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## **Do the Ends Represent the Means? Assessing Adaptive Capacity Determinants against Proactive and Reactive Adaptive Actions in Vietnam's Coffee Growing Region**

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Title: Do the ends represent the means? Assessing adaptive capacity determinants against proactive and reactive adaptive actions in a smallholder system

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## Abstract:

With the introduction of the Global Goal on Adaptation in the Paris Agreement and the mandate to track progress under it, there is an increased demand to assess adaptive capacity to climate and weather risk. In this analysis, we explore how determinants of adaptive capacity relate to proactive and reactive adaptive behaviors. Using a household panel survey in a coffee growing smallholder system in Vietnam, we empirically evaluate three types of adaptive actions: i) *response* to experienced shock events (reactive), ii) *preparation* for perceived future shock events (proactive), and iii) *adjustment* to climate change and slow onset risk (proactive). We find that proactive actions towards shock events (ii) and towards climate change (iii) reflect adaptive capacity theory well—although not identically, while reactive actions towards shocks (i) need more clarification. Our results confirm that key determinants of adaptive capacity do not always lead to increased action, heterogeneously depends on the type of risk and if actions were taken proactively or reactively. The approach allows us to address challenges of conceptual ambiguity—particularly the cyclical nature of determinants and behavior. Our results have implications for designing and monitoring adaptation and development interventions, necessitating a better understanding of the underlying determinants than differentially influence adaptive actions.

## Significance Statement:

Farmers and those working in agriculture are some of the first people to experience climate change, as their livelihood is dependent on the weather. As such, they are already acting in innovative ways in order to deal with new and unexpected changes. Sometimes farmers are dealing with heavy rain events, floods, or droughts, what we call weather shock events. Other times they are dealing with slow changes, such as increasing temperature from year to year, or the gradual delay of the start of the growing season. Farmers can address these events and changes by preparing for them in advance or trying to react to the impacts after the fact. While programs and policies often aim to support the ability of farmers to prepare for and respond to the shocks and changes that they experience, it is not always clear what resources can be provided to best support them. In this article, we look at how coffee growers in Vietnam act in the face of shocks and changes, and how these actions relate to the different resources that the farmers have access to. We find that our understanding of what supports farmers to act is based primarily on resources that allow them to prepare in advance, and not necessarily to react, meaning that more research is needed on what resources can help farmers respond to change in diverse ways.

## 57 1. Introduction

58 As climate risks intensify, along with other environmental and economic pressures in agricultural  
 59 systems, understanding the capacity of farming households to respond, prepare, and adjust  
 60 accordingly becomes increasingly critical. Adaptive capacity– the ability of individuals, households,  
 61 or communities to act in the face of climatic and weather risks– is predicated on the differentiated  
 62 socio-ecological, political, cultural, and individual contexts (Adger 1999; Adger et al. 2013;  
 63 Balikoowa et al. 2019; Chauhan et al. 2020; Grothmann and Patt 2005; Gupta et al. 2010; Huynh  
 64 and Resurreccion 2014; Shukla et al. 2019). Acknowledging the complex contexts in which adaptive  
 65 capacity manifests, introduces challenges to define, monitor, and assess progress (Andrade and  
 66 Szlafsztajn 2018; Ford et al. 2018). This often results in non-standardized characterization and  
 67 measurement of adaptive capacity (Siders 2019) and often leaves the predictive power of adaptive  
 68 capacity theory for adaptive actions largely unexamined. The Global Goal on Adaptation to  
 69 “enhance adaptive capacity, strengthen resilience, and reduce vulnerability to climate change” and  
 70 the mandate to track progress on it introduced under Article 7 of the Paris agreement, reinforces  
 71 the urgency to find workable solutions for characterizing and measuring adaptive capacity, in its  
 72 entire complexity. In order to do so, researchers and practitioners will have to find ways to  
 73 reconcile inconsistencies in definitions of adaptive capacity (Siders 2019; Vincent 2007), quantify  
 74 indicators for adaptive capacity (Siders 2019; Yohe and Tol 2002), and deal with the cyclicity and  
 75 non-linearity between adaptive capacity *determinants*, the influencing and enabling factors, and its  
 76 *outcomes*, the resulting behaviors, actions and state changes (Engle 2011; Mortreux and Barnett  
 77 2017). Adaptive capacity outcomes can be defined across a spectrum: from behavioral change, such  
 78 as implementing climate change adaptation (what we call actions) to changes to certain state  
 79 variables, such as increasing well-being, financial stability, or preparedness. Recent research that  
 80 assesses the relationship between determinant and outcome provides theoretical and empirical  
 81 evidence that adaptive capacity determinants (i.e. resources or assets) do not always lead to  
 82 adaptive actions and ensuing vulnerability reduction outcomes (Mortreux et al. 2020; Mortreux and  
 83 Barnett 2017). This means that the theoretical basis for adaptive capacity used in adaptation  
 84 research and policy could be improved by better formalizing the relationship between multi-  
 85 faceted determinants and the behaviors that they enable. In this article, we first make a clear  
 86 distinction between determinants and outcomes of adaptive capacity, in order to prepare a clean  
 87 empirical slate to examine the relationship between them. Then, in order to make the complexity in

88 adaptive capacity outcomes more granular, we differentiate and define categories of adaptive  
 89 actions into proactive versus reactive, as well as addressing weather risk versus climatic risk, using  
 90 the example of coffee growers in the Central Highlands of Vietnam. We focus on “actions” coffee  
 91 growing households undertake, synonymous with behaviors, as it aligns with the renewed calls to  
 92 focus adaptive capacity on the context that allows individuals and communities *to act*, to enact  
 93 change, both incremental and transformative (Dilling et al. 2019; Nussbaum 2009; Sen 1985;  
 94 Shepherd and Dissart 2022).

95 Within literature that does assess adaptive actions, there is a ‘divide’ between those that assess  
 96 coping, e.g. reactions to weather shocks (see e.g. Jain et al., 2015; Notenbaert et al., 2013), versus  
 97 climate adaptation, e.g. adjustments towards slow-onset climate change (see e.g. Asfaw et al.,  
 98 2016; Below et al., 2012). There is limited empirical research on how adaptive capacity  
 99 *determinants* (i.e. resources or assets) are linked to multiple actions (Engle 2011), as most adaptive  
 100 capacity assessments focus on the description of adaptive capacity or focus on a single adaptive  
 101 action (recent works that have addressed multiple adaptive actions are outlined in Section 2).  
 102 Establishing a link between determinants and actions they enable is made challenging in the first  
 103 place, due to overlapping definitions of what is a determinant versus an outcome of adaptive  
 104 capacity. For example, “agricultural diversity” has been defined as a component to adaptive  
 105 capacity— sometimes as a determinant (primarily as a state variable), sometimes as an outcome  
 106 (primarily as a behavioral change), and sometimes without specification. Assessing the relationship  
 107 between determinants and outcomes is further challenging due to what Engle (2011) refers to as  
 108 ‘latency.’ Latency refers to the cyclical nature that occurs when adaptive capacity determinants can  
 109 facilitate the adaptive actions, which can in turn increase adaptive capacity determinants, in a  
 110 manner that can involve temporal delay, non-linearities, and non-tangible processes. For example,  
 111 high levels of financial resources may allow a household to implement irrigation, which in turn can  
 112 increase their agricultural income. One way suggested by Engle (2011) to address this cyclical nature is  
 113 to look dynamically at a system or actor: pre- and post-shock event, to see the preparation  
 114 beforehand (proactive), and the ability to cope afterwards (reactive). However, many shock events  
 115 are not predictable, and it is only by chance that data is collected pre-shock event (Engle, 2011).  
 116 Further, such an approach does not allow us to look at the slow onset risks of climate change,  
 117 which is a key distinction, as farmers perceive and treat weather shocks and climate risk differently,

although they are often conflated in assessment of adaptive capacity and response (Bruine De Bruin and Dugan 2022; Findlater et al. 2019; Waldman et al. 2020).

In this analysis, we develop a conceptual and empirical framework to test multiple adaptive actions, dealing with slow onset climate risks and shocks, while also addressing the challenge of cyclicity. We define and evaluate three types of actions: *response to shocks (reactive)*, *preparation for shocks (proactive)*, and *adjustment to slow-onset climate change (proactive)*. For determinants, we build on a depth of theory and applications of resource-based framing for adaptive capacity, namely the Sustainable Livelihood Framework, and assess how these determinants relate (or do not relate) to these three adaptive actions, using household panel data of coffee growers in Central Vietnam as an illustrative case. The study proposes a framework for assessing adaptive capacity which makes the clear conceptual and empirical distinction between determinants of adaptive capacity and differentiated adaptive actions (as intended outcomes of adaptive capacity). This allows us to harmonize conceptualizations of adaptive capacity, deal with the challenge of cyclicity, and specify differentiated outcomes and their varied relationships to determinants. Specifically, the paper seeks to understand: 1) How do determinants of adaptive capacity relate to both proactive and reactive adaptation outcomes? 2) How do determinants of adaptive capacity differ for climatic risks versus weather risks? 3) If and why do relationships between determinants and adaptive actions deviate from theoretical expectations, manifesting heterogeneously or inversely?

## 2. Conceptual Framework

### *2.1 Theoretical basis for differentiating determinants and outcomes of adaptive capacity*

Adaptive capacity can be conceptualized as the ameliorative component of vulnerability and as the precursor to prepare, adjust, respond, and cope under stress or change (Adger 2006; Engle 2011; Naylor et al. 2020; Smit et al. 2000; Turner et al. 2003). Formalizing adaptive capacity is challenging as it is multi-faceted, has many interconnected components, and is often intangible (Debortoli et al., 2018; Engle, 2011; Naylor et al., 2020). This is reflected in the inconsistencies in definition and framing in the literature (Siders 2019; Vincent 2007). For example, most articles in the review by Siders (2019) define adaptive capacity as the “ability to change” or as “resources and the ability to use resources.” However, a few articles even define adaptive capacity as “coping capacity” (see Siders 2019). While it is perhaps not possible to completely merge these definitions (from multiple disciplines), there is a possibility to better align them through a clear distinction between

148 *determinants* of adaptive capacity, or the influencing and enabling factors (more aligned with the  
 149 resources definition), and the intended *outcomes* of adaptive capacity, the subsequent actions and  
 150 impacts on the system.

151 Defining *determinants* of adaptive capacity is a common exercise. In literature on adaptive capacity  
 152 in agricultural and rural systems, one of the most prominent theoretical framing of adaptive  
 153 capacity determinants is the Sustainable Livelihoods Framework (Mortreux and Barnett 2017). The  
 154 framework sets generic components on how to assess livelihood resources (assets) as well as how  
 155 they are allocated in pursuit of livelihood strategies (Scoones 1998). The resources are broadly and  
 156 flexibly categorized as: human, social, financial, natural and physical. Multiple studies have  
 157 modified the overarching components to include subjective, and intangible components, such as  
 158 perception of risk or capacity for learning, i.e. dimensions that better capture the translation of  
 159 resources into action (Andrade and Szlafsztajn 2018; Bennett et al. 2014; Elrick-Barr et al. 2017;  
 160 Ifejika Speranza et al. 2014; Jones 2019; Lockwood et al. 2015; Shinbrot et al. 2019). While there is  
 161 a lot of work *describing* adaptive capacity based on the Sustainable Livelihood Framework, fewer  
 162 contributions have validated how theoretical determinants of adaptive capacity and their empirical  
 163 expressions contribute to outcomes (Engle, 2011).

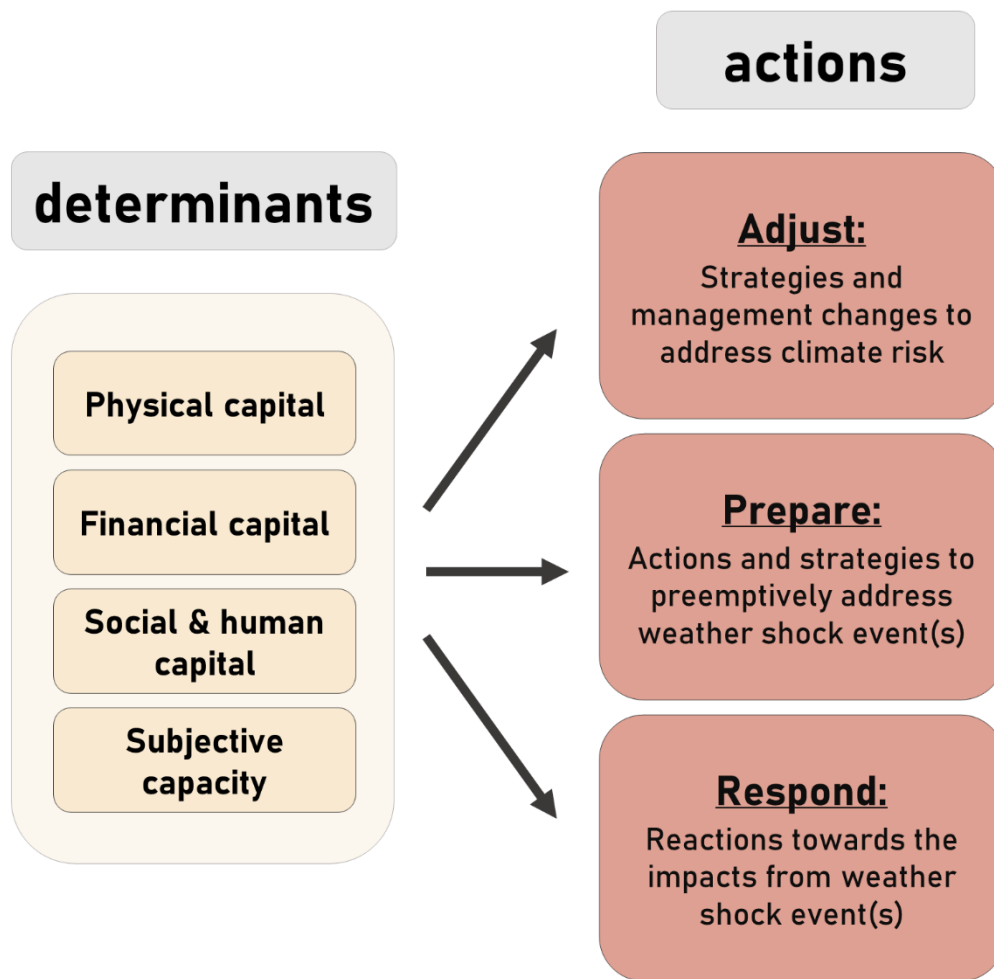
164 With regard to adaptive capacity towards climate change, we can group the literature assessing  
 165 adaptive actions and behaviors into two groups: one that looks at climate change [adaptation  
 166 uptake] and another that looks [at response to] weather shocks (IPCC TAR, in: Hinkel, 2011). In  
 167 most empirical analyses, adaptive capacity *outcomes* are assessed through the lens of adaptation  
 168 implementation or intent, with a focus on linking determinants to actions that households or  
 169 communities take to prepare for the impacts of climate change (Asfaw et al. 2016; Below et al.  
 170 2012; Burnham and Ma 2017; Dang et al. 2019; Mortreux et al. 2020; Panda et al. 2013; Shinbrot et  
 171 al. 2019; Yaméogo et al. 2018). These studies typically explore *proactive actions*, such as preventive  
 172 measures taken to build resilience against long-term climate change. However, some studies also  
 173 address how individuals or communities *react* to specific weather shocks or extreme events, rather  
 174 than general climate risks (Béné et al. 2017; Green et al. 2021; Jain et al. 2015; Notenbaert et al.  
 175 2013). For example, Jain et al. (2015) assess how farmers respond to a delayed monsoon (action)  
 176 and how these coping strategies affect yield and profit (state). There is emerging literature that  
 177 assess multiple behaviors, both proactive and reactive, against adaptive capacity determinants,

however they focus specifically on climatic risk (Fischer and Denny 2024; Green et al. 2021; Tetteh et al. 2020; Wu and Xu 2024). For example, Tetteh et al. (2020) distinguishes between “coping” and “adaptation” strategies towards impacts of climate change undertaken by goat producers in Northern Ghana, where specific strategies were categorized as coping or adaptation (e.g. sale of livestock as coping, and livestock species diversification as adaptation), although there was no definition given for coping. Fischer & Denny (2024) also distinguish between “coping” and “adaptation” with respect to impacts of climate change, using an index-based approach to place specific strategies for woodland owners in the United States along a spectrum between coping and adaptation. They define “coping” as an additive function of being reactive, autonomous (defined as practices based on existing knowledge, continuation), and incremental (stepwise changes), and “adaptation” as the opposite side of the spectrum, being an additive function of proactive, planned, and transformative. In their meta-analysis, Green et al. (2021) make a distinction between (1) adaptation (proactive adjustment), (2) intentional reactionary response, and (3) coping, or passive acceptance of circumstance. The definitions for proactive, reactive, adaptation, and coping are already inconsistent among the articles which address multiple behaviors. In order to concretize the types of adaptation actions, we would argue for the distinction of the type of risk being addressed and the temporal nature of the adaptive action with respect to the risk. Green et al. (2021) make a clear distinction between reactive response and coping, which allows actions in response to an event to also be intentional, effective, and productive (wished as an outcome of adaptive capacity). This is congruent with other work that shows reactive and everyday adaptation can be effective and reduce vulnerability (Anh Tran, 2020; Juhola et al., 2022; Pisor et al., 2022; Wilson et al., 2020). We therefore focus on reactive actions in line with this understanding (instead of coping) The three outcomes assessed in this article cover both proactive actions (*preparation* and *adjustment*) and reactive actions (*response*). The proactive actions deal with two types of risk: i) shock events, which have a high intensity over a relatively short time period, such as droughts, floods, or market shocks (*preparation*), and ii) long-term or slow onset changes, in this case longer time horizons of climate impacts (*adjustment*; Table 2). Reactive actions deal with only shock events (*response*). The three adaptive actions each have their inherent timeframe that is contingent on the timeline of the risk they are addressing. *Prepare* actions always happen before a shock event and *response* always after. *Adjust* actions are less concrete, in that long-term changes can be slow manifesting, and actors can react before the impacts of the change or while the impact is occurring.

209 We conceptualize the relationship between determinants and outcomes of adaptive capacity in  
210 Figure 1. Determinants are based on an adapted Sustainable Livelihoods Framework (SLF), which  
211 draws on both tangible assets or capitals and intangible and subjective capacity. These include four  
212 overarching components: physical capital, financial capital, human and social capital, and subjective  
213 capacity (Figure 1). Physical capital encompasses tangible land resources, such as the amount of  
214 agricultural land, and tenure security of the land. Financial capital indicates the economic  
215 resources, such as savings, that enable households to invest in adaptive actions. Social and human  
216 capital refers to the social resources (networks, membership of groups, relationships of trust,  
217 access to wider institutions of society), and skills, knowledge, and abilities that household members  
218 have which can support the enactment of adaptive actions. The subjective capital captures the  
219 experiences, attitude, values and beliefs that determine household choices and motivation for  
220 adaptive actions.

221 All these capitals collectively allow for households to prepare, adjust, and respond to shocks and  
222 slow onset risks. There are, however, distinct relationships for how determinants differentially  
223 contribute to the three adaptive actions. While most previous adaptive capacity research considers  
224 only *adjustment* or *response*, we look to contribute to the differentiation of the multiple outcomes  
225 of adaptive capacity. While we apply this conceptual framework in a coffee growing system in  
226 Central Vietnam, the assessment method has the possibility to be applied in other smallholder  
227 systems in order to better understand how adaptive capacity manifests into differentiated action.

228



229  
 230 Figure 1. Conceptual framework showing the relationship between adaptive capacity determinants  
 231 and adaptive actions (as a outcomes of adaptive capacity). The adaptive capacity determinants  
 232 have a distinct relationship for how they influence each of the adaptive actions.

### 233 3. Coffee farmers in Vietnam

234 Vietnam is second only to Brazil in coffee production, and the world's largest producer of Robusta  
 235 coffee (ICO 2019). Robusta coffee (*coffea robusta*) is mostly grown in the Central Highlands region,  
 236 which consists of five hilly provinces, of which Dak Lak, the focus of this analysis, has the highest  
 237 share of area under coffee production. The majority of coffee growers in Vietnam are smallholders,  
 238 operating on less than two hectares of land (Marsh 2007). Robusta coffee in Dak Lak is  
 239 characterized by high inputs, including labor, fertilizer, pesticide, and irrigation, as well as high  
 240 yields (Amarasinghe et al. 2015; Byraredddy 2020; Byraredddy et al. 2019; D'haeze et al. 2005; Marsh  
 241 2007). In the Central Highlands of Vietnam, growers have dealt with severe droughts in the last  
 242 decade, which put additional pressure on their already stressed groundwater sources (Byraredddy

2020; Pham et al. 2020; Phuong et al. 2022). Additionally, recent research shows that Robusta is more sensitive to higher temperatures than previously thought (Kath et al. 2020). This physical sensitivity to climate change is paired with a socioeconomic sensitivity, in that coffee is integral to livelihoods in the region, which is also shown by a vulnerability study, which determined high levels of vulnerability for coffee growers in Dak Lak (Parker et al. 2019).

Coffee production faces not only climate stressors but also risks associated with market fluctuations, and the interaction between the two (Eakin et al. 2009; Ha and Shively 2007). Growers and administrations have already undertaken some measures to mitigate these climate risks (Thi and Chaovanapoonphol 2014). Measures include various irrigation schemes, soil conservation practices, cropping diversification at the farm level, but also farmer trainings and landscape level initiatives. There are some studies that already look at influencing factors of e.g. sustainable agricultural practices (Nguyen and Drakou 2021; Pham et al. 2022) and agroforestry adoption (Do et al. 2020; Simelton 2016; Thuy et al. 2018). These studies find that coffee growers prefer practices that have higher profits, lower risks, and higher environmental benefits (Pham et al. 2022) and uptake is related to perception of social pressure, capability to implement such practices, and perception of climate change (Nguyen and Drakou 2021).

#### 4. Household data on coffee growers in Dak Lak: Thailand Vietnam Socioeconomic Panel (TVSEP)

In order to look at coffee-growing household's proactive and reactive actions to climatic risk, we use the Thailand Vietnam Socioeconomic Panel (TVSEP) in our analysis (<https://www.tvsep.de/>), focusing on coffee growers in Dak Lak province (Figure 2). The TVSEP dataset contains information on vulnerability dynamics, rural household's behavior, living standards, geography, shocks, risks, and agriculture (Hardeweg et al., 2007). We use the TVSEP data because it encodes detailed information on (1) how households perceive and proactively act on multiple risks, and (2) how they respond to multiple shocks (reactive). In Dak Lak, both mountainous areas and plains were surveyed representatively. Of the sampled Dak Lak households, 79% grow coffee (Table 1), with a larger share of mountainous households growing coffee (85%), compared to in the plains (63-65%) (SM Table 2). In all of the villages sampled in Dak Lak, there is at least one household that grows coffee. While the panel survey has been running since 2007, we use panel waves from 2013 and 2017, as the questions on risks and the preparation towards risks are only available for those years. In 2013, a module on climate perception, impact, and adaptation was also included. The descriptive

statistics of outcome variables and determinants are presented in SM Section 2. It is a limitation that we do not have a more recent dataset, however, the temporally coded information on proactive and reactive actions towards multiple distinct shocks is a unique feature of the TVSEP data that allows us to explore multiple outcomes of adaptive capacity, making this dataset particularly valuable. Our analysis would not be possible with other datasets.

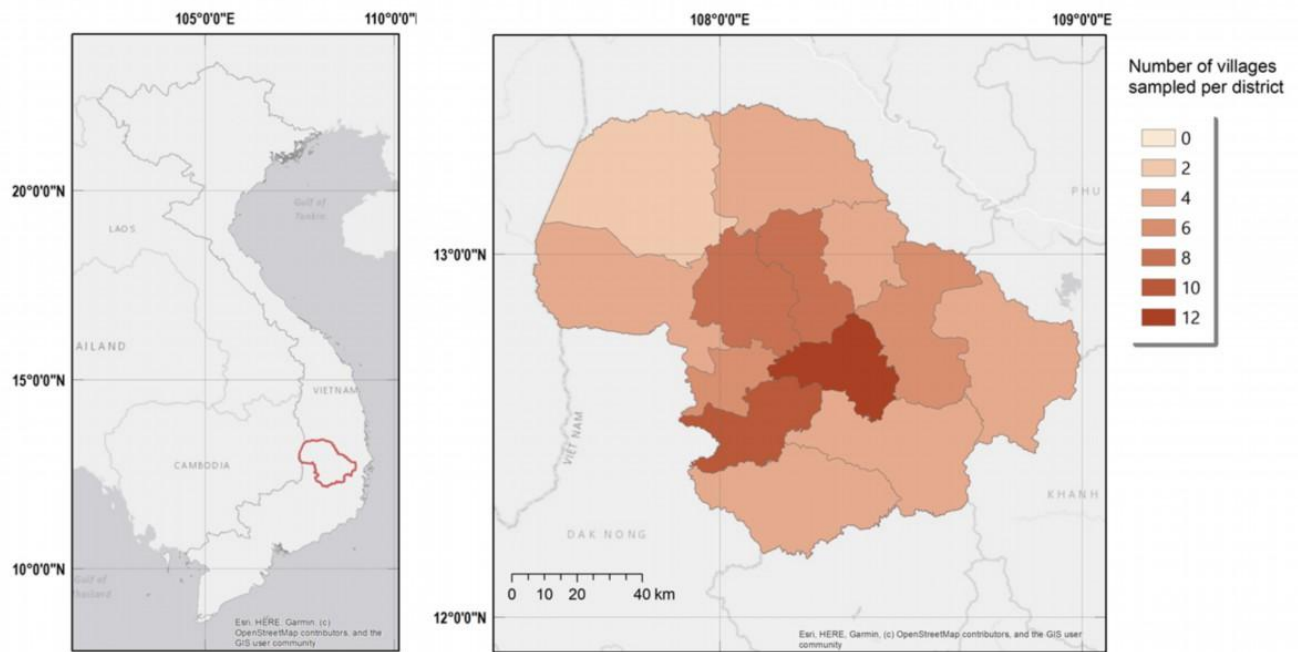


Figure 2. Map depicting the province of Dak Lak within Vietnam and the communes surveyed in the stratified random sampling. The color of the commune denotes the number of villages surveyed in each commune.

Table 1. Number of households surveyed in Dak Lak province under TVSEP in each wave, as well as the number and percent of those households that grow coffee.

| wave year | sampled households in Dak Lak | sampled households in Dak Lak growing coffee | percentage of households sampled in Dak Lak that grow coffee |
|-----------|-------------------------------|----------------------------------------------|--------------------------------------------------------------|
| 2013      | 699                           | 547                                          | 0.783                                                        |
| 2017      | 646                           | 511                                          | 0.791                                                        |

## 5. Methods

Based on our conceptual framework, we build three regression models to empirically assess how adaptive capacity determinants are related to *prepare*, *response*, and *adjust* actions. Section 5.1

describes in detail how we calculate our outcome variables. Section 5.2 describes the regressors we selected within the Sustainable Livelihoods Framework. Lastly, section 5.3 lays out the empirical specification of our models.

### 5.1. Outcome variables: adaptive actions taken by coffee growers in Dak Lak

An overview of all three outcome variables, with their definitions and specifications can be found in Table 2. Adaptive action variables (representative of outcomes of adaptive capacity) are aggregated from survey items under the shock and risk modules of TVSEP. We use information from 2013 and 2017 for *response* and *preparation* towards shocks. Information on climate adaptation *adjustment* is only available for 2013. For *response* actions, the household is asked, when considering the last three years, if there have been any event causing a big problem (shock) which has affected the household. If so, respondent lists up to three major shocks. Shocks can be natural, such as flood and drought, social, personal (such as sickness), economic, or crime related. For any shocks recorded, the year, total loss of income, and loss of assets are also recorded, as well as any “coping activities” undertaken, listing up to three activities (full documentation of answer codes are listed in SM Section 1.1, and those actually selected by coffee growers are listed in Table 2 as “specific actions occurring in Dak Lak”). If a household undertook any “coping activities” **in the last year** towards flooding of agricultural land, drought, or strong decrease in of prices for outputs, then we consider these as “response” to the shock. For *prepare* actions, the household is then asked for each shock, if they think it could occur in the next five years. If households answer yes, perceiving a risk associated with that shock, they are then asked, what, if any, actions are undertaken to prevent or mitigate impacts of that risk (answer codes are listed in SM Section 1.1, and those actually selected by coffee growers are listed in Table 2 as “specific actions occurring in Dak Lak”). If a household took any actions to prevent future perceived impacts towards flooding, drought, or strong decrease of price of outputs, then we considered these as “preparation” towards shocks. For *adjust* actions, in 2013, households were also asked specifically if they perceive changes in climate (weather) since they have been living in that village/area, and what impacts they already experienced and foresee. Then, the household is asked what adaptation adjustments they have undertaken to address these impacts (answer codes are in SM Section 1.1, and those actually selected by coffee growers are listed in Table 2 as “specific actions occurring in Dak Lak”). More

319 information on the TVSEP data can be found in SM Section 1 and the full questionnaire can be  
320 accessed via [tvsep.de](http://tvsep.de).

321 For *prepare* and *respond*, we consider not only reactions to drought and floods (weather shocks),  
322 but also price drops for coffee (market shocks), as these risks can and do interact (Eakin et al. 2014;  
323 Ha and Shively 2007). There is a large overlap of actions that deal with weather and market shocks,  
324 and we assume that actions addressing one shock also have mitigative or ameliorative effects on  
325 other types of shocks. As we include actions aimed at both weather and market risks for  
326 *preparation* and *response*, we also perform a sensitivity analysis by running our model with just  
327 market risks and just weather risks, to confirm that market risk is not biasing our results (SM Table  
328 10). In the *response* model, of the 347 shocks experienced over the two time steps, only 63 were  
329 market shocks. In the *preparation* model, of the 226 risk preparedness actions in 2013, 29 were  
330 towards perceived market risks (SM Table 5). For the 327 actions in 2017, 82 were towards  
331 perceived market risks (SM Table 5).

332

333 Table 2. Overview of all outcome variables. The columns specify: how the variable is defined, the  
 334 risk addressed by each outcome variable, if the risk is being address proactively or reactively, and  
 335 the specific actions occurring in Dak Lak.

| <i>adaptive action</i> | <i>definition</i>                                                                                                                                                                                                                                                                                                                                                                                                         | <i>towards what risk</i>                                                                            | <i>proactive or reactive</i> | <i>specific actions occurring in Dak Lak</i>                                                                                                                                                                       |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b><i>respond</i></b>  | If a household experienced one or more shocks during the reference period for that survey year (e.g. May 2012- April 2013 or May 2016- April 2017) and undertook one or more actions in reaction to a shock experience, then the <i>respond</i> variable for that household is coded as 1. If the household experienced a shock and did not respond, it is coded as 0. If they did not experience a shock it is coded NA. | <i>shocks:</i><br>flood or drought,<br>price drop for output                                        | reactive                     | borrow money (e.g. from family, friends, neighbors, or the money lenders),<br>used savings,<br>sold assets,<br>took up additional occupation,<br>substitute crops,<br>diversify crops,<br>reduce production inputs |
| <b><i>prepare</i></b>  | If a household undertakes or has undertaken any actions in pre-emption to a shock event happening, then it is coded as 1. If a household has not done anything to prepare for one of the shocks listed in the next column, the household is coded as 0,                                                                                                                                                                   | <i>shocks:</i><br>flood or drought,<br>price drop for output                                        | proactive                    | agriculture diversification,<br>income diversification,<br>investment in farm equipment, labor, etc.,<br>buffer stocks,<br>collective actions for canals and dikes                                                 |
| <b><i>adjust</i></b>   | Households are explicitly asked if they implemented and changes to deal with climate impacts. If they specified any activities, they are coded as 1, otherwise as 0.                                                                                                                                                                                                                                                      | <i>climate impacts:</i><br>more droughts (compared to “past”),<br>more pests,<br>more crop failure, | proactive                    | investment in more irrigation,<br>investment in more dams,<br>grow more varieties,<br>stop growing certain crops,<br>spray more pesticide,<br>use more fertilizer,<br>save money,                                  |

|  |  |              |  |                                                           |
|--|--|--------------|--|-----------------------------------------------------------|
|  |  | lower yields |  | take up non-farm employment,<br>start a non-farm business |
|--|--|--------------|--|-----------------------------------------------------------|

## 5.2. Regressors: determinants of adaptive capacity

Each of these components of the Sustainable Livelihood Framework is comprised of a few contributing variables, for example, “amount of agricultural land” and “formalized land tenure” are the representative variables for physical capital (Table 3). As many questions are asked for each parcel of land or each household member, variable is aggregated to the household level. For example, if a household had multiple plots, a percentage of plots is used to represent the household. “Savings” and “agricultural labor costs” are included as dummy variables, indicating whether a household has any savings or agricultural labor costs (in order to deal with scaling of variables, as amounts in Vietnamese Dong are multiple orders higher than all other variables included). “Experience of a weather/market shock” was calculated for the previous one, two, and three years. Each time period was tested and is presented in SM Table 13. There is a slight trend in that experience of market shocks becomes less significant and less strongly related to our adaptive capacity outcome variables when aggregating over a longer period of time. The opposite is true for weather.

In many measurements of adaptive capacity, “income multiplicity” is included as a determinant (Daramola et al. 2016; Notenbaert et al. 2013; Panda et al. 2013; Ruiz Meza 2015). In Dak Lak, some coffee growers prepare for and respond to risk by taking up non-farm labor, such as self-employment or wage labor. Because income multiplicity variables are then implicit in the outcome variable, this introduces issues with cyclicity and endogeneity (a point also brought up by Bacon et al., 2017). This highlights an existing inconsistency in adaptive capacity definitions and indicators (Siders 2019). To address this, we do not include income multiplicity as a determinant in our models, as it is already partially accounted for as an outcome. This was also the case for “cropping diversity” variables such as total number of crops grown, or number of intercropped plots, which we also do not account for as a determinant in our models.

Table 3. shows the adaptive capacity determinants assessed. Overarching components are adapted from the sustainable livelihood framework and contributing variables are sourced from the

364 literature (both theoretical and empirical). The translation of these theoretical determinants to the  
 365 TVSEP data are also presented.

| <u>Theoretical</u>                |                                                         |                                                                                                                      | <u>empirical</u>                                                                                                                    |
|-----------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| overarching components            | determinant                                             | citation (non-extensive; other examples from empirical work in rural systems)                                        | TVSEP variables                                                                                                                     |
| <i>Physical capital</i>           | amount of agricultural land                             | Bryan et al., 2015; Phuong et al., 2018; Quandt et al., 2019; Trinh et al., 2018; Tucker et al., 2010                | number of agriculture plots                                                                                                         |
|                                   | formalized land tenure                                  | Antwi-Agyei et al., 2015; Below et al., 2012; Yaméogo et al., 2018                                                   | percentage of plots with a land certificate                                                                                         |
| <i>Financial capital</i>          | savings                                                 | Campbell, 2021; Ifejika Speranza et al., 2014; Notenbaert et al., 2013; Sen et al., 2020                             | if a household has savings (0/1)                                                                                                    |
|                                   | ability to hire agricultural labor                      | Swami and Parthasarathy, 2021; Thulstrup, 2015; Vo et al., 2021                                                      | if a household hires labor for land preparation, planting, harvesting, or input application (0/1)                                   |
| <i>Social &amp; human capital</i> | access to institutional financial support               | Cinner et al., 2015; Gaworek-Michalczenia et al., 2022                                                               | receiving support from a social or credit program (0/1)                                                                             |
|                                   | participation in a network or social/professional group | Below et al., 2012; Ifejika Speranza et al., 2014; Notenbaert et al., 2013; Quandt et al., 2019                      | number of household members in a social or political organization                                                                   |
|                                   | education                                               | Ifejika Speranza et al., 2014; Mazhar et al., 2021; Muttarak and Lutz, 2014; Panda et al., 2013; Phuong et al., 2018 | the maximum education reached of any household member (1- primary, 2- secondary, 3- high school, 4- vocational or university level) |

|                                |                           |                                                                                                      |                                                                                               |
|--------------------------------|---------------------------|------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
|                                | trust                     | Bennett et al., 2014;<br>Cinner et al., 2015;<br>Ifejika Speranza et al.,<br>2014; Paul et al., 2016 | trust in other village<br>members (0-5 likert scale)                                          |
| <i>Subjective<br/>capacity</i> | attitudes towards<br>risk | Mortreux et al., 2020                                                                                | willingness of household<br>head to take risk (0-10 likert<br>scale)                          |
|                                | previous<br>experience    | Habtemariam et al.,<br>2020; Mortreux et al.,<br>2020; Sharma and Patt,<br>2012                      | experience of a shock event<br>in the previous year, previous<br>2 years, or previous 3 years |

### 5.3. Model specifications

We empirically evaluate the relationship between adaptive capacity determinants and adaptive actions using three logistic regression analysis, evaluating the three action types as outcome variables and SLF-derived variables as predictors. This allows us to distinguish how theoretical determinants have (or do not have) varied relationships with the multiple outcomes. As our outcome variable is binary in all three cases, we use a multivariate logistic regression (logit), which employs a log odds transformation. In all three models, we control for general household characteristics, such as age, gender, and ethnicity of household head. Where temporal data is available (for *preparation* and *response*), we use a pooled model (pooling data from 2013 and 2017 into one model) and control for the year (Equation 1). We pool the data because we do not focus on the difference or change in the outcome variables (adaptive actions) between 2013 and 2017 (the within panel relationship), but the relationship between determinants and each outcome, as generalizable through time. An assumption of a pooled model is that the relationship between adaptive capacity determinants and outcomes is the same in both years. In robustness tests where *prepare* and *response* models were run for 2013 and 2017 separately, we find that coefficients are only marginally different (SM Table 8 & 9). Because we pool a model that includes two time steps from the same panel, it entails that in most cases, there are two observations per household (one for 2013 and one for 2017). To account for this as well as survey design effects, we cluster standard errors at the household level, using the R package sandwich (Zeileis 2006; Zeileis et al. 2020). Standard errors and significance values are only slightly different between the clustered and the non-adjusted version in both the *preparation* and *response* model (SM Table 6, SM Table 7).

388 Additionally, to test our model set-up, we check collinearity with variable inflation factor (VIF; SM  
389 Table 4).

390 Equation 1.

$$391 \text{ logit}(Y) = \ln\left(\frac{P}{P-1}\right) = \alpha + \mathbf{X}^T \boldsymbol{\beta}, \text{ where } P = \text{Probability}\{Y = 1\}$$

392 Outcome variable  $Y$  represents *preparation*, *response*, and *adjustment* in the three models,  
393 respectively.  $\mathbf{X}$  is a vector of independent variables that includes adaptive capacity determinants  
394 and household controls for all three models, and also time for *preparation* and *response*.  $\boldsymbol{\beta}$  is a  
395 vector of corresponding coefficients for all independent variables. As we use a logit model, the  
396 coefficient can be understood as the effect on the log odds ratio.  $\alpha$  is the intercept.

397

## 398 6. Results

399 For coffee growers in Dak Lak, at least one variable from each physical capital, financial capital,  
400 social & human capital, and subjective capacity is significantly and positively related to *preparatory*  
401 or *adjustment* actions (Table 4). Results from the pooled regression model with *prepare* actions as  
402 the outcome variable are presented in column 1 of Table 4. Physical capital in the form of land  
403 (“number of plots”) has a positive and significant relationship to *prepare* actions. In our sample of  
404 coffee farmers in Dak Lak, there was an increase in landholdings from 2013 to 2017, in tandem with  
405 a decrease in number of households with their main occupation in agriculture (SM Table 3). These  
406 trends point towards a concentration of households who invest further in agriculture, land, and also  
407 proactive measures to prevent future impact, while a smaller proportion of households do the  
408 opposite: divest from agriculture and land, and not necessarily take sustainable actions to mitigate  
409 future risk. Physical capital variables, such as land, indicate and/or allow for a long-term investment  
410 in the future, which can positively influence actions which are forward looking and proactive.  
411 Financial capital in the form of costs allocated to agricultural labor has a positive and significant  
412 relationship to *prepare* actions. Human & social capital in the form of “membership in a social or  
413 political association” has a significant and positive association with *prepare* actions. And subjective  
414 capacity, in the “previous experience of weather shocks in the past 3 years,” has a strongly  
415 significant and positive relationship to *prepare* actions. The year control having a significant  
416 positive relationship to *preparation* implies more *prepare* actions in 2017. In the sensitivity test of

417 *prepare* actions towards weather shocks versus market shocks, we see that the aggregated results  
 418 are primarily aligned with the model with preparedness towards risk of drought or flood (SM Table  
 419 11).

420 Table 4. Results from multivariate logistic regressions estimating the relationship between adaptive  
 421 capacity determinants and *prepare*, *response*, and *adjust* actions (each column representing one  
 422 model). The coefficient estimation for each adaptive capacity determinant is followed by the  
 423 standard error (in parentheses). In logistic regression the coefficient can be interpreted as: for each  
 424 unit increase in an adaptive capacity variable, there is an increase/decrease in the log odds of our  
 425 outcome variable. The coefficients can therefore not be interpreted linearly, but in relationship to  
 426 each other, in their direction, and significance. Significance codes of + < 0.05, \* < 0.01, \*\* < 0.001,  
 427 and \*\*\* 0 are given to the right.

| overarching components     | adaptive capacity determinants                       | <i>prepare</i>                                                                             | <i>respond</i>                                                                         | <i>adjust</i>                                       |
|----------------------------|------------------------------------------------------|--------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------|
|                            |                                                      | implementation of a risk preparedness strategy towards drought, flood, or price drop (0/1) | reaction to a shock event such as drought, flood, or price drop in the last year (0/1) | implementation of a climate adaptive strategy (0/1) |
|                            | <i>intercept</i>                                     | -427.553<br>(99.667)***                                                                    | 672.553<br>(172.623)***                                                                | -0.337 (0.913)                                      |
| Physical & natural capital | No. plots                                            | 0.160 (0.064)*                                                                             | 0.028 (0.098)                                                                          | 0.219 (0.101)*                                      |
|                            | Percentage plots with land certificate               | -0.299 (0.405)                                                                             | -0.579 (0.672)                                                                         | -0.299 (0.549)                                      |
| Financial capital          | Savings                                              | 0.048 (0.155)                                                                              | 0.127 (0.269)                                                                          | 0.406 (0.238)+                                      |
|                            | Labor costs for crop production                      | 0.189 (0.051)***                                                                           | 0.011 (0.081)                                                                          | -0.197 (0.234)                                      |
| Social and human capital   | Participation in a gov't credit or social program    | -0.060 (0.165)                                                                             | -0.138 (0.272)                                                                         | -0.246 (0.227)                                      |
|                            | No. hh members in a social or political org.         | 0.293 (0.161)+                                                                             | -0.136 (0.283)                                                                         | 0.087 (0.068)                                       |
|                            | Maximum education level of any hh member             | 0.100 (0.088)                                                                              | 0.180 (0.150)                                                                          | 0.326 (0.125)**                                     |
|                            | Trust in villagers (1-5)                             | 0.152 (0.103)                                                                              | -0.387 (0.169)*                                                                        | 0.010 (0.129)                                       |
| Subjective capacity        | Willingness to take risk (1-10)                      | 0.012 (0.035)                                                                              | 0.172 (0.063)**                                                                        | 0.005 (0.055)                                       |
|                            | Experience of a <b>weather</b> shock in last 3 years | 0.509 (0.156)**                                                                            | 0.210 (0.273)                                                                          | 0.056 (0.226)                                       |

|                                |                                                           |                           |                           |                |
|--------------------------------|-----------------------------------------------------------|---------------------------|---------------------------|----------------|
|                                | Experience of a<br><b>market</b> shock in last 3<br>years | 0.281 (0.219)             | -0.712 (0.373)+           | 0.829 (0.351)* |
| <i>household<br/>controls</i>  | Age of household head                                     | 0.002 (0.007)             | -0.004 (0.012)            | -0.015 (0.011) |
|                                | Gender of household<br>head                               | -0.093 (0.235)            | 0.323 (0.433)             | 0.348 (0.346)  |
|                                | Ethnicity of household<br>head                            | 0.428 (0.181)*            | 0.204 (0.320)             | -0.004 (0.269) |
|                                | No. household<br>members                                  | -0.046 (0.040)            | -0.007 (0.066)            | 0.005 (0.054)  |
|                                | Agricultural as main<br>occupation (0/1)                  | 0.663 (0.191)***          | 0.894 (0.402)*            | 0.331 (0.274)  |
|                                | Coffee as main<br>agricultural crop (0/1)                 | 0.151 (0.162)             | 0.054 (0.266)             | -0.212 (0.249) |
| <i>time control</i>            | year                                                      | 0.211 (0.050)***          | -0.334 (0.086)***         | n/a            |
| <i>No. of<br/>observations</i> |                                                           | 888                       | 341                       | 432            |
| <i>Standard errors</i>         |                                                           | clustered at<br>household | clustered at<br>household | standard       |
| <i>adj. R2<br/>(McFadden)</i>  |                                                           | 0.26                      | 0.26                      | 0.218          |

428

429 Results from the pooled regression model with *response* as the outcome variable are presented in  
430 column 2 of Table 4. There are more negative relationships between adaptive capacity  
431 determinants and *respond* actions compared to *prepare* actions. Here, we find a negative and  
432 significant relationship between “trust in other villagers” and “experience of a market shock in the  
433 last 3 years” and *respond* actions. These negative relationships are further examined in the  
434 discussion. In addition, there is a significant and positive relationship between “willingness to take  
435 risks” and *respond* actions. For time control, we see the opposite of the *prepare* model, in that year  
436 is negatively and significantly related to *response* actions, indicating more *response* in 2013. In the  
437 sensitivity analysis, which disaggregates the *response* model to (1) response towards weather  
438 shocks and (2) response towards market shocks, we see the same patterns between the aggregated  
439 model (Table 4) and reaction to weather shocks (SM Table 12).

440 Results from the regression model with *adjustment* as the outcome variable are presented in  
441 column 3 Table 4. Again, we see positive and significant relationships between “number of plots”  
442 (physical & natural capital) and newly, with “savings” (financial) and “maximum level of education  
443 attained” (social and human capital) with *adjust* actions. From subjective capacity, “experience of a

market shock in the previous years” has a strongly positively and slightly significant relationship to implementation of a climate adaptive strategy.

## 7. Discussion

Most previous adaptive capacity works consider only one action type in adaptive capacity assessments: *adjustment* or *response*, but not multiple types of actions. Our results show that while *adjustment*, *preparation*, and *response* are all adaptive actions, which can be seen as intended outcomes of adaptive capacity, they are addressing distinct (yet overlapping) capabilities, where the relationship between determinant and action are also distinct. In some ways, the relationship between determinants and adaptive actions manifests differently than expected. On the one hand, our results offer a confirmation of adaptive capacity theory when looking at *preparation* and *adjustment*, while on the other bringing into question the congruence for *response*. Our results contribute to the existing discussion on how high levels of theoretical adaptive capacity determinants do not always transpose adaptive capacity outcome (Green et al. 2021; Mortreux et al. 2020). In some ways, this has been addressed in terms of how affluence does not always impact adaptive capacity and vulnerability in the way that would be expected (Eriksen et al., 2020; Nelson et al., 2016) or how some adaptive capacity determinants are mediated through more subjective contexts (Mortreux et al., 2020). With our empirical analysis, we highlight that depending on the type of adaptive actions, the theoretical determinants do not necessarily all influence the outcome in the same direction or magnitude. This is particularly the case for *response* actions, pointing to the need for more research in order to inform a well-rounded theory on the contributing capacity towards reactive actions.

In our *response* model, we find counter-indications for adaptive capacity theory. The *response* model (Table 4) was the only of the three models to have negative relationships. Here, previous experience of a market shock is also significantly related to *response* actions, however in this case, negatively. The experience of a market shock previously can be associated with lingering financial impacts (Newhouse 2005). If a household has already responded to a market shock in previous years, there may be less resources to respond again, or there could be a saturation of actions. This is similar to findings in the Blue Mountains coffee growing region in Jamaica, where coffee farmers are “self-reliant” in their coping, meaning they draw from their own financial resources, which are

then depleted in the face of multiple and interacting market and weather shocks (Guido et al. 2020). This implies that programs and policies targeting adaptive capacity towards weather shocks (both proactive and reactive) need to consider not only the co-benefits of actions which address multiple shocks (including market shocks), but also the prohibitive impact that interacting and cascading shocks can have in leading to non-action. Trust also has a significant and negative relationship to *response* actions. In Dak Lak, many of the *response* actions are financial in nature, for example borrowing money or taking up a second income (especially in comparison to *prepare* actions; Figure 6). With less trust, individual households have less buffer in a community or social network that forces them into more individual coping responses. For example, in Paul et al. (2016), the authors evaluate how trust influences community-improving activities and individual adaptation for smallholders and herders in the Ethiopian Rift Valley. They find that (subjective) trust is significantly linked to community activities, but negatively linked to individual adaptation. The role of trust is dependent on the types of actions being undertaken, not only in terms of their timing (proactive v. reactive) but also in terms of their collective v. individual nature. Further research is needed to elaborate on the relationship between collective versus individual *adjustment*, *preparation*, and *response*, particularly to explore the relationship between trust and collective proactive actions, versus individual reactive actions. And lastly, looking at the *response* model, there was one significant and positive relationship between willingness to take risks and *response* actions. The relationship was significant only for reactive actions, but not proactive ones (*preparation* and *adjustment*). It is likely riskier for a household to only respond when impacted by a shock, rather than reducing exposure by proactively implementing actions in preparation for shocks or changes. Overall, more significant negative associations with *response* actions point to a mismatch with theoretical adaptive capacity determinants, in that adaptive capacity is not necessarily allowing farmers to react to shocks, which is a vital ability in the face of increased weather variability under climate change.

An interesting aspect, which is most likely coffee-specific (or related to agricultural products dependent on a global market) is the role market shocks play (Table 4). Other studies have established a relationship between experience with previous weather shocks in activating adaptive capacity (Demski et al. 2017; Hamilton-Webb et al. 2017; Mortreux et al. 2020), but the role of multiple and interacting shocks, particularly non-weather shocks is less established. We did not expect a positive and significant relationship between a previous experience of a market shock and

505 *adjustment* outcomes based on adaptive capacity theory. We suppose that this is an expression of  
 506 the varied and complex reasoning that determine climate adaptation adjustments. The decision-  
 507 making process for adjustments of agricultural management to address climate risk does not only  
 508 take into account climate risk, but also other risks (e.g. market) (Bacon et al. 2017; Eakin et al. 2014;  
 509 Räsänen et al. 2016; Tessema et al. 2019). For example, Eakin et al. (2014) find that while climate  
 510 risk is one of the factors that influences decision-making, it is not the primary factor for coffee  
 511 farmers in Mexico, Guatemala, Honduras, and Costa Rica. Tucker et al. (2010) find that coffee  
 512 farmers in Mexico, Guatemala, and Honduras are more concerned with drops in coffee prices than  
 513 climate change or weather shocks. Farmers' adjustment actions can have multiple benefits in  
 514 addition to ameliorating climate impacts, including addressing market risks. For example, investing  
 515 in more varieties (which some coffee growers in our sample undertake) helps to buffer against  
 516 financial impacts of a price drop (Ha and Shively 2007). Our results offer an indication of the role  
 517 that multiple, interacting, and compounding risks can play in influencing adaptive actions. This  
 518 necessitates that market risks and dynamics to which smallholder farmers may be exposed, need to  
 519 be considered when targeting farmers' *preparation*, *adjustment*, and *response* actions to climatic  
 520 risks. Programs and interventions not sensitive to these market pressures may fail by not  
 521 recognizing farmers' prioritized concerns, particularly for market-oriented crops.

522 Further research covering other geographical areas could provide additional insights into the  
 523 external validity of this study. This is related to a discussion point brought up by Siders (2019) in  
 524 their review on adaptive capacity, which finds that while many studies cite adaptive capacity as  
 525 being locally dependent and highly context specific, there is still little empirical evidence testing the  
 526 generalizability of adaptive capacity across contexts (both in space and time). There are some  
 527 indications of temporal generalizability from our results, in how adaptive capacity manifests for  
 528 prepare and response actions consistently over time (in a period of four years, between 2013 and  
 529 2017). While our results are consistent for 2013 and 2017, there is still further research needed to  
 530 assess whether these effects persist through large systemic changes, such as the COVID pandemic,  
 531 as well as over a longer time period, in general. Additionally, each application of the Sustainable  
 532 Livelihoods Framework uses a slightly different set of capitals, with different subsets of variables  
 533 (e.g. some might attribute formalized tenure security to physical capital, as we did, or to social  
 534 capital, as it relates to ability to participate in an institution). This is the pitfall of measuring a fuzzy  
 535 concept, such as adaptive capacity: flexible interpretation makes it complicated to compare across

case studies and geographies. Lastly, while we have a representative sample, meaningful inference may be limited for some adaptive actions, given relatively few occurrences in the data.

Finally, we want to highlight how focusing on differentiated adaptive actions, as intended outcomes of adaptive capacity, as a method of assessment, can contribute to harmonizing adaptive capacity definitions, and better place it with the context of related but often silo-ed research fields: adaptation, vulnerability, and resilience. Siders (2019) finds that research on adaptive capacity is fragmented due to high disciplinaryity and lack of cross-citation. This is also apparent in the slight divergence in definitions of adaptive capacity between the “ability and potential to change” (more proactive) versus the “ability to cope or evolve the ability to cope” (more reactive) (Siders, 2019). Adaptation research often focuses on the slow onset risk of climate change, whereas resilience and vulnerability research focus on shocks (Miller et al. 2010). One of the distinctions between resilience versus vulnerability and adaptation assessment is the focus on system properties of the former, as opposed to the actor-orientation (human-centric) of the latter two (Miller et al. 2010). There is still a research gap empirically testing how these abstract concepts are linked: how actor-specific adaptive capacity determinants facilitate adaptive actions (such as *preparation*, *response*, and *adjustment*) and how these actions then cyclically affect both actor-specific and system functionalities, and ameliorate exposure (to shocks and slow onset risk). The limited empirical work is partly due to the cyclicity between determinants and outcomes (conceptual) and the associated endogeneity in the assessment (empirical). Adaptive actions are concrete and observable, i.e. a farmer growing more varieties. They can act as the empirical ‘joint’ between adaptive capacity determinants and the ensuing implications and impacts for system outcomes of resilience and vulnerability (which are often more difficult to measure, such as the variability or stability in agriculture outputs, or rely on subjective assessments). The challenge and question for further research is how we integrate adaptive capacity assessment based on multiple adaptive actions (Nussbaum 2009; Robeyns 2005; Sen 1985; Shepherd and Dissart 2022) with systems and state variables to better capture the fuzzy concepts of adaptive capacity, resilience, and vulnerability. By better understanding the multiple definitions of adaptive capacity and how they related to differentiated adaptive actions, practitioners and policy makers can better assess adaptive capacity through targeting and differentiating adaptive outcomes.

## 8. Conclusions

566 Our study provides empirical evidence from Vietnam's coffee-growing smallholder systems that  
567 adaptive capacity theory is more congruent with proactive outcomes than with reactive ones. In the  
568 literature, adaptive capacity outcome actions are varied, ranging from implementation of climate  
569 change adaptation to coping ability in the face of a weather shock. Here, we define and evaluate  
570 three types of adaptive actions: *response (to weather and market shocks)*, *preparation (to future*  
571 *weather and market risks)*, and *adjustment (to slow onset risks)*. With our empirical analysis, we  
572 highlight that depending on the type of adaptive action, the theoretical determinants do not  
573 necessarily all influence the outcome in the same direction or magnitude. We find that the two  
574 proactive adaptive actions: *prepare* and *adjust* are more aligned with theoretical determinants in  
575 the Sustainable Livelihoods Framework. *Response*, the only outcome action that is reactive in  
576 nature, displays a couple of significant negative relationships, less fitting to theory of adaptive  
577 capacity. We additionally find that the determinant "previous experience of market shocks" plays a  
578 bigger role than hypothesized, perhaps due to the nature of growing coffee for a global market.  
579 Overall, these findings suggest the need for a more nuanced understanding of adaptive capacity,  
580 particularly when it comes to reactive outcomes. The results have theoretical and practical  
581 implications for how we understand, assess, and foster adaptive capacity in smallholder systems.  
582

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594

595 Data Availability Statement

596 The pseudonymized TVSEP data can be requested for research purposes from colleagues at the  
597 Leibniz University Hannover via their user registration form at [https://www.tvsep.de/en/tvsep-](https://www.tvsep.de/en/tvsep-data-access)  
598 [data-access](https://www.tvsep.de/en/tvsep-data-access). Use of the data is limited to research purposes and attached to a confidentiality  
599 agreement, succinctly outlined at the same link.

600

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