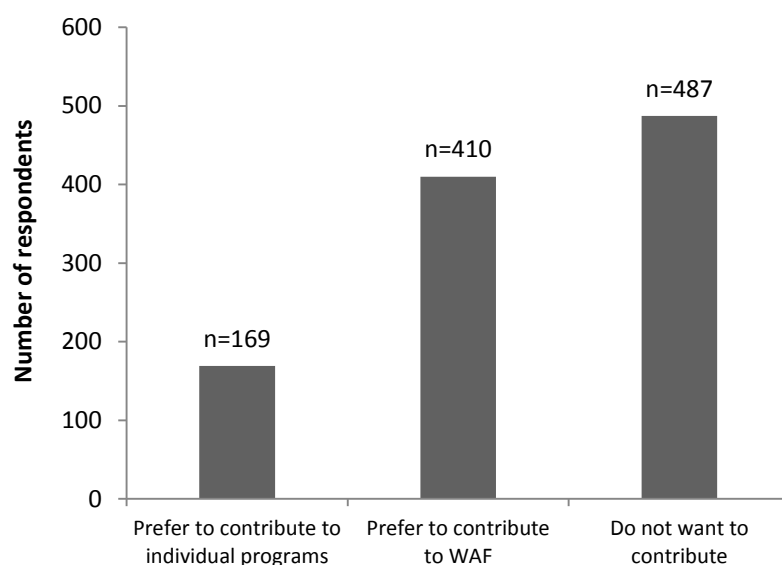


Table 2: Summary Statistics Willingness to Pay for Adaptation to Climate Change^a

	Sample statistics
Sample size (non-valid 'protest' zeros excluded)	949
Proportion of sample WTP=0 (valid zero's)	0.61
WTP statistics (incl. all valid WTP=0) (£)	
Mean total WTP	26.67 (78.48)
Median total WTP	6
Conditional WTP statistics by payment format (only WTP>0) (£)	
Conditional mean WTP to Worldwide Adaptation Fund	41.66 (105.37)
Conditional median WTP (WAF)	11
Conditional mean WTP to the sum of all individual sector programs	48.73 (71.56)
Conditional median WTP (sum of all individual sector programs)	24

Standard deviations in parentheses.

^a Non-valid zero WTP have been removed from all mean and median calculations.

First inspection of the data reveals that the standard deviations are at least double the mean WTP value (Table 2). This is due to the fact that the WTP distributions are positively skewed, indicating a large number of small values and a long tail, including a few outliers with very high WTP for adaptation⁵. Of those respondents who stated a positive WTP, most (71%) preferred to contribute a lump sum to the WAF. Using the mid-point of the payment card intervals (see Methods), mean conditional WTP (i.e. all WTP>0) to the hypothetical WAF fund comes to £41.66; the median value however is only £11. However, respondents who chose to contribute towards individual sector programs had a higher overall conditional mean WTP of £48.73 (median of £24). Non-parametric Mann-Whitney testing indicates that the means are significantly different ($p=0.0001$).

This difference in conditional estimates across payment methods suggests the possible presence of part-whole bias, often seen in CV studies (Foster and Mourato, 2003). Part-whole bias occurs when the sum of the valuations of the parts exceeds the valuation of the whole, and is thought to occur when there is conflict between the experimenter's and subject's view of the good and its valuation (Mitchell and Carson, 1989). However, in our study, there is less scope for conflict between our view of the good and the respondent's view of the good because we allowed them the choice of contributing in one of two ways, one representing a holistic view and the other representing the partitioned view of the good. Thus, we are confident that the discrepancy between values is not a result of a conflict between ours and the respondents' perception, but indicates perhaps a simple difference in preferences towards adaptation in developing countries. However, we cannot validate this with our present data.

⁵ There were $n=2$ values of £1250 (mid-interval of £1000-£1500), and $n=3$ values of $n=£625$ (mid-interval of £600-£650) in the Worldwide Adaptation Fund subsample. Summary statistics show that these respondents have very high income levels (mean £113,000/yr, median: £125,000/yr), and that mean WTP of this subsample represents about 0.8% of the mean income of this subsample. This suggests that these high WTP values reflect valid preferences of wealthier individuals who highly value adaptation. To ascertain whether this is indeed the case, we conducted a quantile regression analysis of the overall conditional distribution at the 99.75th percentile (equivalent to all WTP values of £625 and over). Results confirm that income has a significant and positive effect on WTP as expected (coeff 0.74, $p=0.004$), and that all other coefficients also have the expected direction (although only knowledge and contribution to the SP are significant). Finally, we confirm that truncation of the outliers has no significant effect on the direction or size of the coefficients. Hence we conclude that these values represent valid preferences, and retain them in the analysis.

Table 3 | Summary WTP Statistics for Individual Sector Adaptation Programs. This includes all (valid) n=169 respondents who chose this method of contributing towards adaptation.

Individual Sector Adaptation Programs				
Summary statistics	Nature & the Environment	Agriculture	Human Health	Built Environment
No. respondents WTP>0	150	148	134	109
Proportion respondents WTP>0 ^a	0.88	0.87	0.78	0.64
Mean WTP	16.34* μ	13.80 μ	11.68 μ	6.91*
SD	(28.98)	(25.54)	(20.77)	(12.24)
Median	6.00	6.00	6.00	1.50
Max	250	175	112.5	92.5

^a This proportion is in relation to all respondents (n=169) who selected to pay towards the individual programmes.

* Significantly different to mean WTP for Human Health adaptation program at 5% level or less

μ Significantly different to mean WTP for Built Environment adaptation program at 5% level or less

WTP statistics for the individual programmes (Table 3) shows that the ‘Nature and the Environment’ and ‘Agriculture’ adaptation programmes were the most favoured by respondents (88% and 87% of respondents chose to contribute to these programmes; mean WTP is £16.34 and £13.80 respectively), followed by ‘Human Health’ (78% chose to contribute; mean WTP: £11.68). ‘Built Environment’ is the least favoured (64% contribute; mean WTP: £6.91). These results highlight those sectors that are likely to attract more public investment.

Overall, taking all responses together, results show that respondents are willing to pay about £27 per year in income taxes to support adaptation efforts in developing countries. This is equivalent to \$29.37, using purchasing power adjustments (World Bank, 2014), significantly less than the back-of-the-envelope \$100-150 per capita (based on the World Bank adaptation cost estimates discussed earlier). However, if we take the median WTP of £6 per year as our statistic of choice, with the understanding that support for developing country adaptation would depend on majority (at least 50%) support from the public, then it is clear that public support for developing adaptation is negligible.

3.3 Regression Analyses

Regression analyses were used to investigate the influence of various socio-economic, attitude and knowledge-related variables on: 1) the initial participation decision (1=contribute to individual sectors; 2=contribute to WAF; 3=no contribution); and 2) the contribution decision (how much to pay amongst those who gave a positive WTP). Given that these various choices were presented separately, we consider it appropriate to model them as separate choices, starting with the participation decision. Results of all regressions are presented in Table 4 while the explanatory variables used in the regressions are described in Table 1.

Participation decision

As noted in Section 3.2, the initial participation decision entailed a choice between three discrete (unordered) choices: 1) contribute lump sum towards the WAF, 2) contribute to individual programmes, and 3) don't contribute. In order to explore the likelihood that a respondent would choose either of these three options given a range of socio-economic, knowledge and attitudinal characteristics, this data was analysed using a multinomial logistic regression, with "no contribution" as the reference category (Hausman & McFadden, 1984). Multinomial logit models are extensions of standard binary logistic regressions, and are well-suited to analysing discrete data with more than two categories.

Results from the multinomial logit regression (left-hand columns, Table 4) indicate that most of the variables representing knowledge, attitudes and behaviour relating to climate change and the environment significantly influence participation both in the overall programme (the WAF) and in the individual sectoral programmes when compared to non-participation. For example, membership of an environmental organisation, self-reported knowledge about climate change and positive environmental attitudes (indicated by 'Environment_publicfunds') significantly increase the likelihood that a respondent will contribute towards adaptation either via the WAF or the individual programmes.

Interestingly, a belief in nature as the main cause of climate change (31% of the entire sample) has a strong negative influence on participation overall. Perhaps this suggests a fatalistic attitude of those with such beliefs. Or perhaps the causality lies in the opposite direction: those who do not wish to support adaptation projects for vulnerable others, justify their choices by explaining climate change as natural phenomenon. This would suggest that,

for these respondents, moral responsibility for others is excused by the presence of some external factor (in this case, nature) over which the respondent feels they have no control (Eshleman, 2014). One might consider this a form of ‘strategic’ fatalism. Whatever the reason for this interesting result, however, the implication is clear: a belief that climate change is caused by nature allows some people to absolve themselves of responsibility towards those who will be negatively impacted by climate change.

Another interesting finding is that one quarter of the ‘climate sceptic’ subsample (n=5) expressed a positive WTP (mean £7.45, median £0) despite claiming that ‘climate change is not happening’. One explanation for this apparent inconsistency between belief and preference is that these respondents changed their minds about climate change during the course of the survey. Unfortunately we did not examine beliefs before and after the provision of information, so we cannot verify whether this is indeed the case. Alternatively, the positive WTP of these five respondents may reflect their preferences for the proposed programmes *independent* of whether they think climate change exists or not. For example, a climate sceptic might value improved soil management and erosion control because it delivers important development outcomes. This highlights the fact that most adaptation measures also deliver development outcomes, and vice versa (OECD, 2009). Hence, it is possible that these (and other) respondents valued the development or conservation aspects of the proposed adaptation programmes, independent of the adaptation aspect. This is a very interesting issue that potentially raises fundamental questions about overlapping preferences for adaptation and development; it may also have important implications for how public information about climate change responsibilities is framed and targeted. However, the precise motivations of these particular climate sceptics remain unknown to us, so we hesitate to embark on any in-depth discussion here. This remains an interesting area for future research.

In terms of differences in *how* respondents prefer to contribute, we note that greater real knowledge relating to climate change (indicated by agreement with the statement “*Carbon dioxide emissions are the main cause of climate change*”) influences the likelihood of contributing towards the WAF, whereas this has no influence on likelihood of contributing towards the individual programmes (compared to not contributing at all). Moreover, older women (but not older people in general) are significantly more likely to contribute towards individual programmes, but not towards the WAF. We also note that income does not appear to influence the likelihood of contributing towards the WAF, although it does influence the decision to contribute towards the sectoral programmes. In fact, socio-economic variables

appear to have no bearing on participation in the WAF; the likelihood of contributing towards the overall programme is mostly determined by attitudes, perceived knowledge and opinions about the existence and causes of climate change. We are not aware of a conceptual framework that explains the contrasting influence of socio-economic characteristics on preferences between paying taxes towards sectoral vs. aggregated aid programmes, so we hesitate to speculate on the reasons for this difference.

Finally, it is worth noting that participation overall is very strongly and negatively determined by agreement with the statement: “*I already knew before this survey whether I would support adaptation to climate change*” (indicated by ‘Already_decided’), such that respondents who agreed with this (32% of the sample) were more likely *not* to support adaptation in any form. In other words, respondents who had already decided in advance that they did not support climate change adaptation were unlikely to reconsider their preferences in the light of new information. From a policy perspective, this suggests that reaching these people with information alone may not suffice, and may require a more targeted communication strategy that takes into account their existing mental models, perceptions of climate change, and underlying values, worldviews and identities (CRED, 2014). We will discuss communication strategies further in Section 4.

Table 4 | Regressions results predicting participation decision and conditional contribution decision

	Multinomial logit model of participation decision (base category: prefers not to pay for adaptation)				OLS regression on conditional contribution (Dependent variable is logWTP)					
	Prefers to contribute to individual programmes		Prefers to contribute to Worldwide Adaptation Fund		Towards individual programmes		Towards Worldwide Adaptation Fund		Overall (all WTP>0)	
<i>Socio-economic variables</i>										
LogIncome	0.31	(0.14)*	0.21	(0.12)	0.33	(0.14)*	0.41	(0.09)***	0.40	(0.07)***
Female	-1.41	(0.62)*	-0.34	(0.54)	0.28	(0.69)	0.34	(0.43)	0.39	(0.36)
Age	-0.02	(0.01)**	-0.01	(0.01)	0.00	(0.01)	0.01	(0.01)*	0.01	(0.01)
Female*age ^a	0.03	(0.01)**	0.01	(0.01)	-0.00	(0.01)	-0.01	(0.01)	-0.01	(0.01)
Education	0.52	(0.21)*	0.27	(0.17)	0.35	(0.20)	-0.16	(0.14)	-0.00	(0.11)
<i>Knowledge and 'beliefs' about climate change</i>										
Know_selfreport	0.52	(0.13)***	0.37	(0.10)***	-0.12	(0.11)	0.15	(0.09)*	0.08	(0.07)
Know-CO2	0.10	(0.23)	0.41	(0.19)*	-0.14	(0.22)	-0.03	(0.13)	-0.07	(0.11)
CC_causenature	-0.56	(0.26)*	-0.98	(0.21)***	-0.22	(0.23)	-0.31	(0.18)	-0.19	(0.14)
CC_nothappen	-1.65	(0.82)*	-2.20	(0.80)***	-0.38	(0.90)	-1.27	(0.49)**	-1.18	(0.52)*
CC_dontknow ^c	0.11	(0.27)	-0.17	(0.22)	-0.40	(0.23)	-0.02	(0.17)	-0.14	(0.14)
Alreadydecided	-0.72	(0.23)***	-0.58	(0.18)***	0.56	(0.21)**	0.49	(0.16)**	0.49	(0.13)***
<i>Environmental attitudes and behaviour</i>										
Environment_publicfunds	1.10	(0.28)***	1.03	(0.23)***	0.23	(0.21)	0.13	(0.14)	0.17	(0.12)
Reduce_energy	0.58	(0.23)**	0.68	(0.17)***	0.42	(0.21)*	0.14	(0.14)	0.22	(0.12)*
Member_envorg	0.94	(0.34)**	0.77	(0.29)**	-0.10	(0.31)	0.43	(0.19)*	0.30	(0.16)*
<i>Controls for survey versions/treatments</i>										
Version ^b	0.26	(0.21)	-0.32	(0.16)	-0.02	(-0.10)	-0.03	(0.13)	-0.01	(0.11)
Contributed to individual sector programmes	-	-	-	-	-	-	-	-	0.43	(0.12)***
Constant	-5.10	(1.57)***	-2.92	(1.37)*	-0.42	(-0.23)	-2.89	(1.07)**	-2.56	(0.91)**
Wald chi2	174.31 (df=30)***				-		-		-	
R2					0.18		0.16		0.15	
N	169		410		169		410		579	

*p<0.05, **p<0.01 ***p<0.001. Numbers in parentheses are robust standard errors. Non-valid zero WTP have been removed from all regressions.

^a This interaction variable controls for the influence of being an older female on the likelihood of participation, and on conditional WTP.

^b There were two versions of the survey as per a methodological treatment outlined in the 'Methods' section. The 'VERSION' dummy controls for possible influences of the methodological treatments on WTP. 1=respondent received survey version1, 0=respondent received survey version 2 (with persuasive information treatment).^c We collapsed the two 'don't know' categories (see Fig 2) to produce one single category representing respondents who do not have a firm belief regarding climate change (its existence or its causes).

Conditional contributions (WTP>0)

In order to explore the determinants of WTP, we present results of linear regressions on conditional contributions (i.e. all positive WTP) towards the WAF, the individual programmes, and on all positive WTP data pooled together⁶. As noted in Table 2, the WTP distributions are positively skewed. For this reason, the models have been estimated using a lognormal transformation of WTP, which normalises the data. We also include the natural log of income as an independent variable, making the coefficient of the income variable easy to interpret as the elasticity of WTP. In our full sample model (last column, Table 4), we control for the choice to contribute towards the individual sector programmes, which as noted in Table 2, results in significantly higher WTP when compared to stated contributions towards the WAF.

Results from the linear regressions show that income is a consistently positive and significant determinant of WTP towards both the individual sector programmes and the WAF (as well as in the pooled model). This result conforms to theoretical expectations and provides an important validation of our results.

The model exploring conditional payments to the WAF indicates that WTP is also significantly influenced by age, self-reported knowledge about climate change, membership of an environmental organisation, and a belief that climate change is not happening (this latter has a negative influence on WTP). And, with the exception of age, all these variables are significant in the pooled model when controlling for contributions towards the individual sector programmes. These results are uncontroversial, although it is interesting to note that real knowledge about climate change (indicated by ‘Know-CO2’) has no effect on WTP in any of the models. Thus, it appears that self-perceptions of knowledge are a more important influence on the WTP amount than real knowledge as measured by the ‘Know-CO2’ variable.

In contrast to the findings in the participation (multinomial logit) model, WTP is now *positively* influenced in all three models by whether respondents had already made up their

⁶ We also carried out selectivity-corrected regressions using Stata’s `selmlog` function (Stata, 2006), developed by Bourguignon, Fournier and Gurgand (2007). This model is appropriate when the selection variable is multinomial, which is the case in the present study (the standard approach used for binary selection variables is the well-known Heckman selection model). However, we found that that sample-self-selection is not an issue in our data; hence we do not report these results here. However, results from these selectivity-corrected regressions can be obtained from the authors upon request.

minds about whether or not to support adaptation prior to the survey (indicated by ‘Alreadydecided’). Thus, we find an apparent polarisation among individuals with existing and non-constructed preferences: either they do not support adaptation, or they support it a lot.

Overall, results confirm that WTP for adaptation in developing countries is strongly dominated by income, which is expected, but also by beliefs about whether climate change is happening, and existing preferences *vis a vis* support for adaptation.

4. Discussion and conclusions

Our study focused on WTP of UK residents for adaptation projects in less-developed countries. We found they were prepared to pay on average £27, or just under \$30 per year, using purchasing power adjustments (World Bank, 2014). This is less than one third of the back-of-the-envelope estimate of \$100-140 annual tax per capita that we estimated would be needed to raise the \$70-100bn in funds for developing country adaptation. Of course, we note that that the UK population may not representative of other country populations with regards to climate change concern levels, non-use values, or attitudes towards adaptation in developing countries. More research on WTP for adaptation across a range of developed country contexts would be useful at this stage.

However, the main aim of this paper was to stimulate discussion regarding responsibilities associated with climate change adaptation. We did this by highlighting the UK public’s willingness to support adaptation efforts in developing countries. Our findings show that public support falls way below the levels needed for developing countries to successfully adapt. Furthermore, if we take the median value of £6 per year as a more appropriate indicator of the UK public’s WTP (i.e. the amount that 50% of the population would be willing to pay), then we may consider public support to be negligible.

Clearly, much needs to be done to motivate people to lend support to those who – despite contributing relatively little to global carbon emissions - are likely to bear the brunt of climate change impacts. However, regression results on our data suggest that this will be no easy task. Together with ability to pay, WTP appears to be strongly driven by a combination of beliefs and individuals’ perception of their own knowledge levels, rather than actual knowledge of climate change or education levels. In particular, a belief that nature is the main

cause of climate change appears to have a strong negative influence on the decision whether to contribute or not. A key issue emerging from this discussion is that of moral responsibility. Social psychologists have identified a number of cognitive mechanisms employed by individuals to justify engaging in unethical behaviour (Bandura, 2002), one of which involves displacement of responsibility onto something external to the individual. We observe this displacement of responsibility amongst respondents that attribute climate change to natural causes. We propose that these individuals may be targeted via a public information campaign emphasising that ‘nature’ is no longer external or outside of our control, and that human activities are fundamentally altering the functioning of hydrological, atmospheric and ecosystem processes – that we now live in an era that earth scientists are increasingly referring to as the ‘Anthropocene’ (Crutzen and Stoermer, 2000). This focused information may bring these disengaged individuals one step closer to taking moral responsibility for those affected by climate change.

Given our findings on the importance of beliefs and attitudes on WTP for climate change adaptation, we propose that climate change communication should move beyond simple information provision to more targeted approaches aimed at different groups based on their values, identities, mental models and personal priorities. More information is not always the solution (Cook and Lewandosky, 2011), and in fact can lead to rejection of a message. Climate change communication is an area of research that is generating a very large literature (e.g. Marx et al, 2007; Petrovic et al, 2014; Hardisty et al, 2010), much of which is synthesised in the “Guide to Effective Climate Change Communication” report (CRED, 2014). As noted in the CRED (2014) report “*One of the most important things climate communicators need to understand is that climate communication is not a one-size-fits-all practice*” (p78). This means recognising that there are many different ‘publics’. Thus, communicators must align messages with the audience’s worldviews, and frame these messages in terms that matter to the audience.

We anticipate that, if the findings of this study are in any way indicative of preferences of citizens of pledging countries in general, then developing country adaptation is unlikely to be backed by an engaged and financially supportive citizenry in the pledging countries. To engage the many different audiences that make up the ‘public’, communication efforts must move beyond the simple provision of information and instead, connect with people’s existing values and beliefs.

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Supplemental data

Supplemental data for this article can be accessed at:
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