



# THE CLIMATE TECH OPPORTUNITY

OXFORD CLIMATE TECH INITIATIVE | 2023

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The research and report were overseen by the Oxford Climate Tech Initiative team:

Jamil Wyne (Project Lead), Minahil Amin, Abrar Chaudhury, Courtney Savie Lawrence, Aoife Brophy, and Michelle Lee. The team also benefited from research support from Gen Shiraishi, Jordan Zele, Aishwarya Geete, Joseph Letrosne, Yuki Nakagawa and Robert Edge Partington.

To cite this work please use "Wyne, et al., The Climate Tech Opportunity. Oxford Climate Tech Initiative, 2023."

For further acknowledgements, please see page eleven.

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# EXECUTIVE SUMMARY

#### CLIMATE TECH IS EVOLVING RAPIDLY.

Climate tech startup and investment activity is growing rapidly. While reported numbers vary, since 2013, there have been over 6,000 investors (private, public and philanthropic) in climate tech startups, and 2022 alone saw over 3,000 VC rounds into climate tech. Over the past decade, there has been an estimated 40X increase in overall climate venture capital globally.

#### CLIMATE TECH BY THE NUMBERS<sup>1</sup>

#### USD \$70bn+

Overall venture capital funding for climate tech in 2022

#### 83

Climate tech unicorns primarily in the US, China, Germany, UK and Sweden

#### 89%

Increase in global climate tech funding from 2021 to 2022

#### USD **\$1.4tn+**

Expected value of companies in carbon removal or reduction by 2027<sup>2</sup>

#### USD \$18.4bn

Climate tech funding going into storage (the largest of any sector globally) in 2022

#### 2X+

EU climate VC activity from 2021 to 2022 (largest increase of any geography)

#### 3,300+

Climate tech investment deals globally in 2022<sup>3</sup>

#### **40**x

Growth in overall climate tech funding over the past decade

#### USD \$22.6bn+

Invested in climate tech outside of US, EU and China from 2010 -2022

#### MOST PROMISING OPPORTUNITIES IN THE ENERGY SECTOR

Energy Storage 50% Grid Management 40% Solar Energy efficiency Nuclear 30% Biomass / Waste Alternative Fuels 20% Wind Geothermal Hydro / Ocean 10% 0% N=149

# MOST PROMISING OPPORTUNITIES



Sector:

#### **ENERGY**

# Most promising opportunities:

#### STORAGE AND GRID MANAGEMENT

Data is taken from a survey of 149 climate tech practitioners (entrepreneurs, investors, policymakers, etc.) wherein respondents were asked to select the top-two most promising opportunities in each category.

#### Sector:

#### TRANSPORTATION

Most promising opportunities:

#### BATTERIES, FUEL CELLS AND SMART INFRASTRUCTURE

Sector:

FOOD,

LAND USE

LAND USE



#### MOST PROMISING OPPORTUNITIES IN THE FOOD, AGRICULTURE, LAND USE SECTOR

#### MOST PROMISING OPPORTUNITIES IN THE INDUSTRY SECTOR



Sector:

#### **INDUSTRY**

Most promising opportunities:

**RECYCLING AND CIRCULARITY**, **CONCRETE AND** CEMENT

Sector:

BUILT

**ENVIRONMENT** 

Most promising opportunities:

**HEATING AND** 

**EFFICIENCY AND CONSTRUCTION** 



#### MOST PROMISING OPPORTUNITIES IN THE BUILT ENVIRONMENT SECTOR

MOST PROMISING OPPORTUNITIES IN THE GHG CAPTURE, USE AND REMOVAL SECTOR



Sector:

#### **GHG CAPTURE, USE AND REMOVAL**

Most promising opportunities:

**FORESTATION AND HABITAT** RESTORATION



MOST PROMISING OPPORTUNITIES IN THE MANAGEMENT AND REPORTING SECTOR

Sector:

#### MANAGEMENT AND REPORTING

Most promising opportunities:

EMISSIONS DATA, MONITORING, MANAGEMENT

N=149

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#### MOVING FORWARD

Despite the increase in climate VC and startup activity, there are still key challenges, including the need for additional and diverse funding sources, mobilizing more support from governments and corporates, leveraging technology to support adaptation goals, and ensuring that the climate tech ecosystem is inclusive.

#### Increase the amount, as well as types of available funding for climate tech innovations

Although climate tech funding and overall climate finance have significantly grown in recent years, major financing gaps still remain. For instance, the Climate Policy Institute suggests that climate finance must increase from the annual investment of \$640 billion in 2020 to \$4.35 trillion in annual investment in 2030 to almost \$6 trillion in 2040 in order to maintain the 1.5 °C pathway.<sup>4</sup> While this encompasses all forms of climate finance and not all of it will focus on climate tech, climate tech will feature prominently within it. Experts interviewed emphasized the need for more and faster capital deployment for every stage of the technology development cycle—e.g. R&D, pilots, and commercialization.

#### 2) Corporations and governments must help enable climate tech growth

Over 60% of respondents said that corporations need to play a larger role in supporting climate tech companies, and over 50% pointed out that governments need to as well. Large corporate entities—e.g. utilities—as well as government agencies can help throughout a climate tech company's life cycle. From R&D funding, to product testing support, to large market access and contracts, corporate and government players have a significant role in the climate tech ecosystem. Survey respondents stated that incentivizing adoption in the market, pricing externalities, and passing regulations to phase out old technologies were three ways in which governments can support the climate tech ecosystem.

#### 3) Strategies are needed to build the talent pool for climate tech

#### 4) Climate tech solutions must reach developing countries and vulnerable populations

#### 5) Build out the adaptation solution set and create the necessary investment strategies around it

Nearly 40% of respondents pointed to talent as being a key constraint, second only to needing more support from governments and corporations. The success of climate technology is contingent on a massive "human element"—i.e. talent and workforce. There is no single figure that quantifies the demand for talent in the climate-tech field, though, for starters, the International Labor Organization reports that a greener economy could create 24 million jobs worldwide.<sup>5</sup> Talent constraints could be even more prominent in developing countries. For example, interviewees based in Asia, Africa, and Latin America frequently pointed to the lack of sufficient talent and workforce as a barrier to building and scaling of climate tech companies.

Eighty-nine percent of survey respondents do not believe that climate tech solutions are reaching the people who need them most. For example, only 8% of energy transition investments in 2021 went to emerging markets.<sup>6</sup> Interviewees had differing perspectives on this issue–while there was broad consensus that climate tech is neglecting vulnerable communities, some interviewees believed that the current focus on mitigation—i.e. ensuring that countries with the most emissions, which tend to be wealthier countries, reduce those emissions—is the best way to limit the impact of climate change on developing countries. Beyond this, tech transfer, customization and local engagement are critical to ensuring inclusion in climate tech.

Currently, only around 7% of global climate funding (climate tech and other) is being allocated to adaptation projects, and roughly 2% was used for projects that tackle both mitigation and adaptation.<sup>7</sup> While climate change is a global phenomenon, countries and populations will ultimately experience it differently. Simultaneously, material and sustainable outcomes from mitigation activities will require years, and in the interim period countries need to invest heavily in adaptation. Climate tech has an important role to play in filling the adaptation funding gap, yet there is little sector-wide consensus on what the adaptation solution set looks like. Fleshing out the scope of adaptation technologies and the specific barriers they face is a critical step in ensuring more equitable development of climate tech.

- 5 World Employment and Social Outlook 2018: Greening with jobs. International Labour Organization, 2018.
- 6 BloombergNEF (2022)
- 7 Climate Policy Initiative (2021)

#### DEEPENING THE KNOWLEDGE BASE

This research is just the beginning of the conversation on how to advance the climate tech ecosystem globally and capitalize on the climate tech opportunity. Given that the climate tech field is still young, there are many areas where we need to deepen the knowledge base. The below list provides a snapshot of some of the key questions needed answers, which we hope can help shape a more robust research agenda.

#### PRIORITY AREA KEY RESEARCH QUESTIONS

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- What types of funding beyond standard equity and debt instruments are most needed, particularly for R&D intensive and hardware companies?
- What innovative financing solutions can be leveraged in climate tech?
- Which organizations are best suited to provide grants and concessionary funding to early stage climate tech solutions, and how do we mobilize support from them?
- How do we ensure that the sectors with the greatest potential for impact are receiving the necessary funding?

#### 2) GOVERNMENTS AND INCUMBENT CORPORATIONS

- How do governments and corporations add value across the lifecycle – from conceiving and commercializing solutions all the way to scaling and liquidity events?
- What are the specific partnership strategies that climate tech startups can pursue with governments and corporations?
- How do governments avoid crowding out investors?
- What strategies and policies can governments provide to encourage investments in climate tech?

#### 3) TALENT AND WORKFORCE

- What are the necessary taxonomies and frameworks for education and employment in the climate tech sector?
  - How do we improve the linkages between the private sector and academia to ensure a steady flow of talent from universities and research centers into climate tech companies?
  - How do we rapidly upskill individual students and job seekers as well as larger populations to ready them for working in climate tech, at scale?

#### PRIORITY AREA KEY RESEARCH QUESTIONS

#### 4) DEVELOPING COUNTRIES AND VULNERABLE POPULATIONS

- How do we improve investment conditions for climate tech in developing countries?
- What types of climate tech solutions, both mitigation and adaptation, are most needed in developing countries?
- How do we engage local communities in the development and implementation of climate tech solutions?
- Which organizations are best-placed to lead climate tech efforts in developing countries and vulnerable populations?
- Which resources beyond funding e.g. policy, talent, etc. are most critical to supporting climate tech innovation in these markets?

#### **5) ADAPTATION**

- What does the full climate tech adaptation solution set look like?
- Are there specific business models that are more prevalent amongst adaptation solutions?
- Which funding vehicles and strategies are most applicable for adaptation solutions?
- How do we customize adaptation solutions to different contexts?
- What are the best metrics for quantifying adaptation impact?

Image by Karsten Würth, found on Unsplash



# ABOUT THIS REPORT

In a short period of time, climate tech has become a well-funded sector that has drawn the attention of entrepreneurs, investors, scientists, academics, policy-makers, and other key stakeholders across global markets. As the effects of climate change become more pronounced, the demand for technology solutions that remove and reduce GHG emissions and build resilience against growing temperatures and climate risk is rapidly growing. There are few sectors in recent history that have brought together such a mixture of innovation, talent, policy support and investment.

Thus, the **climate-tech opportunity** is timely, unique as well as urgent.

Yet despite the growing momentum, the sector is still in its nascent stages, and numerous uncertainties persist. Which sectors are considered the most promising by investors and entrepreneurs? Are underprivileged communities reaping the benefits of climate tech advancements? How do we build more efficient climate tech ecosystems? How can we reduce the barriers to scaling climate tech startups?

This report offers a preliminary response to these questions. It is based on a survey of over 140 climate tech practitioners (including investors, entrepreneurs, scientists and policy-makers) and interviews with over 60 experts from over twenty countries. It assesses some of the challenges and opportunities within the climate tech ecosystem, in hopes of equipping stakeholders in the field, as well as new entrants into it, with insights they can use to build better programs, strategies, platforms and policies to support climate tech innovation. The trends in this field are evolving rapidly, and as more funds, entrepreneurs, governments and other players look to capitalize on it, we hope that the research can provide a starting point for understanding the **climate-tech opportunity**.

# ACKNOWLEDGMENTS

The research and report were overseen by the Oxford Climate Tech Initiative team: Jamil Wyne (Project Lead), Minahil Amin, Abrar Chaudhury, Courtney Savie Lawrence, Aoife Brophy, Michelle Lee, and Robert Edge Partington.

We also benefited from research support from Gen Shiraishi, Jordan Zele, Aishwarya Geete, Joseph Letrosne and Yuki Nakagawa.

We would also like to thank Margarita Zulueta, the lead designer for this report, and we would also like to thank Cyntia Abarca for advising on design.

Our team also benefited from input from Stefano Gurciullo (deep-tech investor), Eric Berlow (Vibrant Data Labs) and Abdullah Al-Shakarchi (Harvard Business School).

We would also like to thank the Skoll Centre for Social Entrepreneurship at Oxford Saïd Business School and the Beck Family Foundation for their financial support in undertaking this study.

We are also grateful to the following individuals who provided feedback on our research methodology and publication: Alexis Caporale (World Fund), Daniel Layug (International Finance Corporation), Daniel Kriozere (Climate Capital), Don Meier (Deloitte), Elzan Godlewski (Planet Positive Labs), Manuel Bueno (DAI), Malini Samtani (IDB Invest), Michelle Lee (Climate Policy Initiative).

# Additionally, we would like to thank the following individuals for their time in participating in an interview with our team:

Aakash Shah Peak Sustainability Ventures

Andrew Wong TRIREC

Anshuman Bapna Terra.do

Antoine Pradayrol Green Angel Syndicate

Bankole Oloruntoba Nigeria Climate Innovation Center

Belem Saucedo DAI

Ben Attia BlackRock

Brad Hiller Islamic Development Bank

Chris Aidun Persistent Energy Capital

Chris Chang Elemental Excelerator

Cris Davila DAI

Dan Goldman Clean Energy Ventures

Daniel Goldsmith Julius Education

Danny Kennedy New Energy Nexus

Dave Miller Clean Energy Ventures

Del Mackey New Mexico State University

Derek Handley Aera VC

Edgar Adrian Parra Oyervides Innovation Laboratory of the Inter-American Development Bank Ennis Rimawi Catalyst Investment Management

Ethan Zindler Bloomberg NEF

Eric Wilburn Nature-based solutions expert

Ezgi Canpolat Climate Investment Funds

Farah Tubeileh Catalyst Investment Management

Felix Magaju Kenya Climate Innovation Center

Gabriel Kra Prelude Ventures

**Gaurav Gupta** Dalberg Advisors

Greg Pope Rappel

Habiba Daggash Rocky Mountain Institute

Himanshu Sharma Theia Ventures

Jade Bouhmouch Ambo VC

James Ellis Bloomberg NEF

Jay Dessy Breakthrough Energy

**Jen Loong** Venture Capital Investor

**Jinesh Shah** Omnivore

Joel Nana Sustainable Energy Africa

Jonah Wagner Wagner Advisory Services Ltd Julie Mae Gabato Persefoni

**June Lukuyu** EED Advisory

Kamal Kapadia Terra.do

Katie Auth Energy for Growth Hub

Keri Browder Prime Coalition

Kerry Duggan SustainabiliD

Lawrence Ang Climate Smart Ventures

Marga Manzo Mirova SunFunder

Mia Diawara Lowercarbon Capital

Mona Alsubaei Union Square Ventures

Murefu Barasa EED Advisory Limited

Nalin Agarwal Climate Seeds Fund

Olamide Oguntoye Tony Blair Institute

Patricia Huidobro Global Environment Facility

PuiYan Leung Vertex Ventures SE Asia & India

Rafael Aldon regenr8

Ruth Ndegwa (formerly) Kenya Climate Innovation Center

Ryan Dings ClimateHaven Saliem Fakir The African Climate Foundation

Sarah Bermeo Duke University

Sebastian Castellano World Resources Institute

Shaun Abrahamson Third Sphere

**Stephen Musyoka** Kenya Climate Innovation Center

Steve Melhuish Wavemaker Impact

Stonly Blue Third Sphere

Susan Su Toba Capital

Tamer El-Raghy Acumen Resilient Agriculture Fund (ARAF)

Tim Christophersen Salesforce

Tom Mitchell Climate KIC

Victor Ndiege Kenya Climate Ventures

Vincent Ogaya Kenya Climate Innovation Center

Yasser Biaz UM6P Ventures

Zaki Raheem DAI



# METHODOLOGY

Data for this report was collected through a combination of survey and interviews. In total, our team conducted an online survey of 149 climate tech practitioners (investors, entrepreneurs, accelerator managers, academics, nonprofit executives, government officials, etc.) and also interviewed 67 individuals from the same categories. The participants in the study came from over 20 countries, with the bulk working on climate tech in the US and EU, followed by East and Southeast Asia, Sub-Saharan Africa, South Asia, the Middle East and North Africa, South America, Central America and the Caribbean, and Oceania.

To analyze trends, challenges and opportunities across the climate tech sector, we segmented our analysis across seven sub-verticals, informed by research done by PwC, Holon IQ, the Climate Policy Initiative, Pitchbook, and Silicon Valley Bank. The climate tech verticals covered in this report are 1) Energy; 2) Transportation; 3) Food, agriculture and land use; 4) Industry; 5) Built environment; 6) Greenhouse gas (GHG) capture, utilization and removal; 7) Climate change management and reporting.

While there is no universally agreed definition of climate tech, for the purpose of this report, we define **climate tech** as technology built with the intent to mitigate, or adapt, or increase resilience to the negative impacts of climate change.

Image by Dmitry Fisenko, found on Unsplash.

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# DEFINITIONS

#### **ADAPTATION**

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

#### BIOMASS FUELS OR BIOFUELS

A fuel produced from dry organic matter (e.g. firewood, alcohol fermented from sugar, and combustible oils extracted from soybeans or combustible oils produced by plants).

#### **CAPACITY BUILDING**

Developing the technical skills and institutional capability to enable economies/countries to effectively address the causes and results of climate change.

#### **CARBON MARKET**

A trading system through which private and public entities may buy or sell units of greenhouse-gas emissions in an effort to meet emissions limits, either under the Kyoto Protocol or under other agreements.

#### **CARBON SEQUESTRATION**

The process of removing carbon from the atmosphere or capturing it before it enters the atmosphere and storing it in a stable, long-term way via either natural or artificial processes.

#### **CLIMATE FINANCE**

Local, national or transnational financing—derived from public, private and alternative sources of financing—that seeks to support climate mitigation and adaptation efforts.

#### **CLIMATE RISK**

Risk assessments based on formal analysis of the consequences, likelihoods and responses to the impacts of climate change and how societal constraints shape adaptation options.

#### CLIMATE-SMART AGRICULTURE

Integrated approach to managing landscapes—cropland, livestock, forests and fisheries—that address the interlinked challenges of food security and climate change.

#### **CLIMATE TECH**

Technology built with the intent to mitigate or adapt to the negative impacts of climate change.

#### **TECHNOLOGY TRANSFER**

The movement of data, designs, inventions, materials, software, technical knowledge or trade secrets from one organisation to another or from one purpose to another.

#### **DEVELOPED COUNTRY**

Sovereign state that has a high quality of life, developed economy and advanced technological infrastructure relative to other less industrialized nations.

#### **DEVELOPING COUNTRY**

Also called a less developed country or emerging market—has a lower gross domestic product (GDP) than developed countries, with a less mature and sophisticated economy.

#### **EMERGING MARKET**

Economy that's transitioning into a developed economy.

#### LAND USE, LAND-USE CHANGE, AND FORESTRY (LULUCF)

A greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities.

#### LEAST DEVELOPED COUNTRIES (LDCS)

The world's poorest countries. The criteria currently used by the Economic and Social Council (ECOSOC) for designation as an LDC include low income, human resource weakness and economic vulnerability.

# DEFINITIONS

#### LOW CARBON TECHNOLOGY

Technologies that emit low levels of CO2 emissions, or no net CO2 emissions.

#### NATURE-BASED SOLUTIONS (NbS)

Solutions that work with nature to address environmental and societal challenges, providing benefits for both human well-being and biodiversity

#### NATIONAL DETERMINED CONTRIBUTIONS (NDC)

Individual country plans and commitments to reduce national emissions and adapt to the impacts of climate change, in the context of the Paris Agreement.

#### **NET ZERO**

Achieving a balance between the greenhouse gases put into the atmosphere and those taken out such that net greenhouse gas emissions are effectively zero.

#### **OFF-GRID ENERGY**

Energy created independent of an electrical grid.

#### **MITIGATION**

Intervention to reduce the sources or enhance the sinks of greenhouse gases.

#### **PARIS AGREEMENT**

International treaty on climate change that was adopted in 2015, focusing on climate change mitigation, adaptation, and finance.

#### REFORESTATION

Replanting of forests on lands that have previously contained forests but that have been converted to some other use.

#### **RENEWABLE ENERGY**

Energy from a source that is not depleted when used, such as wind or solar power.

#### RESEARCH AND DEVELOPMENT (R&D)

Work in academia or industry directed toward the innovation, introduction, and improvement of products and processes.

#### SUSTAINABLE DEVELOPMENT

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

#### UNICORN

A privately held startup company valued at over USD \$1 billion.

#### **VENTURE CAPITAL (VC)**

Capital invested in a small, earlystage company with potential to scale

rapidly—in exchange, capital providers receive minority ownership stakes in the company. Since investing in young companies involves substantial risk, investors expect to receive, on average across a portfolio invested in many early-stage companies, a high rate of return on their original investment.

#### WASTE MANAGEMENT

Processes of waste collection, transportation, processing, as well as waste recycling or disposal.

# ACRONYMS

**CO**<sub>2</sub> Carbon Dioxide

**EU** European Union

**FDI** Foreign direct investment

GCF Green Climate Fund

**GHG** Greenhouse gas

**LATAM** Latin America

LDC Least developed country **LCT** Low carbon technology

#### MENA

Middle East and North Africa

#### MRV

Measurable, reportable, and verifiable

#### NAPAs

National adaptation programmes of action

#### NDC

Nationally determined contribution

#### NGO

Non-governmental organization

#### OECD

Organisation for Economic Co-operation and Development

#### REDD

Reducing emissions from deforestation and forest degradation

### R&D

Research and development

**SSA** Sub-Saharan Africa

**UN** United Nations

#### WASH

Water, Sanitation and Hygiene



#### INTRODUCTION

# **CLIMATE TECH IS** EVOLVING RAPIDLY

Climate tech encompasses a range of verticals, including energy, transportation, food, agriculture and land use, industry, built environment, GHG capture, utilization and removal, and climate change management and reporting. While reported numbers vary, since 2013, there have been over 6,000 investors (private, public and philanthropic) in climate tech startups, and 2022 alone saw over 3,000 VC rounds into climate tech. Over the past decade, there has been an estimated 40X increase in overall climate venture capital globally.8910



8 Dealroom, "Global Venture Capital Monitor." 9

10 PwC (2021). State of Climate Tech 2021: Scaling breakthroughs for net zero. www.pwc.com/gx/en/sustainability/publications/ assets/pwc-state-of-climate-tech-report.pdf. 18

HolonIQ (2023), "2022 Climate Tech VC Funding Totals \$70.1B, Up 89% from \$37.0B in 2021." www.holoniq.com/notes/2022climate-tech-vc-funding-totals-70-1b-up-89-from-37-0b-in-2021.

### FIGURE 1: GLOBAL CLIMATE VC FUNDING (2010-2022, IN BILLIONS)<sup>10</sup>

By some accounts, as of late 2022 roughly 25% of all VC dollars had been allocated to some form of climate technology, up from roughly 14% the previous year.<sup>11</sup>



### FIGURE 2: CLIMATE TECH BY THE NUMBERS<sup>1</sup>

### **USD \$70bn+**

Overall venture capital funding for climate tech in 2022

### 83

Climate tech unicorns primarily in the US, China, Germany, UK and Sweden

### **89%**

Increase in global climate tech funding from 2021 to 2022

## USD \$1.4tn+

Expected value of companies in carbon removal or reduction by 2027<sup>2</sup>

## USD \$18.4bn

Climate tech funding going into storage (the largest of any sector globally) in 2022

#### 2X+

EU climate VC activity from 2021 to 2022 (largest increase of any geography)

### 3,300+

Climate tech investment deals globally in 2022<sup>3</sup>

# **40**x

Growth in overall climate tech funding over the past decade

# USD \$22.6bn+

Invested in climate tech outside of US, EU and China from 2010–2022

44 The majority of the world, civilization itself, a hundred years hence will run on solar power, because nothing beats a flat plate semiconductor that sits in the sun and makes electricity for free. Nothing with a moving part can beat that. So that wins the technology game."

- Danny Kennedy, New Energy Nexus

### FIGURE 3: CLIMATE UNICORNS IN FOCUS<sup>13</sup>

Additionally, there is now a growing population of **over 80 climate "unicorns", companies worth more than USD \$1 billion**, the majority of which are in mobility and energy<sup>14</sup>.

#### USD \$180B+

Collective valuation of climate unicorns



#### CLIMATE AS A PERCENTAGE OF NEW UNICORNS<sup>15</sup>

	2018	2019	2020	2021	2022
New Climate Unicorns	5	8	6	37	20
New Unicorns	262	270	314	774	312
Climate as a % of New Unicorns	1.9%	3.0%	<b>1.9%</b>	<b>4.8</b> %	<b>6.4</b> %

<sup>13</sup> HolonIQ, "Global Climate Tech Unicorns", 2023.

15

<sup>14</sup> Tiseo, Ian (2023)

Unicorns analysis combines HolonIQ climate unicorn data with Dealroom overall unicorn data: https://dealroom.co/guides/ guide-to-unicorns#:~:text=Since%202018%2C%20over%20250%20new,unicorn%20rate%20within%20five%20quarters." Retrieved on August 20, 2023.

Beyond VC and startup activity, we have also seen a large uptick in general technology innovation around climate in the past several decades, as well as a growing demand for climate tech to help in meeting global climate objectives.

There is a critical role for current and emerging technologies to drive the decarbonization movement, and also for meeting adaptation objectives. Solutions that are currently in the market are crucial for meeting climate goals by 2030. The majority of annual CO2 emissions savings needed to reach 2030 net zero objectives are expected to come from currently available solutions. There is an even larger role for new technologies to support 2050 net zero goals, as roughly half of CO2 emissions savings are forecasted to come from technologies that are presently under development.<sup>15</sup>

316%

#### FIGURE 4: ANNUAL CO<sup>2</sup> EMISSIONS SAVINGS IN THE NET ZERO PATHWAY (2020)<sup>16</sup>



FIGURE 5:

TOTAL VALUE OF LCT EXPORTS, 1990-2017<sup>17</sup>



16 Net Zero by 2050 A Roadmap for the Global Energy Sector. International Energy Agency, 2021

17 Pigato, Miria; Black et al. (2020). Technology Transfer and Innovation for Low-Carbon Development. World Bank. https:// openknowledge.worldbank.org/handle/10986/33474

# The majority of climate tech funding is taking place in the United States (US), followed by China, and the EU.

While China has received the majority of overall climate finance (including venture capital, along with other forms of capital), as of 2019, the bulk of venture capital funding specifically for climate tech takes place in the US.<sup>18</sup> In 2022, US investors alone deployed more VC dollars into climate tech than the entire amount invested from 2006-2011, during the Cleantech 1.0 period.<sup>19</sup> To put things into perspective, the first climate tech wave from 2006-2011 saw US investors alone allocate just over USD \$25 billion to climate tech startups. There is also a large and growing number of climate-tech unicorns globally. The US is also home to the majority of climate unicorns, 45 of the 83 to date, which are collectively valued at over USD \$180 billion.<sup>20 21</sup> The unicorn population, alongside the sums of aggregate VC funding over the past several years may make the first cleantech boom and bust no longer a relevant comparison.

- I think the biggest thing to take note of is just capital. The momentum of capital has accelerated massively in the last two to three years. Four or five years ago I would say it was still peripheral in the venture space, but in the last couple of years it has exploded. I think that overrides any other kind of trend."
  - Derek Handley, Area VC



Background Image by Jason Leung on Unsplash

- 20 HolonIQ, "Global Climate Tech Unicorns"
- 21 HolonIQ (2023)

<sup>18</sup> HolonIQ (2023), In China, the government and corporations have begun to play a larger role in climate tech funding, thus private investors are no longer the main funders for climate tech in the country.

FIGURE 6:

### REGIONAL BREAKDOWN OF CLIMATE VC ACTIVITY, REGIONAL FUNDING TOTALS (2010 – 2022)<sup>22</sup>



# During the 2010-2022 period, outside of the US, China, EU, and India, the rest of the world accounted for only 8% of total climate VC activity.<sup>23</sup>

While climate change challenges are global, and climate entrepreneurs can be found in any country, climate tech funding is still predominantly focused on a select few geographies. In large part, this concentration could be due to the fact that the climate tech ecosystem – the collection of funds, organizations, regulations, markets and talent pools – to start and build climate tech companies, are still nascent in much of the world, comparable to the overall concentration of the VC financing ecosystem globally.<sup>24</sup>

# SPOTLIGHTING OPPORTUNITIES

As more funds and startups enter the climate tech sector, the field is no longer a niche, but a mainstream investment theme. This section focuses on where climate tech experts see the most promising opportunities across seven climate tech sub-sectors. It is based on a survey of 149 practitioners working on climate change issues globally. The opportunities in each sector were identified though an online survey where respondents were asked to identify the top two opportunities in each sector: energy; transportation; food, agriculture and land use; industry; built environment; GHG capture, use and removal; management and reporting.

Most of the respondents work in the US and EU, followed by East and Southeast Asia, Sub-Saharan Africa, South Asia, and the Middle East and North Africa, and were composed of climate capital (dilutive and non-dilutive)<sup>24</sup> providers, founders, and senior executives at climate tech firms. Understanding where these domain experts believe the most promising opportunities in climate tech lie is critical to gauging where momentum and resources may be headed in the near future.

Background Image by Olesia Bahrii on Unsplash

24 Dilutive capital refers to financing methods that involve the issuance of new shares or equity in a company or project, resulting in the dilution of the existing shareholders' ownership. Non-dilutive capital refers to financing methods that do not involve the issuance of new equity or shares, such as debt.

# ENERGY

Image by Bruno Figueiredo, found on Unsplash

#### **KEY STATISTICS ON** ENERGY AND CLIMATE

The energy supply sector is responsible for 35% of global emissions and is the largest contributor to greenhouse gas emissions.<sup>26</sup>

13% of the world still does not have access to energy. The majority of these individuals live in Africa.27

In high income countries, per capita electricity consumption is more than 100-fold higher than in low income countries.<sup>28</sup>

- " Climate has many angles and energy has many adjacent sectors like agriculture and water waste recycling. All of these sectors used to be pretty siloed, but I think over the last few years there's this trend towards breaking down those walls. For example, one of the thematic areas that we're really keen to do more deals in is this nexus between energy and agriculture. We're also interested in the intersection between poverty alleviation and carbon - for instance, we can use energy focused money for irrigation and solar powered greenhouses for cooling or storage for food."
  - Marga Manzo, Mirova SunFunder

#### ENERGY STORAGE

#### AND GRID MANAGEMENT

were the top-two sectors where respondents perceived the most promising opportunities to develop and scale technologies.

#### **FIGURE 7: MOST PROMISING OPPORTUNITIES IN THE ENERGY SECTOR**



- " There's a lot of open space for thinking about energy storage and how we leverage assets and underutilized assets for energy storage throughout the grid. I'd say the other reason why that's important is because no matter what kind of grid you build, it's physically vulnerable to weather disasters, weather-related disasters."
  - Stonly Blue, Third Sphere

Image by Martin Adams, found on Unsplash

26 Intergovernmental Panel on Climate Change (2018). " Chapter 7: Energy Systems. 27

Ritchie, Hannah et al. "Access to Energy."

Ibid



Image by Hanson Lu, found on Unsplash

#### **KEY STATISTICS ON** TRANSPORTATION AND CLIMATE

GHG emissions from the transport sector have more than doubled since 1970, with 80% of this rise stemming from road vehicles.29

Around 10% of the world's population accounts for 80% of total motorized passenger-kilometers.30

Aviation is responsible for about 10% of global emissions in the transport sector.31

- In Latin America we have fewer venture capital funds than in the US and EU, and climate-tech is not yet an attractive sector when compared to others such as e-commerce, fintech, software, etc. However, in terms of sectors that are worth noting, e-mobility is gaining momentum. Having said that, from my point of view it's a much more incipient sector compared to energy and ag-tech. It's also important to note that energy and mobility are moreso focused on climate change mitigation, while ag-tech is more focused on climate change adaptation and smarter use of natural resources."
  - Edgar Parra, Innovation Laboratory of the Inter-American Development Bank

#### **INVESTMENTS IN BATTERIES** AND FUEL CELLS AS WELL AS SMART INFRASTRUCTURE

were identified by survey respondents as the most promising opportunities within the transportation sector.

#### FIGURE 8: MOST PROMISING **OPPORTUNITIES IN THE TRANSPORTATION SECTOR**



" Mobility is one of the most important sectors in sustainability. Interestingly, a lot of the technology and innovation here transcends borders, and solutions like BMS and grid storage can be applied across geographies. Within India, mobility has become one of the most well-funded sectors within the sustainability space. There's more innovation needed, because lithium doesn't solve for all use-cases - ie. Heavy Duty Trucks - which creates the need for different chemistries and alternative fuels like CNG or Hydrogen."

- Aakash Shah, Peak Ventures

Image by Jerry Zhang, found on Unsplash

29 Intergovernmental Panel on Climate Change (IPCC) (2018). "Chapter 8: Transport." Ibid

30 31 Ibid

# FOOD, AGRICULTURE, LANDUSE

Image by Raphael Rychetsky, found on Unsplash

#### KEY STATISTICS ON FOOD, AGRICULTURE, AND LAND USE

The global food system is responsible for **31-37% of annual GHG emissions**.<sup>32</sup>

33% of total global food production is wasted.33

Meat and dairy provide **18% of calories but account for 83% of global farmland** and **60% of agriculture's GHG emissions**.<sup>34</sup>

" At ARAF, we invest in both tech-enabled and traditional business models. On one hand, we invested in a company that develops solar-powered irrigation systems where they use data to predict weather and advise farmers on when to irrigate. Those farmers reported an increase in their crops' yield by up to three times! On the other hand, we invested in a company that sells dual purpose day-old-chicks and feed where farmers can generate daily/weekly income from selling eggs which helped those farmers not only increase their income but also reduce their income volatility which helps those farmers adapt, and become more resilient to, climate change."

 Tamer El-Raghy, Acumen Resilient Agriculture Fund (ARAF)

#### LAND USE MANAGEMENT AND ALTERNATIVE FOODS AND LOW GHG PROTEINS

were identified by survey respondents as the most promising opportunities in the food, agriculture and land use sub-sector.

#### FIGURE 9: MOST PROMISING OPPORTUNITIES IN THE FOOD, AGRICULTURE, LAND USE SECTOR



" Agriculture is one of the biggest contributors of greenhouse gasses via dairy and general food production. Both in developed and developing markets, agriculture contributes a large amount of usage of water. At the same time, as climate change worsens, it will also impact agriculture in a major, major way. For example, smallholder farmers and the coastal areas with agriculture sectors, will be significantly affected. So it's both a culprit as well as a victim from a climate perspective. We have a huge overlap and have to account for the climate angle within the agriculture ecosystem as well."

- Jinesh Shah, Omnivore

32 Bélanger, Josée, et al. (2020)
33 UNEP (2010)
34 United Nations Framework Convention on Climate Change (UNFCCC) (2021)

# INDUSTRY



#### KEY STATISTICS ON INDUSTRY AND CLIMATE

Energy use in industry represented **24.2% of GHG emissions** globally in 2016, with **iron and steel comprising 7.2%** of those GHG emissions.<sup>35</sup>

**Only 9%** of plastic waste ever produced **has been recycled**.<sup>36</sup>

Industry represented **24% of GHG** emissions in the United States in 2020.<sup>37</sup>

There are sectors that I think are underfunded to help decarbonize the world and the one I would point out would be waste to value. There's an incredible number of waste streams that can be turned into valuable products and done so at zero or very low carbon emissions - socalled circular economy - in comparison to mining, refining and manufacturing. For example, we've invested in a company, Nth Cycle, that recovers critical minerals from waste streams such as end of life batter e-waste, mine ores and tailings, at 759 lower cost and carbon intensity. There many such technologies emerging where for example, carbon and hydrogen can be used for fuels, wastes can be turned into chemicals and capture carbon dioxide in the process, and we can produce cement from waste streams while sequestering carbon. We anticipate that waste-to-value will become an extraordinary investment opportunity in the next decade.

- Daniel Goldman, Clean Energy Ventures

#### RECYCLING AND CIRCULARITY AS WELL AS CONCRETE AND CEMENT

were the most promising opportunities that survey respondents perceived in the industry sub-sector.

#### FIGURE 10: MOST PROMISING OPPORTUNITIES IN THE INDUSTRY SECTOR



" They're making progress in decarbonizing steel. In Europe at least, they're talking about hydrogen as the solution to steel and they are already investing a lot, they're redesigning their systems, etc. Huge steel companies now have a consortium and the EU is pouring money into it, and it's incredible how fast the conversation around steel has changed."

- Kamal Kapadia, Terra.do

Image by Valentin Salja, found on Unsplash

35 Ritchie, Hannah et al. "Emissions by Sector."

36 UNEP "Our Planet is Choking on Plastic"

37 EPA (2023)
# BUILT ENVIRONMENT



Image by Gritt Zheng, found on Unsplash

## KEY STATISTICS ON BUILT ENVIRONMENT AND CLIMATE

Residential and commercial buildings consume over half of all electricity.<sup>38</sup> Emissions from air conditioning and refrigeration are expected to rise by 90% from 2017 levels by 2050.<sup>39</sup>

The built environment generates **40% of all global GHG emissions**.<sup>40</sup>

If you look at the scale of people that are going to need cooling in the next decades as temperatures rise, I don't think we're going to get there if we focus only on incremental efficiency gains, especially since a lot of the African market is going to be people using second-hand air conditioners from other countries. Innovation in that space and thinking about how we do that differently is critical."

- Katie Auth, Energy for Growth Hub

## HEATING AND COOLING AS WELL AS ENERGY EFFICIENCY AND CONSTRUCTION

were identified by survey respondents as the most promising opportunities in the built environment sub-sector.

## FIGURE 11: MOST PROMISING OPPORTUNITIES IN THE BUILT ENVIRONMENT SECTOR



Image by Steven Weeks, found on Unsplash

- 38 "Global Status Report for Buildings and Construction: Towards a Zero-Emission, Efficient, and Resilient Buildings and Construction Sector."
- 39 United Nations, "ActNow Facts and Figures–Home Energy."
- 40 Architecture 2030, "Why the Built Environment?"

# GHG CAPTURE, USE AND REMOVAL



Image by Marjin Vandevoorde, found on Unsplash

## **KEY STATISTICS ON** GHG CAPTURE, USE AND REMOVAL

Carbon capture, use, and storage technologies can capture more than 90% of CO2 emissions from power plants and industrial facilities.<sup>41</sup>

Carbon capture can achieve 14% of global GHG emissions reductions needed by 2050.42

Deforestation contributes up to 10% of CO2 emissions caused by human activity.43

" High quality forestation projects include native forest restoration, agroforestry, and any ones that work in partnership with small landowners, indigenous communities or local communities in key biodiversity areas where you're part of a key hydrological watershed. Restoring forests also contributes to protecting forests that otherwise would be cut down, and so there's a systems piece here. We need projects that are going far beyond carbon capture in terms of the ecosystem service benefits, biodiversity, the livelihoods, community benefits, but also need projects that are a part of a larger system that are the beginning of what could be landscape level restoration and protection for some of the key ecosystems around the world."

- Eric Wilburn, Nature Based Solutions expert

## FORESTATION AND HABITAT RESTORATION

were the most promising opportunities perceived by survey respondents in the GHG capture, use and removal sub-sector.

#### FIGURE 12: MOST PROMISING OPPORTUNITIES IN THE GHG CAPTURE, USE AND REMOVAL SECTOR



- " Nature based solutions are arguably the most cost effective approach and they have wide impact beyond climate mitigation and adaptation. They have community and biodiversity benefits that go beyond pure carbon benefits. Nature based solutions can bring together all of these types of impact into one project, to meet several objectives at the same time. Agroforestry is a great example of this, helping with everything from food security and job creation to building more resilient forests. There is also an important overlap between nature based solutions and technology solutions - e.g. biochar - that we need to acknowledge as well."
  - Tim Christopherson, Salesforce

Image by Renaldo Matamoro, found on Unsplash

41 Center for Climate and Energy Solutions (C2ES) "Carbon Capture."

42 Ibid 43

# MANAGEMENT AND REPORTING

Image by Mika Baumeister, found on Unsplash

## KEY STATISTICS ON MANAGEMENT AND REPORTING

The global emissions management software market is expected to reach \$43.6 billion by 2030, with a 15.7% CAGR from 2021 to 2030.<sup>44</sup>

A study that examined 48 urban inventories in the US found that they **underestimated emissions on average by 20%**.<sup>45</sup>

- " In order to advance well in your sustainability strategy, including managing climate risks and opportunities, as well as, reporting requirements for compliance (i.e. for investors, customers, and/or statutory), one needs to have a robust and reliable measuring mechanism. To date, most large corporations are relying on consultants to do their greenhouse gas (GHG) measurement, reporting, and management, which is very expensive. Software as a Service (SaaS) is much more efficient, cost-effective, and scalable. There is also an huge opportunity to work with smaller companies - carbon accounting is initially targeted at big corporations, but working with SMEs, which is an integral part of many companies' value chain, can be a new opportunity to help close the existing gap in Scope 3 (i.e. the value chain emissions). The same is true geographically. Outside of the US, UK and EU there is a need to build in measurement, management and reporting disclosures more quickly."
  - Julie Mae Gabato, Persefoni

### **EMISSIONS DATA, MONITORING**

### MANAGEMENT AND REPORTING, AS WELL AS CLIMATE RISK AND RESILIENCE MANAGEMENT

were the most promising opportunities perceived by survey respondents in the management and reporting sub-sector.

#### FIGURE 13: MOST PROMISING OPPORTUNITIES IN THE MANAGEMENT AND REPORTING SECTOR



Image by Markus Spiske, found on Unsplash

## MOVING FORWARD

Despite a significant increase in funding and an influx of talent and startup activity, climate tech is still a young field and faces many challenges to building, implementing and scaling solutions. These include the need for additional and diverse funding sources, mobilizing more support from government and corporate entities, talent and workforce, supporting adaptation goals, and ensuring that solutions reach vulnerable communities and populations, among others. Addressing these concerns should be a top priority. This section will explore five significant themes that emerged during conversations with experts. These themes shed light on how we should direct our efforts to ensure that funding, solutions, and the surrounding ecosystem are scaling efficiently and equitably.

Image by Qingbaao Meng, found on Unsplash

## FIGURE 14: PRIORITY AREAS FOR IMPROVING CLIMATE TECH ECOSYSTEMS GLOBALLY

### **PRIORITY AREA**

## 1) FUNDING

Main objective: Increase the amount, as well as types of available funding for climate tech innovations.

### **KEY INSIGHTS**

- More climate funds are being launched, and more investment is flowing into climate tech, yet we need to diversify the funding supply
- Grant and concessional funding are critical yet in low supply – e.g. hardware risk and long timelines for realizing returns are prevalent, creating the need for patient and low returns capital
- Mismatches between sectors of highest impact and where investment is flowing could impede progress

## 2) GOVERNMENTS AND CORPORATIONS

Main objective: Governments and corporations must help enable climate tech growth and impact at the national and local levels.

- Supporting R&D, helping to accelerate market access and development, enable testing of new technologies in the market, etc. are all within the public sector remit
- Need taxonomies around climate tech, climate funding, ESG, etc. to better streamline efforts
- Creating an enabling environment for climate tech, whether through regulation that favors climate tech (such as feed-in tariffs), phasing out of fossil fuel subsidies, or providing subsidies (such as accelerated depreciation, etc) for climate tech

## 3) TALENT AND WORKFORCE

Main objective: Create national strategies to build the talent pool for climate tech.

- Climate tech investment and climate finance, in general, are already creating jobs, and are predicted to continue to be massive employment generators in the future
- Deep technical skill sets and industry experience are in high demand, but currently difficult to access
- Need private sector partnerships with universities and academia, as well as educational guiding frameworks

## FIGURE 14: PRIORITY AREAS FOR IMPROVING CLIMATE TECH ECOSYSTEMS GLOBALLY

## PRIORITY AREA

4) DEVELOPING COUNTRIES AND VULNERABLE POPULATIONS

Main objective: Ensure that climate tech solutions are reaching communities vulnerable to climate change both in developing countries and developed countries.

## 5) ADAPTATION

Main objective: Build out the adaptation solution set and create the necessary investment strategies around it.

## **KEY INSIGHTS**

- Few funds and climate tech solutions are built to focus on developing countries and vulnerable populations
- Tech transfer and local capacity in developing countries are lacking, and must be improved to attract capital and talent
- Local populations need to be included in the process of designing and deploying climate tech solutions, which often need to be customized to fit local contexts

- Adaptation funding globally is lacking, and the bulk of climate tech activity to date has focused on mitigation
- Need to define where the main adaptation investment opportunities are, and the appropriate types of capital and instruments to fund them

## 1) FUNDING INCREASE THE AMOUNT, AS WELL AS TYPES OF AVAILABLE FUNDING FOR CLIMATE TECH INNOVATIONS

Image by Josefin, found on Unsplash

## Although climate tech funding and overall climate finance have significantly grown in recent years, major inancing gaps still remain.

For instance, the Climate Policy Institute suggests that climate finance (including VC and other types of funding) must increase from USD \$640 billion in 2020 to USD \$4.35 trillion annually by 2030 to almost USD \$6 trillion by 2040 in order to maintain the 1.5 °C target.<sup>46</sup> While this encompasses all forms of climate finance and not all of it will focus on climate tech, climate tech will feature prominently within it. Experts interviewed emphasized the need for more and faster capital deployment for every stage of the technology development cycle – e.g. R&D, pilots, and commercialization.

" Few people realize just how much capital we need to deploy and how much energy and other infrastructure we need to build. For example, plants for hydrogen at scale require enormous amounts of infrastructure. I think the scale of that construction is not grasped by many."

- Gabriel Kra, Prelude Ventures

Grant funding and pre-seed funding were the two-most cited funding needs, suggesting that more instruments and strategies beyond VC are needed.

Grants from foundations and public sector entities could be instrumental for proving first-of-a-kind technologies, as well as providing longer financial runway for more R&D-intensive companies that require more time to pilot. FIGURE 15:

## WHERE IS MORE FUNDING FOR CLIMATE TECH SOLUTIONS NEEDED?



### Grant funding can have a particularly high impact on early-stage climate startups.

Early grants may in fact have a significant positive impact on the ability of climate-tech startups to survive to later stages and raise follow-on funding. For example, based on a sample of over 1,000 climate startups in the U.S., companies that received a grant were twice as likely to raise more funding in the future, and were also more likely to survive.<sup>47</sup>

### FIGURE 16: IMPACT OF EARLY-STAGE GRANTS ON CLIMATE TECH STARTUPS



Berlow, Eric and Jones, Ryan. "Venture capital investors in climate tech are closer to government than they might want to admit" Impact Alpha, 2023. https://impactalpha.com/venture-capital-investors-in-climate-tech-are-closer-to-government-than-they-might-want-to-admit/

47

## Mismatches between sectors of highest impact and where investment is flowing could impede progress.

While climate challenges and climate technology vary by region, interviewees across geographies mentioned that sectors such as the built environment, heavy industry, and agriculture and land use were all underinvested. Others insisted that we need to broaden the conventional definition of climate tech to include water and waste technologies, as well as nature tech (technology designed to enable and scale nature based solutions), and that these technologies were in dire need of investment.



The chart above, adapted from PwC and supplemented with data from Climate Policy Initiative, shows the discrepancies between sectors receiving the most funding and those producing the most emissions. Notably, the bulk of VC funding has gone to transportation, while a disproportionately low amount went into the built environment and food agriculture and land use, despite these sectors emitting similar amounts of GHG relative to transportation and energy.<sup>50</sup>

Climate tech funding needs may also differ between geographies. For example, interviewees in Africa highlighted that while much effort had gone into decentralized renewables, another pressing priority in the region was strengthening and providing clean power to central grids for commercial and industrial activity. Interviewees in Southeast Asia and Latin America mentioned that while mobility has received significant investment to date, agriculture and land use is an area of great importance that requires more funding.

## Diversifying climate investment products can accelerate capital allocation.

" We've spent a lot of time trying to figure out what are the other types of capital beyond VC or private equity. There's a gap in familiarity around other types of capital or even off balance sheet structures that become very useful under policies like the US Inflation Reduction Act. And then just familiarity of the VC ecosystem with other types of financial products - in the last 25 years of mostly software investing, it just wasn't necessary to know much about other types of capital."

- Shaun Abrahamson, Third Sphere

Several interviewees held the view that we need more instruments than standard venture capital to fund climate tech companies. For example, some types of climate tech will not generate the returns that VC's seek, while others need longer timelines for testing and implementation in the market. Hardware startups are prominent in the climate tech space, and typically have much longer testing and launch periods, and may not be a fit for many VC's.<sup>51</sup>



Image by Anthony Melone, found on Unsplash

Many climate entrepreneurs will need a range of different funding instruments. Companies who build R&D-intensive products may need longer financing runways, just as first of a kind technologies and novel solutions may need more time for adoption in the market. The below figure maps out the range of different instruments that could build out the climate tech capital stack.



#### Note:

Visual is meant to show a potential fundraising scenario, though specific types of funding will vary across business models and technology readiness levels, and not all types of capital will be needed or applicable for all types of climate companies.

2) GOVERNMENTS AND CORPORATIONS CORPORATIONS AND GOVERNMENTS MUST HELP ENABLE CLIMATE TECH GROWTH

Image by Ricardo Gomez Angel, found on Unsplash

## Over 60% of respondents said that corporations need to play a larger role in supporting climate tech companies, and over 50% pointed out that governments need to as well.

Large corporate entities—e.g. utilities —as well as government agencies can help throughout a climate tech company's life cycle. From R&D funding, to product testing support, to large market access and contracts, corporate and government players have a significant role in the climate tech ecosystem.



- " Decarbonizing our energy sector requires utilities to play a leading role. I believe utilities want to innovate, but they have a hard time doing so given the way they are financially structured and the critical role they play in the health, safety, and continuity of our economy. They need to deliver power all the time, and failure to do so is not an option. But a renewables sector plagued by interconnection delays and transmission constraints is equally troublesome for our planet. We must meet this challenge and create incentives for utilities to accelerate the adoption of renewables and foster meaningful innovation in grid management, without compromising anyone's safety."
  - Ryan Dings, ClimateHaven

## Over 60% of respondents said that governments need to play a larger role in enabling market access for climate tech solutions and incentivizing the adoption of new technologies.

Survey respondents stated that incentivizing adoption in the market, pricing externalities, and passing regulations to phase out old technologies were three ways in which governments can support the climate tech ecosystem. To date, government incentives, regulations, and investments in countries such as the United States have been crucial to some of the most notable climate tech success stories-e.g. accelerating solar energy and electric vehicles adoption in the US and EU. Legislations passed by the US government in 2022 -e.g. the Inflation Reduction Act and the CHIPS and Science Act are set to have catalytic impact on climate tech adoption.<sup>52</sup> With these new policies in place, the US government will spend over US\$500 billion on climate technology over the next 10 years, three times levels during the 2009-2017 period, and 15 times higher than in the late 20th and early 21st centuries.<sup>53</sup> Even in low-income countries, interviewees pointed to solutions such as minigrids in Nigeria and utility-scale solar in India as examples of other climate technologies that have scaled in part due to government support.

### FIGURE 20: GOVERNMENT'S ROLE IN SUPPORTING CLIMATE TECH



" It's not just carbon, it's a lot, lot deeper than that. What we've struggled with in India, for example, is that the policy framework is not really there yet. India is very far from the 2070 net zero commitment. There is a lack of political movement to push climate into the mainstream. Climate is ultimately politics and therefore technology has an important role to play to make the political conversation easier but ultimately somebody has to win elections on something that looks like a climate plank, and that hasn't really happened."

- Anshuman Bapna, Terra.do



Image by Yen Vu, found on Unsplash

Pricing externalities is a critical role that governments can play to enable a just transition, but an area that has historically been challenging.

" Government needs to champion the use of green technology. There must be a very big push on a very high level from the national government. They should be able to propagate the adaptation of green technology. So far, there has been little messaging from the government in terms of the benefits of adopting green technology. There needs to be a deliberate long-term plan by our government in terms of green technology, it needs to be laid bare. We also must have crosssectoral collaboration where the Ministry of Energy pushes for adaptation of green energy, and does so in collaboration with the Ministry of Trade. Having that crosssectoral collaboration from a national perspective would add a lot of value."

### - Ruth Ndegwa, (formerly) Kenya Climate Innovation Center

Image byMatthew TenBruggencate found on Unsplash



For example, since the 1997 Kyoto Protocol, there has been an ongoing effort for governments around the world to price GHG emissions, in the hopes of building a market and making an economic case around reducing emissions.<sup>54</sup> While both survey respondents and interviewees agreed that putting a price on carbon could help in making climate technologies more viable, success in this domain has been mixed, to date.<sup>55</sup> In addition to the lingering challenges of pricing emissions, interviewees also pointed to parallel, counter-productive efforts from government that have stifled climate tech innovation. For instance, in both Sub-Saharan Africa and Southeast Asia, governments have subsidized fossil fuel companies, and without equivalent schemes for renewables, coal, gas, and oil continue to dominate. Utilities that are constrained by limited fiscal and operational resources were another frequently mentioned challenge. In low-income countries, failing grids and credit risk make it difficult for renewable energy producers to effectively sell power to a centralized grid. Moreover, a functioning centralized grid is critical infrastructure for other climate technologies that run on electricity (electric vehicles, electric stoves, etc.). Corporations also create similar bottlenecks. Interviewees in Southeast Asia and Latin America discussed difficulties to incentivize corporations to adopt new technologies in the conventional agriculture, forestry, and land use sectors, especially if the benefit to their profitability is not apparent.

 54 United Nations Framework Convention on Climate Change (UNFCCC), "Emissions Trading"
 55 Ibid.

## 3) TALENT AND WORKFORCE STRATEGIES ARE NEEDED TO BUILD THE TALENT POOL FOR CLIMATE TECH

Image by Ben Lambert, found on Unsplash

## Nearly 40% of respondents pointed to talent as being a key constraint, second only to needing more support from governments and corporations.

The success of climate technology is contingent on a massive "human element"-i.e. talent and workforce. There is no single figure that guantifies the demand for talent in the climate-tech field, though, for starters, the International Labor Organization reports that a greener economy could create 24 million jobs worldwide. While it's difficult to break down this figure further, these jobs will likely be a mixture of new firms and projects focusing on climate mitigation and adaptation, as well as in incumbent firms as they transition from fossil fuels to clean energy and reduce Scope 1, 2, and 3 emissions. Keeping pace with demand for new solutions is contingent on having a pipeline of entrepreneurs and skilled professionals that possess the requisite expertise.

## Despite the growing interest in working on climate, we need unprecedented levels of talent to enter this field.

We urgently need to close climate financing gaps, yet talent gaps are being discussed increasingly.<sup>56</sup> Interviewees pointed out how waves of people in the US and EU in particular, at every stage in their careers, are searching for jobs that focus on some aspect of addressing climate change. They also point to how this trend has been a critical enabler to the climate tech boom in those geographies. The climate "talent stack" is diverse – entrepreneurs, engineers, scientists, community leaders, architects, urban designers, policy-makers, and economists,

to name only several - and activating it will require wide scale policy response.



Image by Marcos Paixão, found on Unsplash

" A lot of climate tech start-ups do require founders to have domain expertise, which can only come after a few years in industry. In South Asia, we don't see too many entrepreneurs coming straight out of university. Most of the best climate entrepreneurs are professionals from industry who then find a problem to solve in that industry. Especially today with the climate tech space consisting predominantly of B2B businesses, we need more domain expertise both on the founder and investor side of things."

- Nalin Agarwal, Climate Seeds Fund

### FIGURE 21: BUILDING THE CLIMATE TECH TALENT STACK<sup>57</sup>



## Talent constraints could be even more prominent in developing countries.

- " India is an ideal global climate tech leader due to the abundance of natural resources, the regulatory push for decarbonization of sectors, and a large pool of talent building innovative technologies, however, the startup venture ecosystem needs more patient and diverse capital to grow exponentially for the country to reach its net zero goals."
  - Himanshu Sharma, Theia Ventures

Interviewees based in Asia, Africa, and Latin America frequently pointed to the lack of sufficient talent and workforce as a barrier to building and scaling of climate tech companies. Constraints were more pronounced in particular for companies building earlier stage technologies (e.g. low carbon cement startups), as well as the larger pool of skilled workforce required to build and operate climate technology at scale (e.g. solar plants across).

Interviewees pointed to a combination of brain drain, which has a higher frequency in developing countries, as well as lingering educational challenges and minimal private sector growth as impediments to talent access in developing countries.<sup>58</sup> Climate change may in fact exacerbate these conditions. For instance, ample literature suggests that an increase in climate-related natural disasters can lead to increased migration, which could worsen brain drain in some markets and generally disrupt labor outcomes.<sup>59</sup> As the occurrence of climaterelated calamities rises and climate-induced migration intensifies, the emigration of skilled workers could increasingly deplete the talent pool in developing nations.<sup>60</sup>

Image by Madison Oren, found on Unsplash



## 4) DEVELOPING COUNTRIES AND VULNERABLE POPULATIONS CLIMATE TECH SOLUTIONS MUST REACH DEVELOPING COUNTRIES AND VULNERABLE POPULATIONS

Image by Simon Berger, found on Unsplash

## Beyond the question of which technologies are underfunded, there is also the question of who climate tech is (or is not) serving

Eighty-nine percent of survey respondents do not believe that climate tech solutions are reaching the people who need them most. Low-income communities and developing countries are already feeling the effects of climate change and are under-equipped to address them. While climate tech holds immense promise, by and large it is not reaching those in most need. Similarly the majority of climate tech funding originates from as well as targets wealthier countries, and, in terms of global climate finance flows, wealthier countries have consistently fallen short of meeting their climate finance pledges to developing nations.<sup>61</sup> For example, only 8% of energy transition investments in 2021 went to emerging markets.<sup>62</sup>

## FIGURE 22: CLIMATE TECH SOLUTIONS AND VULNERABLE COMMUNITIES

Q: To what degree do you agree with the following statement: climate tech solutions are adequately reaching the populations that are most vulnerable to the impacts of climate change?



Interviewees had differing perspectives on this issue—while there was broad consensus that climate tech is neglecting vulnerable communities, some interviewees believed that the current focus on mitigation—i.e. ensuring that countries with the most emissions, which tend to be wealthier countries, reduce those emissions—is the best way to limit the impact of climate change on developing countries. Others believe that we need to focus on aggressively expanding renewable energy in developing countries, especially in regions where energy demand is expected to dramatically rise. Another group underlined the need to prioritize technology for adaptation, which received only 7.5% of global funding in 2019-20.<sup>63</sup> Engaging local communities in the solution development and deployment process was also a common theme reiterated during interviews.

- 61 Gabbatiss, Josh (2021)
- 62 BloombergNEF (2022)
- 63 Climate Policy Initiative (2022)

## Equity and inclusion are also critical to building a healthy climate tech ecosystem, yet to date these principles have not taken root.

There are few examples of climate technologies that are built in order to serve marginalized communities and under-represented populations. For example, in the U.S., among energy and mobility startups, mentions of equity, inclusion and similar themes in company descriptions and mandates are rare. Fewer than 10% of companies focusing on electric vehicles, energy efficiency, battery charging, and transit have any discussion of equity and justice in their mission statements.

#### FIGURE 23: MENTIONS OF EQUITY AND JUSTICE IN COMPANY MISSION STATEMENTS<sup>64</sup>



" We have to involve the local communities from the ground up. If the local population does not buy into a solution, it won't work. This means that we need to work directly with local organizations at the community level, in both rural and urban areas. There is of course a role for third party support, but they need to help in building local understanding of different technologies as opposed to playing the role of directly choosing what type of climate innovation to adopt. You must partner with groups that understand the local situation, have the local knowledge both for what the needs are, but also for how to roll these things out and make them successful.

#### - Sarah Bermeo, Duke University

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Berlow, Eric and Jones, Ryan. "Venture capital investors in climate tech are closer to government than they might want to admit" Impact Alpha, 2023. https://impactalpha.com/venture-capital-investors-in-climate-tech-are-closer-to-government-than-they-might-want-to-admit/

Supporting climate tech in developing countries is also critical to ensuring wide access to solutions. While startup ecosystems are growing quickly in many parts of the global south, many are still in their early days, relative to those in the US and EU. Several interviewees in Southeast Asia and Latin America stated that the relatively low number of climate tech deals in their regions can be attributed to this nascency. As one interviewee put it, many countries have not yet had the chance to go through the cycles of building funds and companies that generate capital and expertise, which then get reinvested into the next cycle of funds and companies. Similarly, many climate tech startups build hardware that requires extensive R&D as well as deep technical skill sets, which may not be as widely available in certain geographies.

Climate technology transfer will be critical to supporting low-income countries, though it has typically been a slow process.

"We have all these technologies that we think would be great to use in place of whatever the incumbent technologies are. And very little work has been done to understand people's needs and preferences or even educate people on, and have their voice included in making a choice of 'OK, I think this makes sense for me, I don't think this makes sense for me'."

- June Lukuyu, Energy Growth Hub



Image by Alexander Cifuentes, found on Unsplash

Historically, technologies that support green transition have not found their way into developing countries. For example, during the 2015-2016 period low-income countries accounted for roughly 0.01% of low carbon technology (LCT) exports and 0.3 percent of LCT imports.<sup>65</sup> Around that same time period, high-income countries accounted for around 80% of all LCT innovations and 70% of all LCT exports.<sup>66</sup> There has been improvement since last century, when only 5.2% of global LCT exports flowed from developing to developed countries - by 2016, this proportion had increased to 18.1%. However, there is still a long way to go, to ensure that the poorest countries and most vulnerable populations (in both low and high-income countries) are benefitting from the uptick in climate tech investment and innovation.

" Developing local solutions is as important as importing external solutions. Developing countries should adopt imported solutions to learn and to create new knowledge. But at the same time it is important to develop local solutions according to the local issues. Not every solution is applicable in every country around the world, maybe there are some that do, but there are other ones that need to be created according to a specific situation's needs and markets. Climate change is happening and the consequences will be there for decades, so it is important to create solutions that allow for adaptation, particularly for vulnerable communities."

- Edgar Parra, Innovation Laboratory of the Inter-American Development Bank

## Tech transfer, customization and local engagement are critical to ensuring inclusion in climate tech.

While there are certain climate technologies that can be physically replicated across geographies, they may require different business models and sales strategies for customers to adopt them. One interviewee pointed to how much the success of solar in certain sub-Saharan African countries was due to innovative financing models like pay-as-you-go. Another interviewee shared the example of smart meters in Latin America, noting that even though smart meters financially benefit the customer, the lack of a thoughtful communication strategy for the roll-out of the technology led to its failure in several instances. In other cases, the technology itself must be adapted to local context. One interviewee pointed to the case of electrical vehicles-noting that while the bulk of lightduty EVs in the US are currently passenger vehicles, the bulk of EVs in Asia and Africa are two-wheelers. Finally, there are certain technologies that have to be developed locally to maximize their chances at success. Interviewees who worked on regenerative agriculture and nature-based solutions spoke of the importance of finding solutions specific to the land and communities on that land. Further, respondents noted that climate-tech solutions need to be deployed with the end-user in mind, such as women for many agri-tech solutions and indigenous communities for nature-based solutions. If the tech is not built and deployed with local constraints and considerations in mind, then uptake may be limited.



Image by Chandra Oh, found on Unsplash





## Implementing and scaling climate tech solutions in developing countries still faces investment and transactional challenges.

Perceived and actual risk in emerging markets is a major barrier to unlocking finance, for both climate and non-climate projects and businesses. From deal origination to exit the investment process in these countries is still beset by a range of challenges. A lack of institutional authority, information asymmetries, underdeveloped deal pipelines, few exit pathways and even at times political and security risk, among others, are often-cited challenges preventing capital to flow into lower income countries. The challenge may be even more acute in the most vulnerable nations. As of 2018, only 1% of global Foreign direct investment (FDI) went to fragile and conflict affected situations (FCS).<sup>67</sup>

- " In order for climate tech to really be deployed at the largest scale, there has to be a series of factors, from political stability and an enabling environment to innovative business models that bring in the financial sector of the country. This may also include bringing in multilateral development banks and funds like the Global Environment Facility that can provide concessional finance that is required especially at the early stages of some projects."
  - Patricia Huidobro, Global Environment Facility
- " In parallel to customizing climate technologies to fit with local contexts of developing countries, governments in these countries also have to then address the underlying issues – e.g. regulatory reform, capacity building, etc. - that make it easier to scale these technologies to underserved markets."
  - Olamide Oguntoye, Tony Blair Institute for Global Change

### 5) ADAPTATION

## BUILD OUT THE ADAPTATION SOLUTION SET AND CREATE THE NECESSARY INVESTMENT STRATEGIES AROUND IT

Image by Kalle Kortelainen, found on Unsplash

Globally, there is a massive shortfall in climate adaptation funding, and our research suggested that adaptation solutions in the climate tech stack are also under-represented.

" It is crucial that we bolster our financial commitment towards climate adaptation and resilience. When we talk about the just transition agenda, it's not sufficient to simply focus on mitigation. And we see that when we support climate-resilient technologies in an inclusive way, with the backing of the private sector, the impact is profound. Take for instance, the adoption of drip-irrigation systems. These technologies represent more than just innovative solutions; they are pivotal in enhancing agricultural productivity, with particular benefits for women. Furthermore, they significantly bolster the climate resilience of communities. We need more substantial funding and attention on such transformative, resilience-enhancing initiatives."

Currently, only around 7% of global climate funding (climate tech and other) is being allocated to adaptation projects, and roughly 2% was used for projects that tackle both mitigation and adaptation.<sup>68</sup> Moreover, adaptation finance for developing countries in particular are 5-10 times below estimated needs of US\$ 160-340 billion annually by 2030 and USD 315-565 billion annually by 2050.<sup>69</sup> While climate tech funds typically do not define themselves in terms of their focus on mitigation or adaptation, as most investment to date has gone into the transportation and energy sectors, mitigation tends to be the dominant theme for most funds.

- Ezgi Canoplat, World Bank



Image by Johannes Hofmann, found on Unsplash

## Climate tech has an important role to play in filling the adaptation funding gap, yet there is little sector-wide consensus on what the adaptation solution set looks like.

There is still much debate around the full adaptation technology solution set. Fleshing out the scope of adaptation technologies and the specific barriers they face is a critical step in ensuring more equitable development of climate tech. The suite of products and services within the climate mitigation domain are fairly well-known at this point– technologies that directly reduce or remove GHG's from the atmosphere. Renewable energy, carbon sequestration, energy efficiency, and the larger grid electrification process are all in the mitigation domain, and entrepreneurs and investors are actively converging on these opportunities.



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Image by Annie Spratt, found on Unsplash
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" The issue around climate adaptation is becoming more pronounced because some of these areas that are supposed to contribute to food security have tremendously been affected by climate change. So the arable area, because of population growth and other issues, is diminishing. So what are the options, what do we need to do so that we can be able to push for the arid and semi-arid areas to at least cope with adverse effects of climate change? We are keen to see what technologies are coming up to support adaptation around these areas and also to see if the government can also be able to push and allocate some more resources in their budgetary allocation."

- Stephen Musyoka, Kenya Climate Innovation Center

There is more clarity as well on who the core customer is for these products and services, thus easier for entrepreneurs to build companies that deliver on these needs, and for investors to follow suit. However, adaptation spans a much larger set of needs – protecting coastal communities from rising sea levels, shoring up food and water systems, resilient buildings, insurance products and more accurate forecasting of extreme weather events are all part of the adaptation solution set.<sup>70</sup> Part of the challenge in funding scalable adaptation is that many of the solutions may need to be tailored to fit local contexts, thus are not as easily replicated across geographies.



Image by Ivan Bandura, found on Unsplash

- " A lot of the adaptation solutions I've come across are focused on a mixture of technology as well as behavioral change. For instance, in the land use change and forestry sector, a lot of it has to do with just changing farming practices and changing behaviors, which tends to be very specific to the local context. Adaptive measures need to be tailored to the communities that they're going to be implemented in."
  - Habiba Daggash, RMI

While climate change is a global phenomenon, countries and populations will ultimately experience it differently. Small island developing states and coastal cities, agriculture-based communities and countries, and densely populated metropolitan areas will all need unique adaptation strategies and solutions. Thus, it is more difficult to pinpoint one singular business model or investment strategy that can be scaled across these varied needs. Adaptation is also critical to the discussion of bringing climate tech solutions into developing countries and vulnerable populations.



Image by Larm Rmah, found on Unsplash

As of 2019, the 46 least-developed countries (LDCs) in the world contributed roughly 1.1% of global CO2 emissions from fossil-fuel combustion and industrial processes.<sup>70</sup> Even beyond the LDCs, developing countries account for a small percentage of global emissions. For example, India's per capita coal consumption was roughly half the global average in 2019.72 And while developing countries have accounted for only 21% of historical carbon emissions, they are being disproportionately affected by climate change.<sup>73</sup> In fact, climate change has already increased economic inequality between developed and developing nations by 25% since 1960, and an estimated 100 million people in developing countries may be pushed into poverty by 2030, as a result of climate change.<sup>7475</sup> Adaptation in developing countries is tantamount to protecting and sustaining their populations and livelihoods. While not every adaptation solution will have a technology component, there is a large role that climate tech can play in these geographies to help with adaptation agendas. Startups building better algorithms for weather forecasting, companies improving public health outcomes, and building more resilient infrastructure all fall in the adaptation category.<sup>76</sup>

- 71 UNCTAD (2021)
- 72 Tongia, Rahul (2022)
- 73 Center for Global Development (CGD) "Developed Countries are responsible for 79% of historical carbon emissions"
- 74 Garthwaite, Josie (2019)
- 75 U.S. Global Leadership Coalition (USGLC) (2021)
- 76 United Nations Framework Convention on Climate Change (UNFCCC) (2006)

#### FIGURE 24: DEFINING THE CLIMATE TECH ADAPTATION SOLUTION SET<sup>77 78</sup>

CATEGORY	USE CASES
WATER	MAIN NEED Safeguard current water supplies while also scaling technologies that can support in the sanitation, transportation, conservation and even the re-use and creation of water.
	<b>OPPORTUNITY</b> Purifying and recycling, desalination, managing and conserving water, as well as creating water in the face of increasing water scarcity.
AGRICULTURE	<b>MAIN NEED</b> Ensure that agriculture systems can continue to function and properly, so that food can be sustainably produced and equitably distributed, and overall ensure food security.
	<b>OPPORTUNITY</b> Resilient crops that can withstand droughts and floods, better irrigation systems, as well as bolstering supply chains to ensure that food can be steadily distributed, regenerative agriculture techniques.
WEATHER FORECASTING	MAIN NEED Improve climate models that can provide more accurate predictions on where and how societies will be most impacted and improve early warning systems
	<b>OPPORTUNITY</b> Deep-tech innovations - e.g. sensors and supercomputing solutions to guide investment, emergency response, and policy decisions, among others.
HEALTH	MAIN NEED Provide better and more accessible preventative and curative treatments for air, water and food-born diseases.
	<b>OPPORTUNITY</b> Innovations around infectious disease treatment, as well as supply chain protection and other innovations to improve delivery of medicine and provision of medical supplies.

Ibid
Produced by Oxford Climate Tech Initiative team, with support from interviewees and insights taken from The Hot New Sector in Greentech: Adaptation. Reuters, 2010.

#### FIGURE 24: DEFINING THE CLIMATE TECH ADAPTATION SOLUTION SET (CONTINUED)

CATEGORY	USE CASES
COASTAL ZONES	MAIN NEED Protect communities and economies in coastal zones against rising sea levels and extreme weather events.
	<b>OPPORTUNITY</b> Better data to predict the timing and severity of extreme weather events in coastal areas, as well as innovations in hardware and infrastructure to safeguard real estate against rising tides, such as sea walls, artificial reefs, and artificial mangroves.
INFRASTRUCTURE	MAIN NEED Fortify infrastructure (buildings, roadways, ports, etc.) as temperatures rise and extreme weather events become more frequent.
	<b>OPPORTUNITY</b> More resilient materials to make infrastructure able to withstand extreme weather, as well as sensors to provide reliable monitoring of buildings, roadways, building of new shelters for relocation
FINANCE	MAIN NEED Build innovative finance products that can respond quickly to extreme weather events, and also incentivize more private sector investment.
	<b>OPPORTUNITY</b> New insurance products to provide better-informed and faster- deployed funding in response to climate-related damage.
PUBLIC SECTOR	MAIN NEED Local and national governments need better strategies for dealing with climate risk, including understanding specifically how their constituents and economies will be affected by climate change and preparing accordingly.
	<b>OPPORTUNITY</b> Build disaster risk management strategies and tools to help governments prepare for addressing the range of climate change challenges unique to their areas.

It is important to note that the technologies in Figure 24 are not exhaustive and that, as adaptation needs vary from population to population, the solutions will be equally diverse. Additionally, the solution set includes a mixture of hardware and software technologies, with a spectrum of risk-return profiles, meaning that not all will be relevant for VC strategies. As such, a range of investors and investment strategies are needed to meet adaptation goals.

## DEEPENING THE KNOWLEDGE BASE

This research is just the beginning of the conversation on how to advance the climate tech ecosystem globally and capitalize on the climate tech opportunity. Given that the climate tech field is still young, there are many areas where we need to deepen the knowledge base. The below list provides a snapshot of some of the key questions needing answers, which we hope can help shape a more robust research agenda.

## PRIORITY AREA KEY RESEARCH QUESTIONS

## 1) FUNDING

- What types of funding beyond standard equity and debt instruments are most needed, particularly for R&D intensive and hardware companies?
  - What innovative financing solutions can be leveraged in climate tech?
  - Which organizations are best suited to provide grants and concessionary funding to early stage climate tech solutions, and how do we mobilize support from them?
- How do we ensure that the sectors with the greatest potential for impact are receiving the necessary funding?

## 2) GOVERNMENTS AND CORPORATIONS

- How do governments and corporations add value across the lifecycle – from conceiving and commercializing solutions all the way to scaling and liquidity events?
- What are the specific partnership strategies that climate tech startups can pursue with governments and corporations?
- · How do governments avoid crowding out investors?
- What strategies and policies can governments provide to encourage investments in climate tech?

## 3) TALENT AND WORKFORCE

- What are the necessary taxonomies and frameworks for education and employment in the climate tech sector?
- How do we improve the linkages between the private sector and academia to ensure a steady flow of talent from universities and research centers into climate tech companies?
- How do we rapidly upskill individual students and job seekers as well as larger populations to ready them for working in climate tech, at scale?

## DEEPENING THE KNOWLEDGE BASE

PRIORITY AREA

### **KEY RESEARCH QUESTIONS**

## 4) DEVELOPING COUNTRIES AND VULNERABLE POPULATIONS

- How do we improve investment conditions for climate tech in developing countries?
- What types of climate tech solutions, both mitigation and adaptation, are most needed in developing countries?
- How do we engage local communities in the development and implementation of climate tech solutions?
- Which organizations are best-placed to lead climate tech efforts in developing countries and vulnerable populations?
- Which resources beyond funding e.g. policy, talent, etc. are most critical to supporting climate tech innovation in these markets?

## 5) ADAPTATION

- What does the full climate tech adaptation solution set look like?
- Are there specific business models that are more prevalent amongst adaptation solutions?
- Which funding vehicles and strategies are most applicable for adaptation solutions?
- How do we customize adaptation solutions to different contexts?
- What are the best metrics for quantifying adaptation impact?



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## THE CLIMATE TECH OPPORTUNITY

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