ideas 42

# Act to Adapt

## Behavioral Design for Climate Adaptation

**Authors:**
Maya Faulstich-Hon
Erin Sherman
Griffin Smith

**December 2019**

# Acknowledgements

We conducted multiple informational interviews that provided key insights for structuring this piece. Thank you to: Omair Ahmad, Rachel Banay, Amanda Carrico, Rebecca Carter, Julie Doll, Eric Fernandez, Tyler Ferdinand, Paul Ferraro, Jason Glaser, Bill Hyde, Evan Jones, Fred Kirschenmann, Karina Lorenzana, Valarie Mac, Susanne Moser, Solomon Nzioka, Robert Paarlberg, Colin Quinn, Will Rogers, Linda Rudolph, Marc Schenker, Renata Serra, Jana Smith, Susan Wengraf, and Matthew Wibbenmeyer.

We are also grateful to the reviewers who provided thorough and thoughtful feedback on our initial drafts. We appreciate the help of Karen Akerlof, Julie Doll, Tyler Ferdinand, Dana Guichon, Kim Howell, Bill Hyde, Liana Johnson, Leidy Klotz, Valeria Mac, Mitra Salasel, Tom Tasche, Matthew Wibbenmeyer, and Josh Wright.

Thank you to Elise Grinstead for graphic design.

# About ideas42

At ideas42, we look for deep insights into human behavior—into why people do what they do—and use that knowledge in ways that help improve lives, build better systems, and drive social change. Exploring innovative, often unexpected, solutions to difficult problems, we focus on areas that are vitally important to our collective wellbeing—including environmental sustainability.

For more than a decade, we've been at the forefront of applying behavioral science in the real world. And as we've developed our expertise, we've helped to define an entire field. Our efforts have so far extended to over 30 countries as we've partnered with governments, foundations, NGOs, private enterprises, and a wide array of public institutions. In addition to designing and testing effective solutions that can be scaled for maximum impact, we help organizations develop the knowledge and skills they need to improve existing programs and policies—or create new ones.

Visit ideas42.org and follow @ideas42 on Twitter to learn more about our work. Contact Erin Sherman at erin@ideas42.org with questions.

# Contents

# How to read this report

Climate adaptation intersects with many different fields, and some portions of this report will be more relevant than others for readers. The paper is structured to allow readers to start anywhere and only read sections of interest.

1. In ***"Diagnosing challenges and designing solutions,"*** we discuss common behavioral barriers to adaptation, lay out possible design tools to address them, and showcase example projects.
2. The ***case studies*** demonstrate the role for behavioral design in different adaptation impact areas:
    a. **Impact Area:** Adaptation to extreme events, with a focus on fires in the U.S. and cyclones in South Asia.
    b. **Impact Area:** Adaptation in the health sector, with a focus on heat-related illness in the U.S. and malaria in East Africa.
    c. **Impact Area:** Adaptation in the agriculture sector, with a focus on the U.S. and the Sahel.
3. In ***"Beyond nudges: SCOPE decisions,"*** we make the case for using behavioral science to tackle the complicated systems and behaviors often associated with adaptation decisions.

# EXECUTIVE SUMMARY

## A call for adaptation

The world is changing, and we must change too. From heat to hurricanes, floods to fires, climate change cuts across all aspects of life on Earth. While we can, and must, continue to address today's unprecedented scale of atmospheric greenhouse gases (GHGs) through intensified mitigation efforts, it is also essential to adjust our structures, systems, and societies in response to the impacts of climate change that are already occurring. It is time to recognize that those who are hardest hit have least contributed to the problem, and it is time to reduce the harm that is yet to come. It is time to adapt.

## Why behavioral science?

At ideas42, we're interested in people. We look for deep insights into human behavior—into why people do what they do—and use that knowledge in ways that help improve lives, build better systems, and drive social change.

When it comes to climate change, we know from studying behavior that many of our instincts fail us. Humans are not natural long-term planners, and we all share tendencies that make it challenging to adapt to complex new realities. However, using knowledge of human behavior, we can identify barriers to effective action and then design better programs, products, and policies that help more everyday people and key decision-makers follow through on adaptation efforts—setting everyone up for stronger futures.

## A closer look

In this paper, we examine the ways behavioral design can meaningfully support adaptation efforts across three impact areas. For each area we provide two real-world case studies and draw from behavioral principles and design processes to propose new behavioral solutions to pressing problems. These proposed solutions have not yet been implemented or tested in the real world, and they would need to be customized to take full account of context-specific opportunities and limitations. Our intention is to provide a taste of what is possible with behavioral science and connect with organizations and decision-makers interested in designing and evaluating solutions tailored for their audiences and circumstances.

1 ***Extreme events***

Climate change is making extreme weather events—like cyclones, hurricanes, floods, droughts, heat waves, and blizzards—both more likely to happen and more severe when they do. ***In 2018 alone, extreme weather events directly impacted over 57 million people worldwide*** and caused thousands of deaths. Here, we consider the cases of wildfires in California and cyclones in South Asia and explore strategies for communities and individuals to adapt in the face of these increasing disasters.

### 2 *Disease*

Hotter temperatures and higher humidity mean more heat-related illness as well as more spread of infectious disease to new geographies. By 2030, climate change will conservatively lead to an additional 250,000 to 529,000 deaths every year through the spread of malaria, diarrheal disease, heat illness, and malnutrition alone. ***Climate change will conservatively incur $2-4 billion in annual health-related costs.***[1] Here, we explore heat illness among U.S. agricultural workers and the spread of malaria in East Africa. We highlight interventions to reduce mortality and morbidity.

### 3 *Agriculture*

Agriculture and climate are intimately and intrinsically linked. Without strong and swift climate action, ***we may face a 30% decline in global yields by 2050*** as more extreme and unpredictable temperature and precipitation patterns make growing food, feed, fuel, and fiber more difficult. We take a look at the cases of cereal crop production in the Midwestern U.S. and subsistence agriculture in the Sahel and suggest solutions to increase farmers' capacity to cope with these changes and uncertainties.

## SCOPE Decisions

While influencing decisions and behaviors through quick, cost effective, and incremental interventions is one key focus of our work, behavioral science can, and must, also address more complex adaptation-related decisions, which we refer to as SCOPE decisions: **Structural, Contextual, Occasional, Political, and Expert-Driven.** These decisions might look like:

- Developing long-term climate adaptation plans for cities
- Designing agricultural extension services
- Allocating dwindling water resources
- Rolling out disaster response protocols
- Establishing early warning systems for disease outbreaks

***These high-stakes decisions, in turn, determine the choice sets available to others.*** These decisions must take into account the complex lives of real people to ensure that they are ultimately effective and equitable. As we begin to design and pilot climate adaptation interventions, we must also decide how to test the impact we're having to ensure our projects achieve their intended goals without causing any unintended, negative impacts. Accumulating this sector-specific knowledge about what works and what does not will allow for better design and implementation of behavioral solutions.

Climate change is a challenge of unprecedented scope and scale, but with collaboration, tenacity, and humility, we can create equitable solutions where all people can thrive. We look forward to using behavioral design to accelerate the urgent work of adapting our world while continuing our mitigation efforts at the same time.

# INTRODUCTION

***The radio program cuts out suddenly and Jordan hears a familiar chime, followed by the words: "Fire warning. Immediate evacuation in progress. Proceed to meeting places for Scenario A. Repeat: Fire warning. Immediate evac-"***

***Jordan turns down the radio and grabs the keys. "Sam! Let's go, it's a fire!" Sam runs down the stairs and into the hallway, where Jordan is waiting with a bag that was stashed in the coat closet. They leave the house within five minutes and join four of their neighbors at the end of the block; the Moores have their passenger van waiting. Within ten minutes, they're on the evacuation route with the radio on, listening for updates.***

***Jordan and Sam live within an hour of Paradise, California, on what their town supervisor calls the "wildland urban interface." They know what happens to a town that isn't prepared for a firestorm—how quickly a whole block can be reduced to melted aluminum and ash. That's why Jordan was glad when they got a letter from the town letting them know about their evacuation team. It was so easy. The first few drills were a little awkward, but they worked it all out with practice. They got to know their neighbors, even the older folks and the Peñas, who'd just moved in last year but had already earned their Fire Protector post for clearing out their defensible zone.***

***By the time the real warning chime came, piling into the van was practically second nature. Together, they navigated to the refuge center and waited. In a few days, they would see if their preparations to their yards and homes had paid off—but for now, they were all safe.***

Humans possess an instinct for self-preservation. In many situations, this instinct serves us very well: we generally eat when hungry, sleep when tired, try to make peace with those close to us, and otherwise look out for our well-being. Yet for the past several decades, when faced with the existential threat of climate change, our instincts have failed us. Behavioral science—the study of how humans behave and make decisions in the real world, drawn from psychology, neuroscience, behavioral economics, sociology, and related disciplines—can help us understand how our instincts fall short, and how we can intelligently reignite and mobilize them for survival in a new era of global change.

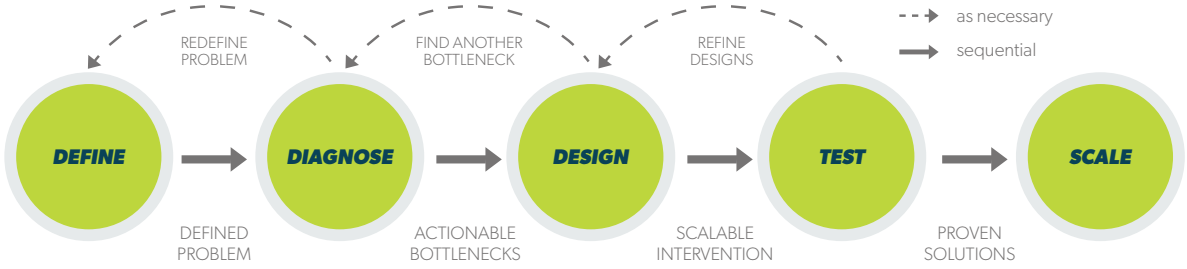
The practice of using behavioral science to address real-world problems is called ***applied behavioral design.*** It's what we do at ideas42: tailor programs and products for real human behavior with the goal of aligning people's best intentions to their actions. ***Applied behavioral design is critical for advancing our world from an unsustainable present to a sustainable future.***

Few problems require applied behavioral design more than the human response to climate change. Every day, powerful governments, large corporations, and well-resourced people make decisions that continue or accelerate greenhouse gas (GHG) emissions and delay or stop appropriate, adaptive responses necessary to protect life on Earth. These decisions affect both the mitigation of climate change—defined as "limiting or preventing GHG emissions and enhancing activities that

remove these gases from the atmosphere"—and adaptation—"adjustments in human and natural systems, in response to actual or expected climate stimuli or their effects, that moderate harm or exploit beneficial opportunities."[2] Adaptation also entails a focus on improving social-ecological resilience, or the capacity of systems to regain their fundamental function and structure after shocks. On the whole, humankind's mitigation and adaptation efforts, while accelerating, must be increased to a speed and intensity far greater than what the world's governments are on track to accomplish. This task will require changing human decisions and actions at every level of society.

Fortunately, behavioral science has already begun to show promise for addressing climate change. Several scholars and teams (including Robert Gifford,[3] the Center for Research on Environmental Decisions (CRED),[4] Akerlof and Kennedy,[5] and Yoeli and colleagues)[6] have drafted helpful frameworks detailing behavioral tools that policymakers can leverage for pro-environmental goals. So far, these frameworks and their applications have largely focused on two topic areas: how to help people form receptive attitudes, accurate beliefs, and sound judgments about climate change, and how to encourage them to develop intentions and follow through on actions that will lead to reduced GHG emissions. Behavioral design has already proven valuable in encouraging conservation behavior in a variety of contexts, and continuing to apply it in the service of mitigation will be critical to achieve a livable climate.

In this report, our aim is to build upon these frameworks to illustrate how behavioral design tools may be applied to climate adaptation. Adapting to the many changes that warming will bring—from hotter temperatures to more fragile ecosystems, and the social and political changes warming may create—is not an alternative to mitigation. ***Adaptation is, alongside mitigation, a necessity.*** As the effects of climate change have become increasingly evident, countries, cities, corporations, and international organizations have already begun to take action, in many cases directing significant resources toward structural changes to protect people and assets against intensifying storms, fires, droughts, and other climate-related risks. This is good news: the political will and economic wherewithal to successfully adapt to climate change is gathering momentum. The challenge will be to ensure that these stakeholders' responses reflect the scale and nature of changing risks. Successfully harnessing people's awareness of the changing climate and desire to act is where behavioral design may prove critical for humankind to survive and thrive in the 21st century.




## The Behavioral Design Process

Systematic, scalable behavior change is the result of a thoughtful, deliberate process, combining the best of behavioral science, design thinking, and impact evaluation. ideas42's behavioral design process has five key phases: Define, Diagnose, Design, Test, and Scale.

- **Define.** To address a problem, a behavioral designer must first accurately and concisely define it. Helpful problem definitions have two parts: a brief, verifiable summary of a stakeholder's current behavior, and a clear statement of the desired change in behavior. This phase often involves breaking down larger problems into subproblems that are appropriate targets for detailed behavioral design.
- **Diagnose.** Diagnosis aims to answer the question: "If the desired behavior is such a good idea, why aren't people already doing it?" Behavioral designers draw from scientific literature and analytical frameworks to formulate hypothetical answers, then investigate those answers' plausibility through qualitative research and quantitative analysis of the available data on stakeholder behavior. Through diagnosis, we develop a shortlist of possible factors in the context—structural, economic, social, or psychological—that may account for the behaviors we observe.
- **Design.** Drawing on our diagnosis and the behavioral science literature, we design interventions that address the contextual causes of behavior. Designs range from subtle variations on existing programs and products to more complex interventions. We work closely with partners, providing operational and technical assistance, to finalize and implement the designs. We build designs that could be scaled later if our test proves promising.
- **Test.** To determine the validity of our hypotheses and the efficacy of the design, we rigorously test interventions, ideally through a randomized controlled trial (RCT)—the gold standard in evaluations.
- **Scale.** Once we know what works, we then seek to refine our designs and adapt them for scale using a variety of channels, including policy change, dissemination, replication, or the creation of new organizations or services.

# DIAGNOSING CHALLENGES AND DESIGNING SOLUTIONS

Our practitioner partners often want to jump to solutions once they've defined a problem. Practitioners arrive at problems with years of experience, and over those years, they develop intuitions and habits regarding how best to address the issues on which they work. Behavioral design brings a complementary perspective to subject matter experts' intuitions. Through the diagnosis step of the behavioral design process, we ask experts to suspend their judgments about solutions until the root causes of behaviors have been investigated with fresh eyes.

The diagnosis process includes several activities: first, we map each step required to follow through on target behaviors. Next, we review related behavioral science research and interventions. We draft hypotheses about a situation's plausible effects on behavior, then investigate those hypotheses through context-specific primary research, such as observation and interviews.

Diagnosis leads directly into design. With clear theories and contextual knowledge in hand, we prototype designs that address the root causes of behavior. Through iteration with partners and stakeholders, we then hone the designs into implementation-ready interventions.

Below, building on past typologies of behavioral concepts to understand climate-related attitudes and behaviors, we illustrate eight potential barriers to adaptation-related behaviors among everyday actors such as households and small businesses. We then show design tools that may help address each barrier, and share an example of each tool's prior application in a field context. While not comprehensive, they show how simple behavioral principles can inform helpful, real-world solutions.

**FIGURE A:** A selected typology of behavioral barriers, associated design tools, and example interventions

| Barrier | Design Tools | Example Intervention |
|---|---|---|
| **Choice conflict:** We tend to make no choice or a suboptimal choice when faced with numerous or difficult-to-compare options. | **Defaults:** Set a default option that will be selected in the absence of an active choice to guide decision-making toward the optimal choice for most people.<br><br>**Curated lists:** In lieu of offering an exhaustive choice set, present a manageable number of good options with the most important decision-making criteria, such as costs or benefits. | Participation in 401(k) savings plans significantly increased when employees were automatically enrolled in the plan compared to those who had to opt-in to participate.[7] |
| **Invisible behaviors:** When we don't know how others behave with regard to a specific goal—or how we have behaved in the past—the goal and the steps to achieve it tend not to be salient, or are not deemed worthy of effort. | **Social norms and feedback:**[8] Provide people with ***descriptive norms—***descriptions of others' behavior with regard to a specific goal. It can be paired with feedback about personal behavior or ***injunctive norms—*** messaging about specific behaviors that conveys social approval or disapproval. | People who consumed more household energy significantly reduced their energy consumption when provided with descriptive norms (information on neighbors' energy usage) as well as injunctive norms (a sad face).[9] |

| | | |
|---|---|---|
| **Status quo bias:** When an action is unfamiliar, we tend to consider its disadvantages first or avoid considering it altogether. | **Demonstration:** Display the previous option alongside the new one to highlight the advantages of the new option. | Seaweed farmers learned to optimize growing practices when presented with summaries of results of experimental plots, with key dimensions highlighted.[10] |
| **Present bias:** We greatly prefer reaping benefits and avoiding costs in the present rather than the future. | **Reduce hassles:** Simplify and streamline processes to make them easier to complete. | By pre-filling the FAFSA (federal financial aid form) with tax information and providing guidance on filling it in, the percentage of college students successfully completing the form and subsequently enrolling in college significantly increased.[11] |
| **Psychological distance:** We tend to consider issues that have not affected us personally as abstract and irrelevant, so we are unlikely to decide to address them. Even when we do, it can be difficult to take the right steps toward an abstract-feeling goal. | **Prospection prompts:** Allow people to take the perspective of their future selves, encouraging present behavior to meet the wants and needs of that future self.<br><br>**Planning prompts:** Prompt people to create detailed plans for action. Prompts can be paired with ***social accountability*** or a ***commitment device***. | **Prospection prompts:** Participants were prompted to more vividly think about their future needs by seeing renderings of their future selves. These participants more than doubled their contributions to a hypothetical retirement account, compared to control participants.[12]<br><br>**Planning prompts:** Employees who were prompted to make a detailed plan to receive a flu vaccination were significantly more likely to follow through than those in a control group.[13] |
| **Scarce cognitive bandwidth:** We attend only to our most urgent problems, particularly when we are pressed for time, money, or other resources. Lower priorities are left by the wayside, especially when they require a lot of attention. | **Timely reminders:** Provide reminders at strategic moments when people are able to take action.<br><br>**Rules of thumb/heuristics:** Distill key information into simple, easy-to-remember principles. | **Timely reminders:** A low-cost fare rebate incentive significantly decreased metro ridership during peak hours compared to text message alerts and a control group.[14]<br><br>**Rules of thumb/heuristics:** Microentrepreneurs who received a heuristics-based training delivered via mobile phones were significantly more likely to take up several best management business practices, compared to control participants.[15] |
| **Weber-Fechner law:** Our ability to notice a change in physical stimulus depends on the original level of the stimulus. For instance, turning on a dim light in a bright room is far less noticeable than turning on the same dim light in a dark room.<br><br>The Weber-Fechner law can both act as a barrier (e.g. limiting our attention to an increase in a negative stimulus, such as heat, if it's already hot) or a channel (e.g. making it easier to add on a beneficial product, such as climate smart agricultural supplies, if a farmer is already buying a substantial amount of equipment). | | People perceive the difference between $10 and $20 as greater than the difference between $110 and $120.[16] |
| **Overestimation of small probability events:** People tend to overweigh the potential occurrence of unlikely outcomes and events. | **Lottery incentives**: Provide a lottery incentive for taking a desired behavior. Since people overweigh low probabilities, the possibility of attaining a large benefit—however slim—may be sufficient to galvanize behavior in the present. | Participants in a weight-loss study who received a lottery incentive lost significantly more weight than those in a control group.[17] |

# SIX ILLUSTRATIVE CASE STUDIES FOR ADAPTATION BEHAVIOR CHANGE

In the case studies below, we briefly describe climate change's projected effects on three spheres of human experience—how we survive extreme events, cope with disease, and grow crops—and how behavioral science can help us understand and improve adaptation efforts in these contexts. In each of the case studies, we provide a few examples, borne of initial research into the focal contexts, of what behaviorally designed interventions to address adaptation challenges might look like.

These case studies and the interventions proposed within them are illustrative, not exhaustive. In some instances, the examples incorporate behaviorally designed elements into today's best practices, or they leverage similarities between problems in order to adapt an existing solution to a related challenge. Contextual details can substantially affect behavior, so we do not anticipate that every principle we highlight will be relevant across towns, countries, or regions. Rather, we aim to put forward initial hypotheses regarding why adaptation behaviors may not yet be as widespread and rapid as necessary, so that these hypotheses could be further investigated—and designs further tailored—to best suit specific situations.

We encourage our readers to imagine analogies to their objectives at work, as well as their aspirations for their homes and communities, as they read the examples below. We hope that those analogies will inspire you to explore further, and we are equally eager to hear how they reveal limitations in our vision or awareness. Behavioral design comes alive when applied to the contours of real places and people, and you, the expert in your own sphere, hold vital knowledge: your intuitions, developed through experience, could suggest which barriers to action will leave your colleagues and neighbors with regrets next year or next decade—and which pathways might unlock no-regrets solutions for this century and the next.

★ **Share your thoughts on adaptation behavior change** at bit.ly/Act2Adapt


Impact Area Study

# Extreme Weather Events

## Climate Change and Extreme Weather

Not only are extreme climate events one of the most visible impacts of climate change, they also pose the most immediate danger, directly threatening lives, personal property, and communal infrastructure. In 2018 alone, extreme weather events like cyclones, wildfires, and blizzards—strengthened by climate change—directly impacted more than 57 million people worldwide and caused thousands of deaths.[18]

Climate change can make these extreme weather events both more likely to happen and more severe.[19,20] Scientists can even approximate the impact of climate change on a single storm. One report calculates that Hurricane Harvey—which dropped over 60 inches of rain, impacted 13 million people, and cost over $125 billion in the Houston, Texas area—was three times more likely to occur and 15% stronger due to climate change.[21,22] Such extreme climate events will only become more intense and more frequent.[23]

## Why Behavioral Science?

Lack of adequate funding for disaster preparedness presents a significant barrier to adaptation behaviors that could save lives or protect infrastructure. Proactive spending to protect against extreme events can save governments and individuals significant money in the long run. In the case of coastal storms, ***every $1 spent on protection can prevent almost $4.50 in recovery costs.***[24] Unfortunately, there is a 438% gap between current spending on adaptation in high-income

countries and the amount needed to reach conservative spending requirements for adequate protection in 2050.[25] Low-income countries face an even larger shortfall. Wealthy cities, like Paris, spend over 84 times per capita more every year on disaster preparedness than developing cities, such as Addis Ababa.[26] This spending gap will further compound existing inequalities, especially given the high costs of recovery given the high costs of recovery and the need to focus on other pressing development needs.

Common behavioral tendencies both compound barriers and present a channel to implement fixes. Low risk perceptions and uncertainty pose major challenges to adaptation, as there is a strong, positive correlation between threat perception and taking adaptive action.[27,28] The majority of Americans now believe in climate change; they just don't think it will threaten them directly, limiting necessary adaptive efforts.[29]

On the other hand, natural disasters—including coastal floods, droughts, wildfires, and excessive heat—can increase attention to climate change. Under the right conditions, this attention translates into willingness to adapt.[30] In a survey of Kentucky residents, those who experienced drought and water restrictions were more likely to develop pro-environmental worldviews,[31] and in New Jersey, people who experienced major hurricanes later expressed more environmentalism and support for green politicians.[32] Policymakers can channel this sentiment to prevent future tragedies,[33] but must also consider the demographics of the target population. Social and economic identities, such as class, race, and geography, add another layer that changes how people respond to disasters.[34]

### » Using behavioral science to increase responses to flood insurance affordability survey[35]

***Intervention:*** Redesign of city letters to residents

***Focus population:*** Thousands of households in high flood-risk NYC neighborhoods targeted for a flood insurance affordability survey

***Barrier:*** Despite significant monetary incentives for taking the survey—a $50 gift card and an offer for free elevation surveying valued at $1,000—response rates were extremely low, at 11%.

***Design tools:*** ideas42 redesigned a reminder letter that increased the salience of incentives and clarified action steps for completing the survey. Social norms messaging on the envelope grabbed recipients' attention (e.g. "Join hundreds of property owners in your area lowering their flood insurance costs"), and a soft deadline ("You must respond within 1 week!") conveyed urgency to further increase salience of the letter. The results were striking; households that received our behaviorally designed reminder letter were 15.5 times more likely to provide the city with flood-risk information.

***Partner:*** The City of New York

***Relevance:*** The threat of extreme events, such as floods, often seems abstract and far removed. Behaviorally informed messaging can help people recognize the risk and take advantage of existing programs and services to prepare for these events.

# California Wildfires

***Devastating wildfires in California have burned millions of acres every summer in the last decade. In the last 50 years, the size of summer fires has increased eightfold.***[36] ***Seven of the state's most destructive fires occurred in the last decade. California's Mendocino fire, the state's largest in recorded history, and the Camp fire, the most destructive, both occurred in the same year, 2018.***[37,38]

Climate change has increased this threat as hotter temperatures dry out vegetation and facilitate the spread of insect infestation, killing trees and making forests more flammable. Human encroachment into wildland-urban interfaces (WUIs), where homes are built in areas prone to destruction from wildfire, has also heightened the danger.[39,40] ***Almost 30% of California's housing is in the WUI—a 25% increase in the last three decades.***[41]

Here, we focus primarily on facilitating household-level behavior change. It is worth noting, however, that the state government spends far more on costly suppression of active fires than mitigating future risk through controlled burns and fuel clearing.[42,43,44] At the city level, policies that improve long term safety, like stricter zoning in the WUI to curb additional home construction in these areas, may incur short-term losses in tax revenue.[45,46] In both cases, government decision-makers may be prone to present bias and other patterns of judgment likely to reduce long-term adaptive measures. Behavioral designs could prove equally effective with high-level stakeholders, like state and local governments, whose policy decisions are also powerfully influenced by decision-making biases.[47]

People living in the WUI must choose whether to support city-wide protective policies like tree cutting, take personal actions like clearing defensible spaces around their houses, and—in the moment—evacuate from wildfires in a safe and timely manner. The characteristics of at-risk communities vary widely in terms of size, affluence, fire preparedness, and urbanization.[48] While we believe the below interventions may be effective in many WUIs, the implementation of each must be tailored to address specific contexts.

## Behaviorally Designed Approaches

***Refer to Figure A on page 9 for explanations of these behavioral barriers and design tools.***

| Intervention Idea | Focus Population | Barrier | Design Tool | Partner & Channel |
|---|---|---|---|---|
| **Fire Protector Maps:** Mail to residents color-coded maps scoring the level of fire safety measures for houses in their neighborhood | California residents in moderately to heavily populated communities in the WUI | • Invisible behaviors | • Social norms and feedback | City officials within the WUI |
| **Evacuation Groups:** Create designated evacuation groups for vulnerable rural residents | Vulnerable citizens living in high fire-risk communities | • Choice conflict | • Defaults | City officials within the WUI |
| **Community Fire Drills:** Simulate an evacuation and provide home fire safety audits | Entire fire-risk neighborhoods or small communities | • Psychological distance<br>• Present bias | • Planning prompts<br>• Lottery incentives | City officials and firefighters within the WUI |

## Fire Protector Maps


***Barrier to action:*** Residents of high fire-risk areas may not develop intentions to reduce their property's risk if the incentives to do so are abstract and distant. Fire-risk behaviors feel private; there is a lack of visible descriptive norms around the actions being taken by others. Furthermore, a lack of feedback on personal behavior leads to relatively low attention to improving home safety.

***Intervention idea:*** At the beginning of the summer, cities would mail out annual "fire protector" maps with color-coded dots to indicate the level of home fire risk (e.g. green-shaded dots on houses that have taken fire risk reduction actions and pose low risk and red-shaded dots on those that have not taken action and pose high risk). Maps would include language asking "Are you being a good neighbor?" Residents who take fire risk reduction actions during the following month would then receive yard signs showcasing their behavior with a simple message like, "We are a fire-free family."

***Behavioral science contribution:*** This intervention would surface norms around a positive hard-to-discern behavior to make it salient and observable to others—a key driver of prosocial behavior.[49] Through social comparisons, it would emphasize good behavior and create a norm to prepare for wildfire. The yard signs would provide social recognition for this prosocial behavior[50]and provide reminders to comply with the norm.

## Evacuation Group

***Barrier to action:*** During evacuation, residents may be overwhelmed by several decisions that must be made in the moment: what items to bring, which escape route to use, and where to go.[51] Moreover, elderly residents, residents with disabilities, low income residents, and residents without vehicles in remote rural communities may lack the ability or means to evacuate effectively.[52]

***Intervention idea:*** Actively connect vulnerable residents to "evac groups" composed of neighboring households. Evac groups would designate a shared vehicle to be stocked with an evacuation kit, meet at a rendezvous point, and leave together to a predetermined safe location. Residents could sign up for a group when applying for state assistance programs such as CalFresh or California Head Start, as well as when applying for city permits, or at clubs and community events. All residents who join evac groups would receive prizes or discounts on city services.

***Behavioral science contribution:*** In addition to providing a safe means of evacuation and reducing traffic congestion during emergencies, this strategy creates defaults of who to leave with, what to take, and where to go. It also counters people's tendency to insufficiently plan ahead, even for critical moments like evacuations. Finally, it leverages social accountability as residents are accountable to and for other members of their evac groups, encouraging timely action and support for vulnerable members.

## Community Fire Drills

***Barrier to action:*** When the threat of wildfire isn't salient, people don't make plans for protecting their houses or evacuating.[53] If people have never experienced the threat of a wildfire, they may think of it in abstract and impersonal terms, making it difficult to prepare and act.

***Intervention idea:*** City officials would give community members lottery tickets for a prize. On a predetermined day, households would be asked to practice evacuation from their homes. Community firefighters would then visit houses to check whether people evacuated. If a person is found inside their home, they would lose their tickets. People could also lose

tickets for high risk factors (e.g. overhanging tree branches). Firefighters would leave a brief audit note, highlighting the risks to the house in the case of an actual fire and indicate protective steps to take after the simulation.

***Behavioral science contribution:*** The Community Fire Drill frames fire evacuation drills as positive, community events while making the risk of fire salient enough to trigger plan-making and practice. The game uses trusted messengers—firefighters—to clearly convey risk and encourage responsive action. The lottery tickets would counteract low attention and increase participation by creating a competition.

## Other Possible Interventions:

- Require disclosure on home and lot real estate listings regarding high insurance premiums due to fire risk to discourage home building in WUIs.
- Send K-12 students home with reminders for families to prepare fire evacuation kits and plans on the first day of school. Organize demonstrations of key items to include in the kit at school.
- Send firefighters to distribute short implementation guides that highlight the high potential cost of taking no protective action. Encourage people to make a commitment to act, and include brief advice for safely evacuating and measures for protecting homes.

# South Asia Cyclones

***South Asia experiences one of the world's highest incidences of devastating natural disasters.*[54] *Climate change will heat the Indian Ocean's surface, whereby increasing the frequency and intensity of cyclones and the devastation they cause.*[55] *In a region with large vulnerable populations, this trend could displace millions of people. However, both India and Bangladesh have developed highly successful cyclone shelter programs to protect large populations during severe storms.***

A 1999 super cyclone centered on the eastern Indian state of Odisha killed over 10,000 people and caused extensive damage. To prevent such a tragedy from reoccurring, Odisha officials built a system of 450 cyclone shelters. In May 2019, Cyclone Fani tested and proved the value of this program.[56,57] As Fani headed toward 28 million people with 127 mile-per-hour winds, officials in Odisha evacuated over a million people from over 15,000 villages and towns into shelters, warning them of the imminent danger via millions of text messages, thousands of volunteers and emergency workers, public announcements, and buses.[58,59,60] In total, 64 people died in Odisha and Bangladesh—a drastic difference from the 10,000 deaths that occurred 20 years before.[61] Behavioral designs can contribute to the success of cyclone shelter programs, particularly in areas with newly constructed shelters that have weaker social norms about evacuation. Vulnerable populations face a range of serious barriers to evacuation, such as the need to harvest the crops they depend on in short time periods and property theft. The interventions below focus on overcoming a subset of barriers to encourage people to evacuate to shelters in a timely manner. However, they should be paired to comprehensive measures sensitive to the needs of the most vulnerable populations.

## Behaviorally Designed Approaches

***Refer to Figure A on page 9 for explanations of these behavioral barriers and design tools.***

| Intervention Idea | Focus Population | Barrier | Design Tool | Partner & Channel |
|---|---|---|---|---|
| **Shelter assignments:** Assign residents a default shelter to which they would evacuate in case of an emergency. Run evacuation drills and provide clear instructions, options and expectations. | Residents in coastal, cyclone-prone cities | • Psychological distance | • Planning prompts<br>• Defaults | South Asian state and municipal government officials; National and state response teams; Red Cross |
| **Share the risk:** Create and share videos featuring survivors of past cyclones who emphasize the need to evacuate well in advance, and show the aftermath of storms. | Residents in the path of a cyclone uncertain about the need to evacuate | • Invisible behaviors<br>• Psychological distance | • Social norms<br>• Prospection prompts | South Asian state and municipal government officials |

## Shelter Assignments

***Barrier to action:*** People know they should go to a shelter during evacuations. What may be less clear is the locations of shelters and the key steps for a successful evacuation. When a cyclone evacuation is ordered, people may not have time or cognitive bandwidth to review their options and choose the best one.

***Intervention idea:*** Municipal officials could provide people with default assignments to one shelter and evacuation bus time. Evacuation drills would allow people to rehearse the necessary steps and and allow them to switch to another shelter if they prefer. City officials would also send SMS texts to all citizens listing shelter options when a cyclone is approaching, regardless of their participation in the drill.

***Behavioral science contribution:*** Designating a default shelter could help people avoid inaction during emergencies by simplifying the choices they have to make. This is particularly important during moments when people's attention is already compromised—such as during moments of high stress and danger. The dry run allows people to practice evacuation during a low-stress moment. Furthermore, the SMS acts as a timely reminder to encourage evacuation during the appropriate window of time.

## Share the Risk

***Barrier to action:*** The moments where people must make the decision and take the action to evacuate happen before there is a visible threat, making the need to evacuate uncertain. In addition, if people have not experienced recent cyclones to benchmark the danger against, they may prefer the uncertain danger of staying home rather than the certain hassles of evacuating.

***Intervention idea:*** State and municipal government officials could create videos that feature people who experienced similar cyclones in the past and highlight the aftermath of previous storms. Video subjects could discuss both how the actual storm proved much more devastating than they initially thought and the need to evacuate in advance (e.g. "We thought the cyclone wouldn't be that bad, but it was much worse than expected. Our entire house was destroyed. I'm thankful that my friends and family encouraged me to join them in a shelter. Even though the winds may not seem that bad, I now know that the weather service can see many things that I can't. I can trust them more than I can trust my own eyes.") The videos would also show the aftermath of the cyclone.

***Behavioral science contribution:*** This video could help make the threat of the disaster more salient through a narrative frame showing clear examples. Furthermore, people are often most concerned about natural disasters in their aftermath, but their concern (and adaptive responses) fade over time as the memory becomes less recent. The video could both resurface the threat and make evident what someone has to lose by not evacuating.

# Impact Area Study
# Disease

## Climate Change and Disease

Climate change already impacts the health of people across the planet, and the scale of the problem is predicted to increase. By 2030, climate change will conservatively lead to an additional 250,000 to 529,000 deaths every year through the spread of malaria, diarrheal disease, heat illness, and malnutrition alone, and it will create an additional $2-4 billion in annual health-related costs.[62,63]

Hotter weather, higher humidity, and lengthened transmission seasons will contribute to increased ranges and altered patterns of animal vectors, such as ticks, snails, and mosquitoes.[64] This will, in turn, contribute to the spread of diseases including dengue, Zika, malaria, and Lyme disease. Warmer winters have already allowed ticks to expand their range across the U.S., Europe, Africa, and Asia.[65,66] ***In the U.S. alone, the number of Lyme disease cases has tripled since the late 1990s,***[67] ***and in increasingly hot and humid areas, an additional one billion people could contract mosquito-borne diseases in the next 100 years.***[68]

Higher heat and humidity will also cause more cases of heat illness, respiratory disease due to lower air quality, and malnutrition due to crop failure. The spread of waterborne diseases is expected to increase due to heat, flooding, and other disasters.[69,70] Shifting seasons may lead to more allergies,[71] and warming temperatures could even reanimate long-frozen pathogens in Arctic regions.[72] Infants, the elderly, pregnant women, and low-income populations will face particularly heightened health risks, deepening existing inequalities.[73] Public health professionals need long-term, systematic approaches for addressing these growing threats.

## Why Behavioral Science?

Barriers to adaptation include political and social challenges, such as coordinating proactive responses to emerging health threats among often-discordant stakeholders and providing health services in politically unstable areas.[74] Behavioral interventions in the health space offer the prospect of working in tandem with policies and programs to tackle these barriers, providing powerful, cost-effective aids for improving existing supports and designing new ones.

The public health space has a substantial and growing track record of using behavioral interventions to influence both provider and patient behavior in a variety of settings, including those directly relevant to adaptation.[75,76,77] Many successful programs can be tailored to new contexts as health threats spread and intensify due to the effects of climate change, with the caveat that climate change may compound existing challenges of uncertainty and risk misperception.[78]

The geographic expansion of vector-borne and heat-related disease ranges may raise additional behavioral obstacles to effective adaptation. Health officials and providers may, understandably, focus on immediate outbreaks at the expense of preparing for increasingly dire threats in the future.[79,80,81,82] In addition, ingrained treatment and prescription habits and mental models of which diseases exist in certain areas may inhibit appropriate provider responses.

### » Using behavioral science to diagnose malaria[83]

***Intervention:*** A data-based accountability program to encourage providers to reflect on their performance and solve problems in groups; sequencing malaria testing before clients' consultations with providers (instead of post-consultation); patient assessment consultation tools to encourage providers to consider illnesses besides malaria; and client-and provider-facing communications materials to address misconceptions and increase trust in test results.

***Focus population:*** Health care providers in Nigeria

***Barrier:*** Providers tend to treat most fevers as malaria without giving due consideration to the appropriate diagnostic tests, which leads to the unnecessary overprescription of anti-malarial medication.

***Design tools:*** These interventions employ several behavioral design tools to help providers make more informed decisions. The accountability program creates reference points and reflection opportunities for providers to compare their actual performance to their ideal performance. Testing before consultation changes the default so providers no longer have to make the decision, and frees up patient and provider time. Consultation tools and communication materials reduce ambiguity and correct misperceptions.

***Partner:*** Johns Hopkins Center for Communication Programs and the Breakthrough ACTION consortium

***Relevance:*** As diseases spread to geographies where they were not found previously, stakeholders at all levels—from ministries of health, to providers, to patients—will have to respond. There is often a tendency to focus behavior change interventions on patients, but this example illustrates the importance of focusing on upstream decision-makers as well.

# U.S. Heat Illness

***Heat illness presents a serious concern for U.S agricultural laborers who work long, strenuous hours in hot, humid conditions.***[84] ***Heat stroke, the most acute manifestation of heat illness, kills agricultural laborers at a rate 20 times greater than the average worker.***[85] ***From 1992 to 2016, 69,000 workers suffered severe heat injuries and 783 died.***[86] ***However, due to the marginalized nature of the agricultural workforce, official statistics likely significantly underreport heat deaths. As climate change pushes up the heat index in the U.S., heat illness morbidity and mortality will increase unless effective countermeasures are taken.***[87] ***Relatively small shifts in average temperatures can result in dramatic increases in the number of severe heat illness cases and deaths.***[88]

Higher temperatures will also bring new health challenges for agricultural laborers. A silent killer—chronic kidney disease of unknown origin (CKDu)—has claimed the lives of over 20,000 sugar cane workers over the last decade in Nicaragua alone.[89,90] CKDu is believed to be caused by repeated exposure to heat in strenuous working conditions. These conditions lead to repeated acute kidney injury (AKI).[91] In a sample of U.S. agricultural workers, 33% of those tested had signs of AKI, a potential precursor of CKDu.[92]

Both morbidity and mortality associated with heat illness and acute kidney injury are easily preventable if workers have adequate rest, shade, and hydration. While the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) in the U.S. promote these preventive behaviors, they do not set limits for working in the heat or mandated shade and cooling breaks above certain temperatures.[93] Only California and Washington have implemented state-level standards.[94,95] Pay structures also exacerbate the problem; agricultural laborers often receive piece rate pay based on the amount of produce they harvest, disincentivizing rest and water breaks.[96] Eventually, improvements in automation technology and increasingly dangerous heat conditions may lead to the technological replacement of many workers. However, protecting workers' welfare both before and during the turbulence of this transition pose critical adaptation tests.

In the short-to-medium term, there are also behavioral factors to consider. Insofar as workers have protective habits and knowledge today, they must continue to update those habits—ideally proactively—as the weather gets hotter. Habits are notoriously difficult to change, and aversion to lost productivity in the short term may cause workers and employers alike to jeopardize worker safety. It will also be increasingly important for supervisors, crew-leaders, and workers to quickly identify and treat early symptoms of heat illness and take the appropriate measures to prevent further progression to severe heat illness (i.e. heat stroke).[97,98]

Further, training that is too abstract, or that does not help workers anticipate and plan for their physical and cognitive state during an emergency, may not succeed in preparing them to take action when it matters most.

## Behaviorally Designed Approaches

***Refer to Figure A on page 9 for explanations of these behavioral barriers and design tools.***

| Intervention Idea | Focus Population | Barrier | Design Tool | Partner & Channel |
|---|---|---|---|---|
| **Heat-reactive bottles:** Provide bottles/cards made from heat sensitive material and connect changes in their color to responsive action | Agricultural workers and field supervisors | • Scarce cognitive bandwidth<br>• Weber-Fechner law<br>• Misleading mental models | • Timely reminders<br>• Rules of thumb | Agricultural employers; labor union; agricultural/ labor nonprofits; state-level OSHA agencies |
| **Supervisor incentives:** Distribute lottery tickets to supervisors for bonuses that are taken away if their workers do not take sufficient protective actions | Supervisors of agricultural workers | • Present bias | • Lottery incentives | Agricultural employers |
| **Buddy system:** Pair new workers with mentors to instill good habits and safety information | New agricultural laborers | • Invisible behavior | • Social norms and feedback<br>• Rules of thumb | Agricultural employers; labor unions; agricultural/labor nonprofits |

Structural and policy changes are critical to addressing many of the above-mentioned risks. In particular, mandated and enforced limits on work in dangerously hot conditions; restrictions on piece rate pay; and requiring water, shade, and bathroom facilities to be kept within a set distance to workers could prove essential to protecting worker safety and productivity.[99,100] Behavioral design tools can both improve these structures from the ground up and strengthen existing safeguards in contexts where employers already seek to protect worker health.

## Heat-Reactive Bottles

***Barrier to action:*** Workers and supervisors do not have clear guidelines regarding how many breaks to take and how much fluid to drink under variable heat conditions. Subsequently, they may not notice and/or attend to temperature increases that require robust responses.[101,102]

***Intervention idea:*** Provide employers, supervisors, and workers with visible reminder cards or water bottles made from heat-sensitive material that change color under different temperature conditions. The reminder card or bottle would include a color key with simple-to-follow instructions (e.g. pink means taking a break every hour and blue means a break every two hours). They would also include simple rules of thumb for identifying and treating heat illness and could also direct people to the OSHA-NIOSH heat safety app.[103]

***Behavioral science contribution:*** The reminder cards and bottles serve as both physical environmental cues and decision aids by translating a range of ambient temperature into a set of colors that correspond to simple rules of thumb. The color change provides accurate timely reminders to enable the workers to take action at key moments when the temperature rises to dangerous thresholds. Finally, the color change may also overcome barriers explained by the Weber-Fechner law. In this case, since the weather is already hot, people may not perceive small but dangerous increases in temperature.

## Supervisor Incentives

***Barrier to action:*** Supervisors don't encourage breaks or hydration because there is no near-term incentive to do so. Present bias makes it such that short-term costs (reduced immediate productivity) is weighed more heavily than long-term benefits (health of workers and increased long-term productivity).

***Intervention idea:*** Give supervisors lottery tickets for a bonus payment and take them away if their workers do not complete a set of protective actions. Supervisors would need to feel supervised themselves to encourage honest reporting, which could be done through random checks and/or anonymous worker polling.

***Behavioral science contribution:*** Lottery incentives cost effectively increase peoples' motivation to complete behaviors as we tend to overestimate the odds of low-probability events. This design also uses the endowment effect—giving supervisors lottery tickets that can be taken away—to strengthen the impact of the lottery.

## Buddy System

***Barrier to action:*** Workers, especially new ones (the most susceptible group to heat illness), may not take enough breaks or drink water due to uncertainty about how best to protect themselves and social norms around toughness and working hard.[104,105,106]

***Intervention idea:*** Create buddy systems where workers monitor each others' health and set norms around safe work. New workers could be paired with a mentor for the first few weeks to guide safe habits. Mentors would be paid a slight bonus, and to become a mentor, workers should demonstrate that they take a certain percentage of suggested breaks and document doing so for several weeks. Mentors would also be trained to share rules of thumb on the risks of CKDu and identifying and treating heat illness.

***Behavioral science contribution:*** Through example and teaching, the mentors can instill positive descriptive norms while also holding the new workers accountable to safe practices and teaching them simple rules of thumb for protecting themselves. Meeting the requirements to become a mentor would also positively influence their behavior through incentives and goal setting.

# East Africa Malaria

> ***Malaria remains one of the world's most intractable public health issues. Though the malaria burden has significantly decreased over the last decade, every year, more than 200 million new cases of malaria continue to be reported; nearly 90% of these are in sub-Saharan Africa.***[107]

Malaria is transmitted by the female Anopheles mosquito and is caused by five types of *Plasmodium* parasites, of which *Plasmodium falciparum* is the most common in sub-Saharan Africa. Since mosquitoes—along with many other vectors of disease—do not have internal systems for regulating temperature, their survival is limited by environmental temperatures.[108] ***As temperatures increase, not only are parasite-carrying mosquitoes able to survive in larger ranges, but they also bite people more frequently and reproduce more rapidly.*** Though there is still some debate around whether the increased incidence of malaria in the East African highlands is solely due to temperature, it is clear that temperature is and will continue to be a contributing factor, along with greater precipitation variability, increased drug resistance, and land use change.[109,110,111]

Malaria is endemic to many lowland regions where it remains a public health issue. However, a large proportion of the population has acquired natural semi-immunity to the disease, offering some protection.[112] In the highlands, populations are not routinely exposed to the parasite and thus have no acquired immunity. Highland populations are at greater risk, and merit particular attention in adaptation efforts, because they are neither immune nor familiar with the disease's symptoms, limiting their likelihood to seek effective care.[113] In addition to building appropriate capacity in terms of medical expertise and public health campaigns, health practitioners can use the tools of behavioral science to address this risk.[114,115]

## Behaviorally Designed Approaches

***Refer to Figure A on page 9 for explanations of these behavioral barriers and design tools.***

| Intervention Idea | Focus Population | Barrier | Design Tool | Partner & Channel |
|---|---|---|---|---|
| **Norm-setting radio show:** Record and broadcast a radio show incorporating best practices for malaria prevention | Rural highland communities in East Africa | • Invisible behaviors | • Social norms and feedback | Public radio stations |
| **Early warning signals:** Send tailored preparation messages to health workers in regions projected to experience malaria outbreaks | Health care workers in non-endemic areas | • Scarce cognitive bandwidth | • Timely reminders<br>• Rules of thumb | Health clinics; national and local health agencies |
| **Net distribution points:** Distribute mosquito nets in at high traffic points in rural highlands | Rural highland communities in East Africa | • Hassle factors | • Reduce hassles | Public health agencies and non-governmental entities; regional and local governments; private entities (e.g. soccer franchises); religious organizations |

## Norm-Setting Radio Show

***Barrier to action:*** In the highlands, where malaria is not endemic, people have limited familiarity with the disease: what causes it, how it spreads, how to prevent it, what its symptoms are, who is most vulnerable, and when to seek care.[116]

***Intervention idea:*** Write, produce, and air a publicly broadcasted radio soap opera about a town experiencing a malaria outbreak. The show might follow a family in a real town, using familiar landmarks, common customs, and the local dialect. It would clarify misconceptions about malaria (such as the inaccurate perception that it is transmissible from person to person) and demonstrate best practices around using mosquito nets, disposing of standing water, and seeking care within 24 hours after the first symptoms appear.

***Behavioral science contribution:*** The radio show would communicate norms about malaria-prevention behaviors. Usage of local slang and context-specific references in the show would increase the salience of the setting and allow people to visualize themselves in a similar situation. Similar radio- and TV-based interventions have seen success in the past; for example, a radio show in Mexico increased rejection of domestic violence[117] and a reality TV show in Kenya, *Shamba Chef*, incorporated cooking contests to showcase clean cookstoves and achieved widespread popularity.[118]

## Early Warning Signals

***Barrier to action:*** Health workers at rural clinics do not receive, communicate, and act on warnings about potential malaria outbreaks in ways that are timely and effective.[119] Information about a potential outbreak may not be salient due to limited attention and present bias, with providers focusing on immediate threats. Even if they do intend to prepare, they may not follow through.[120]

***Intervention idea:*** Send short SMS and/or voice messages to health care workers in non-endemic areas that are projected to experience a malaria outbreak within the next month. The messages would contain simple, easy-to-follow rules of thumb about malaria risks, outbreaks, and best practices to plan for and to treat possible cases. These messages can be tailored according to each country's national guidelines for the treatment of malaria. A prior intervention using daily SMS messages was highly successful in getting health care workers to better treat malaria in endemic areas.[121]

➤ ***Examples of SMS messages***

"Malaria risk in your region: if a patient comes in with a fever above 38.5°C, perform an RDT."[i]

"Child under 5 and with fever above 38.5°C and vomiting or chills: immediately treat with AL[ii] pills."

***Behavioral science contribution:*** Timely reminders and planning prompts can target health care providers at the appropriate times to maximize response to warnings, while providing them with information to motivate and help them prepare for the coming threat. Providing rules of thumb affords providers with actionable information for responding to an unfamiliar threat.

## Net distribution points

***Barrier to action:*** There are multiple hassle factors in the process of going to a distribution point to get a mosquito net. Even when nets are distributed for free, people must set aside time and figure out how to get to the locations.

***Intervention idea:*** Use events and places where communities regularly gather as distribution points, such as soccer matches, marketplaces, church sermons, and at community celebrations.

***Behavioral science contribution:*** Locating net distribution points at high congregation areas reduces hassles by allowing people to conveniently bundle activities together.

[i] Rapid diagnostic test; a fast, low-cost way of testing for presence of malaria parasites.

[ii] Artemether-lumefantrine; a common and effective malaria treatment drug.

Impact Area Study

# Agriculture

## Climate Change and Agriculture

Agricultural systems are intimately and intrinsically linked to climate systems. Throughout the globe, we are already seeing fundamental shifts in which crops are grown, where crops are grown, and how crops are grown. Climate change will continue to impact the way we produce food, feed, fuel, and fiber. These impacts will vary across geographies. Some areas, like the southeastern United States, southern Chile and Argentina, and West Africa are projected to become hotter and drier, while other areas, like western Canada and parts of East Africa, will likely experience more rainfall.[122] Many high-latitude areas will benefit from warming temperatures with longer growing seasons and the ability to grow food in areas previously too cold, but tropical and subtropical areas are projected to experience massive losses in yields, as increased daytime and nighttime temperatures preclude healthy crop growth, especially for major cereals such as maize, rice, and wheat.[123] More important than these directional changes, and harder to predict and quantify, are the increased inter- and intra-seasonal oscillations in weather patterns and the increase in both the frequency and magnitude of extreme events like droughts, floods, hurricanes, heat waves, freezes, and wildfires.[124]

The good news is that farmers are already familiar with adjusting practices to the local climate. Farmers must constantly plan, change, improvise, and react in response to conditions around them. Some farmers put it this way: "You use the term adaptation, we use the term management decisions. It's all the same thing."[125] However, while farmers may be adept at reactively managing

responses to weather events, what is exponentially more difficult is managing for variability as the climate oscillates in increasingly unpredictable ways, and building resilience to withstand these shocks and oscillations. ***This variability demands preparation that goes beyond adjusting to the effects of climate change that are already underway and are directionally predicted to happen again in the near future.*** A climate-smart agriculture approach focuses not only on reactively responding to changes, but on proactively building resilient systems that regenerate after climate events which equitably ensure food security, and that reduce or remove greenhouse gas emissions.[126] Behavioral science is well-positioned to address these challenges and accelerate the adoption of climate-smart agricultural practices.

## Why Behavioral Science?

Successful adaptation requires the ability to plan and act despite uncertainty about future conditions. Many climate-smart agriculture practices incur a high upfront cost—whether directly through time and money, or indirectly through yield—such as purchasing new equipment or technology, installing new infrastructure, or switching to a new growing regime. These upfront costs impose both a financial burden and a psychological burden; losses in the short-term loom greater than future benefits, even if those benefits will ultimately far outweigh the immediate costs.

Farmers must make decisions far in advance of knowing the exact conditions under which they will later operate. Because growing plants takes time, feedback cycles are long; it takes months or years before farmers are able to see the effects, whether positive or negative, of changes they have implemented. And even when the effects are visible, it is difficult to attribute these effects to earlier individual actions, as farming is a system with many inputs and many sources of feedback. Behavioral science can help design policies, programs, and products that explicitly address these behavioral barriers.

Here, while we focus primarily on farmers as end users and target actors, we recognize that no agricultural decision is made in a vacuum. Successful adaptation will require the coordination and cooperation of multiple stakeholder groups, ranging from policymakers at the state and national levels to agricultural extension to private-sector consultants. The case studies below take a look at two very different agricultural contexts—the U.S. Midwest and the African Sahel—where, in both cases, farmers must plan and make decisions under uncertainty. We explore innovative ways to build a "climate resilience toolbox,"[127] integrating different types of resources: natural, human, social, physical, and financial. The designs we suggest go beyond simple nudges, and many of them address decisions that are structural, contextual, occasional, political, or expert-driven.

## Using behavioral science to reduce post-harvest loss[128]

***Proposed intervention:*** Provide flexible financing and coupons to Tanzanian farmers to purchase pest-resistant bags at optimal moments

***Focus population:*** Smallholder maize farmers in Tanzania

***Barrier:*** In Tanzania, 20-40% of farmers' maize harvest is lost every year, in part due to spoilage from inadequate storage. Despite this loss, few farmers purchase and use sturdier, multi-layer storage bags, opting instead for single-layer plastic sacks. We identified farmers' cyclical flow of income and expenses as a key barrier contributing to these low rates of adoption. Farmers have the most liquid financial resources after selling their crops at the end of the harvest season, and they are most financially strapped at the beginning of planting season. However, there is a misalignment of timing between the period that farmers have the most capital (after harvest) and when they typically purchase storage bags (before harvest). This misalignment of capital means that the prospect of purchasing the slightly more expensive but higher-quality storage bags all at once—in the present—"hurts" quite a bit, while the future benefits of these bags are discounted.

***Design Tools:*** While we didn't implement and test an intervention in this context, we suggested behaviorally designed interventions to address these barriers. Farmers could choose to divert some of their profits at the end of the harvest (when capital is plentiful) toward coupons redeemable for high-quality bags at the beginning of harvest the following year (when capital is scarce). These bags might also be included in bundles of supplies (including seeds, fertilizer, and tools) that farmers already receive on credit through certain programs at the beginning of the season.

***Partners:*** YieldWise initiative team at the Rockefeller Foundation and local farmer associations

***Relevance:*** This project illustrates the importance of designing agricultural products and programs that are tailored to the specific contexts of farmers.

## Using behavioral science to create heuristics for microentrepreneurs[129]

***Intervention:*** Deliver short, simple financial and business management heuristics to microentrepreneurs

***Focus population:*** Microentrepreneurs in the Dominican Republic, the Philippines, and India

***Barrier:*** Traditional financial education programs all over the world attempt to help microentrepreneurs navigate the complexities of running a small business by providing in-depth training on accounting and money management. But despite their prevalence, these programs have been shown to have very little effect on improving financial management. Physically attending trainings can incur costs in time and money, and it is overwhelming for participants to have to distill and adapt an abundance of complex information into actionable steps for their own businesses.

***Design Tools:*** With these barriers in mind, we distilled best financial practices into short, simple rules of thumb (also known as heuristics) and designed a mobile-based training program. Microentrepreneurs received these heuristics on a weekly basis via mobile phones. As a result of these messages, we found a statistically significant uptake of a few key best management practices, such as physically separating household cash and business cash, collecting customer information for those who purchased goods on credit, and checking competitors' pricing.

***Partners:*** The Institute for Financial Management and Research (IFMR); Janalakshmi, a large Indian microfinance institution; and Negros Women for Tomorrow Foundation (NWTF) in the Philippines

***Relevance:*** Like financial education programs, agricultural workshops and trainings provide important information but can be excessivley detailed. We can use the power of heuristics to boil down key takeaways into rules of thumb that are more easily remembered and easily implemented.

# U.S. Midwest Agriculture

***Agriculture dominates the Midwest region of the United States. More than two thirds of the region is farmland,[130] of which 85% is corn and soybeans.[131] An increase in average temperatures over the last several decades has lengthened the growing season in this area and opened up the possibility for farmers to plant new varieties. But simultaneously, climate change is contributing to a greater frequency of anomalous weather events—floods, droughts, early frosts, and cold springtime air—that threaten the resilience of Midwestern agriculture.[132]***

The contiguous U.S. experienced its wettest 12-month period on record from May 2018 to April 2019, leading to extensive flooding. For the first time on record, corn planting in the Midwest did not reach its halfway mark by May 19th—a key mid-spring moment by which planting should be well under way. The later crops are planted, the less time they have to mature before the first killing frost in the fall. The flooding even inspired the hashtag #NoPlant19, where farmers commiserated on social media by sharing pictures and videos of inundated, unplanted fields and relentless rain.

Farmers in the Midwest and across the country are increasingly adopting conservation agriculture practices, or practices that minimize soil disruption while building soil structure and biodiversity. These include minimizing tilling and planting cover crops. The rate of adoption is encouraging: from 2012 to 2017, there was a 50% increase in acreage planted with cover crops nationwide, and six of the top 10 states with the greatest gains were Midwestern states.[133] Many of these adaptive practices have the added bonus that they work to mitigate emissions as well. While this progress is promising, accelerating the adoption of these best practices is important to support both farmers and the food supply. Below, we describe three behaviorally informed ideas for encouraging adoption of adaptive practices among cereal farmers in the Midwest.

## Behaviorally Designed Approaches

***Refer to Figure A on page 9 for explanations of these behavioral barriers and design tools.***

| Intervention Idea | Focus Population | Barrier | Design Tool | Partner & Channel |
|---|---|---|---|---|
| **Post-disaster plan-making**: After flood events, support severely and mildly affected farmers to develop implementation plans for resilience measures | Farm owner/ operators in the Midwest affected by and in the vicinity of an extreme weather event | • Psychological distance | • Planning prompts | Extension agents; crop consultants |
| **Resilient Farmers, Resilient Farms:** Have farmers make public commitments to adopt climate smart practices; display commitments via signs in front of farms and at state/county fairs | Farm owner/ operators in the Midwest | • Invisible behavior<br>• Psychological distance | • Social norms and feedback<br>• Planning prompts | Extension agents; land-grant universities |
| **Bundled purchases:** Offer discounts for bundles of climate smart products and services | Farm owner/ operators in the Midwest | • Present bias | • Reduce hassles<br>• Weber-Fechner Law | Seed, fertilizer, and irrigation companies; insurance companies; banks and other credit-providing institutions |

## Post-Disaster Plan-Making

***Barrier to action:*** Even if farmers have an intention of implementing an adaptive practice, there may be no salient moment of action to do so.

***Intervention idea:*** After extreme flooding events, extension and private sector farmer advisors and consultants will contact and set up meetings with farmers within the most affected areas as well as those within a 50-mile radius of these areas. During these meetings, farmers and advisors will develop three-year implementation plans for adaptive practices, such as planting strips of native perennial grasses along gulleys or planting cover crops over the winter to improve soil retention during floods.

***Behavioral science contribution:*** After vivid disaster events, people are more likely to recognize a personal risk. This design capitalizes on the momentum created by an event and uses plan-making, an effective tool to help people commit to decisions after the moment of making the decision has passed. Since the provision of public goods following a disaster is highly biased according to the salience of the event,[134] we suggest targeting farmers in lower-salience areas in addition to farmers who were most affected by the event.

## Resilient Farmers, Resilient Farms

***Barrier to action:*** Implementing adaptive behaviors is largely invisible; farmers have no visibility into what other farmers are doing. Furthermore, even if farmers intend to change a practice, there is little social or personal accountability to do so.

***Intervention idea:*** Through a campaign called "Resilient Farmers, Resilient Farms," encourage farmers to make public commitments to implement climate-smart practices such as reduced tillage or cover cropping. Existing social media hashtags like #NoTillNovember, #KeepTheStubble, and #DontFarmNaked would help to share a website where farmers could fill out a short form describing their commitment and making an implementation plan. They would then be mailed yard signs with the commitments to place on the road at the entrance of their farms. At county and state fairs, farmers who have taken the commitment would also be identified through a sign, banner, or ribbon.

***Behavioral science contribution:*** Publicly stating a commitment increases follow-through on that commitment,[135,136] especially if the commitment involves a visible marker (like a pin, sign, or sticker). This intervention makes visible what would otherwise be a private, invisible behavior, and thus serves to provide descriptive feedback on social norms.

## Bundled Purchases

***Barrier to action:*** Upfront costs hurt, and it can be especially difficult to pay an upfront cost for equipment, products, or services to reap benefits that will not be realized until far in the future—as is the case for many long-term adaptive agricultural practices.

***Intervention idea:*** Partner with companies to offer bundled purchases of products or services that increase agricultural resilience. These partnerships might be with seed companies to incentivize trial rows of a new, more resilient seed; with irrigation companies to encourage more efficient irrigation methods; or with banks to incentivize resiliency-building property upgrades along with the purchase or loan that the farmer is already planning to acquire. Embed resilience advisors in these companies to perform assessments. After the purchase or contract, set up periodic text- or phone-based reminders to create accountability for the implementation.

***Behavioral science contribution:*** This intervention takes advantage of the Weber-Fechner law. Applied here, if farmers are already intending to make a big purchase—such as a new seeder, or fertilizer for the season—the additional cost of a batch of a new variety of seed or a consultation for a more efficient irrigation system is perceived as proportionally less expensive than it would be perceived if it were purchased on its own.

# Sahel Agriculture

***The Sahel region of Africa is a transitional zone, located south of the Sahara and north of the lusher savannas and rainforests of central Africa. It stretches east to west across the continent and includes regions of Senegal, Mauritania, Mali, Burkina Faso, Niger, Nigeria, Chad, Sudan, and Eritrea. The Sahel is predicted to be one of the regions hardest hit by climate change, with higher projected temperatures, increased variability in rainfall, and more frequent droughts.***

***Over 50% of the population is employed in the agricultural sector,***[137] ***which relies heavily on rain.***[138] These vulnerabilities are further compounded by a growing population and significant political and economic instability. The following ideas integrate insights from behavioral science with the aim of facilitating the adoption of climate-smart agriculture practices among subsistence farmers in the Sahel. It's critical to note that, in any location where many people live near or below global poverty benchmarks, it would be irresponsible, ineffective, and immoral to place the financial and cognitive burden of adaptation on individuals and households. Upstream decision-makers, including governments, development banks, and NGOs, must address the structural barriers facing subsistence farmers in the Sahel and worldwide if global food systems are to endure climate change. Once farmers have access to money and equipment, their resourcefulness is striking—especially women farmers, whose adaptations to volatile conditions increasingly form the bulwark against climate change in agricultural communities.[139]

## Behaviorally Designed Approaches

***Refer to Figure A on page 9 for explanations of these behavioral barriers and design tools.***

| Intervention Idea | Focus Population | Barrier | Design Tool | Partner & Channel |
|---|---|---|---|---|
| **Agricultural heuristics:** Provide short, simple rules of thumb for farmers to aid in implementing new adaptive practices | Smallholder farmers in the Sahel | • Scarce cognitive bandwidth | • Rules of thumb | Extension agents; cooperative leaders; producer groups |
| **Noticing in pilot plots:** Provide support to farmers to plant pilot rows of crops using novel practices | Smallholder farmers in the Sahel | • Status quo bias<br>• Scarce cognitive bandwidth | • Demonstration<br>• Rules of thumb | Extension agents; cooperative leaders; producer groups |

## Agricultural Heuristics

***Barrier to action:*** Agricultural workshops and trainings provide important information but can be unnecessarily complex. Heuristics, or rules of thumb, simplify this information into actionable, easy-to-use shortcuts to help farmers implement adaptive practices in rapidly changing climate regimes.

***Intervention idea:*** Provide training for extension agents, cooperative leaders, and producer groups in teaching simple, easy-to-use rules of thumb, or heuristics. These heuristics can be communicated either in-person during workshops, trainings, and farmer field schools or via mobile-based voice messages and timed to correspond with planting and harvest cycles.

➤ ***Examples of heuristics for climate-smart practices***

| | | |
|---|---|---|
| **Digging zai pits:** Plant each seed in a circular pit that's as deep as your wrist to the top of your fingers, and as wide as your elbow to the top of your fingers. | **Nutrient deficiency:** If leaves on sorghum and corn plants are pale or yellow, sprinkle 800g of chicken manure fertilizer per 100m row. | ***Stone bunds for water management:*** Build stone bunds 20 paces apart for very steep land, and 40 paces apart for slightly sloped land. |

***Behavioral science contribution:*** Behavioral science tells us that people are more likely to understand and recall information when it is presented in simple, digestible chunks.[140] Where traditional extension education and training efforts focus on providing *more* information, we know that having a lot of secondary background information surrounding key information can obscure the message, making it less likely that the information will be remembered and applied.

## Noticing in Pilot Plots

***Barrier to action:*** While pilot plots, or small test areas, are a promising tool to overcome status quo bias and demonstrate novel techniques, farmers may not necessarily attend to key factors that are not salient but still important when implementing these new practices.[141] This inattention can lead to ineffective learning of new techniques. It can also lead to the initial adoption but later abandonment of new practices.

***Intervention idea:*** During farmer field schools and extension workshops, provide farmers with summary tools that clearly lay out results from the pilot plots, broken down by variable (such as type of fertilizer, type of seed, distance between plants, distance between rows, amount and frequency of fertilizer application, etc).

***Behavioral science contribution:*** Here, farmers' attention is explicitly directed to notice factors that may have otherwise been overlooked. Since people only have so much cognitive bandwidth and a limited ability to attend to everything that's going on, they tend to only attend to the most salient factors (such as a new type of seed) and disregard other variables that may be as equally important (such as the spacing of rows to maximize moisture retention). Therefore, they may overestimate the importance of the salient factors and underestimate the importance of the less salient factors.

# BEYOND NUDGES: SCOPE DECISIONS

Climate change affects, or will soon affect, nearly every aspect of human life. Many towns and cities are becoming more dangerous places to live as extreme weather events increase in frequency and severity. Plant and animal life cycles and the complex, interconnected web of ecosystems are changing, exposing people to new diseases and keystone species to new predators and competitors. Customary agricultural practices and crops face decreasing yields or total failure as rainfall patterns change and aquifers are depleted—just to name a few of the many changing risks we face.

Adaptation behaviors include those that reduce the negative risks associated with these changes, as well as those that take advantage of warming-related opportunities. They can include behaviors for times of emergency, such as evacuations from fires and floods, as well as behaviors planned and executed over months and years, like new land management regimes. Individuals, households, and small enterprises will face adaptation decisions, as will large corporations, cities, and countries.

So which, among these many behaviors, are candidates for a behavioral designer's attention? In short, all of them. Behavioral design is sometimes understood to be the province of quick, cheap, incremental, and easily measurable improvements, or so-called "nudges"—think text message reminders and planning prompts. Nudges very likely have a place in accelerating climate adaptation, as some of the case studies above demonstrate. ***But many adaptation decisions will defy the model of the nudge—they will take considerable resources to execute, must be conducted hand-in-hand with policy or structural changes, or will occur at too low a frequency to support most rigorous evaluation methods.*** Despite these departures from behavioral design norms, adaptation decisions are too important not to address with the best available behavioral science. We think of these nudge-resistant decisions as meeting some or all of the following overlapping criteria. From our perspective, all of these decision varieties are in ***SCOPE:***

1. **Structural**: Structural decisions have impacts orders of magnitude greater than those of private individuals or households, and they have a determining role in the choices available to other actors. An urban planner's decision of whether to include district heating in a block undergoing redevelopment would be considered structural.
2. **Contextual**: While most behavior change goals require some attention to contextual factors, some decisions may be so dependent on the specifics of the decision-maker's situation that a typical behavioral intervention could not confidently recommend a course of action, even directionally. How to optimally design a passively heated home on any specific building site is a contextual decision.
3. **Occasional**: Occasional decisions occur infrequently and have effects for a long time after they are made. The decision of a farmer to plant fruit or nut trees, or whether to plant a

drought-resistant variety of tree, is one example of an occasional decision. Unlike annual crops such as cotton or wheat, trees represent a long-term commitment: they require a minimum level of resources, especially water, if they are to survive to maturity and produce enough product to justify the investment, usually over several years or decades.

4. **Political**: Political decisions, as we define them, are made by or for groups of people with a common interest—usually, who live in the same place—about how to cooperate and use their pooled resources. Whether a community will move away from an area that is projected to sink below sea level or run out of potable water within a matter of decades is an example of a political decision.

5. **Expert**: Expert decisions are undertaken by stakeholders possessing technical, traditional, or local knowledge that others do not have. Experts may have made similar decisions in the past and likely process decisions related to their area of expertise differently from laypeople. Revising the zoning of a coastal area or wildland urban interface is one example of an expert decision.

While behaviors that fall within SCOPE decisions may be challenging to study, it is the duty of behavioral scientists, policymakers, and other influential stakeholders to consider how to facilitate their understanding and, ultimately, influence them in the direction of climate adaptation (and mitigation). This may require changing the incentive structures faced by researchers, the design criteria used by policymakers, the convening methods that facilitate community engagement and consensus-building, and more.[142]

## Three Principles for SCOPE Decisions

SCOPE decisions, more so than their more nudgeable counterparts, have ripple effects. The policies, structures, and design choices espoused by powerful actors will determine the choice sets available to everyone else. For that reason, it is particularly important that we attend to the potential for bias in SCOPE decisions.

Below, we list three principles that we suggest powerful decision-makers follow when considering how to adapt to climate change. We hope that these principles will serve as an impetus to a continuing conversation about the effect of power differentials on adaptation behaviors—and, ultimately, on all of us.

### 1 Think From the Future, Not the Present

Climate policy discourse is replete with comparisons and trade-offs. Which deserves more preferential funding: solar or wind power? Is climate change the fault of all of us, or only a hundred or so CEOs and politicians? Does "individual action" matter, or only "structural change?" And of course, should we still be trying to mitigate climate change at all, or should we accept it and focus entirely on adapting to its effects?

Each of these questions presents a false choice, and to accept their premise is to fall prey to a variant of ***single-action bias.*** Single-action bias is the human tendency to channel pro-environmental motivations into one symbolic action. It then feels acceptable to resume ordinary activities, even if the problem isn't fully addressed. Among individuals as well as powerful influencers like corporations, lobbies, and governments, single-action bias can result in a curious allegiance to a relatively small subset of mitigation and adaptation solutions and a substantial under-commitment of resources to addressing climate change, given the magnitude of risk it poses.

Single-action bias is an example of what we call "thinking from the present." Humans think from the present (also known as being present biased) in a variety of ways. We secure gains and avoid losses in the moment, notice the benefits of the status quo before its disadvantages, seek to protect our reputations by conforming to present-day norms, and conserve our attention moment-to-moment by sticking to habits—even when they have negative long-term consequences. The extent of our focus on the present is so great that it can be difficult to even perceive that bias, let alone challenge it. This is true even for SCOPE decision-makers hoping to address climate change, who may "think from the present" by choosing from a limited set of adaptation and mitigation actions that represent small increments of change from the status quo.

If thinking from the present inappropriately constrains our response to climate change, what is the alternative? The scientific community often thinks from the future by utilizing potential climate scenarios, or models that estimate how certain policy, economic, and climate conditions could affect key outcomes decades or centuries from now. Particularly popular and intuitive examples of scenarios include Pacala and Socolow's stabilization wedges[143] and Project Drawdown's ranked solutions.[144] Scenarios do not ignore present circumstances, but suggest plausible paths between the present and different futures, counterbalancing present-biased patterns of thought and allowing decision-makers to frame climate action decisions as choices between possible futures.

Scenarios have played a major role in guiding conversations about climate policy decisions, but they have significant drawbacks: they are expensive to produce, require experts to update, and are often intended to model average outcomes at a global scale, rather than the local scale at which many adaptation decisions must be made. ***When scenarios are not available, other, good-enough tools can be used to correct for present bias and help decision-makers think from the future.*** We describe some of these tools in the table below.

## **FIGURE B:** High-impact decision errors and corrective tools

| Error | Definition | Example | Example tool to correct |
|---|---|---|---|
| **Single-action bias** | People tend to perform just one symbolic action to resolve pro-environmental motivations. | Communities may complete only reactive or superficial actions to reduce fire risk, such as clearing brush in wooded areas, rather than undertaking a comprehensive set of actions, which may include clearing brush, hardening households, and improving evacuation routes. | **Reframe trade-offs:** Instead of accepting business-as-usual as the default option, accept total adaptation as the default option. Consider each adaptive action not completed as a loss. |
| **Sunk cost fallacy** | People continue to invest (money, time, or other resources) in an endeavor based on investments that have already been made and cannot be recouped (known as sunk costs), even if changing behavior would be more beneficial. | Cities and municipalities may continue investing in existing gray infrastructure rather than investing in new green infrastructure. | **Factor out costs:** Factor out the sunk costs that have already been invested while factoring in the future costs of *not* taking the adaptive action to arrive at a more accurate assessment of the cost of each option.<br><br>**Reframe:** Instead of viewing sunk costs as investments into a specific endeavor or project, frame them as investments into building an evidence base for different strategies or a series of steps to be evolved and built upon. |
| **Present bias** | People favor immediate rewards, and minimizing immediate costs, at the expense of long-term goals. | Coastal cities build pumps, raised roads, and other short-term immediate changes to address flood risk, instead of making more comprehensive improvements that have high upfront costs. | **Highlight the higher costs of inaction and make them personally salient:** Emphasize the higher future costs of *not* taking adaptive action as opposed to saving money through immediate action. Translate these costs into tangible impacts on individuals. |
| **Tunneling** | People focus on the most urgent or pressing unmet needs in situations of scarcity. | In the wake of fires, municipal leaders focus on quick recovery rather than building communities back resiliently to better withstand future fires. | **Set defaults and plan in advance:** Before disasters strike, municipalities can adopt codes and zoning to guide rebuilding efforts in the aftermath of a disaster, making resilient rebuilding the automatic path forward. |

| Error | Definition | Example | Example tool to correct |
|---|---|---|---|
| **Availability** | Situations or facts that people have most recently or frequently encountered come to mind first, so decisions and actions tend to address those situations or facts (and not others). | Adaptation-related aid is directed primarily toward areas that have recently experienced extreme events, even if the next event is more likely to occur somewhere else––for example, in a wildland area that has not recently burned, and therefore has a build-up of fuel that should be cleared to reduce risk. | **Proactive choice rules of thumb:** Set heuristics that distribute resources to areas of greatest need, not merely greatest salience. For example, for every dollar directed to recovery in a recently burned area, direct another dollar to proactive risk reduction in an area at risk of burning in the near future. |
| **Anchoring** | Decisions related to quantities are biased toward salient numbers. | Wealthy countries and companies commit to carbon neutrality by 2050—a benchmark associated with the Paris Agreement goal of limiting warming to two degrees Celsius—instead of a shorter decarbonization timeline that could plausibly lead to *global* carbon neutrality by 2050. | **Scale anchors up or down:** As a heuristic, consider that actors with 2x global average resources should pursue global goals 2x faster than average. |
| **Norm compliance** | Parties who hold uncommon views in private may publicly concur with views they perceive as common to achieve in-group consensus and/or avoid reputational risk. | The scientists who draft the IPCC Assessments report only the range of climate risks agreed upon by most members. They omit the long, upper tail of risk estimates, resulting in artificially deflated estimates and less urgent calls for action.[145] | **Use means:** If consensus estimates of risk resemble median or modal estimates, replace them with mean estimates. |
| **Tragedy of the commons** | Individuals using resources that affect collective outcomes, in the absence of management structures, may optimize short-term individual outcomes rather than long-term individual and collective outcomes. | City officials know that certain infrastructure changes will help improve resilience but hesitate to implement those changes because of vocal opposition from a subset of residents or stakeholders. | **Deliberate and discuss:** Group deliberation around civic issues can encourage stakeholders to hold less polarized opinions, more pro-community positions, and improve decision quality, compared to individual-level civic input.[146,147] |

## 2 Make Structural Decisions to Empower Downstream Decisions

Any person making a SCOPE decision undertakes a serious responsibility for many others: their choice will determine how difficult it is for individuals, households, and communities to adapt in the present and the future and can either ease or exacerbate the trade-offs along the way. We call these later decisions—those that follow and are influenced by SCOPE decisions, and that must be made by many different parties—downstream decisions.

Choices of such gravity must be approached with humility. The best SCOPE decisions will be made jointly with those they impact, with the goal of making it easy for downstream decision-makers to perceive, consider, and choose adaptive paths. ***Critically, this means that SCOPE decision-makers must take on the costs of adaptation themselves—whether in money, time, or cognitive resources—so that downstream decision-makers do not have to.*** Imposing these costs of adaptation on everyday actors virtually guarantees that adaptation will not occur, or will occur inequitably, and it represents a failure of upstream stakeholders in executing their responsibilities.

Consider, for example, the downstream decision of where to live. Residents weigh many factors when choosing a home, and distant, abstract climate-related risks do not likely figure among those factors. Even mechanisms that should make hazard risks salient, such as mandatory insurance costs, often fail to do so—or have opposite effects by subsidizing risky choices about where to live. For instance, the National Flood Insurance Program (NFIP) makes flood insurance widely available in the absence of a viable private market. However, though residents may purchase flood insurance, few take protective mitigative measures—such as elevating homes[148]—possibly due to a false sense of security created by having insurance.

Imagine an alternative: upstream stakeholders, recognizing that residents would struggle to prioritize adaptation in their decision-making, choose to make the adaptive path the easiest to follow. They revise the choice architecture encountered by downstream decision-makers to include new hazard disclosures on property listings, payment into relocation funds, or revised insurance programs. People can still choose to live in risky areas, and some do—but most choose a safer alternative.

This example also brings an enormous challenge of adaptation to the fore: climate justice. ***Transitioning from the status quo to an adaptation-conscious world will impose costs, and without careful consideration, those costs are likely to fall on those least responsible for climate change and least able to pay for its impacts.*** That's why, while SCOPE decision-makers have responsibility for downstream adaptation decisions and outcomes, they must also co-create solutions with downstream decision-makers. The environmental justice community has long advocated for procedural, distributional, and structural justice in dealing with the impacts of pollution and other environmental harms.[149] In the Anthropocene, these facets of a just and equitable approach will be indispensable to clear the way for downstream decisions to be adaptive not merely from an ecological perspective but from a social one as well.

## 3 Design and Test for the Long Run

Given the substantial and multifaceted impacts of SCOPE decisions, we must make all reasonable efforts to measure the direction and size of their impacts, and more challengingly, monitor for any unintended effects. This won't be easy. By their nature, SCOPE decisions will cause ripple effects with a range of secondary and tertiary impacts. Thus, a meta-science approach—evaluating the

evaluations—to studying, developing, and implementing projects focused on SCOPE decisions should help guide their success.

The idea of changing decisions and actions to adapt to climate change is not new, but the outcomes of adaptation behavior-change programs are seldom rigorously evaluated. We therefore have little evidence about whether conventional approaches to adaptation behavior change are effective. ***Evidence particularly matters here because programs that sound promising may not have the intended impact, with initial attempts to influence adaptation behavior proving how challenging this can be.*** In a recent example, a randomized controlled trial tested the effect of a one-day workshop among community-based water management organizations in Costa Rica. The study yielded no detectable effect on the increase in best management practices, and it serves as a cautionary tale against the assumption that promising-sounding interventions will, in fact, result in long-term behavior change.[150]

Judicious evaluations at this level of behavior change are challenging: smaller sample sizes and longer time horizons needed to obtain and analyze results run counter to the traditional incentive structure for academic research, which rewards quick and prolific publication of findings based on large datasets. In addition, much of the behavioral evidence we have focuses on short term effects. Evaluations that only capture such time-bounded effects will be insufficient for SCOPE focused projects, which will entail long term shifts and potential rebound effects. We will need to both focus on interventions thought to be effective and put in place robust monitoring programs to ensure their long-term effectiveness and precision.

Furthermore, the diverse range of SCOPE behavioral interventions likely will not allow for completely consistent evaluations. This should not preclude piloting of promising designs. Instead, working groups should include experts who can flexibly design situationally appropriate interventions. Though this approach is generally true of behavior change interventions, attention to evaluation details and robust flexibility will be even more important when intervening on high-impact, low-frequency SCOPE decisions. Flexible and responsive approaches will also allow us to iterate and appropriately react to unforeseen changes and failures throughout the lifespan of long-term projects to ensure their continued reliability, relevancy, and success.

Ideally, these monitoring programs will also resolve the tension between the need to consider long run impacts and make evidence-based decisions in the immediate future. Making evidence-based decisions requires evidence, and thus, evaluations of SCOPE programs also should include iterative analysis of results during the program to provide preliminary results when sufficiently robust.

# CONCLUSION

It's too late to completely forestall the impacts of climate change, but it's not too late to prepare and protect our systems, infrastructure, and communities in parallel with strong mitigation actions. Unfortunately, while there is growing recognition of the need for robust, global adaptation efforts, the dire warnings and calls for additional hundreds of billions of dollars in funding at global conferences are not translating into adequate action. The gap between what adaptation efforts are needed and what is actually happening remains immense. Behavioral science provides one powerful means to close this discrepancy.

Humans are uniquely skilled at shaping the world to meet our needs, but in the case of climate change, we've not yet proven capable of stopping and responding to the consequences of our actions. Today, the world is reciprocating the unprecedented changes we have made to it by changing the nature of our place within it. Behavioral science provides insight both into why we struggle to confront climate change—from discounting threats that seem far away (in both space and time) to defaulting to status quo operations—as well as tools to remedy these barriers.

Applied behavioral science examines people and the contexts in which they operate to understand how interventions can align best intentions with actual action. The field has already contributed to climate mitigation: for example, we know now better than ever how to guide people to form scientifically sound environmental beliefs, then act on them to reduce their GHG emissions and conserve other natural resources. The same set of behavioral science tools and techniques that have succeeded in mitigating climate change can also be used by policymakers at all levels to encourage robust adaptation to climate change before, during, and after climate induced threats.

At ideas42, we have seen and leveraged the power of behavioral science's insights and interventions across multiple sectors in more than one hundred projects. Using this toolkit, we've partnered with cities, states, national governments, philanthropies, NGOs, private sector actors, academics, and other practitioners to make people, places, and processes more sustainable, healthy, equitably wealthy, and just. It's time to bring the potential and promise of behavioral science to climate adaptation.

We look forward to tackling this challenge through building upon our approach and experience. Climate change poses a threat that requires a collective response. ***We will need to partner with a wide variety of organizations and people (including you, we hope) to make progress.*** Our partners bring critical subject matter expertise, lived experience, connections to stakeholders, and so much more to our projects. We can't do it alone. And, while we don't have a silver bullet for climate adaptation, we can join collectively to meaningfully protect the people and places we love. Behavioral science needs to be part of the collective action to bolster climate adaptation practices around the world.

★ **Share your thoughts on adaptation behavior change** at bit.ly/Act2Adapt

***Jordan and Sam stand together looking at their house. They made it safely to the refuge center, along with their neighbors, and stayed there for a little over eight days. As they made the trip back home, each mile felt longer and longer as they waited to see what was left of their house and community.***

***They were relatively fortunate. While many lost their homes or experienced extensive damage, Jordan and Sam's house only suffered minor exterior damage. They're thankful they made the decision to protect their house and yard from fire, though it did take some convincing and some long weekends of gutter cleaning and brush clearing. While they know that nothing can fully negate the risk of fire where they live, they're grateful their proactive measures may have made the difference.***

# Endnotes


[1] Climate change and health. (n.d.). Retrieved July 19, 2019, from https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

[2] IPCC Working Group. (n.d.). Working Group III —IPCC. Retrieved September 9, 2019, from IPCC Working Group website: https://www.ipcc.ch/working-group/wg3/

[3] Gifford, Robert. (2011). The Dragons of Inaction: Psychological Barriers That Limit Climate Change Mitigation and Adaptation. *American Psychologist*—AMER PSYCHOL. 66. 290-302. 10.1037/a0023566.

[4] Center for Research on Environmental Decisions. (2009). The Psychology of Climate Change Communication: A Guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public. New York.

[5] Akerlof, Karen & Kennedy, Chris. (2013). Nudging toward a healthy environment: How behavioral change research can inform conservation. *Energy and Environment.*

[6] Yoeli, E., Budescu, D., Carrico, A. R., Delmas, M. A., DeShazo, J. R., Ferraro, P. J., . . . Weber, E. U. (2017). Behavioral science tools to strengthen energy & environmental policy. *Behavioral Science & Policy, 3*(1), 69-79.

[7] Madrian, B. C., & Shea, D. F. (2001). The power of suggestion: Inertia in 401 (k) participation and savings behavior. *The Quarterly journal of economics*, *116*(4), 1149-1187.

[8] Bobrow, E. (2018, October 16). Fight Climate Change with Behavior Change. Retrieved September 25, 2019, from Fight Climate Change with Behavior Change website: https://behavioralscientist.org/fight-climate-change-with-behavior-change/

[9] Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological science*, *18*(5), 429-434.

[10] Hanna, R., Mullainathan, S., & Schwartzstein, J. (2014). Learning through noticing: Theory and evidence from a field experiment. *The Quarterly Journal of Economics*, *129*(3), 1311-1353.

[11] ideas42. (2015). Increasing FAFSA applications: Making college more affordable. http://www.ideas42.org/wp-content/uploads/2015/12/FAFSA-Brief.pdf

[12] Hershfield, H. E., Goldstein, D. G., Sharpe, W. F., Fox, J., Yeykelis, L., Carstensen, L. L., & Bailenson, J. N. (2011). Increasing saving behavior through age-progressed renderings of the future self. *Journal of Marketing Research*, *48*(SPL), S23-S37.

[13] Milkman, K. L., Beshears, J., Choi, J. J., Laibson, D., & Madrian, B. C. (2011). Using implementation intentions prompts to enhance influenza vaccination rates. *Proceedings of the National Academy of Sciences, 108*(26), 10415-10420.

[14] ideas42. (2017). Incentivizing Commuter Behavior: Using Focused Incentives to Reduce Transit Overcrowding. http://www.ideas42.org/wp-content/uploads/2017/11/Incentivizing-Commuter-Behavior.FINAL_.pdf

[15] ideas42. (2018). The Financial Heuristics Training: A proven mobile-based tool for teaching business lessons that stick. https://www.ideas42.org/wp-content/uploads/2018/08/Ideas42_ProjectBrief_FinHeuristics_3.pdf

[16] Thaler, R. (1999). Mental Accounting Matters. *Journal of Behavioral Decision Making*, *12*, 183–206.

[17] Volpp, John, Troxel, Norton, Fassbender, Loewenstein. 2008. Financial incentive-based approaches for weight loss: A randomized trial. *JAMA. 300*(22): 2631-2637.

[18] UN Office for Disaster Risk Reduction. (n.d.). Retrieved July 8, 2019, from ReliefWeb website: https://reliefweb.int/organization/undrr

[19] *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. (2012). https://doi.org/10.1017/CBO9781139177245

[20] Mapped: How climate change affects extreme weather around the world. (2019, March 11). Retrieved July 16, 2019, from Carbon Brief website: https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world

[21] Hurricane Harvey Facts and Figures—National VOAD. (n.d.). Retrieved July 15, 2019, from https://www.nvoad.org/harveyfacts/

[22] Extreme weather gets a boost from climate change. (n.d.). Retrieved September 11, 7019, from Environmental Defense Fund website: https://www.edf.org/climate/climate-change-and-extreme-weather

[23] Pachauri, R., Leprince-Ringuet, N., Barros...M. R. (2014). The Intergovernmental Panel on Climate Change—Climate Change 2014: Technical Support Unit for the Synthesis Report

[24] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018

[25] Dougherty-Choux, L. (2015, April 23). The Costs of Climate Adaptation, Explained in 4 Infographics. Retrieved September 25, 2019, from World Resources Institute website: https://www.wri.org/blog/2015/04/costs-climate-adaptation-explained-4-infographics

[26] Georgeson, L., Maslin, M., Poessinouw, M., & Howard, S. (2016). Adaptation responses to climate change differ between global megacities. *Nature Climate Change, 6*(6), 584–588. https://doi.org/10.1038/nclimate2944

[27] Burch, S., & Robinson, J. (2007). A framework for explaining the links between capacity and action in response to global climate change. *Climate Policy, 7*(4), 304–316. https://doi.org/10.1080/14693062.2007.9685658

[28] Bulla, B. R., Craig, E. A., & Steelman, T. A. (2017). Climate change and adaptive decision making: Responses from North Carolina coastal officials. *Ocean & Coastal Management,* 135, 25–33. https://doi.org/10.1016/j.ocecoaman.2016.10.017

[29] Leiserowitz, A., Maibach, E., Rosenthal, S., Kotcher, J., Ballew, M., Goldberg, M., & Gustafson, A. (2018). Climate change in the American mind: December 2018. Yale University and George Mason University. New Haven, CT: Yale Program on Climate Change Communication.

[30] Sisco, M. R., Bosetti, V., & Weber, E. U. (2017). When do extreme weather events generate attention to climate change? *Climatic Change, 143*(1), 227–241. https://doi.org/10.1007/s10584-017-1984-2

[31] Arcury, T. A., & Christianson, E. H. (1990). Environmental Worldview in Response to Environmental Problems: Kentucky 1984 and 1988 Compared. *Environment and Behavior, 22*(3), 387–407. https://doi.org/10.1177/0013916590223004

[32] Rudman, L. A., McLean, M. C., & Bunzl, M. (2013). When Truth Is Personally Inconvenient, Attitudes Change: The Impact of Extreme Weather on Implicit Support for Green Politicians and Explicit Climate-Change Beliefs. *Psychological Science, 24*(11), 2290–2296. https://doi.org/10.1177/0956797613492775

[33] Anderson, S. E., Bart, R. R., Kennedy, M. C., MacDonald, A. J., Moritz, M. A., Plantinga, A. J., … Wibbenmeyer, M. (2018). The dangers of disaster-driven responses to climate change. *Nature Climate Change, 8*(8), 651–653. https://doi.org/10.1038/s41558-018-0208-8

[34] Sisco, M. R., Bosetti, V., & Weber, E. U. (2017). When do extreme weather events generate attention to climate change? *Climatic Change, 143*(1), 227–241. https://doi.org/10.1007/s10584-017-1984-2

[35] https://www.ideas42.org/blog/project/new-york-behavioral-design-team/

[36] Williams, A. P., Abatzoglou, J. T., Gershunov, A., Guzman-Morales, J., Bishop, D. A., Balch, J. K., & Lettenmaier, D. P. (2019). Observed Impacts of Anthropogenic Climate Change on Wildfire in California. *Earth's Future, 7*(8), 892–910. https://doi.org/10.1029/2019EF001210

[37] Interview. Evan Jones. 2019

[38] Williams, A. P., Abatzoglou, J. T., Gershunov, A., Guzman-Morales, J., Bishop, D. A., Balch, J. K., & Lettenmaier, D. P. (2019). Observed Impacts of Anthropogenic Climate Change on Wildfire in California. *Earth's Future, 7*(8), 892–910. https://doi.org/10.1029/2019EF001210

[39] Interview. Bill Hyde. 2019

[40] Interview. Evan Jones. 2019

[41] Doumar, K. (2018, November 16). What California's Cities Can Do to Prevent Wildfires. *CityLab*. Retrieved from https://www.citylab.com/environment/2018/11/california-wildfire-prevention-wildland-urban-interface-zones/575827/

[42] Interview. Evan Jones. 2019

[43] Interview. Bill Hyde. 2019

[44] Interview. Matthew Wibbenmeyer. 2019

[45] Interview. Susan Wengraf. 2019

[46] Interview. Evan Jones. 2019

[47] Interview. Matthew Wibbenmeyer. 2019

[48] Sabalow, R., Reese, P., & Kasler, D. (2019, April 11). These California communities could be the next Paradise. Is yours one of them? *The Sacramento Bee*. Retrieved from https://www.sacbee.com/news/california/fires/article227589484.html

[49] Nowak MA, Sigmund K (2005) Evolution of indirect reciprocity. *Nature 437*(7063): 1291–1298. https://www.ncbi.nlm.nih.gov/pubmed/16251955

[50] Marcello Graziano, Kenneth Gillingham, Spatial patterns of solar photovoltaic system adoption: The influence of neighbors and the built environment , *Journal of Economic Geography,* Volume 15, Issue 4, July 2015, Pages 815–839, https://doi.org/10.1093/jeg/lbu036

[51] Interview. Susan Wengraf. 2019

[52] Interview. Evan Jones. 2019

[53] Interview. Matthew Wibbenmeyer. 2019

[54] Eckstein, D., Hutfils, M.-L., Winges, M. (2018). Global Climate Risk Index 2019 Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2017 and 1998 to 2017.

[55] Schiermeier, Q. (2008). Hurricanes are getting fiercer. *Nature, news.*2008.1079. https://doi.org/10.1038/news.2008.1079

[56] Interview. Omair Ahmad. 2019

[57] What states can learn from Odisha in disaster preparedness and mitigation. (2019, June 14). Retrieved July 26, 2019, from World Bank website: https://www.worldbank.org/en/news/speech/2019/06/14/odisha-fani-disaster-preparedness

[58] Vogel, E. (n.d.). With deadly cyclones on the rise, UNICEF raises concern about impact of climate change on children [Unicef]. Retrieved July 26, 2019, from https://www.unicef.org/press-releases/deadly-cyclones-rise-unicef-raises-concern-about-impact-climate-change-children

[59] Van Sant, S. (2019, May 6). Rare Summer Cyclone Leaves Dozens Dead In South Asia. Retrieved July 26, 2019, from *NPR:* https://www.npr.org/2019/05/06/720786266/rare-summer-cyclone-leaves-dozens-dead-in-southeast-asia

[60] Kumar, H., Gettleman, J., & Yasir, S. (2019, May 3). How Do You Save a Million People From a Cyclone? Ask a Poor State in India. *The New York Times*. Retrieved from https://www.nytimes.com/2019/05/03/world/asia/cyclone-fani-india-evacuations.html

[61] What states can learn from Odisha in disaster preparedness and mitigation. (2019, June 14). Retrieved July 26, 2019, from World Bank website: https://www.worldbank.org/en/news/speech/2019/06/14/odisha-fani-disaster-preparedness

[62] Climate change and health. (n.d.). Retrieved July 19, 2019, from https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

[63] Springmann, M., Mason-D'Croz, D., Robinson, S., Garnett, T., Godfray, H. C. J., Gollin, D., … Scarborough, P. (2016). Global and regional health effects of future food production under climate change: A modelling study. *The Lancet,* 387(10031), 1937–1946. https://doi.org/10.1016/S0140-6736(15)01156-3

[64] Climate Change and Vector-Borne Disease | UCAR Center for Science Education. (n.d.). Retrieved July 19, 2019, from https://scied.ucar.edu/longcontent/climate-change-and-vector-borne-disease

[65] Cheng, A., Chen, D., Woodstock, K., Ogden, N., Wu, X., & Wu, J. (2017). Analyzing the Potential Risk of Climate Change on Lyme Disease in Eastern Ontario, Canada Using Time Series Remotely Sensed Temperature Data and Tick Population Modelling. *Remote Sensing, 9*(6), 609.

[66] Léger, E., Vourc'h, G., Vial, L., Chevillon, C., & McCoy, K. D. (2013). Changing distributions of ticks: Causes and consequences. *Experimental & Applied Acarology, 59*(1–2), 219–244. https://doi.org/10.1007/s10493-012-9615-0

[67] CDC. (2019, April 22). Prevention is key in fight against Lyme and other tickborne diseases. Retrieved July 19, 2019, from Centers for Disease Control and Prevention website: https://www.cdc.gov/ticks/

[68] Ryan, S. J., Carlson, C. J., Mordecai, E. A., & Johnson, L. R. (2019). Global expansion and redistribution of Aedes-borne virus transmission risk with climate change. *PLOS Neglected Tropical Diseases, 13*(3), e0007213. https://doi.org/10.1371/journal.pntd.0007213

[69] Ebi, K.L., J.M. Balbus, G. Luber, A. Bole, A. Crimmins, G. Glass, S. Saha, M.M. Shimamoto, J. Trtanj, and J.L. White-Newsome. (2018). Human Health. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. U.S. Global Change Research Program, Washington, DC, USA, pp. 572–603. doi: 10.7930/NCA4.2018.CH14

[70] US EPA.. (n.d.). Climate Impacts on Human Health [Overviews and Factsheets]. Retrieved July 19, 2019, from /climate-impacts/climate-impacts-human-health

[71] Climate Change and Public Health—Climate Effects on Health | CDC. (2019, September 9). Retrieved July 19, 2019, from https://www.cdc.gov/climateandhealth/effects/default.htm

[72] Goudarzi, S. (n.d.). As Earth Warms, the Diseases That May Lie within Permafrost Become a Bigger Worry. *Scientific American*. https://doi.org/10.1038/scientificamerican1116-11

[73] UNFCCC. Subsidiary Body for Scientific and Technological Advice (SBSTA). (2017). Human health and adaptation: Understanding climate impacts on health and opportunities for action.

[74] Interview. Karina Lorenzana. 2019

[75] Interview. Jana Smith. 2019

[76] Desmon, S. (2019, April 29). Taking Aim at Zika—and Other Mosquito-Borne Illnesses. Retrieved July 19, 2019, from Johns Hopkins Center for Communication Programs website: https://ccp.jhu.edu/2019/04/29/zika-prevention-mosquito/

[77] USAID ACCELERATE: Behavior Integration Guidance. (n.d.). Retrieved July 19, 2019, from USAID Accelerate website: https://acceleratorbehaviors.org/guidance

[78] USAID. (2019). Integrating Social and Behavior Change in Climate Change Adaptation: An Introductory Guide.

[79] Interview. Jana Smith. 2019

[80] Interview. Karina Lorenzana. 2019

[81] Interview. Colin Quinn. 2019

[82] Interview. Rachel Banay. 2019

[83] https://www.ideas42.org/blog/project/breakthrough-action-breakthrough-research/

[84] Heat Illness and Agriculture. (n.d.). Retrieved July 19, 2019, from Penn State Extension website: https://extension.psu.edu/heat-illness-and-agriculture

[85] Heat Stress Prevention—Association of Farmworker Opportunity Programs. (n.d.). Retrieved July 19, 2019, from https://afop.org/health-safety/heat-stress-prevention/

[86] As Climate Heats Up, Government Must Protect Workers From Heat. (n.d.). Retrieved July 19, 2019, from Public Citizen website: https://www.citizen.org/news/as-climate-heats-up-government-must-protect-workers-from-heat/

[87] Agricultural Workers and Extreme Heat in the Age of Climate Change. (2016, August 12). Retrieved September 19, 2019, from US Climate and Health Alliance website: http://usclimateandhealthalliance.org/agricultural-workers-extreme-heat-age-climate-change/

[88] Kilbourne EM. Illness due to thermal extremes. In: Last JM, Wallace RB, editors. *Public Health and Preventive Medicine*. 13. Norwalk, CT: Appleton Lang; 1992

[89] Interview. Eric Fernandez. 2019

[90] Interview. Jason Glaser 2019

[91] Interview. Valarie Mac. 2019

[92] A Disease That Kills Sugar Workers is Spreading in the U.S. (2018, September 25). *Bloomberg*. Retrieved from https://www.bloomberg.com/news/articles/2018-09-25/ckdu-disease-that-kills-sugar-workers-is-spreading-in-the-u-s

[93] Heat Illness Prevention—Title 8 Section 3395. (n.d.). Retrieved July 19, 2019, from https://www.dir.ca.gov/dosh/etools/08-006/EWP_shade.htm

[94] Interview. Marc Schenker. 2019

[95] Public Citizen, Labor Groups Seek OSHA Heat Standard. (2019, May 21). Retrieved July 19, 2019, from EHS Today website: https://www.ehstoday.com/environment/public-citizen-labor-groups-seek-osha-heat-standard

[96] Interview. Eric Fernandez. 2018.

[97] Interview. Valarie Mac. 2019

[98] Agricultural Workers and Extreme Heat in the Age of Climate Change. (2016, August 12). Retrieved July 19, 2019, from US Climate and Health Alliance website: http://usclimateandhealthalliance.org/agricultural-workers-extreme-heat-age-climate-change/

[99] Interview. Marc Schenker. 2019

[100] Interview. Marc Schenker. 2019

[101] Interview. Valerie Mac. 2019

[102] Interview. Marc Schenker. 2019.

[103] OSHA-NIOSH Heat Safety Tool App | Heat Stress | Workplace Topics | NIOSH | CDC. (2018, November 14). Retrieved July 19, 2019, from https://www.cdc.gov/niosh/topics/heatstress/heatapp.html

[104] CDC—Heat Stress—Recommendations—NIOSH Workplace Safety and Health Topic. (2018, November 14). Retrieved July 19, 2019, from https://www.cdc.gov/niosh/topics/heatstress/recommendations.html

[105] OSHA. Protecting Workers from Heat Stress.

[106] Interview. Linda Rudolph. 2019

[107] Malaria. (n.d.). Retrieved July 19, 2019, from https://www.who.int/news-room/facts-in-pictures/detail/malaria

[108] Patz, J. A., Campbell-Lendrum, D., Holloway, T., & Foley, J. A. (2005). Impact of regional climate change on human health. *Nature, 438*(7066), 310.

[109] Hay, S. I., Cox, J., Rogers, D. J., Randolph, S. E., Stern, D. I., Shanks, G. D., ... & Snow, R. W. (2002). Climate change and the resurgence of malaria in the East African highlands. *Nature, 415*(6874), 905.

[110] Interview. Solomon Nzioka. 2019

[111] Interview. Colin Quinn. 2019

[112] Doolan, D. L., Dobaño, C., & Baird, J. K. (2009). Acquired immunity to malaria. Clinical microbiology reviews, 22(1), 13-36.

[113] Interview. Solomon Nzioka. 2019

[114] Interview. Colin Quinn. 2019

[115] Interview. Karina Lorenzana. 2019

[116] Interview. Solomon Nzioka. 2019

[117] Arias, E. (2019). How does media influence social norms? Experimental evidence on the role of common knowledge. *Political Science Research and Methods, 7*(3), 561-578

[118] Evans, W., Johnson, M., Jagoe, K., Charron, D., Young, B., Rahman, A. S. M. M., ... & Ipe, J. (2017). Evaluation of behavior change communication campaigns to promote modern cookstove purchase and use in lower middle income countries. *International journal of environmental research and public health, 15*(1), 11.

[119] Interview. Solomon Nzioka. 2019

[120] Interview. Colin Quinn. 2019

[121] Zurovac, D., Sudoi, R. K., Akhwale, W. S., Ndiritu, M., Hamer, D. H., Rowe, A. K., & Snow, R. W. (2011). The effect of mobile phone text-message reminders on Kenyan health workers' adherence to malaria treatment guidelines: a cluster randomised trial. *The Lancet, 378*(9793), 795-803.

[122] Nelson, G. C., Rosegrant, M. W., Palazzo, A., Gray, I., Ingersoll, C., Robertson, R., ... & Msangi, S. (2010). Food security, farming, and climate change to 2050: scenarios, results, policy options (Vol. 172). *Intl Food Policy Res Inst.*

[123] Searchinger, T., Hanson, C., Ranganathan, J., Lipinski, B., Waite, R., Winterbottom, R., ... & Dumas, P. (2014). *Creating a sustainable food future. A menu of solutions to sustainably feed more than 9 billion people by 2050. World resources report 2013-14: interim findings.* Creating a sustainable food future. A menu of solutions to sustainably feed more than 9 billion people by 2050. World resources report 2013-14: interim findings, World Resources Institute (2014).

[124] Hatfield, J., G. Takle, R. Grotjahn, P. Holden, R. C. Izaurralde, T. Mader, E. Marshall, and D. Liverman, 2014: Ch. 6: Agriculture. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 150-174. doi:10.7930/J02Z13FR.

[125] Doll, J. E., B. Petersen, and C. Layman. 2017. Skeptical but adapting: What Midwestern farmers say about climate change. *Weather, Climate, and Society* 9:739-751

[126] Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., ... & Hottle, R. (2014). Climate-smart agriculture for food security. *Nature climate change, 4*(12), 1068.

[127] Lengnick, L. (2014). Resilient agriculture: Cultivating food systems for a changing climate. *New Society Publishers.*

[128] https://www.ideas42.org/blog/project/reducing-post-harvest-loss/

[129] https://www.ideas42.org/blog/project/financial-management-training-mobile-phones/

[130] Pryor, S. C., R. J. Barthelmie, and J. T. Schoof, 2013: High-resolution projections of climate impacts for the midwestern USA. *Climate Research,* 56, 61-79, doi:10.3354/cr01143.

[131] National Agricultural Statistics Service, 2012: Crop Production 2011 Summary. 95 pp., U.S. Department of Agriculture.

[132] Hatfield, J., G. Takle, R. Grotjahn, P. Holden, R. C. Izaurralde, T. Mader, E. Marshall, and D. Liverman, 2014: Ch. 6: Agriculture. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 150-174. doi:10.7930/J02Z13FR.

[133] 2017 Census of Agriculture. United States Department of Agriculture.

[134] Wibbenmeyer, M., Anderson, S. E., & Plantinga, A. J. (2019). Salience and the government provision of public goods. *Economic Inquiry.*

[135] Cialdini R.B. & Trost M.R. (1998). Social influence: social norms, conformity, and compliance. In D.T. Gilbert, S.T. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology* (4th ed.) (pp. 151–92). Boston: McGraw-Hill.

[136] Pallak, M. S., Cook, D. A., & Sullivan, J. J. (1980). Commitment and energy conservation. in L. Bickman (Ed.), *Applied social psychology annual* (pp.235-253). Beverly Hills, CA: Sage Publications

[137] Sissoko, K., van Keulen, H., Verhagen, J., Tekken, V., & Battaglini, A. (2011). Agriculture, livelihoods and climate change in the West African Sahel. *Regional Environmental Change, 11*(1), 119-125.

[138] Dube, T., Moyo, P., Ncube, M., & Nyathi, D. (2016). The impact of climate change on agro-ecological based livelihoods in Africa: A review, *Journal of Sustainable Development, 9*(1), 256-267.

[139] Empowering women on the frontlines of climate change. (2019, March 8). Retrieved November 15, 2019, from United Nations Environment Program website: https://www.unenvironment.org/news-and-stories/story/empowering-women-frontlines-climate-change

[140] Kahneman, Daniel. 2011. *Thinking, Fast and Slow.* Farrar, Staus and Giroux.

[141] Hanna, R., Mullainathan, S., & Schwartzstein, J. 2014. Learning through noticing: Theory and evidence from a field experiment. *The Quarterly Journal of Economics, 129*(3), 1311-1353.

[142] Klotz, L., Pickering, J., Schmidt, R., and Weber, E.U. (2019), Design for Sustainability, *Nature Sustainability,* forthcoming.

[143] S. Pacala, R. Socolow. Stabilization wedges: solving the climate problem for the next 50 years with current technology. *Science* 305, 968 (2004).

[144] Hawken, P. (2017). Drawdown: The most comprehensive plan ever proposed to reverse global warming. https://www.drawdown.org/solutions-summary-by-rank

[145] Oreskes, N., Oppenheimer, M., & Jamieson, D. (2019). "Scientists Have Been Underestimating the Pace of Climate Change." *Scientific American: Observations.* https://blogs.scientificamerican.com/observations/scientists-have-been-underestimating-the-pace-of-climate-change/#

[146] Grillos, T. (2019). "Deliberation Improves Collective Decision-Making: Experimental Evidence from Kenya." American Political Science Association Annual Conference.

[147] Akerlof, K., Rowan, K., La Porte, T., Batten, B., Ernst, H., & Sklarew, D. (2016). Risky business: Engaging the public on sea-level rise and inundation. *Environmental Science & Policy, 66,* 314-323.

[148] Michel-Kerjan, E. O. (2010). Catastrophe Economics: The National Flood Insurance Program. *Journal of Economic Perspectives, 24*(4), 165–186. https://doi.org/10.1257/jep.24.4.165

[149] Climate Justice Alliance: Just Transition Principles. https://climatejusticealliance.org/just-transition/.

[150] Alpízar, F., Bernedo Del Carpio, M., Ferraro, P. J., & Meiselman, B. S. (2019). The impacts of a capacity-building workshop in a randomized adaptation project. *Nature Climate Change, 9*(8), 587–591. https://doi.org/10.1038/s41558-019-0536-3