

# Co-benefits of addressing climate change can motivate action around the world

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**Personal and political action on climate change is traditionally thought to be motivated by people accepting its reality and importance. However, convincing the public that climate change is real faces powerful ideological obstacles<sup>1–4</sup>, and climate change is slipping in public importance in many countries<sup>5,6</sup>. Here we investigate a different approach, identifying whether potential co-benefits of addressing climate change<sup>7</sup> could motivate pro-environmental behaviour around the world for both those convinced and unconvinced that climate change is real. We describe an integrated framework for assessing beliefs about co-benefits<sup>8</sup>, distinguishing social conditions (for example, economic development, reduced pollution or disease) and community character (for example, benevolence, competence). Data from all inhabited continents (24 countries; 6,196 participants) showed that two co-benefit types, Development (economic and scientific advancement) and Benevolence (a more moral and caring community), motivated public, private and financial actions to address climate change to a similar degree as believing climate change is important. Critically, relationships were similar for both convinced and unconvinced participants, showing that co-benefits can motivate action across ideological divides. These relationships were also independent of perceived climate change importance, and could not be explained by political ideology, age, or gender. Communicating co-benefits could motivate action on climate change where traditional approaches have stalled.**

Those trying to motivate widespread action on climate change face two hurdles. The first is to convince enough people that climate change is real and important. The second is to move people from accepting its reality and importance to acting, both in pressuring their governments and in their personal lives. A single strategy has typically been used to overcome both hurdles: present the science and consequences of climate change in more compelling ways<sup>9</sup>.

This intuitive strategy was initially successful, but in many places progress has stalled or even reversed. Communicating climate science is now failing to persuade those who remain unconvinced climate change is real ('unconvinced', or climate sceptics)<sup>10</sup>, and the public priority of climate change is declining in many countries<sup>5,6</sup>. These issues are strongly linked to political ideology<sup>1–4</sup>, giving cause for pessimism—if people need to shift their basic political ideologies to act on climate change, the prospect for further progress is bleak.

New approaches are emerging that could sidestep these hurdles. One promising approach has been to highlight the co-benefits for society from acting on climate change<sup>7</sup>, referring to community benefits resulting from mitigation behaviours. As examples, mitigation efforts can reduce pollution<sup>11,12</sup>, support economic development through green industries<sup>13,14</sup>, or benefit population health by reducing disease or promoting healthier lifestyles (for example, cycling/walking instead of driving)<sup>12,15,16</sup>. A less obvious co-benefit involves community functioning, where climate change action can contribute to a more benevolent (caring and moral) community<sup>8,17</sup>.

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One advantage of co-benefits is that they can appeal to people unconvinced or unconcerned about climate change, as they do not depend on believing climate change is real or important. However, two challenges remain for establishing their effectiveness in motivating public action. First, researchers have focused on some co-benefits, such as reduced pollution or economic development, without an integrated approach to understand how co-benefits are related and comparing their importance for motivating public action. Second, climate change requires a global solution, but most co-benefits research has been conducted in Western countries (for example, USA (ref. 16)). It is therefore unclear whether some co-benefits are more influential in different countries, similar to the variation observed in climate change risk perceptions across countries<sup>18</sup>.

Our research addresses these challenges by providing an integrated framework for examining co-benefits, and by collecting data from around the world. By showing how perceptions of co-benefits are related to people's motivations to act on climate change around the world, the findings could help researchers, policymakers and communicators develop effective local and global strategies for using co-benefits to motivate action.

Data were obtained from 24 countries spanning all inhabited continents and with diverse carbon emission levels (see Supplementary Table 1). University student samples were selected to facilitate comparisons, as students typically occupy similar socio-economic positions across countries. We also obtained community samples in ten countries to establish the generalizability and robustness of findings.

Research participants first indicated their beliefs about the reality and importance of climate change. Those who believed climate change is real ('convinced') considered what their nation would be like in the future if action had successfully mitigated climate change. Those unconvinced that climate change is real, for whom successful mitigation is not applicable, considered what their nation would be like in the future if people had taken action aimed at mitigating climate change.

Participants then considered the potential co-benefits for their society in these scenarios. To develop an integrated framework, we noted that many co-benefits, such as economic development, new technologies, and improvements in disease or poverty, are captured in a model of people's beliefs about the future of society that has been validated across a wide range of social issues, including climate change<sup>8,17</sup>. We used this 'collective futures' model and added two mitigation co-benefits for this research: pollution, and green space (extent of parks and reserves).

The collective futures model has four dimensions of co-benefits. Two dimensions address the social 'conditions' in which people live: Development (for example, economic development, scientific progress) and Dysfunction (for example, pollution, disease). Two further dimensions address the 'character' of people in society: Benevolence (whether people are caring and moral) and Competence (whether people are skilled and capable), reflecting the fundamental dimensions used to understand groups<sup>19,20</sup>. Participants indicated whether these co-benefits would improve or worsen in their society (for example, if there were to be greater/lesser economic development, or if people would become more/less moral). The four dimensions formed reliable scales, as in previous research<sup>8,17</sup>, indicating that people see close relationships between some co-benefits (for example, pollution and disease were components of a broader Dysfunction dimension), with lower reliabilities for unconvinced samples in a few countries (see Supplementary Section 1).

We examined how these co-benefit dimensions were related to three measures of motivations to act on climate change<sup>21</sup>. The first assessed public and political actions (citizenship), such as voting for pro-environmental politicians and contributing time/money to

pro-environmental groups. The second involved personal domestic actions, such as conserving energy and green consumerism. The third measured financial behaviour (donation), where participants were entered into a prize draw (150 US dollars in local currency), and committed an amount for the researchers to donate to a pro-environmental organization if they won.

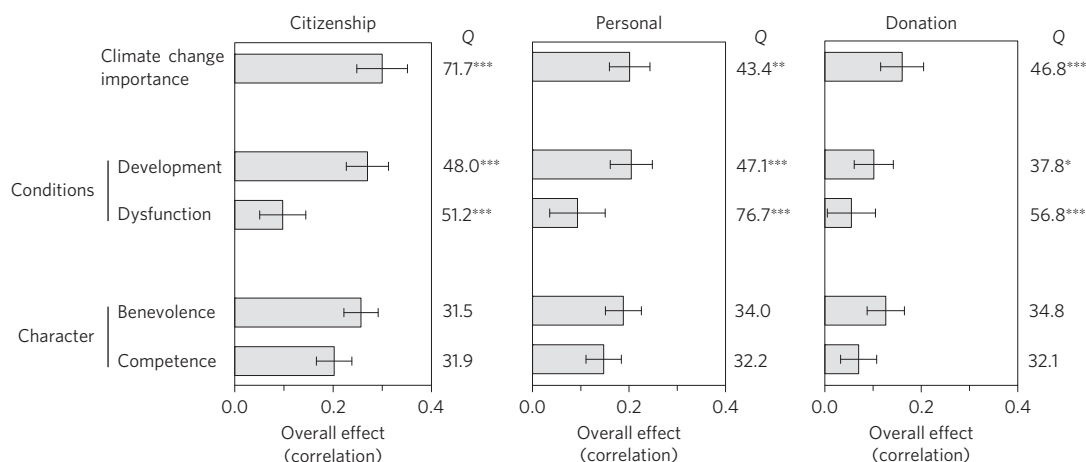
Correlations between these variables were computed in each country, and meta-analysis<sup>22</sup> was used to identify how each co-benefit dimension was related to motivations to act. Meta-analysis computes the average correlation across all samples (effect size) weighted by sample size, with a 95% confidence interval indicating the likely range of this correlation. Meta-analysis also identifies whether the magnitude of the correlations varies substantially across the samples (Q-statistic).

We first established the strength of relationships between co-benefits and motivations to act, including climate change importance as a benchmark. To provide the toughest test of the additional value of co-benefits, we focused first on 'convinced' participants, who were expected to show strong effects for climate change importance. Figure 1 shows that believing climate change is important had the strongest effect size across all action measures for student samples ( $n = 4,049$ ). However, this effect varied significantly across countries. Critically, two co-benefits had effects of a comparable size to climate change importance. Development showed the strongest effect sizes for citizenship and personal actions and a weaker effect for donations, with effect sizes also varying across countries. Effect sizes for Benevolence were also relatively strong but were less variable across countries.

We also conducted additional analyses to examine the robustness of these findings (details in Supplementary Section 3). Effect sizes for co-benefits were slightly stronger in community samples (ten countries;  $n = 1,239$ ), suggesting that results for student samples may be underestimates. Effect sizes in both student and community samples were not influenced by demographic variables often linked to climate change action: political ideology, age, and gender<sup>3,23</sup>. Effect sizes for climate change importance and co-benefits were also independent of each other, showing that they provide separate motivations for climate change action.

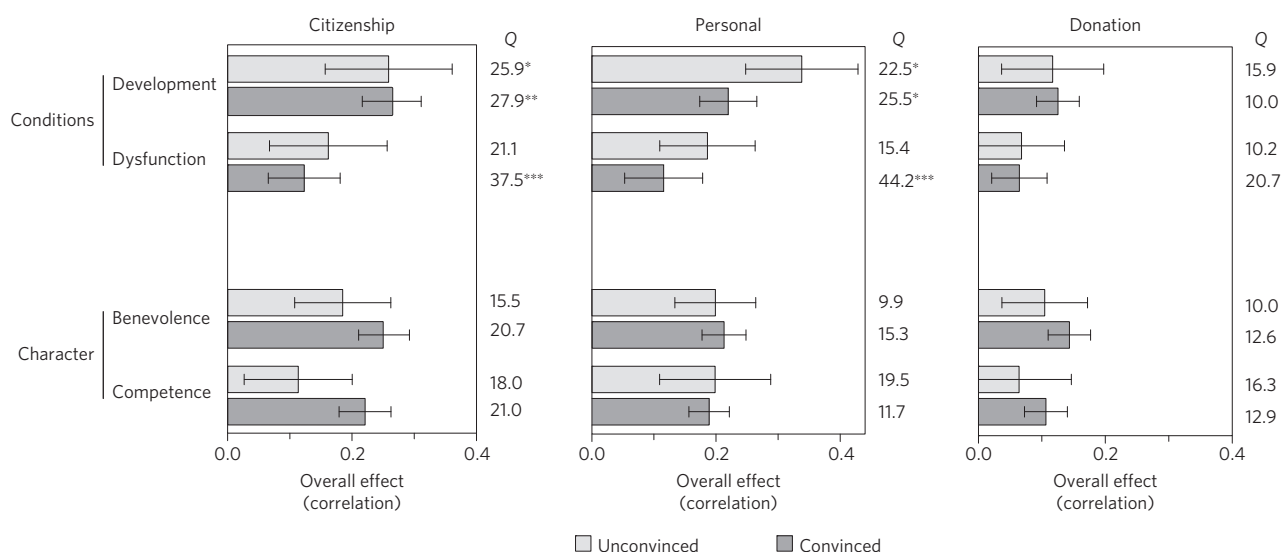
These findings indicate that co-benefits have impressive effect sizes for convinced participants, but their usefulness would be greatly enhanced if they also motivate action for the unconvinced. Most samples included a small unconvinced minority, and to increase power we analysed countries with at least 20 unconvinced participants combined across student and community samples (14 countries;  $n = 908$ ). Figure 2 shows effect sizes comparing the unconvinced and convinced (student and community combined) from the same countries. Development and Benevolence again had the strongest effects. Compared to convinced participants, unconvinced participants showed similar or stronger effects for co-benefits related to societal conditions, and similar or weaker effects for character co-benefits. Unconvinced participants seemed particularly motivated by Development co-benefits.

For climate change importance, Development and Dysfunction, correlations varied significantly across countries (see Q-statistics in Figs 1 and 2). We examined whether this variability was related to two theoretically grounded explanations: differences in climate change contributions (greenhouse gas emissions and renewable energy)<sup>24</sup> and country wealth (GDP per capita)<sup>25,26</sup>. We performed meta-regression<sup>22</sup>, a meta-analytic technique analogous to regression, to explain this variability across samples, using student samples to maximize the number of countries. Country wealth explained significant variation for climate change importance, indicating that its relationship with motivations to act was weaker in poorer countries. However, these predictors did not account for the variation in Development and Dysfunction effect sizes, nor did other predictors testing alternative explanations



**Figure 1 | Meta-analyses showing average effect sizes (with 95% confidence intervals) and tests for cross-country variability (Q) for climate change importance and co-benefit dimensions with motivations to act on climate change for 'convinced' participants ( $n = 4,049$ ) across 24 countries.**

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.005$ . Citizenship refers to public/political behaviours, Personal to domestic behaviours, and Donation to financial behaviour. The bars show the average correlation effect across countries, with the 95% confidence interval for this average effect. The Q-statistic evaluates cross-country variability in effect sizes. Development and Benevolence co-benefits showed comparable effect sizes to climate change importance across the behavioural measures. Q-statistics show that climate change importance and Development/Dysfunction co-benefits varied in their effects across countries, whereas Character co-benefits showed more consistent effects across countries.



**Figure 2 | Meta-analyses showing average effect sizes (with 95% confidence intervals) and tests for cross-country variability (Q) for climate change importance and co-benefit dimensions with motivations to act on climate change for 'unconvinced' participants from 14 countries ( $n = 908$ ; student and community combined), and for 'convinced' participants (student and community combined) from the same countries.** \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.005$ . Unconvinced and convinced participants showed the strongest effects for Development and Benevolence co-benefits. Compared to those convinced, those unconvinced showed similar or stronger effects for Conditions co-benefits (but with variation across countries) and similar or weaker effects for Character co-benefits.

(details in Supplementary Section 4), meaning that explanations of the variation in correlations for these dimensions remain to be established.

The results tell a consistent story. Motivations to act on climate change were clearly related to beliefs about co-benefits, especially for economic and scientific development (Development) and for building a more caring and moral community (Benevolence). Commonly cited co-benefits addressing Dysfunction (for example, pollution, disease<sup>11,12,15,16</sup>) were actually the weakest motivators of action overall. For those convinced that climate change is real, co-benefit effects were independent of believing climate change is important, yet were of comparable strength

in motivating action. Unconvinced participants showed similar effects to those convinced, and were especially motivated by Development co-benefits.

It is worth noting that the number of unconvinced participants was relatively small and, although community samples increased the generalizability, our samples were not fully representative of the populations of each country. The correlational data also means further research is needed to verify causal relationships. However, the strong and consistent findings across student and community samples, and across those convinced and unconvinced, gives a firm basis for further research on these co-benefits, which are at present not measured in consortium-funded representative surveys.

The findings give cause for hope at a critical time, contrasting with the pessimistic implications of research suggesting action is prevented by ideology<sup>1–3</sup>, or relies on personal experience of climate change<sup>27,28</sup>. Communicating the co-benefits of addressing climate change could provide a way to foster public action, and thereby influence government action, even among those unconvinced or unconcerned about climate change. Communicating climate change importance may continue to be effective in promoting action in those convinced climate change is real, but less so in poorer countries. Communicating Benevolence co-benefits is likely to have the most consistent effects for a worldwide audience, but in some countries emphasizing Development may have greater impact.

Communicating climate science and co-benefits of acting should be complementary, not competing, strategies. How to combine these approaches most effectively requires further consideration, with research suggesting that importance and co-benefit messages may counteract each other when used together, at least for conservatives in the United States<sup>29</sup>. Crucially, addressing co-benefits requires moving beyond communication to include co-benefits in policy design and decision-making, so that addressing climate change delivers the broader benefits that the public value.

The prospect of mitigating climate change is greater when more people act. We identified which co-benefits can motivate action independently of views about climate change importance, even for those unconvinced climate change is real. Rather than insisting that the public develop stronger concerns about climate change, the present findings show the potential for connecting climate change mitigation to the broader social concerns of the public<sup>30</sup>.

## Methods

Methods and any associated references are available in the [online version of the paper](#).

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## References

- Bliuc, A.-M. *et al.* Public division about climate change rooted in conflicting socio-political identities. *Nature Clim. Change* **5**, 226–229 (2015).
- Hoffman, A. J. The growing climate divide. *Nature Clim. Change* **1**, 195–196 (2011).
- McCright, A. M. & Dunlap, R. E. Cool dudes: The denial of climate change among conservative white males in the United States. *Glob. Environ. Change* **21**, 1163–1172 (2011).
- McCright, A. M. & Dunlap, R. E. The politicization of climate change and polarization in the American public's views of global warming, 2001–2010. *Sociol. Q.* **52**, 155–194 (2011).
- Pew Research Center *Thirteen Years of the Public's Top Priorities* (2014); <http://www.people-press.org/interactives/top-priorities>
- United Nations Development Group *A Million Voices: The World We Want* (2013); <http://www.worldwewant2015.org/millionvoices>
- Moser, S. C. & Dilling, L. in *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change* (eds Moser, S. C. & Dilling, L.) Ch. 32, 491–516 (Cambridge Univ. Press, 2007).
- Bain, P. G., Hornsey, M. J., Bongiorno, R., Kashima, Y. & Crimston, D. Collective futures: How projections about the future of society are related to actions and attitudes supporting social change. *Pers. Soc. Psychol. Bull.* **39**, 523–539 (2013).
- Bowman, T. E. *et al.* Time to take action on climate communication. *Science* **330**, 1044 (2010).
- Whitmarsh, L. Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. *Glob. Environ. Change* **21**, 690–700 (2011).
- Nemet, G. F., Holloway, T. & Meier, P. Implications of incorporating air-quality co-benefits into climate change policymaking. *Environ. Res. Lett.* **5**, 014007 (2010).
- West, J. J. *et al.* Co-benefits of mitigating global greenhouse gas emissions for future air quality and human health. *Nature Clim. Change* **3**, 885–889 (2013).
- UNEP *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication—A Synthesis for Policy Makers* (2011); <http://www.unep.org/greeneconomy>
- Fabian, N. Economics: Support low-carbon investment. *Nature* **519**, 27–29 (2015).
- Thurston, G. D. Mitigation policy: Health co-benefits. *Nature Clim. Change* **3**, 863–864 (2013).
- Maibach, E. W., Nisbet, M., Baldwin, P., Akerlof, K. & Diao, G. Reframing climate change as a public health issue: An exploratory study of public reactions. *BMC Public Health* **10**, 299 (2010); [www.biomedcentral.com/1471-2458/10/299](http://www.biomedcentral.com/1471-2458/10/299)
- Bain, P. G., Hornsey, M. J., Bongiorno, R. & Jeffries, C. Promoting pro-environmental action in climate change deniers. *Nature Clim. Change* **2**, 600–603 (2012).
- Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C.-Y. & Leiserowitz, A. A. Predictors of public climate change awareness and risk perception around the world. *Nature Clim. Change* <http://dx.doi.org/10.1038/nclimate2728> (2015).
- Fiske, S. T., Cuddy, A. J. C. & Glick, P. Universal dimensions of social cognition: Warmth and competence. *Trends Cogn. Sci.* **11**, 77–83 (2006).
- Leach, C. W., Ellemers, N. & Barreto, M. Group virtue: The importance of morality (vs. competence and sociability) in the positive evaluation of in-groups. *J. Pers. Soc. Psychol.* **93**, 234–249 (2007).
- Stern, P. C. Toward a coherent theory of environmentally significant behavior. *J. Soc. Issues* **56**, 407–424 (2000).
- Lipsey, M. W. & Wilson, D. B. *Practical Meta-Analysis* (Sage Publications, 2000).
- Hunter, L. M., Hatch, A. & Johnson, A. Cross-national gender variation in environmental behaviors. *Soc. Sci. Q.* **85**, 677–694 (2004).
- Hsu, A. *et al.* *The 2014 Environmental Performance Index* (Yale Center for Environmental Law and Policy, 2014).
- Franzen, A. & Meyer, R. Environmental attitudes in cross-national perspective: A multilevel analysis of the ISSP 1993 and 2000. *Eur. Sociol. Rev.* **26**, 219–234 (2010).
- Freymeyer, R. H. & Johnson, B. E. A cross-cultural investigation of factors influencing environmental actions. *Sociol. Spectr.* **30**, 184–195 (2010).
- Spence, A., Poortinga, W., Butler, C. & Pidgeon, N. F. Perceptions of climate change and willingness to save energy related to flood experience. *Nature Clim. Change* **1**, 46–49 (2011).
- Broomell, S. B., Budescu, D. V. & Por, H.-H. Personal experience with climate change predicts intentions to act. *Glob. Environ. Change* **32**, 67–73 (2015).
- Gromet, D. M., Kunreuther, H. & Larrick, R. P. Political ideology affects energy-efficiency attitudes and choices. *Proc. Natl Acad. Sci. USA* **110**, 9314–9319 (2013).
- Hackmann, H., Moser, S. C. & St Clair, A. L. The social heart of global environmental change. *Nature Clim. Change* **4**, 653–655 (2014).

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## Author contributions

P.G.B., T.L.M., and Y.K. designed and coordinated the research project and collected data, with input into design and measures from all authors. P.G.B. analysed the data and wrote the paper, in conjunction with T.L.M. and Y.K. and with input from all authors. M.B., G.D., R.B.G., V.V.G., Y.G., L.-O.J., C.P., V.C.-V., J.I.A., A.U., C.D., S.O., J.P., M.S., L.S., R.G., N.L., O.J.M., C.W., G.E. and N.M.S. also translated materials, collected data and contributed to the manuscript. C.S.A., T.K., J.L.S. and P.W.S. also collected data and contributed to the manuscript.

## Additional information

Supplementary information is available in the [online version of the paper](#). Reprints and permissions information is available online at [www.nature.com/reprints](http://www.nature.com/reprints). Correspondence and requests for materials should be addressed to P.G.B.

## Competing financial interests

The authors declare no competing financial interests.



## Methods

The sections below describe the samples, data collection procedures, measures, and basic analytical approach. Additional information is provided in Supplementary Information.

**Samples and data collection.** Data were collected from 24 countries (24 student samples and 10 community samples) in the period of June 2013 to July 2014. Countries were targeted to span geographic regions and a wide range of climate change contributions based on the Environmental Performance Index<sup>24</sup>, which reflects national CO<sub>2</sub> emissions (both industrial and residential) and traditional/renewable energy production. Countries included 11 high carbon emitters (USA, Netherlands, Russia, Poland, Germany, Australia, China, Japan, South Korea, Israel, South Africa), 9 medium emitters (United Kingdom, France, Spain, Sweden, Norway, Venezuela, Mexico, Chile, New Zealand), and 4 low emitters (Brazil, Switzerland, Iceland, Ghana). Contributors from additional countries were involved in the research (especially in low-emitter countries), but were not able to provide a viable sample within the data collection time frame. Sample details are shown in Supplementary Table 1.

Contributors in each country were instructed to obtain a student sample of citizens from their country (target  $N = 200$ ), aiming for an even gender split and a diversity of study disciplines. Contributors who agreed to provide community samples were instructed to obtain a non-student citizen sample (target  $N = 200$ ). Community samples were typically sourced through commercial market research companies who specialize in recruiting across a country population, but some were convenience samples based on local recruitment strategies (for example, Poland).

Participants completed a survey developed with feedback from country contributors for applicability and relevance. Surveys were completed either online (17 countries) or on paper where local contributors viewed online administration as less practical (7 countries: Ghana, Japan, Mexico, Poland, South Korea, Spain and Venezuela). The paper version of the survey adhered strictly to a template developed by the project coordinators to ensure consistency and to match the online surveys.

Surveys were completed in the major local language, except in Switzerland, Ghana and South Africa, where multiple major languages are spoken. Swiss participants could complete the survey in German or French. The common language of student instruction was used in Ghana (English) and South Africa (English or Afrikaans). Translations were obtained using translation-back-translation by competent bilingual speakers, or using parallel translation where multiple bilingual speakers independently translated the survey. In both approaches, discussion of discrepancies between the translators and the project coordinators continued until an acceptable translation was agreed on.

**Measures.** The research project was designed to address several research questions in addition to those reported in the article. Below we describe the measures used in the article, and describe additional measures in Supplementary Section 1. Reliability indices (Cronbach's alphas) for multi-item scales and descriptive statistics for all measures are shown in Supplementary Tables 2 and 3, respectively.

**Climate change importance.** Participants first rated the item measuring perceived climate change importance, which was embedded among other items: "Addressing climate change is one of the most important issues facing society today (1 = strongly disagree, 5 = strongly agree)."

**Climate change beliefs.** Participants then completed a screening item asking them to choose from the following three options used in previous research<sup>17</sup>: "(1) I believe climate change is occurring, and human activities are having significant effects on climate change; (2) I believe climate change is occurring, but human activities are not having significant effects on climate change; or (3) I do not believe climate change is occurring." Participants who selected (1) were categorized as believing in anthropogenic climate change ('convinced'), and those who chose (2) or (3) were categorized as unconvinced or sceptical about the reality of anthropogenic climate change ('unconvinced').

**Co-benefits scenarios.** To give participants a context for thinking about co-benefits of climate change action, we asked them to think about what their society would be like in the future. Specifically, convinced participants were instructed to think about their country in 2050 where people have taken action that has prevented significant climate change. Unconvinced participants were instructed to think about their country in 2050 where people have taken action aimed at preventing significant climate change. The reason for using separate scenarios for convinced and unconvinced participants arose from pilot testing: the scenario where climate change was prevented (used for convinced participants) was deemed unsuitable for those unconvinced, and responses from a substantial number of convinced participants indicated they interpreted the more general scenario (used for unconvinced participants here) as indicating that action was not successful. Participants were then instructed to imagine what their country would be like in this scenario, and then proceeded to answer the co-benefit measures.

**Co-benefits measures.** For the scenario participants were instructed to imagine, they then rated their country in 2050 on scales from the validated

collective futures model<sup>17</sup>, in which conditions, character and societal values are distinguished.

**Conditions.** Participants rated the extent to which the following aspects of their country would become worse or improve compared to today ( $-5 =$  much worse,  $0 =$  same as today,  $+5 =$  much improved). The aspects of society reflected Development and Dysfunction dimensions. Development items were 'economic development', 'education levels', 'volunteering', 'scientific progress' and 'extent of community groups'. Dysfunction items were 'violent crime', 'poverty', 'disease', 'pollution', 'theft' and 'unemployment levels'.

**Character.** Participants rated how typical a list of personal characteristics would be of people in their country compared to today ( $-5 =$  much less typical than today,  $0 =$  same as today,  $+5 =$  much more typical than today). These characteristics reflected two dimensions. Benevolence items were 'caring', 'warm', 'considerate', 'honest', 'sincere', 'trustworthy', 'unfriendly' (reversed), 'immoral' (reversed), 'insensitive' (reversed) and 'unethical' (reversed). Competence items were 'competent', 'capable', 'assertive', 'lazy' (reversed) and 'unskilled' (reversed).

**Societal values.** Ratings of how values would change in society were also made, using 12 values selected from the Schwartz Value Survey<sup>31</sup> to reflect four quadrants (three values per quadrant). However, scales created to reflect each quadrant showed low reliabilities across many countries and were excluded from analyses.

**Motivations to act on climate change.** The three pro-environmental measures were presented in the context of addressing climate change.

**Citizenship.** Environmental citizenship intentions items were taken from an existing measure<sup>32</sup>, and adapted and extended based on feedback from contributors in the different countries. The final 12-item scale focuses on behaviours aimed at bringing about public and political action. Items added included exerting influence within a person's social network (friendship networks and social media). The scale header and items were: "Many individuals and groups interested in protecting the environment believe addressing climate change is a key concern. With this in mind, how likely are you to engage in the following activities in the next 12 months? (If it is not possible for you to perform an activity, please choose 'not applicable'.) (1 = not at all likely, 5 = very likely, na = not applicable.) (1) Sign a petition in support of protecting the environment. (2) Join or renew membership of an environmental group. (3) Join public demonstrations or protests supporting environmental protection. (4) Write a letter or call your member of Parliament or another government official to support environmental protection. (5) Give money to an environmental group. (6) Read a newsletter, magazine or other publication written by an environmental group. (7) If a local, state or Federal election was called, vote for a candidate at least in part because he or she was in favour of strong environmental protection. (8) Write to a newspaper in support of protecting the environment. (9) Boycott companies that are not environmentally friendly. (10) Volunteer to help an environmental group or event. (11) Post pro-environmental messages or links on social media (for example, Facebook, Twitter). (12) Speak in favour of pro-environmental policies in conversations with your friends or family." As some behaviours were less applicable to some people and in some countries, scale scores were created where participants provided answers (excluding 'not applicable') for at least six items. The 'not applicable' choice was selected less than a third of the time for every item in every country, indicating that overall participants believed these behaviours were possible in their country. To create scores for each individual, missing and 'not applicable' items were excluded, and the scale score was computed by averaging over the remaining items.

**Personal.** Personal sphere behavioural intentions differ from citizenship in focusing on household domestic behaviours. This scale was drawn from several sources<sup>32-34</sup>, and the final 12-item scale was developed with feedback from contributors about local pro-environmental behaviours. The scale header and items were: "Some people support action on climate change through activities in their personal lives. With this in mind, how likely are you to engage in the following activities in the next 12 months? (If it is not possible for you to perform an activity, please choose 'not applicable'.) (1 = not at all likely, 5 = very likely, na = not applicable.) (1) Install products to save energy (for example, low-energy light bulbs). (2) Buy environmentally-friendly products. (3) Conserve water at home (for example, when cooking or showering). (4) Minimize use of air-conditioning or heating. (5) Reduce car travel (for example, walk, cycle, use public transport). (6) Turn off lights and appliances when not in use. (7) Avoid or reduce eating meat. (8) Recycle. (9) Turn off electrical equipment rather than use 'standby' mode. (10) Eat food which is locally-grown or in season. (11) Use car-sharing or car-pooling schemes. (12) Buy products with less packaging." Scale scores were created where participants provided responses (excluding 'not applicable') for at least six items. In Norway and Sweden, the item 'Use car-sharing or car-pooling schemes' was rated as 'not applicable' by more than one-third of participants, but the vast majority of people viewed the behaviours as possible across the remaining items and countries. Missing and 'not applicable' items were excluded, and the scale score was computed by averaging over the remaining items.

**Donation behaviour.** In this measure participants were told they would be entered into a prize draw for a gift card to the value of 150 US dollars (in local currency equivalent, rounded to the nearest large number in the local currency).

They were asked whether they would allow the researchers to donate an amount of this prize (if they won) to an environment organization on their behalf. They nominated the amount (which could be zero), and were given the option to nominate an environmental organization. They were told that if they did not nominate an organization, the researchers would donate the amount to an international not-for-profit environmental organization. When this prize draw was conducted, the winner actually received the full amount (no money was withheld for donation). Analyses were conducted on the proportion of the prize participants nominated.

**Political ideology.** Political ideology was measured using a single item from previous research<sup>35</sup>: “In political matters, people sometimes talk about ‘liberals’ and ‘conservatives’. How would you place your views on this scale, generally speaking?” A seven-point scale was used, labelled 1 = very liberal, 2 = liberal, 3 = slightly liberal, 4 = moderate/middle of the road, 5 = slightly conservative, 6 = conservative, 7 = very conservative.

**Analyses.** Analyses were conducted on participants who identified themselves as citizens of the country of data collection, and who identified as students (student samples) or non-students (community samples). All data meeting these criteria were included in analyses, except for a single extreme outlier in the Swedish ‘unconvinced’ sample.

Meta-analysis was used to examine the average correlations between co-benefits and motivations to act across countries, as well as whether these relationships varied significantly in strength across countries (*Q*-statistic). A related analytical method, meta-regression, was used to examine explanations for significant cross-country variation where this occurred. More detailed descriptions of meta-analysis, including comparisons with other analytical approaches, and meta-regression are presented in Supplementary Sections 2 and 4, respectively.

## References

31. Schwartz, S. H. in *Advances in Experimental Social Psychology* Vol. 25 (ed. Zanna, M. P.) 1–65 (Academic Press, 1992).
32. Stern, P. C., Dietz, T., Abel, T., Guagnano, G. A. & Kalof, L. A value-belief-norm theory of support for social movements: The case of environmentalism. *Hum. Ecol. Rev.* **6**, 81–97 (1999).
33. McDonald, R. I., Fielding, K. S. & Louis, W. R. Energizing and de-motivating effects of norm conflict. *Pers. Soc. Psychol. Bull.* **39**, 57–72 (2012).
34. Whitmarsh, L. & O'Neill, S. Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. *J. Environ. Psychol.* **30**, 305–314 (2010).
35. Schwartz, S. *et al.* Basic personal values underlie and give coherence to political values: A cross national study in 15 countries. *Polit. Behav.* **36**, 899–930 (2014).

## Corrigendum: Co-benefits of addressing climate change can motivate action around the world

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In the version of this Letter originally published, the following affiliation was missing for Paul G. Bain: Institute for Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Australia. This has now been corrected in the online version of the Letter.