China Economic Review 77 (2023) 101879

Contents lists available at ScienceDirect

China Economic Review

journal homepage: www.elsevier.com/locate/chieco

Individuals' and households' climate adaptation and mitigation behaviors: A systematic review

Jie-Sheng Tan-Soo [a], Jun Li [b], Ping Qin [b,*]

[a] Lee Kuan Yew School of Public Policy, National University of Singapore, Singapore
[b] School of Applied Economics, Renmin University of China, China

ARTICLE INFO

JEL classifications numbers:
D10
D6
D91
Q50
Q54

Keywords:
Climate change
Climate inequality
Low- and middle-income countries
Climate mitigation and adaptation

ABSTRACT

There is increasing recognition that individuals have larger roles to play in reducing greenhouse gas (GHG) emissions. As such, we conduct a systematic literature review to consolidate existing evidence, and examine which factors are most important in driving individuals' and households' climate adaptation and mitigation behaviors in developing countries. A comprehensive literature search yields 58 empirical studies, and 158 usable analyses with which we conduct a vote-counting exercise. We first find evidence of climate inequality as adoption of adaptation behaviors are strongly driven by income. Furthermore, this inequality is likely to exacerbate as most adaptation behaviors (e.g., air-conditioners) emit high levels of GHG. A second major observation is that education and environmental knowledge (rather than income) are more important drivers for climate mitigation behaviors. The two findings mean that in order to reduce climate inequality, policymakers should target and assist vulnerable population according to their ability to adapt, and also implement more intensive educational outreach and information campaigns to encourage individuals and households to adopt GHG mitigation activities.

1. Introduction

Ever since the United Nations Framework Convention on Climate Change was established in 1992, policymakers worldwide have been trying to coordinate greenhouse gas (GHG) emissions cuts. Starting with the Kyoto Protocol in 1997 to the yearly Conference of the Parties meetings, attempts to reduce GHG emissions have mostly been unsuccessful as global GHG emissions are 60% higher now compared to 1990 – when the first Intergovernmental Panel for Climate Change report was published (Clémençon, 2016; Harris, 2007; Rosen, 2015; Stoddard et al., 2021). As skillfully summarized by Stoddard et al. (2021), failure to mitigate is mostly due to vested interests that exist within governments and corporations.

In turn, there are now increasing calls to re-focus efforts toward the grassroot level (i.e., on individuals and households) to pursue a less carbon-intensive lifestyle (Stern, 2021; Stoddard et al., 2021). Such an approach makes intuitive sense as individuals and households are responsible for 17% of carbon dioxide (CO_2) emissions worldwide (Nejat, Jomehzadeh, Mahdi, & Gohari, 2015). Being the final consumer, the public is also indirectly responsible for emissions in the transportation and industrial sectors (Geng et al., 2017). In this regard, effective reduction in GHG emissions depends crucially on inducing behavioral changes in the public to reduce their carbon footprint (Scannell & Gifford, 2013).

However, shifting the responsibility of GHG mitigation to the public does not mean that earlier dilemmas will dissipate.

* Corresponding author.
E-mail address: pingqin@ruc.edu.cn (P. Qin).

https://doi.org/10.1016/j.chieco.2022.101879
Received 10 May 2022; Received in revised form 8 October 2022; Accepted 1 November 2022
Available online 5 November 2022
1043-951X/

First, just as there exists misalignment between emitters and responsibility of mitigation at the macro-level, similar inequality exists for individuals (Cazorla & Toman, 2001; Sturm, Pei, Wang, Löschel, & Zhao, 2019).[1] This is especially true as GHG emissions are typically highly correlated with income and socioeconomic status even at the individual level (Nielsen, Nicholas, Creutzig, Dietz, & Stern, 2021; Salo, Savolainen, Karhinen, & Nissinen, 2021). Similarly, in the manner that richer countries can better insulate themselves from climate change, climate inequality is also manifested through impacts for individuals as there are conclusive evidence showing that wealthier residents can better adapt to climate change through costly investments in protective or defensive expenditures, e.g., air-conditioners, water, heating, migration, etc. (Hoffmann, Šedová, & Vinke, 2021; Li, Pizer, & Wu, 2019; Qin, Chen, Tan-Soo, & Zhang, 2022; Rode et al., 2021).

Second, just as countries have a battery of policy options with respect to climate change (e.g., reduce greenhouse gases emissions, strengthen coastlines, etc.), there are also many ways in which individuals or households can react toward climate change. For instance, they can choose to engage in climate mitigation behaviors by adopting carbon-friendly behaviors such as switching to public transport or electric vehicles, consuming more plant-based food, recycling and reducing overall consumption. Osberghaus and Demski (2019) found that German households that were previously exposed to floods showed more interest in purchasing electricity from renewable sources. On the other hand, individuals can also elect for climate adaptation actions to better protect themselves from adverse impacts of climate change or extreme weather events. For example, Auffhammer (2014) showed using aggregated data that ownership of air conditioners increases in Chinese cities that had abnormally hot summer in the preceding year.

Toward this end, individuals protecting the environment (mitigation) or protecting themselves from the environmental harms (adaptation) is not a new phenomenon as many disciplines and fields (most notably, environmental economics) have introduced frameworks to examine such behaviors in the context of issues such as pollution and forest conservation (e.g., see Champ, Boyle, Brown, and Peterson (2003) for an overview of such methods and framework). Even though there are many insights from existing literature into the interaction between individuals' behaviors and their environment, an important point of departure is that threats from climate change are different from other environmental harms in several ways.

First, unlike air pollution and most other environmental problems that pose health threats, the harms from climate change are not as direct and immediate (IPCC, 2014a). As such, the decision-making process of individuals may deviate from conventional models predicting adoption of protective measures. Second and related, there are many controversies behind the science of climate change, ranging from causes to the extent of impacts (Hess & Maki, 2019; Paavola & Adger, 2006; Pidgeon, 2012; Scruggs & Benegal, 2012). Taken together with the first point, this means that the motivation behind individuals' responses to climate change may largely depend on one's inherent knowledge and preferences. Third and importantly, a distinction between climate change and other environmental problems is that individuals can choose to either lessen their impacts via reducing carbon footprint or alleviate the impact on climate change on themselves.

As both sets of behaviors are resource intensive and have diametrically opposite outcomes on climate change, it thus becomes an important policy question to understand the drivers or motivations behind them.

In this regard, the purpose of this study is to conduct a systematic review of the motivations behind individuals' and households' climate mitigation and adaptation behaviors toward to climate change, with a specific focus on developing countries. There are several reasons why such a study is sorely needed.

First and most importantly, climate inequality is fast emerging as an important consideration as it becomes increasingly clear that the impacts of climate change are distributed unevenly across the socioeconomic spectrum (Islam & Winkel, 2017). Put differently, individuals and households that have the economic means and knowhow to adapt to extreme weather and changing climate are less impacted by climate change. As such, uncovering the broad population factors and trends behind adoption of climate adaptations can help governments better identify and assist citizens vulnerable to climate change.

Second and related, our dual focus on adaptation and mitigation behaviors introduces a previously unconsidered dimension to climate inequality. That is, to the extent that climate adaptation helps insulate one from the adverse impacts of climate change, they also emit considerable GHG emissions to exacerbate the problem (Auffhammer, 2014; Li et al., 2019). Conversely, while climate mitigation behaviors do not offer direct protection, they help reduce the likelihood of severe climate change. This situation depicts moral hazard where individuals and households are skewed toward behaviors and actions that increase risk for others. Policymakers can design interventions and program to help channel more people toward climate mitigation if they have clearer understanding of the driving factors behind these behaviors.

Third, we gather and summarize evidence from developing countries because even though the effects of climate change are projected to be worst in these parts of the world, there are relatively fewer studies focusing on them (Chinowsky et al., 2011; Ford, Berrang-Ford, & Paterson, 2011). According to latest available data, there were over 9000 and 10,000 publications on climate change specific to North America and Europe for the period of 2000 to 2010. On the other hand, Asia with around 60% of the world's population has around 8000 publications for the corresponding period (IPCC, 2014c).[2] In this regard, a review of research from lower- and middle-income countries will help consolidate the current thin and scattered evidence, and redirect future research efforts toward noticeable knowledge gaps.

Lastly, to the best of the authors' knowledge, even though there are two existing reviews of research on climate adaptation, our focus differs from theirs'. A systematic review conducted by van Valkengoed and Steg (2019) examined factors motivating climate

[1] For instance, it is estimated that around 86% of historical cumulative CO_2 emissions from 1750 to 2020 is accounted by high-income and upper-middle income countries. Source: https://ourworldindata.org/contributed-most-global-co2. Last accessed: 8 May 2022.

[2] In a later section, we will also conduct an algorithm search of existing studies conducted in developed countries, to highlight the disparity in research output across these two regions.

adaptation behaviors. In that review, the authors summarized 106 set of results (from 90 papers) across 23 different countries to examine how 13 motivational factors relate to various adaptation behaviors. However, the authors define adaptation as any behavior or intention that reduces the impacts of climate-related hazards, when it is well-known that there is a large behavior-intention gaps in pro-environmental behaviors (Carrington, Neville, & Whitwell, 2010). In addition, that review did not distinguish between stages of economic development (developed or developing countries), and actors (farmer or household). These are important points of consideration due to different response strategies across different sets of stakeholders in various underlying economic conditions. A second review by Noll, Filatova, and Need (2020) instead summarizes factors motivating individual flooding adaptation from 25 countries, and more than 50 publications. Although that review focused on actual household behaviors, it only considered flood adaptation. A central point of differentiation from this study is that they paid more attention on the effects of locational-culture characteristics, and rarely discussed individual characteristics. In summary, this review fills a void in the literature as we systematically summarize rapidly accumulating evidence on factors behind adoption of climate mitigation and adaptations behaviors in developing countries settings.

Following an extensive search, and careful curating of unrelated studies, we end up with 28 and 30 studies (72 and 86 analyses respectively) for adaptation and mitigation behaviors respectively. We apply separate vote counting exercise to each set of literature, and arrived at the following main findings.

First, across both sets of literatures, the most widely included variables are socioeconomic factors (e.g., education, income, age, and gender). While these variables generally affect adoption of climate adaptation and mitigation in expected ways, there are important dichotomies between them. We observe that climate adaptation behaviors are more readily affected by income whereas climate mitigation behaviors are more responsive toward education. The implication of the former is that climate adaptation is not only an outcome of climate inequality (since only those with the necessary economic means to adapt can lessen their impacts to climate change), it can potentially exacerbate current uneven distribution of impacts as many adaptation behaviors (e.g., air-conditioners) have high carbon footprint. On the other hand, the latter confirms that more intensive information campaigns and interventions can lead to more adoption of climate mitigation behaviors by individuals and households.

Second, even though there are relatively fewer studies that included environmental-related variables, we can still discern its overall trend. Our observation corroborates the first finding as variables representing knowledge of climate change and past experiences of extreme weather matters more for adoption of climate mitigation behaviors. However, given their importance in driving behaviors, it is still concerning environmental-related variables are mostly ignored. As such, it is useful for future research to standardize data collection method to objectively assess individuals' environmental knowledge and perception. Moreover, there already exist "big data" sources (e.g., historical weather data from satellite sources) that can readily attribute past experiences of climate change.

The rest of the paper proceeds as follows. The next section describes our search process, and the vote-counting procedure. The third section contains results, and its corresponding discussion. Lastly, we conclude with research and policy implications in section four.

2. Methodology

2.1. Literature search

The central purpose of this study is to consolidate current evidence on drivers of individuals' climate adaptation and mitigation behaviors in developing countries. We begin this process by applying two sets of Boolean search queries to three academic databases: Google Scholar, Web of Science, and Scopus:

i) ((climate change OR global warming) AND (mitigate* OR mitigating* OR mitigation*) AND (developing country* OR lower-income OR middle-income OR LMIC*) AND (human* OR individual* OR household*) NOT (agriculture* OR farm*))
ii) ((climate change OR global warming) AND (adapt* OR adapting* OR adaptation*) AND (developing country* OR lower-income OR middle-income OR LMIC*) AND (human* OR individual* OR household*) NOT (agriculture* OR farm*))

The first part of the search algorithm restricts to studies that focus on climate change. We include "global warming" as a substitute as this phrase has been commonly used to describe rising temperatures or changing weather or climatic conditions (Benjamin, Por, & Budescu, 2017; Zaval, Keenan, Johnson, & Weber, 2014).

Second, the following part of the search query pertains to the behaviors under review in this study, and is the only portion that differs between the two algorithms. Specifically, i) is used for retrieving studies on mitigation behaviors whereas ii) is for climate adaptation. Toward this end, we include each type of behavior as a verb, and two other versions where common suffixes are added. Even though there are a multitude of mitigation and adaptation behaviors that individuals and households can undertake (e.g., adoption of air-conditioner, adoption of electric vehicles), we elect to not search each behavior separately. The main reason being that there are many behaviors that fall under the category of climate adaptation or mitigation behaviors, and search outcomes can easily become unmanageable if we attempt to include all behaviors-type separately. Moreover, if these behaviors are adopted or practiced in response to climate change, then it must also be the case that the article would contain the keywords "adapt" and/or "mitigate".

Third, to fit with the theme of this review, the next part of the search algorithm ensures that we are only picking up studies from developing countries. We additionally include "lower- and middle-income" to capture other modes of describing developing countries.

Fourth, the last two portions of the algorithm relate to the target of investigation. The inclusion of "individuals" and "households" is self-explanatory. However, an earlier search attempt yielded many studies on agricultural practices designed to combat climate change. As such, we add the last search term to exclude any studies that pertains to agriculture or farm-related topics.

Panel A of Fig. 1 shows the outcome of the literature search for climate adaptation-related studies. The search algorithm initially recovered 1101 studies across the three academic databases (i.e., Google Scholar, Web of Science, Scopus), of which 17 are duplicates. To refine the selection of 1084 unique studies, we first read the abstracts to exclude studies that are not on climate change and/or adaptation behaviors (502 studies), and not conducted in developing countries settings (381 studies). Specifically, we look out for studies broadly covering climate-related hazards, including floods, heatwaves, vector-borne diseases, land/mudslides, drought, (tropical) storms and wildfires.

This pass-through yield 201 studies which we examine in greater detail. Of these, we further excluded 133 studies that did not focus on actual individuals' behaviors (e.g., Osberghaus and Demski (2019) found that residents that experienced floods are more likely to search for information on electricity generated by renewable sources), and 40 studies that did not provide statistical or econometric evidence. Toward this end, adaptation behaviors are defined as any actual behavior that reduces the impacts of climate-related hazards, including preparatory action (e.g., having an emergency kit or moving furniture), purchasing insurance, evacuating from climate-related hazards, and migration. Similarly, mitigation behaviors are defined as (actual rather than intended) actions that reduce one's carbon footprint (e.g., adoption of electric vehicles, purchasing carbon credits). Lastly, statistical or econometric evidence are defined as empirical analyses that examine the relationship between adaptation (or mitigation) behaviors and at least one motivational factor. These evidence needs to be accompanied by the estimated coefficient, standard errors and/or *p*-values.

In all, we arrive at 28 studies that provide individual- or household-level quantitative evidence on climate adaptation behaviors. As some of the studies contain more than one analyses (e.g., sub-sample regressions, different types of climate adaptation behaviors), we count each analysis separately and reach a total of 72 analyses.

Using the same process, we end up with another 30 studies and 86 analyses that focus on climate mitigation behaviors (Fig. 1, Panel B).[3]

Lastly, to highlight the difference in research attention toward developed viz-a-viz developing countries, we apply the same search algorithm to retrieve studies conducted in the former settings (Fig. A1). The same search criteria yield 83 and 91 studies respectively for climate adaptation and mitigation behaviors in developed countries, thereby underscoring the disparity in current knowledge base across different parts of the world.

2.2. Vote counting approach

Our main analytical approach for synthesizing current literature is vote counting.

While meta-regression is another commonly-used method in systematic reviews (e.g., Wolf et al., 2014), we elect for vote counting here as the former approach is most suitable where the outcome of interest is aggregated at a population level. For instance, meta-regression would be appropriate if we are instead reviewing the prevalence of adoption of climate mitigation or adaptation behaviors at a country- or city-level. In that case, we would use overall prevalence levels as the dependent variable in the meta-regression, and various locational- and study design- attributes as the covariates. However, because we are reviewing micro-level studies, there are no natural candidates for the dependent variable in a meta-regression.

On the other hand, vote counting, while simple, can effectively summarize the effects of variable across the entire literature. Due to its intuitive approach, vote counting has also been utilized widely in systematic reviews of environmental topics (e.g., Lewis & Pattanayak, 2012; Mazumdar, Learnihan, Cochrane, & Davey, 2018; Pullin & Stewart, 2006).

The vote counting method is implemented in the following manner. First, for each regression or econometric analyses where mitigation or adaptation behavior is the dependent variable, we list out all the explanatory variables used in the model. Second, from the list of variables, we group the similar ones together to generate a list of unique variables across all studies. To ensure sufficient comparability, we only include variables that have been used in at least five analyses. Third, we compile the outcome of each variable by counting the number of times the coefficient turned up positive, negative, statistically significant, and so on.

In all, this exercise will yield a summary of the estimation outcomes of each factor across all the studies in which they are included. If a variable or factor mostly have statistically significant outcomes of the same direction, then it is concluded that there is evidence for its effectiveness, and vice versa(Bushman & Wang, 1994).

2.3. Publication trends

To gain a broad overview of the studies included in this review, we first summarize their background information across three dimensions.

First, Table 1 shows the locations of these studies. The vast majority of studies (around 66%) are conducted using data from Asia. This is an understandable location choice as, on a continent basis, Asia accounts for the most GHG emissions (BP., 2021). However, as Asia is a large continent, it is useful to delve deeper into which parts of Asia are most of these studies originating from. Toward this end, China and India, being the two largest countries in the world, account for most of Asian research studies. Southeast Asia is another popular location for research in Asia (17%) as they are highly vulnerable to the effects of climate change (Nitivattananon & Srinonil, 2019). On the other hand, studies from African and South American countries are relatively under-represented at around 22% and 12% respectively.

Second, we plot studies by their publication years (Fig. 2). Across both adaptation and mitigation studies, this literature started circa 2010, and has a consistent upward trend signaling increasing attention and data availability to study these topics.

[3] See Table A1 for list of studies included in the systematic review.

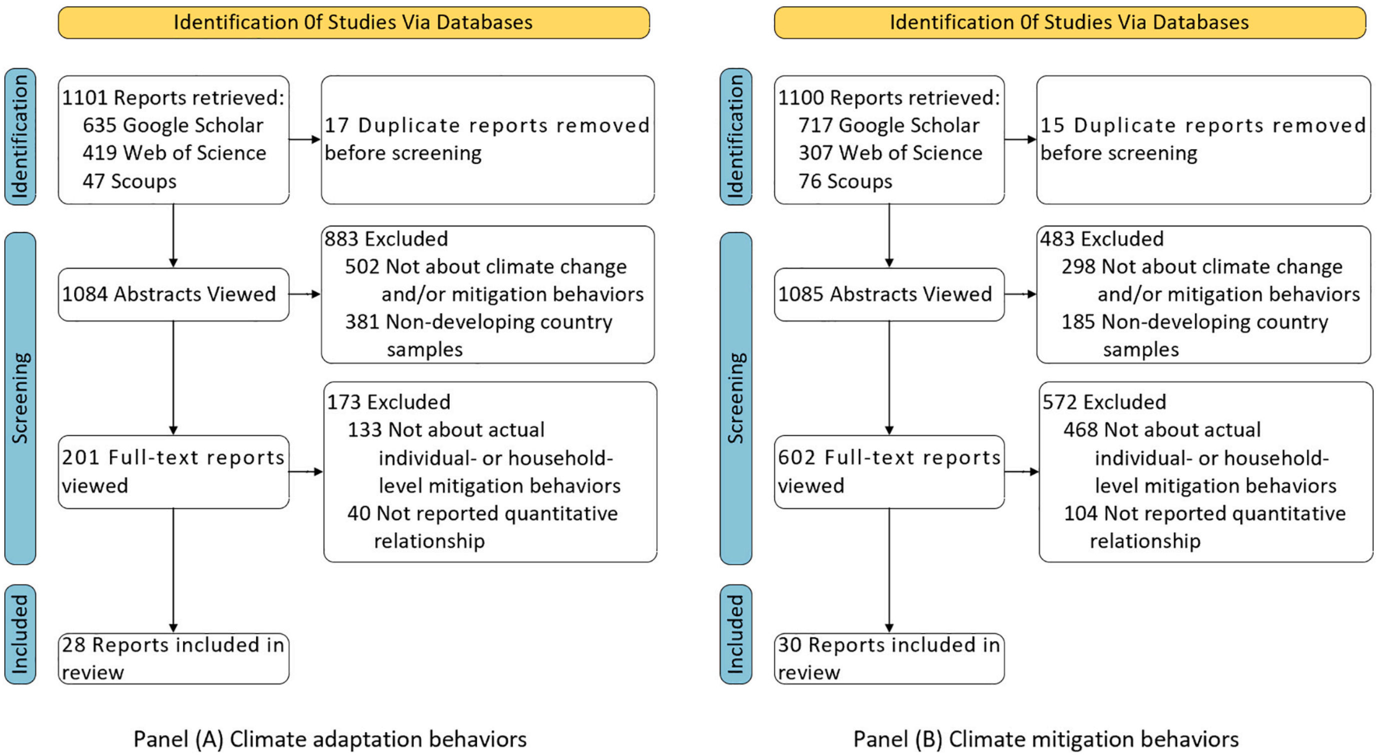


Fig. 1. Flow chart of abstract and full-text screening process.
Notes: The search algorithms used in the "Identification" stage is ((climate change OR global warming) AND (mitigate* OR mitigating* OR mitigation*)/(adapt* OR adapting* OR adaptation*) AND (developing country* OR lower-income OR middle-income OR LMIC*) AND (human* OR individual* OR household*) NOT (agriculture* OR farm*))

Table 1
Countries in which studies are based on.

Continent (number of studies)	Countries (total number of studies)	Countries (climate adaptation studies)	Countries (number of climate mitigation studies)
Asia (38)	China (9)	China (2)	China (7)
	India (6)	India (3)	India (3)
	Southeast Asia (10)	Southeast Asia (3)	Southeast Asia (7)
	Pakistan (4)	Pakistan (4)	Pakistan (0)
	Others (9)	Others (4)	Others (5)
Africa (13)	Ghana (3)	Ghana (2)	Ghana (1)
	Kenya (3)	Kenya (2)	Kenya (1)
	Others (7)	Others (5)	Others (2)
South America (2)	Chile(1), Ecuador(1)	Chile(1)	Ecuador(1)
North America(3)	Mexico(3)	Mexico(1)	Mexico(2)
Europe(2)	Serbia(1), Lithuania(1)	Serbia(1)	Lithuania(1)

Third, we categorize studies according to the broad disciplinary field of the journals in which they are published (Fig. 3).[4] We see that vast majority of studies (53%) are published under journals in the field of "environmental studies". Even though the remaining studies are evenly distributed among various disciplines with no clear second place, several related disciplines (e.g., business and economics, business and finance, economics, demography, development studies) can be combined to form a larger category of social sciences (around 19%).

3. Results and discussions

3.1. *Vote counting for climate adaptation behaviors*

Using the vote counting procedure described in Section 2.2, we end up with a list of 12 variables that are most commonly included in studies examining motivations behind individuals' adaptation behaviors. These 12 variables can be broadly categorized as socio-economic status and environmental-related, and the results of the vote counting exercise are collected in Table 2.

The first observation we make is that educational level and age are the most used explanatory variables in climate adaptation studies where they are found in around 75% of analyses. Even though the effects of education are mostly positive (42 out of 54 instances), they only returned statistically significant coefficients in around 57% of the analyses where they were found positive. On the other hand, the effects of age on climate adaptation behaviors are more varied as 21 analyses (38%) returned negative coefficients. Similar to education, the relationship between age and adoption of climate adaptation behaviors is not particularly strong as only 56% of the positive coefficients are statistically significant.

Second, income, gender, and household size are also commonly-used variables as they are found in around 46%–58% of analyses. Of these, the effects of income are unequivocal as almost all (87%) studies found that income is positively correlated with climate adaptation behaviors, and 70% of the coefficients are statistically significant. In contrast, the manner in which gender and household size affect climate adaptation behaviors is less telling as their estimated coefficients are split somewhat evenly between positive and negative, and on either ends of statistical significance.

The next tranche of socioeconomic variables are home ownership, marital status, and residence size. These variables are sparsely found in around 14%–17% of analyses. Of these three variables, home ownership stands out as 90% of the included analyses returned positive coefficients. Moreover, they collectively showed a strong relationship with climate adaptation behaviors as 67% of them are statistically significant.

Fourth, we turn out attention to environmental-related variables. As a whole, perhaps partly reflecting the difficulty of accurately measuring these covariates, they are less used in comparison to their socioeconomic status counterparts. However, whenever they are included, the direction of their effects on adaptation behaviors is consistent. Prior experience of climate change and extreme weather events (e.g., droughts, heatwaves, and torrential rainfall) is the most included of this sub-category at around 44.4% of all analyses. We see that respondents with such experiences overwhelmingly adopt climate adaptation behaviors (30 out of 32). Moreover, more than 75% of the estimated coefficients returned statistically significant results. Self-assessed knowledge of climate adaptation measures, and perception of impacts of climate change are only found in around 15%–24% of analyses. However, when included, their effects are mostly positively related with adaptation behaviors.

3.2. *Vote counting for climate mitigation behaviors*

In this sub-section, we focus on climate mitigation behaviors where we similarly begin by generating a list of variables commonly used in the selected studies. By using the same selection process, we end up with a list of 13 variables that are also broadly grouped as socioeconomic and environmental-related. The results are collected in Table 3.

The most widely included variables are educational level and gender, at around 53%. For the former, education predominantly

[4] To ensure consistent definition, we obtain disciplinary field of each journal from *Web of Science*.

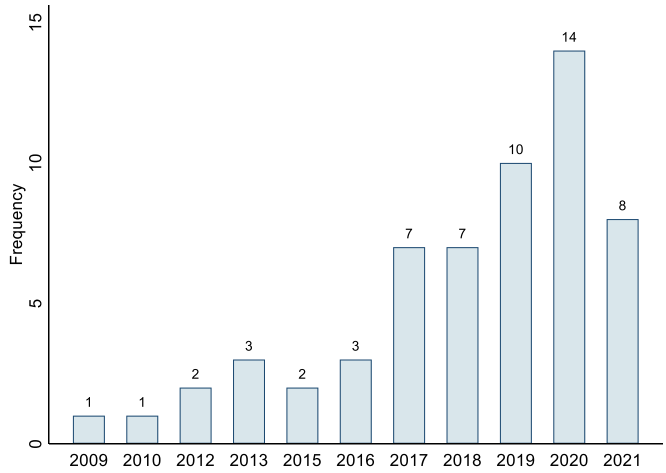


Fig. 2. Number of studies by year of publication.

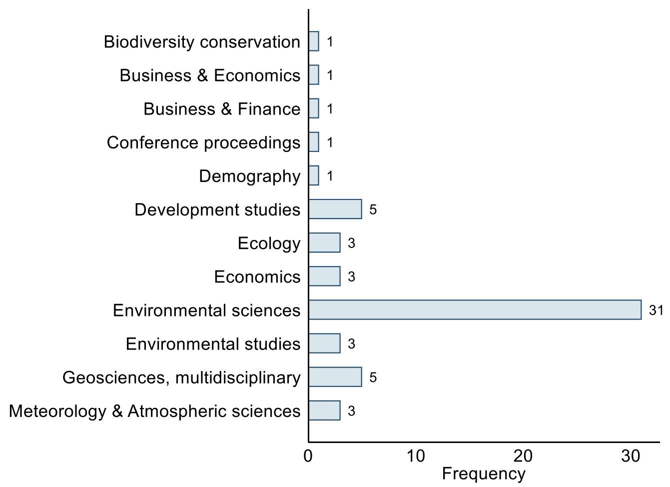


Fig. 3. Number of studies by journal's disciplines.

yields positive coefficients at around 88% of included analyses. Moreover, their estimated effects are mostly statistically significant at 79% of analyses. On the other hand, gender shows no discernible trends as its coefficient are evenly split between positive and negative. Interestingly though, the coefficient is mostly statistically significant when estimated as negative, i.e., males are less likely to engage in climate mitigation behaviors.

The next group of variables are income, age, and marital status (included in around 30%–40% of all analyses). Of these variables, the effect of income on climate mitigation behaviors is most consistent where they are positive and statistically significant in 47% of inclusions. In comparison, the effects of age and marital status are less remarkable as they straddle rather evenly between positive and negative, and statistical significance. Religion and internet usage are the least-used socioeconomic variables as they are found in around 10% of analyses. While the effects of religion on climate mitigation behaviors is unremarkable, internet usage is unequivocally positive and statistically significant.

There are relatively more variables representing different aspects of environmental knowledge in climate mitigation studies. Of these, the two most included are "climate responsibility" and "climate knowledge" at around 35% of all analyses. The former measures the extent to which respondents agree it is their personal responsibility to combat climate change, and the latter captures their topical knowledge in climate change. Not surprisingly, both variables return positive coefficients in most cases. In around 78% of analyses, respondents with higher sense of personal responsibility on climate change are more likely to engage in mitigation behaviors. Similarly, "climate knowledge" returned positive coefficient in 90% of analyses where almost all are statistically significant.

Next, "climate concern" and "perceived impacts of climate change" are featured in around 14% of all analyses. Their relationship with climate mitigation behavior is consistent with earlier findings as respondents that i) show more concern on climate change, and ii) assess higher levels of danger from climate change are much more likely to engage in climate mitigation behaviors.

Table 2
Vote counting exercise for studies on climate adaptation behaviors.

	Motivational factors	Negative coefficient		Positive coefficient		Total inclusions
		Statistically significant	Statistically insignificant	Statistically significant	Statistically insignificant	
		(i)	(ii)	(iii)	(iv)	(v)
Socioeconomic variables	Income level	0	5 (100.0%)	23 (69.7%)	10 (30.3%)	38 (52.8%)
	Educational level	8 (66.7%)	4 (33.3%)	24 (57.1%)	18 (42.9%)	54 (75.0%)
	Gender (1 = male)	5 (33.3%)	10 (66.7%)	12 (44.4%)	15 (55.6%)	42 (58.3%)
	Age	7 (33.3%)	14 (66.7%)	19 (55.9%)	15 (44.1%)	55 (76.4%)
	Household size	5 (31.3%)	11 (68.7%)	8 (47.1%)	9 (52.9%)	33 (45.8%)
	Marital status (1 = married)	1 (20.0%)	4 (80.0%)	1 (20.0%)	4 (80.0%)	10 (13.9%)
	House ownership (1 = own house)	0	1 (100.0%)	6 (66.7%)	3 (33.3%)	10 (13.9%)
	Residence size	1 (100.0%)		3 (27.3%)	8 (72.7%)	12 (16.7%)
Environmental-related variables	Perception of climate change impacts	1 (50.0%)	1 (50.0%)	6 (66.7%)	3 (33.3%)	11 (15.3%)
	Climate change experience (self-assessed)	2 (100.0%)		23 (76.7%)	7 (23.3%)	32 (44.4)
	Adaptation knowledge (self-assessed)		1 (100.0%)	12 (75.0%)	4 (25.0%)	17 (23.6%)
	Perceived efficacy			5 (100%)		5 (6.9%)

Notes: The integers in top row of each motivation factors indicate the number of studies corresponding to nature of its regression coefficient (i.e., positive or negative, and statistically significant or not). The percentages in parentheses in Column (i) and (ii) respectively corresponds to the proportion of studies that are statistically significant, and insignificant for negative coefficients. Similar interpretation applies to Column (iii) and (iv). The percentages in parentheses in Column (v) refer to the proportion of studies where each motivational factor is found.

3.3. Comparison of effect sizes

A distinctive shortcoming of vote counting is that it does not take into account of effect sizes. That is, even though a variable may have overwhelmingly positive (or negative) coefficients, it's effect on the outcome of interest may be smaller compared to another variable with fewer positive coefficients due to the latter having larger-sized coefficients. In this sub-section, we standardize and transform coefficients from each study, and compare their magnitude to assess which variables play larger roles in affecting climate mitigation and adaptation behaviors.

To ensure comparability, we first standardize the estimated coefficient from each study by using the following formula[5]:

$$\beta_{x,std} = \frac{\sigma_x}{\sigma_y}\beta_x \tag{1}$$

β_x is the coefficient retrieved directly from the study, and σ_x and σ_y are respectively the standard deviation of variable x and the dependent variable y.[6]

This transformation ensures the variances of both the dependent and independent variables are equal to one, and are thus comparable across different studies.

The standardized effect sizes for climate adaptation studies are plotted in panel A of Fig. 4.

First, despite their lower inclusion rate as observed in the vote-counting exercise, environmental-related variables mostly have large impacts on adaptation behaviors. Among them, "previous experience with climate change" have the largest impact where a one standard deviation increase is positively associated with a 0.3 standard deviation change in adaptation behaviors. The sole variable with statistically insignificant effects is "perceived impacts of climate change", unlike its vote-counting outcome. Second, among the socioeconomic variables, house ownership and income have the largest effects at around 0.28 and 0.17 standard deviations respectively.

We now turn our attention to effect sizes for climate mitigation studies in panel B of Fig. 4.

Similar to climate adaptation, we see that environmental-related variables have mostly large impacts on behaviors. Of the four most

[5] See Appendix 1 for a derivation of Eq. (1).

[6] There are some studies that only offered correlation coefficients. For such cases, please see Appendix 1 for detailed exposition of how standardized coefficients are derived.

Table 3
Vote counting exercise for studies on climate mitigation behaviors.

	Motivational factors	Negative coefficient		Positive coefficient		Total inclusions
		Statistically significant	Statistically insignificant	Statistically significant	Statistically insignificant	
Socioeconomic variables	Income	8 (57.1%)	6 (42.9%)	16 (80.0%)	4 (20.0%)	34 (39.5%)
	Educational level	3 (50.0%)	3 (50.0%)	33 (78.6%)	9 (21.4%)	48 (55.8%)
	Gender (1 = male)	20 (83.3%)	4 (16.7%)	7 (33.3%)	14 (66.7%)	45 (52.3%)
	Age	9 (56.3%)	7 (43.7%)	9 (47.4%)	10 (52.6%)	35 (40.7%)
	Household size	6 (42.9%)	8 (57,1%)	3 (60.0%)	2 (40.0%)	19 (22.1%)
	Marital status (1 = married)	5 (45.5%)	6 (54.5%)	13 (61.9%)	8 (38.1%)	32 (43.0%)
	Location (1 = urban)	1 (33.3%)	2 (66.7%)	14 (82.4%)	3 (17.6%)	20 (23.3%)
	Religion (1 = yes)		1 (100.0%)	2 (25.0%)	6 (75.0%)	9 (10.5%)
	Internet usage frequency			8 (100.0%)		8 (9.3%)
Environmental-related variables	Climate concern	1 (100.0%))	0	8 (72.7%)	3 (27.3%)	12 (14.0%)
	Climate knowledge		3 (100%)	22 (81.5%)	5 (18.5%)	30 (34.9%)
	Climate responsibility		7 (100.0%)	19 (76.0%)	6 (24.0%)	32 (37.2%)
	Perception of climate change impacts		1 (100.0%)	9 (81.8%)	2 (18.2%)	12 (14.0%)

Notes: The integers in top row of each motivation factors indicate the number of studies corresponding to nature of its regression coefficient (i.e., positive or negative, and statistically significant or not). The percentages in parentheses in Column (i) and (ii) respectively corresponds to the proportion of studies that are statistically significant, and insignificant for negative coefficients. Similar interpretation applies to Column (iii) and (iv). The percentages in parentheses in Column (v) refer to the proportion of studies where each motivational factor is found.

commonly-included variables, "climate knowledge", "perception of climate change impacts", and "climate responsibility" have the largest impacts at around 0.25 standard deviations.

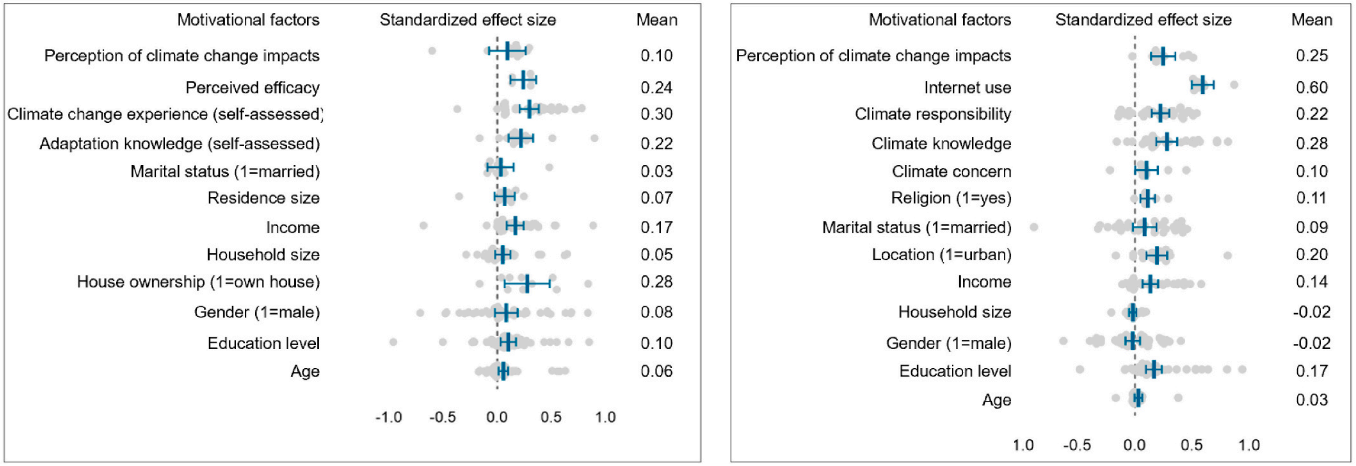
As for socioeconomic variables, a point of departure from the vote counting exercise is the effects of income compared to education. The vote counting exercise showed that education plays a larger role in promoting individuals' and households' climate mitigation behaviors. However, the reverse is true when effect sizes are computed as income has a slightly larger impact (0.19 std. dev. vs. 0.17 std. dev.). A somewhat unexpected finding is that frequency of internet usage has by far the largest impact on promoting climate mitigation behaviors at around 0.6 standard deviations.

Lastly, one central concern with systematic reviews is the risk of publication bias where scientific journals tend to only publish papers with large effect sizes, and statistically significant coefficients. In turn, this bias may skew the true picture of the factors affecting adaptation and mitigation behaviors. We assess the occurrence of publication bias by plotting the standardized effect sizes against their standard error (Fig. 5) (Egger, Smith, Schneider, & Minder, 1997). Each dot in Fig. 5 represent the effect size for one variable, and they should ideally be symmetrically distributed on either sides of the x-intercept, and have varying levels of statistical precision. Panel (a) of Fig. 5 shows that the standardized effect sizes for climate adaptation behaviors are mostly concentrated in the upper part of the funnel plot, and symmetrically distributed on either side. Panel (b) of Fig. 5 shows similar trends for climate mitigation. In summary, there is no strong evidence to indicate that publication bias influenced the observed effect sizes in the current analyses. Discussions.

The vote-counting exercise and comparison of effect sizes conducted across the two separate literature on climate mitigation and climate adaptation behaviors in developing countries reveal several important insights on the motivating factors behind each type of behaviors.

First, across the two types of responses toward climate change, it is evident that existing studies place outsized attention on the influence of socioeconomic factors compared to environmental-related variables. The lack of focus on the latter is contrary to findings from related literature. For instance, both Zanocco, Boudet, Nilson, and Flora (2019) and Hart, Nisbet, and Myers (2015) found using stated preference surveys that respondents with more knowledge of climate change, and experiences of previous extreme events tend to have larger willingness-to-pay for climate change mitigation policies. Moreover, compared to socioeconomic status, environmental knowledge or concern are more pliable by policies such as information or education campaigns (Schäfer, 2012).

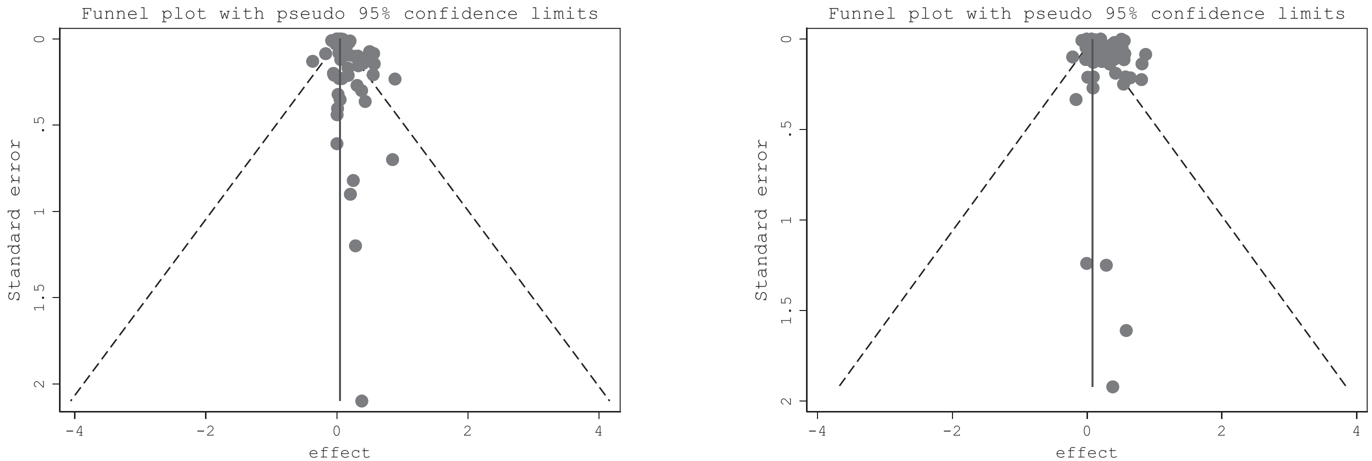
Second, we observe two important dichotomies between the various socioeconomic factors. First, the impact of income on adaptation behaviors is unequivocally positive whereas it is not for mitigation behaviors. This finding is despite both climate change responses are financially- or resource-intensive for individuals or households. Second and conversely, education has a slightly different relationship as



Panel (A) Climate adaptation behaviors **Panel (B) Climate mitigation behaviors**

Fig. 4. Standardized effect sizes*Notes*: The x-axis represents the standardized effect sizes as defined in the section 3.3, and the y-axis represents the standard error of standardized effect size in the original studies.

***Notes*:** The standardized effect sizes are computed by multiplying regression coefficient for each motivational factor with the ratio of its standard deviation to that of the dependent variable (see Appendix for derivation of formula).



Panel (A) Climate adaptation behaviors **Panel (B) Climate mitigation behaviors**

Fig. 5. Funnel plots for standardized effect sizes.
Notes: The x-axis represents the standardized effect sizes as defined in the section 3.3, and the y-axis represents the standard error of standardized effect size in the original studies.

even though this variable mostly shares positive relationship with adaptation and mitigation behaviors, it is statistically significant in 52% of all positive coefficients for the former and 82% for the latter. These two findings highlight key differences between the decision-making process of adaptation vs. mitigation. For starters, they show that unlike for adaptation behaviors, financial resources are not a sufficient condition to convince individuals or households to undertake climate mitigation behaviors. Similarly, even though education is highly correlated to income, the fact that both variables have differing impacts on adaptation and mitigation highlight that adoption of climate mitigation behaviors is more of a cognitively-involved process. The large effect size of "internet usage" corroborate this finding that education and outreach plays an outsized role in promoting climate mitigation behaviors (Qin, Liu, Su, Fei, & Tan-Soo, 2022). However, it should also be noted that the effects size comparison showed that income and education have roughly similar magnitude in affect climate mitigation behaviors. One plausible explanation is that income and education jointly affect climate mitigation behaviors.

Third, even though environmental-related variables are scarce in both sets of literature, and not entirely consistent for direct comparison, we can still discern some differences in how they affect each type of behaviors. A stark observation is that across all environmental variables, around 53% and 67% return positive and statistically significant relationship with climate adaptation behaviors and mitigation behaviors respectively. This difference in the importance of environmental knowledge driving behaviors once again confirms that adaptation and mitigation are formed by different motivations. In particular, prior experience with extreme weather is a main driving factor for adaptation behaviors whereas sense of responsibility and concern for climate change are main important drivers for mitigation behaviors.

In the remaining of this section, we attempt to explain why there are differences in the driving factors behind adoption of climate adaptation and mitigation behaviors.

First, while adaptation behaviors are mostly actions taken at the individual-level to alleviate the personal impacts of adverse climatic events, mitigation behaviors are taken by individuals to reduce the global odds of adverse climatic events (Kane & Shogren, 2000). As such, the public goods characteristic of climate mitigation behaviors makes them susceptible to the risk of free riding. In turn, it is more likely that individuals with sense of responsibility and concern for environmental outcomes will engage in mitigation behaviors.

Second, another key difference is the temporal lag between actions and outcomes. Mitigation behaviors usually provide global benefits in the future whereas adaptation provides immediate- or medium-term benefits. Based on the above differences, the following mechanisms might explain the different effects of different environmental-related variables on adaptation and mitigation behaviors. In this regard, theories and framework from environmental economics and behavioral psychology suggest that individuals will seek out immediate relief when faced with adverse climatic events (Bockarjova & Steg, 2014). For instance, Auffhammer (2014) and Li et al. (2019) both found that residents in China purchase or use air-conditioners (i.e., climate adaptation behaviors) at a higher frequency during periods of high temperature. In contrast, because mitigation actions cannot readily reduce adverse impacts, experience with extreme weather is a main driving factor for adaptation behaviors rather than mitigation.

4. Conclusions

In this study, we conduct a systematic review of the literature that focuses on individuals' and households' adoption of climate mitigation and adaptation behaviors in developing countries. Such a review is timely and important for several reasons. First, due to failure to coordinate meaningful reduction in worldwide GHG emissions, there are now increasing calls on individuals and households to lessen their carbon footprint (Stern, 2021; Stoddard et al., 2021). However, just as countries have their set of macro-level concerns, individuals are governed by unobserved decision-making processes. As such, this review study gathers the thin and scattered literature to summarize existing findings. Second, it is now widely acknowledged that the effects of climate change are likely to be unevenly distributed across countries (IPCC, 2014b). However, less is known if it is also the same within each country (Islam & Winkel, 2017). In this review, we examine if there are groups of population that are better equipped to adapt or protect themselves from climate change.

Following an extensive search on three major academic databases, we arrive at 28 and 30 studies on climate adaptation and mitigation behaviors respectively. Using a vote-counting exercise where we list out commonly-use variables in each literature, and compare the signs of the coefficients and statistical significance, we arrive at the following findings.

Using these findings, we conclude with the following policy and research implications.

First, we see that income plays a large role in enabling individuals and households to adapt to climate change. This is unsurprising as protecting oneself from environmental harms is a resource-intensive endeavor (Du, Yu, & Wei, 2020; Li et al., 2019). However, this relationship highlights that climate inequality exists not only between countries in terms of their (historical) emissions, but also between different segments or social classes of citizens within the same locations. Lower-income residents that cannot readily adapt to climate change will be faced with higher mortality and morbidity, lower work productivities, among other adverse effects (Fouillet et al., 2006; Park, Goodman, Hurwitz, & Smith, 2020; Somanathan, Somanathan, Sudarshan, & Tewari, 2021; Xu, FitzGerald, Guo, Jalaludin, & Tong, 2016). Moreover, just as Tan-Soo, Qin, and Zhang (2018) showed that Beijing residents using air purifiers cause more air pollution, similar arguments can be applied here. That is, as higher-income residents insulate themselves from climate change, they will ostensibly increase their carbon footprint (e.g., through the usage of air-conditioners or heaters). In turn, their adaptation behaviors exacerbate climate change, and adds on to climate inequality. As income inequality is already much higher in developing countries, this means that policymakers need to channel resources toward citizens in the lower tiers of society and at locations most vulnerable toward climate change.[7]

Second, even though climate adaptation strategies are needed to protect citizens from the ill-effects of climate change, climate

[7] "Global Inequality Data – 2020 update" https://wid.world/news-article/2020-regional-updates/. Last accessed: April 27, 2022.

mitigation behaviors are the more sustainable approach in tackling climate change. Toward this end, our review shows that ability (i.e., financial means) to adapt is not the only driver of mitigation behaviors. Instead, individuals that are concerned about climate change, and possess stronger sense of responsibility are more susceptible toward mitigation behaviors. Toward this end, governments and NGOs can play a large role in cultivating such behaviors by introducing information and education campaigns at various levels. On the same note, the vast majority of studies in this literature are currently published in journals tagged under "environmental sciences" with much lower representation across other fields and disciplines. While climate change is inherently an environmental issue, individuals' and households' behaviors are social science topics where models and theoretical frameworks have been developed specifically for this purpose. In this regard, there is much scope for cross-disciplinary research to better explain, and perhaps even develop new models to understand individuals' and households' mitigation and adaptation response toward climate change (Stoddard et al., 2021).

Third, the literature examining individuals' and households' responses toward climate change in developing countries is thin. In all, we retrieve on average 79 usable analyses for each strand of literature. Although there is an upward trajectory in number of studies conducted in recent years, the total number still pale in comparison relative to the scale of this issue. For instance, Lewis and Pattanayak (2012) in their review of adoption of cooking fuel – an issue most relevant to the rural areas of developing countries – found more than 100 analyses. Individuals' and households' behavioral responses toward climate change is arguably a highly relevant topic for the same population, and more. A plausible explanation for this dearth of research studies is the lack of data. This is especially true for data that depicts actual behaviors. Toward this end, there are novel sources of information that has yet to be fully utilized in climate change research. For example, Sun, Kahn, and Zheng (2017) used online shopping data to examine the relationship between purchases of air purifiers and face-masks, and air pollution in China. One can envisage using similar sources of information to examine climate adaptation and/or mitigation behaviors.

Fourth and related, a commonality between these two strands of literature is that environmental-related explanatory variables are not as commonly included compared to socioeconomic status. Moreover, even when included, they are mostly self-assessed rather than through objective measures, and incomparable between different studies. Toward this end, future field surveys should as much as possible, design standardized objective questions to comprehensively assess participants knowledge or experience with climate change (e.g., the public health discipline has standardized questions to assess common ailments such as depressions). In the meanwhile, there are already existing information that can be readily added to analyses. For example, even though "experience with climate change" is found to have consistent impacts on climate adaptation, they are not commonly included. However, satellite technology has availed historical weather data for most locations (Brönnimann, Martius, Rohr, Bresch, & Lin, 2019). In turn, we can easily pair these information with respondents' location to objectively measure their experience with climate change.

Data availability

Data will be made available on request.

Acknowledgements

We are grateful to two anonymous referees for providing helpful comments. Generous financial support was given by the National Natural Science Foundation of China (grant.: 72173126, 72134006) [to Q.P.], the Fundamental Research Funds for the Central Universities, the Research Funds of Renmin University of China (grant: 22XNA041) [to Q.P.], and the Singapore Ministry of Education Tier 1 FRC grant: A-0003279-00-00 [to J.S.T.S.]. The authors declare that there is no conflict of interests and no other financial support.

Appendix 1

For exposition sake, we begin with a univariate regression model:

$$Y = \beta_0 + \beta_1 X + \varepsilon \tag{1}$$

Next, we subtract the mean of the dependent variable (Y) from both sides, and substitute β_0 using the identity $\overline{Y} = \beta_0 + \beta_1 \overline{X}$ to yield:

$$Y - \overline{Y} = \overline{Y} - \beta_1 \overline{X} + \beta_1 X + \varepsilon - \overline{Y} \tag{2}$$

Following rearrangement, and multiplying and dividing the R.H.S. by its corresponding standard deviation, we get:

$$Y - \overline{Y} = \beta_1 \sigma_X X^* + \varepsilon \tag{3}$$

where $X^* = \frac{(X - \overline{X})}{\sigma_X}$ is the standardized transformation of X.

Lastly, we divide both sides by standard deviation of Y to get:

$$Y^* = \beta_1 \frac{\sigma_X}{\sigma_Y} X^* + \frac{\varepsilon}{\sigma_Y} \tag{4}$$

By comparing Eq. (1) and (4), we can see that the coefficient for standardized covariate, X^*, is equivalent to the multiplication of β_1 with ratio of the standard deviation of variable X to the dependent variable Y.

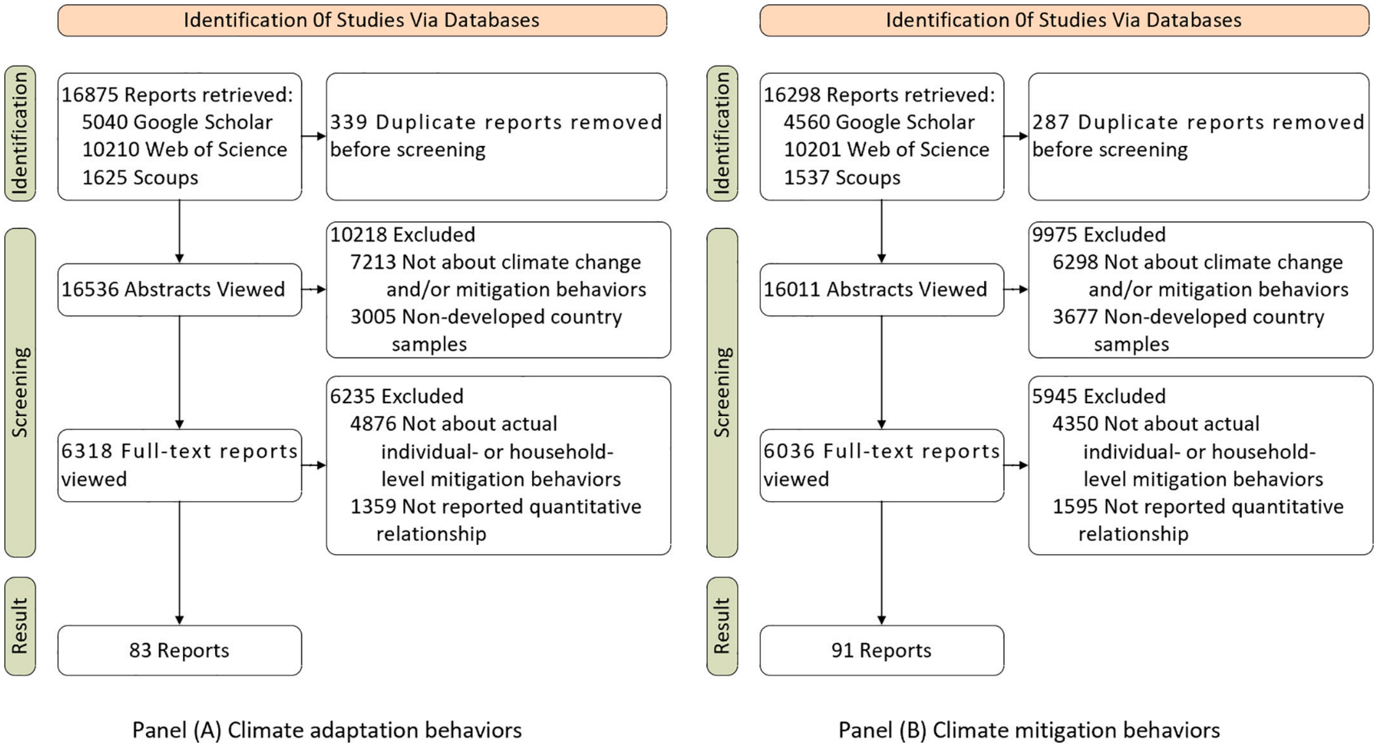


Fig. A1. Flow chart of abstract and full-text screening process for studies conducted in developed countries.
Notes: The search algorithms used in the "Identification" stage is ((climate change OR global warming) AND (mitigate* OR mitigating* OR mitigation*)/(adapt* OR adapting* OR adaptation*) AND (developed country* OR high-income*) AND (human* OR individual* OR household*) NOT (agriculture* OR farm*)).

Table A1
List of studies included in the vote-counting exercise.

Literature	Author and publication year	Country(s) setting	Behavior type	Sample size	Statistical model
	Mueller, Sheriff, Dou, and Gray (2020)	Uganda, Malawi, Ethiopia, Tanzania	Migration	15,241	Probit
	Bryan, Deressa, Gbetibouo, and Ringler (2009)	South Africa and Ethiopia	General climate adaptation behaviors	1756	Probit
	Rauf et al. (2017)	Pakistan	General climate adaptation behaviors	251	Logit
	Bakhsh, Rauf, and Zulfiqar (2018)	Pakistan	General climate adaptation behaviors	150	Logit
	Molua (2012)	Cameroon	General climate adaptation behaviors	200	Linear regression
	Das (2019)	India	Evacuation	320	Logit
	Reynaud, Aubert, and Nguyen (2013)	Vietnam	Floor elevation	448	Linear regression
	Khanal and Wilson (2019)	Nepal	General climate adaptation behaviors	421	Linear regression
	Owusu, Ma, Renwick, and Emuah (2021)	Ghana	General climate adaptation behaviors	203	Probit
	Opiyo et al. (2016)	Kenya	General climate adaptation behaviors	302	Probit
	Nabikolo, Bashaasha, Mangheni, and Majaliwa (2012)	Uganda	General climate adaptation behaviors	125	Logit
	Mashi, Inkani, Obaro, and Asanarimam (2020)	Nigeria	General climate adaptation behaviors	290	Kendall's Tau correlation
	Koubi, Spilker, Schaffer, and Bernauer (2016)	Vietnam	Migration	1200	Logit
	Yin et al. (2021)	Ghana	General climate adaptation behaviors	369	Logit
	Cvetković, Roder, Öcal, Tarolli, and Dragićević (2018)	Serbia	General climate adaptation behaviors	2500	Linear regression
	Tan, Liu, and Hugo (2015)	China	Migration	1048	Logit
	Werg, Grothmann, Spies, and Mieg (2020)	Philippines	General climate adaptation behaviors	70	Kendall's Tau correlation
	Ung, Luginaah, Chuenpagdee, and Campbell (2015)	Cambodia	Anticipatory climate adaptation	1823	Logit
	Ngigi, Mueller, and Birner (2017)	Kenya	General climate adaptation behaviors	156	Probit
	González-Hernández, Meijles, and Vanclay (2019)	Mexico	General climate adaptation behaviors	622	Logit
	Zhang et al. (2020)	China	General climate adaptation behaviors	536	Logit
	Qazlbash, Zubair, Manzoor, Ul Haq, and Baloch (2021)	Pakistan	General climate adaptation behaviors	240	Logit
	Shah, Ye, Abid, and Ullah (2017)	Pakistan	Floor elevation	600	Probit
	Sharma, Patwardhan, and Patt (2013)	India	Evacuation	212	Logit
	Okunola and Bako (2021)	Nigeria	General climate adaptation behaviors	384	Linear regression
	Rahman et al. (2021)	Lao	General climate adaptation behaviors	360	Logit
	Meltzer, Dame, and Gabrysch (2021)	Chile	General climate adaptation behaviors	262	Linear regression
Climate adaptation behaviors	Sam, Padmaja, Kächele, Kumar, and Müller (2020)	India	Migration	157	Logit
	Rajapaksa, Islam, and Managi (2018)	India	General climate mitigation behaviors	1500	Structural equation model
	González-Hernández et al. (2019)	Mexico	General climate mitigation behaviors	622	Logit
Climate mitigation behaviors	Okaka and Odhiambo (2018)	Kenya	Conservation behavior	290	Logit
	Masud, Akhatr, Nasrin, and Adamu (2017)	Malaysia	General climate mitigation behaviors	360	SEM
	NwaJesus, Okokon, and ChukwumaOtum (2019)	Nigeria	Purchase of less carbon-intensive products	120	Logit
	Amoah and Addoah (2021)	Ghana	General climate mitigation behaviors	1648	Logit

(*continued on next page*)

Table A1 (*continued*)

Literature	Author and publication year	Country(s) setting	Behavior type	Sample size	Statistical model
	Hong and Park (2018)	China	General climate mitigation behaviors	2997	Linear regression
	Gong et al. (2020)	China	General climate mitigation behaviors	10,663	Linear regression
	Ifegbesan and Rampedi (2018)	Nigeria	General climate mitigation behaviors	1758	Linear regression
	Chen et al. (2013)	China	Garbage sorting	5073	Logit
	Zhou, Yin, Yuan, and Wang (2019)	China	Garbage sorting	11,438	Logit
	Filippini and Srinivasan (2019)	India	Less carbon-intensive diet	49,659	Probit
	Ponce et al. (2019)	Ecuador	Garbage sorting	1106	Linear regression
	Rahman et al. (2021)	Laos	General climate mitigation behaviors	360	Logit
	Zeng, Jiang, and Yuan (2020)	China	General climate mitigation behaviors	8084	Linear regression
	Chankrajang and Muttarak (2017)	Thailand	General climate mitigation behaviors	3900	Probit
	Bhuian, Sharma, Butt, and Ahmed (2018)	Sultanate of Oman	Purchase of less carbon-intensive products	306	Structural equation model
	Choon, Ong, and Tan (2019)	Malaysia	General climate mitigation behaviors	191	Structural equation model
	Halady and Rao (2010)	India	General climate mitigation behaviors	58	Structural equation model
	Masud, Akhtar, Afroz, Al-Amin, and Kari (2015)	Malaysia	General climate mitigation behaviors	385	Structural equation model
	Lee, Tung, and Lin (2019)	China	General climate mitigation behaviors	582	Linear regression
	Shafiei and Maleksaeidi (2020)	Iran	General climate mitigation behaviors	310	Structural equation model
	Yusliza et al. (2020)	Malaysia	General climate mitigation behaviors	72	Structural equation model
	Ateş (2020)	Turkey	General climate mitigation behaviors	340	Structural equation model
	Arı and Yılmaz (2017)	Turkey	Purchase of less carbon-intensive products	335	Structural equation model
	Liu, Teng, and Han (2020)	China	General climate mitigation behaviors	1174	Structural equation model
	Bülbül, Büyükkeklik, Topal, and Özoğlu (2020)	Turkey	Purchase of less carbon-intensive products	335	Structural equation model
	Corral-Verdugo, Lucas, Tapia-Fonllem, and Ortiz-Valdez (2020)	Mexico	General climate mitigation behaviors	200	Structural equation model
	Masud et al. (2017)	Malaysia	General climate mitigation behaviors	360	Structural equation model
	Liobikienė, Liobikas, Brizga, and Juknys (2020)	Lithuania	Conservation behavior	1007	Structural equation model

References

Amoah, A., & Addoah, T. (2021). Does environmental knowledge drive pro-environmental behaviour in developing countries? Evidence from households in Ghana. *Environment, Development and Sustainability, 23*(2), 2719–2738.

Arı, E., & Yılmaz, V. (2017). Effects of environmental illiteracy and environmental awareness among middle school students on environmental behavior. *Environment, Development and Sustainability, 19*(5), 1779–1793.

Ateş, H. (2020). Merging theory of planned behavior and value identity personal norm model to explain pro-environmental behaviors. *Sustainable Production and Consumption, 24*, 169–180.

Auffhammer, M. (2014). Cooling China: The weather dependence of air conditioner adoption. *Frontiers of Economics in China, 9*(1), 70–84.

Bakhsh, K., Rauf, S., & Zulfiqar, F. (2018). Adaptation strategies for minimizing heat wave induced morbidity and its determinants. *Sustainable Cities and Society, 41*, 95–103.

Benjamin, D., Por, H.-H., & Budescu, D. (2017). Climate change versus global warming: Who is susceptible to the framing of climate change? *Environment and Behavior, 49*(7), 745–770.

Bhuian, S. N., Sharma, S. K., Butt, I., & Ahmed, Z. U. (2018). Antecedents and pro-environmental consumer behavior (PECB): the moderating role of religiosity. *Journal of Consumer Marketing*.

Bockarjova, M., & Steg, L. (2014). Can protection motivation theory predict pro-environmental behavior? Explaining the adoption of electric vehicles in the Netherlands. *Global Environmental Change, 28*, 276–288.

BP.. (2021). *BP statistical review of world energy* (p. 2021).

Brönnimann, S., Martius, O., Rohr, C., Bresch, D. N., & Lin, K. H. E. (2019). Historical weather data for climate risk assessment. *Annals of the New York Academy of Sciences, 1436*(1), 121–137.

Bryan, E., Deressa, T. T., Gbetibouo, G. A., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental Science & Policy, 12*(4), 413–426.

Bülbül, H., Büyükkeklik, A., Topal, A., & Özoğlu, B. (2020). The relationship between environmental awareness, environmental behaviors, and carbon footprint in Turkish households. *Environmental Science and Pollution Research, 27*(20), 25009–25028.

Bushman, B. J., & Wang, M. C. (1994). Vote-counting procedures in meta-analysis. In *, 236. The handbook of research synthesis* (pp. 193–213).

Carrington, M. J., Neville, B. A., & Whitwell, G. J. (2010). Why ethical consumers don't walk their talk: Towards a framework for understanding the gap between the ethical purchase intentions and actual buying behaviour of ethically minded consumers. *Journal of Business Ethics, 97*(1), 139–158.

Cazorla, M., & Toman, M. (2001). International equity and climate change policy. In *Climate change economics and policy: An RFF anthology* (p. 235).

Champ, P. A., Boyle, K. J., Brown, T. C., & Peterson, L. G. (2003). *A primer on nonmarket valuation* (Vol. 3). Springer.

Chankrajang, T., & Muttarak, R. (2017). Green returns to education: does schooling contribute to pro-environmental behaviours? Evidence from Thailand. *Ecological Economics, 131*, 434–448.

Chen, X., Peterson, M. N., Hull, V., Lu, C., Hong, D., & Liu, J. (2013). How perceived exposure to environmental harm influences environmental behavior in urban China. *Ambio, 42*(1), 52–60.

Chinowsky, P., Hayles, C., Schweikert, A., Strzepek, N., Strzepek, K., & Schlosser, C. A. (2011). Climate change: Comparative impact on developing and developed countries. *The Engineering Project Organization Journal, 1*(1), 67–80.

Choon, S.-W., Ong, H.-B., & Tan, S.-H. (2019). Does risk perception limit the climate change mitigation behaviors? *Environment, Development and Sustainability, 21*(4), 1891–1917.

Clémençon, R. (2016). The two sides of the Paris climate agreement: Dismal failure or historic breakthrough?. In *, Vol. 25. In* (pp. 3–24). Los Angeles, CA: SAGE Publications Sage CA.

Corral-Verdugo, V., Lucas, M. Y., Tapia-Fonllem, C., & Ortiz-Valdez, A. (2020). Situational factors driving climate change mitigation behaviors: the key role of pro-environmental family. *Environment, Development and Sustainability, 22*(8), 7269–7285.

Cvetković, V. M., Roder, G., Öcal, A., Tarolli, P., & Dragićević, S. (2018). The role of gender in preparedness and response behaviors towards flood risk in Serbia. *International Journal of Environmental Research and Public Health, 15*(12), 2761.

Das, S. (2019). Evaluating climate change adaptation through evacuation decisions: a case study of cyclone management in India. *Climatic Change, 152*(2), 291–305.

Du, K., Yu, Y., & Wei, C. (2020). Climatic impact on China's residential electricity consumption: Does the income level matter? *China Economic Review, 63*, Article 101520.

Egger, M., Smith, G. D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *Bmj, 315*(7109), 629–634.

Filippini, M., & Srinivasan, S. (2019). Impact of religious participation, social interactions and globalization on meat consumption: evidence from India. *Energy Economics, 84*, Article 104550.

Ford, J. D., Berrang-Ford, L., & Paterson, J. (2011). A systematic review of observed climate change adaptation in developed nations. *Climatic Change, 106*(2), 327–336.

Fouillet, A., Rey, G., Laurent, F., Pavillon, G., Bellec, S., Guihenneuc-Jouyaux, C., Clavel, J., Jougla, E., & Hémon, D. (2006). Excess mortality related to the August 2003 heat wave in France. *International Archives of Occupational and Environmental Health, 80*(1), 16–24.

Geng, Y., Chen, W., Liu, Z., Chiu, A. S., Han, W., Liu, Z., Zhong, S., Qian, Y., You, W., & Cui, X. (2017). A bibliometric review: Energy consumption and greenhouse gas emissions in the residential sector. *Journal of Cleaner Production, 159*, 301–316.

Gong, X., Zhang, J., Zhang, H., Cheng, M., Wang, F., & Yu, N. (2020). Internet use encourages pro-environmental behavior: evidence from China. *Journal of Cleaner Production, 256*, Article 120725.

González-Hernández, D. L., Meijles, E. W., & Vanclay, F. (2019). Factors that influence climate change mitigation and adaptation action: a household study in the Nuevo Leon Region, Mexico. *Climate, 7*(6), 74.

Halady, I. R., & Rao, P. H. (2010). Does awareness to climate change lead to behavioral change? *International Journal of Climate Change Strategies and Management*.

Harris, P. G. (2007). Collective action on climate change: The logic of regime failure. *Natural Resources Journal, 47*, 195.

Hart, P., Nisbet, E. C., & Myers, T. A. (2015). Public attention to science and political news and support for climate change mitigation. *Nature Climate Change, 5*(6), 541–545.

Hess, D. J., & Maki, A. (2019). Climate change belief, sustainability education, and political values: Assessing the need for higher-education curriculum reform. *Journal of Cleaner Production, 228*, 1157–1166.

Hoffmann, R., Šedová, B., & Vinke, K. (2021). Improving the evidence base: A methodological review of the quantitative climate migration literature. *Global Environmental Change, 71*, Article 102367.

Hong, Z., & Park, I. K. (2018). The effects of regional characteristics and policies on individual pro-environmental behavior in China. *Sustainability, 10*(10), 3586.

Ifegbesan, A. P., & Rampedi, I. T. (2018). Understanding the role of socio-demographic and geographical location on pro-environmental behavior in Nigeria. *Applied Environmental Education and Communication, 17*(4), 335–351.

IPCC. (2014a). Climate change 2014: Impacts, adaptation, and vulnerability. Part a: Global and sectoral aspects. In *Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change*. C. U. Press.

IPCC. (2014b). Climate change 2014: Impacts, adaptation, and vulnerability. Part B: Regional aspects. In *Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

IPCC. (2014c). Climate change 2014: Mitigation of climate change. In *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.

Islam, S. N., & Winkel, J. (2017). *Climate change and social inequality (DESA Working Paper No. 152, Issue)*.

Kane, S., & Shogren, J. F. (2000). Linking adaptation and mitigation in climate change policy. In *Societal adaptation to climate variability and change* (pp. 75–102). Springer.

Khanal, U., & Wilson, C. (2019). Derivation of a climate change adaptation index and assessing determinants and barriers to adaptation among farming households in Nepal. *Environmental Science & Policy, 101*, 156–165.

Koubi, V., Spilker, G., Schaffer, L., & Bernauer, T. (2016). Environmental stressors and migration: Evidence from Vietnam. *World Development, 79*, 197–210.

Lee, Y.-J., Tung, C.-M., & Lin, S.-C. (2019). Attitudes to climate change, perceptions of disaster risk, and mitigation and adaptation behavior in Yunlin County, Taiwan. *Environmental Science and pollution research, 26*(30), 30603–30613.

Lewis, J. J., & Pattanayak, S. K. (2012). Who adopts improved fuels and cookstoves? A systematic review. *Environmental Health Perspectives, 120*(5), 637–645.

Li, Y., Pizer, W. A., & Wu, L. (2019). Climate change and residential electricity consumption in the Yangtze River Delta, China. *Proceedings of the National Academy of Sciences, 116*(2), 472–477.

Liobikienė, G., Liobikas, J., Brizga, J., & Juknys, R. (2020). Materialistic values impact on pro-environmental behavior: the case of transition country as Lithuania. *Journal of Cleaner Production, 244*, Article 118859.

Liu, P., Teng, M., & Han, C. (2020). How does environmental knowledge translate into pro-environmental behaviors?: the mediating role of environmental attitudes and behavioral intentions. *Science of the Total Environment, 728*, Article 138126.

Mashi, S., Inkani, A., Obaro, O., & Asanarimam, A. (2020). Community perception, response and adaptation strategies towards flood risk in a traditional African city. *Natural Hazards, 103*(2), 1727–1759.

Masud, M. M., Akhatr, R., Nasrin, S., & Adamu, I. M. (2017). Impact of socio-demographic factors on the mitigating actions for climate change: a path analysis with mediating effects of attitudinal variables. *Environmental Science and Pollution Research, 24*(34), 26462–26477.

Masud, M. M., Akhtar, R., Afroz, R., Al-Amin, A. Q., & Kari, F. B. (2015). Pro-environmental behavior and public understanding of climate change. *Mitigation and Adaptation Strategies for Global Change, 20*(4), 591–600.

Mazumdar, S., Learnihan, V., Cochrane, T., & Davey, R. (2018). The built environment and social capital: A systematic review. *Environment and Behavior, 50*(2), 119–158.

Meltzer, L., Dame, J., & Gabrysch, S. (2021). Flood affectedness and household adaptation measures in rural northern Chile: a cross-sectional study in the Upper Huasco Valley. *International Journal of Disaster Risk Reduction, 64*, Article 102499.

Molua, E. L. (2012). Gendered response and risk-coping capacity to climate variability for sustained food security in Northern Cameroon. *International Journal of Climate Change Strategies and Management*.

Mueller, V., Sheriff, G., Dou, X., & Gray, C. (2020). Temporary migration and climate variation in eastern Africa. *World Development, 126*, Article 104704.

Nabikolo, D., Bashaasha, B., Mangheni, M., & Majaliwa, J. (2012). Determinants of climate change adaptation among male and female headed farm households in eastern Uganda. *African Crop Science Journal, 20*, 203–212.

Nejat, P., Jomehzadeh, F., Mahdi, M., & Gohari, M. (2015). A global review of energy consumption, CO2 emissions and policy in the residential sector (with an overview of the top ten CO2 emitting countries). *Renewable and Sustainable Energy Reviews, 43*, 843–862. https://doi.org/10.1016/j.rser.2014.11.066

Ngigi, M. W., Mueller, U., & Birner, R. (2017). Gender differences in climate change adaptation strategies and participation in group-based approaches: an intra-household analysis from rural Kenya. *Ecological Economics, 138*, 99–108.

Nielsen, K. S., Nicholas, K. A., Creutzig, F., Dietz, T., & Stern, P. C. (2021). The role of high-socioeconomic-status people in locking in or rapidly reducing energy-driven greenhouse gas emissions. *Nature Energy, 6*(11), 1011–1016.

Nitivattananon, V., & Srinonil, S. (2019). Enhancing coastal areas governance for sustainable tourism in the context of urbanization and climate change in eastern Thailand. *Advances in Climate Change Research, 10*(1), 47–58.

Noll, B., Filatova, T., & Need, A. (2020). How does private adaptation motivation to climate change vary across cultures? Evidence from a meta-analysis. *International Journal of Disaster Risk Reduction, 46*, Article 101615.

NwaJesus, O. A., Okokon, N., & ChukwumaOtum, U. (2019). *Understanding the nexus of households' attributes and climate change mitigation behavior: empirical evidence from Nsukka area of Nigeria*.

Okaka, F. O., & Odhiambo, B. D. (2018). Urban residents' awareness of climate change and their autonomous adaptive behaviour and mitigation measures in the coastal city of Mombasa, Kenya. *South African Geographical Journal= Suid-Afrikaanse Geografiese Tydskrif, 100*(3), 378–393.

Okunola, O. H., & Bako, A. I. (2021). Exploring residential characteristics as determinants of household adaptation to climate change in Lagos, Nigeria. *International Journal of Disaster Resilience in the Built Environment.*

Opiyo, F., Wasonga, O. V., Nyangito, M. M., Mureithi, S. M., Obando, J., & Munang, R. (2016). Determinants of perceptions of climate change and adaptation among Turkana pastoralists in northwestern Kenya. *Climate and Development, 8*(2), 179–189.

Osberghaus, D., & Demski, C. (2019). The causal effect of flood experience on climate engagement: Evidence from search requests for green electricity. *Climatic Change, 156*(1), 191–207.

Owusu, V., Ma, W., Renwick, A., & Emuah, D. (2021). Does the use of climate information contribute to climate change adaptation? Evidence from Ghana. *Climate and Development, 13*(7), 616–629.

Paavola, J., & Adger, W. N. (2006). Fair adaptation to climate change. *Ecological Economics, 56*(4), 594–609.

Park, R. J., Goodman, J., Hurwitz, M., & Smith, J. (2020). Heat and learning. *American Economic Journal: Economic Policy, 12*(2), 306–339.

Pidgeon, N. (2012). Public understanding of, and attitudes to, climate change: UK and international perspectives and policy. *Climate Policy, 12*(sup01), S85–S106.

Ponce, P., Alvarado, R., Ponce, K., Alvarado, R., Granda, D., & Yaguana, K. (2019). Green returns of labor income and human capital: empirical evidence of the environmental behavior of households in developing countries. *Ecological Economics, 160*, 105–113.

Pullin, A. S., & Stewart, G. B. (2006). Guidelines for systematic review in conservation and environmental management. *Conservation Biology, 20*(6), 1647–1656.

Qazlbash, S. K., Zubair, M., Manzoor, S. A., Ul Haq, A., & Baloch, M. S. (2021). Socioeconomic determinants of climate change adaptations in the flood-prone rural community of Indus Basin, Pakistan. *Environment and Development, 37*, Article 100603.

Qin, P., Chen, S., Tan-Soo, J.-S., & Zhang, X.-B. (2022). Urban household water usage in adaptation to climate change: Evidence from China. *Environmental Science & Policy, 136*, 486–496.

Qin, P., Liu, M., Su, L., Fei, Y., & Tan-Soo, J.-S. (2022). Electricity consumption in the digital era: Micro evidence from Chinese households. *Resources, Conservation and Recycling, 182*, Article 106297. https://doi.org/10.1016/j.resconrec.2022.106297

Rahman, M. S., Overgaard, H. J., Pientong, C., Mayxay, M., Ekalaksananan, T., Aromseree, S., … Paul, R. E. (2021). Knowledge, attitudes, and practices on climate change and dengue in Lao People's Democratic Republic and Thailand. *Environmental Research, 193*, Article 110509.

Rajapaksa, D., Islam, M., & Managi, S. (2018). Pro-environmental behavior: The role of public perception in infrastructure and the social factors for sustainable development. *Sustainability, 10*(4), 937.

Rauf, S., Bakhsh, K., Abbas, A., Hassan, S., Ali, A., & Kächele, H. (2017). How hard they hit? Perception, adaptation and public health implications of heat waves in urban and peri-urban Pakistan. *Environmental Science and Pollution Research, 24*(11), 10630–10639.

Reynaud, A., Aubert, C., & Nguyen, M.-H. (2013). Living with floods: Protective behaviours and risk perception of Vietnamese households. *The Geneva Papers on Risk and Insurance-Issues and Practice, 38*(3), 547–579.

Rode, A., Carleton, T., Delgado, M., Greenstone, M., Houser, T., Hsiang, S., Hultgren, A., Jina, A., Kopp, R. E., & McCusker, K. E. (2021). Estimating a social cost of carbon for global energy consumption. *Nature, 598*(7880), 308–314.

Rosen, A. M. (2015). The wrong solution at the right time: The failure of the Kyoto protocol on climate change. *Politics & Policy, 43*(1), 30–58.

Salo, M., Savolainen, H., Karhinen, S., & Nissinen, A. (2021). Drivers of household consumption expenditure and carbon footprints in Finland. *Journal of Cleaner Production, 289*, Article 125607.

Sam, A. S., Padmaja, S. S., Kächele, H., Kumar, R., & Müller, K. (2020). Climate change, drought and rural communities: understanding people's perceptions and adaptations in rural eastern India. *International Journal of Disaster Risk Reduction, 44*, Article 101436.

Scannell, L., & Gifford, R. (2013). Personally relevant climate change: The role of place attachment and local versus global message framing in engagement. *Environment and Behavior, 45*(1), 60–85.

Schäfer, M. S. (2012). Online communication on climate change and climate politics: A literature review. *Wiley Interdisciplinary Reviews: Climate Change, 3*(6), 527–543.

Scruggs, L., & Benegal, S. (2012). Declining public concern about climate change: Can we blame the great recession? *Global Environmental Change, 22*(2), 505–515.

Shafiei, A., & Maleksaeidi, H. (2020). Pro-environmental behavior of university students: application of protection motivation theory. *Global Ecology and Conservation, 22*, Article e00908.

Shah, A. A., Ye, J., Abid, M., & Ullah, R. (2017). Determinants of flood risk mitigation strategies at household level: a case of Khyber Pakhtunkhwa (KP) province, Pakistan. *Natural Hazards, 88*(1), 415–430.

Sharma, U., Patwardhan, A., & Patt, A. G. (2013). Education as a determinant of response to cyclone warnings: evidence from coastal zones in India. *Ecology and Society, 18*(2).

Somanathan, E., Somanathan, R., Sudarshan, A., & Tewari, M. (2021). The impact of temperature on productivity and labor supply: Evidence from Indian manufacturing. *Journal of Political Economy, 129*(6), 1797–1827.

Stern, N. (2021). *A time for action on climate change and a time for change in economics*.

Stoddard, I., Anderson, K., Capstick, S., Carton, W., Depledge, J., Facer, K., Gough, C., Hache, F., Hoolohan, C., & Hultman, M. (2021). Three decades of climate mitigation: Why haven't we bent the global emissions curve? *Annual Review of Environment and Resources, 46*(1), 653–689.

Sturm, B., Pei, J., Wang, R., Löschel, A., & Zhao, Z. (2019). Conditional cooperation in case of a global public good–experimental evidence from climate change mitigation in Beijing. *China Economic Review, 56*, Article 101308.

Sun, C., Kahn, M. E., & Zheng, S. (2017). Self-protection investment exacerbates air pollution exposure inequality in urban China. *Ecological Economics, 131*, 468–474.

Tan, Y., Liu, X., & Hugo, G. (2015). Exploring relationship between social inequality and adaptations to climate change: evidence from urban household surveys in the Yangtze River delta, China. *Population and Environment, 36*(4), 400–428.

Tan-Soo, J.-S., Qin, P., & Zhang, X.-B. (2018). Power stations emissions externalities from avoidance behaviors towards air pollution: Evidence from Beijing. *Energy Policy, 121*, 336–345.

Ung, M., Luginaah, I., Chuenpagdee, R., & Campbell, G. (2015). Perceived self-efficacy and adaptation to climate change in coastal Cambodia. *Climate, 4*(1), 1.

van Valkengoed, A. M., & Steg, L. (2019). Meta-analyses of factors motivating climate change adaptation behaviour. *Nature Climate Change, 9*(2), 158–163.

Werg, J. L., Grothmann, T., Spies, M., & Mieg, H. A. (2020). Factors for self-protective behavior against extreme weather events in the Philippines. *Sustainability, 12*(15), 6010.

Wolf, J., Prüss-Ustün, A., Cumming, O., Bartram, J., Bonjour, S., Cairncross, S., Clasen, T., Colford, J. M., Jr., Curtis, V., & De France, J. (2014). Systematic review: Assessing the impact of drinking water and sanitation on diarrhoeal disease in low-and middle-income settings: Systematic review and meta-regression. *Tropical Medicine & International Health, 19*(8), 928–942.

Xu, Z., FitzGerald, G., Guo, Y., Jalaludin, B., & Tong, S. (2016). Impact of heatwave on mortality under different heatwave definitions: A systematic review and meta-analysis. *Environment International, 89*, 193–203.

Yin, Q., Ntim-Amo, G., Ran, R., Xu, D., Ansah, S., Hu, J., & Tang, H. (2021). Flood disaster risk perception and urban households' flood disaster preparedness: the case of Accra Metropolis in Ghana. *Water, 13*(17), 2328.

Yusliza, M. Y., Amirudin, A., Rahadi, R. A., Nik Sarah Athirah, N. A., Ramayah, T., Muhammad, Z., … Mokhlis, S. (2020). An investigation of pro-environmental behaviour and sustainable development in Malaysia. *Sustainability, 12*(17), 7083.

Zanocco, C., Boudet, H., Nilson, R., & Flora, J. (2019). Personal harm and support for climate change mitigation policies: Evidence from 10 US communities impacted by extreme weather. *Global Environmental Change, 59*, Article 101984.

Zaval, L., Keenan, E. A., Johnson, E. J., & Weber, E. U. (2014). How warm days increase belief in global warming. *Nature Climate Change, 4*(2), 143–147.

Zeng, J., Jiang, M., & Yuan, M. (2020). Environmental risk perception, risk culture, and pro-environmental behavior. *International Journal of Environmental Research and Public Health, 17*(5), 1750.

Zhang, G., Yao, T., Xie, H., Yang, K., Zhu, L., Shum, C., … Jiang, L. (2020). Response of Tibetan Plateau lakes to climate change: trends, patterns, and mechanisms. *Earth-Science Reviews, 208*, Article 103269.

Zhou, H., Yin, H., Yuan, F., & Wang, F. (2019). Social relationships, public media, and pro-environmental behaviors. *Empirical Economics, 57*(2), 569–588.