What resilience theory and praxis can learn from multi-dimensional approaches to understanding poverty: a study of Ghanaian cocoa forest landscapes

Abstract

Resilience – broadly understood as withstanding, and adapting to, shocks and risks – has emerged as a central discursive device for converging humanitarian needs with climate change responses. This paper's human-centred engagement with resilience draws on the case of smallholder farmers engaged in rain-fed cocoa production in Ghana's Central Region, to systematically unpack how poverty shapes smallholders' responses to drought, with differing effects on resilience. The surveys, focus groups, and interviews were gathered before, during, and in the aftermath of, a prolonged El Niño-induced drought, facilitating pre-drought and post-drought comparisons of poverty conditions and their interactions with resilience. We centre our analysis on smallholders' definitions of both poverty and resilience. We consider how co-identified dimensions of poverty interact with the following co-identified, three different dimensions or "outcomes" of resilience: i) meeting critical needs; ii) implementing adaptation; and iii) preparedness for future climate shocks. We find that higher cocoa incomes were not associated with meeting critical needs during a drought, while many other poverty indicators were important across different dimensions of resilience e.g., adequate healthcare access, access to clean drinking water, food security, livelihood diversification, and access to livestock. Thus we advocate that: resilience, like poverty be understood and addressed as multi-dimensional; that resilience be considered in tandem with people's own livelihood concerns; and that interventions look beyond raising cash crop productivity. Although diversifying income is a common resilience-boosting policy, we found greater livelihood diversification was associated with *lower* preparedness scores and meeting *fewer* critical needs in the drought year. Income diversification's ability to alleviate multiple dimensions of poverty is constrained by financial exclusion, lack of market linkages, and structural poverty barriers such as illiteracy, tenure insecurity, or non-potable water. Thus efforts to address households' poverty and climate resilience must be holistic and responsive to local contexts.

Keywords

multidimensional poverty; drought; cocoa; Ghana; agriculture; climate resilience

1. Introduction

For smallholder farmers in rain-fed systems, the impacts of climate change and individual climate shocks can be severe, direct, and inescapable (Cooper et al., 2008; Osumanu, 2022; Rockström, 2003). In sub-Saharan African (SSA) countries, temperature increases, rainfall variability, and droughts are predicted to increase in frequency and intensity in coming decades (IPCC, 2021; Lottering et al., 2020; Yaro, 2013); thereby jeopardising food security and livelihoods, and deepening humanitarian challenges (Challinor et al., 2007; Thornton et al., 2011). Against this backdrop of increasing climate change, along with persistent poverty across the Global South and especially rural SSA, the concept of climate resilience – widely defined as the ability to withstand and adapt to climatic risks and shocks (Adger et al., 2005; Folke, 2016) – has gained significant policy traction in economic-development interventions (Béné et al., 2012, 2016a; World Bank, 2018). Each iteration of the Intergovernmental Panel on Climate Change's (IPCC's) Assessment Report has identified that in terms of biophysical exposure, finances, and formal resources, rain-dependent SSA farmers are severely disadvantaged. Despite long-term recognition of the links between climate impacts, poverty, and resilience, many resilience models fail to appraise their interconnected complexities (Lade et al., 2017), as have resilience interventions (Eriksen et al., 2021; Leal Filho et al., 2021). The pursuit of resilience often overlooks structural and intersectional determinants of vulnerability and poverty (Jackson, 2024). Theoretical and empirical engagement of the relationship between resilience and poverty remains extremely limited.

The prominence of resilience across economic-development interventions is reflected in the Global Resilience Partnership funded by prominent international aid organisations, and by the World Bank Action Plan for Climate Change Adaptation and Resilience to "manage risks for a more resilient future" by providing $50 billion between 2021 and 2025 for direct climate finance across the Global South (World Bank, 2019; Matthews, 2020). Although some resilience interventions failed to serve poor people's needs (Leal Filho et al., 2021), and even *increased* vulnerabilities (Eriksen et al., 2021), resilience has almost usurped poverty alleviation as development's primary goal (Barrett and Constas, 2014; Frankenberger et al., 2014; Mikulewicz and Taylor, 2020). Resilience's rise is also evidenced by the COP's Resilience Hub and 'Race to Resilience' campaign which aim to "strengthen the resilience of 4 billion people" (UNFCCC, 2021); though how resilience across four billion diverse people living in diverse contexts is assessed remains unspecified. Without either meaningfully considering affected people's experiences of climate impacts, or epistemic shifts that normatively ask 'what is being maintained and for whom?' (Cretney, 2014; Cutter, 2016; Quandt and Paderes, 2023), resilience interventions risk entrenching poverty and exacerbating inequalities (Bahadur and Tanner, 2014; Matin et al., 2018). Despite poverty and resilience's interconnections, there remains a lack of research

asking: i) ‘how does poverty undermine resilience?’, or ii) ‘which dimensions of poverty influence resilience?’. This paper probes these questions by embedding the study of resilience within lived experiences of poverty.

Climate change multiplies existing disadvantages (Maru et al., 2014). One climate shock event can further impoverish poorly-resourced people, push individuals deeper into poverty, or lock them into poverty traps, and/or maladaptive practices (Asare-Nuamah et al., 2021; Tongruksawattana and Wainaina, 2019). The 2015-2016 El Niño, which forms the focus of this study, is one such climate shock. Ghanaian cocoa smallholders, who produce ~20% of the world’s cocoa (ICCO, 2020; Van Huellen and Abubakar, 2021), were hit particularly hard by the prolonged drought resulting from this El Niño. Creedy et al.’s (2022) 70-year analysis demonstrates that cocoa production is significantly negatively affected by El Niño events. The 2015-16 El Niño was one of the strongest tropical climate events in a century (Rifai et al., 2019), resulting in prolonged drought, low air humidity, high evapotranspiration, and high maximum daily temperatures over West Africa which dampened global cocoa supply (Abdulai et al., 2018; ICCO, 2016). Drought is cocoa growth’s most critical abiotic threat (Gateau-Rey et al., 2018; Seutra Kaba et al., 2021). Irrigating cocoa is rare in Ghana, where poorly-resourced smallholders are impeded by various social, technical, and economic challenges (Agbenyo et al., 2022a; Bunn et al., 2019b). It is likely that <0.5% of Ghanaian cocoa is irrigated (Carr and Lockwood, 2011). Furthermore, as many Ghanaian cocoa smallholders lack an adequate array of viable income alternatives (Asante et al., 2017), regular rainfall and strong cocoa harvests are necessary (albeit insufficient) to sustain their livelihoods.

The climate threat facing Ghanaian cocoa cultivation is well known, as evinced by chocolate industry initiatives to make cocoa cultivation more ‘resilient’ by securing supplies, e.g., sustainable cocoa, yield intensification, and climate-smart cocoa (Camargo et al., 2019; Carodenuto, 2019; Kalischek et al., 2023). However, as Nasser *et al*. (2020), Maguire-Rajpaul *et al.* (2022), LeBaron (2021), Krauss (2018, 2016), and Odijie (2019, 2018, 2016) highlight, such buyer-driven interventions may perpetuate poverty, entrench inequalities, and exploit cocoa labourers when they fail to foreground cocoa smallholders’ livelihood concerns.

As well as understanding the mounting threat climate change poses, it is imperative to understand how people growing cocoa withstand climate shocks to sustain their livelihoods at different timepoints and how the multiple dimensions of poverty they experience intersect with their resilience. Multidimensional assessments of poverty understand poverty beyond monetary deprivations by incorporating dimensions such as health, food security, living standards, education, infrastructure (Alkire, 2002; Alkire and Santos, 2014; Nguyen et al., 2021). Buyer-centric resilience initiatives to guarantee agricultural supplies regularly overlook underlying poverty conditions and causal economic-development challenges (Barrientos, 2012; Crane et al., 2019; Grabs, 2017; Odijie, 2018). Poverty alleviation and resilience policies centred on monetary improvement by intensifying cash crops (such as cocoa) can

reinforce labour exploitation when they disregard subsistence crops, worsen food insecurity and potentially other dimensions of existing poverty (LeBaron and Gore, 2020; Michler and Josephson, 2017).

This paper politicises climate resilience by fusing it to multiple dimensions of poverty and lived experiences of drought by rain-dependent cocoa smallholders. Our contributions to the literature and policy of resilience include: exploring the merits of embedding poverty within resilience and proposing that both poverty and resilience be treated multidimensionally. Using a longitudinal dataset from before, during, and one year after the 2015-16 El Niño-induced drought, we ask: 'how do different dimensions of poverty shape smallholders' climate resilience?'. With cocoa smallholders, we co-identified different forms of resilience pertinent to their lives – i) meeting basic household needs, ii) carrying out adaptation, and iii) preparedness for future droughts – and analysed how these different forms or "outcomes" of resilience interact with different poverty dimensions. Drawing on three years of surveys (supplemented by focus group discussions and interviews), our dataset assembles climate shock observations made by cocoa-growing households on their responses and adaptive actions to drought. There has been little attention on this important resilience-poverty nexus and, to our knowledge, no work to date engaging longitudinal empirical data spanning a climate shock.

Heeding several IPCC Reports' calls to incorporate the needs of the poor into climate-resilient interventions (IPCC, 2022), this paper focuses on cocoa smallholders' pre-drought economic development challenges and underlying poverty conditions by fusing the multidimensional nature of poverty (Alkire, 2007, 2002) to resilience. An improved understanding of the intertwined dimensions, drivers, and outcomes of poverty and resilience – along with inclusionary governance for equitable resilience (Ensor et al., 2021; Matin et al., 2018) – are critical for upholding the SDGs' central promise to 'leave no one behind' (Schipper et al., 2020).

2. Theoretical foundations

2.1 Resilience – growth and contestation

Resilience broadly refers to a capacity for dealing with change and shock (Lindow et al., 2020). Like sustainability and adaptation, the concept of resilience is appealing because it: is widely understood; is often extolled as universally desirable; and cuts across scientific disciplines and sectorally-divided donor institutions (Béné et al., 2012; Fünfgeld and McEvoy, 2012). Although resilience thinking originates in engineering and ecology, the concept became extensively used to explain how social-ecological systems (SESs) resist climate-related stressors or undergo change. Walker *et al.'s* influential definition states that resilience is the capacity of SESs ''to absorb disturbance and

reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (2004: p.1).

Etymologically and in terms of its engineering definition, resilience refers to bouncing back to a previous steady state. Holling (1973) attested that equilibrium-based approaches were inadequate for explaining ecosystems against anthropogenic disruptions (Cavanagh, 2017). For ecological behaviour, Holling delineated between i) *resilience* as "the ability […] to absorb changes […] and still persist," versus ii) *stability* as "the ability […] to return to *an* equilibrium state after a temporary disturbance" (1973: 17-18), thereby introducing the existence of *numerous* stable states (Holling, 1986).

Other strands of resilience thinking refer to adaptive capacity, transformability, and learning for future shocks (Folke, 2006). Evidently, resilience can refer to many qualities within a system. This necessitates both a multi-dimensional approach to studying resilience, but also a politically engaged approach since resilience involves profound questions concerning how power shapes processes and priorities in pursuing resilience (Bahadur and Tanner, 2014; Quandt and Paderes, 2023).

Davoudi *et al.* (2012), Weichselgartner and Kelman (2015) warn of important issues to consider when transposing resilience from ecological description to social prescription: how political dimensions are expunged (Mikulewicz and Taylor, 2020), or how many SES approaches fail to capture underlying poverty and inequalities (Wachsmuth, 2015). An issue oft-neglected in development policy is that Holling defined resilience and disequilibrium to *describe* (1986, 1973) the "paradigms of ecological function" (Holling, 1987), rather than *prescribe* "how coupled SES *should* behave" (Brand and Jax, 2007; Brown, 2016; Cavanagh, 2017: 114). Resilience's systems approach does not equally engage social and ecological aspects, with Mikulewicz (2019) cautioning that "resilience should not be considered a human-centred approach to development" (p.277). Nevertheless, "resilience is everywhere in contemporary debates about global environmental change," (Brown, 2014: 107) where it is used normatively as a desirable state.

This paper acknowledges the contestations surrounding resilience as a term, goal (Cote and Nightingale, 2012), or even the preferred outcome (Lo et al., 2020). Unlike many international development agencies, we do not accept resilience as an "unalloyed good for promoting sustainable development" (Mikulewicz, 2019: 290). Resilience's reductivist nature has been met by abundant critical backlash (Béné et al., 2016b; Jennings, 2011; Taylor, 2014). There are myriad limitations to resilience-based approaches: often against what is excluded from resilience measures (e.g. underlying vulnerability drivers, chronic poverty, structural poverty, recovery over time, enacting adaptive strategies, future preparedness), or the ways in which top-down objective measures of livelihood resilience by external 'experts' exclude context-specific indicators of resilience (Quandt, 2018: p.254). To address some of these criticisms, this paper pluralises what resilience can mean by integrating smallholders' perspectives and other subjective

measures of resilience gained through participatory methods (Clare et al., 2017; Jones, 2019; Quandt and Paderes, 2023). With cocoa smallholders' input, we co-defined distinct 'dimensions' or 'outcomes' of resilience pertinent to how they cultivate cocoa and sustain their household livelihoods (cf. sections 3.2 and 3.4).

Cote and Nightingale (2012) critique SES approaches to resilience thinking as ''inadequate […] because it repeats the weaknesses of earlier approaches in risk and hazard science that overemphasized the role of physical shocks and undertheorized that of political economic factors in conceptualizing vulnerability" (p.478). Accordingly, resilience is lambasted for focussing on climate events, thereby side-lining non-climatic, social, and political-economy causes of crises (Rao et al., 2020; Schipper et al., 2020; Singh et al., 2021, 2016), as well as being constrained by ecological assumptions and/or single equilibrium assumptions wholly inapplicable to human communities (Cretney, 2014; Wachsmuth, 2015). Others rail against how pursuing resilience upholds neoliberal, capitalist pathways that fuel climate change, perpetuate unequal resource distribution (Barnett, 2020; Nagoda, 2015), while stifling the potential for radical transformation (Carr, 2019; Manyena et al., 2019; McKeown et al., 2022).

Furthermore, prevailing conditions in high-poverty, low-income communities mean many households are insufficiently resourced for meeting basic needs, much less for accumulating resources to adapt to – and prepare for – climate shocks (Bailey, 2017; Sen, 1999; Thiede, 2016). When resilience theory and policy focus primarily on climate change and climate shock events as the primary cause of crises, myriad social, political, and economic causes are silenced (Kashwan and Ribot, 2021; Ribot, 2022). Despite extensive critique and empirical data against interventions aiming to bolster resilience in isolation, without considering social issues, poverty's causal foundations, or the lived experiences of Global South communities, myopic 'techno-fix' approaches pervade development programmes (Béné et al., 2011; Boyd, 2017; O'Brien and Selboe, 2015).

2.2 Fusing resilience to multiple dimensions of poverty

To counter techno-fix reductivism (Nightingale et al., 2020; Rasmussen, 2018) and generate more human-centred framings of resilience (Mikulewicz, 2019), this paper's pluralistic approach examines multiple dimensions of poverty in tandem with resilience and thereby accords with livelihood resilience which is centred on the capacity of people to sustain their livelihood opportunities and well-being despite disturbances (Tanner et al., 2015: p.23). We deem poverty as a dynamic process, transformable by shocks such as droughts, harvest losses, etc. Following Sen (1985, 1976), Bourguignon and Chakravarty (2002, 1999), and particularly Alkire and Foster (2011a, 2007), we deem poverty to be a pluralised, multi-dimensional experience and recognise that low income people may also suffer insufficient levels of other well-being attributes, e.g., literacy, numeracy, health care, living standards.

We draw on Alkire-Foster's multi-dimensional poverty index (MPI) approach which broadens uni-dimensional monetary measures of poverty to incorporate other dimensions of poverty and welfare (Alkire, 2007, 2002; Alkire et al., 2017). Education, health, and living standards are three core poverty dimensions which recur across many studies (Alkire and Santos, 2010; Alkire and Seth, 2015; Saboor et al., 2015) to which other context-dependent dimensions and indicators of poverty – including income – are included (Bérenger and Verdier-Chouchane, 2007; Calvo, 2008). All can be readily adjusted to incorporate alternative poverty dimensions, indicators, cut-offs, and weights (Santos and Alkire, 2011, p.1). Alkire-Foster's MPI has made a significant, lasting impact on poverty measurement. Several national governments use MPI measures that rely on Alkire–Foster's methodology; yet within agri-development policy, income still dominates target setting.

Typically, multiple dimensions of poverty – including income, education, social exclusion, assets, and infrastructure – influences people's vulnerabilities (Casale et al., 2010; Eakin et al., 2012; O'Brien and Barnett, 2013; Wisner et al., 2004). Nevertheless, poverty, adaptation, and resilience interventions in agri-development in general – and cocoa specifically – have focussed on narrowing yield gaps by intensifying production. This includes many corporate sustainable intensification efforts to directly boost cash crop income, such as cocoa's newly implemented living income differential. This is problematic because many issues relevant to what constitutes poverty are overlooked. A singular focus on export crop productivity *neglects*: (i) diversifying farmers' income streams (Thompson et al., 2022); (ii) addressing poverty's root causes and social differentiation e.g., gender dynamics (Asaaga, 2021; Busquet et al., 2021; Quisumbing and Pandolfelli, 2010); (iii) problematising agricultural and economic growth (Mikulewicz and Taylor, 2020); and (iv) alleviating non-income dimensions of poverty such as wider food security (Kumeh et al., 2022).

Poverty alleviation and resilience policies concentrated on intensifying cash crops risk disregard subsistence crops for securing food and household resilience, potentially exacerbating existing poverty (Michler and Josephson, 2017). For example, even if a farmer harvested a large volume of cash crop, they may nevertheless suffer food insecurity if subsistence crop yields were poor. Similarly, limited infrastructure may impede access to healthcare, agronomic information, education, or banking services, regardless of export-crop income. Therefore, this paper draws on theories of multiple dimensions of poverty (Alkire, 2007; Atkinson, 2019; Cohen, 2010; Thiry et al., 2018) to examine simultaneous deprivations.

While resilience has been linked theoretically to vulnerability – which is itself linked to poverty – by various scholars (e.g., Adger, 2006; Akter and Mallick, 2013; Maru et al., 2014; Miller et al., 2010; Nyantakyi-Frimpong and Bezner-Kerr, 2015), overall such work has tended to be conceptual rather than empirical. Despite resilience's and poverty's interconnections, explicit linking of poverty to resilience is rarer (Barrett and Constas, 2014; Lade et al., 2017); even rarer are situated analyses of tangible, complex social issues faced by communities striving for resilience.

Notable exceptions include: Béné *et al.*'s (2011) evaluation of resilience's usefulness among Nigerian small-scale fishers; Forsyth's (2018) identification of socially-inclusive resilience pathways in Myanmar; Hirons *et al*.'s (2018) demonstration of how livelihood practices among Ghanaian smallholders can enhance or undermine resilience; and Mikulewicz's (2019) grounded critique of 'dehumanised' resilience interventions in São Tomé and Príncipe. Forging empirical connections between resilience and experiences of poverty is imperative given accelerating climate breakdown along with persistent poverty, particularly in rural SSA. We do this by drawing on longitudinal data surrounding a climate shock of a drought to examine how poverty dynamics are immediately impacted by drought, and the ways in which experiences of poverty are counterbalanced by household capabilities, including adaptation, recovery, and preparedness, or all that is broadly termed resilience.

Akin to livelihood resilience which intends to minimise harm and loss by bringing people's lives to the fore and commands attention on societal root causes (Quandt, 2018; Tanner et al., 2015), our people-centred approach does not limit resilience to withstanding only climatic phenomena, but examines poverty dimensions before the climate shock to examine their role in enabling coping, adapting, and preparedness. Our foundational premise is that resilience-building interventions that neglect poverty could lead to outcomes that exacerbate vulnerabilities and poverty, and possibly even maladaptive outcomes (Asare-Nuamah et al., 2021; Eriksen et al., 2021; Schipper, 2020). Thus, this paper examines poverty and resilience's interactions, and treats both concepts as multi-dimensional phenomena.

Given resilience's polysemic nature (cf. Brand and Jax, 2007; Manyena et al., 2019), we do not produce a single resilience measurement; indeed, Weichselgartner & Kelman (2015) highlight the need to look beyond quantitative streamlining of resilience into one index. Instead – and analogous with recognition that poverty is a multi-dimensional phenomenon – we acknowledge that multiple types of resilient states exist (Holling, 1986), and that these are highly *context-dependent.* Thus we identify with smallholder input distinct, subjective "resilient outcomes" (Jones and d'Errico, 2019; Jones and Tanner, 2017): e.g., cocoa smallholders' ability to meet basic household needs during or after a drought, or their preparedness for future climate shocks. We regard each of resilient outcomes as specific realisations of the broader concept of resilience. Indeed, the malleable concept of resilience has been surmised as "too vague and frequently too poorly understood by those who offer to deliver it to local people" (Mikulewicz, 2019: 276). Such appraisals motivated us to incorporate smallholders' perspectives and experiences, elucidated in our methodology to which we now turn.

3. Methodology

3.1 Study sites

We draw on a unique longitudinal dataset collected across three years (before, during, and after the 2015-16 El Niño-induced drought) in six cocoa-growing villages in Assin South district of Ghana's Central Region (see Fig 1). This study formed part of the socio-ecological ECOLIMITS consortium which explored ecosystem limits to poverty alleviation in forest-agriculture landscapes. The landscape is dominated by the 375km² Kakum National Park (gazetted since 1992), which is surrounded principally by <5ha smallholdings growing cocoa, oil palm, and subsistence crops (Hirons et al., 2018b; Moore et al., 2019). The locations of the villages and nearby plots were chosen to assess the influences of intact forest and shade management on ecosystem services and their impacts on cocoa yield. Ecological and meteorological plots were stratified by distance from forest edge. That consortium had, since 2013, forged strong relationships with these six cocoa-growing villages, so we were welcomed to return to conduct surveys in three consecutive years. While our study focused on one district in Ghana, climate shocks have broadly similar biophysical impacts across the tropical south of Ghana and Côte d'Ivoire where rain-dependent smallholders grow >60% of the world's cocoa (Bunn et al., 2019a; Läderach et al., 2013)[1].

Cocoa ideally requires regular rainfall of 1,500-2,500mm annually (Ross, 2014), but can grow under 1,300-2,800mm annual precipitation (Carr and Lockwood, 2011). Ghana's Central Region's annual average rainfall of 1380mm is at cocoa's lower threshold (Whitfield et al., 2019). Ghana's 2015–16 cocoa harvest was reduced by the prolonged El Niño-induced drought (Abdulai et al., 2018; ICCO, 2016; Maguire-Rajpaul et al., 2020). Elevated temperatures intensified water vapor deficits and lowered soil moisture (Morel et al., 2019). These hydroclimatic conditions were comparable to climate change projections for the next few decades (Schroth et al., 2016). Instead of speculating how smallholders might respond to possible future extreme weather or ask them to recall responses to historical shocks, we could focus on smallholder experiences of that recent drought.

[1] Such an extreme geographical concentration of cocoa production makes the global industry highly vulnerable to a regional decline in climatic suitability (Schroth et al., 2015). Cocoa's dependence on regular rainfall, teamed with low irrigation possibilities, makes smallholders especially susceptible to the impacts of climate variability and change.

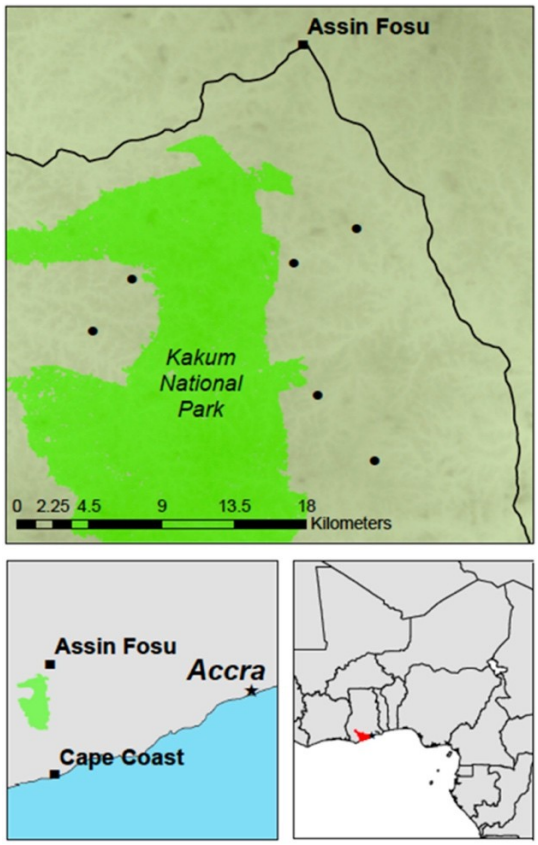


Fig. 1. Map showing study sites. Circles represent approximate location of studied villages. Squares represent major settlements and the black star denotes Ghana's capital cities of Accra.

3.2 Co-producing knowledge via scoping interviews and focus group discussions

Many empirical resilience approaches solicit little (if any) judgement from the subjects in question (Ensor et al., 2021; Jones, 2019). The norm for measuring both poverty and resilience has been via pre-defined variables (e.g., Armitage et al., 2012; Bebbington, 1999; Chantarat and Barrett, 2012; Scoones, 2015, 2009) external 'experts' according to framings of 'objectivity' (Jones, 2019; Jones and d'Errico, 2019; Jones and Tanner, 2017; Quandt et al., 2019) which results in their values forming the inquiry, rather than those who intimately understand their own capacities, limits, and poverty experiences (Bahadur et al., 2015; Carpenter et al., 2001). Accordingly, participatory approaches assessing resilience and poverty through subjects' experiential expertise are increasingly advocated (Beebeejaun et al., 2015; Béné et al., 2016a; Bennett and Roberts, 2004; Clare et al., 2017; Collins and Evans, 2002). Our epistemological foundation was first to listen to what constitutes poverty locally and to smallholders' self-assessments of how they fared managing their households and farms (i.e., their 'resilience') before, during, and after the El Niño-induced drought.

We held 12 gender-segregated FGDs in 2015, four in July 2016, and six in April 2017. We hosted separate FGDs for men and women as access to resources can be heavily gendered as can perspectives about resilience among smallholders (Quandt, 2019). Within many SSA agricultural communities, positionalities and power dichotomies are discernible between genders meaning that some might feel uneasy discussing their thoughts in front of other people and some voices might dominate over others (Bourey et al., 2012; Caretta and Vacchelli, 2015). The FGD and interviews were conducted in Twi and live interpreted into English and recorded through detailed note-taking. These data were then thematically coded Fereday and Muir-Cochrane (2006) to draw out insights into respondents' perspectives on poverty and resilience, and these findings were then used to inform the development of the household survey questions. From these smallholder accounts, our surveys and analyses considered the following nine dimensions when estimating poverty in this cocoa smallholder social-ecological system: income, health, education, basic needs, assets, land assets, food security, empowerment, and social connectedness. Each of the nine dimensions consists of between two and six indicators. To provide a degree of standardisation and comparability, the nine poverty dimensions and 38 indicators for poverty (presented in Table 4.2) combine the literature (e.g., Alkire-Foster's multi-dimensional poverty index (2011) and Hirons et al., (2018b)) with smallholder accounts from interviews and FGDs. As well as informing the survey design, we use the qualitative data primarily to supplement, illustrate, and enrich the quantitative findings which form the core focus of the analysis presented here.

Following the drought, further interviews and FGDs in 2016 and 2017 were used to refine household surveys in those years (adding questions on drought impacts and adaptation). Our 'experiential expertise' subjective resilience (Jones and Tanner, 2017; Quandt and Paderes, 2023) approach engaged smallholders as stakeholders who co-produced knowledge (Beebeejaun et al., 2015; Wachsmuth, 2015). In interviews and FGDs, smallholders related practical challenges they encountered and situated the drought within their broader social contexts.

3.3 Household surveys

Semi-structured scoping interviews and FGDs elicited rich, highly-localised repertoires which we used to inform the design of survey questions to quantitatively assess distributions of such experiences. In recognition of the centrality of a household in managing shocks (Frankenberger and McCaston, 1998; Toole et al., 2016), our surveys' unit of analysis was households rather than individuals which enabled more community members' experiences to be captured.

Semi-structured scoping interviews and FGDs elicited rich, highly-localised repertoires which we used to inform the design of survey questions to quantitatively assess distributions of such experiences. In recognition of the centrality of a household in managing shocks (Frankenberger and McCaston, 1998; Toole et al., 2016), our surveys' unit of analysis was households rather than individuals which enabled more community members' experiences to be

captured. We surveyed representatives from 108 households (randomly sampled from household lists, stratified by gender of household head) in 2015; 107 in 2016; and 103 in 2017. We gave a verbal preamble that the survey questions would refer to all household members and to decisions made on behalf of the whole household. We acknowledge that surveying the person who makes most of the decisions for a group to answer on behalf of all its members is unlikely to be perfectly representative. However, we designed our research according to locally recognised social units (Newing et al., 2024) (i.e., households) and according to local customs. From our long-standing relationships in these cocoa-growing villages, we deduced that respecting hierarchies by approaching the heads of each household was most culturally appropriate.

Since surveying one member of a household risks overlooking intrahousehold power dynamics (e.g., women being excluded from decision-making processes over land, farming (Friedman et al., 2018), and spending (Barrientos, 2013)), we set out to lessen biases against women, widows, and younger cocoa farmers by conducting focus groups with representatives from these socio-demographic groups, and later creating survey questions based on their insights. We further attempted to minimise bias by inviting additional household members to attend surveys should they wish.

In a few cases, we were unable to match a household from 2015 to details given by respondents in 2016 or 2017 – likely because a household representative was unavailable for survey in a later year. In total, 95 households matched across all three years with at least 10 household representatives surveyed per village. The sample size represents a compromise between depth and richness of survey data needed to sufficiently garner responses across the multiple dimensions of poverty and resilience we are examining and resources available.

We acknowledge the authors' positionality and extrinsic roles (several are foreign nationals) as distinct from Ghanaian partners, enumerators, and surveyed households. Enumerators and interpreters provided essential bridges between the research and cocoa-growing communities. All data (interviews, FGDs, and surveys) were gathered in Twi. All questions posed had already been translated and piloted into formats readily understandable by cocoa smallholders' linguistic and cultural experiences.

3.4 Survey data processing and analysis

To examine poverty and resilience's relationships, we treated each poverty dimension/indicator from 2015 (the pre-drought year) as a single independent variable. As resilience is fraught by "definitional ambiguities" (Jones, 2019: 5), and no consensus exists on measuring resilience (Béné, 2020; Schipper and Langston, 2015), rather than reducing the totality of resilience into a single quantitative index, we constructed composite measurements of distinct,

contextually-relevant types of resilience, hereafter referred to as "resilient outcomes". Following smallholder input, we co-identified resilient outcomes of i) meeting basic household needs, ii) adapting to drought, and iii) being prepared for future droughts. We acknowledge these are not the only outcomes that may be relevant to resilience; rather these are subjective resilience measures that were deemed pertinent by smallholders themselves. "What resilience means within development practice will have important consequences both for development practitioners and the communities in which they work" (Walsh-Dilley et al., 2016: p1). Resilience meaning a household covering their basic needs is essential to many in economically-developing communities, and applying such a "human-centred" subjective approach to resilience (Chandler, 2013; Cutter, 2016) addresses one recurrent critique of the "power-blind" resilience concept (Davoudi et al., 2012).

Three resilient outcomes identified with smallholders were:

- *Ability to meet critical needs*. Each year, households reported whether they could meet six different basic needs (e.g., obtaining enough food; being able to afford medicine) widely identified by smallholders as being critical and fundamental to coping. We computed a critical needs score for each household in 2015, 2016, and 2017 which ranged from 0 (no critical needs met) to 6 (all critical needs met).
- *Drought adaptation*. The "drought adaptation" score was computed from Likert-scale responses to five prompts (asked in either 2016 or 2017) concerning drought adaptation, and specific adaptive changes implemented (e.g., increasing food crop storage, finding wetland area to farm). A single score was computed per household.
- *Preparedness for future droughts*. Analogous to the previous resilient outcome, preparedness was computed from Likert-scale responses to five prompts (asked in either 2016 or 2017) concerning *future* droughts, and adaptive strategies households *planned* to implement in future (e.g., "will change farming approach following drought experienced", "now know how to cope with drought conditions", "future droughts' impacts on me would be similar or less"). Here too a single score was computed per household.

[Table 3.1 here in black & white]

Resilient outcome	**How quantified**	**Range**
Meeting critical needs (all years)	+1 for each of 6 critical needs household met throughout year	0 to 6
Implemented adaptation (2016 & 2017)	+1 for each adaptation already implemented by household (from 9 prompts); +1/+0.5/0/-0.5/-1 for extent of agreement (Likert scale) with five statements about drought adaptation	-5 to 9
Future drought preparedness (2016 & 2017)	+1 for each adaptation planned by household (from 9 prompts, with free response option); +1/+0.5/0/-0.5/-1 for extent of agreement (Likert scale) with five statements about drought preparedness	-5 to 9

Table 3.1. Summary of the different resilient outcomes and how we quantified them in our analyses.

We computed summary statistics on the distribution of scores associated with each of these resilient outcomes. Our main quantitative analysis examined statistical associations – if any – between each resilient outcome and each of the 38 indicators of poverty (listed in Table 4.2) across all nine dimensions considered[2]. The only exception was food security, which we excluded from comparison with the critical-needs resilient outcome, since the same two survey questions that probed food security in 2015 were used to compute the critical needs score in that year; thus this poverty dimension was correlated with the resilient outcome *a priori*[3].

Statistical tests of association performed depended on the type of variable associated with each poverty indicator, i.e. : Spearman rank correlation tests for quantitative poverty indicators, or categorical indicators spanning many (e.g. 10) categories and where the latter could be mapped to an equally-spaced linear interval; Kruskal-Wallis *H*-tests (one-way analysis of variance) for categorical poverty indicators spanning three or more categories; or Mann-Whitney-Wilcoxon *U*-tests for binary categorical variables. Apart from being appropriate for the respective variable types, these tests were chosen as they are all non-parametric, i.e., "distribution-free", and do not assume e.g., normally-distributed variables. In what follows, we report only statistical associations between poverty indicators and resilient outcomes that were statistically significant at $p<.05$ or $p<.10$ (the latter in parenthesis) levels. Survey data were analysed using the Python scipy.stats library.

4. Results and discussion

4.1 Pre-drought sociodemographic characteristics

Demographic variable	**Distribution of responses (2015)**
Respondent gender	Male: 62%; female: 38%
Respondent age (years)	μ = 46.9, M = 48.0, SD = 13.8 (range: 18–91)
No. children (<18 years) in household	μ = 4.8, M = 4.0, SD = 3.8 (range: 0–19)
No. adult males in household (excl. respondent)	μ = 1.6, M = 1, SD = 1.8 (range: 0–10)
No. adult females in household (excl.	μ = 1.4, M = 1, SD = 1.7 (range: 0–8)

[2] We experimented with combining all indicators in each dimension to produce a "master proxies" for all dimensions. However, apart from a great degree of arbitrariness in how the different indicators were weighted within dimensions, we also found that this approach did not change overall conclusions about which poverty dimensions were associated with which resilient outcomes.

[3] While such an issue could be avoided with longer-term and more predictable funding streams for longitudinal research that permits temporal considerations to be embedded into survey design. Furthermore, this illustrates the potential for tautological analyses and the challenge in unambiguously disentangling poverty from resilience.

respondent)	
Time respondent has been in village (years)	μ = 29.1, M = 30, SD = 13.7 (range: 2–66)
Age (average) of cocoa farm (years)	μ = 18.1, M = 15.0, SD = 11.4 (range: 0–46)
Respondent's migrant status	Local: 40%; immigrant: 60%

Table 4.1: summary of sociodemographic demographic characteristics of the 95 household representatives who completed our survey in all three years. Here and hereafter, we use the shorthand notation μ, M, and SD to represent mean, median, and standard deviation, respectively.

Since the impacts of any climate hazard are socially stratified by pre-existing vulnerabilities (De Juan et al., 2020; Ensor et al., 2021), it is imperative to examine poverty conditions before the drought struck. In 2015, the mean household annual cocoa-derived income was 7390 Ghanaian cedis (US $1989), while the mean annual income from all other sources was 2413 cedis (US $650). This translates to US $0.95 per person per day: half the World Bank's international poverty line of $1.90 per person per day[4]. Similarly, LeBaron's (2021) surveys in 74 Ghanaian cocoa communities found farmers were only earning around 30% of the poverty line. Such material poverty among Ghana's cocoa farmers is widely reported in the literature (Asamoah et al., 2013; van Vliet et al., 2021; Waarts et al., 2019). Combining credible datasets from Kongor *et al.* (2018), Akrofi-Atitianti *et al.* (2018), Ingram *et al.* (2018), and Asare *et al.* (2019), Boeckx *et al.* (2020) calculated that the proportion of Ghanaian cocoa households achieving a 'living income' from cocoa production is as few as 5%. Likewise, Cocoa Barometer (2020) concluded that very few West African cocoa farmers earn a living income. Although obtaining accurate and reliable figures is difficult, widespread monetary deprivation among cocoa farmers exists independently of droughts or other climate shocks. Therefore, initiatives claiming to boost farmer resilience by increasing yields are unlikely to serve cocoa households meaningfully; leading some commentators to equate increasing yields to exerting more labour for exploitatively low earnings, and judging this as unjust (Amuzu et al., 2022; Nasser et al., 2020) and tantamount to continuing colonial capitalism (Bernards, 2021; Collins et al., 2021; Odijie, 2019).

Pre-drought, more than a third of surveyed households failed to secure basic food needs and the mean spend on food was 46% of income. Only 52% households believed they had enough savings to cope and feed themselves in a low-cocoa-yield year or recurrent cocoa "lean" seasons, and focus group discussants recounted debt bondage with interest rates as high as 100%, corroborating what LeBaron's (2021) Ghanaian cocoa farmer surveys found. A focus group quote emblematic of this plight was that *"[food] can run out during a lean season and you must buy food and you don't have money either in lean seasons*". The high proportion of income spent on food may be due to several conflating factors e.g., i) only 12% of households having access to a refrigerator, impeding safe food storage – a concern repeated across focus groups; ii) relatively few households owning *any* means of transportation –

[4] The World Bank's international poverty line was set at $1.90 per person per day from 2011 until September 2022.

smallholders recounted how this, combined with unreliable rural taxis, meant that reaching markets to buy and sell food was challenging; combined with iii) the aforementioned prevalent failure to secure a living income;

The typical household dedicated twice as much of their land to cultivating cocoa – a crop exported for consumption as a luxury food abroad – than all other crops combined (see Table 4.2 and Supplementary Material) [Table 4.2 here in the colours used as each colour corresponds to one poverty dimension and repeats across tables]. More than a third of households failed to secure basic food needs. Prevalent food insecurity among Ghanaian cocoa farmers is extensively reported in the literature (Asamoah et al., 2013; Dei Antwi et al., 2018; Hashmiu et al., 2022; Kumeh et al., 2022; Maguire-Rajpaul et al., 2020). Evidence of cocoa's expansion into multiuse croplands across Ghanaian cocoa-producing landscapes is concerning (Ajagun et al., 2022; Asubonteng et al., 2018; Wessel and Quist-Wessel, 2015) since conversion of food-crop lands into cash-crop landscapes often worsens local food security and reduces welfare (Adjei et al., 2020; Bymolt et al., 2018; Tankari, 2017).

70% of households reported frequently suffering poor health before the drought, while 18% had experienced under-five mortality; for comparison, SDG Target 3.2 aims for under-five mortality rates lower than 2.5% of live births. More than half of surveyed households either lacked any access to clean drinking water or had only shared access (9% and 42%, respectively). Nevertheless, the majority of studies on poor health among cocoa farmers tend to neglect such fundamental health issues and instead focus on personal protective equipment against hazardous agro-chemicals (Fosu-Mensah et al., 2016; Okoffo et al., 2016), advocating eye protection (Boadi-Kusi et al., 2017, 2016). Access to potable water, doctors, medicines etc. and improving farmers' health are lacking in interventions, with corporations prioritising securing cocoa supplies, and the state (via Cocobod) prioritising agronomic extension and agro-input provision. Yet as one focus group who unanimously agreed on the importance of health put it: when a cocoa farmer *"is strong and healthy they can farm and you can get whatever you want, but those who are sick or disabled will be poor".*

Table 4.2 summarises our nine dimensions of poverty, the indicators (at least two) for each dimension, and the distribution of responses across all 95 households before the drought. Even under favourable climatic conditions, the surveyed cocoa smallholders suffered material poverty, structural poverty, poor access to public services, food insecurity, and failed to meet basic needs. Such multiple dimensional poverty is ubiquitous among West African cocoa smallholders, and has prompted examinations into the global cocoa value chain's power asymmetries as well as the marginalisation, relative vulnerability, and even exploitation of smallholder labourers (Barrientos, 2014; Krauss and Krishnan, 2022; LeBaron and Gore, 2020; Odijie, 2018). Yet buyer-driven governance overlooks already existing poverties and narrowly equates resilience as guaranteeing cocoa supplies without further deforestation reputational risk (Grabs, 2017; LeBaron, 2021).

Poverty dimension	Indicator	Distribution of responses (2015)
Income	Annual cocoa income, from direct sales and trading (cedis)	μ = 7390, M = 3990, SD = 9237 (range: 350–40000)
	Annual non-cocoa income (cedis)	μ = 2413, M = 1080, SD = 3919 (range: 0–27000)
	Annual cocoa harvest (kg)[1]	μ = 862, M = 640, SD = 1001 (range: 0–6912)
	Livelihood diversification (no. of income sources not related to cocoa)	μ = 4, M = 4, SD = 2. Common income sources: annual crops (73%), commodity trading (53%), oil palm (47%), remittances (34%), daily cocoa labouring (27%), skilled labour (21%), livestock (20%)
	Have enough savings to cope with a year with low cocoa yield	Strongly agree: 16%; agree: 36%; disagree: 18%; strongly disagree: 27%; don't know: 3%.
	Weekly food expenditure (cedis)	μ = 87; M = 70; SD = 120 (range: 0–1050)
Health	Poor health frequently affects household	Strongly agree: 38%; agree: 32%; disagree: 21%; strongly disagree: 9%
	Household has adequate access to healthcare	Strongly agree: 20%; agree: 60%; disagree: 16%; strongly disagree: 4%
	Under-5 mortality in past	Yes: 18%; no: 82%
Education	Education completed (household representative)	No formal: 21%; primary: 24%; junior high: 49%; senior high: 5%; vocational 1%
	Literacy level (household representative)	Illiterate: 45%; read only: 11%; read and write: 44%
Basic needs	Electricity access	No: 34%; grid: 63%; shared from grid: 1%; own generator: 2%
	Sanitation access	No: 11%; yes: 59%; shared: 31%
	Clean drinking water access	No: 9%; yes: 48%; shared: 42%
Assets	Devices and associated services[2] (ownership or shared access)	Radio (74%); TV (35%); mobile phone (72%); bank account (53%); mobile money account (33%); refrigerator (12%);
	Vehicles[3] owned	Bicycle (13%); motorbike (10%); car/other (10%)
	Motorised spraying machine	No: 25%; yes: 26%; share: 8%; rent: 40%
	No. of goats owned	μ = 2.2, M = 0, SD = 5.6 (range: 0–42)
	No. of chickens owned	μ = 20.3, M = 10, SD = 30.5 (range: 0–250)
	Other livestock owned	One household owned one head of cattle; two households owned pigs (4 and 6 pigs, respectively). No horses or donkeys.
Land assets	Cocoa cultivation land area (acres)	μ = 7.9, M = 6.4, SD = 8.0 (range: 0–53)
	Oil palm cultivation area (acres)	μ = 1.2, M = 0, SD = 2.7 (range: 0–20)
	Total cultivation area across all crops other than cocoa and oil palm (acres)	μ = 2.3, M = 1.6, SD = 3.0 (range: 0–17)
	Homestead area (acres)	μ = 0.78, M = 0.40, SD = 1.46 (range: 0–12)
Food security	Adequate food amount (past year)	Yes: 65%; no: 35%
	Adequate food variety (past year)	Yes: 80%; no: 20%
Empowerment	Easy to access more cocoa land?	Strongly agree: 20%; agree: 22%; disagree: 44%; strongly disagree: 12%; don't know: 2%
	Any influential position in village (e.g. elder, committee member, pastor)?	Yes: 39%; no: 61%.
Social connectedness	Social group membership	65% belonged to at least one social group; 35% belonged to none. Common memberships: church group (20%), Enobua[5] (20%); Susu[6] (4%); farmers' association (3%)
	Buying company/purchasing clerk agronomic advice frequency[4]	At least monthly: 12%; at least annually: 23%; less than annually: 3%; never: 62%
	Agri-officer agronomic advice frequency[4]	At least monthly: 5%; at least annually: 47%; less than annually: 7%; never: 41%
	Friend/neighbour agronomic advice frequency (*N*=29 responses only)	More than once a month: 34%; monthly: 48%; at least annually: 18%

Table 4.2: pre-drought poverty dimensions and indicators from 2015, and the distribution of responses (*N=95*, unless otherwise specified) across surveyed households. Notes: (1) Two households had only recently established their cocoa farms and their trees had not yet yielded. (2) Each device or service analysed as a separate poverty indicator. (3) Each vehicle analysed as a separate poverty indicator. (4) Summarised from 14 finer-grained categories of responses, e.g., "3-6 times per year". (5) Shared labour group; (6) Shared savings group.

4.2 Drought's impacts on cocoa and subsistence crops

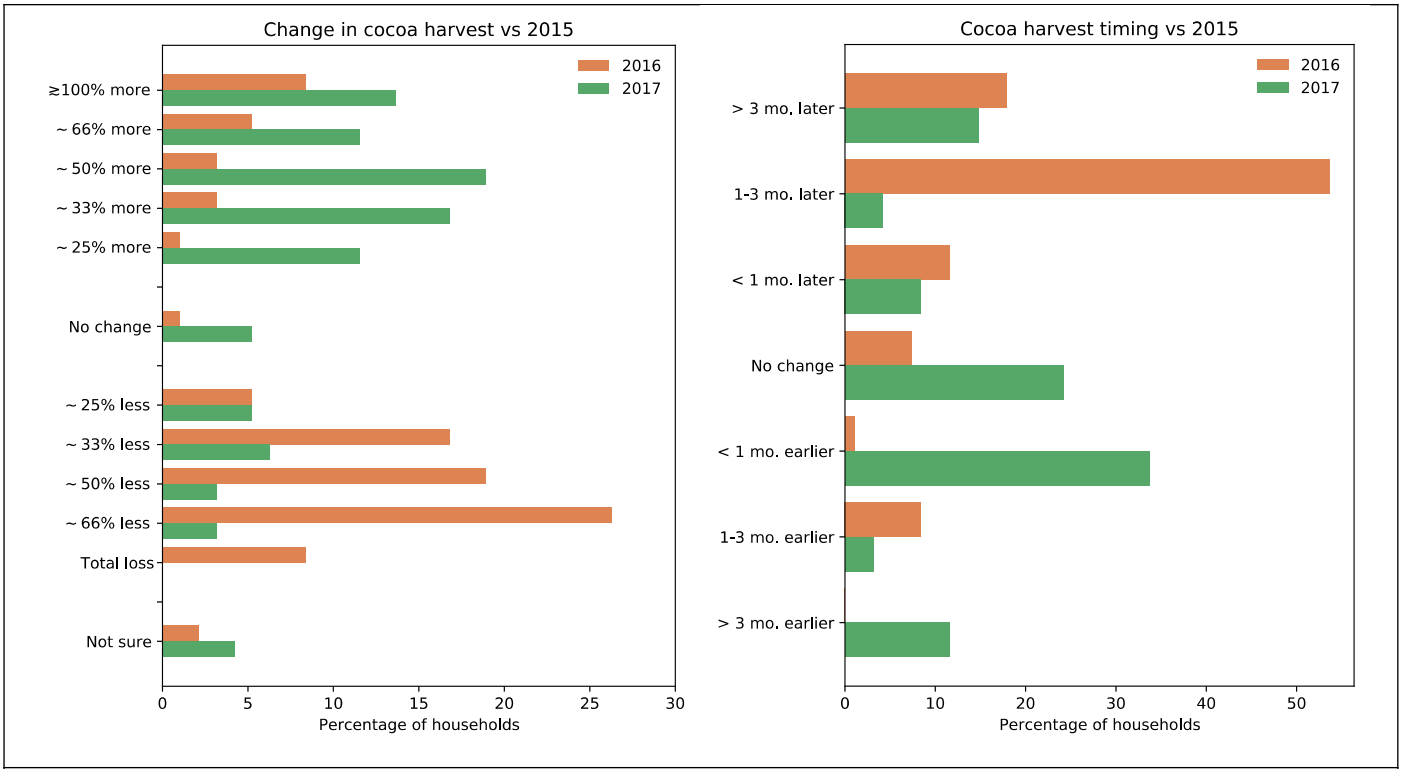


Figure 4.2: reported changes in cocoa harvests (left panel) and changes in harvest timing (right panel) in 2016 and 2017, in both cases compared to the pre-drought year, 2015. The changes are grouped into categories identical to those used in survey questions.

The effect of drought is instantaneously negative on cocoa production (Creedy et al., 2022). Indeed, half of surveyed households reported 2016 cocoa harvests up to 50% less than pre-drought, and a further quarter reported losing up to 66% of their cocoa compared to pre-drought. Given that before the drought hit, the average household was already earning only half of the World Bank's international poverty line, and that adverse climate conditions are predicted to increase in frequency and severity in coming decades (Afriyie-Kraft et al., 2020a; Agbongiarhuoyi et al., 2013; Ibn Musah et al., 2018; Schroth et al., 2017), Ghanaian cocoa smallholders are at risk of suffering deepening poverty. Only 22% of households reported a harvest around the same size or better in 2016 than 2015 (this included two households who had only recently started growing cocoa and had zero yield in 2015 only). In 2017, however, 80% of households reported cocoa harvests comparable to or larger than 2015's, indicating broad recovery of the cocoa crop. Such a recovery resonates with Creedy et al.'s (2022) 70-year analysis which also provides evidence that climate change is altering how the cocoa crop responds to climate shocks.

The drought impacted wider food security in 2016. When asked about the impacts of reduced and/or delayed cocoa harvests in 2016, 65% of all *N*=95 households reported eating less food than usual. FGDs related that it was commonplace for adults to reduce food intake to just once per day and *"sacrifice their second food for their children".*

In the face of high dependency on agriculture, droughts might not only directly lead to lower cash crop income and depressed supplies of food and basic nutrients from subsistence agriculture, but droughts can shock the landscape's entire food system lowering households' ability to secure sufficient nutritional intake (Lohmann and Lechtenfeld, 2015). Focus groups discussants lamented the difficulty buying foods at local markets and how low supplies resulted in high prices during the drought and its aftermath. Of the households that grew the subsistence crops maize, tomatoes, cassava, or plantain (*N*=86, *N*=86, *N*=67, *N*=60, respectively), more than 50% reported harvests up to two thirds *smaller* in 2016 than in 2015.

Oil palm was an exception: 75% of the *N*=52 households cultivating oil palm reported no change in 2016's harvest compared to 2015. The latter result suggests oil palm could be resilient against drought and higher temperatures at least initially, which is consistent with findings from Ruf (2015), Odijie (2018), and Khatun *et al*. (2020); and/or that sustained oil palm yields could be due to changes in how farmers managed their oil palm trees during the drought (Fleiss et al., 2022). Whatever the factor driving sustained yields through the drought, the studied smallholders deem oil palm to be an attractive crop because it smooths household income throughout the year as it yields continuously. Households reported harvesting oil palm kernels "every fortnight". Surveys found that oil palm cultivation area was very significant for meeting critical needs in 2015 (p=.01). Farmers in these landscapes have historically diversified into oil palm (*Elaeis guineensis*) which is native to these Upper Guinean tropical forests and its many products are traditionally used in local cuisine (Khatun et al., 2020). However, commodity-centric governance (Bastos Lima and Persson, 2020; Zu Ermgassen et al., 2022) promotes defying such signals and the need to diversify (Odijie, 2019). Our findings and these observations suggest that resilience interventions which support agricultural diversification away from only cocoa could increase the system's ability to absorb shocks and thereby alleviate poverty. But agricultural diversification is not of concern to cocoa corporations who equate resilience with securing cocoa supplies.

The right panel in Fig. 4.2 [Figure 4.2 here in colours of publisher's choice] shows the reported change in the *timing* of the cocoa harvest in 2016 and 2017 compared to pre-drought. *When* rains arrive matters for agriculture and agricultural livelihoods (Stringer et al., 2021). In 2016, 83% of households reported later-than-usual cocoa harvests, with 71% reporting harvests delayed by at least one month. Decreases and/or delays in cocoa harvests can lead to severe difficulties for households since Ghanaian smallholders depend on cocoa harvests for 60-100% of their household income (McKinley et al., 2014; Tsiboe et al., 2016). Within our surveyed sample, cocoa contributed ~75% of household income before the drought (Table 4.2). Across Ghana, many cocoa smallholders lack adequate savings (Asamoah et al., 2015; LeBaron, 2021; Peprah, 2015), banking facilities (Löwe, 2017; Unnikrishnan et al., 2022), or insurance (Afriyie-Kraft et al., 2020b; Agbenyo et al., 2022b); in our sample pre-drought, only 52% reported inadequate savings to cope with low cocoa-yield years (Table 4.2). Drought-induced cocoa harvest reductions and

delays thus compromised household cashflow and food intake, both of which significantly influenced ability to manage household critical needs (section 4.3.1), adoption of adaptation strategies (section 4.3.2), and preparedness for future climate shocks (section 4.3.3). Only 27% of households reported later-than-usual cocoa harvests in 2017 (compared to 71% in the drought year), again pointing to cocoa's recovery. Although results indicate 'recoveries' in 2017, it must be emphasised that incidences of poverty across multiple dimensions and indicators were significant in the pre-drought baseline year of 2015.

4.3 Resilient outcomes and their interaction with poverty

We now examine three specific resilient outcomes – households meeting critical expenditures, implementing adaptive strategies, and being prepared for future climate shocks – and the interaction of these with multiple poverty indicators.

4.3.1 Meeting critical needs

Poverty constrains economically-developing communities attempts to cope with drought, since poorer individuals are also confronted with non-climatic stressors that restrict their ability to emerge resiliently through, and following, a drought (Antwi-Agyei et al., 2012; Sen, 1999; Stringer et al., 2009). In the study villages, smallholder households struggled with non-climatic stressors such as securing food and raising healthy children, even under favourable climatic conditions. The six basic or critical needs (co-identified with smallholders) we focused on in our survey were being able to: obtain an adequate amount of food; obtain an adequate variety of food; keep children in school; afford medicines when needed; afford to go to a healthcare centre when needed; and contribute to funeral expenses[5].

[5] Elaborate funeral ceremonies are integral to Ghanaian culture (Debrah, 2013; Kutsoati and Morck, 2014). Societal pressure to contribute to funeral expenses is strong; it is an expectation (Bonsu and Belk, 2003; Mohan, 2006). Attending and financially contributing to funerals represent significant social capital to community-level relations which in turn could improve one's experiences of at least two dimensions of poverty: social connectedness and empowerment (Bawa, 2016).



Fig. 4.3.1: month-by-month breakdown of when households were unable to meet specific critical needs.

Figure 4.3.1 [Fig. 4.3.1 here in colours of publisher's choice] presents the distribution of households able to meet each of these critical needs in each month of 2015, 2016, and 2017. Fewer households could obtain an adequate food *amount* and *variety* in the drought year; though these two aspects of food security recovered in 2017. Healthcare centre access and funeral expense contributions were also negatively impacted in 2016. The most difficult months for meeting critical needs were January to July 2016 which corresponds to the hottest and driest part of the prolonged drought and the worst of its aftermath (see Hirons et al., 2018b Fig. 2 for meteorological data which corroborates what we found in surveys as the most difficult months for meeting critical needs) and adds to evidence that livelihood impacts of climate related shocks are strongest in the short term (Cooper et al., 2008; Creedy et al., 2022; Maganga et al., 2021).

We quantified (per Table 3.1) the extent to which each household could meet basic needs in each of the three years. As table 4.3.1 shows fewer critical expenditures were met in 2016 than in 2015, further demonstrating the immediate negative impact of the drought on households. However, table 4.3.1 also shows that households met significantly more critical expenditures in 2017 than in both 2015 and 2016, further evidencing a post-drought 'recovery'.

[Table 4.3.1 here in black & white]

Year	Critical needs score
2015	μ = 3.86, SD = 1.81
2016	μ = 3.42, SD = 1.86
2017	μ = 4.73, SD = 1.51

Table 4.3.1. Quantification of the extent to which each household could meet basic needs in each of the three years, with a given household able to score between 0 and 6 each year. A one-tailed Mann-Whitney test indicated that fewer critical expenditures were met in 2016 than in 2015 (U=5144.5, p=.045), and that more critical expenditures were met in 2017 than in both 2015 (U=3231.5, p<.001) and 2016 (U=2624.0, p<.001).

We now examine the statistical associations between household critical needs scores and 38 poverty indicators. In total, in 2015, 16 indicators spanning six different dimensions of poverty were found to be significantly associated with meeting critical needs (see Table 4.3, Supplementary Materials). More favourable indicators of household income, health, basic needs, asset access/ownership, and land assets were all significantly and positively associated with households meeting more of their critical needs.

Poverty is widely deemed to be a dynamic phenomenon "shaped by the interplay of social, economic, political, and environmental processes" (Leichenko and Silva, 2014), shifting in response to external stimuli such as climate shocks (Birthal and Hazrana, 2019; Hansen et al., 2007), and this was the case in this cocoa smallholder cocoa cultivation system since the picture was markedly different during the drought year, 2016 (see Table 4.4, Supplementary Materials). Only seven indicators of poverty were statistically associated with meeting critical needs under drought conditions. Two of these also featured in 2015 as well, *viz*. adequate access to healthcare and goat ownership, which were both associated with higher critical needs scores in 2016. Using longitudinal survey data, Maganga et al. (2021) also found farmers' drought resilience strengthened through livestock ownership.

It is notable that annual cocoa incomes, harvests, and cultivation areas were *not* found to correlate with meeting critical needs during the drought. Non-cocoa income was similarly uncorrelated with meeting critical needs. Income alone didn't help people meet their basic needs during a prolonged drought, which highlights the salience of multidimensional approaches to understanding poverty. Frequent agronomic advice neither correlated with critical needs scores in 2016. This is perhaps unsurprising, given that formal agronomic advice has tended to focus on

closing yield gaps and boosting cocoa productivity (Abdulai et al., 2020; Amponsah-Doku et al., 2021; Gockowski et al., 2010), rather than drought coping mechanisms or sustaining livelihoods (Belay et al., 2017; Maguire-Rajpaul et al., 2020). The fact that receiving frequent formal agronomic advice didn't boost productivity sufficiently to alleviate several dimensions of poverty underscores the need for resilience and agronomic extension interventions to look beyond raising cash crop productivity so as not to entrench poverty along multiple dimensions. Indeed, Iddrisu *et al.* (2020) and Garrett *et al.* (2021) found productivity gains following certification extension improved neither livelihoods nor food security. These two studies corroborate what we heard in interviews and focus groups that when farmers increasingly specialise in cash cropping, they spend proportionally more buying food for subsistence.

In the post-drought year (see Table 4.5 in Supplementary Materials), only two poverty indicators were associated with meeting critical needs. The first was livelihood diversification which, unlike in 2016, was now associated with meeting *more* critical needs. Based on insights from 2016 and 2017 focus groups and interviews, we infer that this change was because many subsistence crops failed during the drought (in which case some households lost both income and food sources), whereas most subsistence crops had recovered by 2017 meaning more households could secure an adequate amount and variety of food: two of their six critical needs. Focus group discussants noted that failure of local food crops through the prolonged drought led to elevated prices at local markets, but that these had largely returned to normal by 2017.

The second indicator associated with meeting 2017's critical needs was adequate healthcare access, which featured similarly in the two previous years as well. In all three years, this poverty indicator of healthcare access was associated with the resilient outcome of meeting critical needs, suggesting that healthcare investments could support the resilience of smallholders. The many ways in which the drought impacted health were detailed in interviews. Several interviewees described how hot their houses became, causing heat rashes and diarrhoea. Reduced incomes meant it was *"expensive to afford taxi fares to carry sick people to hospitals"* and that those who could travel to hospital didn't always recover because *"national insurance only covered a doctor visit, but not the medication".* A focus group discussant reported in 2016 *"income levels have been badly hit, and now when there is any illness, you will probably die or get worse".* Interviewees illuminated the difficulties of farming as usual under drought conditions when they themselves were in resultant poor health. The households which struggled to pay for essential medication or secure enough food or potable water explained they were less able to consider adapting to the drought or preparing for future droughts.

4.3.2 Implemented adaptation

To quantify the extent to which a household had implemented drought adaptation, and compare this with poverty indicators, we computed "implemented adaptation scores" (see Table 3.1). Across all households, the mean (SD) implemented adaptation score was 1.87 (2.25), well below the maximum possible score of 9. The minimum computed score for any household was -4.0, close to the minimum possible score of -5. Both scores suggests that cocoa households may encounter barriers against implementing drought adaptation. Indeed, cocoa smallholders facing adaptation barriers has been widely reported (Afriyie-Kraft et al., 2020a; Akrofi-Atitianti et al., 2018; Denkyirah et al., 2017; Maguire-Rajpaul et al., 2020). For instance, few households reported nurturing timber or shade trees around cocoa, despite widespread promotion of shade trees as an adaptive, resilient, and climate-smart strategy for cocoa cultivation. Smallholder inability to nurture timber or shade trees is often not due to a lack of volition, but rather insecure land and tree tenure issues (Asare et al., 2019; Damnyag et al., 2012; Hirons et al., 2018a; Maguire-Rajpaul et al., 2022). More cocoa households could implement adaptation if barriers preventing them were recognised by interventions, and how these barriers to adaptation are affected by dimensions of poverty were recognised then embedded into interventions' policies, e.g. accessing clean drinking water and securing adequate food amounts are pre-requisites for being healthy enough before implementing adaptive strategies or preparing for future droughts.

The most frequent adaptive strategies implemented in response to the drought were increasing food crop storage, saving money from harvests, and finding wetland to farm (See supplementary Fig. 4.5). It is noteworthy that the most capital intensive adaptive strategy of digging wells was the least implemented (and least planned). Without adequate savings or a loan possibility, cocoa smallholders will struggle to implement capital intensive technologies to boost climate resilience (Wongnaa and Babu, 2020).

When considering statistical associations between poverty and the resilient outcome of implemented adaptation, six indicators across five poverty dimensions were associated with implemented adaptation (Table 4.6 in Supplementary Materials). Higher cocoa incomes, higher literacy levels, access to clean drinking water, goat and chicken ownership, and adequate food amounts were all associated with higher implemented adaptation scores. Without safe potable water and securing adequate food, households focus more on day-to-day survival through a climate shock than on building resilience with medium- to longer-term adaptation. As was the case with meeting critical needs, it is evident that multiple dimensions of poverty – not just cash crop income – interact with resilience, as measured in this case by the extent to which households had implemented drought adaptation.

4.3.3 Preparedness for future droughts

Precautionary planning for future adaptation assistance could prove a more beneficial type of poverty alleviation intervention than post-shock relief since it could alleviate some *causes* of struggling to cope through

droughts and other climate shocks, rather than merely symptoms. How resource-constrained actors respond to environmental crises and change their behaviour henceforth varies enormously. Several conceptual approaches explore how people cope, learn to adapt, prepare, and transform following environmental shocks; these include experiential learning (Armitage et al., 2008; Turner and Berkes, 2006), cognitive reflection, and social learning (De Kraker, 2017; Tschakert and Dietrich, 2010). In our analyses, preparedness and adaptive planning were constituted by how those surveyed responded to statements about future climate shocks. Drawing again on themes that emerged repeatedly in focus groups and interviews, we surveyed household representatives about the extent to which they agreed with five statements related to preparedness for future droughts. Figure 4.3.3 below [Fig 4.3.3 here or just below, in colours of publisher's choice] shows the five questions, and the distribution of responses to each.

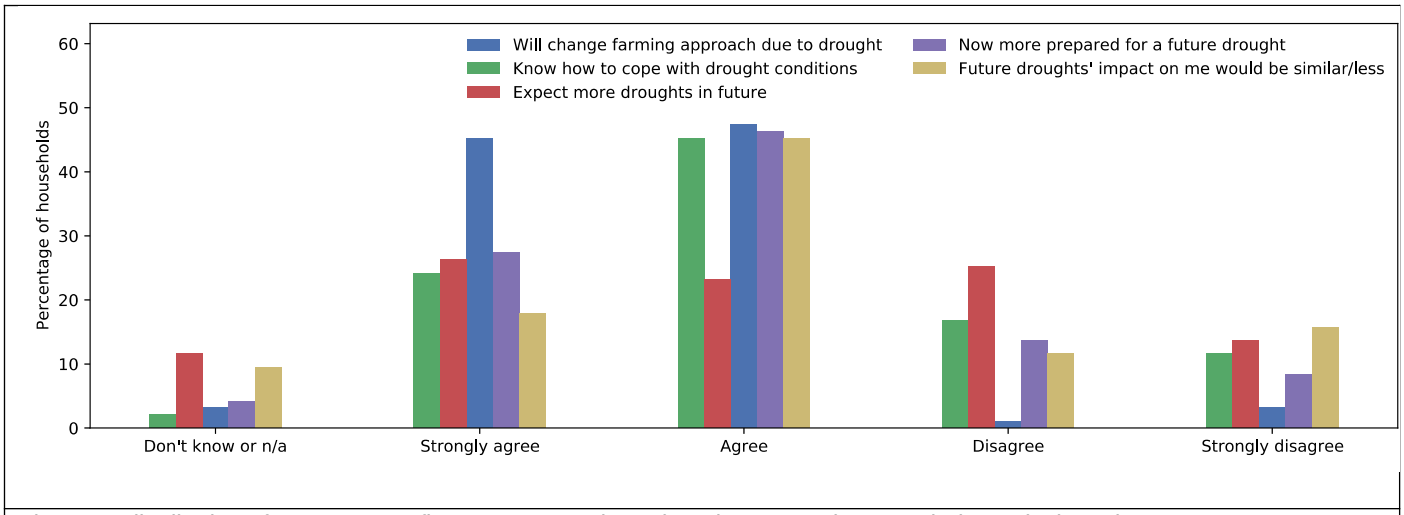


Fig 4.3.3: distribution of responses to five statements about drought preparedness and *planned* adaptation.

To examine preparedness for future droughts, we computed (see Table 3.1) a preparedness score per our implemented adaptation scores, whereby a weight was assigned to the extent of agreement with the five statements (cf. Fig 4.3.3) about drought preparedness. Across all households, the mean (SD) preparedness score was 2.40 (1.75), well below the maximum possible score of 9, suggesting that households' dimensions of poverty may have prevented preparing for future droughts. One might expect that experiencing a drought might encourage precautionary planning to mitigate the effect of future climate shocks. Such widespread drought preparedness was not the case among these cocoa smallholders who detailed a range of barriers preventing them adopting adaptative measures. Recurrent barriers across the sample were insecure tree and land tenure preventing smallholders from planting and nursing shade trees, and insufficient agronomic extension specifically on adapting to and preparing for drought and high temperatures. Additionally, 39% of surveyed households and many focus group discussants said they did not expect any more droughts in the future which goes against climate modelling for the region (Hutchins et al., 2015;

Schroth et al., 2016). Such optimism seems inconsistent with the adverse experiences during the prolonged drought and its aftermath, and could also suggest a need for more culturally- and contextually-appropriate extension services specifically on climate shocks.

Examining statistical associations between poverty indicators and the resilient outcome of drought preparedness reveals seven indicators across six poverty dimensions were associated with implemented adaptation. As with the previous two resilient outcomes we considered, in the case of future drought preparedness, multiple dimensions of poverty were found to be associated with resilience. Higher literacy levels, access to potable water, goat ownership, and adequate amounts of food were all associated with higher *preparedness* scores. We note that all four of these indicators were associated with more *implemented* adaptation too (see Supplementary Material Table 4.7). Goat ownership was also one of the few poverty indicators that correlated with meeting critical needs during the drought year, corroborating Maganga et al.'s (2021) finding that smallholder drought resilience is bolstered by livestock ownership.

Greater livelihood diversification was associated with *lower* preparedness scores; we recall (Section 4.3.1) that livelihood diversification was also associated with meeting *fewer* critical needs in the drought year. We infer from interviews and FGDs that households managing several income streams had less time to prepare for future droughts. However, perhaps more important than the number of income streams would be the extent to which a household can rely on these for steady income (such as palm yielding fortnightly). Reliable income alternatives are not something we explicitly explored. Somewhat surprisingly, social group membership and receiving agronomic advice from neighbours or friends were associated with *lower* preparedness scores. We might infer that social groups and informal sources of agronomic information were not necessarily ideal sources of advice for preparing cocoa farms and households for future climate shocks. If so, this may suggest a need for more culturally- and contextually-appropriate extension services, specifically on climate shocks. Wongnaa and Babu's (2020) study on drought resilience among Ghanaian cocoa farmers recommended farmers join organisations with extension officers trained in educating farmers on climate change resilience strategies. When extension officers or others giving resilient preparedness advice are also aware of the community's dimensions of poverty and barriers to adaptation faced, interventions could be more holistic and potentially more effective for precautionary planning to stymie the impacts of future climate shocks.

4.3.4 Summary of the associations between poverty and resilient outcomes

	Critical needs (2015)	Critical needs (2016)	Critical needs (2017)	Implemented adaptation	Future drought preparedness
Income	Non-cocoa income, *p*=.006; cocoa income, *p*=.03; (cocoa harvest, *p*=.10)	Livelihood diversification – no. income sources*, *p*=.05	(Livelihood diversification – no. income sources, *p*=.06)	(Cocoa income, *p*=.09)	Livelihood diversification – no. income sources,* *p*=.05
Health	No under-5 mortality, *p*=.02; healthcare access, *p*=.04	Healthcare access, *p*=.008	(Healthcare access, *p*=.06)	–	–
Education	–	–	–	Literacy level, *p*=.04	Literacy level, *p*=.05
Basic needs	Clean drinking water access, *p*=.003; (electricity access, *p*=.06)	–	–	Clean drinking water access, *p*=.02	Clean drinking water access, *p*=.05
Assets (ownership or access)	Radio, *p*<.001; mobile phone. *p*=.008; TV *p*=.01; (goats, *p*=.08); (chickens, *p*=.08)	TV, *p*=.008; spraying machine, *p*=.05; (goats, *p*=.07)	–	Chickens, *p*=.04; (goats, *p*=.06)	(Goats, *p*=.07)
Land Assets	Oil palm cultivation area, *p*=.01; (cocoa cultivation area, *p*=.07)	Homestead area, *p*=.03	–	–	–
Food security	n/a	n/a	n/a	(Adequate food amount, *p*=.09)	Adequate food amount, *p*=.04
Empowerment	–	Position of influence in village, *p*=.02	–	–	–
Social connectedness	Agri-officer advice frequency, *p*=.005; (social group membership*, *p*=.10)	–	–	–	(Friend/neighbour advice frequency,* *p*=.06); (social group membership,* *p*=.10)

Table 4.3.4. Poverty dimensions (rows) and indicators found to have statistically-significant associations with resilient outcomes (columns), summarising key results in Supplementary Tables 4.3—4.7. For a given resilient outcome, poverty indicators are listed in decreasing order of statistical significance. Brackets denote poverty indicators with a statistical association with a resilient outcome significant only at a $p \leq .10$ level; non-bracketed indicators have associations that are significant at $p \leq .05$. Asterisks denote a negative association, such that greater poverty was associated with a more resilient outcome. A total of 37 (32 positive and 5 negative) statistical associations are summarised here.

[Table 4.3.4 here in the colours used above as each colour corresponds to one poverty dimension and repeats across tables] Table 4.3.4 ties together key findings from Sections 4.3.1—4.3.3 (and Supplementary Tables 4.3—4.7), summarising dimensions and indicators of poverty that evince statistically-significant associations with resilient outcomes. Table 4.3.4 shows that each of the nine poverty dimensions considered was statistically

associated with at least one resilient outcome, and in the direction expected *a priori*: i.e., less poverty (e.g., better healthcare access) was associated with a *more* resilient outcome. This accords with our premise that farmers who are poorer (along multiple dimensions of poverty) would prove less resilient to climate shocks.

The income from cocoa indicator was associated with only two out of five[6] resilient outcomes considered, and one of those times at a significance of only $p \leq .10$. A crucial reflection of this paper is that because annual cocoa incomes, cocoa harvests, and cocoa cultivation areas were *not* found to correlate with meeting critical needs either during the drought or its aftermath, or with preparing for future droughts it is important for resilience interventions to engage with factors beyond cocoa income. Continued focus on cocoa yields (e.g. through sustainable intensification) is often legitimised by the argument that this would boost farmer resilience. Our results show that this is a necessary – albeit insufficient – strategy for promoting resilience and poverty alleviation in cocoa communities. There are other key investments, such as, healthcare or potable water infrastructure, or supporting landscape-level food security which could bolster resilience and alleviate poverty.

Iddrisu *et al.* (2020) – who found that any increased cocoa productivity and income from the intervention of certification didn't necessarily lead to enhanced food security – recommend that interventions should consider food security indicators. Obtaining enough food and an adequate variety comprised two of the six critical needs, so to avoid double counting we did not analyse associations between aggregate critical needs resilient outcomes and the dimension of food security. Our survey results on securing adequate amounts and variety of food along with details divulged in interviews and FGDs demonstrate that household food security represents a necessary foundation for resilience. Smallholders explained how without adequate food, implementing adaptation and preparing for future droughts prove insurmountable.

Across all nine poverty dimensions and the resilient outcomes considered, there were 38 poverty indicator/resilient outcome pairs that evinced statistically significant associations. 34 out of 38 (89.5%) of these associations were in the direction expected *a priori*. In the drought year, greater livelihood diversification was associated with meeting *fewer* critical needs (and with *lower* preparedness scores). The other three out of the four pairs evincing associations in the unexpected direction involved the dimension of social connectedness. Although social connectedness and group membership were highly valued within the studied communities, they appear less important for climate resilience. Considering this result in tandem with cocoa community engagement, we infer that informal advice from social groups, friends, and/or neighbours may have been suboptimal for engendering drought resilience. For improved drought resilience among Ghanaian smallholders, extension officers need specific training on climate-resilience strategies (Wongnaa and Babu, 2020) and to deliver them in culturally-appropriate ways (Maguire-

[6] The five resilient outcomes considered include all three years of meeting critical needs, implemented adaptation, and future drought preparedness (per Table 4.3.4's columns).

Rajpaul et al., 2020). The adaptation barriers of illiteracy and inadequate food could be lowered if they were embedded into interventions' policies (Iddrisu et al., 2020). Recognising barriers to adaptation and ways to remedy them could assist smallholders implement their desired adaptation and facilitate their future preparedness.

Along with food security and literacy, other dimensions of poverty that showed strong and recurrent associations with our resilient outcomes were clean drinking water, healthcare, diverse livelihood sources, access or ownership of assets particularly goats and chickens. Livestock ownership was positively associated with four out of five resilient outcomes which corroborates Tesfaye and Tirivayi (2020), Thornton and Herrero (2015), and Maganga *et al.* (2021) who emphasise that livestock represent an important buffer against poverty and can strengthen climate resilience among SSA farmers. There is some overlap between the most recurrent dimensions of poverty that we found and Maganga *et al.*'s longitudinal study (2021); as well as with Denkyirah *et al.* (2017) who found that literacy, diverse livelihood sources, access to extension services, household size, and cocoa income influence cocoa farmers' adaptation strategies; and with Wongnaa and Babu (2020) who found that diverse livelihood sources, access to extension services, and cocoa income from cocoa production influence adoption Ghanaian cocoa farmers' adaptation strategies. Our results and these other studies underscore the salience of multidimensional approaches to understanding poverty and its impact on resilience against climate change and climate shocks, thereby highlighting the resultant need for cash-crops interventions to appraise wider poverty issues and barriers to resilience and adaptation. Our results and pluralistic approach show that managing drought for the climate-threatened cocoa crop requires a holistic appraisal of smallholder livelihoods and the whole social-ecological system.

5. Conclusions

Without meaningfully considering affected people's vulnerability, or how climate impacts poverty, or normatively asking 'what is being maintained and for whose benefit?' (Cote and Nightingale, 2012; Cretney, 2014; Cutter, 2016; Quandt, 2018), resilience interventions risk entrenching disadvantage and exacerbating inequalities (Bahadur and Tanner, 2014; Matin et al., 2018). This paper advanced knowledge by combining the assessment of resilience with multi-dimensional understandings of poverty, based on farmers' own experiences and perceptions.

Resilience interventions tend to operate in silos and focus on technical fixes (such as intensifying productivity). This paper departed from technical views of resilience by centring on smallholders' livelihood concerns and experiences of poverty (as opposed to questions of agricultural productivity and outputs that maintain the status quo). We turned our attention to multiple dimensions of poverty, vulnerabilities, and social-ecological interactions by developing an integrated resilience-poverty framework, treating both concepts multidimensionally. Multidimensional approaches to poverty broaden poverty beyond monetary deprivations. In like manner, we broadened resilience to

consider multiple resilience "outcomes" as experienced then voiced by smallholders affected by a climate shock. Our foundational premise was that neglecting multiple dimensions of poverty could lead to inadequate resilience-building, delivering deficient human development outcomes. Our two-part research question asked: i) 'how do experiences of poverty undermine resilience?', and ii) 'which dimensions of poverty influence resilience?'. All poverty dimensions considered were statistically associated with at least one resilient outcome in the direction expected *a priori*: demonstrating that farmers who are poorer along multiple dimensions of poverty are less resilient to climate shocks. Two key findings are: i) cocoa income alone didn't help farmers meet their basic needs during prolonged drought, and ii) cocoa income was associated with only two out of five resilient outcomes considered, and one of those times at a significance of only $p \leq .10$. Both findings highlight the salience of multidimensional approaches to understanding poverty and underscore the need for resilience interventions to look beyond raising cash crop productivity.

Before the drought, surveyed cocoa smallholders already faced material and structural poverty, alongside inadequate access to public services and persistent food insecurity. Such multidimensional poverty suggests systemic issues in the global cocoa value chain and potential exploitation of smallholder labour (LeBaron and Gore, 2020; Odijie, 2018). The drought exacerbated their situation, leading to subsistence crop failures, reduced cocoa harvests, and widespread food insecurity, with 65% of households unable to afford meals. The pursuit of resilience – particularly when serving corporate interests – can often overlook such structural and intersectional determinants of vulnerability and poverty (Jackson, 2024; Thompson et al., 2022). We found this to be particularly the case for global cocoa's buyer-driven governance which narrowly equates resilience as sustaining or intensifying cocoa production without further deforestation reputational risk (Grabs, 2017; LeBaron, 2021). A crucial reflection of this paper is that because annual cocoa incomes, cocoa harvests, and cocoa cultivation areas were *not* found to correlate with meeting critical needs either during the drought or its aftermath, or with preparing for future droughts it is important for resilience interventions to engage with factors beyond cocoa income.

Farmers testified that increased specialisation in cocoa meant spending proportionally more money buying food for subsistence, and worsened food security. Continued roll out of resilience interventions around yield intensification and/or 'climate-smart' goals of a single cash crop risks entrenching multiple dimensions of poverty. When socio-economic contexts go ignored, or when interventions address only climate change *impacts* rather than underlying *drivers* of what makes a community vulnerable to climate change, such interventions might unwittingly exacerbate social disadvantages by: deepening vulnerabilities; reproducing suffering along multiple dimensions of poverty (Jennings, 2011: 238); proving ineffective (Carpenter et al., 2012; Schipper, 2022); resulting in maladaptation (Bertana et al., 2022; Schipper, 2020); or ignoring which specific resources alleviate poverty, enable adaptation, and/or boost climate-resilience. For instance, our longitudinal analyses revealed that farmers with livestock evinced

more resilience. Higher scores for implementing adaptation were associated with goat and chicken ownership, literacy, potable water access, and adequate amounts of food.

The mean implemented adaptation score of 1.87 (SD 2.25) falls well below the maximum of 9. Low levels of adaptation and preparedness among cocoa households can be somewhat explained by a holistic examination: for instance, fewer than half of surveyed households had access to potable water. Factors such as limited access to potable water, food insecurity, insufficient income, and illiteracy contribute to substantial challenges for promoting resilience. Resilience interventions often prioritise external goals, diminishing farmers' flexibility and overlooking local adaptation barriers (Cavanagh et al., 2017; Taylor, 2018). Efforts to enhance resilience must address contextual factors and common barriers like land tenure, agronomic support, drought preparedness, and access to credit, in addition to addressing basic needs like water, food, and healthcare.

We found that income diversification's impact on poverty is limited due to financial exclusion, inadequate market access, and structural barriers like illiteracy, tenure insecurity, and lack of potable water. Therefore, efforts to enhance household resilience should be comprehensive and contextually tailored. Another key conclusion concerns the importance of thinking multidimensionally, holistically, and contextually. Holistic approaches can illuminate complex trade-offs and barriers smallholders endure, as well as vested corporate interests promoting a narrow vision of resilience focussed on sustaining cocoa cultivation. Investing in safe drinking water infrastructure, supporting landscape-level food security, supporting income diversification, and improving healthcare could bolster resilience in cocoa communities, yet these poverty aspects are not central in climate-smart or resilience interventions.

To build towards socially-just, pro-poor resilience, we advocate more contextualised ethnographic approaches and hearing affected communities' perspectives. Bronen and Cochran (2021) warn of "danger and damage … when outside academics define food security, resilience, and adaptation" (p.1245). Therefore, this paper's dimensions and indicators of poverty and resilience proxies were co-defined with cocoa smallholders. Our scoping interviews and focus group discussions invited smallholders to share their experiential expertise and recount contextually-relevant details to how the 2015-16 drought impacted their livelihoods, along with adaptation innovations they had employed. As all dimensions and indicators of poverty and resilient outcomes were co-determined with smallholders affected by the prolonged drought, these insights provide important contextual relevance.

This paper politicises climate resilience by fusing it to multiple dimensions of poverty. Our contributions to the literature and policy of resilience include integrating poverty to resilience, and treating both multidimensionally. Using a longitudinal dataset spanning a major drought, we examined how different dimensions of poverty influence smallholders' climate resilience. Three dimensions or outcomes of resilience were co-identified with cocoa smallholders: i) meeting basic needs, ii) adaptation implementation, and iii) preparedness for future droughts. The

nuanced relationships this study revealed highlight the value of contextualised and longitudinal empirical data in examining and pursing resilience.

References

Abdulai, I., Hoffmann, M.P., Jassogne, L., Asare, R., Graefe, S., Tao, H.-H., Muilerman, S., Vaast, P., Van Asten, P., Läderach, P., 2020. Variations in yield gaps of smallholder cocoa systems and the main determining factors along a climate gradient in Ghana. Agric. Syst. 181, 102812.

Abdulai, I., Vaast, P., Hoffmann, M.P., Asare, R., Jassogne, L., Van Asten, P., Rötter, R.P., Graefe, S., 2018. Cocoa agroforestry is less resilient to sub-optimal and extreme climate than cocoa in full sun. Glob. Chang. Biol. 24, 273–286.

Adger, W.N., 2006. Vulnerability. Glob. Environ. Chang. 16, 268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

Adger, W.N., Hughes, T.P., Folke, C., Carpenter, S.R., Rockström, J., 2005. Social and ecological resilience : are they related ? Science (80-.). 309, 1036–1039. https://doi.org/10.1191/030913200701540465

Adjei, V., Anlimachie, M.A., Ativi, E.E., 2020. Understanding the nexus between climate change, the shift in land use toward cashew production and rural food security in Ghana; the experiences of farmers in the transition zone of Ghana. J. Atmos. Sci. Res. 3.

Afriyie-Kraft, L., Zabel, A., Damnyag, L., 2020a. Adaptation strategies of Ghanaian cocoa farmers under a changing climate. For. Policy Econ. 113, 102115.

Afriyie-Kraft, L., Zabel, A., Damnyag, L., 2020b. Index-based weather insurance for perennial crops: A case study on insurance supply and demand for cocoa farmers in Ghana. World Dev. Perspect. 20, 100237.

Agbenyo, W., Jiang, Y., Jia, X., Wang, J., Ntim-Amo, G., Dunya, R., Siaw, A., Asare, I., Twumasi, M.A., 2022a. Does the Adoption of Climate-Smart Agricultural Practices Impact Farmers' Income? Evidence from Ghana. Int. J. Environ. Res. Public Health 19, 3804.

Agbenyo, W., Jiang, Y., Ntim-Amo, G., 2022b. Impact of crop insurance on cocoa farmers' income: an empirical analysis from Ghana. Environ. Sci. Pollut. Res. 1–11.

Agbongiarhuoyi, A.E., Abdulkarim, I.F., Fawole, O.P., Obatolu, B.O., Famuyiwa, B.S., Oloyede, A.A., 2013. Analysis of farmers' adaptation strategies to climate change in cocoa production in Kwara State. J. Agric. Ext. 17, 10–22.

Ajagun, E.O., Ashiagbor, G., Asante, W.A., Gyampoh, B.A., Obirikorang, K.A., Acheampong, E., 2022. Cocoa eats the food: expansion of cocoa into food croplands in the Juabeso District, Ghana. Food Secur. 14, 451–470.

Akrofi-Atitianti, F., Ifejika Speranza, C., Bockel, L., Asare, R., 2018. Assessing Climate Smart Agriculture and Its Determinants of Practice in Ghana: A Case of the Cocoa Production System. Land 7, 30. https://doi.org/10.3390/land7010030

Akter, S., Mallick, B., 2013. The poverty–vulnerability–resilience nexus: Evidence from Bangladesh. Ecol. Econ. 96, 114–124.

Alkire, S., 2007. The missing dimensions of poverty data: Introduction to the special issue. Oxford Dev. Stud. 35, 347–359.

Alkire, S., 2002. Dimensions of human development. World Dev. 30, 181–205.

Alkire, S., Foster, J., 2011a. Understandings and misunderstandings of multidimensional poverty measurement. J. Econ. Inequal. 9, 289–314.

Alkire, S., Foster, J., 2011b. Counting and multidimensional poverty measurement. J. Public Econ. 95, 476–487.

Alkire, S., Foster, J., 2007. Counting and Multidimensional Poverty Measurement, Oxford Poverty and Human Development Initiative. OPHI Work. Pap.

Alkire, S., Roche, J.M., Vaz, A., 2017. Changes over time in multidimensional poverty: Methodology and results for 34 countries. World Dev. 94, 232–249.

Alkire, S., Santos, M.E., 2014. Measuring acute poverty in the developing world: Robustness and scope of the multidimensional poverty index. World Dev. 59, 251–274.

Alkire, S., Santos, M.E., 2010. Acute multidimensional poverty: A new index for developing countries.

Alkire, S., Seth, S., 2015. Multidimensional poverty reduction in India between 1999 and 2006: Where and how? World Dev. 72, 93–108.

Amponsah-Doku, B., Daymond, A., Robinson, S., Atuah, L., Sizmur, T., 2021. Improving soil health and closing the yield gap of cocoa production in Ghana–a review. Sci. African e01075.

Amuzu, D., Neimark, B., Kull, C., 2022. Bittersweet cocoa: Certification programmes in Ghana as battlegrounds for power, authority and legitimacy. Geoforum 136, 54–67.

Antwi-Agyei, P., Fraser, E.D.G., Dougill, A.J., Stringer, L.C., Simelton, E., 2012. Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. Appl. Geogr. 32, 324–334.

Armitage, D., Béné, C., Charles, A.T., Johnson, D., Allison, E.H., 2012. The interplay of well-being and resilience in applying a social-ecological perspective. Ecol. Soc. 17.

Armitage, D., Marschke, M., Plummer, R., 2008. Adaptive co-management and the paradox of learning. Glob. Environ. Chang. 18, 86–98. https://doi.org/10.1016/j.gloenvcha.2007.07.002

Asaaga, F.A., 2021. Building on “traditional” land dispute resolution mechanisms in rural Ghana: adaptive or anachronistic? Land 10, 143.

Asamoah, M., Ansah, F.O., Anchirinah, V., Aneani, F., Agyapong, D., 2013. Insight into the standard of living of Ghanaian cocoa farmers. Greener J. Agric. Sci. 3, 363–370.

Asamoah, M., Darkwah, A., Amoah, F.M., 2015. Microcredit Schemes: A Tool for Promoting Rural Savings Capacity among Poor Farm Families: A Case Study in the Eastern Region of Ghana. Open J. Soc. Sci. 3, 24.

Asante, W.A., Acheampong, E., Kyereh, E., Kyereh, B., 2017. Farmers’ perspectives on climate change

manifestations in smallholder cocoa farms and shifts in cropping systems in the forest-savannah transitional zone of Ghana. Land use policy 66, 374–381.

Asare-Nuamah, P., Dick-Sagoe, C., Ayivor, R., 2021. Farmers' maladaptation: Eroding sustainable development, rebounding and shifting vulnerability in smallholder agriculture system. Environ. Dev. 40, 100680.

Asare, R., Markussen, B., Asare, R.A., Anim-Kwapong, G., Ræbild, A., 2019. On-farm cocoa yields increase with canopy cover of shade trees in two agro-ecological zones in Ghana. Clim. Dev. 11, 435–445.

Asubonteng, K., Pfeffer, K., Ros-Tonen, M., Verbesselt, J., Baud, I., 2018. Effects of tree-crop farming on land-cover transitions in a mosaic landscape in the eastern region of Ghana. Environ. Manage. 62, 529–547.

Atkinson, A.B., 2019. Measuring poverty around the world. Princeton University Press.

Bahadur, A., Tanner, T., 2014. Transformational resilience thinking: putting people, power and politics at the heart of urban climate resilience. Environ. Urban. 26, 200–214.

Bahadur, A., Wilkinson, E., Tanner, T.M., 2015. Measuring resilience: an analytical review. Clim. Dev.

Bailey, M., 2017. Unequal adaptation: socially differentiated responses to environmental change and food insecurity among smallholder farmers.

Bank, W., Tall, A., Brandon, C.J., 2019. The World Bank Group's Action Plan on Climate Change Adaptation and Resilience: Managing Risks for a More Resilient Future. The World Bank.

Barnett, J., 2020. Global environmental change II: Political economies of vulnerability to climate change. Prog. Hum. Geogr. 44, 1172–1184.

Barrett, C.B., Constas, M.A., 2014. Toward a theory of resilience for international development applications. Proc. Natl. Acad. Sci. 111, 14625–14630.

Barrientos, S., 2014. Gendered Global Production Networks: Analysis of Cocoa–Chocolate Sourcing. Reg. Stud. 48, 791–803. https://doi.org/10.1080/00343404.2013.878799

Barrientos, S., 2013. Gender production networks: Sustaining cocoa-chocolate sourcing in Ghana and India. Brooks World Poverty Inst. Work. Pap.

Barrientos, S., 2012. Ethical sourcing in the global food system. Taylor & Francis.

Bastos Lima, M.G., Persson, U.M., 2020. Commodity-centric landscape governance as a double-edged sword: the case of soy and the Cerrado Working Group in Brazil. Front. For. Glob. Chang. 3, 27.

Bawa, S., 2016. Paradoxes of (dis) empowerment in the postcolony: women, culture and social capital in Ghana. Third World Q. 37, 119–135.

Bebbington, A., 1999. Capitals and capabilities: a framework for analyzing peasant viability, rural livelihoods and poverty. World Dev. 27, 2021–2044.

Beebeejaun, Y., Durose, C., Rees, J., Richardson, J., Richardson, L., 2015. Public harm or public value? Towards

coproduction in research with communities. Environ. Plan. C Gov. Policy 33, 552–565.

Belay, A., Recha, J.W., Woldeamanuel, T., Morton, J.F., 2017. Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agric. Food Secur. 6, 1–13.

Béné, C., 2020. Resilience of local food systems and links to food security–A review of some important concepts in the context of COVID-19 and other shocks. Food Secur. 12, 805–822.

Béné, C., Al-Hassan, R.M., Amarasinghe, O., Fong, P., Ocran, J., Onumah, E., Ratuniata, R., Van Tuyen, T., McGregor, J.A., Mills, D.J., 2016a. Is resilience socially constructed? Empirical evidence from Fiji, Ghana, Sri Lanka, and vietnam. Glob. Environ. Chang. 38, 153–170.

Béné, C., Evans, L., Mills, D., Ovie, S., Raji, A., Tafida, A., Kodio, A., Sinaba, F., Morand, P., Lemoalle, J., 2011. Testing resilience thinking in a poverty context: experience from the Niger River basin. Glob. Environ. Chang. 21, 1173–1184.

Béné, C., Headey, D., Haddad, L., von Grebmer, K., 2016b. Is resilience a useful concept in the context of food security and nutrition programmes? Some conceptual and practical considerations. Food Secur. 8, 123–138.

Béné, C., Wood, R.G., Newsham, A., Davies, M., 2012. Resilience: new utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes, IDS Working Papers. Wiley Online Library.

Bennett, F., Roberts, M., 2004. From input to influence: Participatory approaches to research and inquiry into poverty. Joseph Rowntree Foundation.

Bérenger, V., Verdier-Chouchane, A., 2007. Multidimensional measures of well-being: Standard of living and quality of life across countries. World Dev. 35, 1259–1276.

Bernards, N., 2021. Poverty finance and the durable contradictions of colonial capitalism: Placing 'financial inclusion'in the long run in Ghana. Geoforum 123, 89–98.

Bertana, A., Clark, B., Benney, T.M., Quackenbush, C., 2022. Beyond maladaptation: structural barriers to successful adaptation. Environ. Sociol. 1–11.

Birthal, P.S., Hazrana, J., 2019. Crop diversification and resilience of agriculture to climatic shocks: Evidence from India. Agric. Syst. 173, 345–354.

Boadi-Kusi, S.B., Hansraj, R., Mashige, K.P., Ilechie, A.A., 2016. Factors associated with protective eyewear use among cocoa farmers in Ghana. Inj. Prev. 22, 365–369.

Boadi-Kusi, S.B., Hansraj, R., Mashige, K.P., Osafo-Kwaako, A., Ilechie, A.A., Abokyi, S., 2017. Prevalence and causes of visual impairment and blindness among cocoa farmers in Ghana. Ophthalmic Epidemiol. 24, 17–23.

Boeckx, P., Bauters, M., Dewettinck, K., 2020. Poverty and climate change challenges for sustainable intensification of cocoa systems. Curr. Opin. Environ. Sustain. 47, 106–111.

Bonsu, S.K., Belk, R.W., 2003. Do not go cheaply into that good night: Death-ritual consumption in Asante, Ghana. J. Consum. Res. 30, 41–55.

Bourey, C., Stephenson, R., Bartel, D., Rubardt, M., 2012. Pile sorting innovations: exploring gender norms, power and equity in sub-Saharan Africa. Glob. Public Health 7, 995–1008.

Bourguignon, F., Chakravarty, S.R., 2002. Multi-dimensional poverty orderings. Delta.

Bourguignon, F., Chakravarty, S.R., 1999. A family of multidimensional poverty measures, in: Advances in Econometrics, Income Distribution and Scientific Methodology. Springer, pp. 331–344.

Boyd, E., 2017. Holistic thinking beyond technology. Nat. Clim. Chang. 7, 97–98.

Brand, F.S., Jax, K., 2007. Focusing the meaning (s) of resilience: resilience as a descriptive concept and a boundary object. Ecol. Soc. 12.

Bronen, R., Cochran, P., 2021. Decolonize climate adaptation research. Science (80-.).

Brown, K., 2016. Resilience, development and global change. Routledge.

Bunn, C., Fernandez-Kolb, P., Lundy, M., 2019a. Climate Smart Cocoa in Côte d'Ivoire Towards climate resilient production at scale. CCAFS Info. Note.

Bunn, C., Läderach, P., Quaye, A., Muilerman, S., Noponen, M.R.A., Lundy, M., 2019b. Recommendation domains to scale out climate change adaptation in cocoa production in Ghana. Clim. Serv. 100123.

Busquet, M., Bosma, N., Hummels, H., 2021. A multidimensional perspective on child labor in the value chain: The case of the cocoa value chain in West Africa. World Dev. 146, 105601.

Bymolt, R., Laven, A., Tyzler, M., 2018. Demystifying the cocoa sector in Ghana and Côte d'Ivoire, The Royal Tropical Institute (KIT): Amsterdam, The Netherlands. Amsterdam.

Calvo, C., 2008. Vulnerability to multidimensional poverty: Peru, 1998–2002. World Dev. 36, 1011–1020.

Camargo, M.C., Hogarth, N.J., Pacheco, P., Nhantumbo, I., Kanninen, M., 2019. Greening the Dark Side of Chocolate: A Qualitative Assessment to Inform Sustainable Supply Chains. Environ. Conserv. 46, 9–16. https://doi.org/10.1017/S0376892918000243

Caretta, M.A., Vacchelli, E., 2015. Re-thinking the boundaries of the focus group: A reflexive analysis on the use and legitimacy of group methodologies in qualitative research. Sociol. Res. Online 20, 58–70.

Carodenuto, S., 2019. Governance of zero deforestation cocoa in West Africa: New forms of public–private interaction. Environ. Policy Gov. 29, 55–66. https://doi.org/10.1002/eet.1841

Carpenter, S., Walker, B., Anderies, J.M., Abel, N., 2001. From metaphor to measurement: resilience of what to what? Ecosystems 4, 765–781.

Carpenter, S.R., Arrow, K.J., Barrett, S., Biggs, R., Brock, W.A., Crépin, A.-S., Engström, G., Folke, C., Hughes, T.P., Kautsky, N., 2012. General resilience to cope with extreme events. Sustainability 4, 3248–3259.

Carr, E.R., 2019. Properties and projects: Reconciling resilience and transformation for adaptation and development. World Dev. 122, 70–84.

Carr, M.K. V, Lockwood, G., 2011. The water relations and irrigation requirements of cocoa (Theobroma cacao L.): A review. Exp. Agric. 47, 653–676. https://doi.org/10.1017/S0014479711000421

Casale, M., Drimie, S., Quinlan, T., Ziervogel, G., 2010. Understanding vulnerability in southern Africa: comparative findings using a multiple-stressor approach in South Africa and Malawi. Reg. Environ. Chang. 10, 157–168.

Cavanagh, C.J., 2017. Resilience, class, and the antifragility of capital. Resilience 5, 110–128.

Cavanagh, C.J., Chemarum, A.K., Vedeld, P.O., Petursson, J.G., 2017. Old wine, new bottles? Investigating the differential adoption of 'climate-smart'agricultural practices in western Kenya. J. Rural Stud. 56, 114–123.

Challinor, A., Wheeler, T., Garforth, C., Craufurd, P., Kassam, A., 2007. Assessing the vulnerability of food crop systems in Africa to climate change. Clim. Change 83, 381–399.

Chandler, D., 2013. Freedom vs necessity in international relations: Human-centred approaches to security and development. Bloomsbury Publishing.

Chantarat, S., Barrett, C.B., 2012. Social network capital, economic mobility and poverty traps. J. Econ. Inequal. 10, 299–342.

Clare, A., Graber, R., Jones, L., Conway, D., 2017. Subjective measures of climate resilience: What is the added value for policy and programming? Glob. Environ. Chang. 46, 17–22.

Cohen, A., 2010. The multidimensional poverty assessment tool: A new framework for measuring rural poverty. Dev. Pract. 20, 887–897. https://doi.org/10.1080/09614524.2010.508111

Collins, H.M., Evans, R., 2002. The third wave of science studies: Studies of expertise and experience. Soc. Stud. Sci. 32, 235–296.

Collins, Y.A., Maguire-Rajpaul, V., Krauss, J.E., Asiyanbi, A., Jiménez, A., Bukhi Mabele, M., Alexander-Owen, M., 2021. Plotting the coloniality of conservation. J. Polit. Ecol.

Cooper, P.J.M., Dimes, J., Rao, K.P.C., Shapiro, B., Shiferaw, B., Twomlow, S., 2008. Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? Agric. Ecosyst. Environ. 126, 24–35.

Cote, M., Nightingale, A.J., 2012. Resilience thinking meets social theory: situating social change in socio-ecological systems (SES) research. Prog. Hum. Geogr. 36, 475–489.

Crane, A., LeBaron, G., Allain, J., Behbahani, L., 2019. Governance gaps in eradicating forced labor: From global to domestic supply chains. Regul. Gov. 13, 86–106.

Creedy, T.J., Asare, R.A., Morel, A.C., Hirons, M., Mason, J., Malhi, Y., McDermott, C.L., Opoku, E., Norris, K., 2022. Climate change alters impacts of extreme climate events on a tropical perennial tree crop. Sci. Rep. 12, 19653.

Cretney, R., 2014. Resilience for whom? Emerging critical geographies of socio-ecological resilience. Geogr. Compass 8, 627–640.

Cutter, S.L., 2016. Resilience to what? Resilience for whom? Geogr. J. 182, 110–113.

Damnyag, L., Saastamoinen, O., Appiah, M., Pappinen, A., 2012. Role of tenure insecurity in deforestation in Ghana's high forest zone. For. Policy Econ. 14, 90–98. https://doi.org/10.1016/j.forpol.2011.08.006

Davoudi, S., Shaw, K., Haider, L.J., Quinlan, A.E., Peterson, G.D., Wilkinson, C., Fünfgeld, H., McEvoy, D., Porter, L., Davoudi, S., 2012. Resilience: a bridging concept or a dead end?"Reframing" resilience: challenges for planning theory and practice interacting traps: resilience assessment of a pasture management system in Northern Afghanistan urban resilience: what does it mean in plannin. Plan. theory Pract. 13, 299–333.

De Juan, A., Pierskalla, J., Schwarz, E., 2020. Natural disasters, aid distribution, and social conflict–Micro-level evidence from the 2015 earthquake in Nepal. World Dev. 126, 104715.

De Kraker, J., 2017. Social learning for resilience in social–ecological systems. Curr. Opin. Environ. Sustain. 28, 100–107. https://doi.org/10.1016/j.cosust.2017.09.002

Debrah, Y.A., 2013. Human resource management in Ghana, in: Human Resource Management in Developing Countries. Routledge, pp. 210–228.

Dei Antwi, K., Lyford, C.P., Nartey, R.Y., 2018. Analysis of food security among cocoa producing households in Ghana. J. Agric. Sustain. 11.

Denkyirah, E.K., Okoffo, E.D., Adu, D.T., Bosompem, O.A., 2017. What are the drivers of cocoa farmers' choice of climate change adaptation strategies in Ghana? Cogent Food Agric. 3, 1334296.

Eakin, H., Benessaiah, K., Barrera, J.F., Cruz-Bello, G.M., Morales, H., 2012. Livelihoods and landscapes at the threshold of change: disaster and resilience in a Chiapas coffee community. Reg. Environ. Chang. 12, 475–488.

Ensor, J., Tuhkanen, H., Boyland, M., Salamanca, A., Johnson, K., Thomalla, F., Mangada, L.L., 2021. Redistributing resilience? Deliberate transformation and political capabilities in post-Haiyan Tacloban. World Dev. 140, 105360.

Ensor, J.E., Mohan, T., Forrester, J., Khisa, U.K., Karim, T., Howley, P., 2021. Opening space for equity and justice in resilience: A subjective approach to household resilience assessment. Glob. Environ. Chang. 68, 102251.

Eriksen, S., Schipper, E.L.F., Scoville-Simonds, M., Vincent, K., Adam, H.N., Brooks, N., Harding, B., Lenaerts, L., Liverman, D., Mills-Novoa, M., 2021. Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance? World Dev. 141, 105383.

Fleiss, S., McClean, C.J., King, H., Hill, J.K., 2022. Limited impacts of climatic conditions on commercial oil palm yields in Malaysian plantations. CABI Agric. Biosci. 3, 1–18.

Folke, C., 2016. Resilience (republished). Ecol. Soc. 21.

Folke, C., 2006. Resilience: The emergence of a perspective for social-ecological systems analyses. Glob. Environ.

Chang. 16, 253–267. https://doi.org/10.1016/j.gloenvcha.2006.04.002

Forsyth, T., 2018. Is resilience to climate change socially inclusive? Investigating theories of change processes in Myanmar. World Dev. 111, 13–26.

Fosu-Mensah, B.Y., Okoffo, E.D., Darko, G., Gordon, C., 2016. Organophosphorus pesticide residues in soils and drinking water sources from cocoa producing areas in Ghana. Environ. Syst. Res. 5, 1–12.

Fountain, A.C., Hütz-Adams, F., 2020. Cocoa Barometer 2020. Amsterdam.

Frankenberger, T.R., Constas, M.A., Nelson, S., Starr, L., 2014. How NGOs approach resilience programming. Resil. food Nutr. Secur. 177.

Frankenberger, T.R., McCaston, M.K., 1998. The household livelihood security concept. Food Nutr. Agric. 30–35.

Friedman, R., Hirons, M.A., Boyd, E., 2018. Vulnerability of Ghanaian women cocoa farmers to climate change: a typology. Clim. Dev. 0, 1–13. https://doi.org/10.1080/17565529.2018.1442806

Fünfgeld, H., McEvoy, D., 2012. Resilience as a useful concept for climate change adaptation? Plan. Theory Pract. 13, 324–328.

Garrett, R.D., Levy, S.A., Gollnow, F., Hodel, L., Rueda, X., 2021. Have food supply chain policies improved forest conservation and rural livelihoods? A systematic review. Environ. Res. Lett. 16, 33002.

Gateau-Rey, L., Tanner, E.V.J., Rapidel, B., Marelli, J.-P., Royaert, S., 2018. Climate change could threaten cocoa production: Effects of 2015-16 El Niño-related drought on cocoa agroforests in Bahia, Brazil. PLoS One 13, e0200454.

Gockowski, J., Asamoah, C., David, S., Gyamfi, I., Kumi, M.A., 2010. An evaluation of farmer field school induced changes in Ghanaian cocoa production. J. Int. Agric. Ext. Educ. 17, 43–56.

Grabs, J., 2017. The rise of buyer-driven sustainability governance: emerging trends in the global coffee sector.

Hansen, J.W., Baethgen, W.E., Osgood, D.E., Ceccato, P.N., Ngugi, R.K., 2007. Innovations in climate risk management: protecting and building rural livelihoods in a variable and changing climate. J. Semi-Arid Trop. Agric. Res. 4.

Hashmiu, I., Agbenyega, O., Dawoe, E., 2022. Cash crops and food security: evidence from smallholder cocoa and cashew farmers in Ghana. Agric. Food Secur. 11, 1–21.

Hirons, M., McDermott, C., Asare, R., Morel, A., Robinson, E., Mason, J., Boyd, E., Malhi, Y., Norris, K., 2018a. Illegality and inequity in Ghana's cocoa-forest landscape: How formalization can undermine farmers control and benefits from trees on their farms. Land use policy 76, 405–413. https://doi.org/10.1016/j.landusepol.2018.02.014

Hirons, M., Morel, A., McDermott, C., Boyd, E., Malhi, Y., Norris, K., Mason, J., Asare, R., 2018b. Understanding climate resilience in Ghanaian cocoa communities – Advancing a biocultural perspective. J. Rural Stud. 63, 120–

129. https://doi.org/10.1016/j.jrurstud.2018.08.010

Hirons, M, Robinson, E., McDermott, C., Morel, A., Asare, R., Boyd, E., Gonfa, T., Gole, T.W., Malhi, Y., Mason, J., 2018. Understanding poverty in cash-crop agro-forestry systems: evidence from Ghana and Ethiopia. Ecol. Econ. 154, 31–41.

Holling, C.S., 1987. Simplifying the complex: the paradigms of ecological function and structure. Eur. J. Oper. Res. 30, 139–146.

Holling, C.S., 1986. The resilience of terrestrial ecosystems: local surprise and global change. Sustain. Dev. Biosph. 14, 292–317.

Holling, C.S., 1973. Resilience and stability of ecological systems. Annu. Rev. Ecol. Syst. 4, 1–23.

Hutchins, A., Ehiakpor, D.S., Danso-Abbeam, G., Baah, J.E., Yildiz, F., Tamargo, A., Bailey, C., Kim, Y., Fosu-Mensah, B.Y., Vlek, P.L.G., MacCarthy, D.S., 2015. Assessment of Climate Change Impacts on Cocoa Production and Approaches to Adaptation and Mitigation: A Contextual View of Ghana and Costa Rica. Environ. Dev. Sustain. 14, 1210557. https://doi.org/10.1007/s10668-012-9339-7

Ibn Musah, A.-A., Du, J., Bilaliib Udimal, T., Abubakari Sadick, M., 2018. The nexus of weather extremes to agriculture production indexes and the future risk in Ghana. Climate 6, 86.

ICCO, 2016. Overview of cocoa supply and demand, in: ICCO Cocoa Market Outlook Conference. London.

ICCO, I.M.M., 2020. Quarterly bulletin of cocoa statistics. International Cocoa Organization.

Iddrisu, M., Aidoo, R., Wongnaa, C.A., 2020. Participation in UTZ-RA voluntary cocoa certification scheme and its impact on smallholder welfare: evidence from Ghana. World Dev. Perspect. 20, 100244.

Ingram, V., van Rijn, F., Waarts, Y., Gilhuis, H., 2018. The impacts of cocoa sustainability initiatives in West Africa. Sustainability 10, 4249.

IPCC, 2022. Climate Change 2022: Mitigation of Climate Change. Cambridge University Press, Cambridge (MA), USA. https://doi.org/10.1017/9781009157926

IPCC, Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., 2021. Climate change 2021: the physical science basis. Contrib. Work. Gr. I to sixth Assess. Rep. Intergov. panel Clim. Chang. 2.

Jackson, G., 2024. The influence of climate resilience governmentality on vulnerability in regional Australia. Environ. Plan. E Nat. Sp. 25148486241226920.

Jennings, T.L., 2011. Transcending the adaptation/mitigation climate change science policy debate: Unmasking assumptions about adaptation and resilience. Weather. Clim. Soc. 3, 238–248.

Jones, L., 2019. Resilience isn't the same for all: Comparing subjective and objective approaches to resilience measurement. Wiley Interdiscip. Rev. Clim. Chang. 10, e552.

Jones, L., d'Errico, M., 2019. Whose resilience matters? Like-for-like comparison of objective and subjective evaluations of resilience. World Dev. 124, 104632.

Jones, L., Tanner, T., 2017. 'Subjective resilience': using perceptions to quantify household resilience to climate extremes and disasters. Reg. Environ. Chang. 17, 229–243. https://doi.org/10.1007/s10113-016-0995-2

Kalischek, N., Lang, N., Renier, C., Daudt, R.C., Addoah, T., Thompson, W., Blaser-Hart, W.J., Garrett, R., Schindler, K., Wegner, J.D., 2023. Cocoa plantations are associated with deforestation in Côte d'Ivoire and Ghana. Nat. Food 4, 384–393.

Kashwan, P., Ribot, J., 2021. Violent silence: The erasure of history and justice in global climate policy. Curr. Hist. 120, 326–331.

Khatun, K., Maguire-Rajpaul, V.A., Asante, E.A., McDermott, C.L., 2020. From agroforestry to agroindustry: Smallholder access to benefits from oil palm in Ghana and the implications for sustainability certification. Front. Sustain. Food Syst. 4.

Kongor, J.E., Boeckx, P., Vermeir, P., Van de Walle, D., Baert, G., Afoakwa, E.O., Dewettinck, K., 2018. Assessment of soil fertility and quality for improved cocoa production in six cocoa growing regions in Ghana. Agrofor. Syst. 1–13.

Krauss, J., 2018. Representing environment and development–tracing links between drivers, representations and power dynamics in cocoa sustainability and beyond. J. Polit. Ecol. 25, 426–445.

Krauss, J., 2016. Cocoa sustainability initiatives and the environment: mapping stakeholder priorities and representations.

Krauss, J.E., Krishnan, A., 2022. Global decisions versus local realities: Sustainability standards, priorities and upgrading dynamics in agricultural global production networks. Glob. Networks 22, 65–88.

Kumeh, E.M., Bieling, C., Birner, R., 2022. Food-security corridors: A crucial but missing link in tackling deforestation in Southwestern Ghana. Land use policy 112, 105862.

Kutsoati, E., Morck, R., 2014. Family ties, inheritance rights, and successful poverty alleviation: Evidence from Ghana, in: African Successes, Volume II: Human Capital. University of Chicago Press, pp. 215–252.

Lade, S.J., Haider, L.J., Engström, G., Schlüter, M., 2017. Resilience offers escape from trapped thinking on poverty alleviation. Sci. Adv. 3, e1603043.

Läderach, P., Martinez-Valle, A., Schroth, G., Castro, N., 2013. Predicting the future climatic suitability for cocoa farming of the world's leading producer countries, Ghana and Côte d'Ivoire. Clim. Change 119, 841–854. https://doi.org/10.1007/s10584-013-0774-8

Leal Filho, W., Stringer, L.C., Totin, E., Djalante, R., Pinho, P., Mach, K.J., Carril, L.R.F., Birkmann, J., Pandey, R., Wolf, F., 2021. Whose voices, whose choices? Pursuing climate resilient trajectories for the poor. Environ. Sci.

Policy 121, 18–23.

LeBaron, G., 2021. The role of supply chains in the global business of forced labour. J. Supply Chain Manag. 57, 29–42.

LeBaron, G., Gore, E., 2020. Gender and forced labour: Understanding the links in global cocoa supply chains. J. Dev. Stud. 56, 1095–1117.

Leichenko, R., Silva, J.A., 2014. Climate change and poverty: vulnerability, impacts, and alleviation strategies. Wiley Interdiscip. Rev. Clim. Chang. 5, 539–556.

Lindow, M., Preiser, R., Biggs, R., 2020. Exploring resilience capacities with food innovators: a narrative approach. Glob. Sustain. 3.

Lohmann, S., Lechtenfeld, T., 2015. The effect of drought on health outcomes and health expenditures in rural Vietnam. World Dev. 72, 432–448.

Lottering, S., Mafongoya, P., Lottering, R., 2020. Drought and its impacts on small-scale farmers in sub-Saharan Africa: a review. South African Geogr. J. 1–23.

Löwe, A., 2017. Creating opportunities for young people in Ghana ' s cocoa sector.

Maganga, A.M., Chiwaula, L., Kambewa, P., 2021. Climate induced vulnerability to poverty among smallholder farmers: Evidence from Malawi. World Dev. Perspect. 21, 100273.

Maguire-Rajpaul, V.A., Khatun, K., Hirons, M.A., 2020. Agricultural information's impact on the adaptive capacity of Ghana's smallholder cocoa farmers. Front. Sustain. Food Syst. 4.

Maguire-Rajpaul, V.A., Sandbrook, C., McDermott, C., Hirons, M.A., 2022. Climate-smart cocoa governance risks entrenching old hegemonies in Côte d'Ivoire and Ghana: a multiple environmentality analysis. Geoforum 130, 78–91.

Manyena, B., Machingura, F., O'Keefe, P., 2019. Disaster Resilience Integrated Framework for Transformation (DRIFT): A new approach to theorising and operationalising resilience. World Dev. 123, 104587.

Maru, Y.T., Smith, M.S., Sparrow, A., Pinho, P.F., Dube, O.P., 2014. A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. Glob. Environ. Chang. 28, 337–350.

Matin, N., Forrester, J., Ensor, J., 2018. What is equitable resilience? World Dev. 109, 197–205.

Matthews, N., 2020. The rise of resilience in a new era. Traumatology (Tallahass. Fla). 26, 248.

McKeown, A., Hai Bui, D., Glenn, J., 2022. A social theory of resilience: The governance of vulnerability in crisis-era neoliberalism. Eur. J. Cult. Polit. Sociol. 9, 112–132.

McKinley, J., Nalley, L.L., Asare, R.A., Dixon, B.L., Popp, J.S., D'Haese, M., 2014. Managing risk in cocoa production: assessing the potential of climate-smart crop insurance in Ghana. J. Int. Agric. Trade Dev. 10, 53.

Michler, J.D., Josephson, A.L., 2017. To Specialize or Diversify: Agricultural Diversity and Poverty Dynamics in

Ethiopia. World Dev. 89, 214–226. https://doi.org/10.1016/j.worlddev.2016.08.011

Mikulewicz, M., 2019. Thwarting adaptation's potential? A critique of resilience and climate-resilient development. Geoforum 104, 267–282.

Mikulewicz, M., Taylor, M., 2020. Getting the resilience right: Climate change and development policy in the 'African age.' New Polit. Econ. 25, 626–641.

Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., Walker, B., Birkmann, J., Van der Leeuw, S., Rockström, J., 2010. Resilience and vulnerability: complementary or conflicting concepts? Ecol. Soc. 15.

Mohan, G., 2006. Embedded cosmopolitanism and the politics of obligation: the Ghanaian diaspora and development. Environ. Plan. A 38, 867–883.

Moore, C., Morel, A.C., Asare, R.A., Sasu, M.A., Adu-Bredu, S., Malhi, Y., 2019. Human appropriated net primary productivity of complex mosaic landscapes. Front. For. Glob. Chang. 2, 38.

Morel, A.C., Hirons, M., Adu Sasu, M., Quaye, M., Ashley Asare, R., Mason, J., Adu-Bredu, S., Boyd, E., McDermott, C.L., Robinson, E.J.Z., 2019. The ecological limits of poverty alleviation in an African forest-agriculture landscape. Front. Sustain. Food Syst. 3.

Nagoda, S., 2015. New discourses but same old development approaches? Climate change adaptation policies, chronic food insecurity and development interventions in northwestern Nepal. Glob. Environ. Chang. 35, 570–579.

Nasser, F., Maguire-Rajpaul, V.A., Dumenu, W., Wong, G.Y., 2020. Climate-smart cocoa in Ghana: How ecological modernisation discourse risks side-lining cocoa smallholders. Front. Sustain. Food Syst. 4. https://doi.org/10.3389/fsufs.2020.00073

Newing, H., Brittain, S., Buchadas, A., del Giorgio, O., Grasham, C.F., Ferritto, R., Marquez, J.R.G., Khanyari, M., König, B., Kulkarni, A., 2024. 'Participatory'conservation research involving indigenous peoples and local communities: Fourteen principles for good practice. Biol. Conserv. 296, 110708.

Nguyen, M.C., Wu, H., Lakner, C., Schoch, M., 2021. March 2021 Update to the Multidimensional Poverty Measure.

Nightingale, A.J., Eriksen, S., Taylor, M., Forsyth, T., Pelling, M., Newsham, A., Boyd, E., Brown, K., Harvey, B., Jones, L., 2020. Beyond Technical Fixes: climate solutions and the great derangement. Clim. Dev. 12, 343–352.

Nyantakyi-Frimpong, H., Bezner-Kerr, R., 2015. The relative importance of climate change in the context of multiple stressors in semi-arid Ghana. Glob. Environ. Chang. 32, 40–56.

O'Brien, K., Barnett, J., 2013. Global environmental change and human security. Annu. Rev. Environ. Resour. 38, 373–391.

O'Brien, K., Selboe, E., 2015. The adaptive challenge of climate change. Cambridge University Press.

Odijie, M., 2019. Environmental change and normalization of cash crop systems in Africa: preventing agrarian change

in West Africa cocoa. Int. J. Sustain. Dev. World Ecol. 26, 597–611.

Odijie, M.E., 2018. Sustainability winners and losers in business-biased cocoa sustainability programmes in West Africa. Int. J. Agric. Sustain. 16, 214–227. https://doi.org/10.1080/14735903.2018.1445408

Odijie, M.E., 2016. Diminishing returns and agricultural involution in Côte d'Ivoire's cocoa sector. Rev. Afr. Polit. Econ. 47–60.

Okoffo, E.D., Mensah, M., Fosu-Mensah, B.Y., 2016. Pesticides exposure and the use of personal protective equipment by cocoa farmers in Ghana. Environ. Syst. Res. 5, 1–15.

Osumanu, I.K., 2022. Climate Change Adaptation and Agricultural Livelihoods of Smallholder Farmers, in: The Routledge Handbook on Livelihoods in the Global South. Routledge, pp. 481–489.

Peprah, K., 2015. Sustainability of cocoa farmers' livelihoods: A case study of Asunafo District, Ghana. Sustain. Prod. Consum. 4, 2–15.

Quandt, A., 2019. Variability in perceptions of household livelihood resilience and drought at the intersection of gender and ethnicity. Clim. Change 152, 1–15.

Quandt, A., 2018. Measuring livelihood resilience: The household livelihood resilience approach (HLRA). World Dev. 107, 253–263.

Quandt, A., Neufeldt, H., McCabe, J.T., 2019. Building livelihood resilience: what role does agroforestry play? Clim. Dev. 11, 485–500.

Quandt, A., Paderes, P., 2023. Livelihood resilience and global environmental change: toward integration of objective and subjective approaches of analysis. Geogr. Rev. 113, 536–553.

Quisumbing, A.R., Pandolfelli, L., 2010. Promising approaches to address the needs of poor female farmers: Resources, constraints, and interventions. World Dev. 38, 581–592.

Rao, N., Singh, C., Solomon, D., Camfield, L., Sidiki, R., Angula, M., Poonacha, P., Sidibé, A., Lawson, E.T., 2020. Managing risk, changing aspirations and household dynamics: Implications for wellbeing and adaptation in semi-arid Africa and India. World Dev. 125, 104667.

Rasmussen, L.V., 2018. Re-Defining Sahelian 'Adaptive Agriculture' when Implemented Locally: Beyond Techno-fix Solutions. World Dev. 108, 274–282. https://doi.org/10.1016/j.worlddev.2017.03.034

Ribot, J., 2022. Violent silence: framing out social causes of climate-related crises. J. Peasant Stud. 1–30.

Rifai, S.W., Li, S., Malhi, Y., 2019. Coupling of El Niño events and long-term warming leads to pervasive climate extremes in the terrestrial tropics. Environ. Res. Lett. 14, 105002.

Rockström, J., 2003. Water for food and nature in drought–prone tropics: vapour shift in rain–fed agriculture. Philos. Trans. R. Soc. London. Ser. B Biol. Sci. 358, 1997–2009.

Ross, C., 2014. The plantation paradigm: colonial agronomy, African farmers, and the global cocoa boom, 1870s–

1940s. J. Glob. Hist. 9, 49–71. https://doi.org/10.1017/S1740022813000491

Ruf, F., 2015. Diversification of cocoa farms in Côte D'Ivoire: Complementarity of and competition from rubber rent, in: Economics and Ecology of Diversification. Springer, Dordrecht, pp. 41–86.

Saboor, A., Khan, A.U., Hussain, A., Ali, I., Mahmood, K., 2015. Multidimensional deprivations in Pakistan: Regional variations and temporal shifts. Q. Rev. Econ. Financ. 56, 57–67.

Santos, M.E., Alkire, S., 2011. Training material for producing national human development reports, MPI: Construction and analysis. Oxford: Oxford Poverty and Human Development Initiative.

Schipper, E.L.F., 2022. Catching maladaptation before it happens. Nat. Clim. Chang. 1–2.

Schipper, E.L.F., 2020. Maladaptation: When adaptation to climate change goes very wrong. One Earth 3, 409–414.

Schipper, E L F, Eriksen, S.E., Fernandez Carril, L.R., Glavovic, B.C., Shawoo, Z., 2020. Turbulent transformation: abrupt societal disruption and climate resilient development. Clim. Dev. 1–8.

Schipper, E.L.F., Langston, L., 2015. A comparative overview of resilience measurement frameworks. Anal. Indic. Approaches; Overseas Dev. Inst. London, UK 422.

Schipper, E Lisa F, Tanner, T., Dube, O.P., Adams, K.M., Huq, S., 2020. The debate: Is global development adapting to climate change? World Dev. Perspect. 18, 100205.

Schroth, G., Läderach, P., Martínez-Valle, A., Bunn, C., 2015. Climate vulnerability and adaptation of the smallholder cocoa and coffee value chains in Liberia.

Schroth, G., Läderach, P., Martinez-Valle, A.I., Bunn, C., 2017. From site-level to regional adaptation planning for tropical commodities: cocoa in West Africa. Mitig. Adapt. Strateg. Glob. Chang. 22, 903–927. https://doi.org/10.1007/s11027-016-9707-y

Schroth, G., Läderach, P., Martinez-Valle, A.I., Bunn, C., Jassogne, L., 2016. Vulnerability to climate change of cocoa in West Africa: Patterns, opportunities and limits to adaptation. Sci. Total Environ. 556, 231–241.

Scoones, I., 2015. Sustainable livelihoods and rural development (Agrarian change and peasant studies series: number 4), Bourton on Dunnesmore, Rugby: Practical Action Publishing. Practical Action Publishing, Rugby, UK.

Scoones, I., 2009. Livelihoods perspectives and rural development. J. Peasant Stud. 36, 171–196. https://doi.org/10.1080/03066150902820503

Sen, A., 1985. A sociological approach to the measurement of poverty: a reply to Professor Peter Townsend. Oxf. Econ. Pap. 37, 669–676.

Sen, A., 1976. Poverty: an ordinal approach to measurement. Econom. J. Econom. Soc. 219–231.

Sen, A.K., 1999. Development as Freedom (1 edn.; New York, Knopf Press).

Seutra Kaba, J., Abunyewa, A.A., Kugbe, J., Kwashie, G.K.S., Owusu Ansah, E., Andoh, H., 2021. Arbuscular mycorrhizal fungi and potassium fertilizer as plant biostimulants and alternative research for enhancing plants

adaptation to drought stress: Opportunities for enhancing drought tolerance in cocoa (Theobroma cacao L.). Sustain. Environ. 7, 1963927.

Singh, C., Dorward, P., Osbahr, H., 2016. Developing a holistic approach to the analysis of farmer decision-making: Implications for adaptation policy and practice in developing countries. Land use policy 59, 329–343. https://doi.org/10.1016/j.landusepol.2016.06.041

Singh, C., Iyer, S., New, M.G., Few, R., Kuchimanchi, B., Segnon, A.C., Morchain, D., 2021. Interrogating 'effectiveness' in climate change adaptation: 11 guiding principles for adaptation research and practice. Clim. Dev. 1–15.

Stringer, L.C., Dyer, J.C., Reed, M.S., Dougill, A.J., Twyman, C., Mkwambisi, D., 2009. Adaptations to climate change, drought and desertification: local insights to enhance policy in southern Africa. Environ. Sci. Policy 12, 748–765. https://doi.org/10.1016/j.envsci.2009.04.002

Stringer, L.C., Mirzabaev, A., Benjaminsen, T.A., Harris, R.M.B., Jafari, M., Lissner, T.K., Stevens, N., Tirado-von Der Pahlen, C., 2021. Climate change impacts on water security in global drylands. One Earth 4, 851–864.

Tankari, M.R., 2017. Cash crops reduce the welfare of farm households in Senegal. Food Secur. 9, 1105–1115.

Tanner, T., Lewis, D., Wrathall, D., Bronen, R., Cradock-Henry, N., Huq, S., Lawless, C., Nawrotzki, R., Prasad, V., Rahman, M.A., 2015. Livelihood resilience in the face of climate change. Nat. Clim. Chang. 5, 23–26.

Taylor, M., 2018. Climate-smart agriculture: what is it good for? J. Peasant Stud. 45, 89–107.

Taylor, M., 2014. The political ecology of climate change adaptation: Livelihoods, agrarian change and the conflicts of development. Routledge.

Tesfaye, W., Tirivayi, N., 2020. Crop diversity, household welfare and consumption smoothing under risk: evidence from rural Uganda. World Dev. 125, 104686.

Thiede, B., 2016. Resilience and development among ultra-poor households in rural Ethiopia. Resilience 4, 1–13.

Thiry, G., Alkire, S., Schleicher, J., 2018. Incorporating environmental and natural resources within analyses of multidimensional poverty. OPHI Res. Prog. Ser. 50a January.

Thompson, W., WJ, B.-H., E, D., E, C., RD, G., 2022. Can sustainability certification enhance the climate resilience of smallholder farmers? The case of Ghanaian cocoa. J. Land Use Sci. 17, 407–428.

Thornton, P.K., Herrero, M., 2015. Adapting to climate change in the mixed crop and livestock farming systems in sub-Saharan Africa. Nat. Clim. Chang. 5, 830–836.

Thornton, P.K., Jones, P.G., Ericksen, P.J., Challinor, A.J., 2011. Agriculture and food systems in sub-Saharan Africa in a 4 C+ world. Philos. Trans. R. Soc. A Math. Phys. Eng. Sci. 369, 117–136.

Tongruksawattana, S., Wainaina, P., 2019. Climate shock adaptation for Kenyan maize-legume farmers: Choice, complementarities and substitutions between strategies. Clim. Dev. 11, 710–722.

Toole, S., Klocker, N., Head, L., 2016. Re-thinking climate change adaptation and capacities at the household scale. Clim. Change 135, 203–209.

Tschakert, P., Dietrich, K.A., 2010. Anticipatory learning for climate change adaptation and resilience. Ecol. Soc. 15.

Tsiboe, F., Dixon, B.L., Nalley, L.L., Popp, J.S., Luckstead, J., 2016. Estimating the impact of farmer field schools in sub-Saharan Africa: the case of cocoa. Agric. Econ. 47, 329–339. https://doi.org/10.1111/agec.12233

Turner, N.J., Berkes, F., 2006. Coming to understanding: developing conservation through incremental learning in the Pacific Northwest. Hum. Ecol. 34, 495–513.

UNFCCC, 2021. Race to Resilience - Catalysing a step-change in global ambition to build the resilience of 4 billion people by 2030 [WWW Document]. URL https://racetozero.unfccc.int/race-to-resilience/ (accessed 8.5.21).

Unnikrishnan, V., Pinet, M., Marc, L., Boateng, N.A., Boateng, E.S., Pasanen, T., Atta-Mensah, M., Bridonneau, S., 2022. Impact of an integrated youth skill training program on youth livelihoods: A case study of cocoa belt region in Ghana. World Dev. 151, 105732.

Van Huellen, S., Abubakar, F.M., 2021. Potential for upgrading in financialised agri-food chains: the case of Ghanaian cocoa. Eur. J. Dev. Res. 33, 227–252.

van Vliet, J.A., Slingerland, M.A., Waarts, Y.R., Giller, K.E., 2021. A Living Income for Cocoa Producers in Côte d'Ivoire and Ghana? Front. Sustain. Food Syst. 5, 732831.

Waarts, Y.R., Janssen, V., Ingram, V.J., Slingerland, M.A., van Rijn, F.C., Beekman, G., Dengerink, J., van Vliet, J.A., Arets, E., Sassen, M., 2019. A living income for smallholder commodity farmers and protected forests and biodiversity: how can the private and public sectors contribute?: White Paper on sustainable commodity production. Wageningen Economic Research.

Wachsmuth, J., 2015. Cross-sectoral integration in regional adaptation to climate change via participatory scenario development. Clim. Change 132, 387–400.

Walker, B., Holling, C.S., Carpenter, S.R., Kinzig, A., 2004. Resilience, adaptability and transformability in social–ecological systems. Ecol. Soc. 9.

Walsh-Dilley, M., Wolford, W., McCarthy, J., 2016. Rights for resilience: food sovereignty, power, and resilience in development practice. Ecol. Soc. 21.

Weichselgartner, J., Kelman, I., 2015. Geographies of resilience: Challenges and opportunities of a descriptive concept. Prog. Hum. Geogr. 39, 249–267.

Wessel, M., Quist-Wessel, P.M.F., 2015. Cocoa production in West Africa, a review and analysis of recent developments. NJAS - Wageningen J. Life Sci. 74–75, 1–7. https://doi.org/10.1016/j.njas.2015.09.001

Whitfield, S., Beauchamp, E., Boyd, D.S., Burslem, D., Byg, A., Colledge, F., Cutler, M.E.J., Didena, M., Dougill, A., Foody, G., 2019. Exploring temporality in socio-ecological resilience through experiences of the 2015–16 El Niño

across the Tropics. Glob. Environ. Chang. 55, 1–14.

Wisner, B., Blaikie, P.M., Blaikie, P., Cannon, T., Davis, I., 2004. At risk: natural hazards, people's vulnerability and disasters. Psychology Press.

Wongnaa, C.A., Babu, S., 2020. Building resilience to shocks of climate change in Ghana's cocoa production and its effect on productivity and incomes. Technol. Soc. 62, 101288.

World Bank, W.B., 2018. Accelerating Climate Resilient and Low Carbon Development: The Africa Climate Business Plan – Third Implementation Progress Report and Forward Look. Washington DC.

Yaro, J.A., 2013. The perception of and adaptation to climate variability/change in Ghana by small-scale and commercial farmers. Reg. Environ. Chang. 13, 1259–1272. https://doi.org/10.1007/s10113-013-0443-5

Zu Ermgassen, E.K.H.J., Bastos Lima, M.G., Bellfield, H., Dontenville, A., Gardner, T., Godar, J., Heilmayr, R., Indenbaum, R., Dos Reis, T.N.P., Ribeiro, V., 2022. Addressing indirect sourcing in zero deforestation commodity supply chains. Sci. Adv. 8, eabn3132.