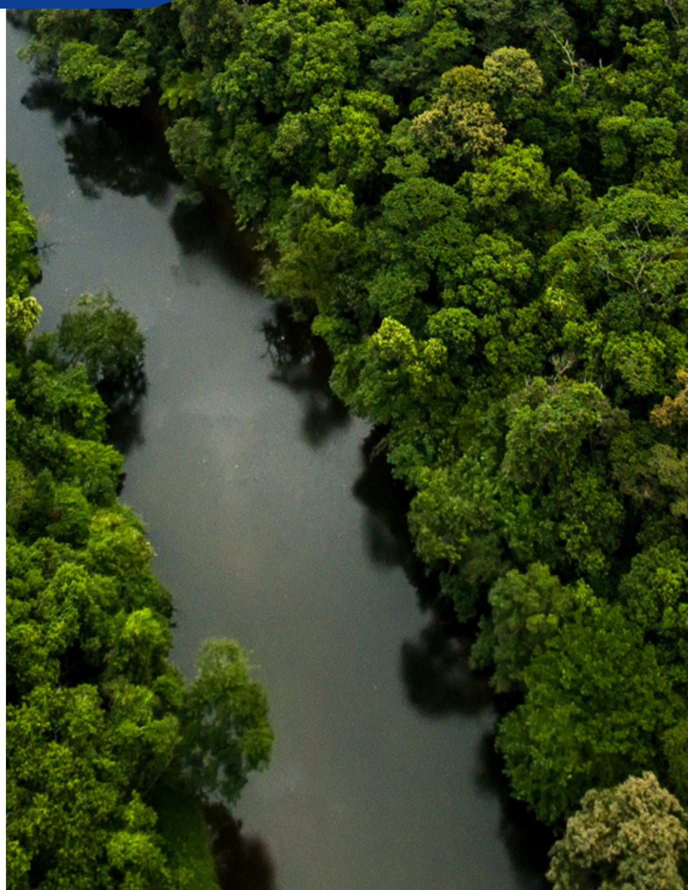
FAIRTRADE AND CLIMATE CHANGE

Systematic review, hotspot analysis and survey

OCTOBER 2021



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1 Executive Summary

It is anticipated that climate change will severely affect agricultural production in the future, which could negatively impact the production of Fairtrade products around the world. Therefore, Fairtrade International commissioned a study to assess potential climate change impacts on the production and producers of major Fairtrade crops. For this purpose, we performed several different analyses: 1. Literature review on how climate change has so far impacted banana, cocoa, coffee, cotton, sugarcane and tea production; 2. A spatially explicit analysis to identify the extent and locations of future climate change extremes; 3. A review of Fairtrade documents regarding future climate change and adaptation; 4. A survey with producing organizations from two hotspot regions: South India (tea and coffee) and Ghana (cocoa).

Climate Change impact analysis

We demonstrated that climate change impacts vary considerably across different regions, crops and climate scenarios. Future assessments need to go beyond generalized average impacts globally, and should perhaps focus on regional and crop-specific approaches to adaptation.

Banana

Under the low-emission scenario, banana producers will not experience a considerable increase in the frequency of hotter and drier days, however producers in Southeast Asia, Oceania and potentially the Caribbean might be subject to more tropical cyclones. Under the more extreme high-emission scenario, however, all current Fairtrade banana producing locations will likely have considerably more days with extreme temperatures, and producers in the Caribbean and Central America will also undergo considerably more days without precipitation.

Cocoa

Most locations of current Fairtrade cocoa production will experience more days with extreme temperatures under the low emission scenarios (except in parts of South America and West Africa). Under the high-emission scenario, all cocoa producing locations will, however, experience considerably more heat stress. Although we identified that cocoa producing locations will experience more days without precipitation under both scenarios, the increases in days without precipitation are not considerable. Most cocoa producing locations outside the Caribbean and Central America will, however, be subject to considerable increases in days with extreme rainfall under both scenarios.

Coffee

Coffee producing locations will be subject to considerable increases in the number of days with extreme temperatures, especially under the high emissions scenario. Particularly problematic are areas where this will coincide with an increase in the number of days without rainfall, such as Brazil, Central America and South India (where all current Fairtrade coffee sourcing areas will experience both). Although there are regions where climate change might not have such negative impacts on coffee production in the future (Colombia, Peru, Ethiopia, Kenya), the extent of other areas that might experience such increases in heat and drought occurrence could severely impact the stability of sourcing of Fairtrade coffee.

Cotton

Most Fairtrade cotton producing areas are projected to experience both an increase in days with extreme temperatures and no rainfall. Particularly worrying is that most of these locations are in water basins which are already depleted, posing a serious risk to the sustainability of sourcing cotton.

Sugarcane

Sugarcane production outside South and Southeast Asia will be subject to both considerable increases in heat and drought stress. Production in South and Southeast Asia, on the other hand, will be impacted by considerable increases in extreme temperatures.

Tea

Tea production in both major regions, East and South Africa and South and Southeast Asia, is projected to be impacted by an increase in heat stress under both scenarios. Asian tea producers will, on average, experience slightly more days without precipitation. While most African tea producers will experience fewer days without precipitation, producers in Malawi and Tanzania will be severely impacted by increases in days without precipitation.

Fairtrade documents review

Of a total of 50 reviewed documents, most focus on coffee, cocoa and banana as the main crops. Several documents were produced by the regional producer networks, mostly in Asia (NAPP) and Africa (FTA). Especially at the global level, most reports focused on climate change adaptation and only some also considered mitigation aspects. Overall, few reports explicitly mentioned the farmers' awareness of Fairtrade's programmatic approach to climate change or their needs from this program. From these, some of the challenges that stood out were limited funding possibilities, especially since most farmers cannot sell 100% of their produce to Fairtrade and thus limiting their Premium. One observation from the documents review was that the incorporation of climate change adaptation strategies in the guidance documents and projects, including trainings, have yielded only preliminary results[1]. It is also unclear whether the projects have been participatory in nature, meaning that producer organizations actively seek to incorporate trainings based on a perceived need. Although it is important and meaningful to promote adaptation strategies at all levels, involvement from key stakeholders is critical.

[1] Note that in parallel to this study, a separate consultancy has been carried out (which was not available during the review) out to systematize 10 Fairtrade climate change projects, identifying their strategies and successes, potential for replication and scaling-up, as well as areas for improvement. This knowledge is available in the following publication: Clements, R. and Pacha, MJ. 2021. Fairtrade Climate Change Projects: Learning from Experience. Fairtrade International.

Hotspot review: Impacts on producers based on surveys in India and Ghana

The producers survey was carried out with the help of Fairtrade and its collaborators in the respective countries. The number of farmers who participated were 125 in India and 11 in Ghana, mainly due to differing data collection conditions.

India

In India, most producers grow coffee, tea and spices in a full sun system. The most frequent climate hazards are extreme temperatures and water scarcity. These hazards mildly impact coffee and have slightly more of an impact on tea, especially the harvest yield and quality. The main response to high temperatures adopted by producers in coffee production is to plant trees (jackfruit, mango and silver oak) which also provide shade and soil protection. Buffer zones are implemented against storms. Against drought, producers use mainly mulch and irrigation. Organic practices and plant pruning are used to manage pests and diseases (in tea production as well). Intercropping is a current practice in coffee production. The producers state that pepper and turmeric are helping to reduce pest and diseases pressure. In tea production, planting trees is also used to mitigate high temperatures and storms. Rainwater harvesting and irrigation are used to mitigate water scarcity. In spices production, similar measures are adopted as in tea production.

In general, Indian producers estimate the future risks due to climate change as mild. Increases in temperatures, unusual rain and increases in flooding are considered the most important risks. They impute the rise in pest and diseases damages to diminishing effectiveness of management strategies based in traditional knowledge. Financially, the main source of income is, by far, crops. Producers estimated that their income was mildly impacted by climate change in 2019. Producers are primarily more concerned about the lack of labor than their financial risk. To access credit, Indian producers turn mainly to money lenders and village lending groups. The main climate occurrences forcing them to contract credits are drought and floods. Their main source of information about the weather are television, newspapers and smartphones.

Ghana

In Ghana, most producers grow cocoa, under shade. The most common climate hazards are water scarcity and high temperature. Especially the yield and in a lesser extend the crop quality and harvesting are impacted. The producers respond to those events by planting trees against drought and high temperatures. They also use mulch and protect water bodies. They create buffer zones against storms and use IPM and pruning against pest and diseases.

Producers in Ghana are more pessimistic than Indian ones regarding the future. They predict land degradation and increase in temperature to be the most important impacts of climate change. They also forecast more drought. For them, the increasing impact of pest and diseases is due to their lack of money to fight them, as well as the increasing ineffectiveness of traditional knowledge.

Like Indian producers, crop is by far their main source of income. They estimate impact of climate change on their income as severe in 2019, improving slightly with time. They are worried about financial risk and fear not having enough income the most. Credit access is difficult in Ghana, with producers stating having no access to credit or through village lending groups. The main climate occurrences forcing them to contract credits are pest and diseases. Information about the weather is primarily accessed by way of television.

2 General background

2.1 Introduction to the climate change problem

2.1.1 Impact on agricultural production

Reducing the risk of crop failure and sustaining or improving crop productivity becomes an increasing challenge as the climate changes land and agricultural production, particularly for smallholders such as those in the Fairtrade system. Yield decline is especially high for tropical crops (IPCC 2019). Compared to farmers in developed countries, smallholders in developing countries in the tropics are often disproportionately affected be these climate change effects and have fewer resources to adapt to changes in climate and other stresses. Climate change has many negative impacts on agriculture, including the effects of changing precipitation patterns, temperature increases and sea-level rise. Changing precipitation patterns (such as more and prolonged droughts, irregular and more concentrated precipitation, and changing patterns in growing seasons) can lead to crop failures or yield declines in the long term (Nelson et al. 2009). For crops such as coffee, rising temperatures also increase the pressure from weeds and pests (ibid.), leading to a decline in yield and quality (Ovalle-Rivera et al. 2015). This is particularly important, as cooperatives will have to resort to the low-price, conventional market if product quality is too low. In view of climate change, not only the incidence of pests and diseases but also resulting resistances towards pesticides could increase (Gregory et al. 2009). This means supporting more resilient production systems and organic methods will be even more important in the future.

2.1.2 Climate change adaptation

Vulnerability to climate change is the predisposition of a socio-ecological system to be adversely affected by climate change (IPCC 2014) and depends on exposure, sensitivity and adaptive capacity. Exposure is pre-determined by the environment (geographic location, ecosystem and climate) and farmers have limited options to influence this except through migration. Sensitivity depends more on the livelihood strategies and choice of farming system. Adaptive capacity, on the other hand, is the result of natural, physical, financial, human and social assets of each household (IFAD 2011). The potential for land-related adaptation is context specific, and adaptive capacity can differ among and between communities and regions (IPCC 2019). By increasing and balancing out their assets, farmers can become more resilient towards climate change; in practice, this means for example increasing off-farm income, keeping savings, attending farmer trainings, or participating in cooperatives.

Adaptation, the process of adjusting to actual or expected climate and its effects (IPCC 2014), is a key factor determining the severity of climate change impacts on agriculture and people's livelihoods. Often, adaptation options are variations of existing climate risk management (Howden et al. 2007) and solutions can also be found in traditional agricultural practices (Li et al. 2013). Novel production techniques or different crop varieties can also play an important role. Management of the local micro-climate through agroforestry and natural vegetation patches in the landscape can provide another means of adapting to changing large-scale climate conditions. Solutions are dependent on the crop, current farming system, anticipated climate change impacts and the physical and socio-cultural context. For climate change adaptation projects to be successful, it is crucial to consider farmers' perspectives on climate change impacts and how they handle new information from science and trade relations (Howden et al. 2007). Many studies found that understanding local level perceptions and smallholders' barriers to adaptation is key for successful adaptation planning (e.g. Deressa et al. 2011, Below et al. 2012, Tambo and Abdoulaye 2013, Dang et al. 2014, Panda 2016). They identified several factors which influence the ability to adapt, of which perception of and knowledge on climate change, social relationships, agricultural extension, availability of credit, land tenure and demographics were the most important ones. In this context of small-scale farmers, the role of local knowledge is crucial regarding the development of responses to climate change. However, the mutual recognition and acceptance of scientific or technical knowledge as well as of indigenous and/or local knowledge is not necessarily given but is often reflected in a strong dichotomy based on historical power relations and marginalization as has been shown by Carey et al. (2012) and Cruikshank (2014), among others.

In this regard, using approaches of co-production of knowledge can contribute to the overcoming of this dichotomy and contribute to the development of more sustainable adaptation measures. During such processes, bearers of different types of knowledge (e.g. scientific and local knowledge) meet, share their knowledge and construct jointly new measures. Approaches for co-production of knowledge have been developed which highlight conditions favouring the co-production of relevant knowledge in particular contexts (Hegger and Dieperink 2014, Jasanoff 2004, Pohl et al. 2010). A crucial condition, among others, is the recognition of differences in the actor perspectives, as well as clearly identifying the knowledge and roles of the actors (Hegger and Dieperink 2014).

Mitigation, in turn, refers to human interventions to reducing the sources and/or enhance the sinks of greenhouse gases, thus limiting climate change (IPCC 2015). Fairtrade's top three products in terms of number of farmers (coffee, tea and cocoa) can all be produced in agroforestry systems, where shade trees can contribute to climate change mitigation. Tropical agroforestry systems can store up to 228 Mt ha^{-1} of carbon (Albrecht and Kandji 2003), which is comparable to storage rates of some secondary forests. At the same time, agroforestry systems are more resilient towards pests, disease and climatic stress (Mbow et al. 2014). The promotion of such shaded systems, if well managed, is thus a good example of a measure which contributes to both mitigation and adaptation. Considering these synergies, the systematic use of shade trees is recommended more and more, for example, in West African cocoa farms (Schroth et al. 2016). Climate change mitigation may also take place through approaches that include natural vegetation and carbon sequestration within the farm, or through intensification that can, under the right conditions, lead to land sparing and thus mitigation. The possibilities for the different options very much depend on the contextual conditions.

Combatting climate change through both adaptation and mitigation is embedded into the Agenda 2030 as one of the global Sustainable Development Goals (SDG 13). In addition, adaptation strategies in smallholder agriculture are key to reaching several other SDGs. By identifying climate-resilient practices for specific regions and crops and supporting a shift towards more resilient farming systems, agricultural landscapes can become more productive in the long-term (SDG 15). Climate-resilient practices can influence the supply of a variety of ecosystem services such as carbon sequestration, water flow regulation and biodiversity. Climate action can reduce poverty (SDG 1) of smallholder farmers in two ways: first, by providing a stable income over the years thus limiting risks of periodic poverty, and, second, through the Clean Development Mechanism (CDM) creating the opportunity to sell carbon credits as additional sources of income. There is evidence that inequalities influence local adaptive capacities (IPCC 2012). Women (SDG 5), who make out the majority of the agricultural sector in many countries, are more vulnerable to climate change (Denton 2010). However, women can also lead the way towards more equitable and sustainable climate change solutions (IUCN 2015). Gender disaggregated information can help to identify suitable adaptation strategies targeting crops which are mostly under the responsibility of women. One of the main drivers of economic growth is employment. Access to decent employment (SDG 8) includes, among others, a fair income, security in the workplace, social protection for families, freedom for people to organize and participate in the decisions that affect their lives—the main pillar of Fairtrade. Furthermore, by promoting resource and energy efficiency, limiting greenhouse gas emissions from the agricultural sector, encouraging mitigation action, and by providing green and decent jobs, a better quality of life for all can be achieved, while minimizing negative impacts to the environment (SDG 12). Consumers are directly involved through their choice of products and awareness of the standards behind certifications.

2.2 Fairtrade and climate change

The IPPC investigates climate change scenarios and projected impacts on a regional basis, including for Central and South America, Africa and Asia, where Fairtrade's producer networks are located. Table 1 (following page) summarizes the projected future changes in temperature, precipitation and extreme weather events for selected regions (IPCC 2014).

As a result of climate change, a global shift of suitable areas for producing selected crops is expected. The top 7 Fairtrade products (bananas, cocoa, coffee, cotton, flowers, sugar, tea) are all highly vulnerable to climate change. A study in East Africa has found expected yield reductions of up to 40% for coffee, tea, banana and sugarcane due to a loss in suitable area by the end of the 21st century (Adhikari et al. 2015).

Fairtrade International, with its broad producers' network in different regions and countries, already offers extension services on a variety of topics, and hopes to intensify these efforts in the future to prepare farmers better for the challenges of climate change. Currently, they are supporting their farmer cooperatives to combat climate change impacts through a programmatic approach to climate change. This includes Fairtrade Carbon Credits, which give smallholders access to the carbon market, as well as the implementation of participatory risk and opportunity assessments.

Additionally, Carbon Credits enable adaptation planning and use of donor funding for adaptation and mitigation measures. Furthermore, Fairtrade producers receive a Fairtrade Premium when selling certified producers under Fairtrade conditions on the use of which producers democratically decide. This can also include climate change relevant projects.

Table 1 Projected future changes in temperature, precipitation and extreme weather for selected regions (adapted from IPCC 2014)

Region	Temperatures	Dryness	Extreme weather
Central America & Mexico	↑	↑	
Amazon	↑	~	• More and longer heat waves
Northeastern Brazil	↑	↑	• More and longer heat waves
Southeastern South America	↑	~	
West Coast South America	↑	↑↓	• More and longer heat waves
West Africa	↑	~	• More and longer heat waves
East Africa	↑	↓	• More and longer heat waves • Increase in heavy precipitation
Southern Africa	↑	↑	• More and longer heat waves
Sahara	↑	~	• More and longer heat waves
Central Asia	↑	~	• More and longer heat waves
East Asia	↑	~	• More and longer heat waves
Southeast Asia	↑	~	• More and longer heat waves
South Asia	↑	~	• More and longer heat waves

↑ increase ↓ decrease ~ slight or no change • high confidence • medium confidence • low confidence

Unfortunately, there is a lack of scientific literature on how the Fairtrade value chain will be impacted by climate change. But climate change and production specific aspects are becoming more and more important for Fairtrade products and producers. Much of the research has focused on globally important staple crops such as maize, wheat or rice, and fewer studies have been carried out on high-end commodities such as Fairtrade products.

For example, the commercial banana cultivars are susceptible to diseases, droughts and temperature extremes (Yadav et al. 2011). In the past 50 years, the global banana yield increased every year on average by 1.37 t/ha. Due to climate change, these annual gains could be slowed down to only 0.19 – 0.59 t/ha by 2050 (Varma and Bebber 2019). In West Africa, studies project that increasing maximum temperatures in the dry season will become a limiting factor for cocoa production (Schroth et al. 2016). For coffee, Arabica in particular was found to be a climate-sensitive species (Davis et al. 2012). In coffee production, the incidence of the important pest ‘coffee berry borer’ has already increased and is predicted to spread to more areas due to higher temperatures (Jaramillo et al. 2011).

2.3 Project objectives

In light of these challenges, this project aimed to enhance the understanding of climate change impacts on Fairtrade farmers globally from a scientific perspective and on the basis of the perspectives of farmers' cooperatives and network organizations on risks and opportunities taking into account the context of the Fairtrade Climate Change Program.

The project had the following specific objectives (SOs):

SO 1 To understand predicted climate change impacts on specific regions and the most important Fairtrade commodities and map the 'climate change hotspots' within the Fairtrade producers' network

SO 2 To get a systematic overview of Fairtrade's programmatic approach to climate change

SO 3 To get deeper insights into the perceptions of farmers' cooperatives and farmers' network organizations on climate change impacts in the context of further risks and opportunities, their perceived barriers to climate change adaptation, and their perceptions in terms of risks and opportunities on Fairtrade's climate change projects

SO 4 Develop a comparison on the three different perspectives developed (SO 1, SO 2, SO 3) in terms of similarities, complementarities and differences

The following research questions were answered in line with the objectives and disaggregated by commodity, geographic region and potential other criteria:

1) Where are 'climate change hotspots' within the Fairtrade producers' network from a scientific point of view?
2) How do Fairtrade farmers' cooperatives and network organizations perceive climate change impacts?
3) How do farmers' cooperatives and network organizations perceive Fairtrade's climate change programs in the context of their risk perceptions?
4) What recommendations and relevant questions can be drawn for the development of the Fairtrade Climate Change program and further research?

The project was carried out jointly by the Institute for Environmental Studies of the Vrije Universiteit Amsterdam (VUA) and the School for Agricultural, Forest and Food Sciences of the Bern University of Applied Sciences (BFH) under close collaboration with Fairtrade International (FI). The Fairtrade Producers Networks played an active role by contributing with their knowledge as participants in expert interviews, commenting on the survey draft in order to contextualize the survey as much as possible. The producer networks also filled the role of gatekeeper, identifying, contacting and supporting (if necessary) the participants in filling out the survey.

3 Project structure and methodology

3.1 Project structure

The project was structured into work packages according to workstreams. Work package 1 included all activities related to the systematic review. Work package 2 included the different activities related to the survey and data analysis. A third work package entailed all activities related to reporting. Figure 1 gives an overview of the work packages as well as the responsibilities according to the originally foreseen timeline. Due to several constraints related to the Covid-19 pandemic and the difficulty in reaching out to the Producer Networks in various countries and regions, the timeline was delayed for six months, with the project ending on 30th June 2021.

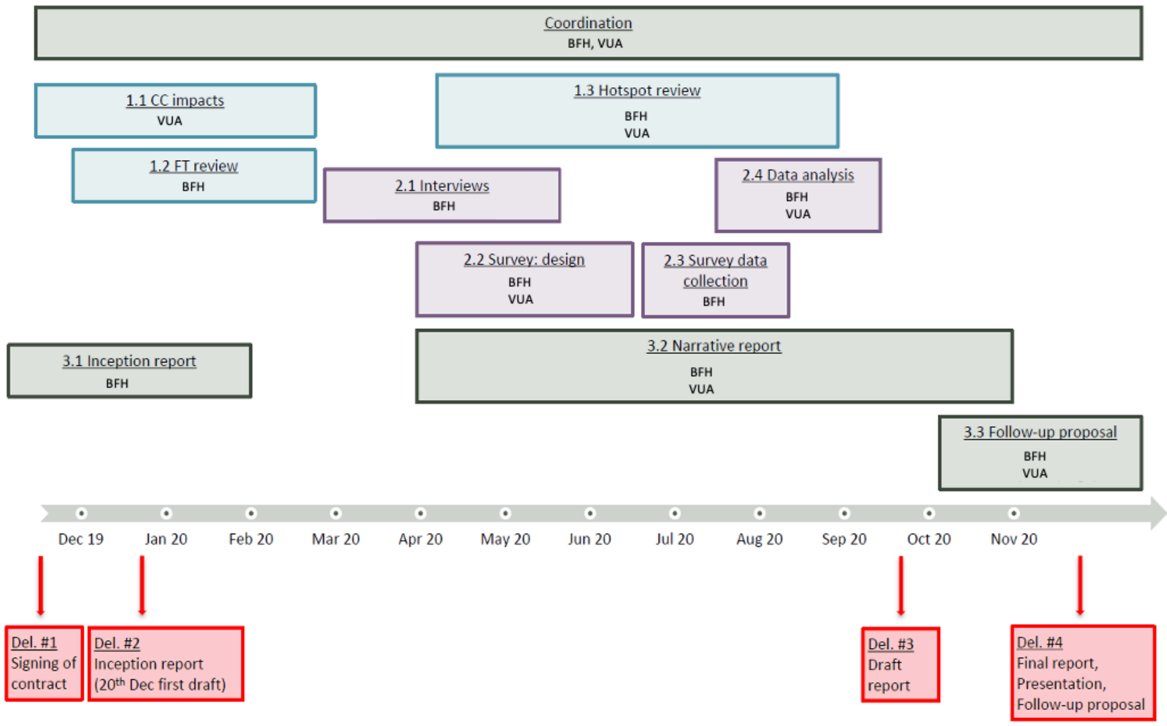


Figure 1 Project structure and work packages along the original timeline

3.2 Overview of the methodology

This chapter briefly presents an overview of the methodology applied to achieve the various objectives of the project. A more detailed methodology is presented in each of the results chapters.

Our methodology included a combination of a literature review (including scientific papers, project documents received by FI and other grey literature), a spatial hotspot analysis, expert interviews and a survey with farmer cooperatives. This mixed methodology ensured data triangulation and validated our results.

3.2.1 Systematic review

The systematic review was done in several steps and contributed to specific objectives 1 (understand climate change impacts and map hotspots) and 2 (develop an overview of Fairtrade's climate change programmatic approach).

In a first step, we studied different climate change effects on the main Fairtrade commodities (banana, cocoa, coffee, tea, sugarcane, cotton) based on literature to identify the main growing regions for individual crops and the main variables for the climate change effects. We then collected global climate change data on these variables and identified their spatial extent in the main regions where Fairtrade crops are produced (Figure 2).

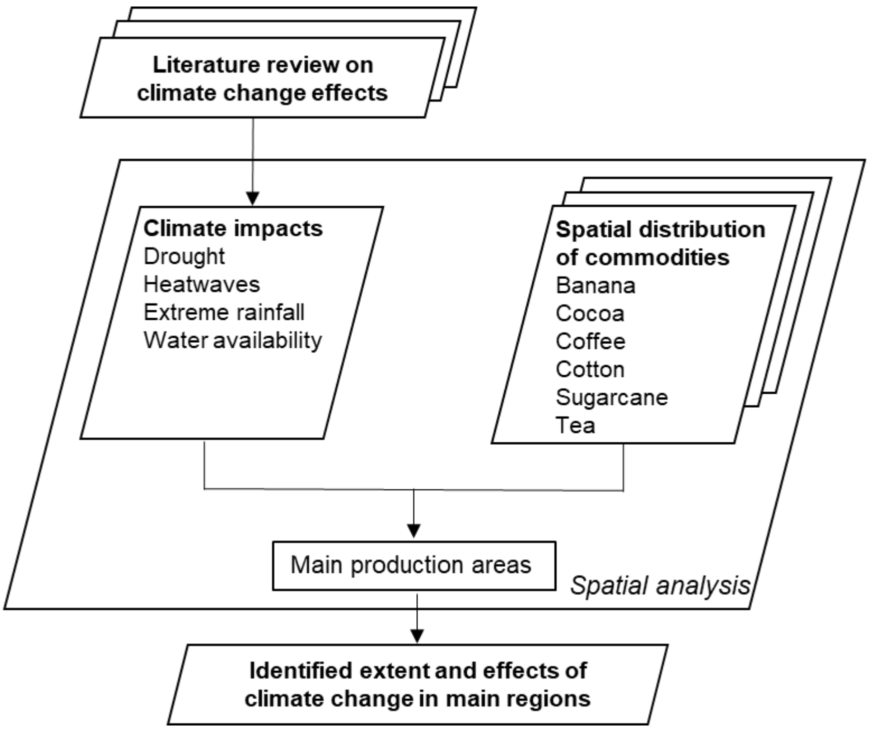


Figure 2 Flowchart of methodology for climate change review

In a second step, we systematically reviewed the literature, in particular Fairtrade internal documents, on Fairtrade programs and interventions related to climate change[2]. We clustered all documents according to a) geographic area, b) commodity and c) their relation to climate change mitigation, adaptation, or both. All documents were analyzed in detail to collect information on

[2] Note that in parallel to this study, a separate consultancy has been carried out (which was not available during the review) to systematize 10 Fairtrade climate change projects, identifying their strategies and successes, potential for replication and scaling-up, as well as areas for improvement. This knowledge is available in the following internal report: Clements, R. and Pacha, MJ. 2021. Fairtrade Climate Change Projects: Learning from Experience. Fairtrade International.

farmers' perception of climate change, adoption of climate-resilient agricultural techniques and challenges linked with the implementation of climate support services as outlined in the documents. The insights gained then contributed to the development of the survey (see next chapter).

As part of the systematic review, a hotspot-specific synthesis was carried out at the end of the project. In line with the geographic and commodity-based hotspots, identified after the first two steps and a consultation with Fairtrade, a hotspot-specific literature review of climate change impacts was conducted, which complemented the other findings (Figure 3).

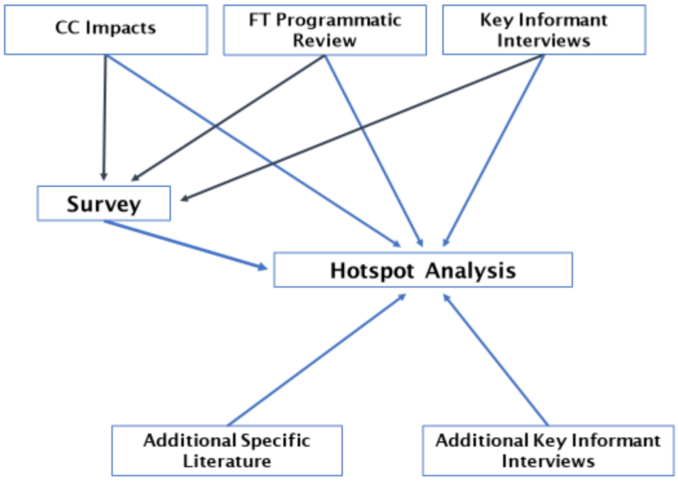


Figure 3 Information flow for the hotspot synthesis

3.2.2 Key informant interviews and survey

We carried out a total of five in-depth expert interviews with representatives from the Fairtrade Producer Networks to a) get an overview on the most important aspects of the field from a global perspective and b) go more into depth looking at the regional and local level. All interviews were carried out online through Skype and followed a semi-structured interview guide with the main topics. The findings, together with results from the systematic review, formed the basis for the design of the survey for the hotspot regions.

For the survey, a closed-ended questionnaire was developed based on the projects' research questions, the results of the climate change impact analysis, the review of literature and the internal documents as well as the results of the experts' interviews. The survey was designed for the producers' organizations (represented by their management) and was sent to the Producers Network Organizations who play the role of so called "gate keepers". The questionnaire was conceptualized in an online format and analyzed using mainly descriptive statistics.

4 Output I: Climate change impacts overview

4.1 Introduction and objectives

The objective of this step of the project is to analyse potential climate change impacts on Fairtrade producers. Particularly, to:

- understand predicted climate change impacts on specific regions and commodities and map the 'climate change hotspots' within the Fairtrade producers' network

In this part of the project, we combined a set of different methods to analyse potential effects of climate change on main Fairtrade commodities. We first performed a literature review to identify the main observed and expected climate change impacts on the following Fairtrade commodities: bananas, cocoa, coffee, cotton, sugar (sugarcane) and tea. Subsequently, we selected climate change indicators that we used in later steps. Secondly, we geolocated all Fairtrade producers. Third, we analysed spatially, how climate change is projected to impact Fairtrade producers, and other areas where the same commodities are being produced.

4.2 Climate change impact on crops

We performed a literature review, by looking at climate change effects for each of the selected crops. We were looking for both scientific and grey literature (e.g. documents on climate change of coffee producer's associations), particularly with respect to future climate change. We used Google scholar for our search, to expand the search beyond only traditional scientific databases. We used general keyword combinations on climate change and each individual crop (banana, cocoa, coffee, cotton, sugarcane and tea):

- climate change
- drought, later expanded to dryness, consecutive dry days, water shortage
- heat, expanded to heatwave, heat stress, extreme temperature, warm stress, warm spell
- rainfall OR precipitation, expanded to extreme rainfall, extreme precipitation, flood*
- cyclone, expanded to typhoon, storm

4.2.1 Banana (*Musa acuminata* C. cultivars)

Historically produced in the form of large-scale monocultures with low genetic diversity, banana is highly vulnerable to climate change. Bananas have a narrow temperature range, and have to grow in humid areas with sufficient rainfall distributed over each month of the year (Simmonds 1962; Turner and Lahav 1983). They will therefore be affected by shifts in upper and lower temperature limits, and precipitation (both in terms of total precipitation and its distribution throughout the year). Additionally, banana growth and production costs are affected by dry periods, as they facilitate implementing irrigation (Machovina and Feeley 2013). As bananas do not have seasonality of production, this makes them constantly exposed to climatic stressors, pathogens and pests (Marín et al. 2003). Nevertheless, studies suggest that areas suitable for cultivating certified bananas in combination with organic production or agroforestry, could increase in the future due to higher resilience of such production systems (Machovina and Feeley 2013).

Banana is projected to experience large-scale shifts in the areas suitable for production – almost half of existing production areas are projected to become unsuitable (Machovina and Feeley 2013). This is mostly due to increases in temperature and decreases in precipitation. However, maximum temperature in the warmest months and driest periods can reduce banana growth due to moisture deficits (Sabiiti et al. 2018). The most suitable production areas are projected to shift northwards, however this can also be accompanied by favorable areas for pathogens (Jesus Júnior et al. 2008; Ravi and Mustaffa 2013). Higher temperatures and lower precipitation (particularly in colder periods) promote the growth of black sigatoka (*Mycosphaerella fijiensis* M.) (Marín et al. 2003). Black sigatoka causes foliar disease and is the most damaging banana disease (Jesus Júnior et al. 2008). Additionally, events such as the latest spread of the Fusarium wilt (*Fusarium oxysporum* f. sp. cubense) to Latin America (Stokstad 2019), could be more frequent and likely with increased temperatures (Ploetz. 2015). Finally, extreme events, such as tropical cyclones, have been demonstrated to have a considerable impact on banana production. Banana production was impacted both by the extreme winds damaging the plantations, as well as flooding due to extreme rainfall (Beer, Abbs, and Alves 2014).

Summary of main expected climate change impacts on banana production:

- Sufficient rainfall over each month of the year necessary, as dry periods affect growth and increase production costs
- High temperatures and dry periods reduce growth
- High temperatures promote spread of pests and diseases (black sigatoka, fusarium)
- Damage by tropical cyclones

Expected main climate change impacts:

- Occurrence of heatwaves
- Occurrence of dry periods
- Occurrence and magnitude of tropical cyclones

4.2.2 Cocoa (*Theobroma cacao* L.)

Cocoa is highly sensitive to droughts, which affect both its growth and yield (Carr and Lockwood 2011; Läderach et al. 2013). Most cocoa is produced in a rather limited area (Ghana and the Ivory Coast), where the genetic diversity of cocoa is small, thus increasing the vulnerability to future climate change (Zhang and Motilal 2016). Future cocoa production is assumed to be impacted mostly by increases in potential evapotranspiration (PET) and consequent plant water demand, as well as decreases in precipitation and increases in temperature (Läderach et al. 2013; Schroth et al. 2016).

Precipitation has been identified as the main factor for cocoa yield, with water limitations leading to up to more than 50% yield gaps (Zuidema et al. 2005). Long dry periods have additionally been observed to increase the mortality of cocoa seedlings (Kassin et al. 2008). Although cocoa, at current conditions, does not seem to be influenced by high temperatures at the same extent as by water availability, this might change in the future. Cocoa photosynthesis decreases in case of exceeding the threshold of optimal temperatures, limiting plant growth (Almeida and Valle 2007). Moreover, substantial increases in maximum temperatures are projected in the main cocoa production regions – such temperatures are currently not experienced within the current range of cocoa, and are also assumed to influence future cocoa production, distribution and water demand through higher PET (Ruf, Schroth, and Doffangui 2015; Schroth et al. 2016; Zuidema et al. 2005). Looking at future maximum temperatures is therefore also necessary, particularly in connection with drought (e.g. max. temperatures in dry periods). Additionally, cocoa plants are sensitive to waterlogging, especially in the juvenile stage (De Almeida, Tezara, and Herrera 2016). Waterlogging decreases yields, or can lead to plant death due to damaged leaves and roots after longer periods of flooding (Bertolde et al. 2012).

The main cocoa producing region of West Africa is also an area with relatively long dry seasons compared to other cocoa producing regions (Wood and Lass 2008). This area has experienced considerable drying of the climate in the recent decades, both in the marginal cocoa production areas in the fringes of the West African Savannah, as well as in the forest zone (Kotir 2011; Ruf, Schroth, and Doffangui 2015). This has resulted in areas becoming unsuitable for cocoa growing, and shifts to wetter regions, often resulting in deforestation (Adjei-Nsiah 2012; Ruf, Schroth, and Doffangui 2015).

Summary of main expected climate change impacts on Cocoa production:

- Highly sensitive to droughts, leading to higher mortality and large yield gaps
- Increased temperatures and evapotranspiration limit production due to decreased photosynthesis
- Flooding events limit growth and can lead to higher plant mortality

Expected main climate change impacts:

- Occurrence of dry periods
- Occurrence of heatwaves
- Occurrence of extreme rainfall events

4.2.3 Coffee (*Coffea arabica* L. and *Coffea canephora* P.)

Coffee has been identified as highly sensitive towards climate change, as it has a narrow climatic range (Bunn et al. 2015; DaMatta 2004). Additionally, successful introduction of adaptation measures to mitigate climate change impacts on coffee require a long period of time (DaMatta 2004). Significant reductions (up to 50%) in the global area suitable for coffee farming are projected in the coming decades (Bunn et al. 2015; Ovalle-Rivera et al. 2015). Although some regions (such as highlands in East Africa and parts of Asia) might experience an increase in suitability for coffee production, losses in production are expected in the main producing regions (e.g. Brazil and current producing regions in lowland East Africa). Future coffee production was identified to mainly be influenced by increased temperatures (Bunn et al. 2015), and less and more unpredictable rainfall with extended droughts (Schroth et al. 2009), which will affect coffee production in different ways.

Longer periods of temperatures over 30 degrees Celsius result in depressed growth and abortion of flowers (DaMatta 2004). Another important climate change effect is that it will affect the geographic distribution of pollinators. This can considerably reduce both the spatial extent of suitable areas and coffee yields (Imbach et al. 2017). Moreover, higher temperatures have been observed to result in increased incidence of pests (such as the coffee berry borer) and diseases, reducing coffee yields (Jaramillo et al. 2011; 2009).

Production of coffee could therefore be displaced to higher latitudes or elevations due to increased temperatures (Schroth et al. 2009; Zullo et al. 2011), which likely would not be enough to replace the lost production of existing areas. Additionally, this would seriously impact current producers, some of them in areas with indigenous coffee varieties, who would not be able to relocate to distant areas (Davis et al. 2012). Finally, higher temperatures lead to faster ripening of berries resulting in poorer coffee quality (Davis et al. 2012; Schroth et al. 2009; Vaast et al. 2006).

Summary of main expected climate change impacts on coffee production:

- Narrow climatic range affected by increases in temperature
- Needs predictable rainfall with no extended drought periods
- Longer periods with high temperatures depress growth and lead to flower abortion
- Periods of high temperatures result in increased incidence of pests and faster berry ripening, leading to lower yield and quality

Expected main climate change impacts:

- Occurrence of dry periods
- Occurrence of heatwaves

4.2.4 Cotton (*Gossypium ssp.*)

Fairtrade cotton is mostly grown in (semi) arid climates, and may actually benefit from increased concentrations of CO_2 in the atmosphere (Gérardeaux et al. 2013). Nevertheless, we have looked at the following potential climate change impacts on Cotton production:

- longer periods with high temperatures affect growth and lead to young bolls to abscise
- water-deficient conditions decrease photosynthetic rates

Expected main climate change impacts:

- Occurrence of dry periods
- Occurrence of heatwaves

4.2.5 Sugarcane (*Saccharum ssp.*)

Similar to cotton, CO_2 fertilization due to higher atmospheric concentrations has, in some areas, lead to offsetting the impacts of climate change, that mostly leads to higher irrigation demands (Knox et al. 2010; Marin et al. 2013). Sugarcane could be impacted by more frequent flooding after extreme rainfall events (Zhao and Li 2015; Biggs et al. 2013).

We have looked at the following main expected climate change impacts on Sugarcane production:

- Higher temperatures lead to crop damage (irrigation not always successful)
- Longer droughts negatively impact yields
- Tropical cyclones negatively impact yields
- Flooding negatively impacts yields

Expected main climate change impacts:

- Occurrence of dry periods
- Occurrence of heatwaves
- Tropical cyclone occurrence
- Heavy precipitation days

4.2.6 Tea (*Camellia sinensis* L.)

Being a perennial plant that can be harvested in different seasons within a single year, tea is highly vulnerable to changes in climate throughout the year. Climate change is already affecting the geographic range suitable for tea production, as well as yields. It will mostly be affected with decreased and changed pattern of precipitation and increased temperature (Ahmed et al. 2014; CIAT DAPA 2011).

Changes to seasonal variability have a significant effect on tea growth and quality, particularly dry periods in the spring and periods with high precipitation in the harvest period (especially in south Asia). Increased precipitation between dry and wet periods negatively affect the quality of the crop, particularly, as this can be the season when high quality tea is primarily produced (CCP FAO 2016). More frequent weather extremes, such as droughts and increased precipitation, affect growth (Ahmed et al. 2014). Looking at changes to precipitation in both the wet and dry periods is therefore important. Additionally, warmer temperatures on a monthly basis have been observed to lead to lower yields (Duncan et al. 2016).

Climate change affects tea quality by altering the concentration of stimulants and other properties (Lin et al. 2003). As these are heavily influenced by the geographic location (including elevation, soil and shade conditions), shifting production to other areas or higher altitudes due to climate change could result in decreased quality and taste of tea (Ahmed et al. 2013; Han et al. 2017; Lin et al. 2003). Increases in number of harvests in a single year have been observed due to warmer temperatures. However, this has also been reported to affect tea quality, as tea plants are usually dormant in periods with colder temperatures (Ahmed et al. 2014; Jeyaramraja et al. 2003).

Summary of main expected climate change impacts on Tea production:

- Longer dry periods negatively affect growth and quality
- Extreme rainfall events can affect growth and quality
- Periods of higher temperatures can lead to lower yields

Expected main climate change impacts:

- Occurrence of dry periods
- Occurrence of extreme rainfall events
- Occurrence of heatwaves

4.3 Climate change impact indicators

Below we present a summary of climate variables that have been identified to influence the distribution of the main Fairtrade commodities, based on our review. Average changes to temperature or rainfall to look at changes to heatwaves and drought as used in most assessments are not a good indicator of the climate change risks as perceived by the farmers. Therefore, risk of heatwaves, droughts and other extreme event occurrence under future climates is likely a more realistic indicator.

We collected data on agroclimatic indicators that can serve as suitable indicators for such risks and are commonly used to describe plant-climate interactions. Agroclimatic indicators are often used to characterize climate variability and change to climate indicators necessary to identify impacts on the agricultural sector (Nobakht et al. 2019). Where possible, we collected data on future climate change scenarios for two climate scenarios (RCP4.5 and RCP8.5), for a period around the year 2050. We chose those two scenarios, because they present a range from a very likely current trajectory (RCP4.5) to an extreme scenarios with high emissions and expected high impacts (RCP8.5).

We considered the latest Representative Concentration Pathways (RCP) scenarios when looking at future climate change. Two scenarios were studied: RCP4.5 and RCP8.5. RCP4.5 presents a future, where greenhouse gas emissions and consequent radiative forcing stabilizes in the year 2100, and is therefore a mitigation scenario (Thomson et al. 2011). RCP8.5 on the other hand, presents a future, where greenhouse gas emissions remain high due to absence of climate change mitigation policies (Riahi et al. 2011). Both result in different climate change impacts and are therefore suitable to explore a spectrum of potential consequences on crops that ranges from medium to extreme.

4.3.1 Consecutive dry days

To look at changes to dry periods and potential droughts, we chose the indicator 'maximum consecutive dry days'. This indicator is suitable when monitoring droughts and provides a number of days where the daily precipitation is below 1mm. An increase in consecutive dry days would not necessarily mean an increase in droughts, as it describes meteorological drought (a deficiency of rainfall, (Palmer 1965; Mishra and Singh 2010)). Other drought indices, such as looking at the hydrological drought (affecting irrigation, (van Loon 2015)), or agricultural drought (looking at soil moisture (Panu and Sharma 2002; Martínez-Fernández et al. 2016) could also be used. However, data on future projections on these indices is not available. Nevertheless, looking at consecutive dry days is suitable, when trying to identify hotspot areas, where farmers need to adapt their practices to potential future climate change. Most importantly, rainfall deficient days have been identified as one of the most important climate change effects as perceived by farmers across the globe (for example, Simelton et al. 2013; Osbahr et al. 2011; Dhaka, Chayal, and Poonia 2012; Biazin and Sterk 2013).

4.3.2 Warm spell duration index

There is no single definition of what constitutes a heatwave, particularly as the effects of (extremely) warm consecutive days are different on the natural and built environment, humans and agriculture

(Perkins, Alexander, and Nairn 2012). We therefore looked at the Warm Spell Duration Index (WSDI) as an indicator for heatwaves (periods with extremely high temperatures). Particularly, we looked at changes to maximum daily temperatures, a common indicator on the occurrence of heat stress (Caesar, Alexander, and Vose 2006; Perkins, Alexander, and Nairn 2012). The WSDI measures any consecutive period of days greater than six in which the maximum daily temperature is higher than the 90th percentile of the maximum daily temperature of the period 1981-2010. Such temperature extremes can lead to crop damage, for which irrigation or shading can be used to adapt (in the case of coffee for example).

4.3.3 Extreme rainfall events

Here, we looked at events with excess precipitation, that could result in for example water-logging and damage to crops. We looked at heavy precipitation days, which describe the number of days where the daily precipitation is over 10mm. This indicator provides information on crop damage and runoff losses. Excess precipitation could result in increased soil erosion, higher incidence of pests and diseases in some crops, or overall reduced yields and quality. Additionally, the indicator presents information on events, where crops and farmer's infrastructure could be damaged more, as we assume that in this case roots and above ground parts of plants could be flooded for a longer period.

4.3.4 Data on present and future climate conditions

For maximum consecutive dry days, warm spell duration index and heavy precipitation days, we used climate projections from the Copernicus Climate Change Service (ECMWF 2019). For the current situation, we calculated the average values for the period between 1981-2010 (average amount of days for each respective indicator). For the future, we calculated the average for the years 2041-2070, using projections from five global climate models (Table 2). We calculated means of all models for both scenarios (RCP 4.5 and RCP8.5) to reduce the uncertainties related to using only one model. We then looked at how each variable might change, on average, in the future, by comparing future projections with the current situation.

Table 2 Overview of the considered climate models. Outputs for all agroclimatic indicators for both climate scenarios (RCP4.5 and RCP8.5), were averaged to derive one single indicator on potential climate change impact.

Climate model	Source
MIROC-ESM-CHEM	JAMSTEC, Japan
HadGEM2-ES	UK Met Office, UK
IPSL-CM5A-LR	IPSL, France
GFDL-ESM2M	NOAA, USA
NorESM1-M	NCC, Norway

4.3.5 Tropical cyclones

We looked at which areas are expected to experience increased occurrence and magnitude of tropical cyclones in the future. Such events of high wind speeds and extreme rainfall, can lead to direct damages to crops and post-event damage due to extensive flooding, both considerably impacting producers and the wide supply chain, as has been demonstrated in the case of banana production (Beer, Abbs, and Alves 2014). Due to inaccessible data on future projections on the occurrence and magnitude of tropical cyclones, we looked at peer-reviewed studies on potential future trends. We particularly looked at modeling studies, from which we could identify areas where increases in tropical cyclones are projected.

4.3.6 Depleted water basins

Besides looking at the evidence of climate change impacts, for two crops (cotton and sugarcane) we also looked at which producers are situated in depleted water basins. Cotton and sugarcane are often grown in dry (sugarcane) or even arid conditions (cotton) where they are irrigated. Some locations of producers suggest that they might be located in depleted water basins, where future climate change might not allow for sustaining production with irrigation. We used data on depleted water basins (Brauman et al. 2016) to identify the locations of such producers for these two crops. Using GIS, we identified producers present in such depleted water basins.

4.4 Mapping Fairtrade producers

We received data on Fairtrade producers for the years 2014-2017 from Fairtrade International. The data had information on the location of the producer or producers' organization (address), type and volume of crops being produced, and the number of producers. This enabled us to identify the hotspots in terms of produced volume and number of farmers affected. Not all addresses consisted of a street name and house number. In some countries (e.g. West Africa), often only a postcode is reported, and in several Latin American countries, the locations are descriptive (e.g. next to the church in the village). This means that not all addresses were possible to identify automatically.

In our subsequent analysis, we, however, did not work with exact locations, but rather used a radius of 20km around the identified location, for several reasons. Therefore, identifying the settlements was our priority. First, due to privacy concerns, we did not want to identify each individual producer. Secondly, a considerable share of addresses did not contain sufficient information to be identified exactly but allowed placing the certificate to a settlement or adequate subnational unit (e.g. municipality). Third, after consultation with Fairtrade, the 20km radius choice was confirmed, as often the certificate presents only the location where the producer's association is, and the producers actually come from the vicinity (neighboring villages). Finally, climate data is available on a much coarser resolution, and in order to work with them, operating on a less detailed resolution is necessary.

For addresses where automatic identification was possible, we used different online tools. First, we used Google Maps (Google 2019), as it presents the most detailed collection of addresses worldwide. To complement Google Maps, we also used Bing Maps (Microsoft 2019). For addresses that were not identified automatically by Google Maps or Bing Maps (even after modifying the addresses), we manually located the settlement using internet search engines, and subsequently locating the settlements and coordinates in Google Maps.

In total, information on the location is available for 1398 producer organizations (consisting of numerous producers and workers, Table 3). Fortunately, only for a few producer organizations (19), addresses could not be geolocated (there was no address, the address was unclear or could not be found). For the rest, we could use the addresses, or we had to modify the information so we could use it in geolocating. For example, some addresses had descriptions that had to be removed from the address (e.g. close to the church), the address was in partly in a different language (e.g. partly in Spanish and English), the settlement name was spelled differently than recognized by google (common in West African countries), or there was a spelling error in the address.

Table 3 Summary of the geolocation procedure of Fairtrade producers

Availability of address	Count	Share (%)
Exact location identified.	257	18.4
Exact location identified, but in a large city	78	5.6
Location is in the radius of 20km	1044	74.7
Cannot be used (no or unclear address, address not found)	19	1.4

In the image below (Figure 4), we can see the spatial distribution of Fairtrade producers of banana, cocoa, coffee, cotton, sugarcane and tea.

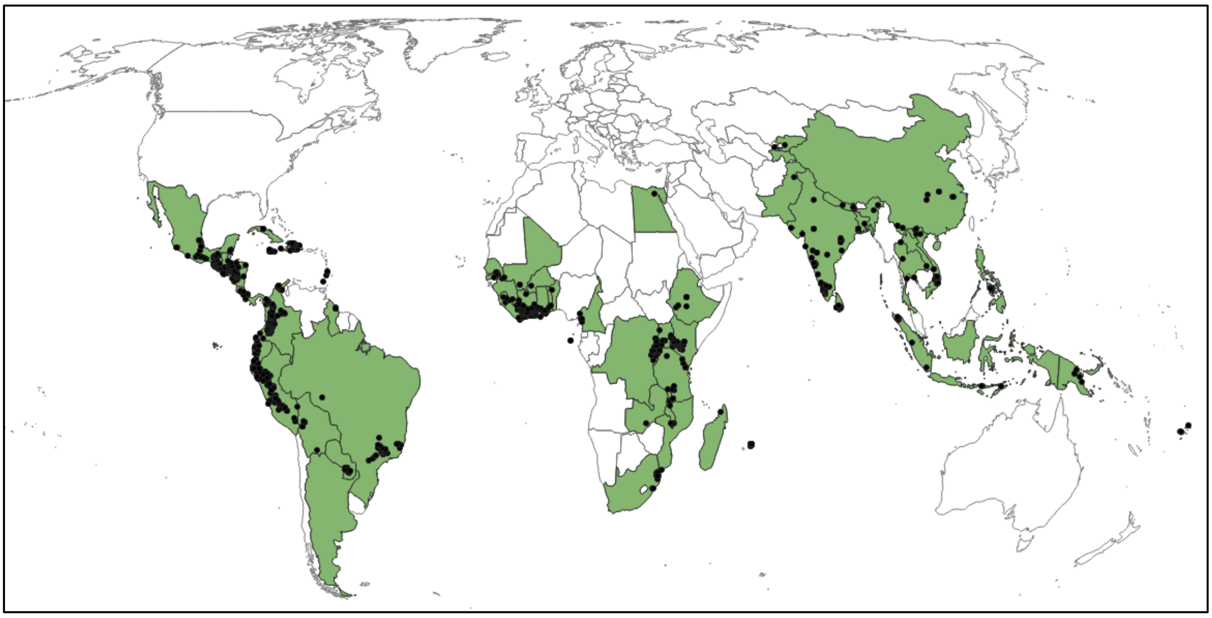


Figure 4 Locations of 1379 Fairtrade producing organizations of the selected crops (black dots), and all countries where the selected crops are produced. Locations per crop type are shown in the following images on climate change impacts.

4.5 Results: Climate change impacts

Below, we present the identified climate change impacts per crop and impact. Detailed high-resolution maps and impacts per country and region are available in the Annex.

4.5.1 Banana producers

Warm spell duration index

On average, areas where Fairtrade bananas are produced will have 7.5 fewer days where the temperature is higher than the 90th percentile of the observed temperatures in the period 1980-2010 under the RCP4.5 scenario. Under the more extreme RCP8.5 scenario, however, these areas will on average experience 42.1 more days with extremely high temperatures, which is considerably more. We observe large differences among the banana producing regions (Figures 5 and 6). Particularly worrisome are the trends in Caribbean and Central American countries. While on average, the whole region will not be impacted in the same extent as other regions, the highest increases in WSDI are observed in individual countries in this region (seen by the outlier points in Figure 5).

Areas with increases in warm days across both scenarios are the following:

- Caribbean and Central America: St. Vincent and the Grenadines, St. Lucia, Nicaragua
- South America: Ecuador and northern Peru in South America,
- West Africa: Ivory Coast
- South and East Asia: Sri Lanka

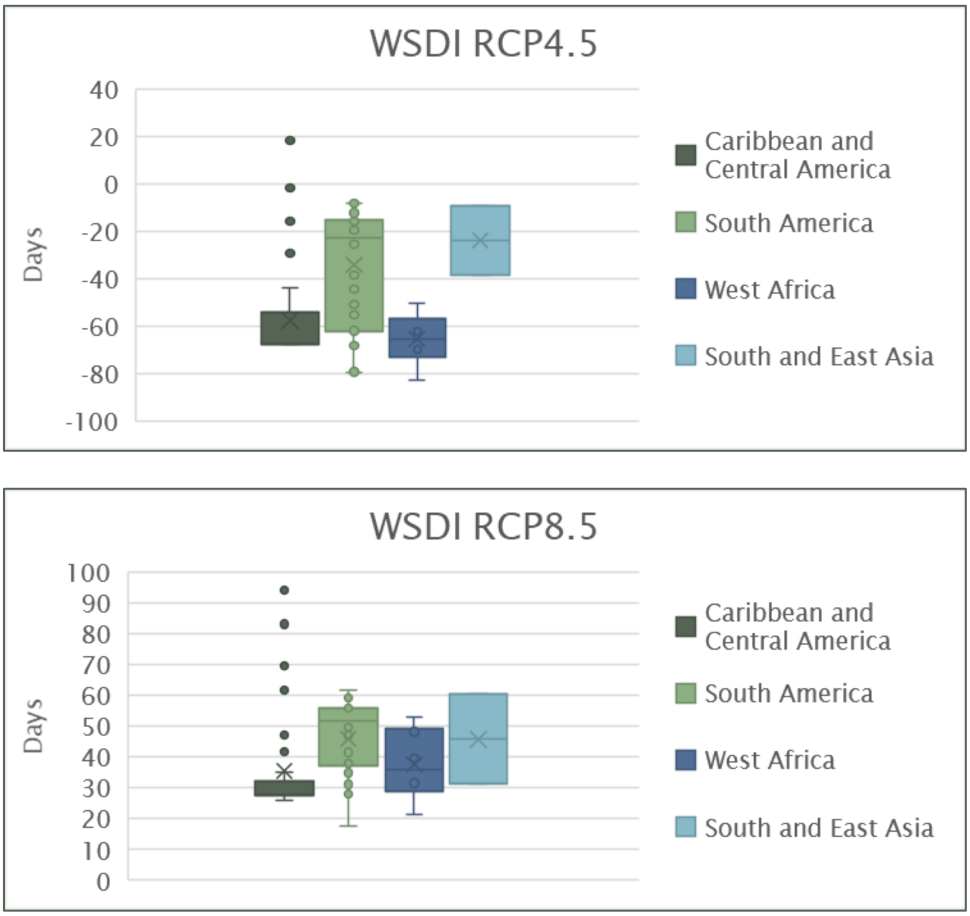


Figure 5 Changes to the Warm Spell Duration Index in different banana producing regions.

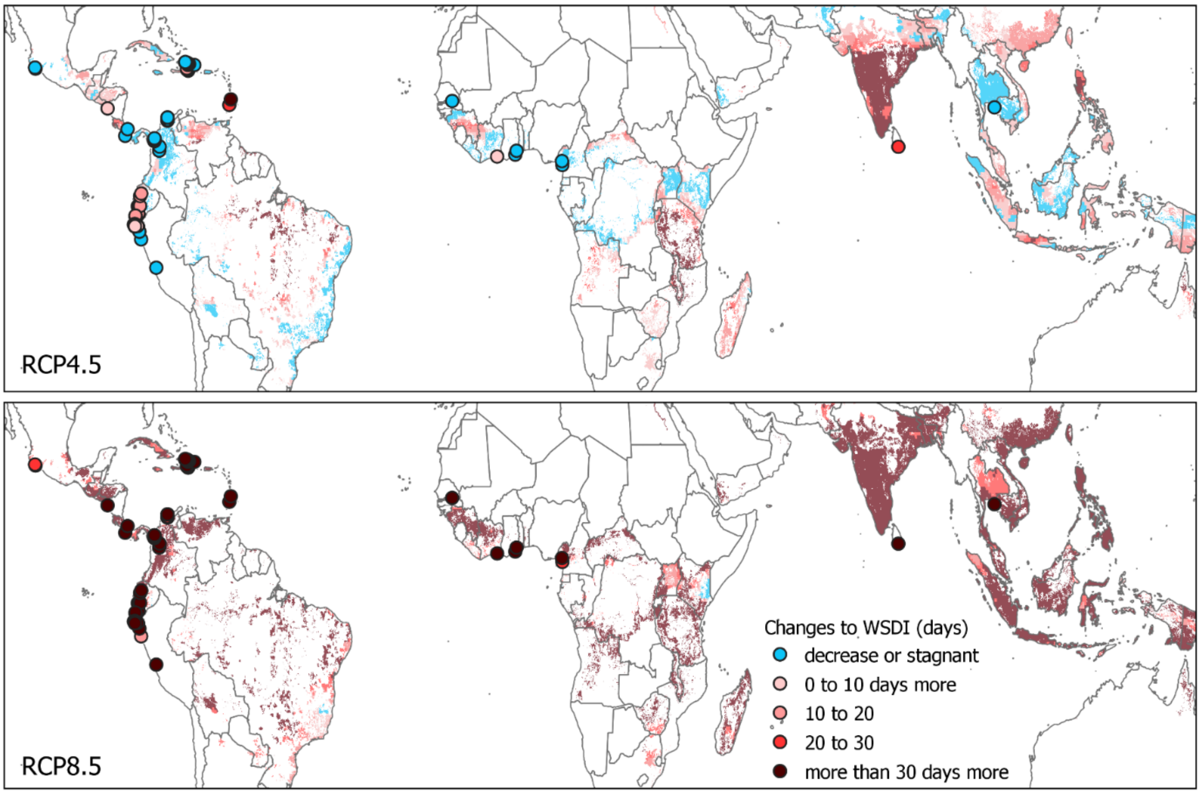


Figure 6 Changes to the warm spell duration index (WSDI, in days) in banana producing regions (surfaces) and Fairtrade banana producers (points)

Consecutive dry days

Under both scenarios, areas where Fairtrade bananas are produced will experience fewer consecutive dry days. Nevertheless, in several other banana producing regions the climate in the future will be defined by more consecutive dry days, and we observe large variation between different regions when it comes to CDD and banana producing regions. For example, the Caribbean and Central American Region, one of the most important banana producing regions, will experience considerably more dry periods, and also has countries that will experience largest impacts in terms of dry periods (Figure 7 and 8). A region where dry periods will not be an issue under both scenarios is South and East Asia, and to some extent also South America.

Areas with increases in consecutive dry days across both scenarios are the following:

- Caribbean and Central America: Costa Rica, Dominican Republic, Mexico, St. Vincent and the Grenadines, Nicaragua
- West Africa: Ghana and Senegal

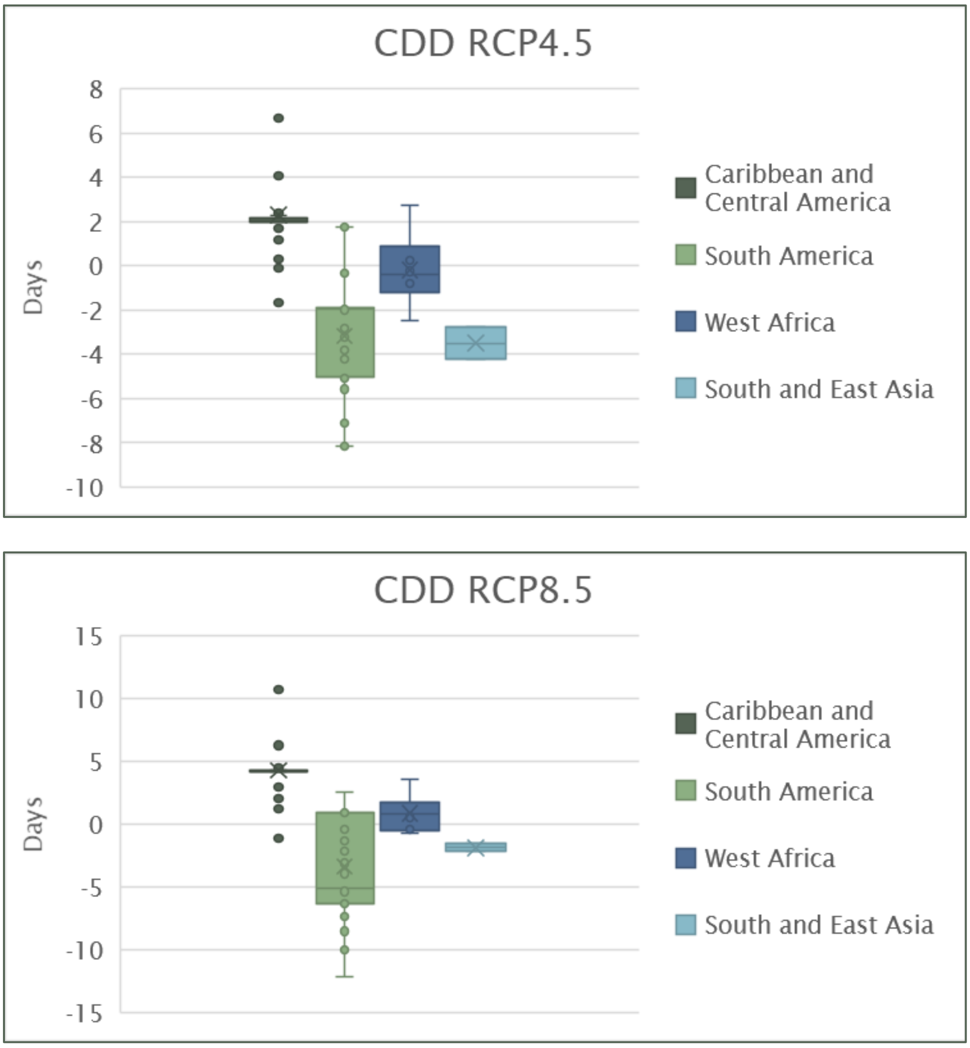


Figure 7 Changes to Consecutive Dry Days in different banana producing regions.

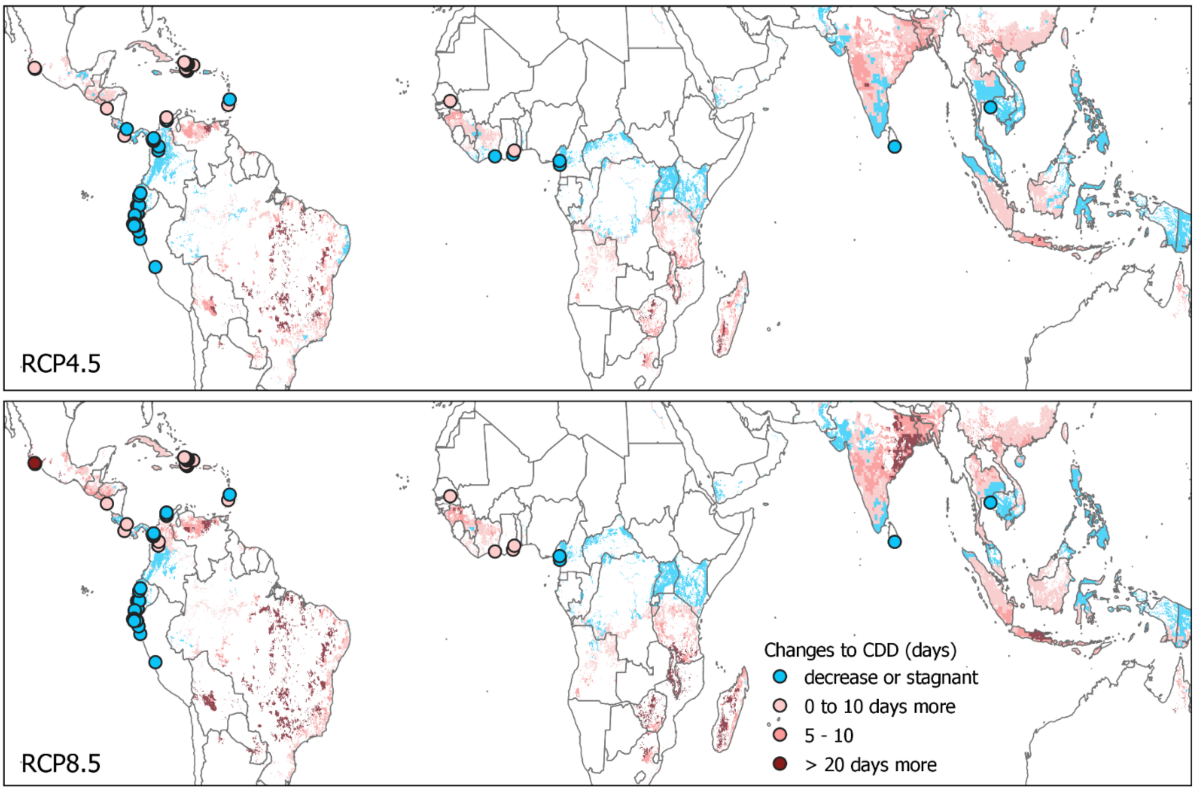


Figure 8 Changes to consecutive dry days (CDD, in days) in banana producing regions (surfaces) and Fairtrade banana producers (points).

Areas experiencing more heatwaves and droughts

Looking at areas where both the WSDI and CDD will increase, we can identify areas that will experience more days with extreme temperatures and more days without rainfall in the future (Figure 9). Under both scenarios, banana producers in the Caribbean and Central America are projected to experience this. Under RCP8.5, banana producers in West Africa are also projected to experience both considerable warming and drying.

Areas with combined increases in warm days and consecutive dry days across both scenarios are the following:

- Caribbean and Central America: Costa Rica, Dominican Republic, St. Vincent and the Grenadines, Nicaragua

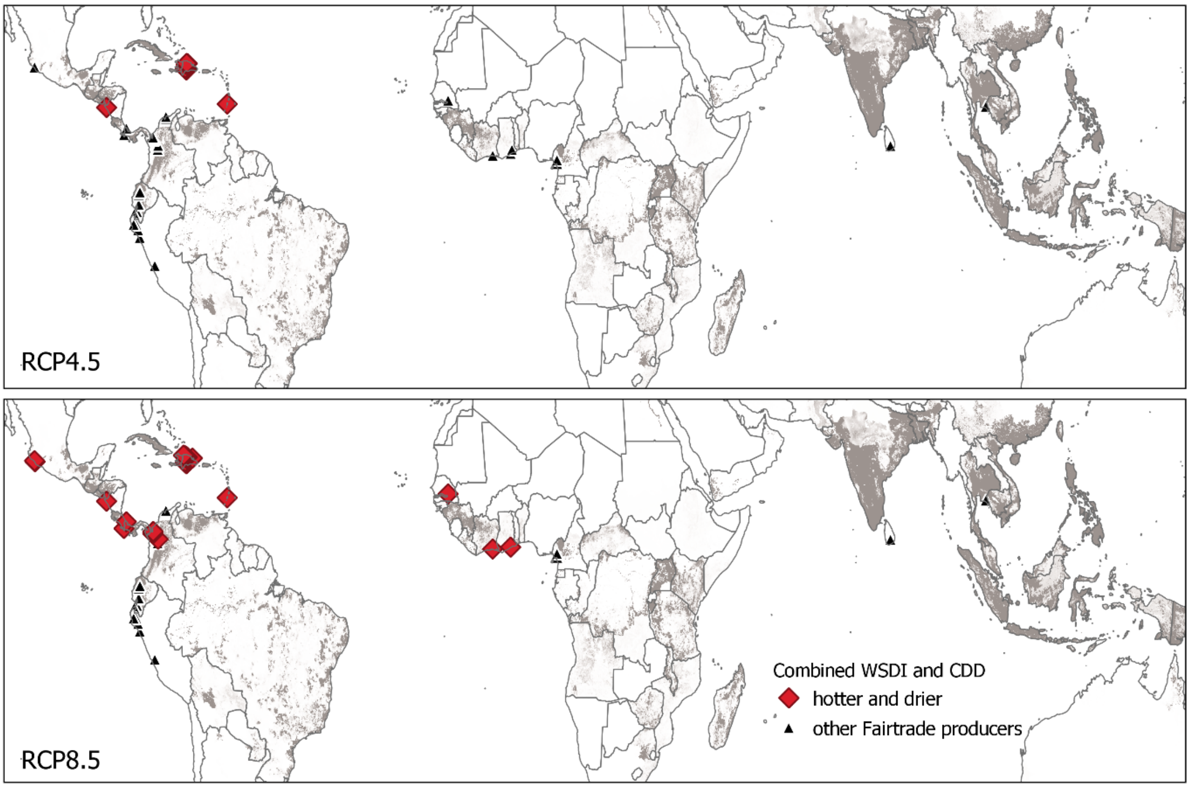


Figure 9 Identified Fairtrade banana producing areas, that will get both drier (increase in consecutive dry days) and hotter (increase in the warm spell duration index) in the future.

Tropical cyclones

Quantitatively assessing the impact of tropical cyclones on future Fairtrade banana production was unfortunately not possible. The data on future cyclones is not easily accessible, and usually also consists only of long-term projections for the period 2070-2100 for one scenario (RCP4.5). Nevertheless, trends from the latest literature (Knutson et al. 2015; Bacmeister et al. 2018) agree on increased likelihood and magnitude of tropical cyclones in Southeast Asia and Oceania (e.g. Papua New Guinea, Figures 10 and 11). The Caribbean region (island states in the Caribbean sea) might also experience an increase in tropical cyclones (Knutson et al. 2015).

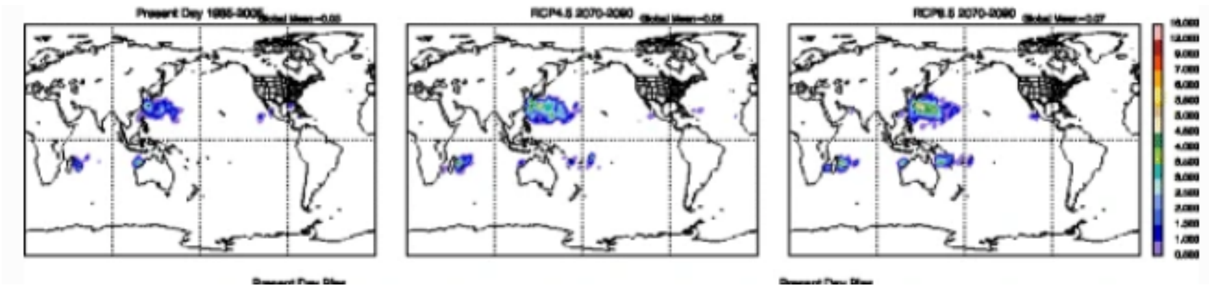


Figure 10. Extreme cyclones under the RCP4.5 scenario for the period 2070-2100 (taken from Bacmeister et al. 2018)

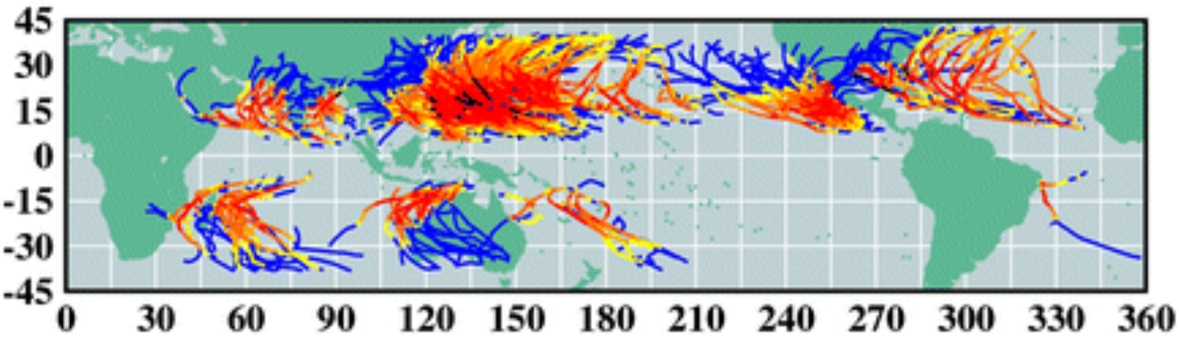


Figure 11 Extreme cyclones under the RCP4.5 scenario for the period 2081-2100, (taken from Knutson et al. 2015)

Climate change impacts hotspots based on production volume and number of producers

By considering the volume of produced banana and number of producers in each of the Fairtrade sourcing locations, we could identify hotspots based also on these two criteria (Figure 12).

Areas of significant production in terms of volume of produced banana, that will be most impacted by future heating and drying are the following:

- West Africa: Ghana
- Caribbean and Central America: Dominican Republic, St. Lucia, Panama
- South America: Colombia

In terms of the number of farmers producing banana in affected regions, the following regions will be most impacted:

- Caribbean and Central America: Dominican Republic, St. Lucia, St. Vincent and the Grenadines

These are areas, where adaptation efforts could make the biggest impact in terms of maintaining livelihoods and current banana production.

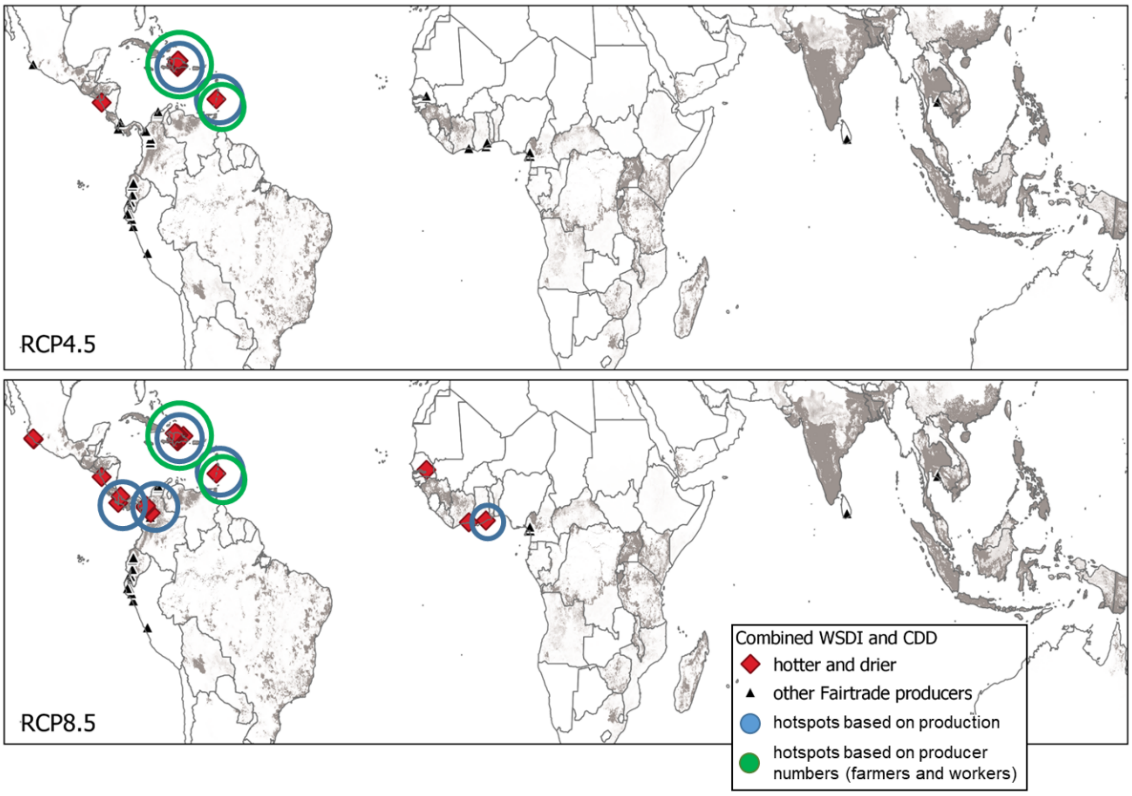


Figure 12 Hotspots of climate change impacts based on Fairtrade banana production and producer numbers

4.5.2 Cocoa producers

Warm spell duration index

A considerable portion of Fairtrade producers will experience increases in heatwaves in the future under the RCP8.5 scenario, as the majority of areas experience more than 30 additional days with extreme temperatures, and most of them over 20 more days. Under the RCP4.5 scenario, the trends are not as dramatic, as most Fairtrade cocoa producing areas are projected to experience fewer (or shorter) heatwaves. On average, Fairtrade regions will experience nearly 14 fewer warm days under the RCP4.5 scenario. We see large regional variation in WSDI for cocoa producing regions, with South and East Asia particularly standing out (Figures 13 and 14). While the main cocoa producing region of West Africa seems to be least affected by WSDI in the future, it will still experience over 20 more warm days under the RCP4.5 scenario, which presents a considerable increase compared to the current climate and could lead to necessary adaptation in cocoa production due to increased heat stress.

Areas with increases in warm days across both scenarios are the following:

- Caribbean and Central America: Belize, Honduras, Grenada, Nicaragua
- South America: Ecuador, north of Peru, Bolivia, south Colombia
- West Africa: Liberia, Sierra Leone, Sao Tome & Principe
- Central and East Africa: Uganda and Madagascar
- South and East Asia: India and Vietnam

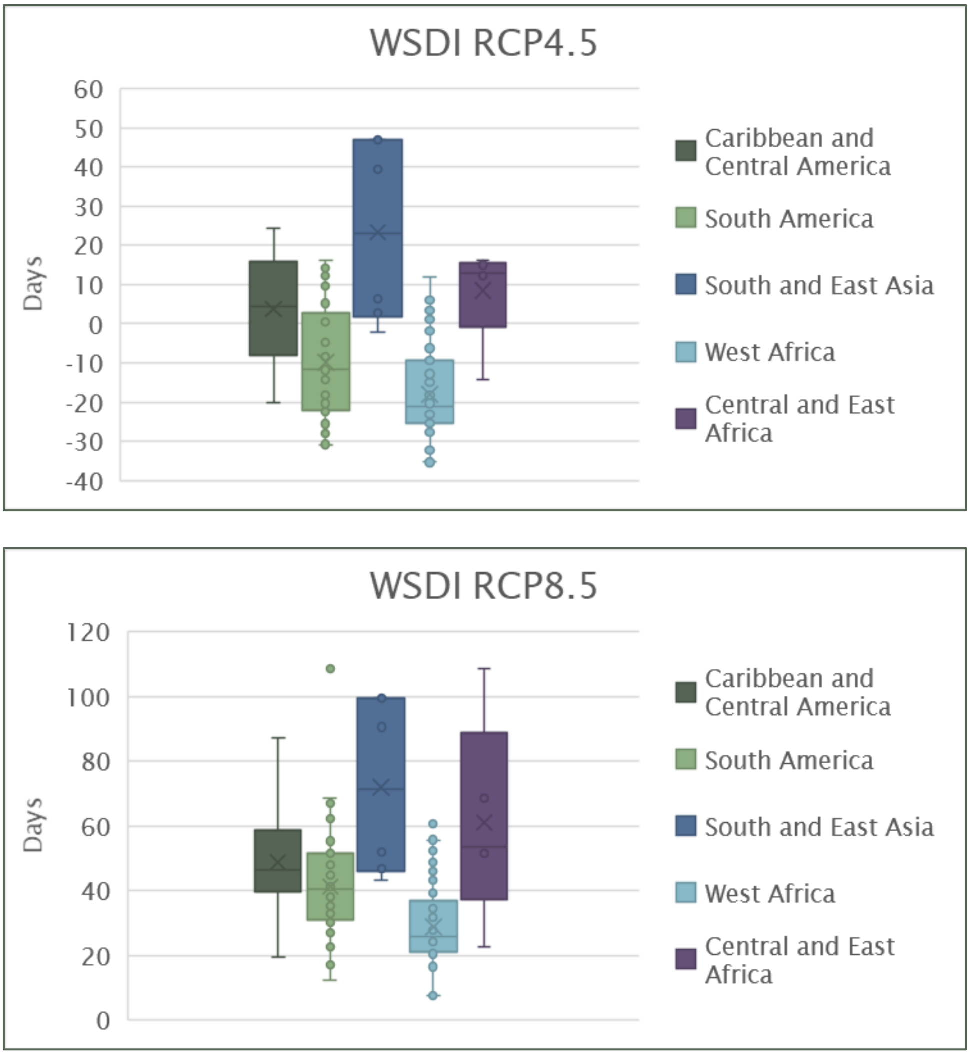


Figure 13 Changes to the Warm Spell Duration Index in different cocoa producing regions

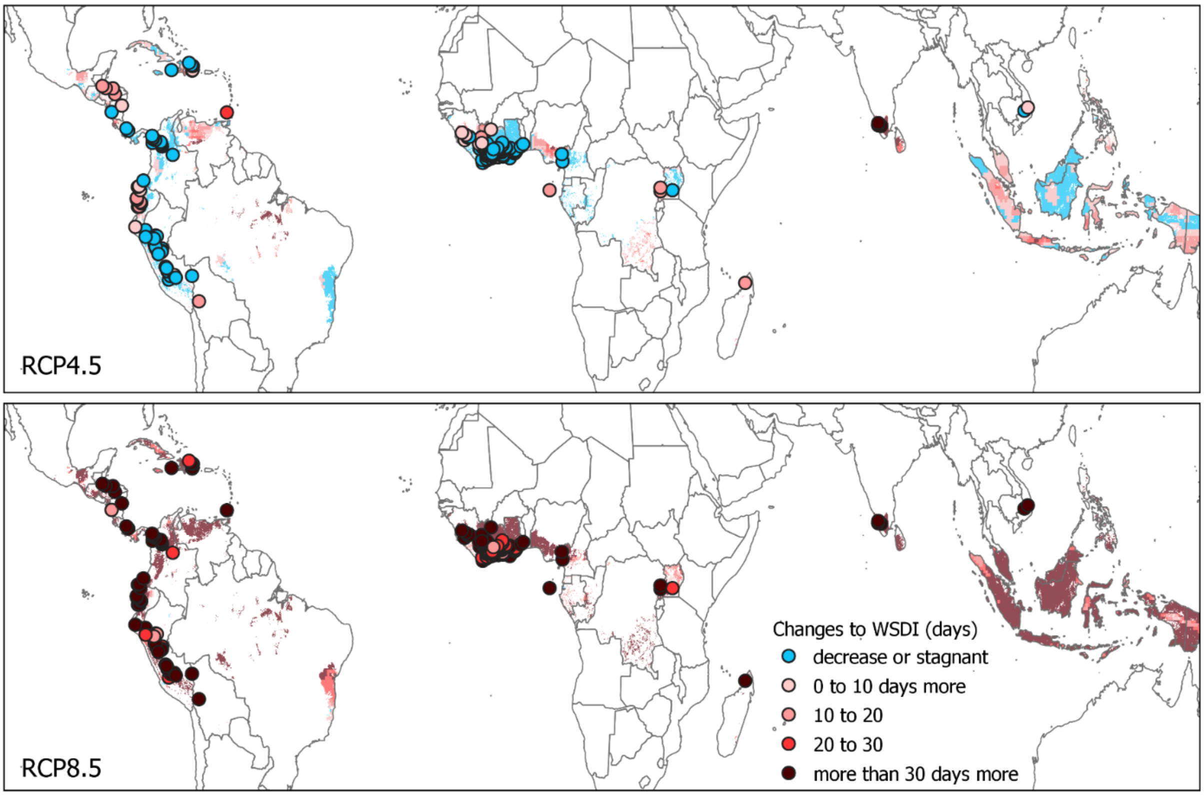


Figure 14 Changes to the warm spell duration index (WSDI, in days) in cocoa producing regions (surfaces) and Fairtrade cocoa producers (points)

Consecutive dry days

A considerable portion of Fairtrade cocoa producers is projected to experience fewer consecutive dry days. On average, areas where Fairtrade cocoa is currently produced will experience a stagnation under both scenarios (Figures 15 and 16). Nevertheless, important cocoa producing regions such as Central America and parts of Ghana and the Ivory Coast are projected to experience more consecutive days without rainfall. The Caribbean and Central America will experience on average 1-3 days longer dry periods and West Africa up to 3 days on average. However, these two regions can also experience large variations (Figure 15). The largest variation can, however, be expected in South America (Figure 15), particularly in areas that are already less humid compared to other cocoa producing areas today (Peru, Bolivia).

Areas with increases in consecutive dry days across both scenarios are the following:

- Caribbean and Central America: Belize, Dominican Republic, Haiti, Honduras, Grenada, Nicaragua, Panama and Costa Rica
- South America: western Ecuador, south of Peru, Bolivia
- West Africa: parts of Ghana and Ivory Coast, Sierra Leone, Liberia
- Central and East Africa: Madagascar

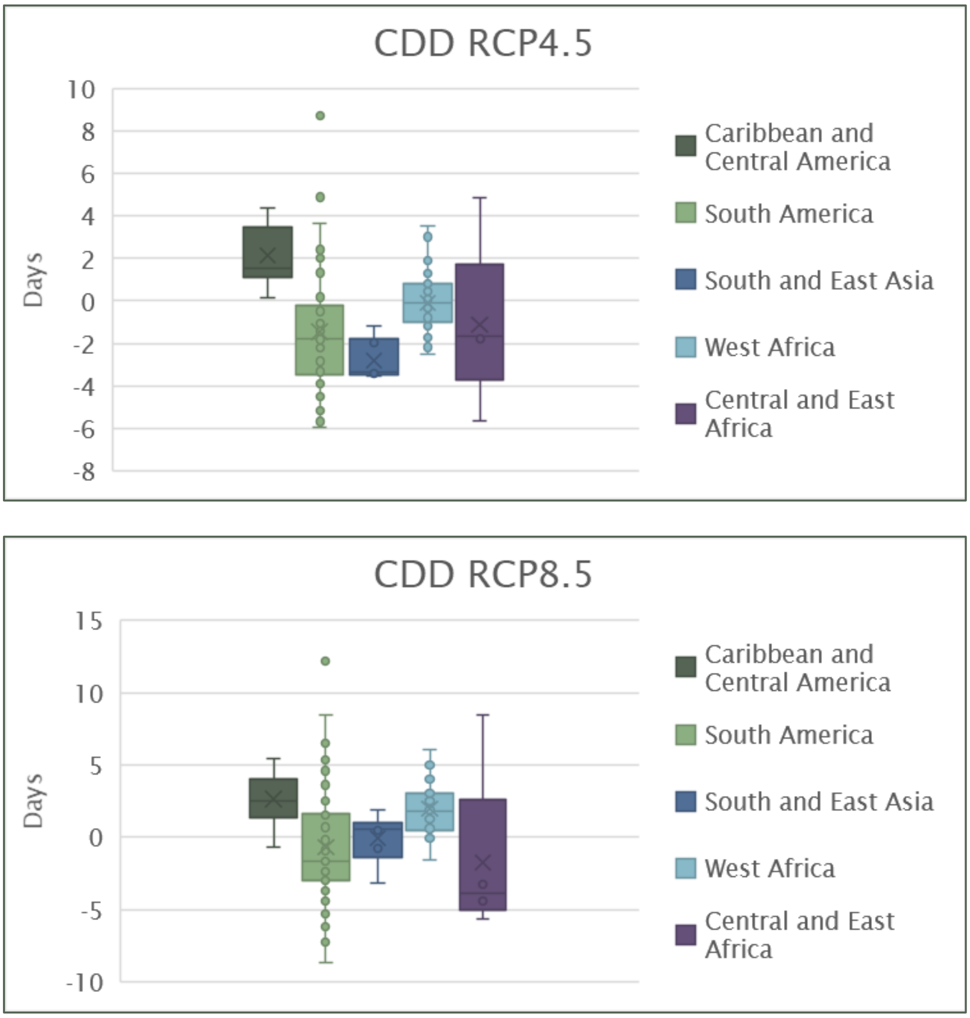


Figure 15 Changes to Consecutive Dry Days in different cocoa producing regions

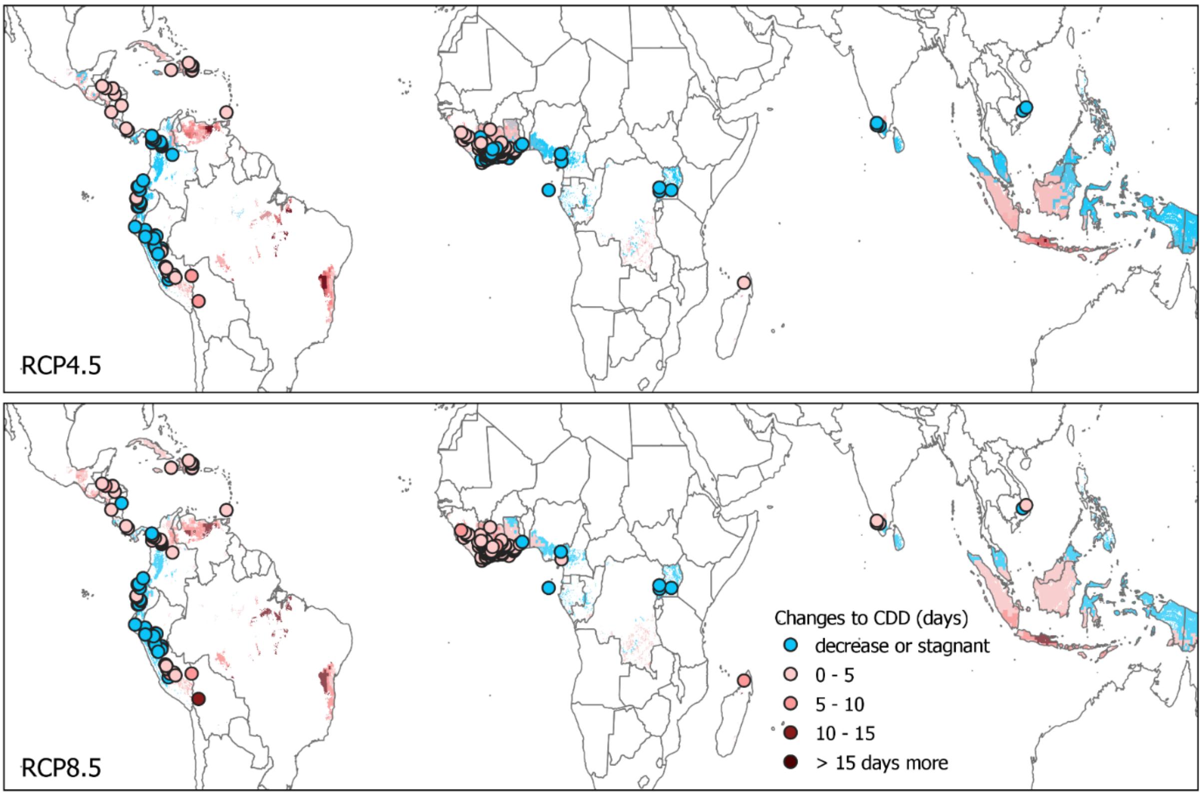


Figure 16 Changes to consecutive dry days (CDD, in days) in cocoa producing regions (surfaces) and Fairtrade cocoa producers (points)

Heavy precipitation days

When it comes to extreme precipitation, and potential water logging, we observe increases in heavy precipitation days in most of cocoa producing regions (Figures 17 and 18). Particularly in Latin America, in areas in which Fairtrade cocoa is being produced, are projected to experience more days with heavy precipitation under both scenarios.

Areas with increases in heavy precipitation days across both scenarios are the following:

- South America: Colombia, western Ecuador, central Peru
- West Africa: eastern Ghana and northern Ivory Coast
- Central and East Africa: Uganda

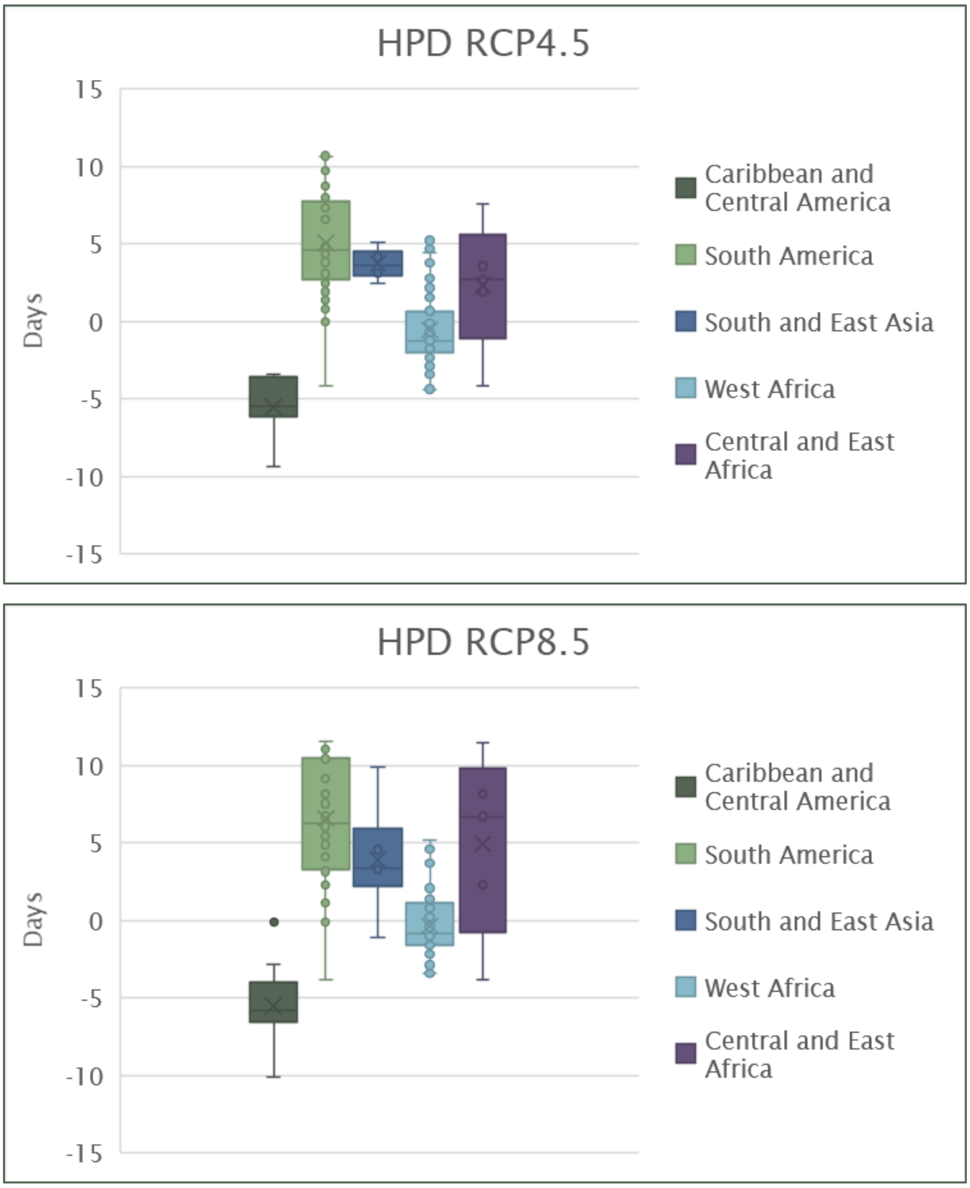


Figure 17 Changes to Heavy Precipitation Days in different cocoa producing regions

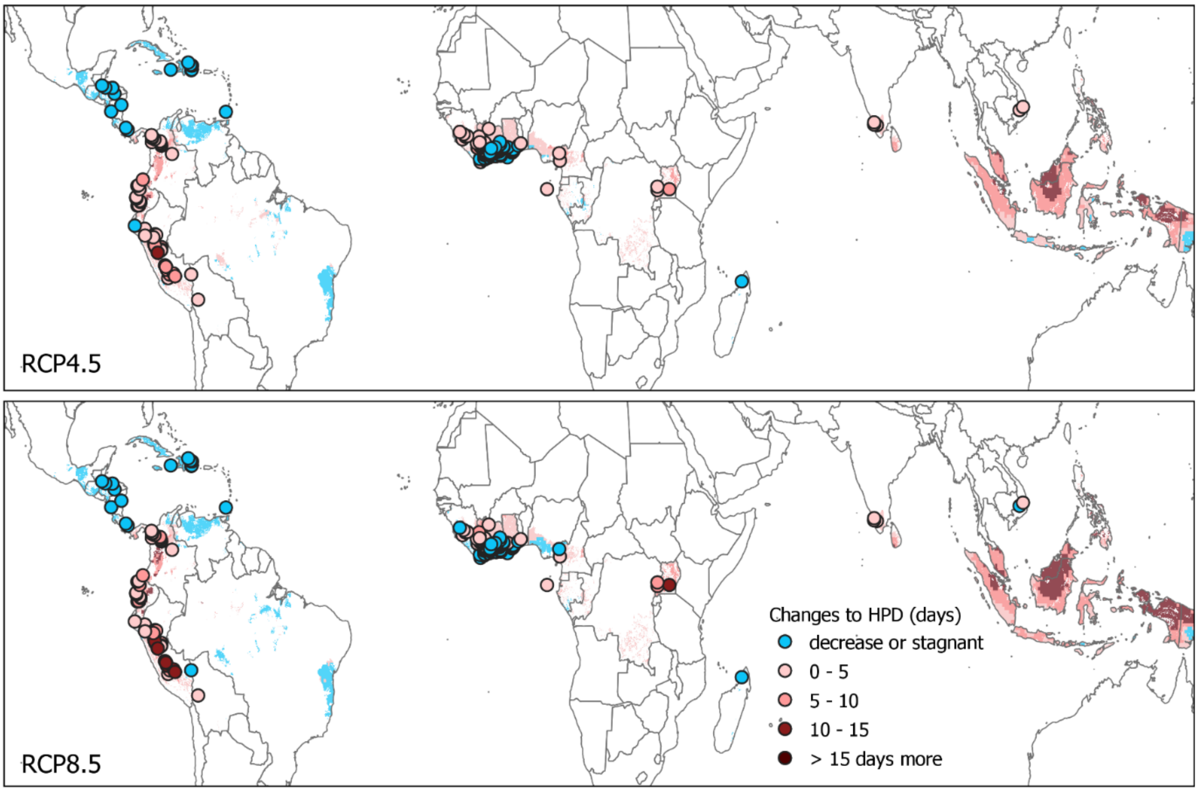


Figure 18 Changes to heavy precipitation days (HPD, in days) in cocoa producing regions (surfaces) and Fairtrade cocoa producers (points)

Areas experiencing more heatwaves and droughts

Considerable parts of current Fairtrade cocoa producing areas are projected to experience more heatwaves and days without rainfall at the same time under both scenarios: Caribbean and Central America, parts of Latin America and West Africa (Figure 19). Under RCP8.5 most of the current Fairtrade cocoa producing areas will experience both more heatwaves and drying.

Areas with combined increases in warm days and consecutive dry days across both scenarios are the following:

- Caribbean and Central America: Belize, Dominican Republic, Honduras, Grenada, Nicaragua
- South America: western Ecuador, Bolivia
- West Africa: northern parts of Ivory Coast, Sierra Leone, Liberia
- Central and East Africa: Madagascar

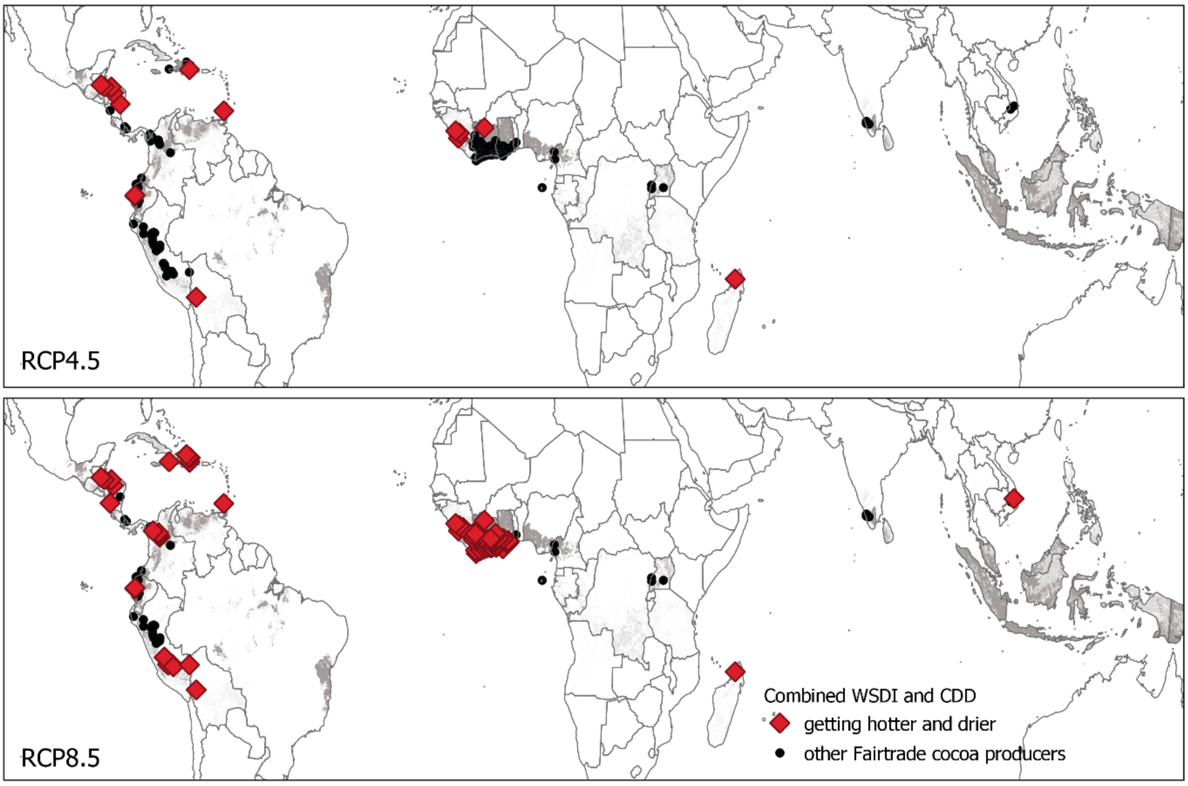


Figure 19 Identified Fairtrade cocoa producing areas, that will get both drier (increase in consecutive dry days) and hotter (increase in the warm spell duration index) in the future

Climate change impacts hotspots based on production volume and number of producers

Accounting for the volume of produced cocoa and number of cocoa producers in each of the Fairtrade sourcing locations, we could also identify hotspots based on these two criteria (Figure 20).

Areas of significant production in terms of volume of produced cocoa that will be most impacted by future heating and drying are the following:

- West Africa: Ghana and Ivory Coast
- Caribbean and Central America: Dominican Republic
- South America: central Peru

In terms of the number of farmers producing cocoa in affected regions, the following regions will be most impacted:

- West Africa: Ghana and Ivory Coast
- South East Asia: Timor Leste
- Caribbean and Central America: Dominican Republic
- South America: Brazil, southern Peru

These are areas where adaptation efforts could make the biggest impact in terms of maintaining livelihoods and cocoa production.

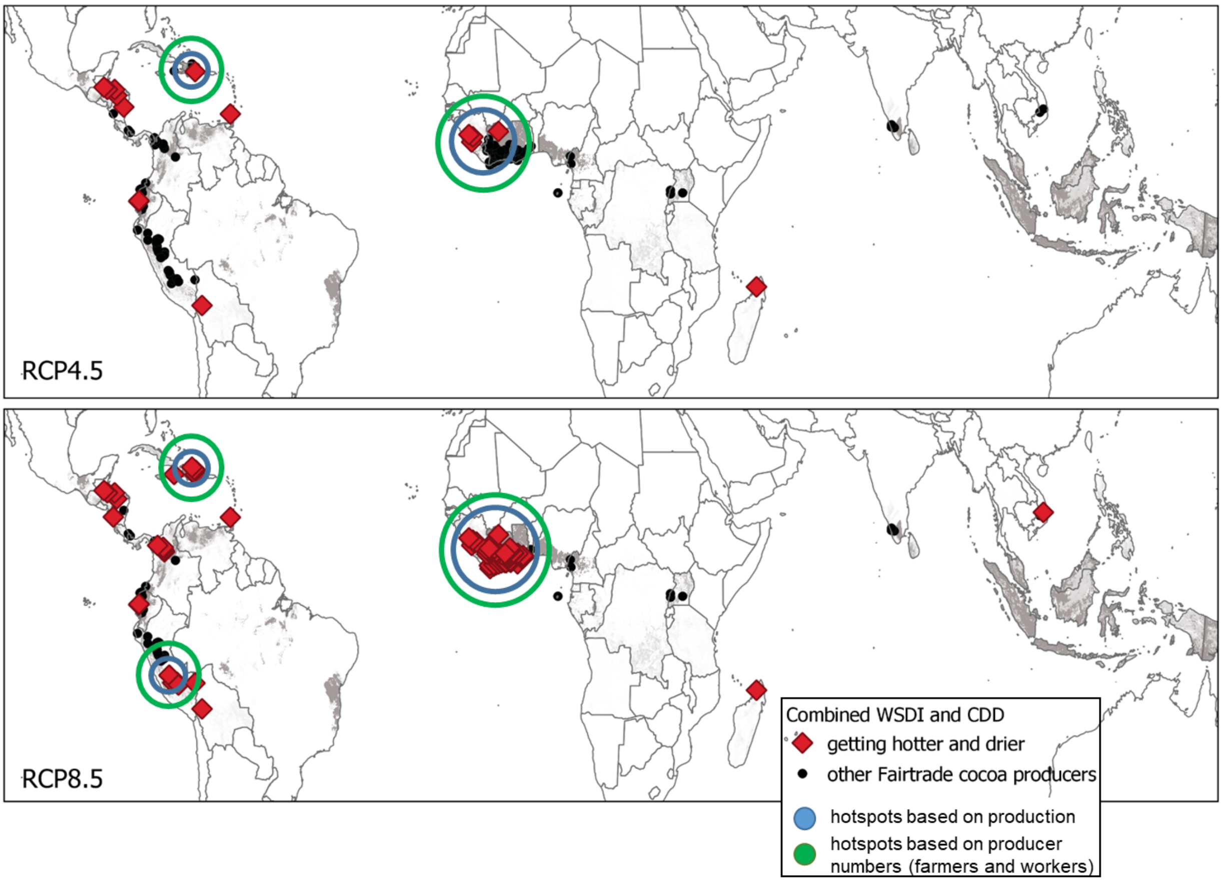


Figure 20 Hotspots of climate change impacts based on Fairtrade cocoa production and producer numbers

4.5.3 Coffee producers

Warm spell duration index

Under the RCP4.5 scenario, all Fairtrade areas will on average experience fewer warm days, mostly due to areas in South America and East Africa with fewer warm days (but large variation within the region (Figure 21)). Nevertheless, under both scenarios, these following areas are projected to experience an increase in heatwaves: India, parts of East Africa, and Central America (Figures 21 and 20). In all major regions, considerable variation of future impacts is observed in terms of WSDI. In RCP8.5, all Fairtrade coffee producers are projected to experience considerably more (more than 30 days more) days of heatwaves annually, with overall over 38 more warm days compared to today globally.

Areas with increases in warm days across both scenarios are the following:

- Caribbean and Central America: Dominican Republic, Mexico, Guatemala, EL Salvador, Honduras, Nicaragua
- South America: Ecuador, Bolivia, northern Peru and Inland Brazil
- West Africa: Guinea, Sao Tome & Principe
- Central and East Africa: Democratic Republic of Congo, southwest Ethiopia, Tanzania, Rwanda, Uganda
- South and East Asia: India, Vietnam, Indonesia

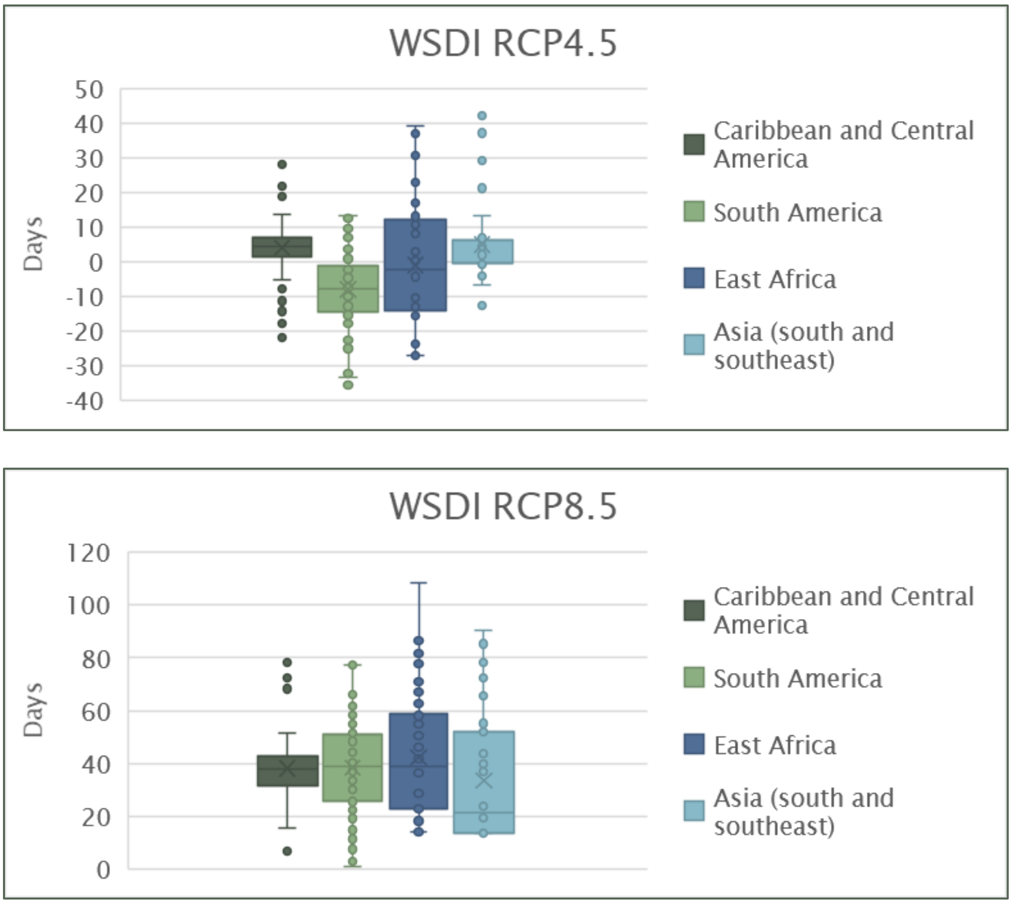


Figure 21 Changes to the Warm Spell Duration Index in different coffee producing regions

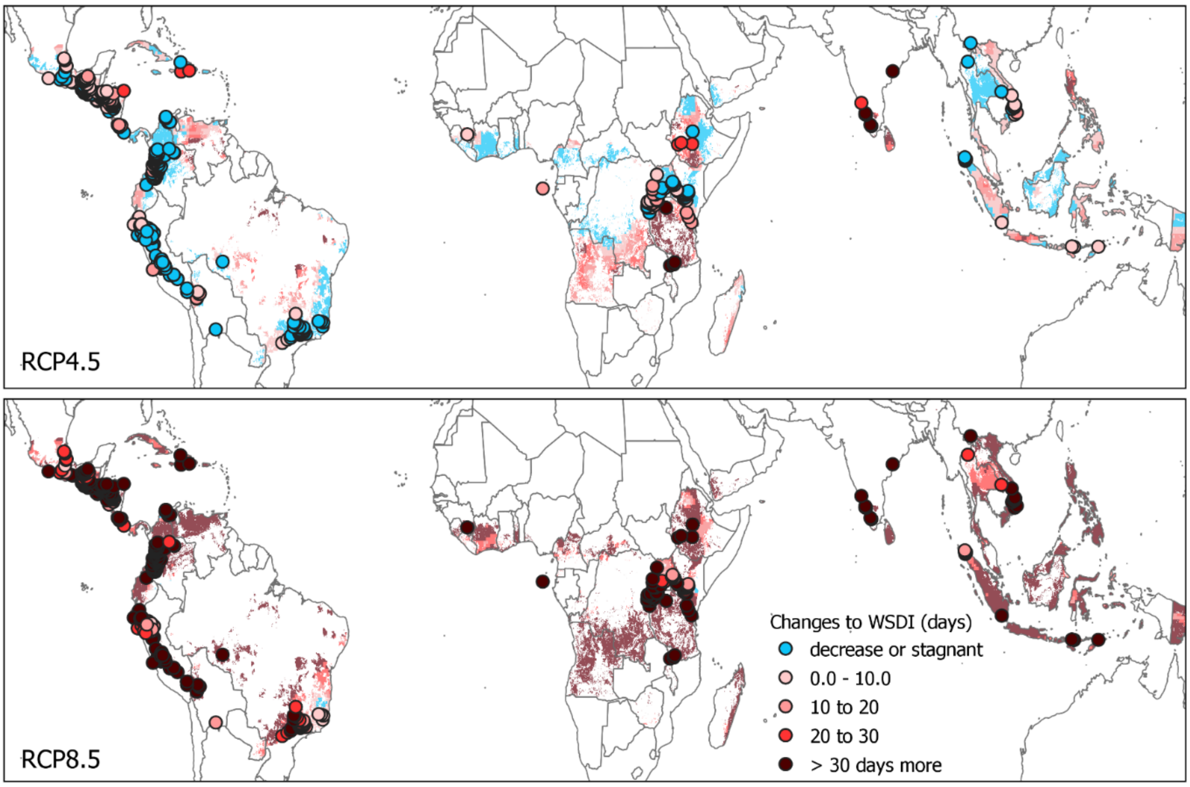


Figure 22 Changes to the warm spell duration index (WSDI, in days) in coffee producing regions (surfaces) and Fairtrade coffee producers (points).

Consecutive dry days

Projections show, that a considerable portion of current Fairtrade coffee producing areas will experience a stagnation of fewer days without rainfall under both scenarios, particularly in East Africa (Kenya and Ethiopia) and parts of South America (Colombia, Ecuador and northern Peru) (Figures 23 and 24). Still, also within such regions with overall fewer drier periods more consecutive dry days are anticipated in, for example, Tanzania and Malawi in East Africa. Nevertheless, outer parts of the tropics which are among the most important coffee producing regions, are projected to experience more dry days (Central America, Brazil, parts of South-east Asia), making it difficult to offset the losses of production in these areas.

Areas with increases in consecutive dry days across both scenarios are the following:

- Caribbean and Central America: Dominican Republic, Mexico, Guatemala, EL Salvador, Honduras, Nicaragua
- South America: Bolivia, southern Peru and Brazil
- Central and East Africa: Democratic republic of Congo, Malawi, Tanzania, Rwanda
- South and East Asia: East India, Thailand, southern China, Indonesia

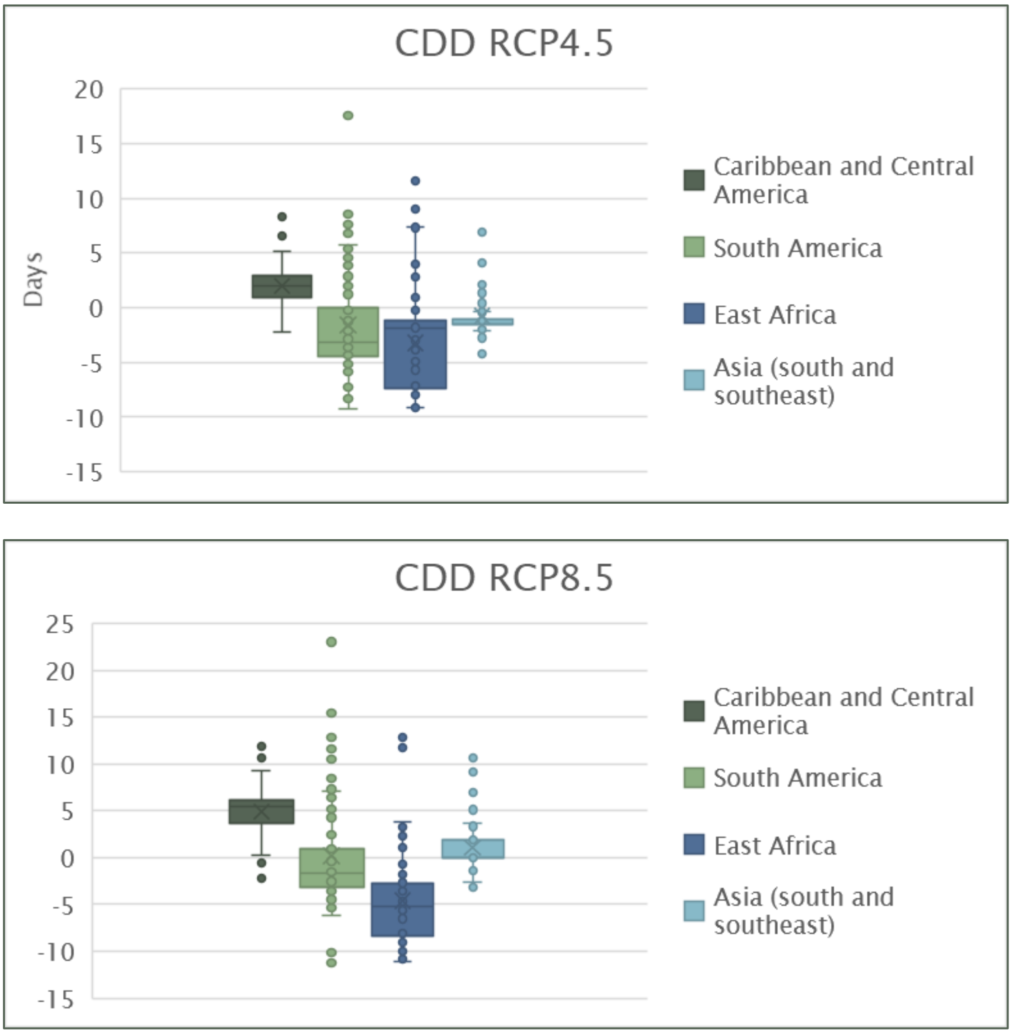


Figure 23 Changes to Consecutive Dry Days in different coffee producing regions

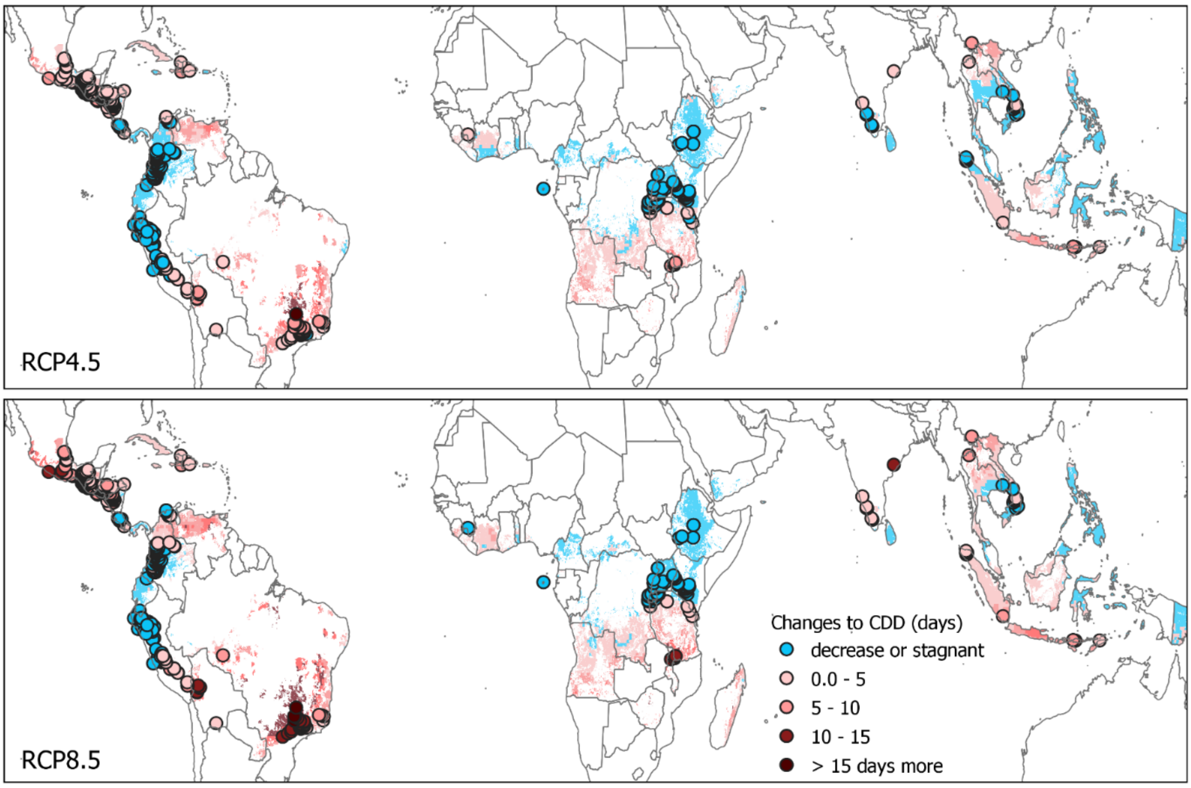


Figure 24 Changes to consecutive dry days (CDD, in days) in coffee producing regions (surfaces) and Fairtrade coffee producers (points).

Areas experiencing more heatwaves and droughts

Under both scenarios, considerable portions of the following major coffee producing areas are projected to experience both more heatwaves and days without rainfall: Caribbean and Central America, Brazil and parts of East Africa (Figure 25). The majority of Fairtrade coffee producers will experience both climate change impacts under the more extreme, RCP8.5 scenario.

Areas with combined increases in warm days and consecutive dry days across both scenarios are the following:

- Caribbean and Central America: Dominican Republic, Mexico, Guatemala, EL Salvador, Honduras, Nicaragua
- South America: Bolivia, and inland Brazil
- Central and East Africa: Democratic Republic of Congo, Malawi, South Tanzania, Rwanda
- South and East Asia: East India, Thailand, southern China, Indonesia

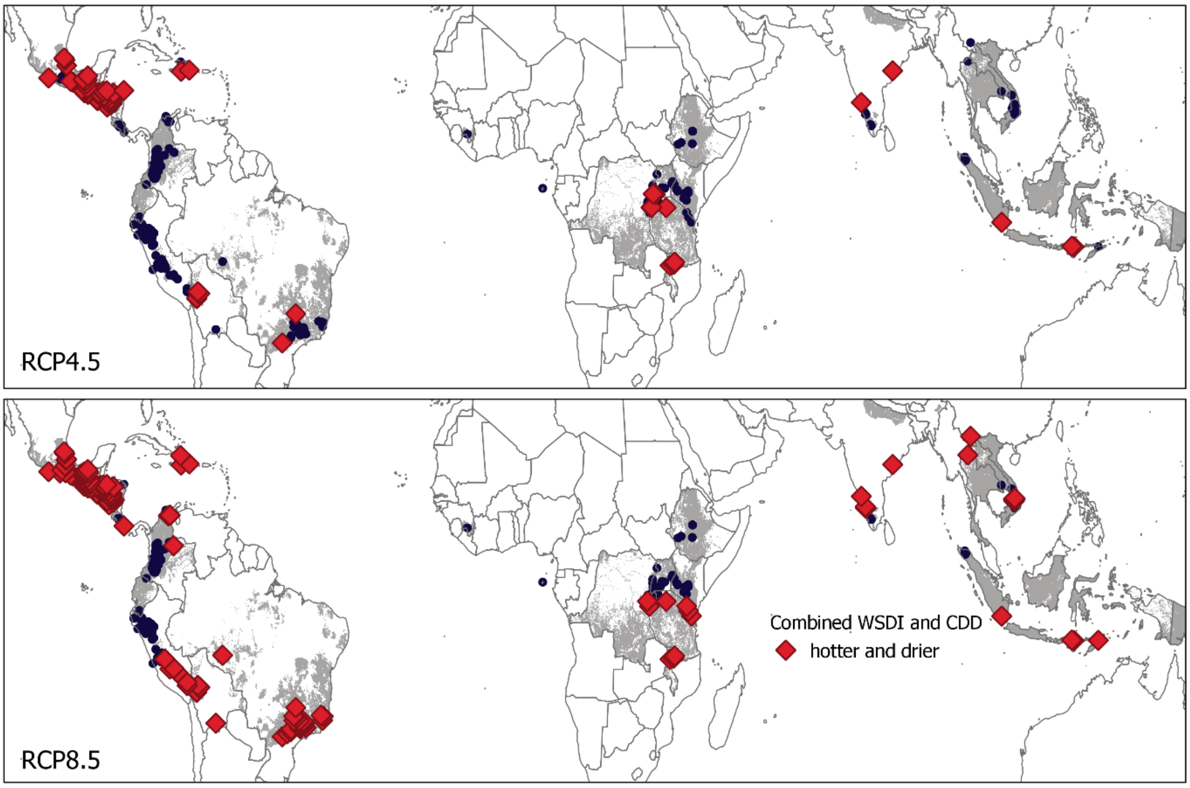


Figure 25 Identified Fairtrade coffee producing areas, that will get both drier (increase in consecutive dry days) and hotter (increase in the warm spell duration index) in the future.

Climate change impacts hotspots based on production volume and number of producers

Considering the volume of produced coffee and number of producers in each of the Fairtrade sourcing locations, we could identify hotspots based also on these two criteria (Figure 26).

Areas of significant production in terms of volume of produced coffee that will be most impacted by future heating and drying are the following:

- Caribbean and Central America: Costa Rica, Honduras, Mexico, Nicaragua,
- South America: Brazil, northern Colombia, southern Peru

In terms of the number of farmers producing coffee in affected regions, the following regions will be most impacted:

- Central and East Africa: Tanzania, Uganda
- South and South East Asia: Timor Leste, India (east and southwest India)
- Caribbean and Central America: Nicaragua
- South America: southern Peru

These are hotspots where adaptation efforts could make the biggest impact in terms of maintaining existing livelihoods and volumes of produced coffee.

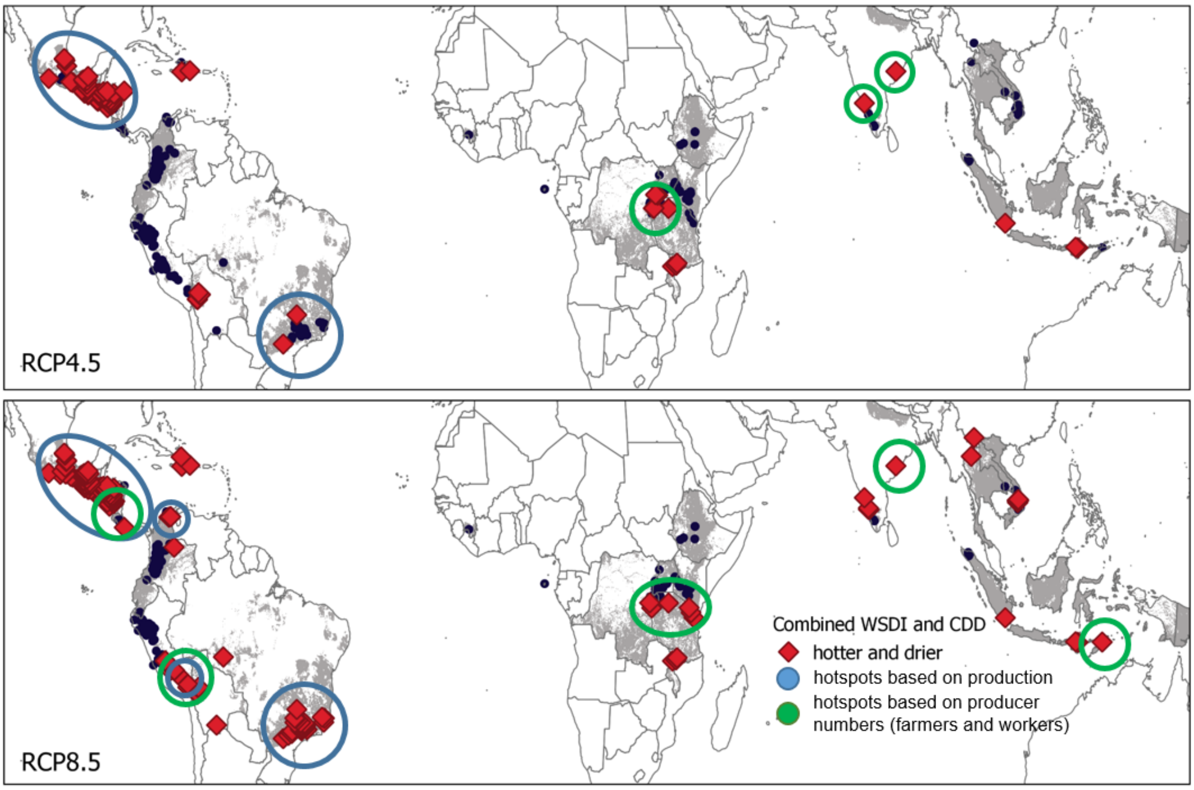


Figure 26 Hotspots of climate change impacts based on Fairtrade coffee production and producer numbers

4.5.4 Cotton producers

Consecutive dry days

We looked at where Fairtrade producers of cotton are projected to experience more dry days in the future (Figure 27). Additionally, we look at which of these producers are situated in depleted water basins.

We can see that producers in the Middle East (Egypt), Central Asia and East India might particularly be impacted by future increases in days without rainfall, as there might not be sufficient water resources to irrigate cotton fields. Already today, the above-mentioned producers are situated in or near depleted water basins, which will likely be even more so in the future.

Areas with increases in consecutive dry days across both scenarios are the following:

- Central Asia: Kyrgyzstan, Tajikistan
- North Africa: Egypt
- West Africa: Mali, Senegal
- South Asia: Pakistan, east India

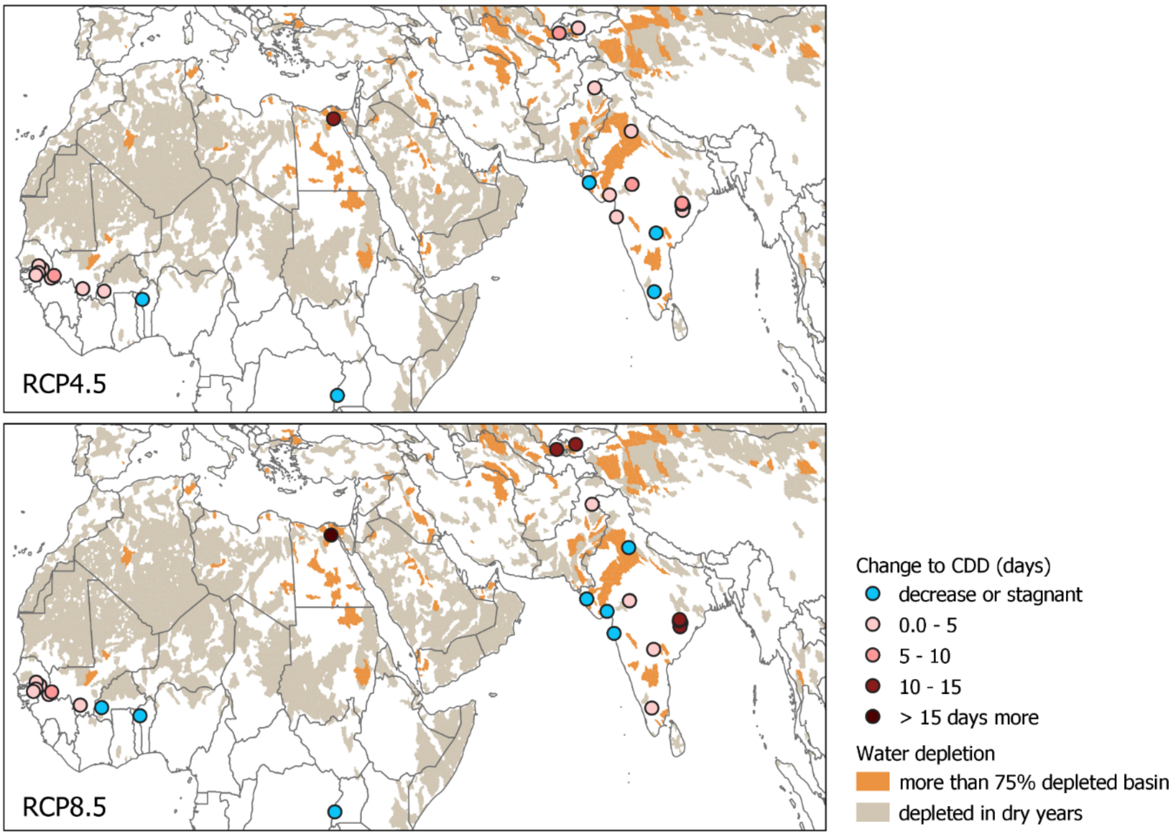


Figure 27 Changes to consecutive dry days (CDD, in days) of Fairtrade cotton producers (points), and depleted water basins.

Warm spell duration index

Similar to CDD, we also looked at which producers that are projected to experience an increase in heatwaves are situated in depleted water basins (Figure 28). Increases in the WSDI will likely lead to higher irrigation needs. Compared to CDD, many more areas where Fairtrade cotton is produced will experience a considerable increase in the WSDI (more than 30 consecutive warm days more), and the majority of them are located in or near depleted water basins.

Areas with increases in consecutive dry days across both scenarios are the following:

- Central Asia: Kyrgyzstan, Tajikistan
- North Africa: Egypt
- West Africa: Burkina Faso, Mali, Senegal
- South Asia: Pakistan, east India

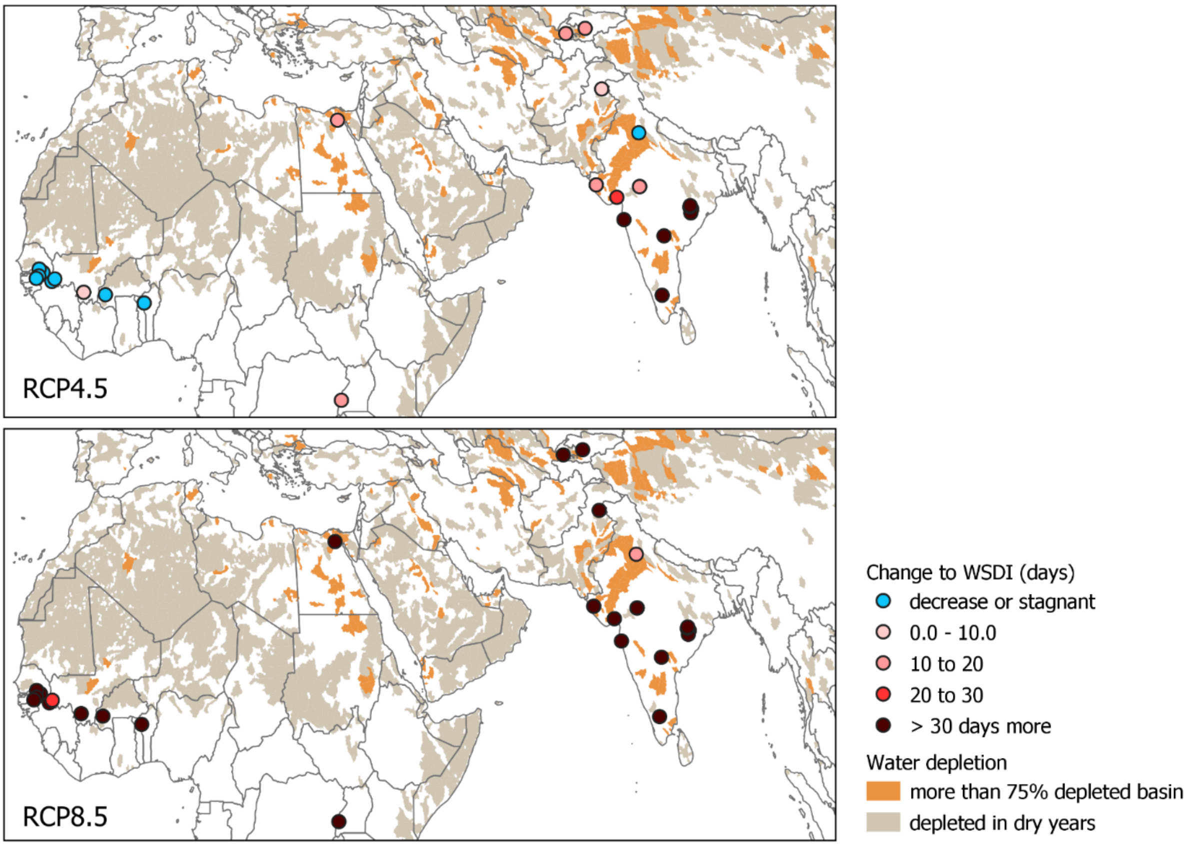


Figure 28 Changes to the warm spell duration index (WSDI, in days) of Fairtrade cotton producers (points), and depleted water basins.

Impact on producers and production

A considerable portion of existing cotton producers (and production in volumes) work in water basins already depleted in the current climate, as cotton is mostly grown in arid conditions. Adaptation for such areas, where it would get warmer and drier, would mean even more water withdrawals for irrigating cotton fields. For this reason, no hotspot areas were isolated. We propose that the focus should be on increasing the sustainability of cotton production (higher irrigation efficiency, production in basins that are not depleted, etc.).

4.5.5 Sugarcane producers

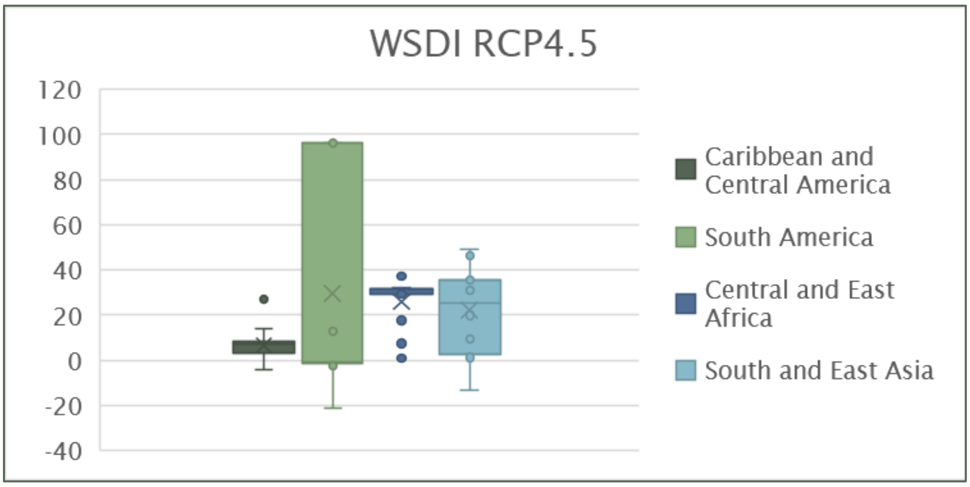
Warm spell duration index

Under the RCP4.5 scenario, sugarcane producers in India and East Africa, and partially also Central America, are projected to experience more warm days. Under RCP8.5 however, most of the Fairtrade sugarcane producers are expected to experience considerable increases in warm days (over 30 more additional consecutive days). In both scenarios, we observe large variations in South America, meaning that the impact on sugarcane production in this region will differ considerably depending the geographic location within the region (Figures 29 and 30).

Areas with increases in warm days across both scenarios are the following:

- Caribbean and Central America: Belize, Costa Rica, Cuba, Jamaica, El Salvador

- South America: Ecuador, Guyana
- Central and East Africa: Eswatini, Malawi, Mozambique, South Africa, Zambia, Mauritius
- South and East Asia: India, the Philippines



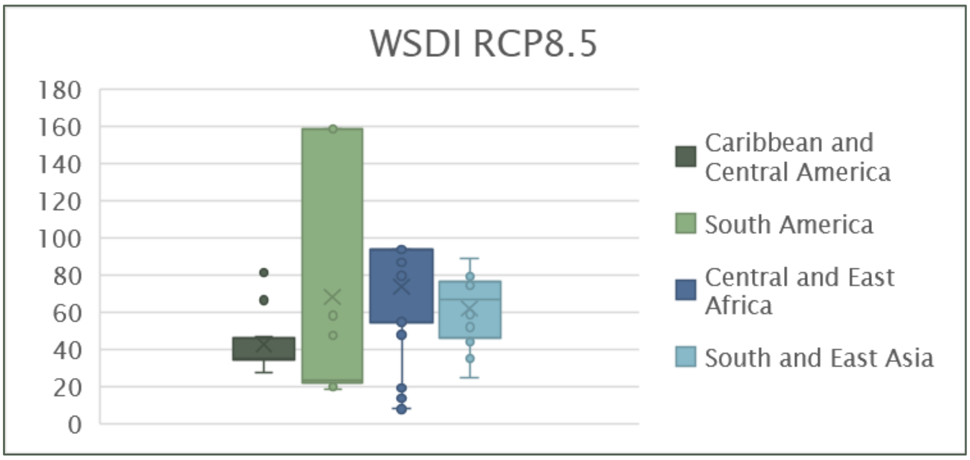


Figure 29 Changes to the Warm Spell Duration Index in different sugarcane producing regions

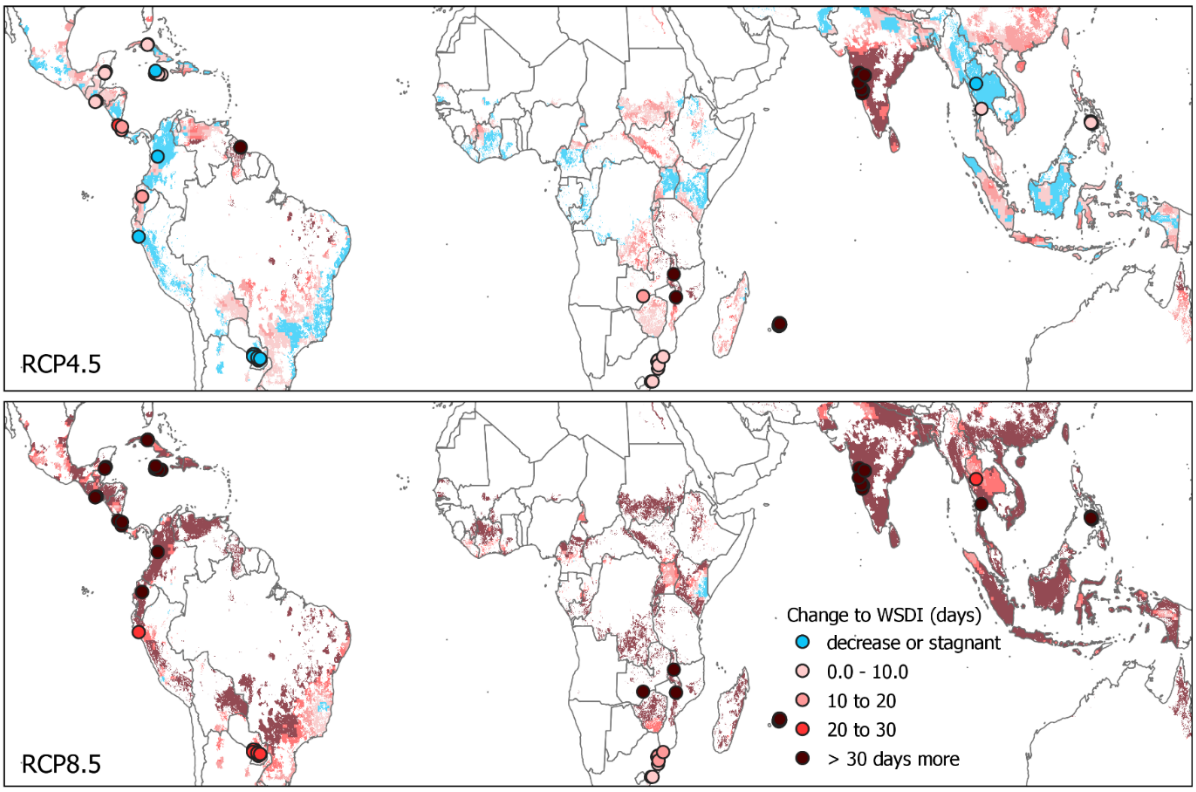


Figure 30 Changes to the warm spell duration index (WSDI, in days) in sugarcane producing regions (surfaces) and Fairtrade sugarcane producers (points).

Consecutive dry days

Under both scenarios, Fairtrade sugarcane producers will on average experience a slight increase in consecutive dry days. We also observe large differences between different regions. South America will experience considerable increases in consecutive dry days under both scenarios (with large variations as expressed by the outliers, Figure 31), and South and East Asia will likely bear the largest variations within the region. Parts of Central and East Africa are also anticipated to experience considerable increases in CDD under both scenarios (Figure 32).

Areas with increases in consecutive dry days across both scenarios are the following:

- Caribbean and Central America: Belize, Cuba, Jamaica, EL Salvador
- South America: Guyana, Paraguay
- Central and East Africa: Eswatini, Malawi, Mozambique, South Africa, Zambia
- South and East Asia: India, central Thailand

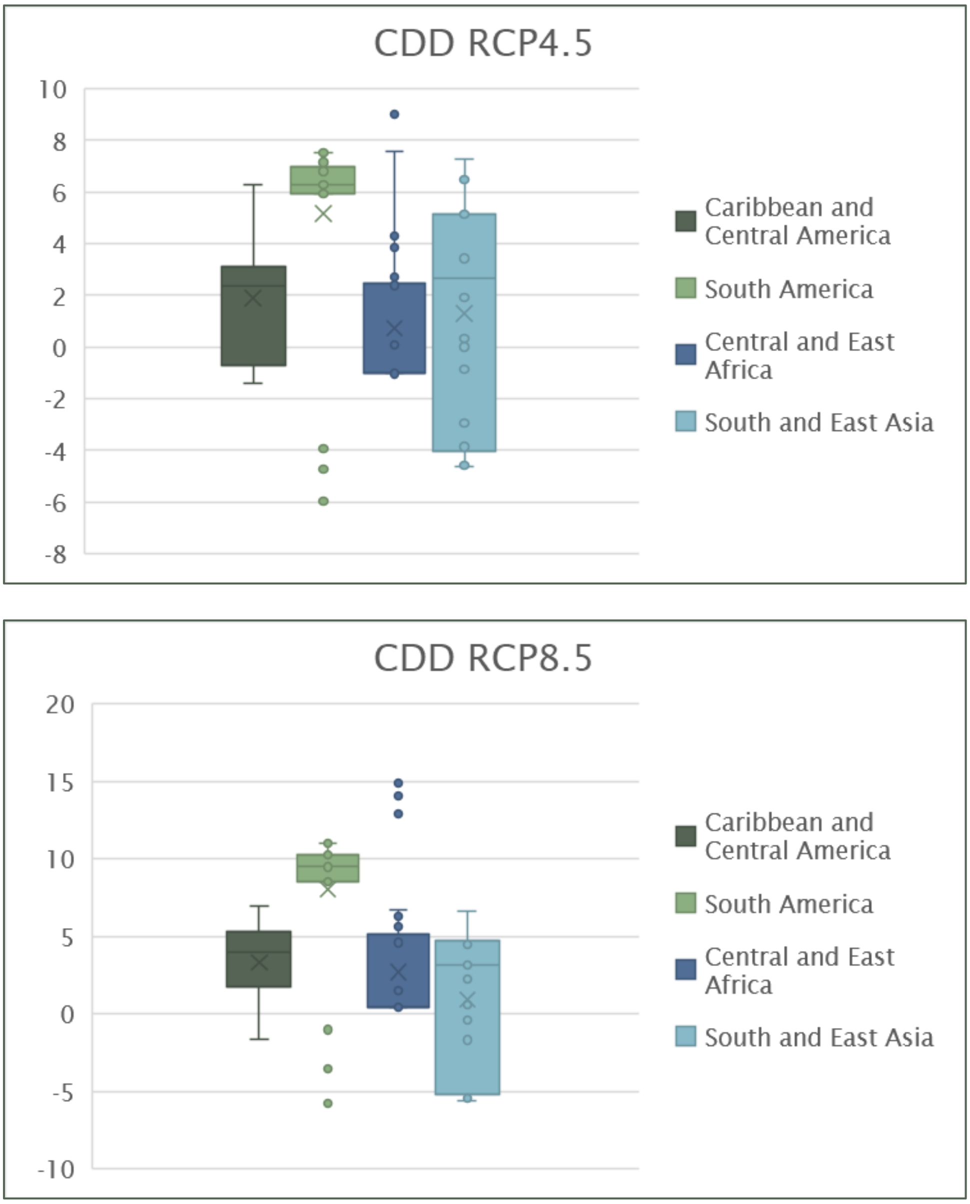


Figure 31 Changes to Consecutive Dry Days in different sugarcane producing regions

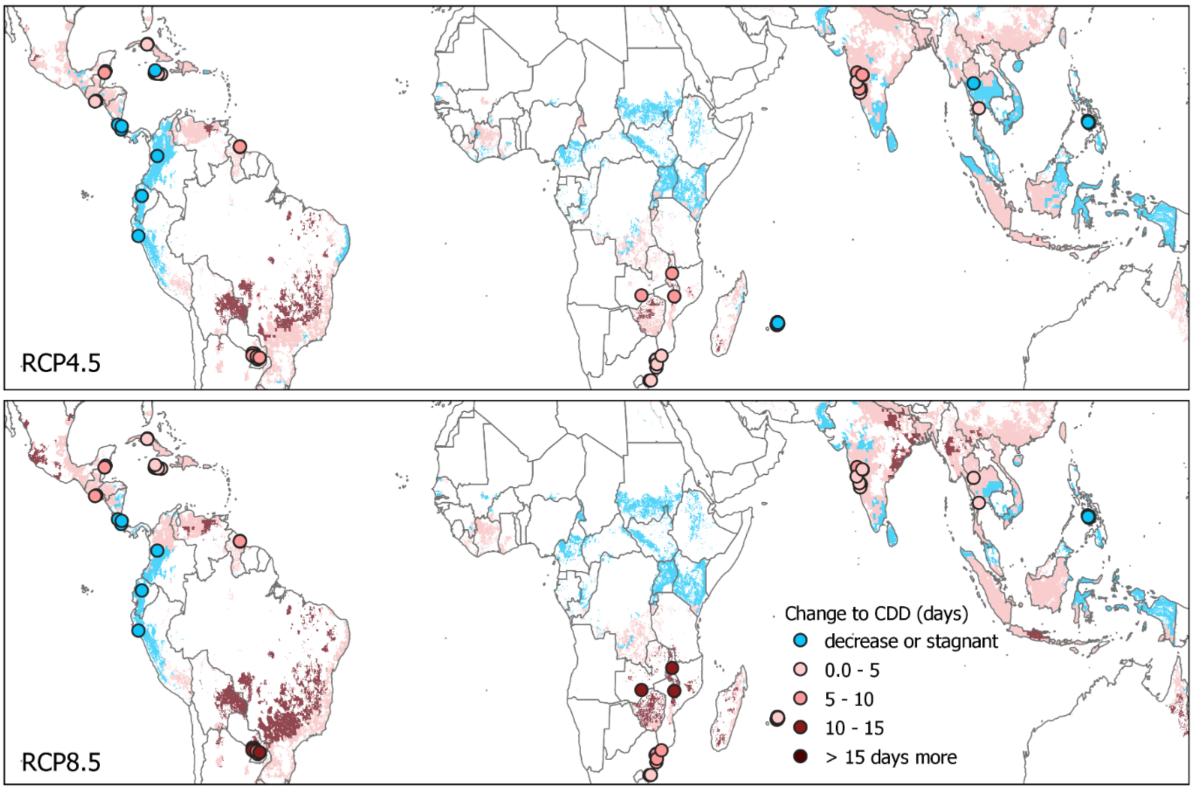


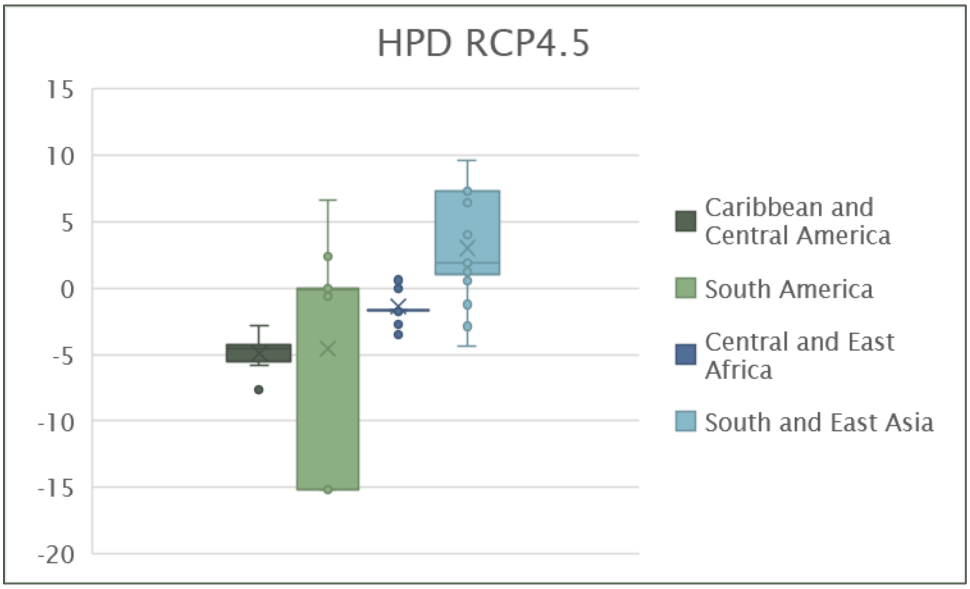
Figure 32 Changes to consecutive dry days (CDD, in days) in sugarcane producing regions (surfaces) and Fairtrade sugarcane producers (points).

Heavy precipitation days

Under both scenarios, Fairtrade sugarcane producers will on average experience less extreme rainfall events (Figure 33). Nevertheless, one region in particular, South and East Asia, will be subject to considerable increases in such rainfall events (Figure 34).

Areas with increases in heavy precipitation days across both scenarios are the following:

- Caribbean and Central America: Belize, Cuba, Jamaica, EL Salvador
- South America: Colombia and Ecuador
- Central and East Africa: Eswatini, Malawi, Mozambique, South Africa, Zambia
- South and East Asia: India, Thailand, the Philippines



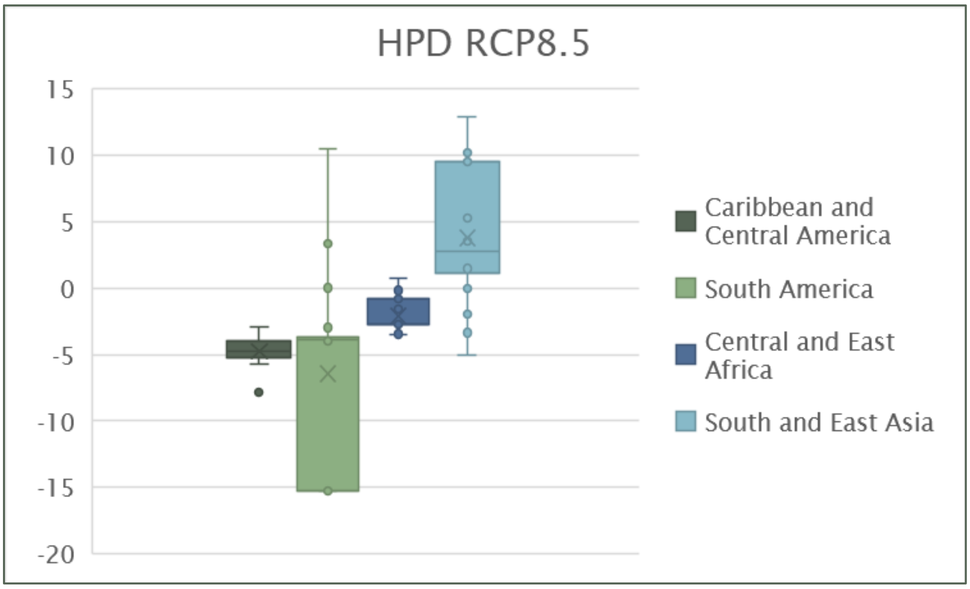


Figure 33 Changes to Heavy Precipitation Days in different sugarcane producing regions

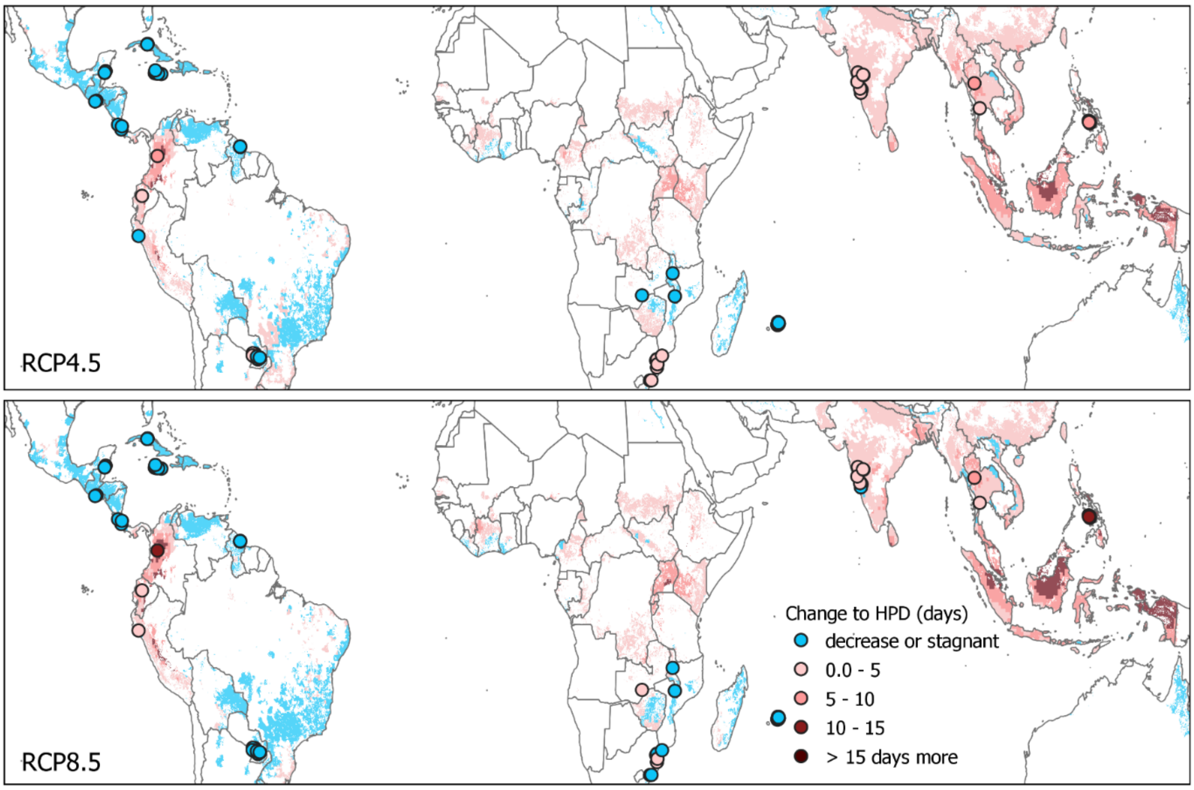


Figure 34 Changes to heavy precipitation days (HPD, in days) in sugarcane producing regions (surfaces) and Fairtrade sugarcane producers (points).

Areas experiencing more heatwaves and droughts

Areas with combined increases in warm days and consecutive dry days across both scenarios (Figure 35) are the following:

- Caribbean and Central America: Belize, Cuba, Jamaica, EL Salvador
- South America: Guyana
- Central and East Africa: Eswatini, Malawi, Mozambique, South Africa, Zambia
- South and East Asia: India

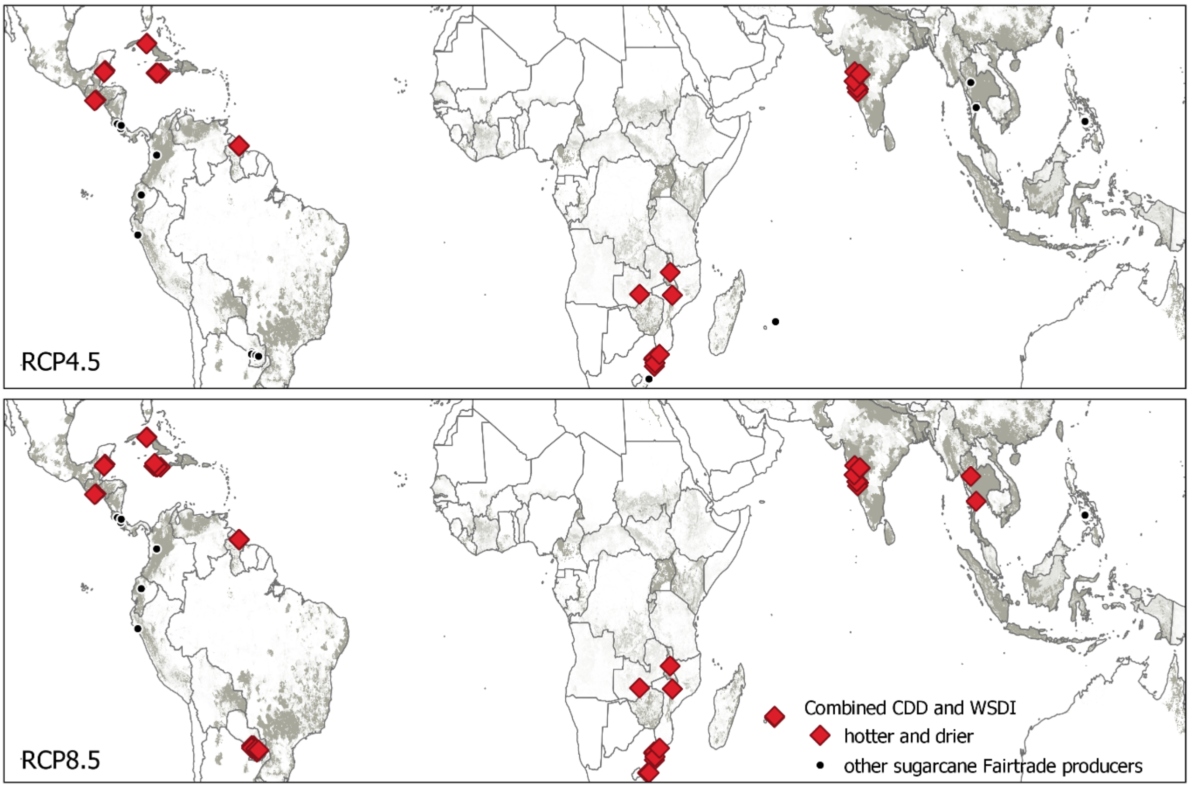


Figure 35 Identified Fairtrade sugarcane producing areas, that will get both drier (increase in consecutive dry days) and hotter (increase in the warm spell duration index) in the future.

Impact on producers and production

Most of the Fairtrade sugarcane producing regions are expected to experience both drying and heating at the same time (Figure 35). Similar to cotton, a considerable part of sugarcane is irrigated and it is among the most water demanding crops. This is why we also do not isolate any particular region, as adaptation would demand more irrigation to maintain production.

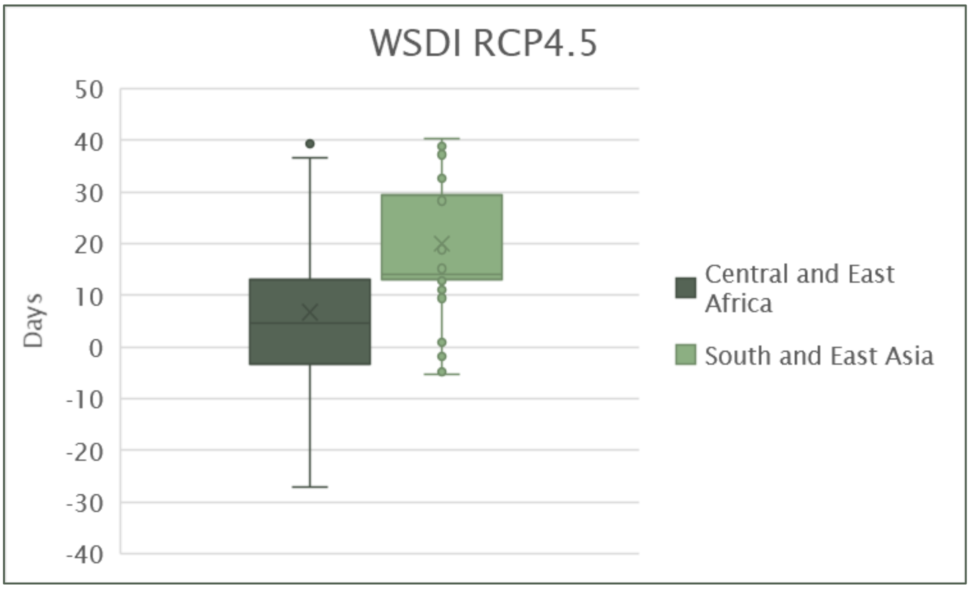
4.5.6 Tea producers

Warm spell duration index

Major tea producing regions are experiencing considerably more warm days under both scenarios (Figures 36 and 37). However, only the south of India and parts of East Africa are projected to experience more than 30 additional warm days. Under the RCP8.5 scenario nearly all tea producing areas are projected to experience a considerable increase in warm days. Areas where there will be fewer warm days are limited to the Sub-Himalayan regions, Southeast Asia and parts of East-Africa.

Areas with increases in warm days across both scenarios are the following:

- Central and East Africa: Malawi, Rwanda, Tanzania
- South and East Asia: Sub-Himalayan and southern India, Nepal, Eastern and Southern China, Indonesia



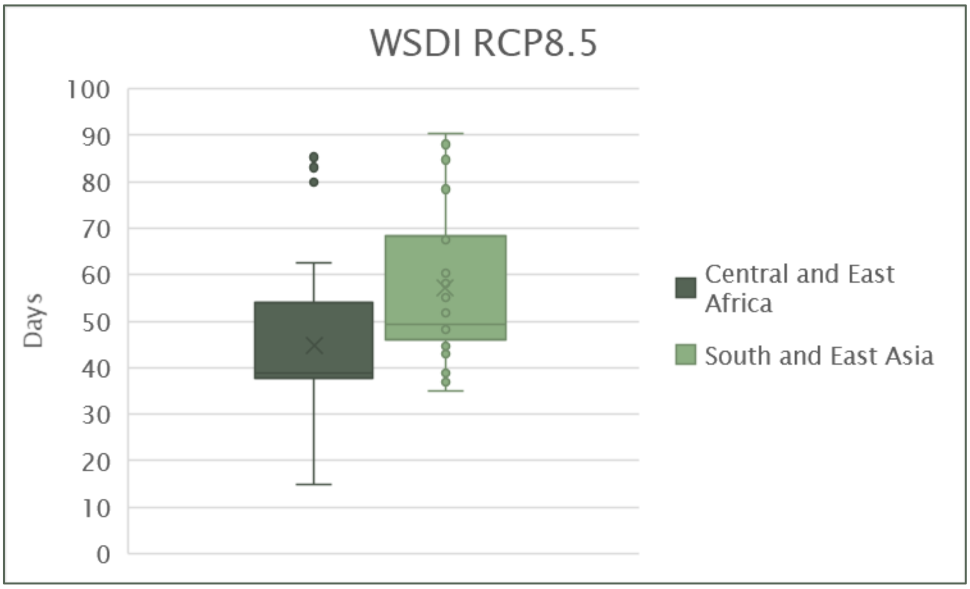


Figure 36 Changes to the Warm Spell Duration Index in the two tea producing regions

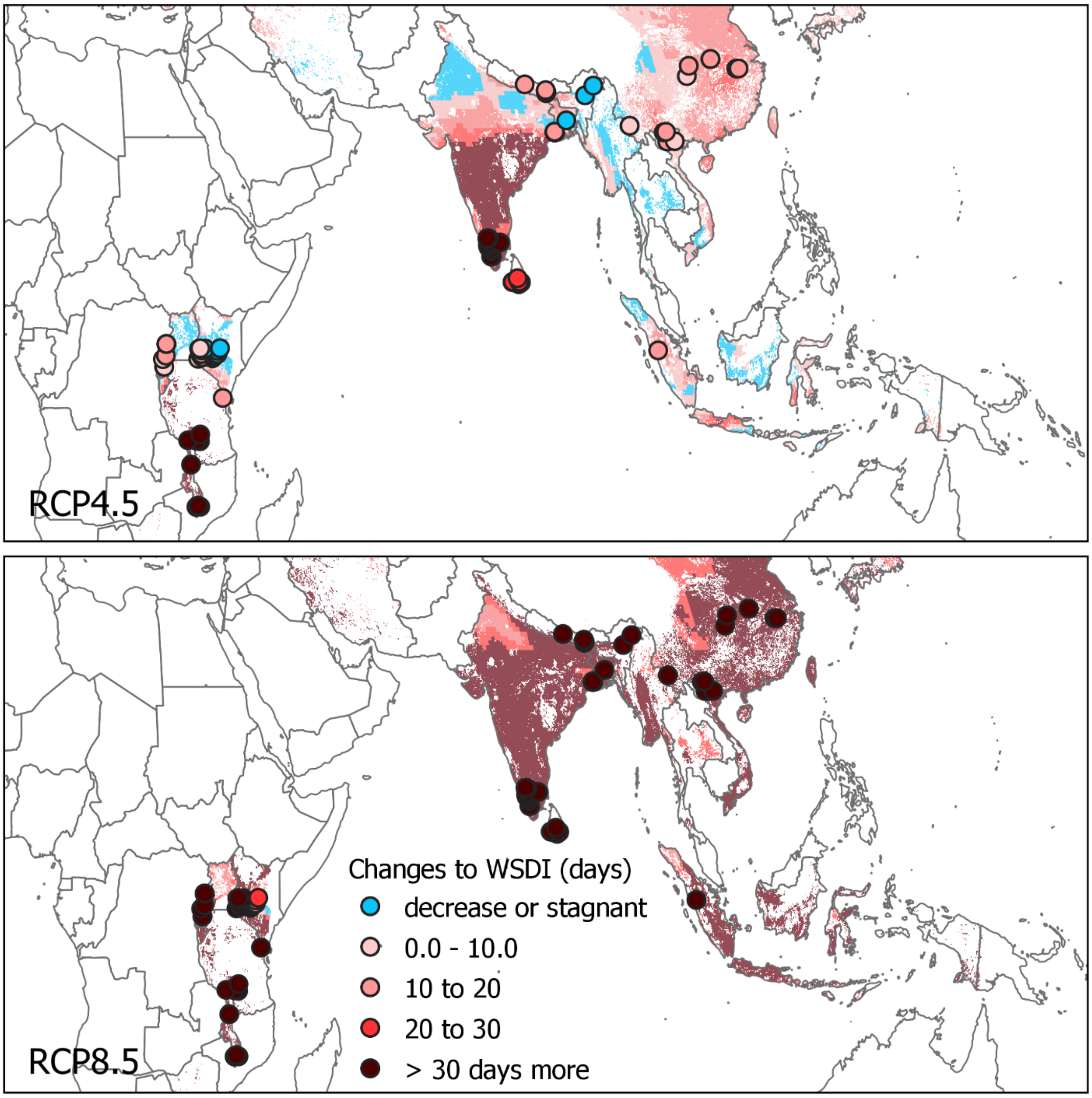


Figure 37 Changes to the warm spell duration index (WSDI, in days) in tea producing regions (surfaces) and Fairtrade tea producers (points).

Consecutive dry days

A considerable part of tea producers under both scenarios are projected to experience more consecutive days without rainfall (Figures 38 and 39). Particularly problematic are areas in the south of East-Africa, and Eastern India, as they are projected to experience more than 10 and 15 consecutive days without rainfall more.

Areas with increases in consecutive dry days across both scenarios are the following:

- Central and East Africa: Malawi, Tanzania
- South and East Asia: Sub-Himalayan India, Nepal, Eastern and Southern China, Indonesia

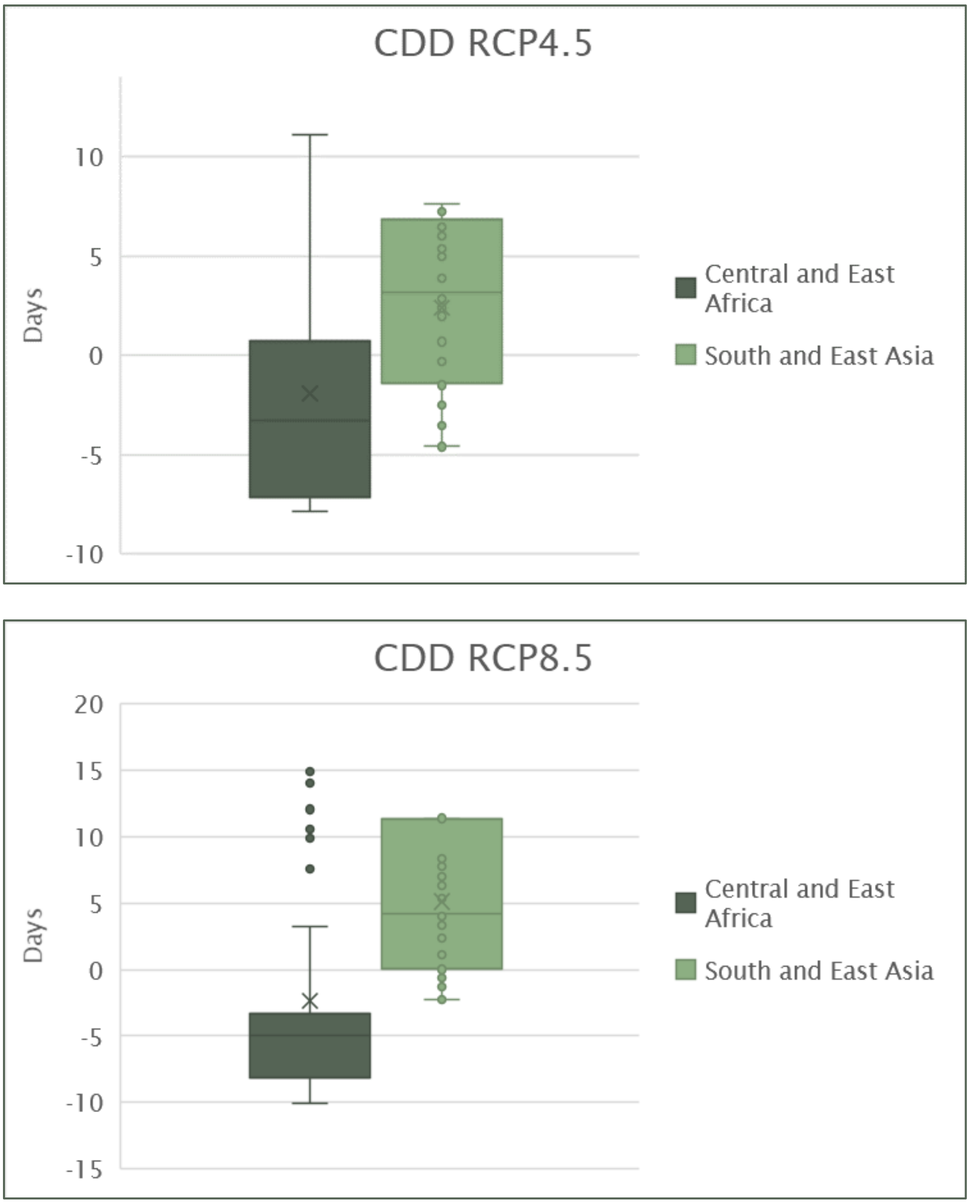


Figure 38 Changes Consecutive Dry Days in the two tea producing regions

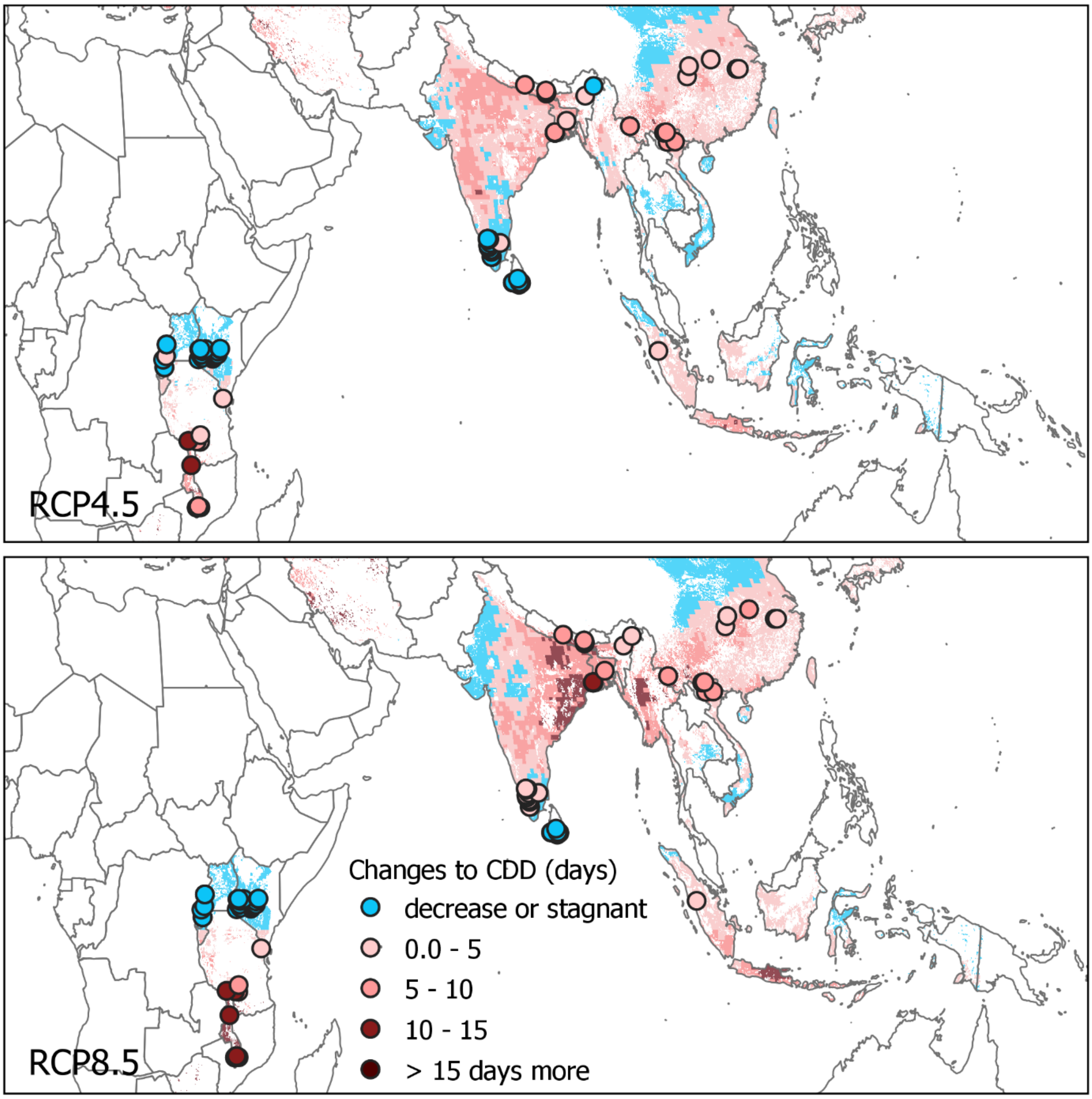


Figure 39 Changes to consecutive dry days (CDD, in days) in tea producing regions (surfaces) and Fairtrade tea producers (points).

Areas experiencing more heatwaves and droughts

Nearly all Fairtrade tea producing areas are projected to experience both more warm days and more days without rainfall under both scenarios (Figure 40). It is worth noting here that these changes are not as profound as in other crops. Tea is also already situated in most humid regions, so more dry and warm days might not have the same impact as on other crops.

Areas with increases in consecutive dry days across both scenarios are the following:

- Central and East Africa: Malawi, Tanzania
- South and East Asia: Sub-Himalayan India, Nepal, Eastern and Southern China

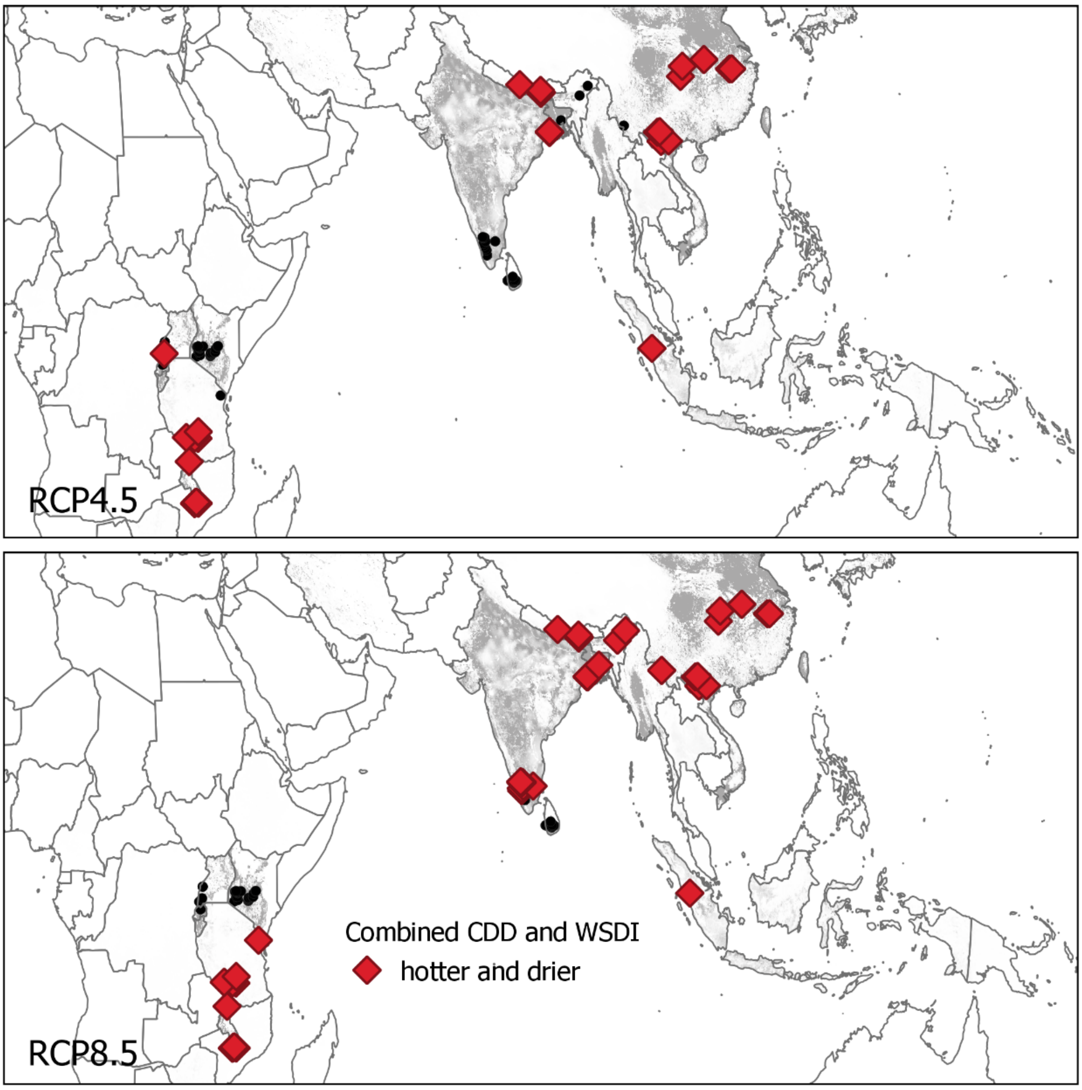


Figure 40 Identified Fairtrade tea producing areas, that will get both drier (increase in consecutive dry days) and hotter (increase in the warm spell duration index) in the future.

Climate change impacts hotspots based on production volume and number of producers

Based on the volume of produced tea and number of producers in each of the Fairtrade sourcing locations, hotspots were identified (Figure 41).

Areas of significant production in terms of volume of produced tea that will be most impacted by future heating and drying are the following:

- Central and East Africa: Rwanda
- South and East Asia: North-East India

In terms of the number of farmers producing tea in affected regions, the following regions will be most impacted:

- Central and East Africa: Tanzania, Rwanda, Malawi

These are hotspots, where adaptation efforts could make the biggest impact in terms of maintaining existing livelihoods and volumes of produced tea.

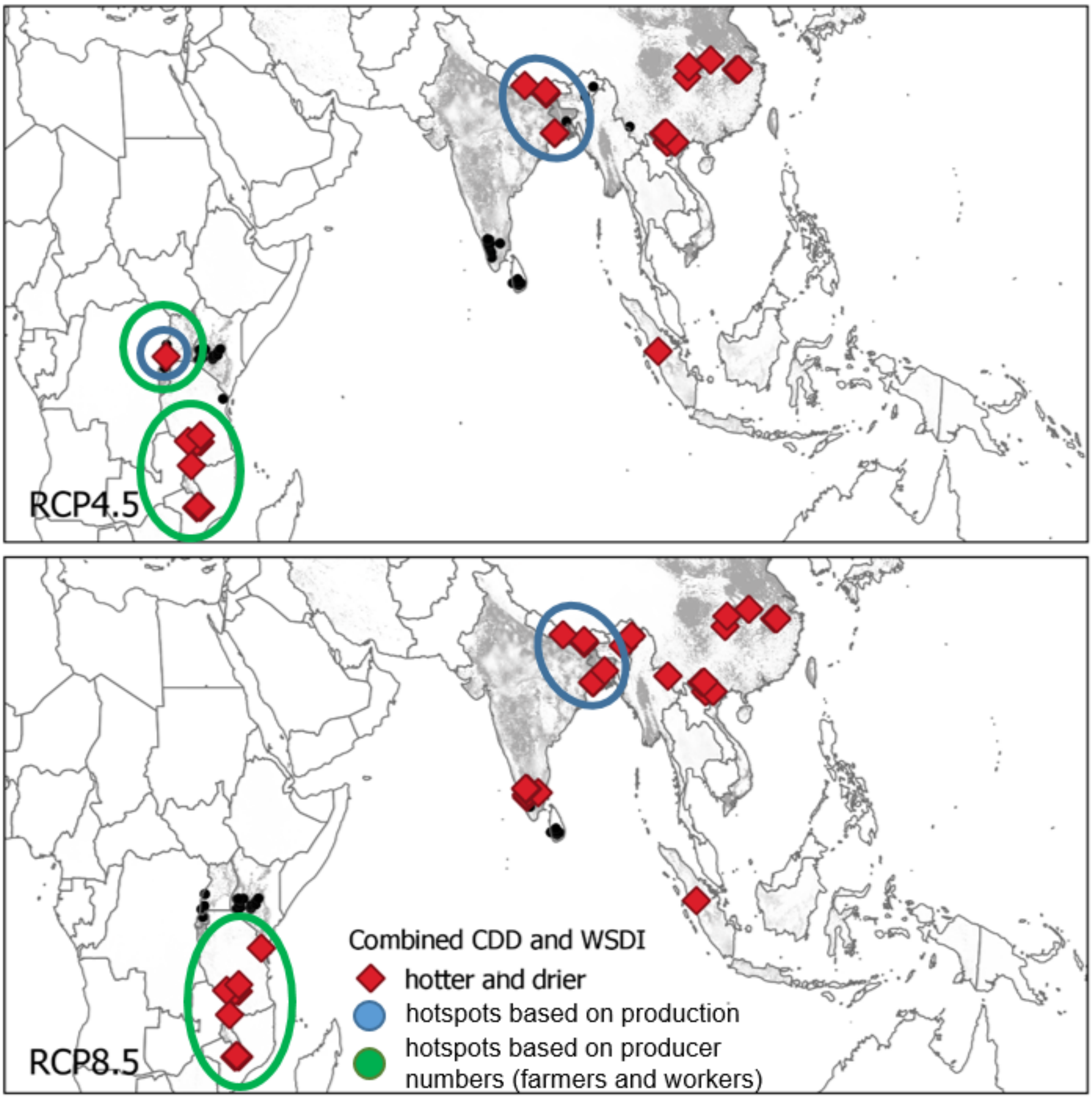


Figure 41 Hotspots of climate change impacts based on Fairtrade tea production and producer numbers

4.5.7 Comparison with other producing areas

In the summary table below (Table 4), we can see, that Fairtrade producers of different crops are projected to experience similar impacts as other, non-Fairtrade producers. This means that potential relocation, or shifts to, for example, higher altitudes cannot fully offset the potential negative impacts to Fairtrade producers in some countries and regions. Nevertheless, there are regional differences and we recommend using the spatial distribution maps (Annex 1) when considering potential new sourcing areas.

Table 4 Summary of mean climate change impacts for crops. Numbers present an increase in days per year under a specific scenario. Numbers in brackets is the standard deviation. Positive numbers mean an increase and negative ones a decrease in the climate change impact on the crop in the near future under the specific scenario.

Crop/producer	WSDI45	WSDI85	CDD45	CDD85	HPD45	HPD85
Banana Fairtrade	-7.5 (18.2)	**42.1** (13.2)	-1.2 (3.3)	-0.6 (4.7)	/	/
Banana other	11.0 (19.6)	**52.2** (22.8)	**2.2** (4.3)	**3.8** (5.9)	/	/
Cocoa Fairtrade	-13.7 (15.4)	**34** (16.6)	-0.2 (1.9)	**1.3** (2.6)	0.7 (3.9)	1.2 (4.3)
Cocoa other	1.1 (14.5)	**46.7** (18.7)	**0.3** (3.6)	**1.6** (4.6)	3.7 (5.1)	4.7 (6.2)
Coffee Fairtrade	-2.55 (12.8)	**38.6** (17.0)	-0.9 (4.0)	0.7 (5.5)	/	/
Coffee other	3.7 (15.7)	**45.8** (20.7)	1.3 (5.0)	2.7 (6.8)	/	/
Sugarcane Fairtrade	23.0 (25.6)	**65.6** **(39.9)**	2.0 (3.8)	3.6 (4.7)	-1.8 (4.8)	-2.3 (5.2)
Sugarcane other	7.6 (18.2)	**46.6** **(22.1)**	2.7 (4.9)	4.5 (6.9)	1.7 (3.9)	1.9 (4.7)
Tea Fairtrade	14.5 (16.1)	**52** (17.4)	0.6 (5.4)	2.0 (7.3)	/	/
Tea other	12.3 (15.1)	**44.9** (19.2)	0.7 (5.0)	1.2 (6.8)	/	/

Note: For example, looking at warm-spell duration for banana we can see that under the RCP4.5 scenario, Fairtrade banana producing locations will experience on average 7.5 fewer days of warm spells (with a range between 25.7 fewer days of warm spell to 10.7 additional warm spell days, given the standard deviation). Under the same scenario, other banana producing areas will experience 11 additional warm spell days (ranging between 8.6 fewer days and 30.3 additional days).

5 Output II: Fairtrade documents review

5.1 Introduction

The present chapter summarizes the systematic review of the internal Fairtrade program and intervention documentation. Most of the documents received were written by FI staff. Few can be considered reviews of Fairtrade International's programs and the documents were mostly destined for internal use. Further details are listed in Table 5.

Table 5 Documents received from Fairtrade International

Document title	Document was written by FI or external staff?	For internal use (within Fairtrade network) or for communication purposes
Fairtrade Standards (5 documents)	FI	internal
Results Satisfaction Survey (7 documents)	FI	internal
Case studies (6 documents)	external staff	internal
Global Report on FT impact	external staff	internal
Lists environmental projects (2 documents)	FI	internal
Impact Monitoring HH and SPO (8 documents)	FI	internal
Methodology and programmatic approach for Climate Change Adaptation (2 documents)	external staff	internal
Fairtrade and the Carbon Market	FI	communication
Fairtrade Climate Standard	FI	communication
Fairtrade Minimum Price and Premium	FI	communication
Fairtrade positioning on climate change	FI	communication
Fairtrade-Climate-Change-Programme_fact sheet	FI	communication
Fairtrade and Environment Final 2017-08	FI	internal
CSA position	FI	internal
Fairtrade_ToC_indicators (June 2018)	FI	internal
1612-Fairtrade Theory of Change	FI	communication
2016-Fairtrade-Global-Strategy-web	FI	communication
Focus Group Discussion Guide	FI	internal
Climate Change STRATEGY Approved LT	FI	internal
Climate Change and Fairtrade (2 documents)	FI	communication
CC Strategy Action Plan Final	FI	internal
COD Impact and Premium Use Categories (2 documents)	FI	internal

The key questions investigated during the review of Fairtrade internal documents were:

Question A) *What is the key information found in the documents?*

In order to analyze the general framework of Fairtrade's climate change program and then cluster the project documents according to a) geographic area, b) commodity and c) their intended contribution to climate change **mitigation**, **adaptation**, or **both**, a clustering was conducted. The documents were reviewed to collect information on farmers' perception of climate change, adoption of climate-resilient agricultural techniques, and challenges linked with the implementation of climate support services as outlined in the documents. The clustering was done according to the criteria listed above and each document was evaluated and classified.

Question B) *How do FI's climate change projects, organized through the programmatic approach, address the farmers and the cooperative's needs in terms of adaptation? Are there any impacts that can be directly derived from the interventions? How are the farmers' and cooperatives' needs understood in the internal documents?*

Taking into consideration that assessing whether there was an impact of the program, a classification using discrete dichotomies was used, placing documents according to the evidence of impacts derived from the intervention (1=Yes, 0=No). This classification was done with the use of an Excel table, where each one of the documents provided for the systematic review were analyzed and referenced.

The concepts of climate change adaptation and mitigation and how to assess them in the scope of the systematic review was discussed prior to the review. As stated in the inception report, adaptation—the process of adjusting to actual or expected climate and its effects (IPCC 2014)—is a key factor in determining the severity of climate change impacts on agriculture and livelihoods. The team acknowledged that adaptation options are variations of existing climate risk management (Howden et al. 2007) and solutions can also be found in traditional agricultural practices (Li et al. 2013), but novel production techniques or different crop varieties can also play an important role. Farmers' perspectives on climate change impacts and how they handle new information was an important consideration. The ability to adapt includes perception of and knowledge on climate change, social relationships, agricultural extension, availability of credit, land tenure and demographics (e.g. Deressa et al. 2011, Below et al. 2012, Tambo and Abdoulaye 2013, Dang et al. 2014, Panda 2016). Mitigation, on the other hand, refers to human interventions to reduce the sources and/or enhance the sinks of greenhouse gases and thus limiting climate change (IPCC 2015). Options to mitigate climate change are varied and may include improvement of agricultural practices.

The insights gained from reviewing these documents will support the development of the survey. The findings will be evaluated and an assessment of whether they are aligned or contradict the program objectives will be provided. The summary of this assessment will be presented in the form of a report and will be one of the deliverables of the systematic review.

5.2 Key information found in the documents

Table 6 Classification of the documents according to the geographic region, commodity and their intended contribution to climate change adaptation, mitigation or both

<table>
<tr><th></th><th>Coffee</th><th>Banana</th><th>Cocoa</th><th>Tea</th><th>Other commodities</th></tr>
<tr><td rowspan="5">FTA</td><td colspan="3">Documents 1, 2, 3</td><td></td><td></td></tr>
<tr><td colspan="3">Documents 4, 6, 8</td><td></td><td></td></tr>
<tr><td colspan="3">Documents 5, 7,9</td><td></td><td></td></tr>
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<tr><td>CLAC</td><td colspan="5">Document 47</td></tr>
<tr><td rowspan="4">NAPP</td><td colspan="3">Documents 1, 2, 3</td><td></td><td></td></tr>
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<tr><td rowspan="3">Global</td><td colspan="2">Document 21</td><td></td><td></td><td></td></tr>
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<tr><td colspan="5">Documents 14, 17, 20, 36, 38</td></tr>
</table>

Latin American and Caribbean Network of Fairtrade Small Producers and Workers (CLAC), Fairtrade Africa (FTA) and Fairtrade Network of Asia & Pacific Producers (NAPP)

Colour code: Information on Adaptation Mitigation Both Not specific

5.3 Review of farmers' awareness on Fairtrade International's programs

Few documents explicitly mentioned the awareness of farmers of the Fairtrade International programs and their needs are only mentioned in the following two documents "Programmatic approach for Climate Change" (Document 28) and "Methodology for Climate Change Adaptation" (Document 27). In the Fairtrade Standards for Small Producer Organizations (SPO), Contract Production, Hired Labour and Traders, guidance statements were made in the form of "must" activities to raise awareness on biodiversity, greenhouse gas emission, soil and water, waste management and use of pesticides and protection (Document 38, 39, 40, 41). These documents correspond to the Fairtrade Standards published in 2011 and 2015.

Information on farmers' **awareness** of Fairtrade International's program on climate change mitigation was scarce in the documents. The documents written after 2015 were satisfaction surveys, impact monitoring questionnaires, project lists and case studies. In some of these documents, information on farmers' awareness was found. This might be because the Methodology for Climate Change Adaptation, the Theory of Change (ToC) and the Fairtrade Climate Standard which were implemented in 2015/2016. This is an important change which needs to be considered when analyzing the documents. There was a shift in the use of specific terminology addressing climate change. The change is particularly notable in the Fairtrade Standard for SPO from 2019 (Document 41). The document includes CC adaptation as an expected outcome and thus provided evidence of the activities expected in the future Fairtrade International programs on CC adaptation and mitigation (Figure 42).

Figure 42 Example of a results chain of the ToC (source: Document 12: 1612- Fairtrade Theory of Change, page 16)

The Methodology for Climate Change Adaptation focuses on the needs of the farmers and their crops regarding climate change adaptation. Specifically, the identification of the needs is done in a participatory way. In the FT documents, the inclusion of farmers' needs in terms of adaptation, the challenges and adoption and planning were highlighted, as illustrated in Figure 43. In the second step of the programmatic approach for climate change, a participatory analysis of the climate change adaptation needs of farmers, SPO, PO or NFO (according to the involved parties) is conducted.

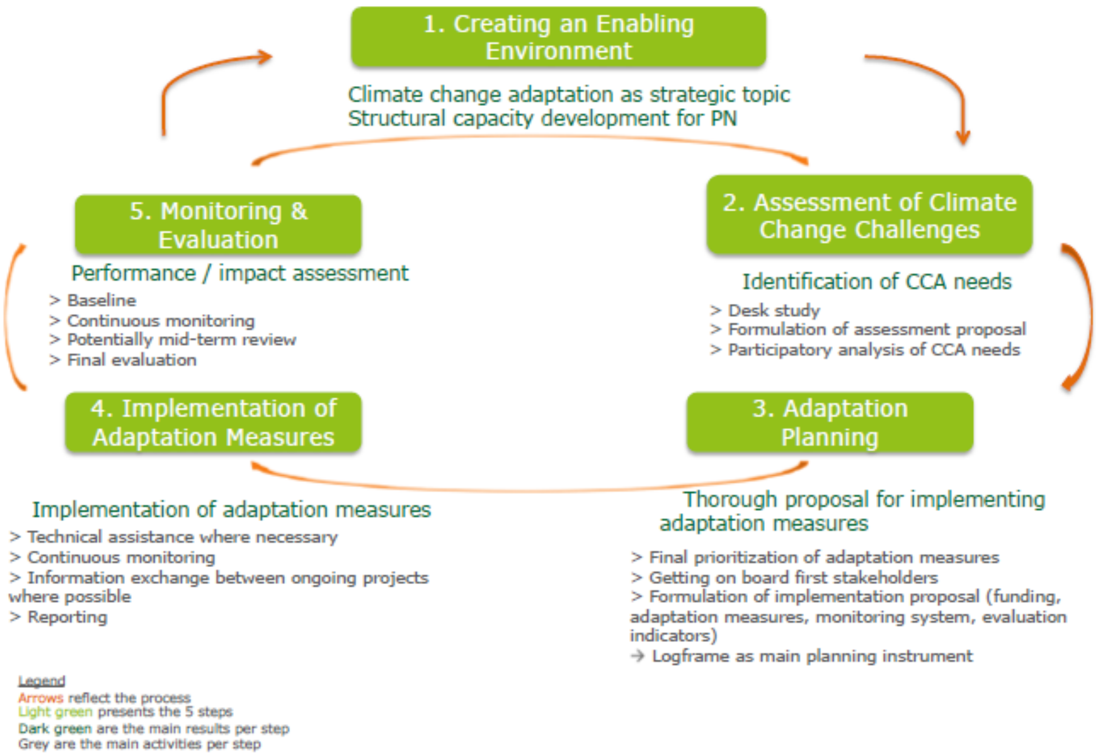


Figure 43 Overview of the programmatic approach for climate change (source: Document 27: Methodology for Climate Change Adaptation_FINAL, page 7)

5.4 Review of adoption of climate-resilient agricultural techniques

The concept of climate-smart agriculture was introduced by FAO in 2010. FT has specified that it follows a people-first approach throughout their climate change adaptation projects. This FT position paper, which was also drafted in 2010, specifies that FT would continue to support climate change mitigation and adaptation as part of its environmentally sustainable development goals.

Supporting climate change adaptation was dealt with from the perspective of adapting agricultural practices and improving water management techniques to prevent migration and displacement. In addition, the document mentions adaptation measures which support the mitigation of carbon emissions or sequestration of carbon. Specific measures were not defined at this point. In terms of climate change mitigation, the document stressed the importance of producers fulfilling requirements such as no planting in virgin forest areas, conserving buffer zones close to water sources, maintaining the fertility and structure of soil, improving the waste management techniques and minimizing the use of energy. There are clear overlaps in the climate mitigation measures and Good Agricultural practices.

Most documents, particularly those prior to 2017, mentioned that farmers are producing according to the Good Agricultural Practices (GAP). Although GAP entail techniques that could help farmers adopt climate-resilient agriculture techniques, this aspect was treated as a common requirement for producing for Fairtrade and not as an additional program for adaptation to and mitigation of climate change. Establishing or attributing causality between adoption of GAP and adoption of climate-resilient agricultural techniques was not possible because discerning through which agricultural practices can be considered climate-resilient agricultural techniques proved too difficult, as the criteria often fit both concepts.

Many technologies contributing to either adaptation, mitigation or both were found in the document. These could be called climate-resilient techniques and can be put in two categories: technologies related to the agricultural production and therefore called climate-resilient agricultural techniques and the other technologies which are not strictly related to production or considered as agricultural measures, but nonetheless help farmers adapt to and mitigate climate change indirectly. As an example, coffee production can be examined. In the first part, the climate-resilient agricultural techniques are mentioned. Further on overall climate-resilient techniques - not strictly related to the agricultural production – are addressed.

Coffee producers in Colombia are working on the efficient use of water, organic fertilizer to improve soil and the establishment of family vegetable gardens. In contrast, coffee producers in Nicaragua are focusing on the minimal use of phytosanitary products based on sampling of diseases and infestation. They also focus on agroforestry systems to control erosion, to have a better water infiltration and achieve a higher organic matter content. Furthermore, they are planting energy- and wood-producing, nitrogen-fixing fruit trees (Document 21). In Haiti, a climate risk analysis in SPOs is done, the coffee farmers are trained in water management and crops are identified, which increase and diversify income and contribute to food sovereignty. Other examples of climate-resilient agricultural techniques in the coffee sector in Kenya are the use of buffer zones around water bodies, more careful chemical use and disposal of chemical containers, and the use of manure to substitute chemical inputs and to enhance soil fertility. This project in Kenya was done in collaboration with an international NGO (Documents 29, 33). Another project in Ethiopia reduced water use in coffee washing stations, established wastewater treatment facilities, and promoted inter-cropping of coffee trees with other nutrient conserving crops in order to reduce deforestation. The establishment of community tree nurseries for agroforestry was one activity in a project with coffee farmers in Uganda (Document 14).

In addition, the following examples of climate-resilient techniques, which are not strictly agricultural measures include:

- Coffee farmers in Ethiopia: new wood stoves to reduce pressure on forests (Document 20) (other techniques mentioned for spice producers in India)
- Coffee in Uganda: production of coffee husk briquettes and the use of improved cooking stoves (Document 14)
- Coffee in Kenya and Ethiopia: use of renewable energy, cook stove, biodigester (Document 36)
- Coffee in Colombia: use of alternative energies (Document 21)
- Coffee in Colombia: biofertilizer plant (Document 36)
- Coffee in Nicaragua: micro-reservoirs for water in farmers' field, reduce water contamination from coffee processing, bio-digesters for kitchens (Document 21)
- Coffee in Honduras: garbage collection, biogas/ethanol from coffee pulp (Document 36)
- Coffee in Vietnam: reducing deforestation by using coffee covers instead of wood to dry coffee (Document 14)

These are examples of climate-resilient techniques, which were planned to be rolled out in projects. Often the information on the adoption of these techniques was missing as the documents rarely mention the situation at the end of the projects. Specifically in document 23, many adaptation measures were pointed out, but were not related to a specific crop, nor was the adoption of these measures mentioned. Adaptation measures could include using scarce water resources more efficiently, adapting buildings to future climate conditions and extreme weather events, building flood defenses and raising the levels of dykes, developing drought-tolerant crops, choosing tree species and forestry practices less vulnerable to storms and fires, and setting aside land corridors to help species migration.

These projects were initiated by the Producer Networks alone or in collaboration with either Fairtrade International or European Fairtrade organizations and are financed by companies, development cooperation organizations, foundations, ministries and others.

5.5 Review of challenges in implementation of climate support services

Several challenges were mentioned in relation to the implementation of climate support services. A main difficulty is to find funding possibilities (Document 16). Furthermore, producers often do not sell 100% of their products to Fairtrade. The lower this percentage, the lower the premium received by the POs. One coffee producing PO in Kenya sells only 4% of their coffee as Fairtrade-certified. It was concluded in the report that "*the investments from the premium into environmental aspects are marginal*" (Document 33). Therefore, additional funding from external sources would be needed to implement climate support services and to have impacts on the environment.

The SPO's capacity to adapt to climate change depends according to Fairtrade International on the access to resources, which "*include, but are not limited to, climate change knowledge and information, knowledge and information on good agricultural practices, farming inputs and relevant machinery / material, funds and labor*" (Document 27). The carbon market was mentioned in one document (Document 24) and one challenge to implement carbon credits with producers is the additional workload. Fairtrade will therefore "*make sure not to bring additional burden to producers*". The limited capacities of PN, in terms of staff time and financial resources, are another challenge (Document 29).

In the Fairtrade Trader Standard (Document 42), some guidance was given on the management of environmental impacts, such as waste management, use of recycled and biodegradable packaging, greenhouse gas emissions and carbon footprint. The guidance did not include the achievement of specific targets.

The 2017 and 2018 satisfaction surveys conducted for CLAC, FTA and NAPP indicate that 30% of the farmers were satisfied with the training or attending events on cross-cutting topics such as environmental sustainability. However, it was unclear what specific event they attended or the activities that took place.

5.6 Summary

In the documents reviewed, there is some evidence of SPO, PN and NFO engaging in activities to enhance farmer awareness on climate change (CC) issues and adoption of climate-resilient techniques, but it is not specific. The support activities are rather vague and little information on specific targets, key impact or performance indicators or enhanced capacities was found. Up until 2019, Fairtrade's Theory of Change did not specifically include CC adaptation outcomes or impacts. As stated in the Draft Global Report on the Analysis of the producer-level impact of Fairtrade on environmentally friendly production (Document 29), "*regarding Fairtrade's Theory of Change, the causal relation between Fairtrade Standards (output) and increased environmental protection and adaptation to climate change (outcome) is quite vague. It is based on the assumption that the standards and their criteria are meaningful and focused on the essence of environmental protection, climate change adaptation and biodiversity conservation for the given context*". Nevertheless, in the latest Fairtrade Guidance for SPO (Document 41) does include these aspects in the Fairtrade's Theory of Change and these changes will include specific and measurable targets and indicators.

One observation from the review of the documents was that the incorporation of CC adaptation and mitigation strategies in the guidance documents and projects—including trainings conducted in Haiti, Dominican Republic, Honduras, Bolivia, Guatemala, El Salvador, Ecuador, Nicaragua, Peru, Kenya, Uganda, Tanzania, Ghana, Ethiopia, South Africa, Vietnam, Papua New Guinea, Sri Lanka and India—have only yielded preliminary results. It is unclear whether the projects have been participatory in nature, meaning that SPO organizations actively seek to incorporate trainings and execute projects based on a perceived need or if this approach is rather a top-down activity promoted by FT. Although it is important and meaningful to promote adaptation and mitigation strategies at all levels, involvement from key stakeholders in SPO is critical.

Several of the questions that remain open after the document review were included in the survey to get producers' perspectives and understanding of climate change impacts, adaptation strategies, and Fairtrade's supporting role. As a general recommendation for a more in-depth evaluation of achievements of Fairtrade's programmatic approach to climate change, it would be important to record the number of farmers benefiting from each project. From the reviewed documents, it is sometimes unclear how many farmers (total count) participated in events or training in the satisfaction surveys administered to SPO.

6 Output IV: Hotspots – Survey results and analysis

6.1 Introduction and methodology

A closed-ended questionnaire was developed based on the projects' research questions as well as the results of the climate change impact analysis, the review of literature, the internal documents as well as the results of the experts' interviews. The survey was divided in three parts: Assessing a) the producers' livelihood b) perceptions of producers and producer organizations on climate change and impacts c) perceptions of producers' and producers' organizations concerning FI's climate change programs. The survey was designed for the producers' organizations and was adapted and sent to the pre-selected (a joint consultation between BFH-HAFL, VUA and FI) producer organization in India and Ghana. Selection criteria included: severity of climate change impacts according to the analysis presented in chapter 3; relevance of affected crop (and number of producers) for FI; expected potential for adaptation; and availability of respondents from producer networks.

The Fairtrade Producer Networks, in consultation with Fairtrade International, were contacted to conduct expert interviews and to assist with the producer surveys. It was their responsibility to (1) identify the responsible persons that participated in the survey, (2) to instruct them in a first step and (3) to remind the participants to fill out the survey if necessary.

The Fairtrade Producers Networks have access to the producers' organizations and thus this support was essential. The questionnaire developed was kept short and specific, which supports a rapid appraisal and a high response rate. Despite the contacts and support of the networks, the response rate in the case of Ghana was very low. It is unclear to what extent the COVID-19 pandemic and the restrictions implemented by the government were a factor in the response rate.

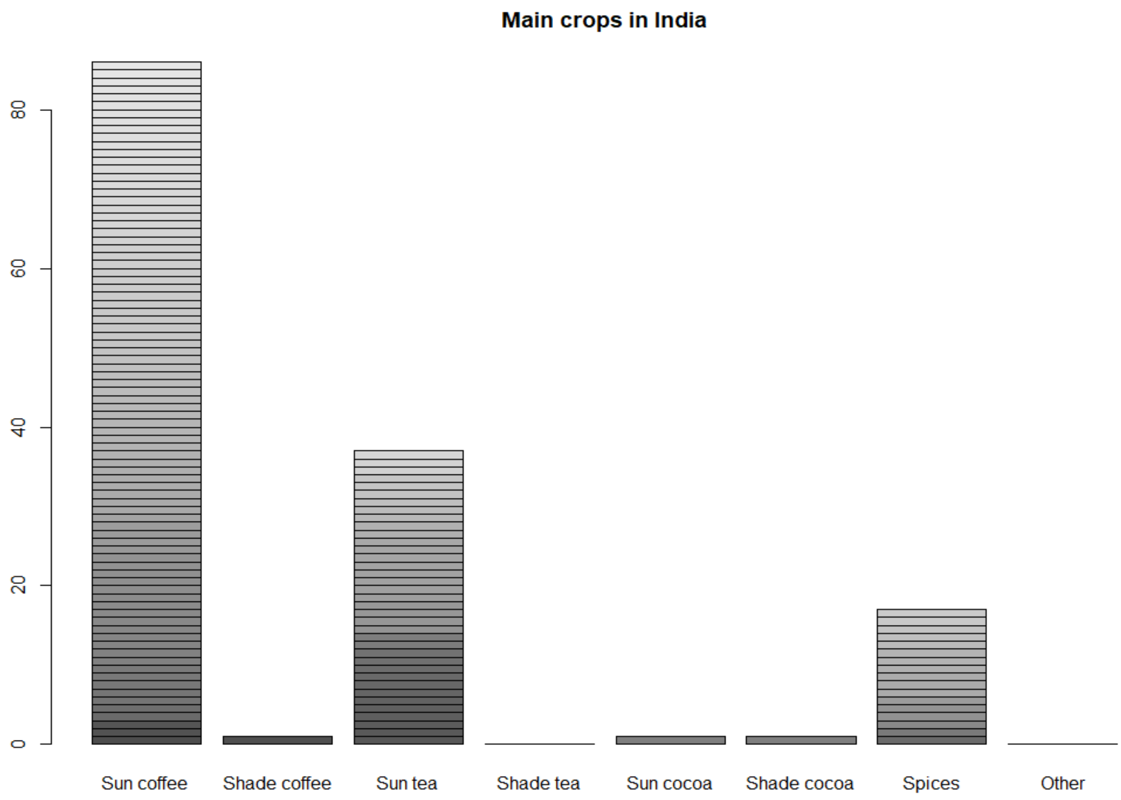
The data collection was done through an online link given to the respondents. The dataset could be used in SPSS and/or Excel. The coding of variables was done prior to the data collection and can be easily managed and copied from one file to another. Descriptive methods were used to summarize the findings of the survey.

Several aspects related to climate change impacts were analyzed, in particular the impact on livelihoods, adaptation and knowledge (i.e., the knowledge gained by the producers to mitigate climate change impacts). The results presented in this section will discuss these aspects in detail. Most of the respondents are located in India (n=125) and the others in Ghana (n=11).

In addition, hotspot-specific literature was consulted to complement the survey findings and help interpret the results. Corresponding literature findings were directly added to the survey results in the following chapter.

6.2 Livelihoods and climate change impact

The respondents in the sample are mostly coffee, tea or cocoa producers (Figure 44). In Ghana, almost all of the farmers have shaded cocoa, and half of them also have plots with full sun cocoa, in addition to some minor crops. The majority of the coffee and tea farmers, almost all of which are located in India, produce in full-sun systems. Thus, shaded systems seem to be very rare among Fairtrade farmers. Most farmers in India also have additional crops such as spices (India) planted in the farms. Other crops include okra, pepper, garden eggs, plantain, cassava and cabbage.



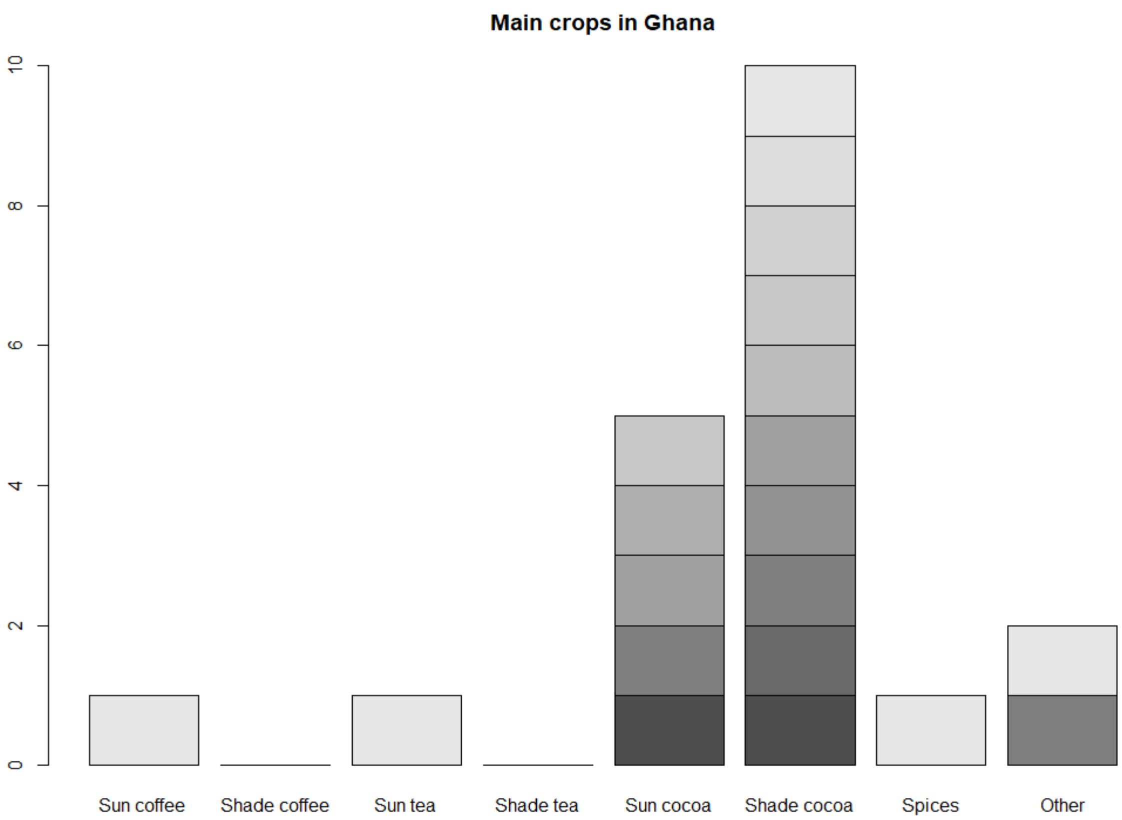


Figure 44 Main crops planted in farms in India (*above*, n=125) and in Ghana (*below*, n=11)

Most of the farmers (n=136) report being affected by climate change events in the past 10 years. In India, the most common events are floods, followed by extreme temperatures and water scarcity. Other disturbances include landslides and storms (Figure 45). In Ghana, the most common extreme climate events are extreme temperatures and water scarcity. Floods are less common in the cocoa producing region. This initial question (indicator) assesses how farmers perceive the effect of climate change, regardless of the main crop they have planted. How the producers perceive the severity of the climate change impacts will be assessed by crop. Over 70% of the total producers sampled have reported at least one impact in the last decade.

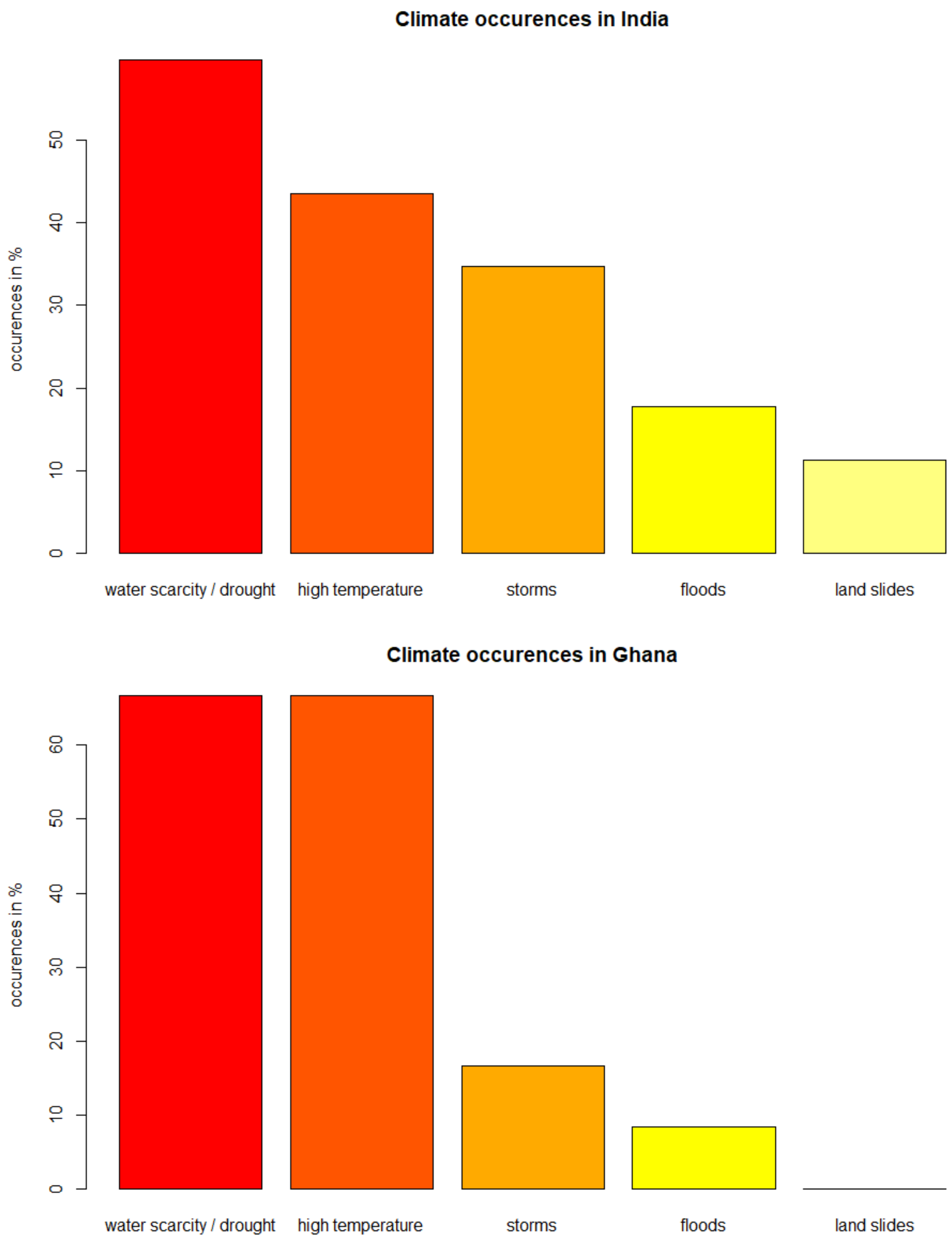


Figure 45 Most common climate occurrences in India (*above*, n=125) and in Ghana (*below*, n=11)

Producers were then asked to assess how severe the impact of these occurrences were on different aspects of production, such as the harvest, processing, the quality of the crop, the storage and the yield. They were given a 5-point scale, where 0=low severity and 4=high severity. Results indicate that cocoa farmers reported the highest severity, particularly when it comes to an effect on the harvest and the yield (Figure 46).

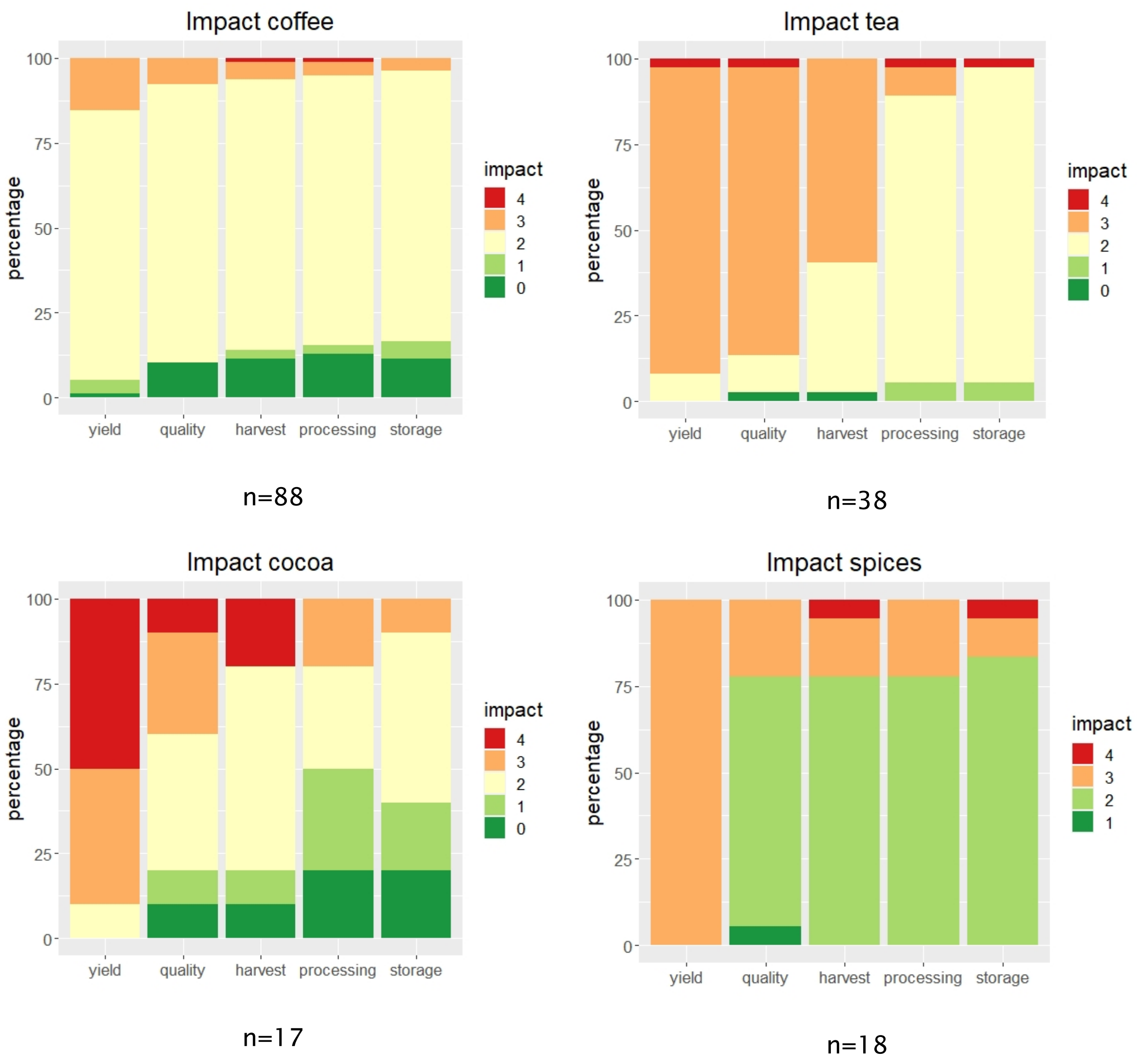


Figure 46 Severity of climate impacts on coffee, tea, cocoa and spices (0 = no impact, 5 = very high impact)[3]

6.3 Adaptation measures taken by producers

The next part of the analysis focused on determining which measures were taken by producers to deal with climate change impacts, particularly droughts, higher temperatures, storms and an increase in incidence of pests and diseases. The measures were analyzed by product. In the case

[3] Yield refers to changes in the amount of crop harvested. Harvest refers to any change in the harvest pattern or time of harvest.

of droughts, producers were asked if they took no measures, if they had any type of irrigation, if they had to change crops or the cropping calendar, if they implemented any mulching practices, if they harvested any rainwater or protected the water bodies and finally, and if they planted new trees. Throughout this chapter, only those farmers that gave a response were considered. Many did not apply any adaptation measures at all. According to the selection of hotspots and the responses, we specifically considered cocoa measures in Ghana and coffee, tea, and spices measures for India.

6.3.1 Coffee

Out of the 88 coffee producers in India, over 30 use mulching practices to combat the effect of droughts and almost as many have access to irrigation. Fifteen each harvest rainwater or protect water bodies and 14 plant new trees (Figure 47).

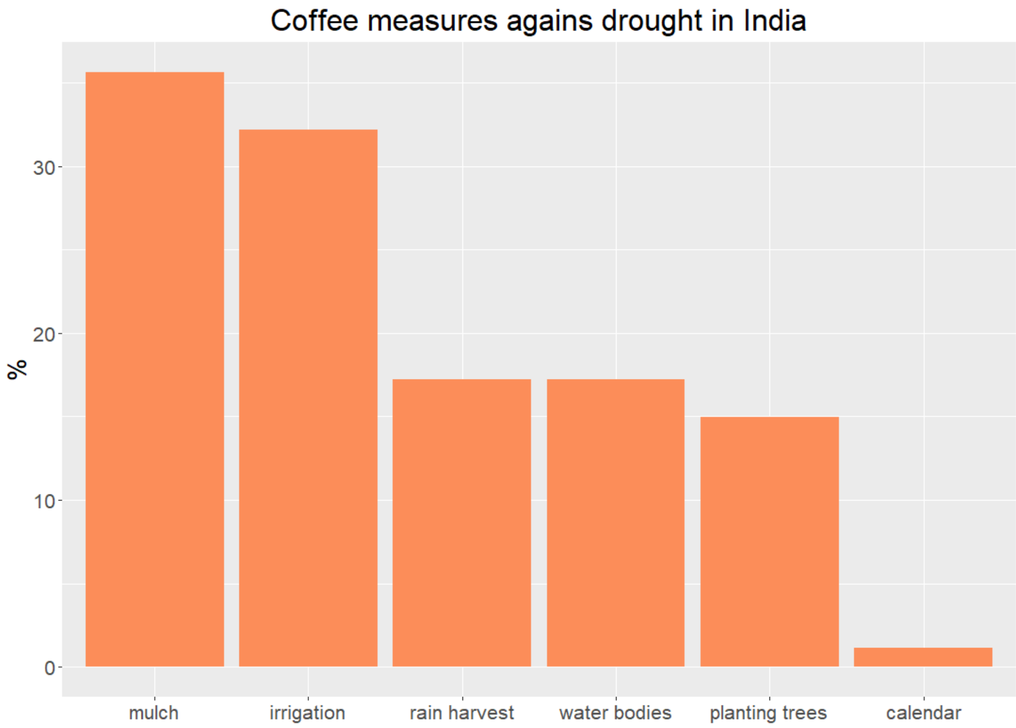


Figure 47 Measures taken by coffee farmers to mitigate the effects of drought

Over 50% of the coffee farmers do not take measures to mitigate the effect of high temperatures (Figure 48). Just over 15 respondents have actually planted new trees to deal with the impact at the farm level and 5 have rejuvenated the coffee plantations with new drought-resistant varieties. Very few farmers actually made any change in the cropping (in this case harvesting) calendar to cope with the effects of high temperatures.

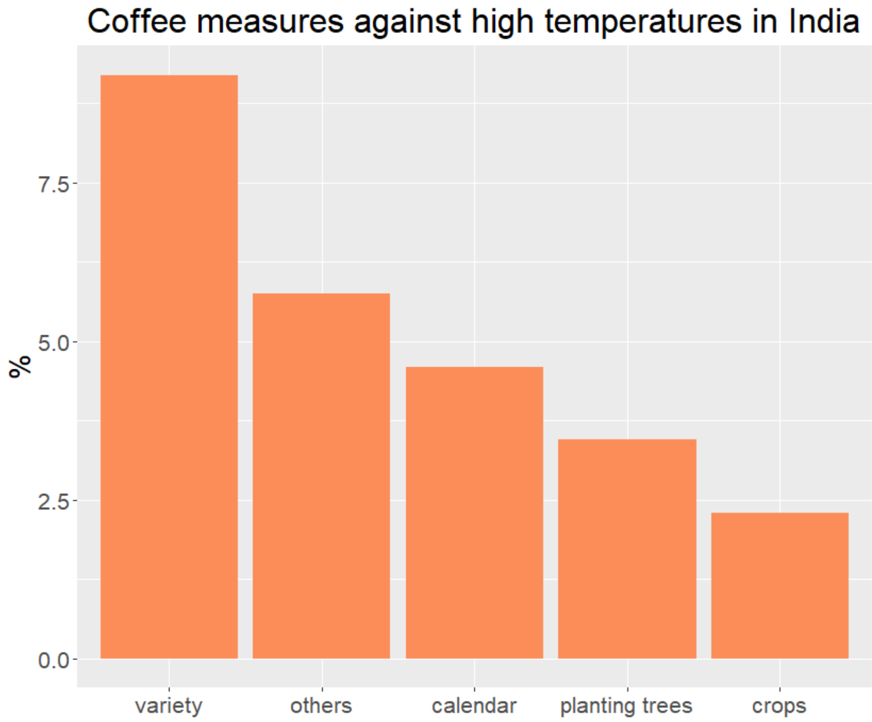


Figure 48 Measures taken by coffee farmers to mitigate the effect of high temperatures

Another issue presented to coffee producers was the impact of storms. The occurrence of severe storms did not affect as many producers as other factors. Most coffee producers do not take any measure to mitigate the effects of severe storms. Those that do either create a buffer or opt for agroforestry systems (Figure 49).

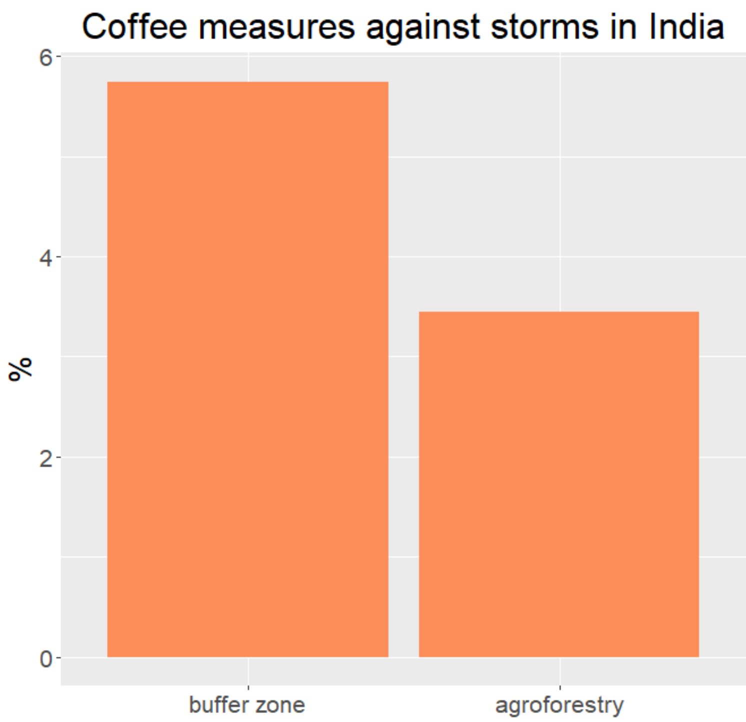


Figure 49 Measures taken by coffee farmers to mitigate the effect of storms

Pest and diseases commonly occur in coffee cultivation. Some areas around the world are more affected than others by diseases such as coffee rust (*Hemileia vastatrix*) or pests. Almost all coffee producers taking measures reported a conversion to organic pest management as a means to combat the effect of these pests and diseases (Figure 50). A similar number of respondents prune their coffee plantations to manage disease.

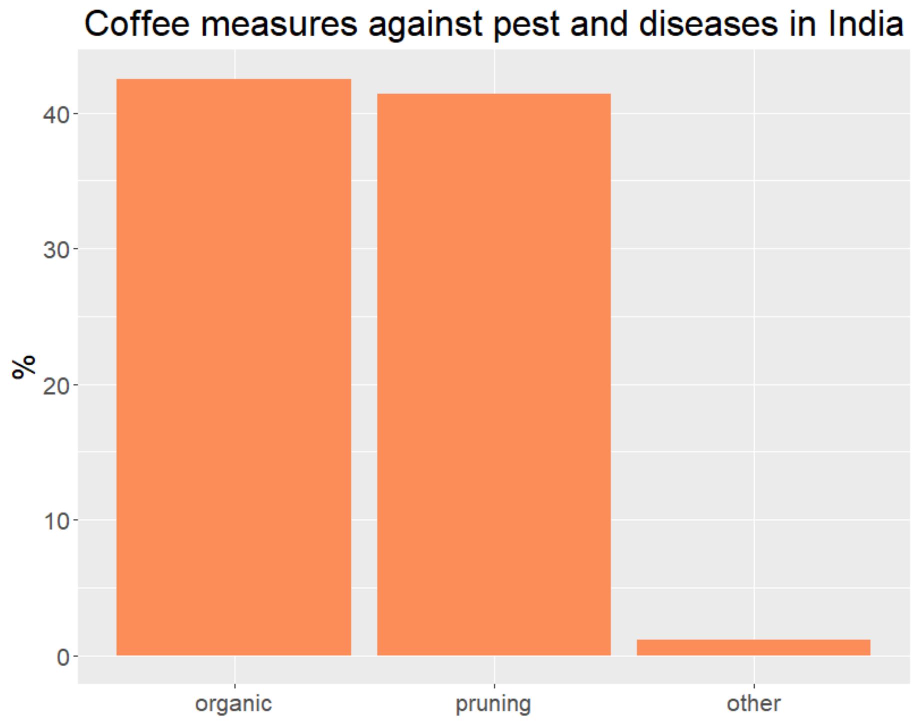


Figure 50 Measures taken by coffee farmers to mitigate the effects of pests and diseases

6.3.2 Tea

The 38 tea producers in the sample deal with similar issues as coffee producers. To mitigate the effect of droughts, most farmers take up several measures at the same time, in particular harvesting rainwater and irrigating their crop, using mulch, planting additional trees and protecting bodies of water to make sure they have access to water (Figure 51).

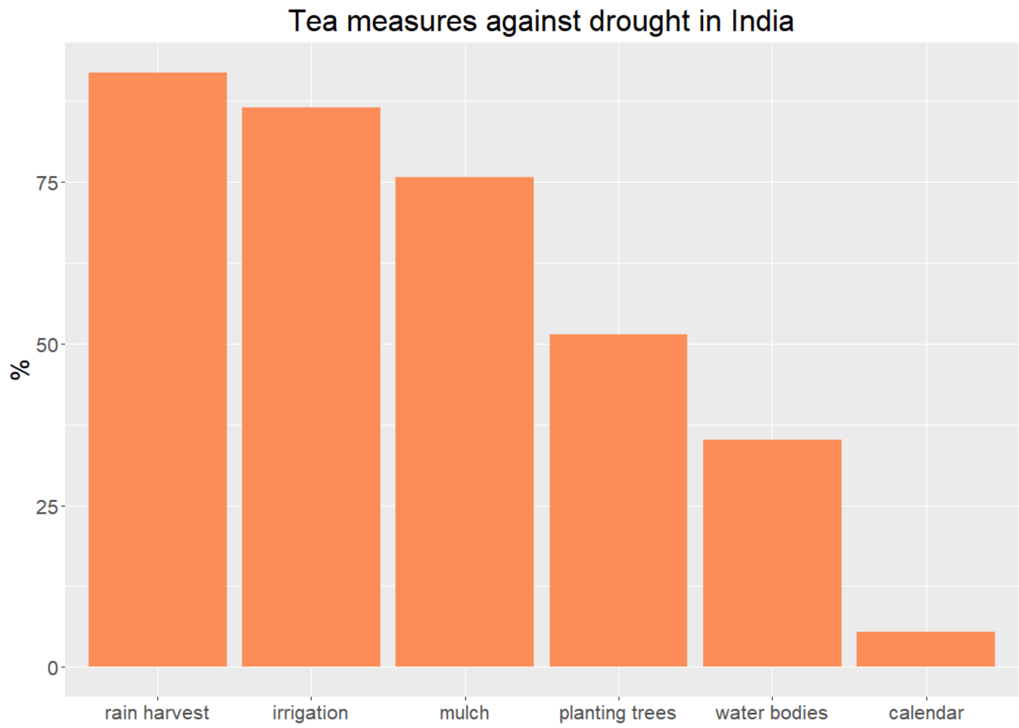


Figure 51 Measures taken by tea farmer to mitigate the effect of droughts

All of the respondents confirmed that they have planted additional trees as a measure to mitigate the effect of higher temperatures in their tea plantations (Figure 52). Very few have changed tea varieties or included other crops in their plantations.

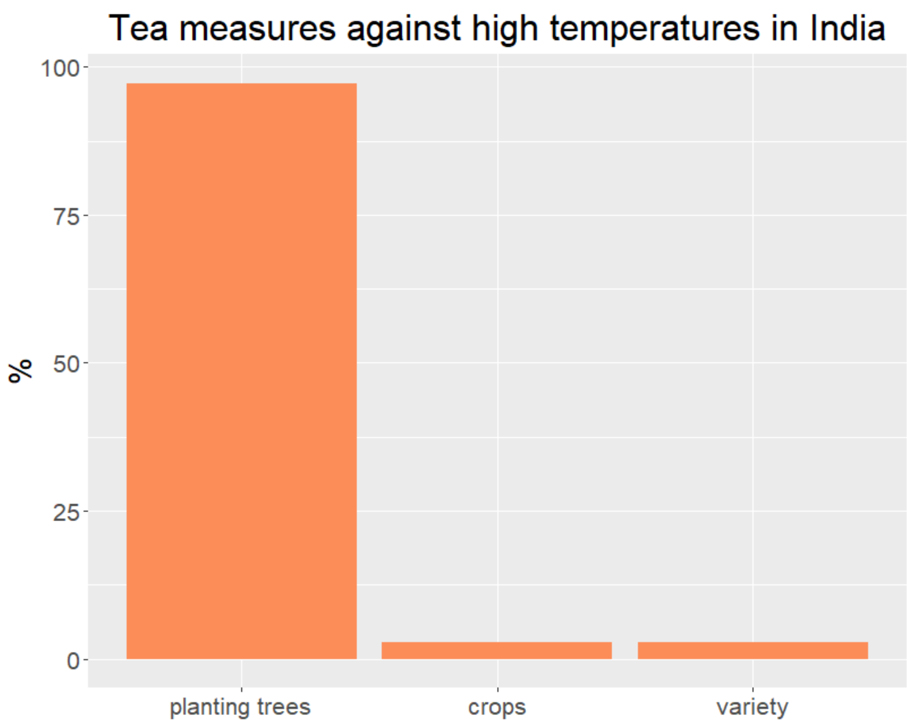


Figure 52 Measures taken by tea farmers to mitigate the effect of high temperatures

In the case of severe storms, tea producers rely on buffer zones and agroforestry systems to minimize impacts (Figure 53), similar to what is done in coffee plantations. Less than 10 producers have improved their drainage systems to prevent severe damage from storms.

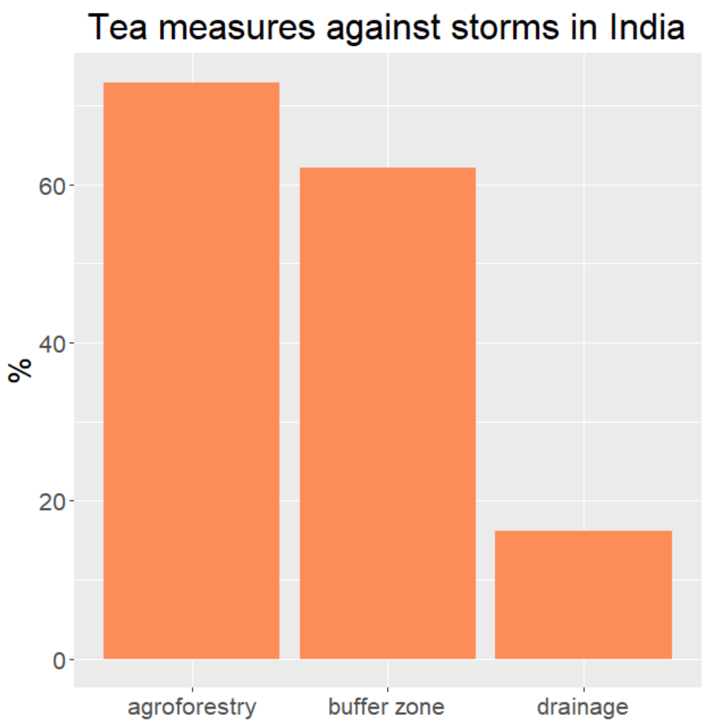


Figure 53 Measures taken by tea farmers to mitigate the effect of storms

As was the case with coffee producers, almost all of the tea farmers surveyed view organic pest management practices as the best mechanism to combat the effect of pest and diseases in their plantations. Over 20 report pruning as a measure to deal with pests and diseases and 10 respondents view integrated pest management (IPM) practices as the right approach to deal with plant health issues (Figure 54).

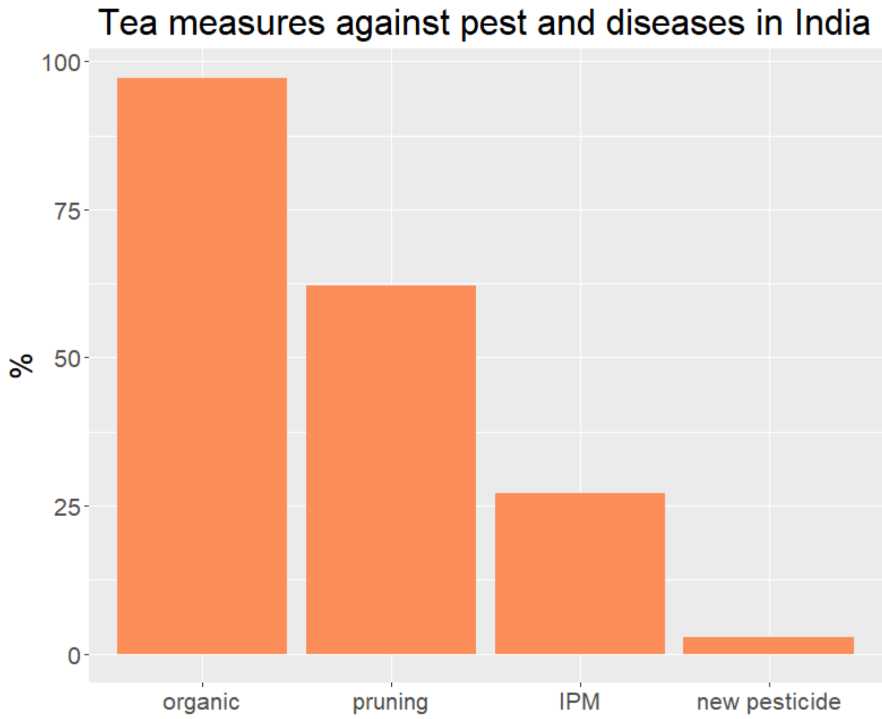


Figure 54 Measures taken by tea farmers to mitigate the effect of pests and diseases

6.3.3 Cocoa

The cocoa producers who were part of the sample reported the highest severity of impact of climate change (Figure 55). Out of the 11 respondents in the sample, most have planted more trees, used mulch and protected water bodies to cope with the effects of drought (Figure 55). Additionally, 2 cocoa farmers also harvest rainwater, planted other crops and had a change in their cropping calendars.

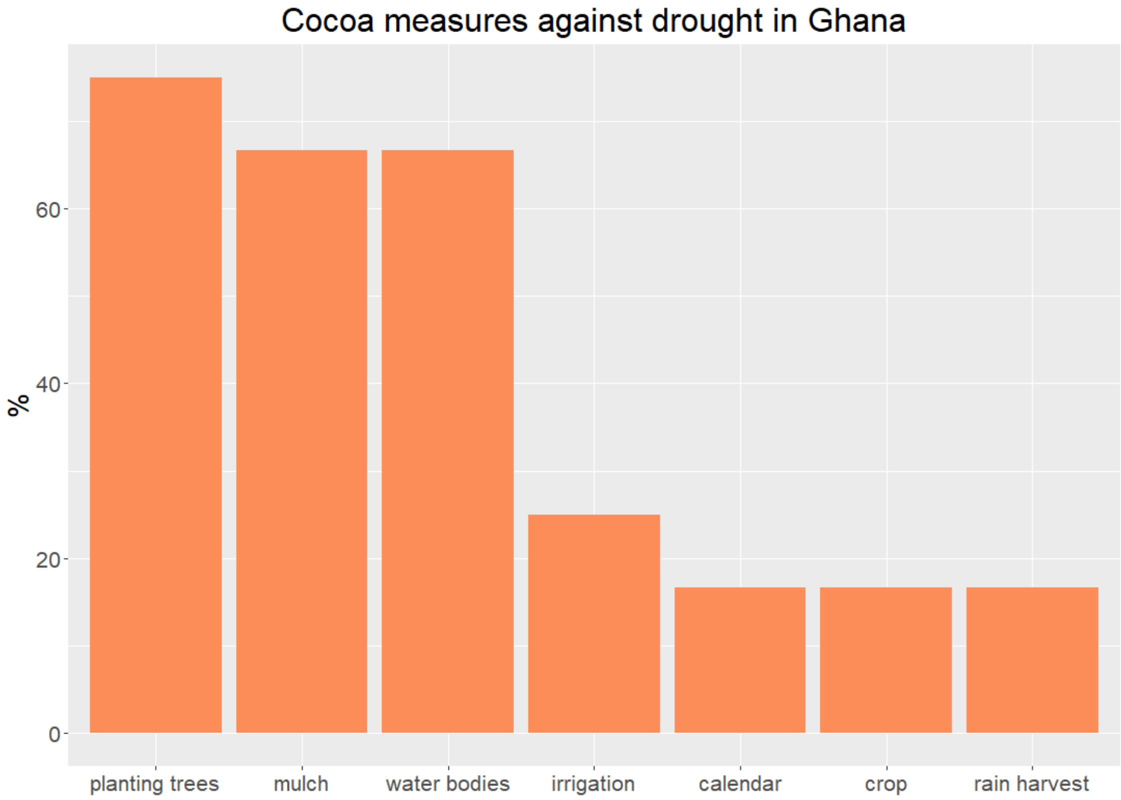


Figure 55 Measures taken by cocoa farmers to mitigate the effect of droughts

For cocoa farmers, planting trees is a measure commonly taken to mitigate the effects of high temperatures (Figure 56). Most of them reported planting new trees. Fewer have actually upgraded to other, more resistant varieties or implemented any change in the planting or harvesting calendars.

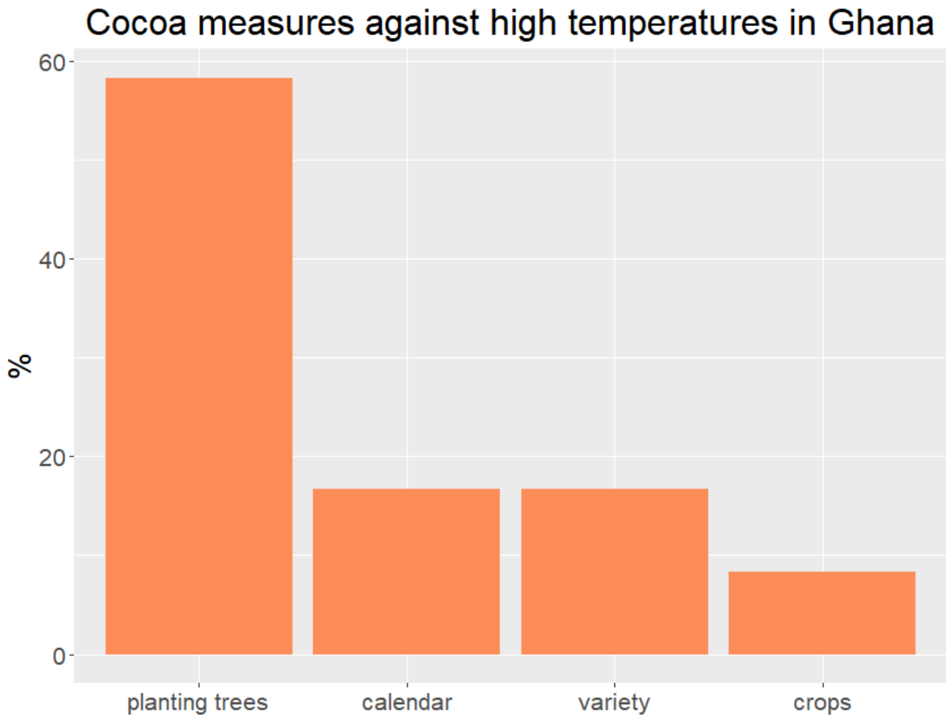


Figure 56 Measures taken by cocoa farmers to mitigate the effect of high temperatures

In the case of the impacts due to heavy storms, cocoa producers rely mostly on buffer zones, so their plantations will not be affected, or agroforestry systems which keep the cocoa trees protected from severe storms (Figure 57).

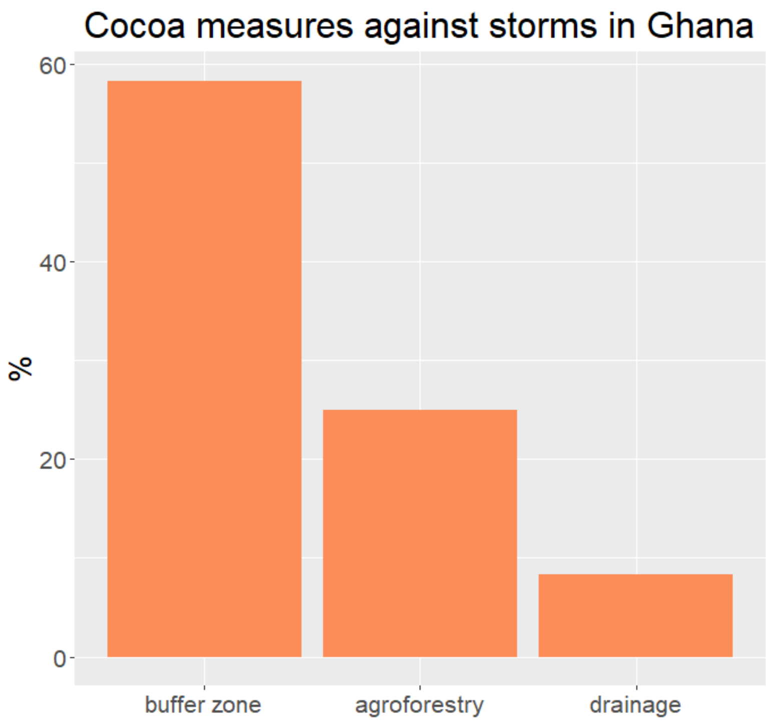


Figure 57 Measures taken by cocoa farmers to mitigate the effect of storms

Cocoa producers have several mechanisms to cope with the effects of pest and diseases. Over two thirds of the respondents regularly prune their cocoa trees or implement IPM practices in their plantations (Figure 58). Sanitary practices are also part of these measures. About 30% of the respondents in the sample are organic producers and rely on organic practices to cope with pests and diseases. Roughly 10% use new pesticides or previously used pesticides.

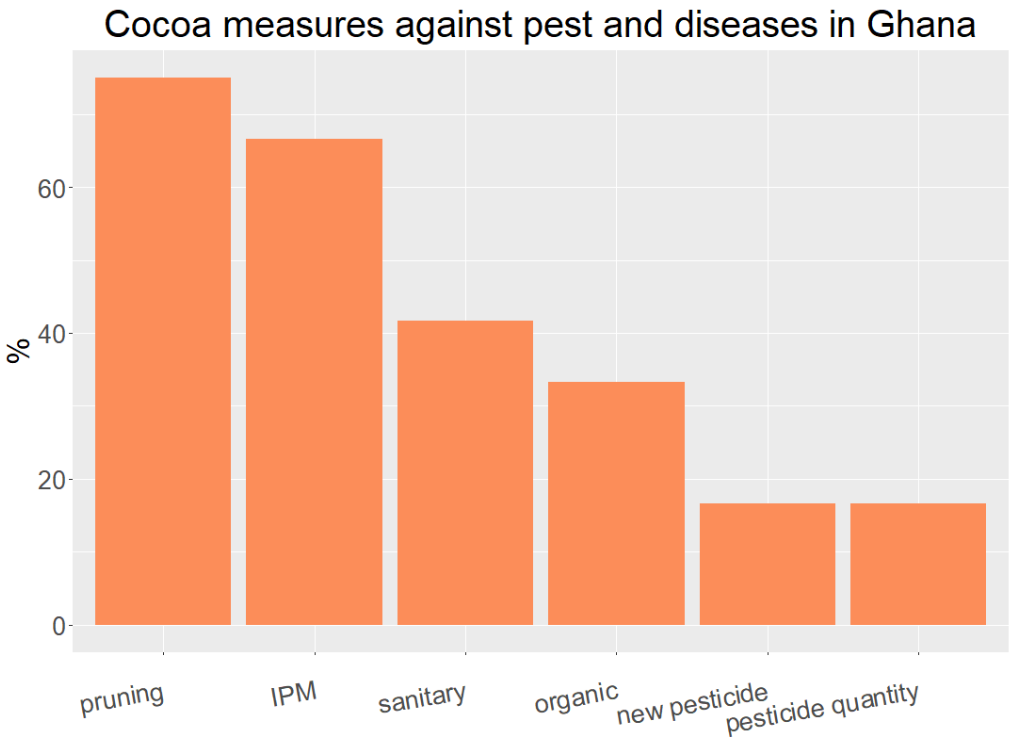


Figure 58 Measures taken by cocoa farmers to mitigate the effect of pests and diseases

6.3.4 Spices

Out of all the farmers surveyed, 18 produced spices. Producers use mulch (16), harvest rainwater (15), use irrigation (14), plant new trees (12) or protect water bodies (8) for conservation (Figure 59).

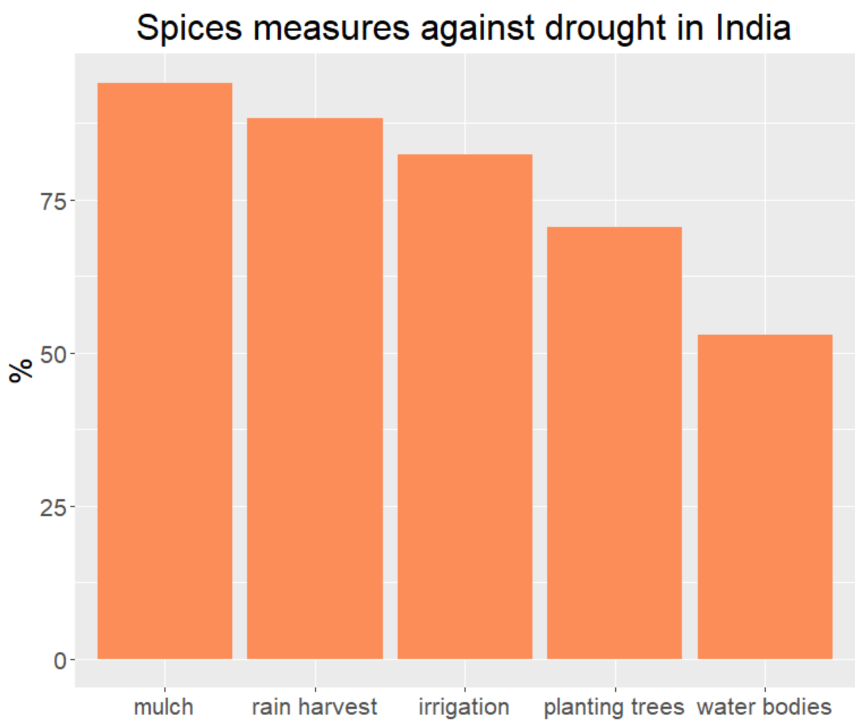


Figure 59 Measures taken by spice farmers to mitigate the effect of drought

In the case of high temperatures, spice producers plant new trees to mitigate the effect and that seems to be the main measure taken by them.

Likewise, in the case of severe storms, spice producers had little to report. Only a handful of the producers reply on agroforestry systems or buffer zones to mitigate the impact of storms, most of them do not take any measure.

Spice producers seem to take more measures to deal with pests and diseases than to manage the other climate change impacts discussed (Figure 60). Most in fact rely on organic agriculture as their main strategy to deal with pests and diseases. Good agricultural practices, such as pruning the crops, is a measure implemented by most of the producers.

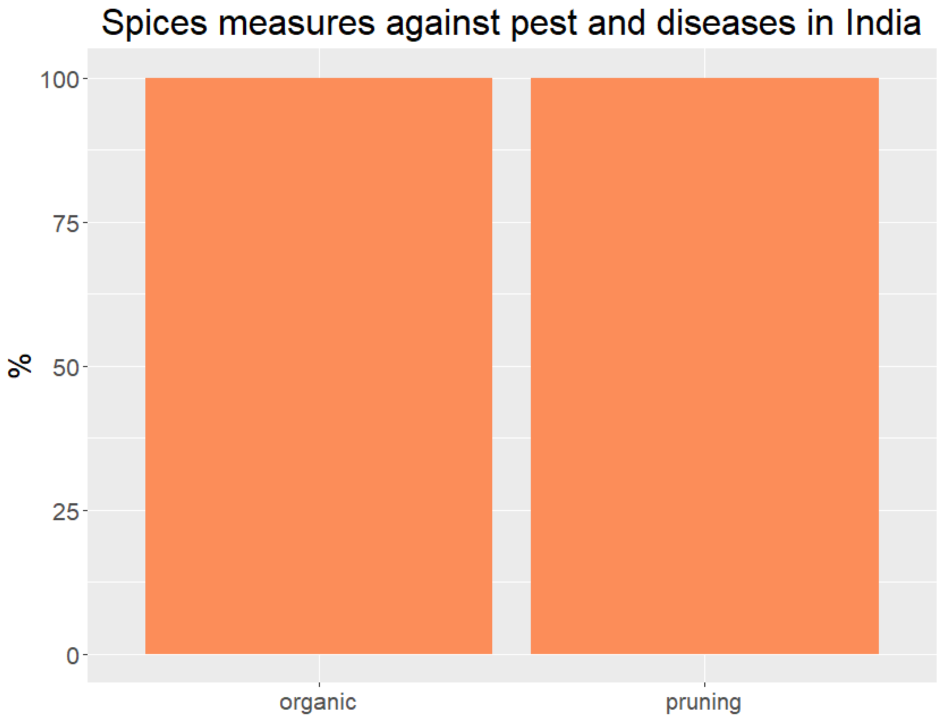


Figure 60 Measures taken by spice farmers to mitigate the effects of pests and diseases

6.4 Changes in agricultural practices

The farmers in the sample (n= 136) were asked if they had implemented any changes in their agricultural practices. First of all, they were asked if they had replaced their main crop as a result of climate change impacts. Only a minority of respondents (10%) reported a change in their crops, while 24% did not respond to this question. Particularly in the case of cocoa farmers, some reported changing to new hybrid varieties. In one case, a farmer replaced maize for cabbage and another farmer mentioned cultivating plantain instead of cassava.

Furthermore, farmers were asked about specific agricultural practices which could help them cope with climate change impacts, such as agroforestry systems, intercropping and changing to organic or non-organic practices (Figures 61 and 62). In India, intercropping was the preferred change in agricultural practices, closely followed by agroforestry. For Ghana, this is similar but reversed—trees are more important than annual crops when intercropping cocoa. It is also worth mentioning that many farmers took up organic practices to cope with climate change. Only in a specific case did a farmer mention changing to non-organic practices.

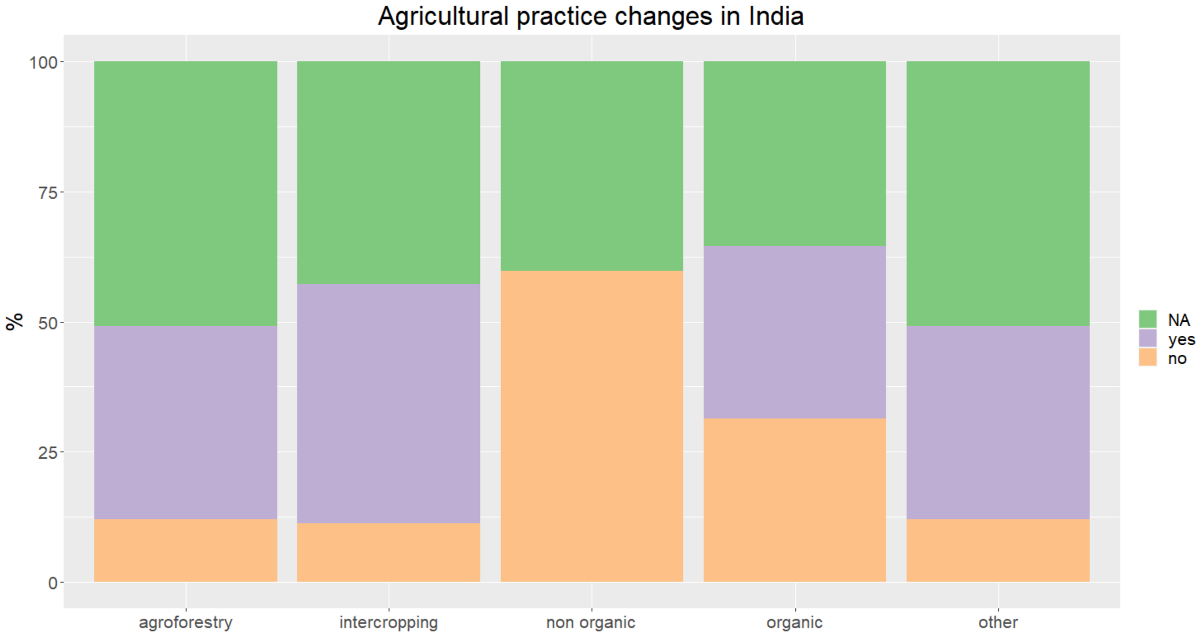


Figure 61 Type of agricultural practices changed in India (n=125)

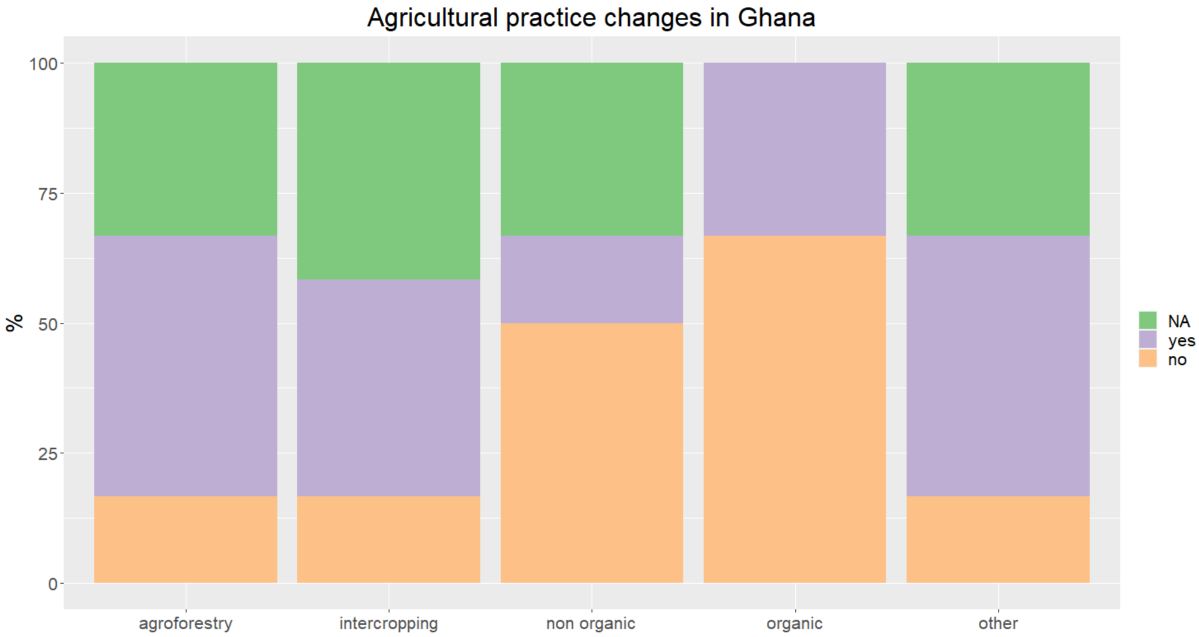


Figure 62 Type of agricultural practices changed in Ghana (n=11)

6.4.1 Organic agriculture

Farmers were then asked to indicate what their motivation to change to organic practices was. Only 33 out of the total of 136 farmers made this change. Most of the farmers had already had an experience with organic agriculture (27%), had general interest on organic agriculture (18%), had concerns about the environment (15%) or considered it good (12%).

Table 7 Reasons of farmers to change to organic agriculture

Reasons to change to Organic Agriculture	Total (n=33)
Already experienced organic agriculture	9
Interest in organic agriculture	6
Environmental concern	5
Human health	5
Considered good	4
Curiosity about difference	3
Soil concern	2
Monocropping	1
Mitigate climate change	1
Reduced pesticide use	1
Quality	1

Three farmers cited reasons for not changing to organic agriculture, which included difficulty to implement organic agriculture in a single farm, lower production costs of conventional farming and higher productivity in non-organic farming.

6.4.2 Intercropping

When discussing changes implemented at the farm level, respondents mentioned intercropping as the main change they have introduced in recent years to mitigate climate change effects. At least 37% have implemented these changes. Most of the intercropping varieties introduced are spices (Table 8), especially pepper and turmeric, but also ginger. These species are intercropped with coffee, mostly in India. One farmer in Ghana reported intercropping with maize, cassava, cocoyam and yam. The main reasons cited for implementing changes were to reduce the pressure of pest and diseases and to have an additional income in the farm.

Table 8 Crops used for intercropping

Crop	Total (n=50)
Pepper	22
Turmeric	17
Ginger	4
Maize, cassava, cocoyam, yam	1

Table 9 Reasons for implementing intercropping

Reason	Total (n=9)
Reduce pressure of pests and diseases	8
Additional income	3
Higher production	2
Crop biodiversity	1
Improved food security	1

6.4.3 Agroforestry

In terms of changes implemented to mitigate climate change effects, agroforestry systems offer an alternative to close to a third of the farmers in the sample. Some farmers consider this to be a good alternative for shade and soil protection (Table 10). The species of trees commonly used in agroforestry systems are jackfruit, mango and silver oak (Table 11).

Table 10 Reasons for implementing agroforestry systems

Reason	Total (n=13)
Shade	5
Soil protection	5
Additional income	1
Mitigate climatic change	1
Crop diversity	1

Table 11 Trees used in agroforestry systems

Tree	Total (n=12)
Jackfruit	11
Mango	6
Silver oak	2

6.5 Finances

Finances were also discussed with the farmers. In order to understand how farmers can cope with climate change impacts, it was important to discuss the options for investing in their farms. To assess if the farmers have sufficient income for such investments, questions were asked about income, investments and access to credit.

6.5.1 Farm investment

Farmers were asked which investments were made in the farm, which could help them cope with any climate change impact. Out of the 35 who confirmed they had made investments, 14 had acquired new technology or equipment or invested in farm inputs (Table 12). They mentioned farm inputs mostly as a measure to increase productivity.

Table 12 Type of farm investments

Investment	**Total** (n=35)
Technology and equipment	14
Farm Inputs	13
Farm expansion	5
Planting trees and vines	5
Labor	4
Diversify production	3
Crops	1
Training	1

Nevertheless, 27 farmers reported not being able to afford any investments in their farm. They consider farm inputs or renovating or planting new trees as non-affordable investments (Table 13). Farmers did not have enough income for these specific farm investments.

Table 13 Non-affordable investments

Non-affordable Investments	Total (n=27)
Farm inputs	8
Technology, equipment	7
Planting trees	4
Crop diversification	3
Farm expansion	3
Labor	2
Irrigation	2
Animal husbandry	1
Rainwater harvester	1
IPM and organic	1

6.5.2 Access to credit

Credit access may be a limitation for farmers who wish to invest in their farms. To assess this barrier, farmers were asked about the most accessible source of credit. Most reported money lenders as a main source of credit as well as village savings and loans associations and family members (Figure 63).

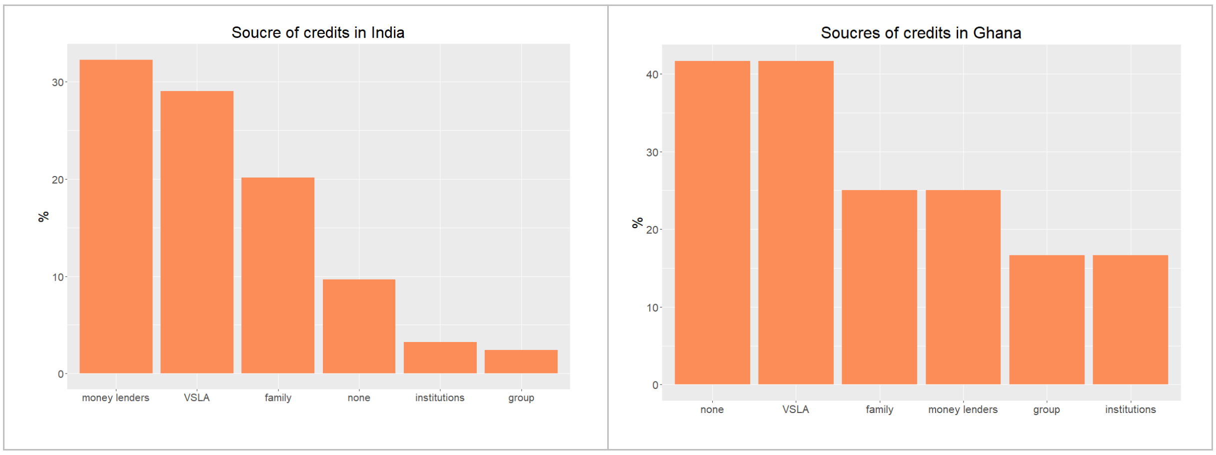


Figure 63 Sources of credit (*left* India, *right* Ghana). VSLA=Village Savings and Loan Association

Farmers reported asking for credit after facing some climate change impact, mainly for drought and floods, but also for pest and diseases (Figures 64 and 65).

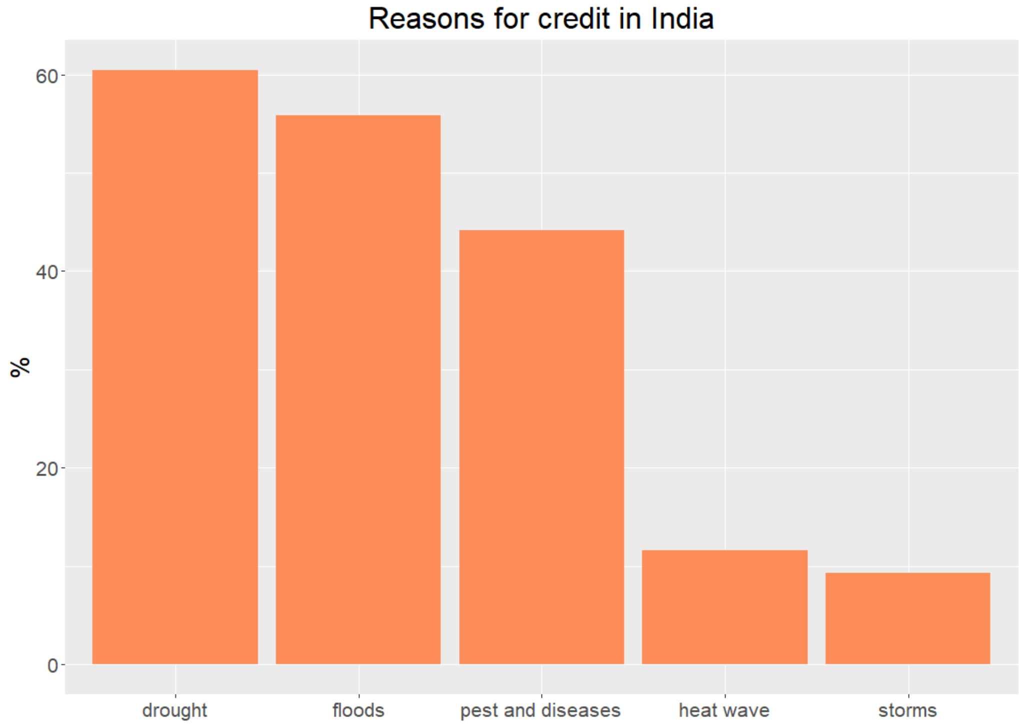


Figure 64 Reasons for credit in India

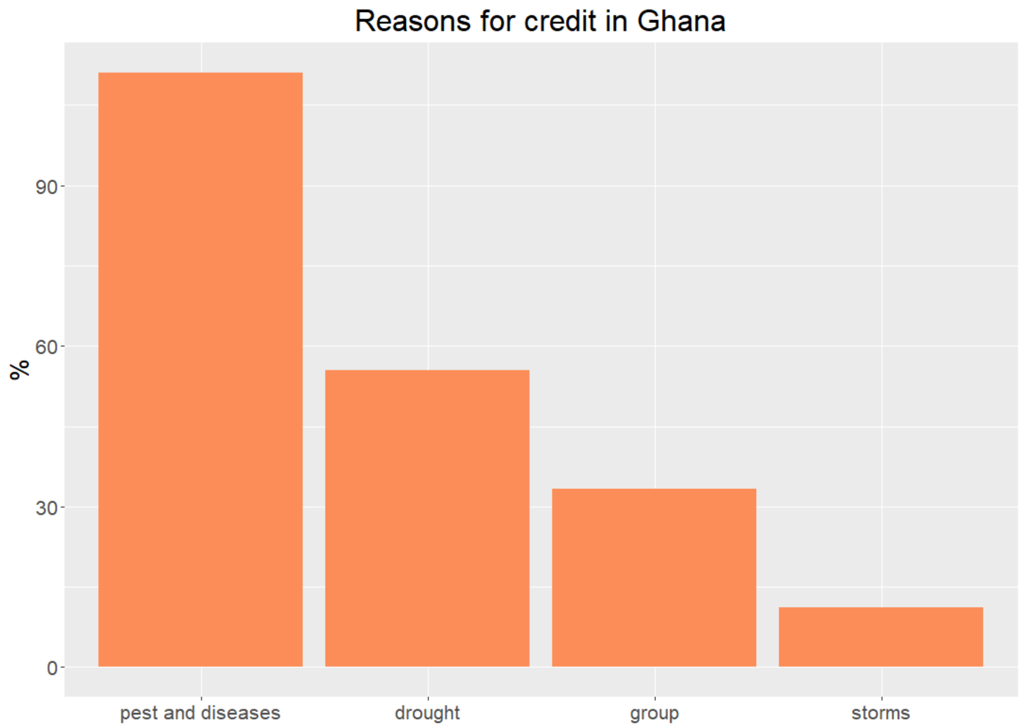


Figure 65 Reasons for credit in Ghana

6.5.3 Covid-19 impact

At the onset of the study, no questions regarding the COVID-19 pandemic had been contemplated but these were incorporated afterwards. The pandemic affected farmers around the world and challenged food systems in many ways. When asked what the impacts of the COVID-19 pandemic were, most farmers reported a shortage of labor and transport possibilities, as well as marketing. Some producers reported health issues in their families and the lack of alternative income-generating activities as a main impact (Table 14).

Table 14 Covid-19 impacts

Type of Impact	Total (%)
Labor shortage	39
Transport	16
Marketing	15
Health	11
Alternative income-generating activities	8
Finance	4
Harvesting	1
Child labor	1
Higher household expenses	1
Decreased productivity	1
Fear	1
Access to training	1
Inflation	1
Change in the planting methods	1

6.5.4 Household income

Respondents were asked to evaluate their household income and the severity of climate change impacts on their income. They were presented with a 5-point scale and had to report if the impact was severe or not at all (Figure 66). Close to half of the farmers' report being in a severe situation, although it was more severe in 2019 than at the beginning of 2021. The data on the previous years was based on what the interviewees recalled.

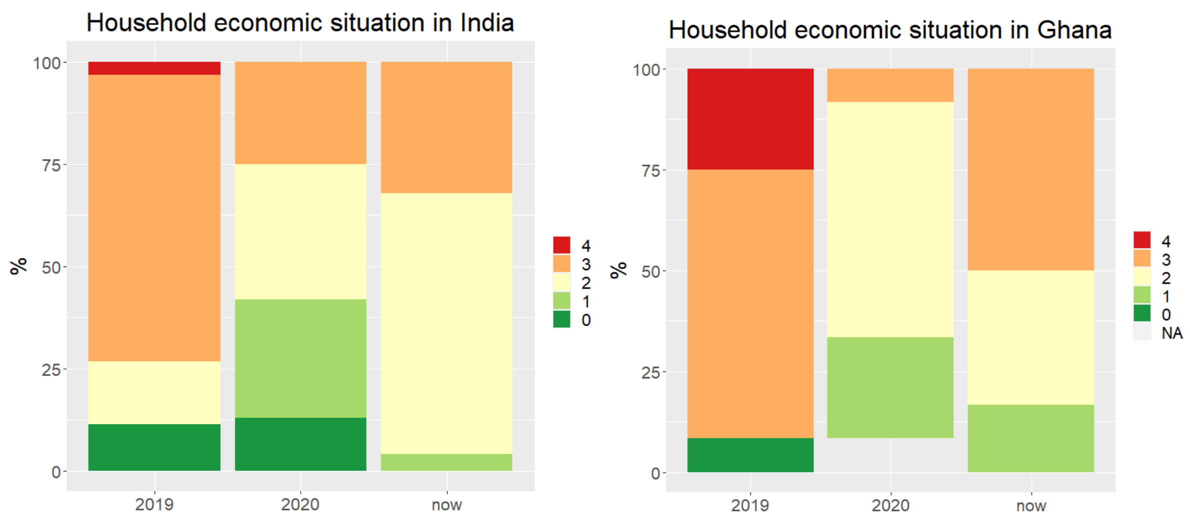


Figure 66 Household economic situation. N/A in 2020 in Ghana refers to some interviewees not recalling the situation for that year.

At least 60% of the farmers reported their crop as their main source of income. However, others need to rely on an additional off-farm salary, side business or remittances from relatives living in other areas of the country or abroad (Figures 67 and 68).

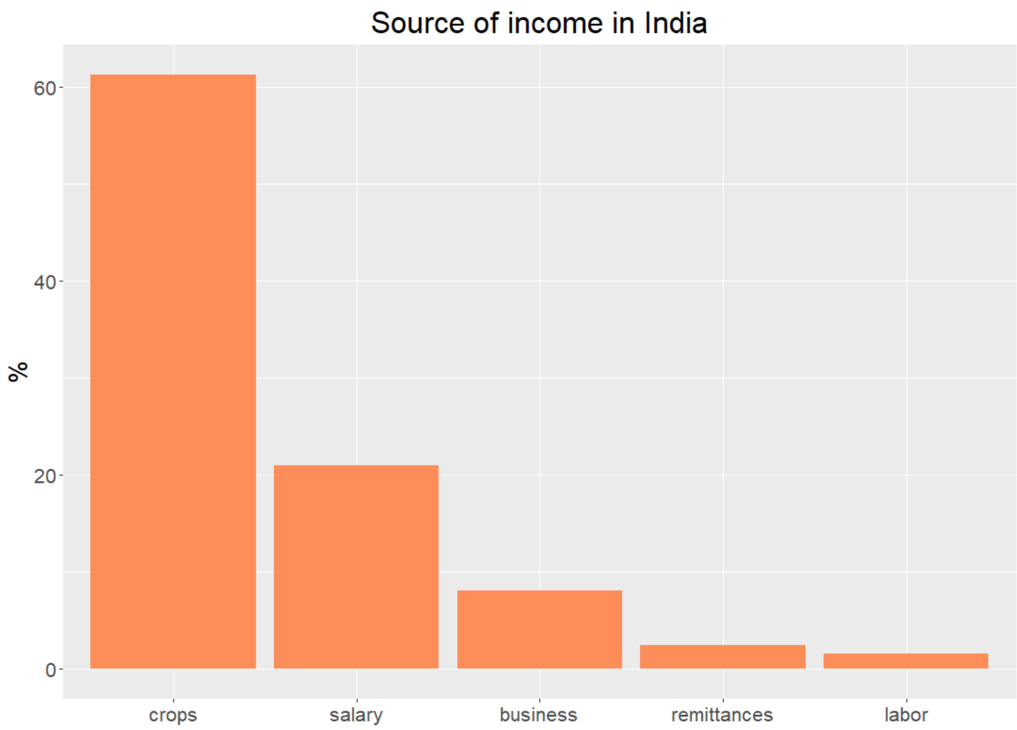


Figure 67 Sources of income in India

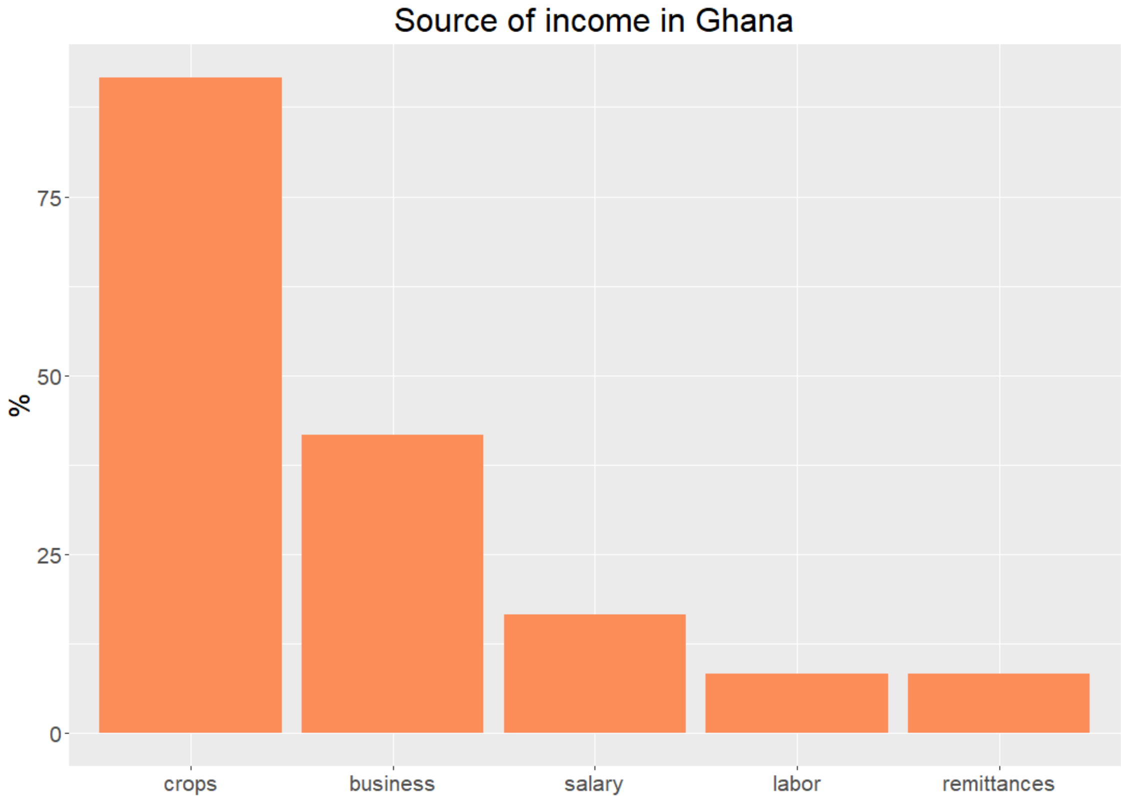


Figure 68 Sources of income in Ghana

6.6 Food security

The food security situation of the farmers was assessed by asking if there was any shortage in food availability as a result of a reduced harvest (due to climate change impacts) or other hazards such as a loss of income due to unforeseen events such as the COVID-19 pandemic. Many farmers reported shortages in food due to loss in harvest, climate change hazards (such as extreme floods or storms) and other reasons. These included one farmer reporting loss due to bush fires.

6.7 Adaptation to climate change impacts

6.7.1 Risk perception

Adaptation to climate change impacts was assessed by asking farmers their perception of future risks. Response options included no perceived risk, low risk, medium risk or high risk. In terms of risks, respondents were asked to assess:

- Land degradation
- Land tenure
- Access to seeds / seedlings/ cuttings
- Changing precipitation patterns
- Availability of water
- Pests and crop diseases

- Change of temperatures

Respondents reported a higher level of risk (medium to high) for high temperatures (50%), followed by higher risk level to changing precipitation patterns and availability of water (Figures 69 and 70).

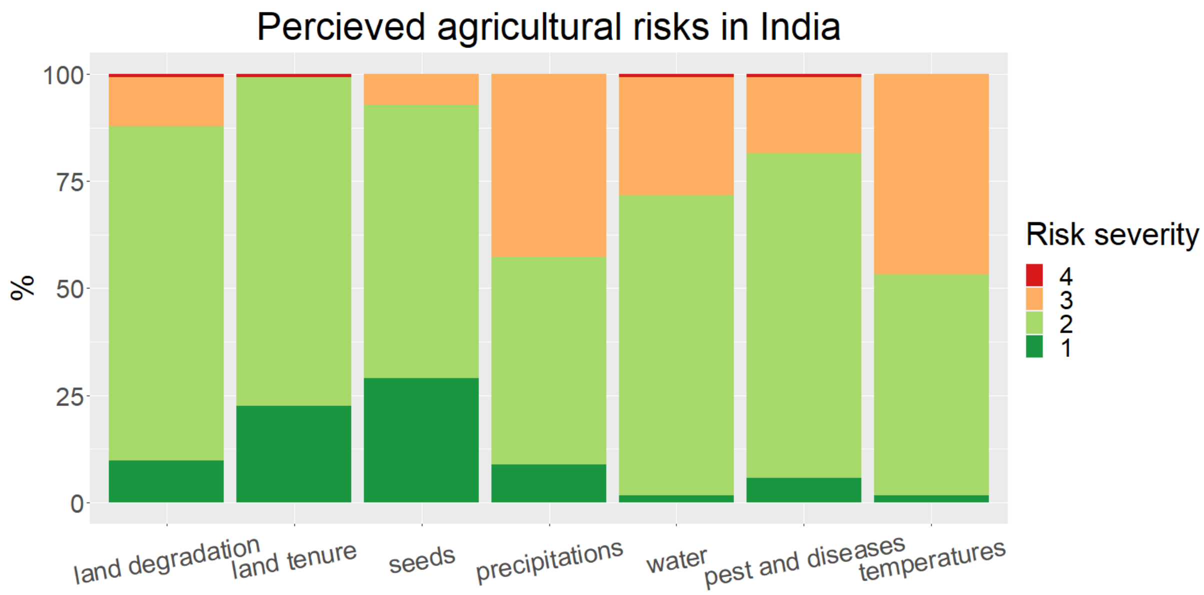


Figure 69 Perceived agricultural risks in India

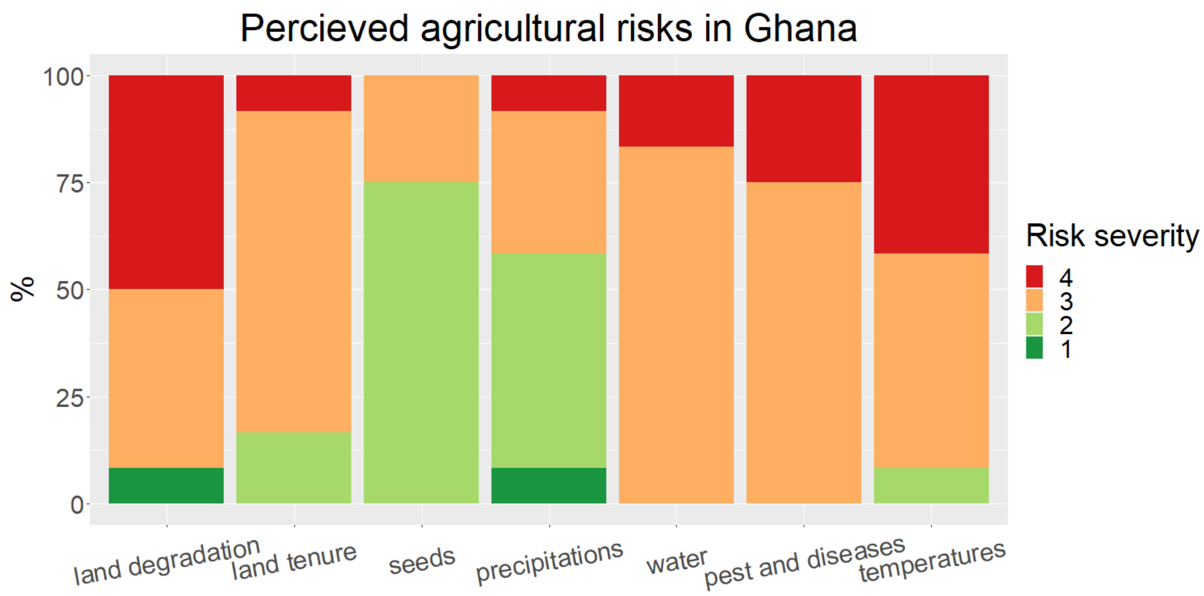
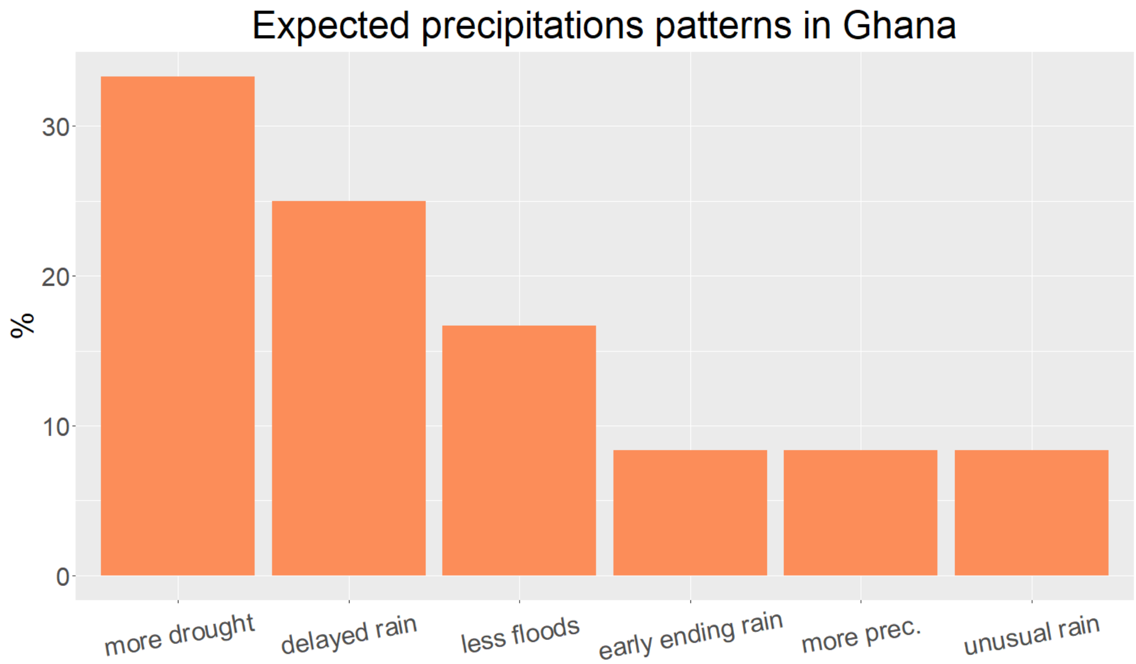


Figure 70 Perceived agricultural risks in Ghana

6.7.2 Precipitation

In the case of changing rain patterns, farmers were asked if they could give their perception of how these patterns are changing. Thirty-six respondents reported no change in rainfall patterns, but 64% have perceived changes like: more precipitation, more droughts, more floods, a delay in the start of rainy season or the rainy season ending earlier (Figure 71).



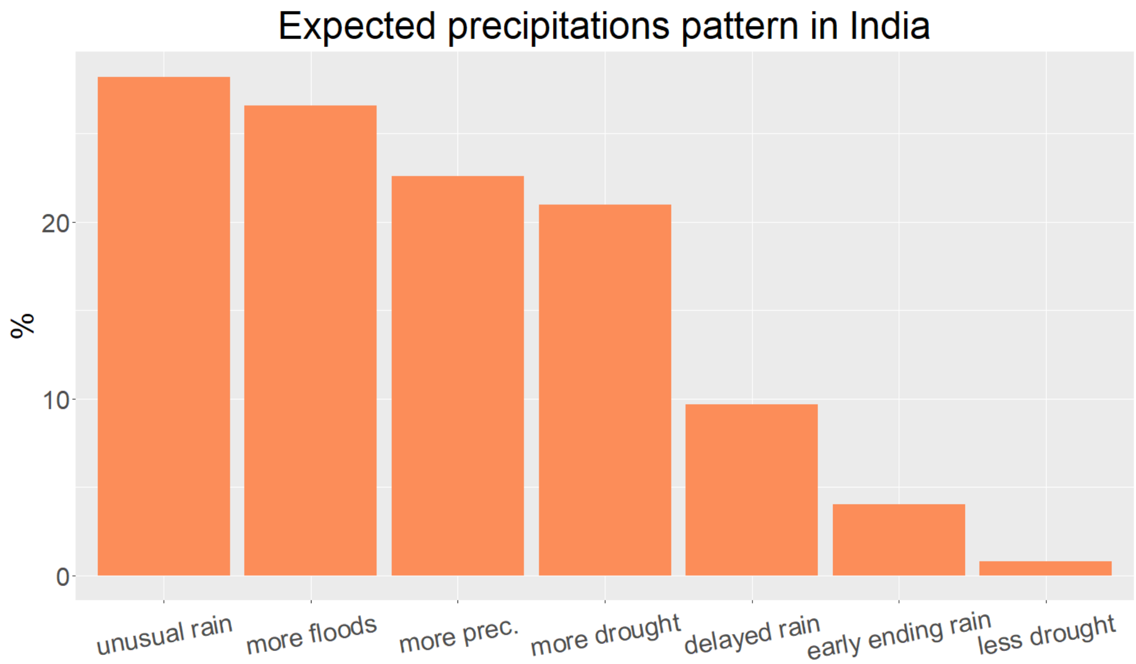


Figure 71 Change in precipitation patterns in India (above) and in Ghana (below)

6.7.3 Pests and Diseases

Pest and diseases in plants are also perceived by farmers and a risk and the management of these issues is becoming more difficult. Out of the respondents who perceive this risk, many affirm that the traditional knowledge they have used to cope with pest and diseases is no longer effective. Others report problems such as the lack of financial means to combat these issues or pest resistance as major issues (Figure 72).

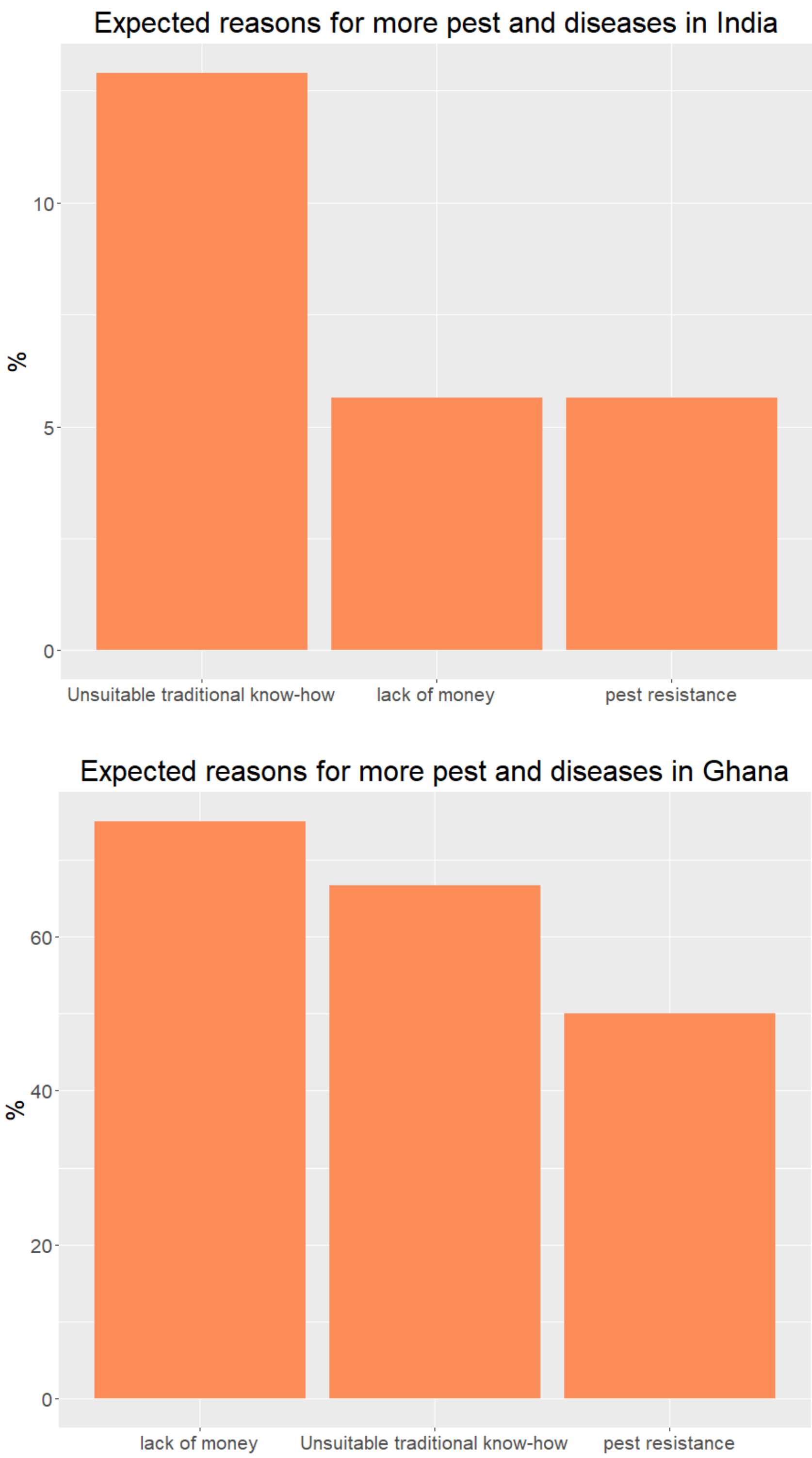


Figure 72 Pest and diseases

6.7.4 Economic Aspects

The economic risks perceived by the farmers are mostly medium. In terms of labor shortages, insufficient income and bad access to markets, most of the sampled farmers view this risk as medium to high (Figure 73).

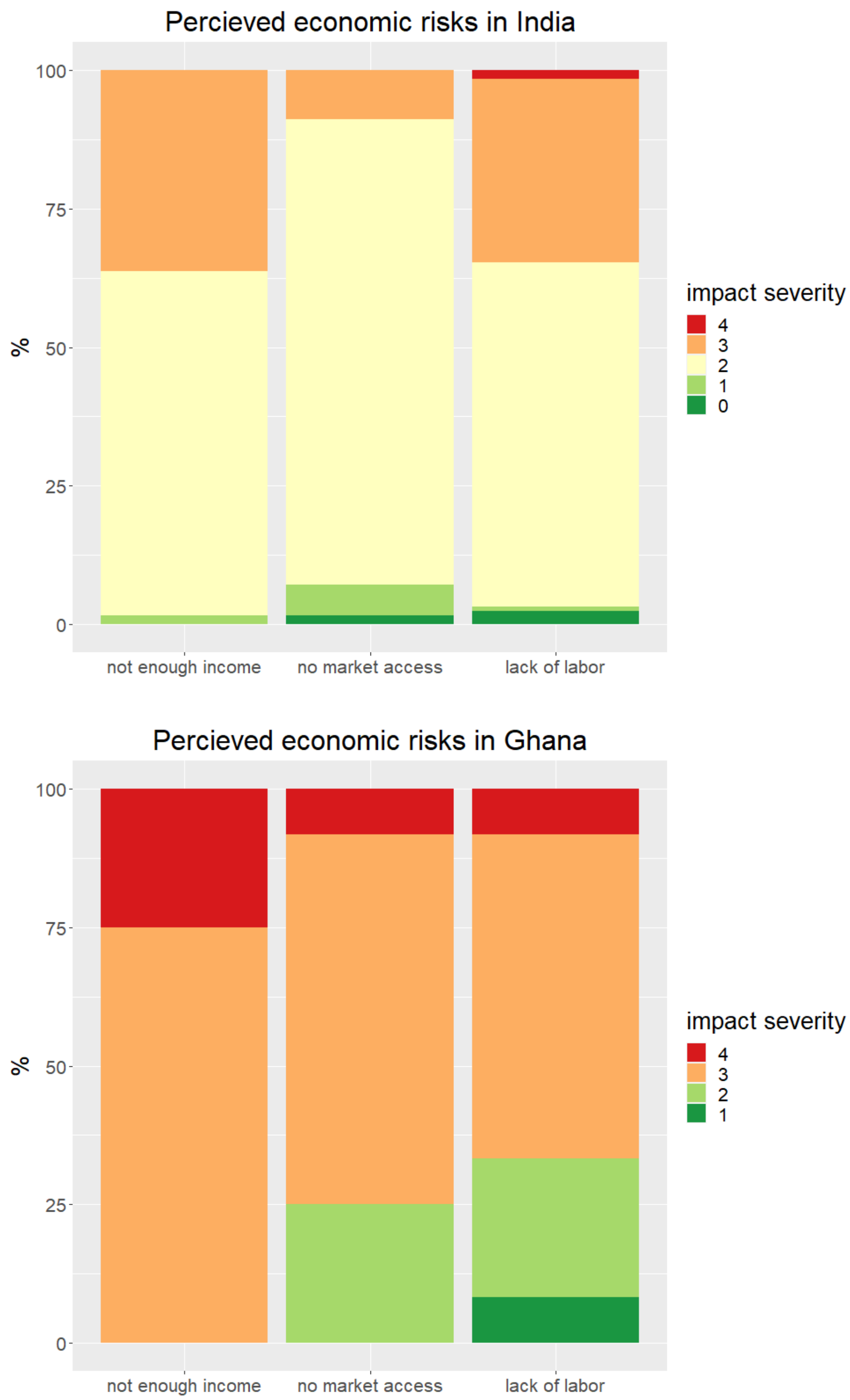


Figure 73 Perceived economic risks

Nevertheless, farmers do perceive a high-risk level when it comes to their health (this is likely an effect of the pandemic), the household food security (medium to high risk) and political situation (Figure 74).

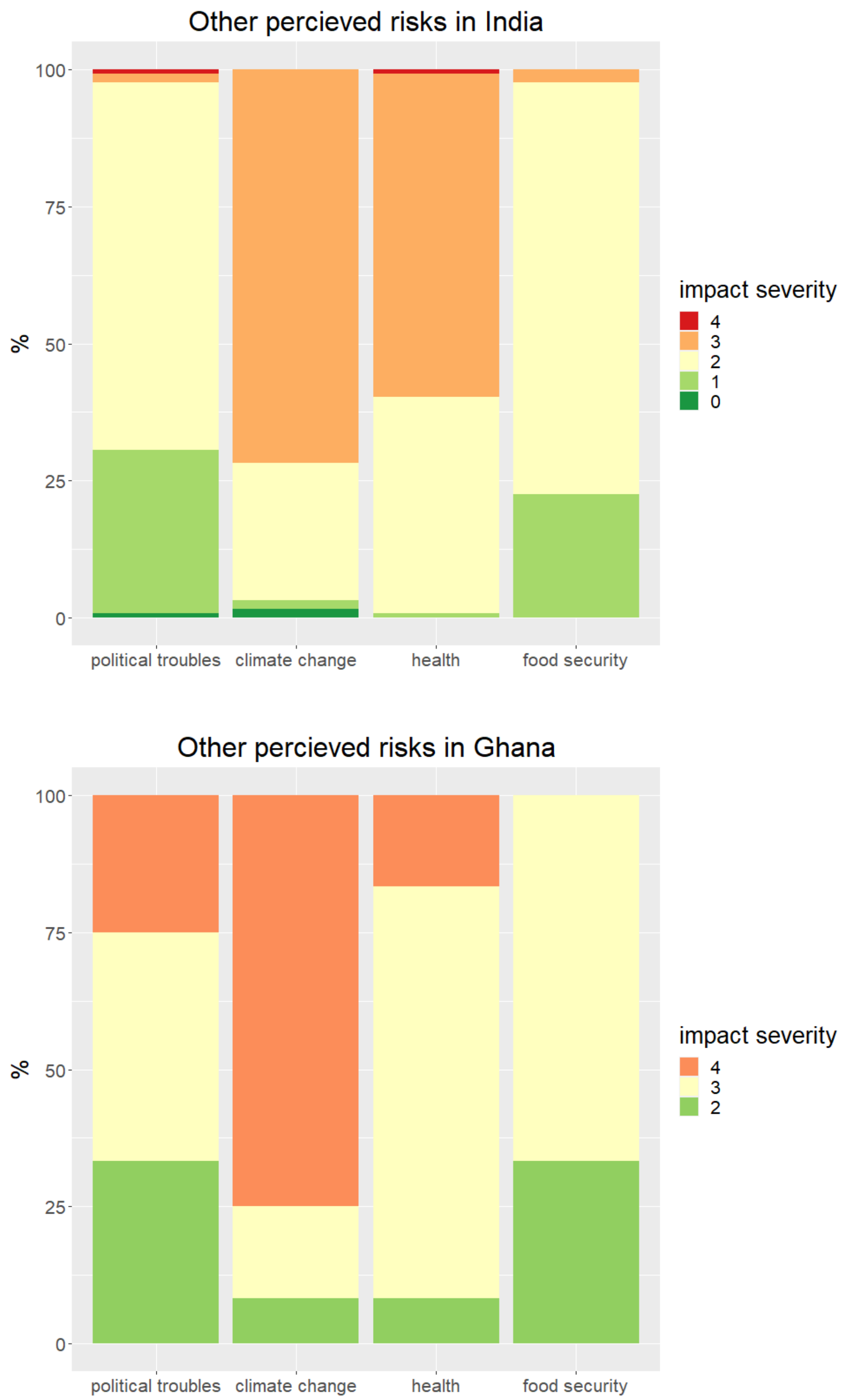


Figure 74 Other perceived risks in India (above) and Ghana (below)

6.8 Weather information

Farmers were asked where they source climate or weather information. They were also asked to give their views on other means of accessing weather information. The three main sources of weather information for the producers in the sample were televisions, smartphones and newspapers (Figures 75 and 76). Community information or extension services were not used as often, and it was the same for the Fairtrade producer organizations.

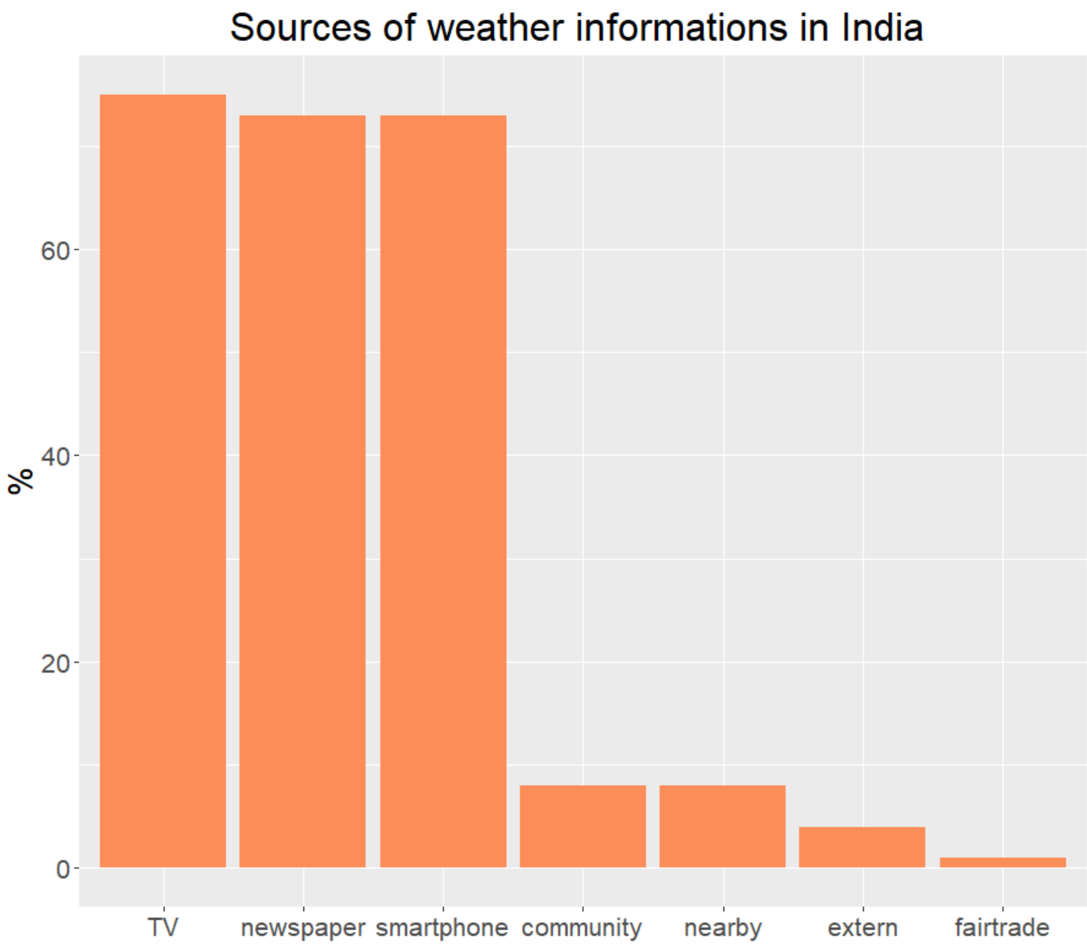


Figure 75 Sources of weather information in Ghana

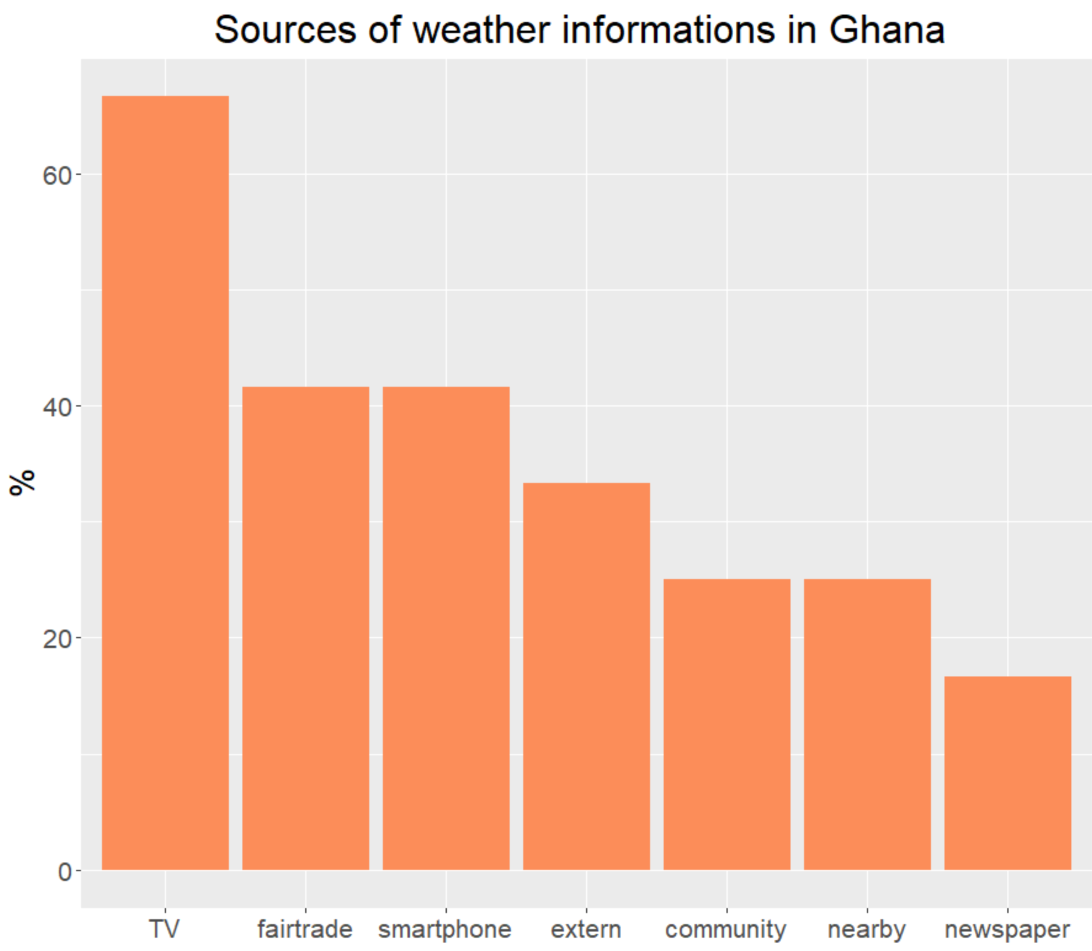


Figure 76 Sources of weather information in India

Farmers were also asked if there was information to which they wished they had more access. Most answered that they would like to receive information on government subsidies, market aspects, health issues and on crops, such as seeds, fertilizers and the use of pesticides. For all of these aspects, the need for more information was equally high.

Based on the survey conducted, it can be concluded that farmers are aware of severe changes that also demand a shift in their agricultural practices and livelihoods. Farmers are aware of these transformations in a changing social, political, economic and health context which can affect their food security. The degree of changes in practices and the responses given varies considerably. Nevertheless, the need for further trials, further adaptations in agricultural practices, and further experiences come alongside economic needs intensified by the unstable context related to Covid-19.

7 Output V: Hotspot-specific literature review

To complement the survey carried out with Fairtrade producers in two regions (India and Ghana), additional literature was reviewed on the role of climate change for crop production specifically for these hotspots.

7.1 India

7.1.1 Climate

India's most important coffee and tea growing regions are located in the South and North-East. While these regions are suitable for both coffee and tea production, the majority of coffee is produced in the Southern regions (Karnataka, Tamil Nadu, Kerala), whereas the majority of tea is produced in the Eastern regions (particularly Assam). Karnataka Region alone accounts for 65% of total coffee production (https://josuma.com/production-today) in India. Its climate is classified as a tropical monsoon climate, shown for the example of Madikeri in Karnataka shown in Figure 77. At over 1000 meters above sea level (MASL), this region experiences average temperatures that range between 20 – 24°C throughout the year. Most of the precipitation falls during the monsoon season, from June to October.

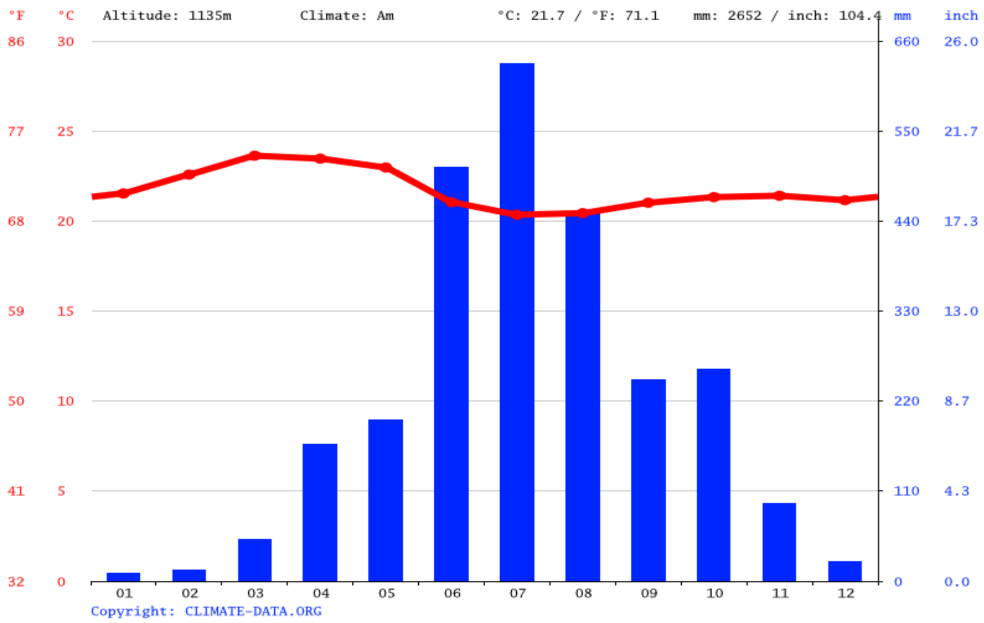


Figure 77 Climate diagram for Madikeri, Karnataka Region, India (source: climate-data.org)

Assam, which has a total of 312 210 ha of tea plantations and produces over 50% of tea in the country (www.indiatea.org/tea_growing_regions), includes different climatic regions. This includes the humid subtropical climate, prevalent for example in Jorhat, which houses India's largest tea research centre and is located below 100 MASL (Figure 80). Compared to the South, temperatures vary much more and range between 18 – 28°C. While total precipitation is more or less the same, rainfall is more evenly distributed throughout the longer monsoon season.

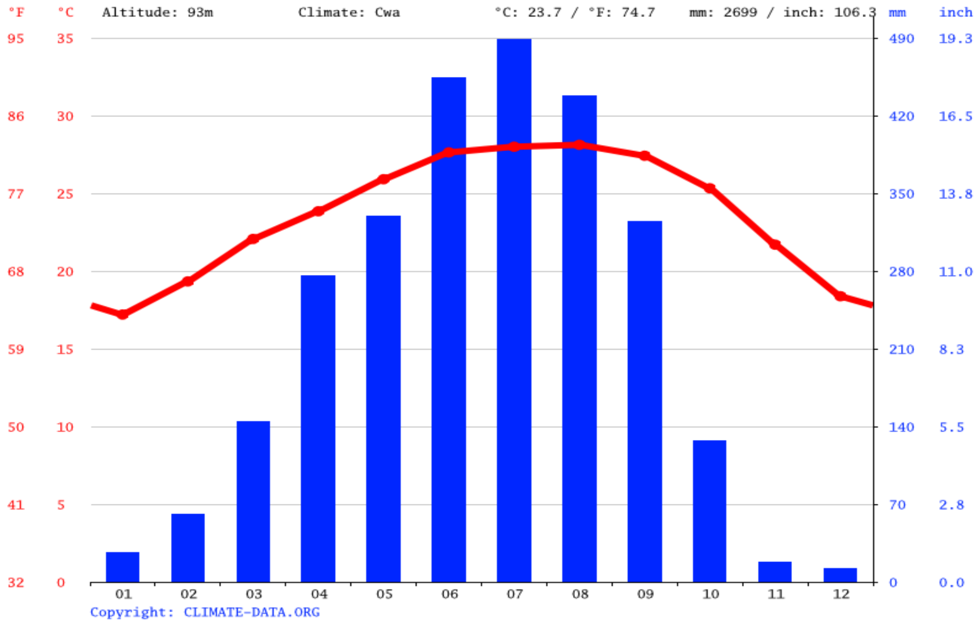


Figure 78 Climate diagram for Jorhat, Assam Region, India (source: climate-data.org)

7.1.2 Climate change scenarios for Southern India

Using the mean of global circulation models for the three climate change impacts (described in chapter 3), we can look into projected future trends for Southern India (Figure 79).

A considerable portion of Southern India will experience a decrease in consecutive dry days under both scenarios. Nevertheless, most of the coffee producers will experience up to 10 days more of consecutive dry days in the future under both scenarios. Most of tea producers will experience fewer CDD under RCP4.5, but all of them will experience up to 10 days more CDD under RCP8.5. Tea and coffee producers in Southern India will, however, be particularly impacted by increased heat stress. Nearly all producers will experience more than 30 additional days with extreme temperatures under both scenarios. At the same time, tea and coffee producers will experience a minor increase in days with heavy precipitation under both scenarios.

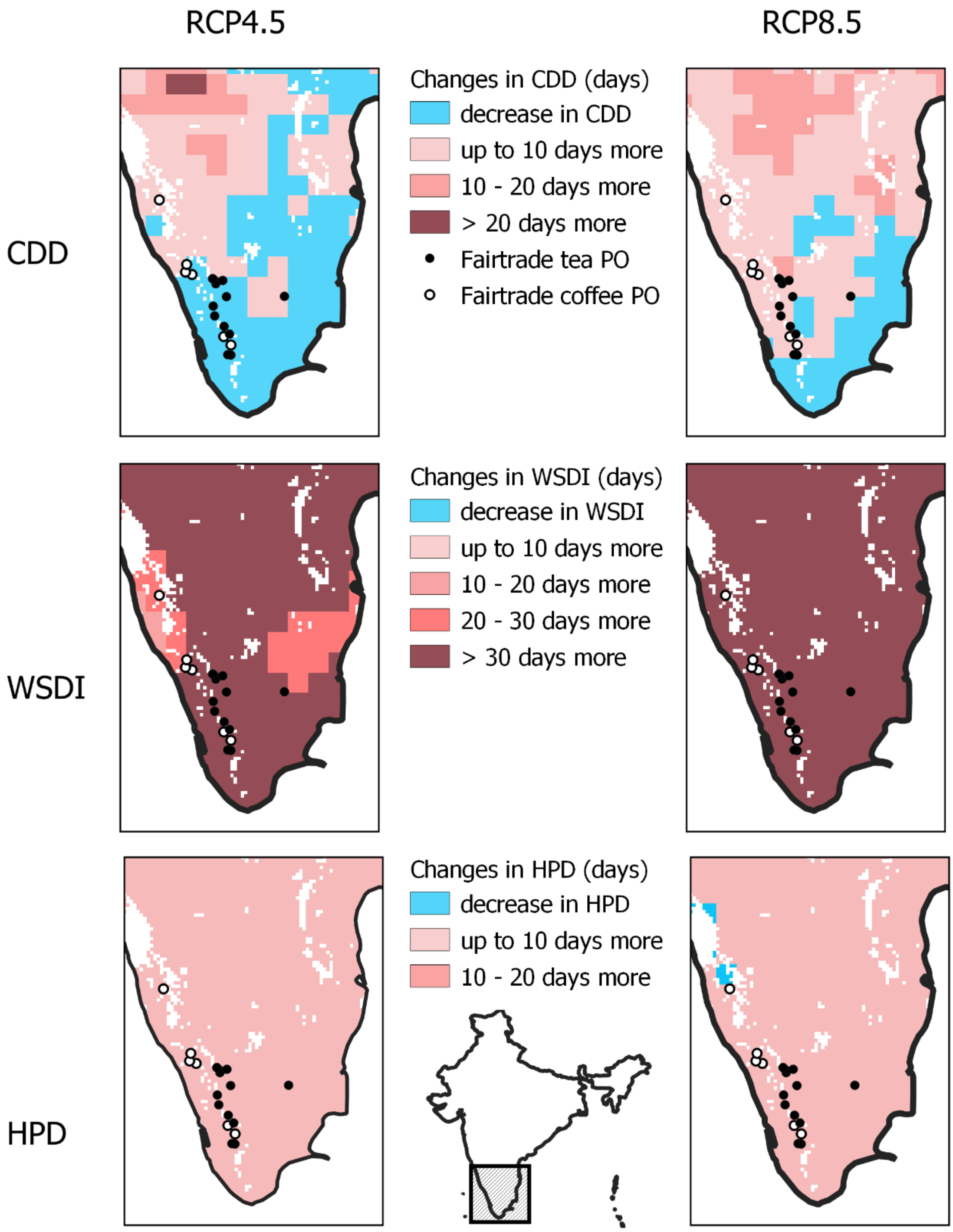


Figure 79 Changes in consecutive dry days (CDD), warm spell duration index (WSDI) and heavy precipitation days (HPD) for the coffee and tea producing areas in Southern India

7.1.3 Tea cultivation in India

Globally, a large number of studies have looked at the impact of climate change on tea quality, followed by tea yield, and a few studies have looked at climate suitability for tea (Jayasinghe and Kumar 2021). Tea is the most important commodity in India and provides livelihoods to millions of smallholders and agricultural workers. Considering the impacts of climate change and variability is therefore highly important. While in South India tea is produced throughout the year, the production season in the East starts in April and goes through to November (India Tea Association).

As outlined in chapter 3, tea is susceptible to changes in precipitation patterns and overall temperature increases linked to climate change. Increasing CO2 concentration in the air is positively correlated with tea yields (Jayasinghe and Kumar 2021). But yield declines can also be expected, especially due to high average temperatures above 26.6°C as well as erratic rainfall (Duncan et al. 2016). Especially lower lying areas, such as Jorhat in Assam (Figure 78), may become problematic if temperatures rise further due to climate change. Heatwaves were found to cause yield damages of up to 50% (Rao 2016). In addition to lower yields, declines in quality are much more concerning for tea. Quality is affected if there is increased precipitation during the main harvesting season between wet and dry seasons or prolonged dry spells. It was found that drought stress significantly altered chemical compounds in the tea leaves and reduced quality (Jayasinghe and Kumar 2021). Not surprisingly, even distribution of rainfall and water availability are important factors in tea cultivation and should be the focus of any adaptation measures.

A recent study in Assam found that between 60 – 80 % of tea farmers plant shade trees as a strategy to improve tea yields (Biggs et al. 2018). This is in contrast to the Fairtrade farmers that responded in the survey, almost all of whom produce coffee in full sun. It is, however, not specifically mentioned how many shade trees per hectare are needed for it to count as a shaded system. Changing practices towards agroforestry were also mentioned by the Fairtrade farmers as an adaptation strategy. Additional practices mentioned in the Assam study were putting in drainage (2 – 18% of farmers) and building storage for water (5 – 22%). Duncan et al. (2016) consider the following adaptation strategies as promising: drought resistant cultivars, infrastructure for irrigation, more efficient pruning practices, mulching, higher density of shade trees, water harvesting structures, early warning systems for droughts, and livelihood diversification to reduce risks for tea producers. Similar to our survey findings, tea planters in Assam also adapt by creating wind barriers, conserving biodiversity, and gradually replacing synthetic fertilizers and adopting organic practices (Baruah and Handique 2021).

Lastly, for India, climate change could also have some positive effect on tea production. It was found that the optimal suitability areas for tea cultivation will grow by 15% until 2050 in India. Tea production will strongly contract in other major tea growing countries including Sri Lanka or Kenya, where suitable areas are expected to decline until 2050 by 29% and 15%, respectively (Jayasinghe and Kumar 2020).

7.1.4 Coffee cultivation in India

Even though there have been many studies on the impact of climate change on coffee, most are concentrated on producer countries in Latin America. As of yet, limited research has been carried out in Asia, which is a becoming a major coffee growing region, particular for Robusta (Pham et al. 2019). In India, coffee is the second most important commodity and its production has steadily increased in the past decade, having reached a total cultivation area of nearly 460 000 hectares in 2020 (Statista 2020). Coffee is mainly produced in the Southern and North-Eastern regions of India, whereas the southern states of Karnataka, Kerala and Tamil Nadu pose the traditional coffee growing areas. In general, Indian farmers grow Robusta between 500 – 1000 MASL, whereas higher altitudes (900 – 1500 MASL) are suitable for Arabica cultivation. A comparative study in coffee-producing countries showed that while climate change may lead to increased opportunities to produce high quality Arabica coffee at higher altitudes, the losses occurring from decreased yields in coffee farms in lower altitudes will probably not be compensated at the global level (Pham et al. 2019).

As a crop, coffee is highly sensitive to a changing climate. As discussed in chapter 3, coffee is particularly affected by long periods of drought and heatwaves, which reduce plant growth, increase pest incidence, or quicken the ripening process of the berries, leading to the abortion of flowers or a decrease in quality. The coffee plant is particularly affected by higher temperatures, which can induce stunted tree growth, reduce flowering and lower bean quality. In Karnataka, a study found that farmers perceived increasing temperatures, delays in the onset of the monsoon season, and more erratic rainfall distributions (Chengappa et al. 2017). In addition, during strong El Niño years, a decline in Arabica yields could be observed (Jayakumar et al. 2017).

Generally, Robusta coffee can withstand higher temperatures of up to 28°C, while Arabica grows best between 18-22°C (Magrach and Ghazoul 2015). In India, around 70% of coffee produced is Robusta (Statista 2020). In the past 10 years, a decrease in Arabica and an increase in Robusta has been observed in the country (Chengappa et al. 2017). Further increasing the share of Robusta in areas with high expected temperature increase can be a solution for a sustained quantity of coffee produced, although at a lower quality. On the other hand, it was also found that Robusta is more susceptible if the climate varies a lot between seasons (Bunn et al. 2015). This additional factor should be taken into account when planning for varieties.

However, other adaptation measures are also promising and are needed to support particular producers that cannot easily move their activities to other areas. At the level of producers, their adaptive strategies consist of crop diversification and different agronomic management interventions (Chengappa et al. 2017). This largely corresponds with our findings from the survey. Apart from relocating coffee plantations to higher altitudes and more suitable climates, the main adaptation strategies for coffee producers mentioned in the literature are irrigation or agroforestry (Pham et al. 2019).

Agroforestry involves the combination of the coffee crop with diverse shade trees. Shade trees generally improve the microclimate in coffee plantations and thus reduce stress caused from extreme temperatures or droughts. In India, several studies have shown the benefits of agroforestry in environmental but also economic terms. In Kodagu, planting 100 native shade trees per hectare increased coffee berry production by 5.6% and increased bean size by 6.3% (Boreux et al. 2016). However, *Grevillea robusta*, the most common shade tree used in coffee agroforestry systems in India, competes more for water and nutrients compared to other trees and should not be dominant (ibid.). Another study also found a decrease in the incidence of pests, including the coffee berry borer (Nesper et al. 2017). The positive impact of shade trees on productivity and pest incidence indicated by the study were consistent across rainfall gradients and management systems. Given the fact that almost all of the interviewed farmers cultivate coffee in full-sun, there is high potential for the introduction of agroforestry for Fairtrade producers in order to support their adaptation to climate change.

Irrigation is particularly important if dry periods become longer and thus reduce flowering. Irrigation in addition to other management practices, such as mulching, can balance out less predictable rainfall patterns and thus reduce stress induced by prolonged dry periods. A study in Kodagu, India, showed that irrigation even increased berry production by 16% (Boreux et al. 2016). It is worth mentioning that Fairtrade farmers participating in the survey mentioned both irrigation and mulching as their main strategies to mitigate the effects of drought.

7.2 Ghana

7.2.1 Climate

In Ghana, cocoa is primarily produced in the Western as well as the Ashanti Region, although the growing area is expanding to several other regions more recently. Below is the example of Tarkwa, a major cocoa producing area in the Western Region, which is classified as having a tropical monsoon climate (Figure 80).

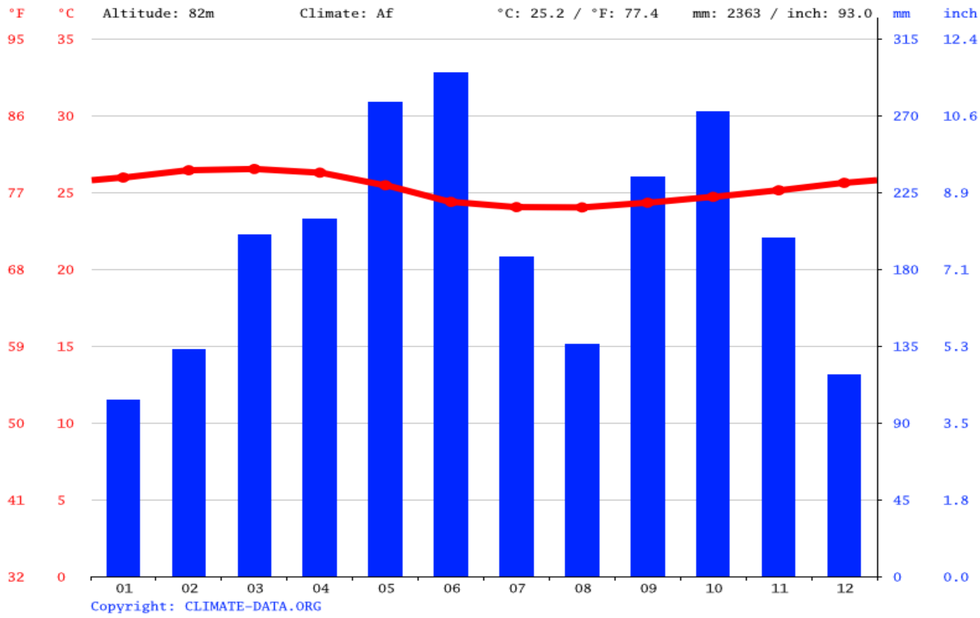


Figure 80 Climate diagram for Tarkwa, Western Region, Ghana (source: climate-data.org)

Average temperatures range between 24 – 27°C. Rainfall is spread throughout the year, with a major rainy season from around March to June and a minor rainy season from September to November.

7.2.2 Climate change scenarios for Ghana

Projected future trends for Ghana suggest, that there are considerable differences in climate change impacts depending on the location in the country (Figure 81).

A majority of current cocoa producers in Ghana will experience up to 10 additional consecutive dry days in 2050 under both scenarios. Under RCP4.5, cocoa producers will experience fewer days with extreme temperatures. However, all producers will experience more than 10 additional days with warm stress, with a large share experiencing even more than 30 additional days. Under both scenarios, most cocoa producers in Ghana will also experience a decrease in heavy precipitation days.

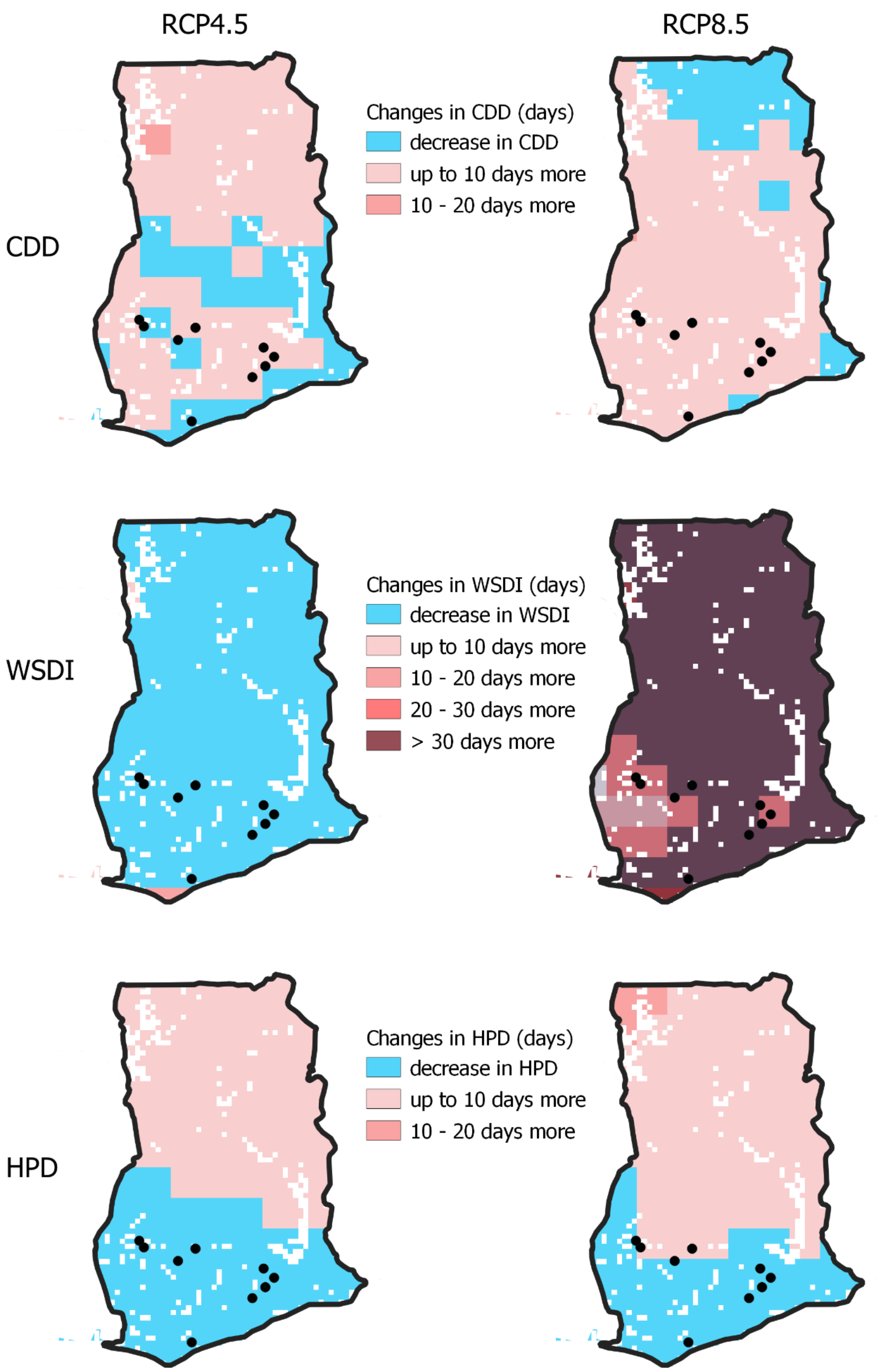


Figure 81 Changes in consecutive dry days (CDD), warm spell duration index (WSDI) and heavy precipitation days (HPD) for Ghana's cocoa producing organizations (dots)

7.2.3 Cocoa cultivation in Ghana

Ghana is the second largest producer of cocoa beans globally behind Côte d'Ivoire. Cocoa is the most important agricultural commodity of Ghana. Apart from climate change, cocoa plantations face several other challenges in terms of management practices. Many plantations are abandoned due to old age and are not rejuvenated because of high labour costs (compared to clearing new land) and decreasing soil fertility. Adoption of climate-resilient and sustainable practices is crucial, but short-term economic factors cannot be underestimated.

As outlined in chapter 3, the cocoa crop is highly sensitive to increasing temperatures and droughts. With limited water availability, cocoa yields can be more than halved (Zuidema et al. 2005). On the other hand, they are also susceptible to waterlogging after extreme rainfall events and flooding.

In Ghana, reduced precipitation and longer dry periods have already led to a shift in cocoa production away from semi-dry areas towards wetter areas of the country, which are at the same time home to the last remaining intact tropical forests. This has already led to land use changes and trade-offs in ecosystem services in the past and is likely to increase with continued climate change. Deforestation for cocoa expansion is a key issue for government institutions as well as the private sector. There are diverging interests to conserve natural resources on the one hand and promote agricultural development on the other. Therefore, law enforcement remains low in these areas.

Bunn et al. (2019) suggest site-specific adaptation for different cocoa-producing regions of Ghana on the basis of climate model (RCP 6.0) predictions for 2050 (Figure 82). In the core cocoa zone (green) in Western and Central Region as well as parts of Ashanti and Eastern Regions, adaptation needs will be very low. On the other end of the spectrum, the outer boundaries (red), particularly in the Brong Ahafo Region, are expected to lose suitability for cocoa to such an extent that it will become inevitable to transition to other crops.

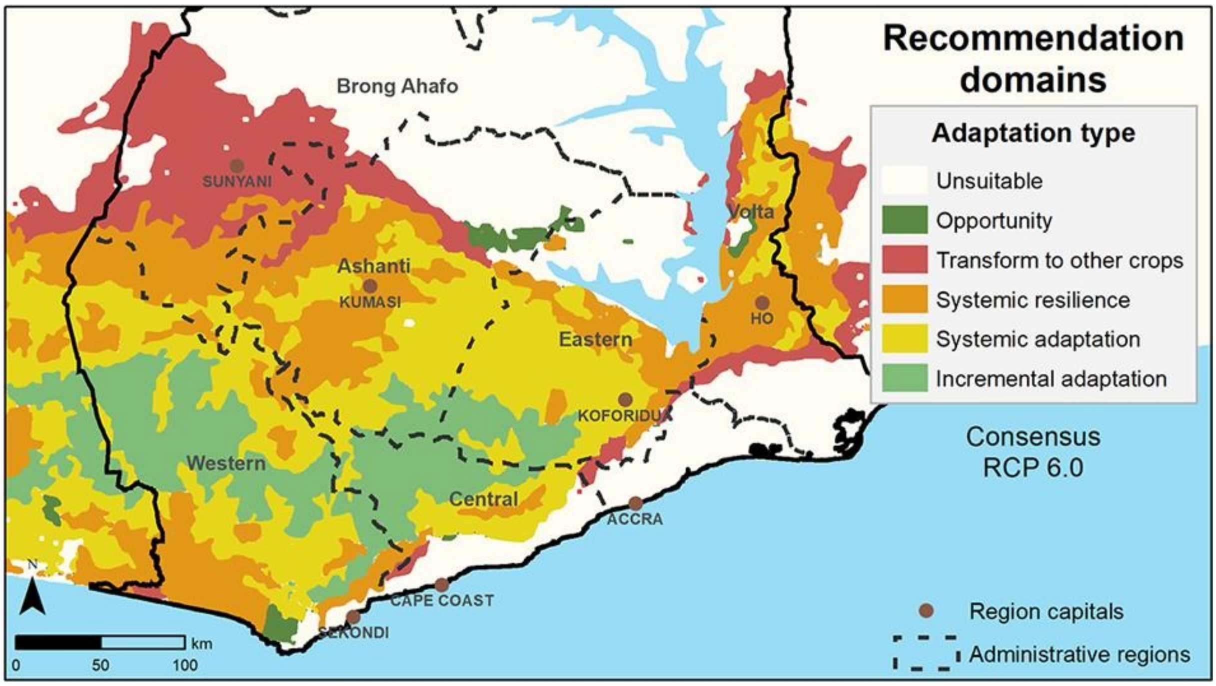


Figure 82 Recommended climate change adaptation domains for cocoa farmers (taken from Bunn et al. 2019)

A study of Ghanaian cocoa farmers showed that those who adopted some types of climate change adaptation technologies had significantly higher farm productivity and overall income compared with non-adopters (Wongnaa and Babu 2020). Similar findings revealed a 29% higher income of Ghanaian cocoa farmers that practiced climate-resilient agriculture compared with those using conventional practices (Akrofi-Atitianti et al. 2018).

Similar to coffee and tea plantations, agroforestry is also one of the most promising options to adapt to climate change and sustain higher yields for a longer time. But unlike for the other crops, the survey revealed that already half of all farmers have agroforestry systems for cocoa. Shade is particularly important for young cocoa seedlings, which have a higher mortality rate if consecutive dry days increase. In Ghana's forest-savannah transitional zone, for example, farmers were observed to increase planting density of banana for shade to reduce the mortality of their cocoa seedlings and have some type of insurance (Asante et al. 2017).

Lastly, Friedmann et al. (2018), who investigated women cocoa farmers' perceptions of climate change and vulnerabilities, stress that in addition to technical or agronomic solutions, social-economic factors are key for supporting the adaptive capacity of smallholders towards climate change, climate variabilities, and extreme events. The interviews as well as the survey carried out as part of this project strongly agree with this statement.

8 Synthesis

8.1 Key messages

Identifying climate change impacts on certified commodity producers remains a challenging task. On one side, there is numerous case-study evidence on past climate change impacts for different regions and crops. Such knowledge is, however, not always transferrable to other regions. On the other side, global studies on potential climate change impacts on main commodities present an overview of potential future impacts, while neglecting regional economic, cultural and biophysical contexts. Our combination of different methods was key to provide to a broad understanding on the impacts of climate change on the producers of Fairtrade commodities on one side, and more detailed regionally specific knowledge on the other.

Maps help to indicate the diversity of climate change impacts across different crops across multiple production regions for major supply chains. By synthesizing spatially explicit data from global climate change models (general circulation models) for a global analysis of climate change impacts on different crops, we can summarize that:

- Impacts vary strongly across different geographic regions, crops and climate scenarios, demonstrating the need to go beyond generalized average impacts globally, and making a regional and crop-specific approach to adaptation necessary.
- Generally, Fairtrade production regions seem to be less affected by climate change indicators (consecutive dry days, warm spell duration index, extreme rainfall events) compared to other, non-Fairtrade production regions for the same crops. Nevertheless, even within major regions, we identified areas which will be disproportionately impacted (e.g. fewer impacts in the Western coast of South America vs the Eastern coast).
- The results from hotspot mapping can be used to prioritize areas for climate change adaptation measures.

We identified the following key areas, which are projected to be particularly impacted by climate change:

- Africa: Ghana (banana, cocoa), Ivory Coast (cocoa), Malawi (sugarcane, tea), Tanzania (tea)
- Central America and the Caribbean: Costa Rica (coffee, sugarcane), Dominican Republic (banana, cocoa), Honduras (coffee), Mexico (coffee), Nicaragua (coffee)
- South America: Brazil (cocoa, coffee), Colombia (coffee), Peru (cocoa, coffee)
- South and South-East Asia: India (coffee, sugarcane, tea), Timor-Leste (cocoa, coffee)

Using interviews and a standardized producer's survey, we have shown that farmers are aware of severe changes that also demand a shift in their agricultural practices and livelihoods. They clearly locate these shifts in a changing social, political, economic and health context which even puts their food security at risk. The degree of changes in practices and the responses they have given varies considerably. Nevertheless, the need for further trials, further adaptations in agricultural practices, and further experiences come alongside economic needs intensified by the unstable context related to Covid-19. Analysing farmers' perceptions in two hotspot areas (Ghana and India), we found that:

- Cocoa farmers reported the highest climate change severity. Particularly, they report a negative effect on yields. They plant trees as a measure to mitigate the effects of high temperatures. However, few have planted more resistant varieties.
- Tea farmers view climate change impacts as moderate to very severe. They especially report an increase in temperatures. In order to mitigate the effect of higher temperatures, they plant additional trees in their plantations.
- In general, farmers perceive the highest levels of risk in connection with high temperatures, changing precipitation patterns and availability of water
- Intercropping is the main change in agricultural practices to cope with climate change risks, followed by agroforestry systems and organic agriculture. Some farmers stated that they had few possibilities of investing in the farm because of little access to financial means
- Mostly, farmers perceive a high risk when it comes to their personal and their families' health (effect of the pandemic), the household food security (medium to high risk) and political situation.

This gives clear hints that apart from the analysis of the farmers' needs, a deeper analysis of risk perceptions, also along the value chain would be helpful in order to develop effective strategies. Farmers continuously need to adapt to many risks simultaneously due to their environment. One of their adaptation approaches, diversification of crops and livelihoods, can also be an opportunity for Fairtrade to increase the portfolio of commodities as well as support farmers in becoming more resilient towards climate change and other risks.

In terms of agricultural practices, we noticed that the vast majority of interviewed Fairtrade farmers in India (n=125) have full sun systems, be it for coffee or tea. On the other hand, nearly all cocoa producers in Ghana (n=11) had shaded systems, with some additionally tending full sun cocoa farms. But the limited adoption of agroforestry practices for coffee and tea remains a question. Although they mention tree planting as a key measure to mitigate climate change impacts, agroforestry is not as widely practiced as recommended based on various studies. It would be important to find the gap here and understand the underlying challenges related to agroforestry systems and tree planting from the farmers' perspectives. It would also be important to know whether the low share of shaded systems is specific per crop (coffee, tea) or specific for India.

Concluding, this study has contributed to mapping climate change effects at global scale, to locating climate change hotspots for key Fairtrade commodities, to reviewing the current work of FI to support its farmers to adapt to climate change, and to assess – in two hotspots – specific impacts of climate change according to farmers' perceptions and their adaptation strategies.

8.2 Study limitations

There are several limitations to our study. The main ones relate to the regional and local context of climate change impacts, different varieties of commodities, geographic characteristics, as well as farmers' diverse adaptive capacities and resilience.

Although we aimed to capture numerous climate change impacts, different regions might be subject to other climate change impacts, or the impacts in those areas might have different consequences. For example, a larger amount of additional dry days in otherwise humid areas might not impact the production of crops considerably. However, a minor increase in CDD might result in catastrophic consequences in more semi-arid environments. We also could not study in detail the extent of crop producers impacted by extreme storms (e.g. tropical cyclones), as future projections on their occurrence and magnitude were not available. It should be noted, however, that this was mentioned as a major impact by the producers we interviewed in the survey. So, while predicting storms is difficult, preparing for them and considering coping mechanisms can be an essential support mechanism for producers. Regarding short term coping mechanisms, our study mostly considered access to credit but limited other options, as it aimed rather to focus on long-term adaptation measures. However, this should be taken into account in future studies.

Additionally, the crops addressed are to a certain extent adapted to local climatic conditions. This means that although even minor changes in climate could impact the crops considerably, they could be substituted with varieties grown in other, neighbouring areas. We were not able to study the differences in the different varieties in detail, despite evidence suggesting that different varieties might respond differently to future climate change (such as the example of the Robusta and Arabica coffee). Nevertheless, although changing cultivars is a suitable adaptation option, it also has its limits. Extreme climate change impacts (more tropical cyclones) will considerably impact production no matter the cultivar (as new varieties will also not be cyclone resistant for example). Changing varieties also has trade-offs related to consumer preference (particularly coffee varieties), or in terms of enabling sufficient yields on the account of quality (e.g. similar tea production, but changes in taste or other quality parameters). Moreover, investing in new varieties for tree crops means that in addition to high costs, produces may experience time lags as production to offset crop loss due to climate change might not be available in sufficient time. At the same time, climate change impacts for some crops might be more subtle and difficult to identify using our approach. For example, while the amount of extreme rainfall might stay the same in a particular region, it might shift to a different time of the year and crop cycle, impacting the production considerably.

Furthermore, more specific information on how expected climate change indicators will affect crop productivity and quality as well as farmers' livelihoods is highly context specific and could be fully explored in this scoping study. This is also the case for specific climate-resilient agricultural practices. This includes, among others, what would be the increased water demands or necessary measures to combat pests and diseases. Although to some extent this could be estimated by crop yield models, most of those models are not very accurate for this type of crop. Additionally, interannual climate variability might impact yields more than average conditions, as indicated by the climate scenarios. Nevertheless, the information we provide can be used by Fairtrade to discuss with producing organizations in different parts of the world on what they can expect in the future in terms of needs and further context analysis including further social, economic, political and cultural risks and risk perceptions.

Finally, we faced several challenges regarding the objective to capture the more local context. In our spatial analysis, we were unable to capture local specifics in terms of relative relief, slope, aspect and elevation, as these define the local micro-climate. We operated on the scale of general circulation model outputs of ca. 30 km and had only approximate locations of our producing organizations (with actual producers being in the radius of 20 km). This means that, considering local geographic characteristics factors, that could actually exacerbate or mitigate climate change impacts, was not possible. Local micro-climate can provide very different impacts, from more extreme conditions at exposed sites to more sheltered and tempered micro-climates, for example in valleys. Farmers can use these micro-climatic variations by using the local variations to adapt the crop mix to the new conditions. However, this might have strong implications on the particular farmers' group and their social, economic, cultural and political context as well as their health situation. Moreover, local practices, such as agroforestry, make important contributions to the micro-climate and provide large potential to, in case of not so extreme changes, adaptation to changing average climate conditions.

For the evaluation of farmers' perspectives, the main limitations of this study were the challenges in reaching out to the producer networks and the farmer cooperatives and receiving the responses required to assess perceptions of climate risks, adaptation measures and needs. In particular, we received only a total of 11 responses from Ghana, which strongly limits the conclusions we can draw on the quantitative data from Ghana and thus from cocoa farmers in particular.

8.3 Potential for follow-up studies

In order to plan for resilient adaptation solutions, follow-up studies should focus on capturing the regional or variety dependent climate change impacts. This means, that climate change impacts should be identified for each regional context (e.g. different Fairtrade sourcing regions), which would also enable identification of critical thresholds for different climate change impacts. This could be done with dedicated regional literature reviews, but also expanding the range of interviews with local producing organizations, based on past experiences of local farmers. It is important to note that confronting interview-based and climate modelling-based data is required. While the large climate models may lack detail on micro-climate and the specific aspects of climate and climate variability important to the farming systems, local stakeholders might misinterpret climate change due to high inter-yearly variations and habituation to gradual change ('shifting baseline syndrome'). Data triangulation by combining different types of quantitative data and especially also including additional qualitative interviews and observations to be able to better interpret survey data, is key to untangling the complex context of climate change impact and adaptation opportunities.

Regionalized assessments would support identification of the extent to which overall production (changes to yields or likelihood of crop failures) would be impacted; or, which field-specific adaptation measures would be most suitable in that regional context. They would also enable empirically derived relationships between climate change and crop yields, pest occurrence or other impacts for that region. Although empirically derived relationships between climatic characteristics and their changes are available for some regions and crops, evidence also suggests that specific agricultural systems (such as the Fairtrade voluntary sustainability standard and other certification) can respond differently to climate change than those which are not certified. This is why separating non-certified crop production systems with Fairtrade in specific regions might also be interesting, as it would enable a more detailed analysis of how Fairtrade production systems differ from conventional.

An additional follow-up would be actual testing and prototyping of different adaptation measures in a scenario-based approach. In this way, we could test how well different adaptation options in terms of crop production would perform (given different assumptions on the relationships between climate change and crop production), associated costs, or potential trade-offs (for example, increased water demand, agricultural work force, etc). Such an approach would, however, demand a combination of environmental modelling, agricultural field research (potentially even field trials) and iterative, in-situ stakeholder participation. Involvement of stakeholders from different regions would also be necessary as the adaptation measures may differ considerably depending on the socio-economic, cultural and bio-physical context. Support to farmers to adopt the different adaptations is another important area of future attention, but needs should take advantage of previously gained knowledge on current challenges limiting changing practices or from increasing adaptive capacity to deal with the long-term impacts of climate change. In addition, short term mechanisms to deal with immediate impacts, such as complete crop failures from storms and other extreme weather events, need to be assessed and supported in order to increase farmers' resilience and to guarantee that they remain invested in a particular supply chain.

Overall, this study has indicated the need to enhance the adaptive capacity of farmers contributing to specific value chains which are important to Fairtrade. These might be far-reaching adaptations at the farm level, by changing to different crops; or, the need to diversify into other crops in regions where the production of a specific commodity is not possible in a sustainable matter under future climate change. But, in many regions with milder impacts, other adaptations are possible. These range from the selection of different crop varieties to managing the micro-climate through agroforestry and improved shade tree management, mulching, and intercropping for diversification.

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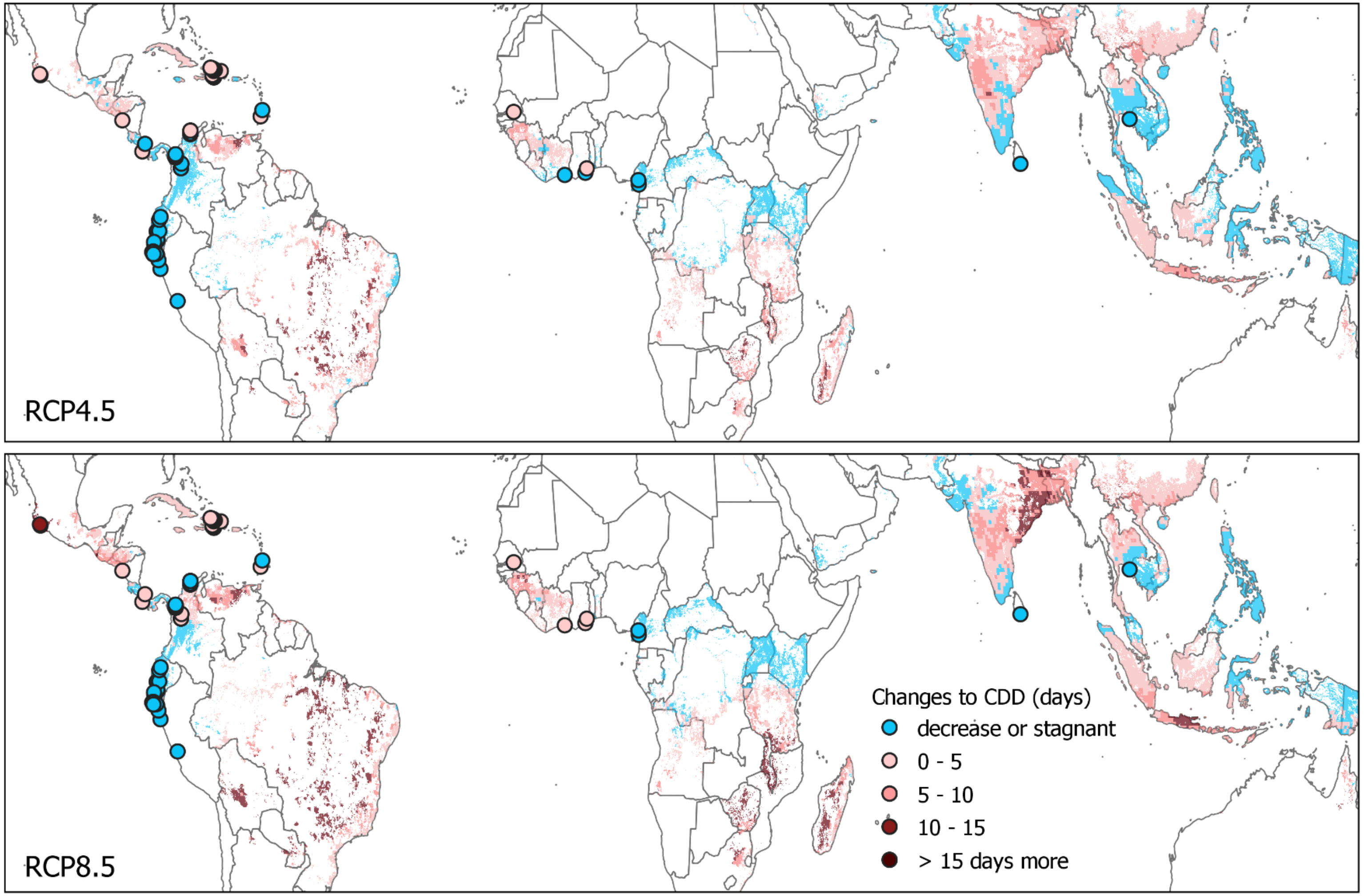
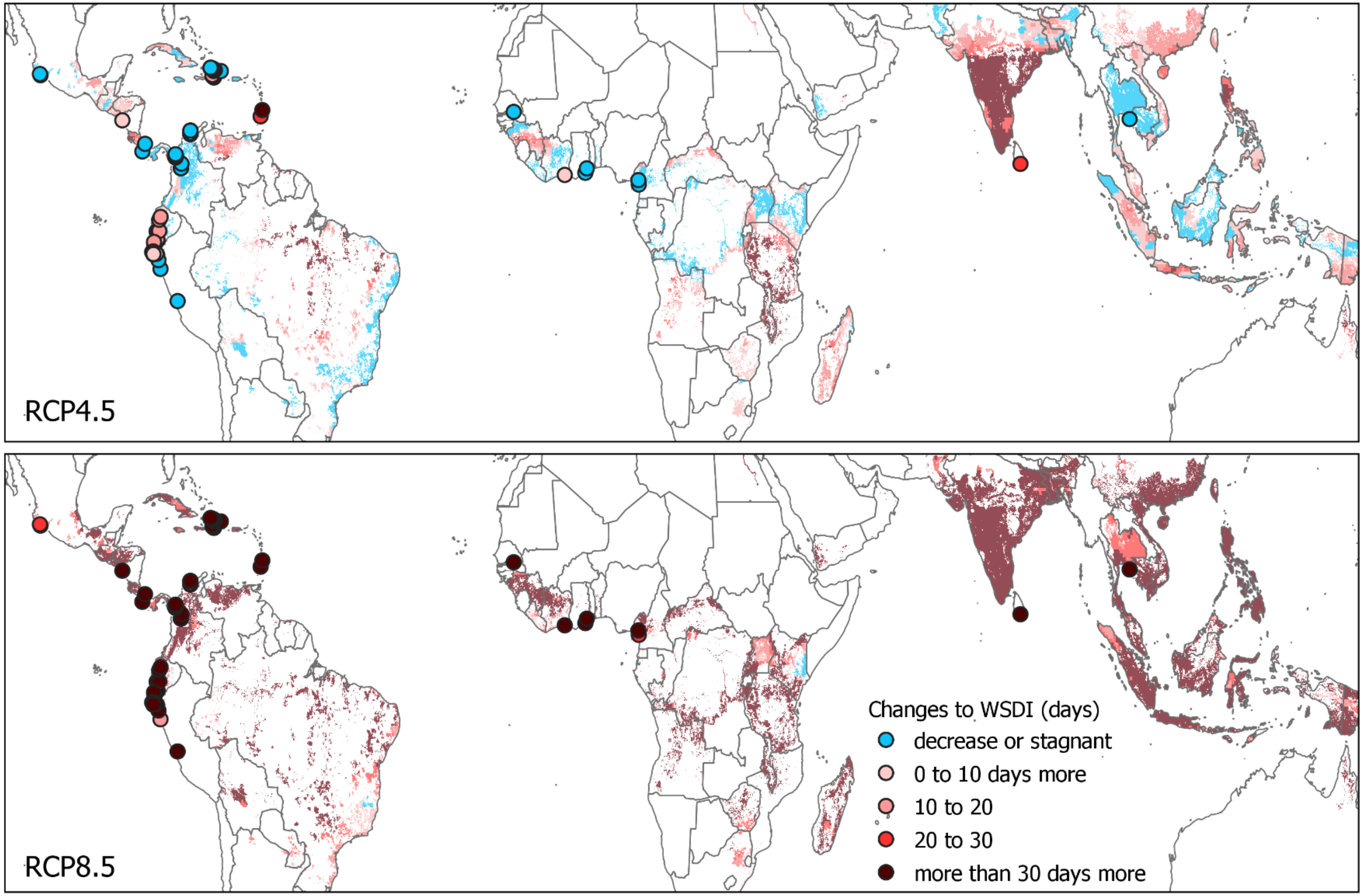
10 Annex

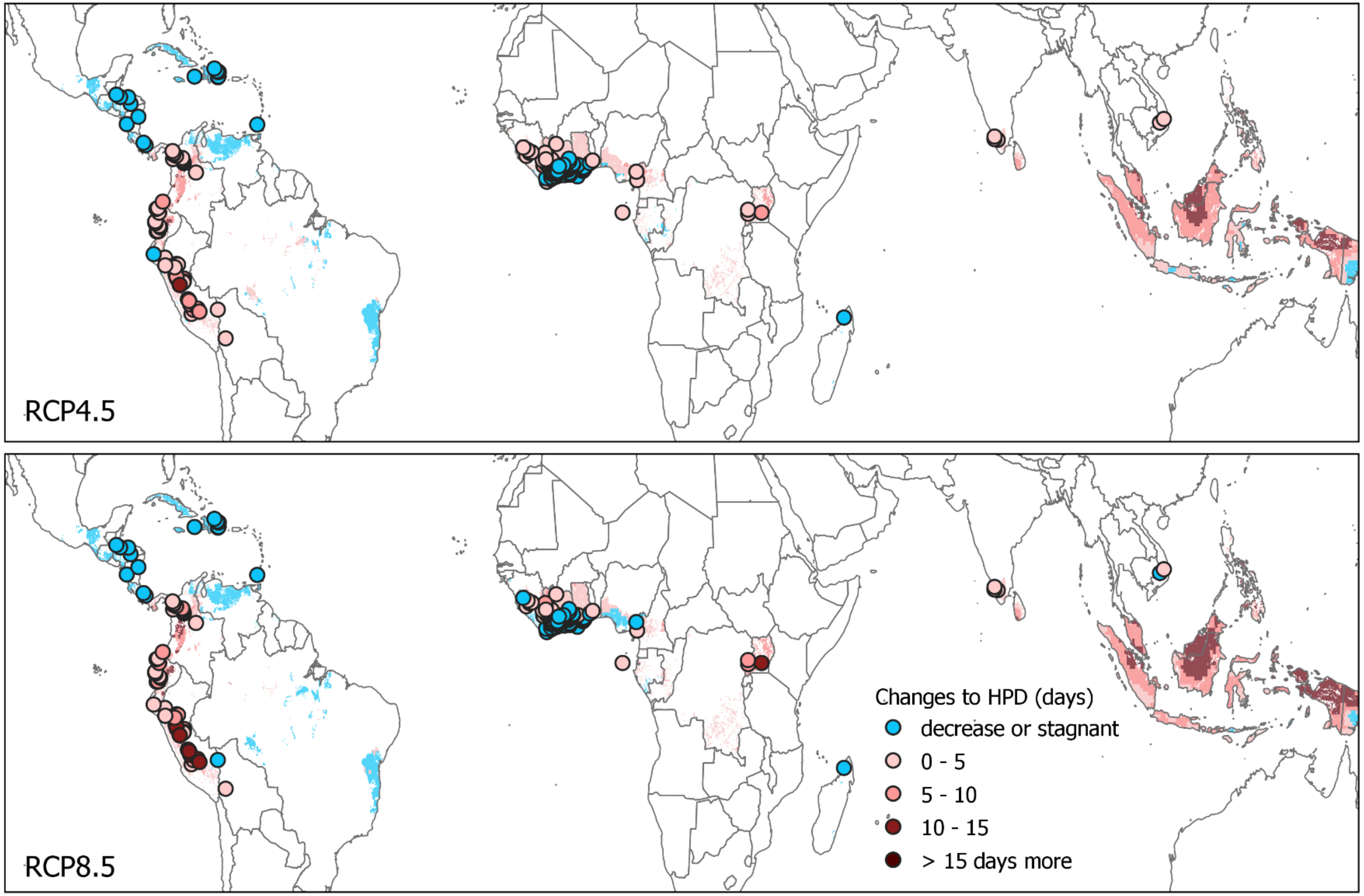
10.1 High resolution climate change impact maps



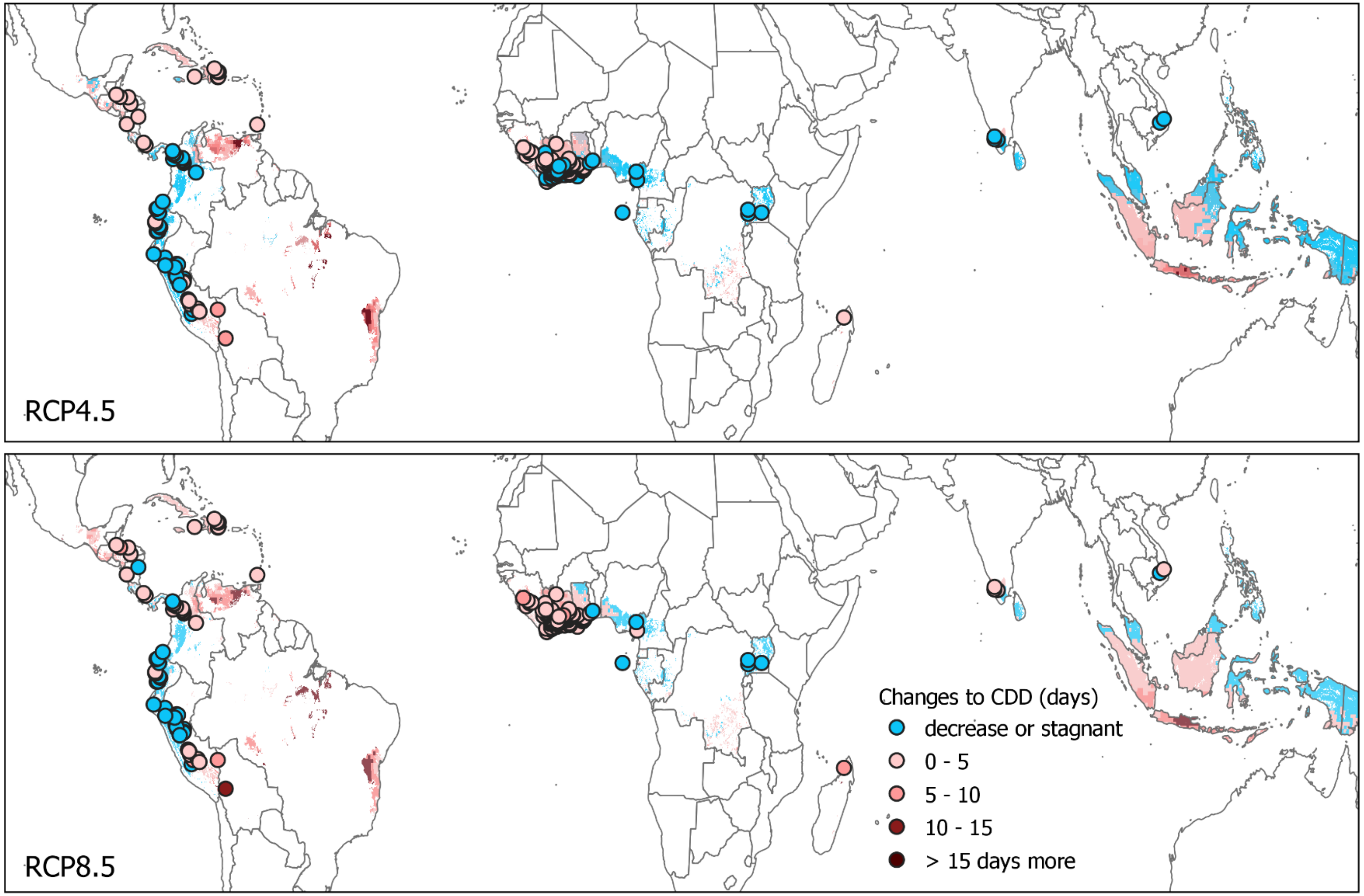
Supplementary Figure 1 Changes to Consecutive Dry Days (CDD) in days in 2050 compared to 2010 for Fairtrade banana producers (points) and other banana production areas (other areas)



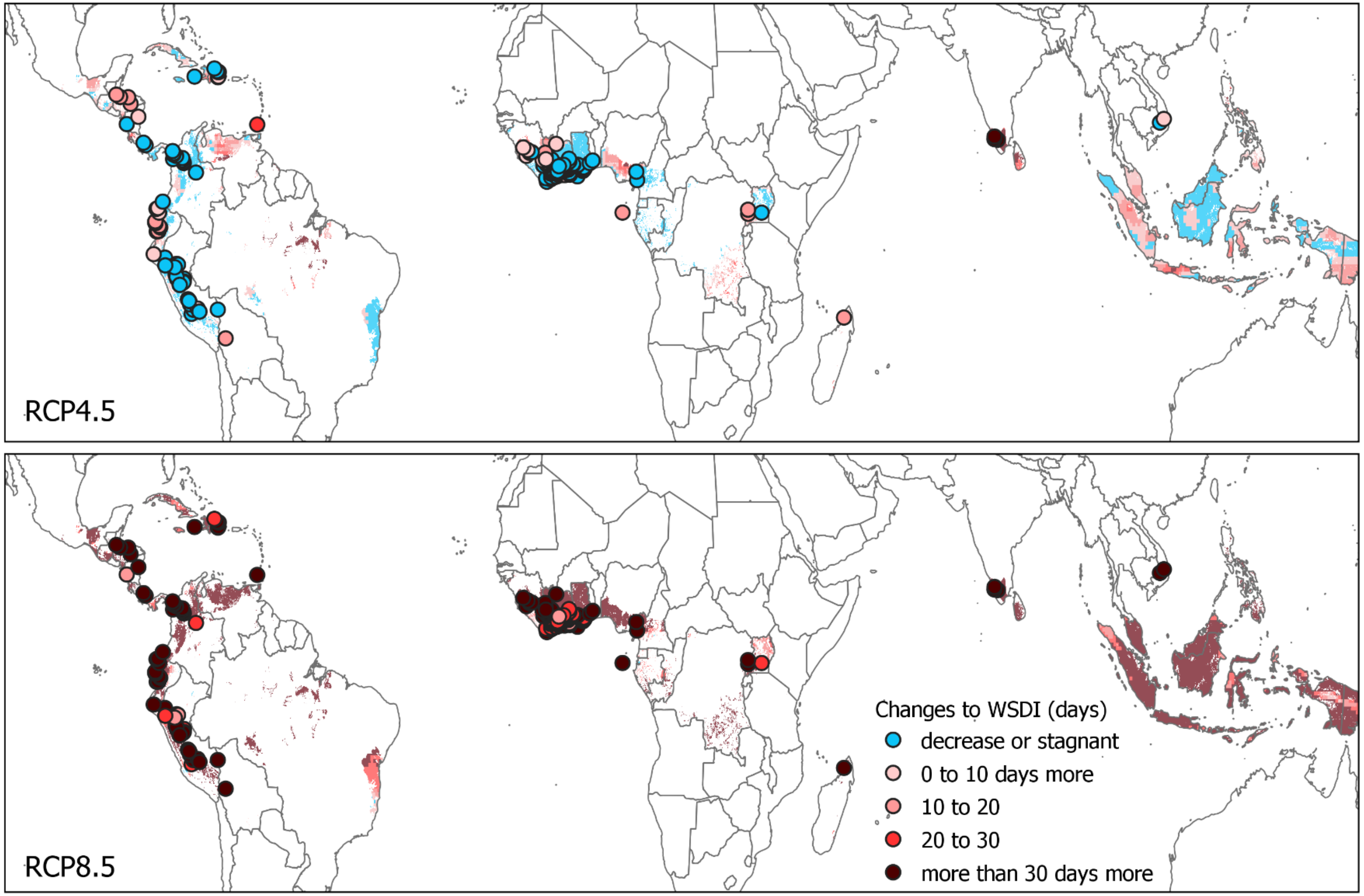
Supplementary Figure 2. Changes to the Warm Stress Duration Index (WSDI) in days in 2050 compared to 2010 for Fairtrade banana producers (points) and other banana production areas (other areas)



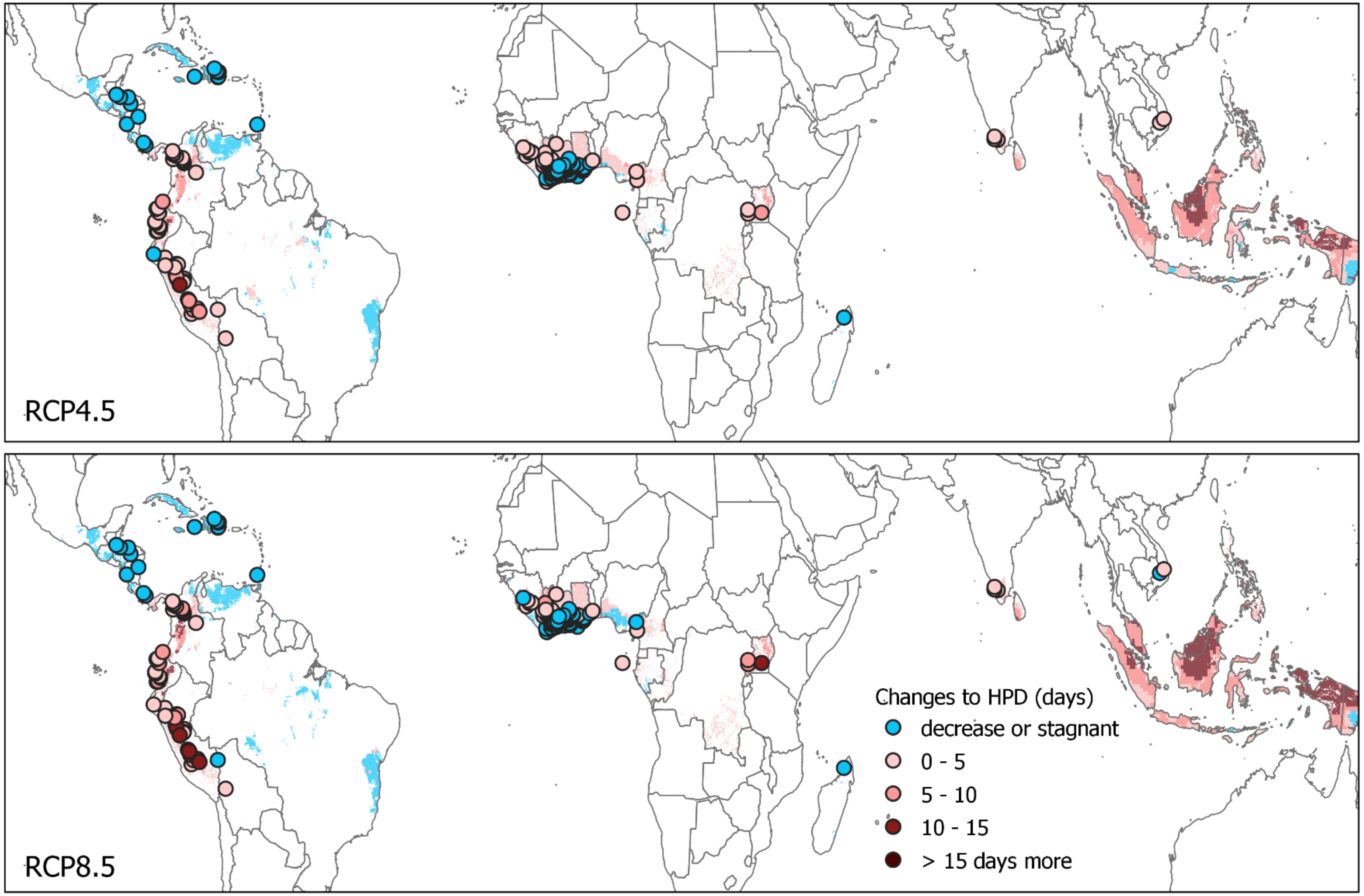
Supplementary Figure 3 Changes to the Heavy Precipitation Days (HPD) in days in 2050 compared to 2010 for Fairtrade banana producers (points) and other banana production areas (other areas)



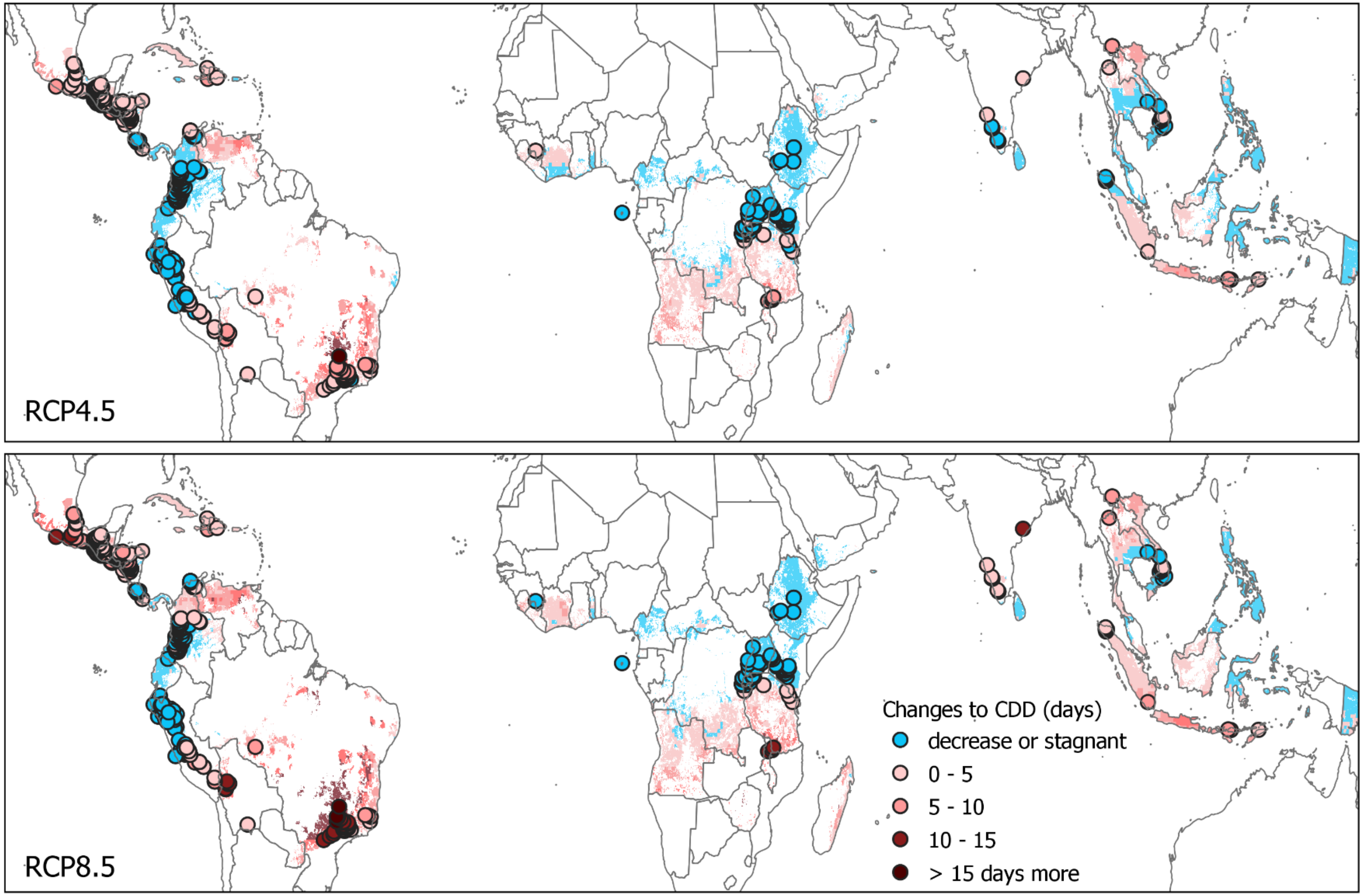
Supplementary Figure 4 Changes to Consecutive Dry Days (CDD) in days in 2050 compared to 2010 for Fairtrade cocoa producers (points) and other cocoa production areas (other areas)



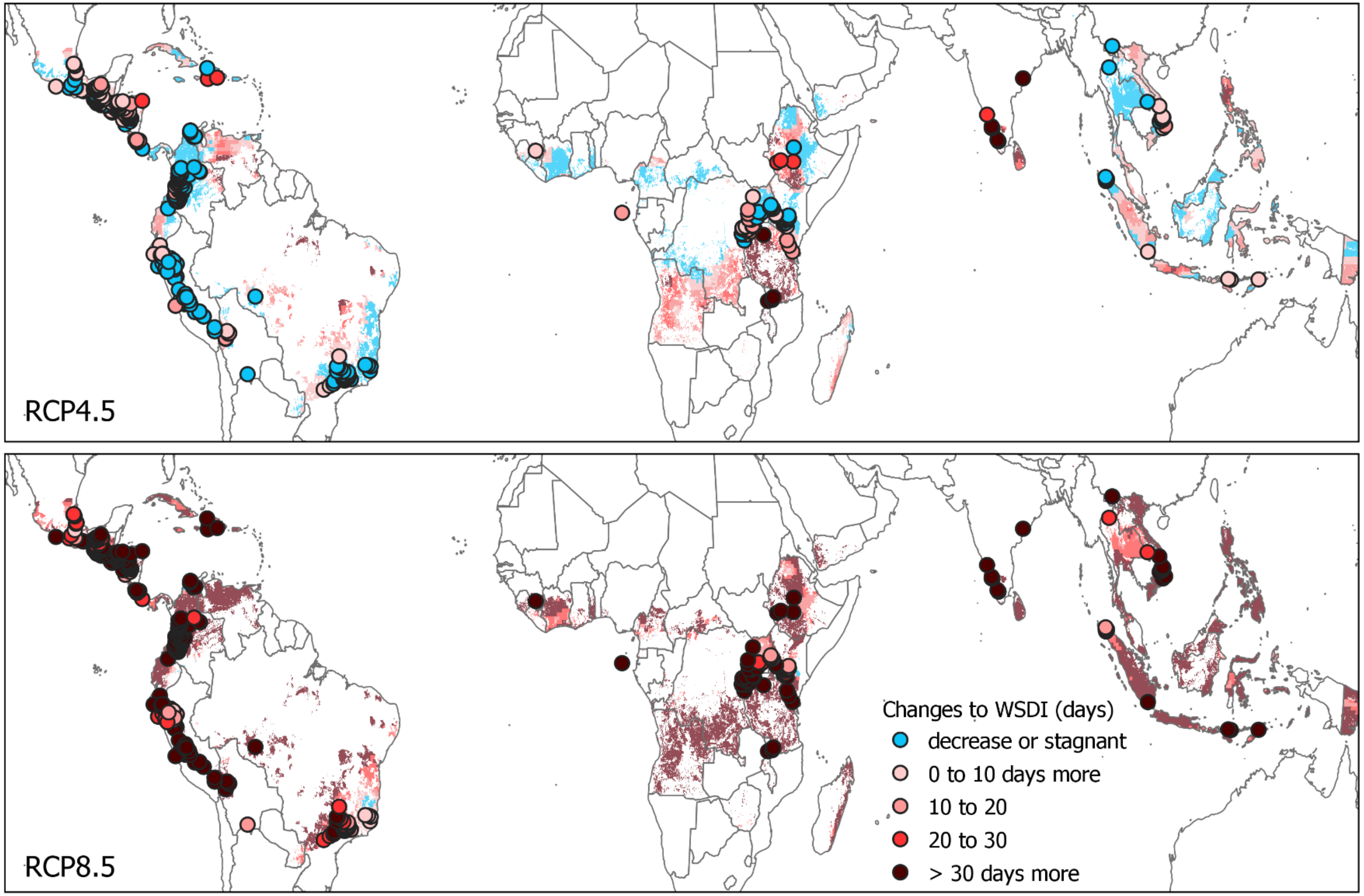
Supplementary Figure 5 Changes to the Warm Stress Duration Index (WSDI) in days in 2050 compared to 2010 for Fairtrade cocoa producers (points) and other cocoa production areas (other areas)



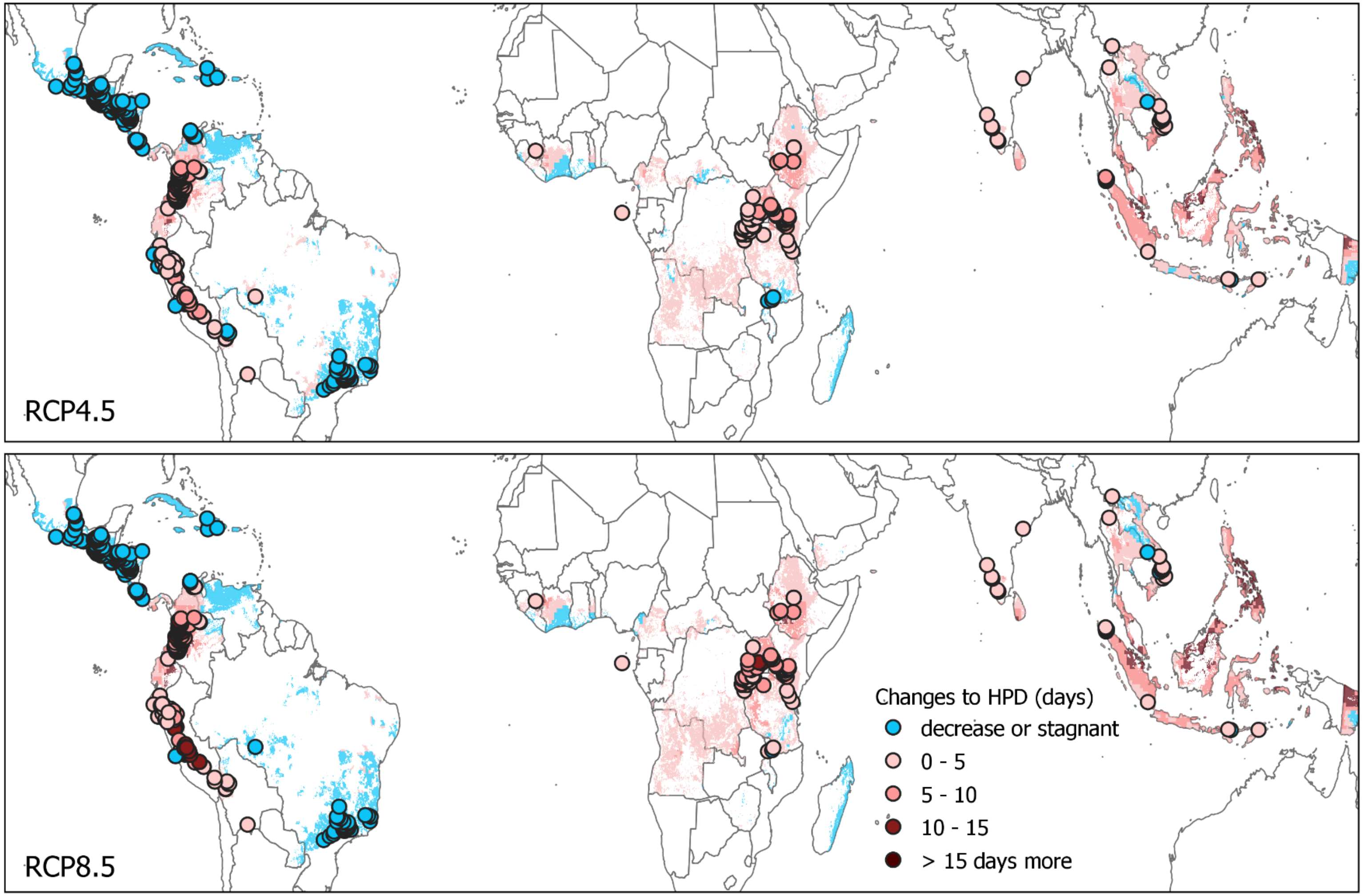
Supplementary Figure 6 Changes to the Heavy Precipitation Days (HPD) in days in 2050 compared to 2010 for Fairtrade cocoa producers (points) and other cocoa production areas (other areas)



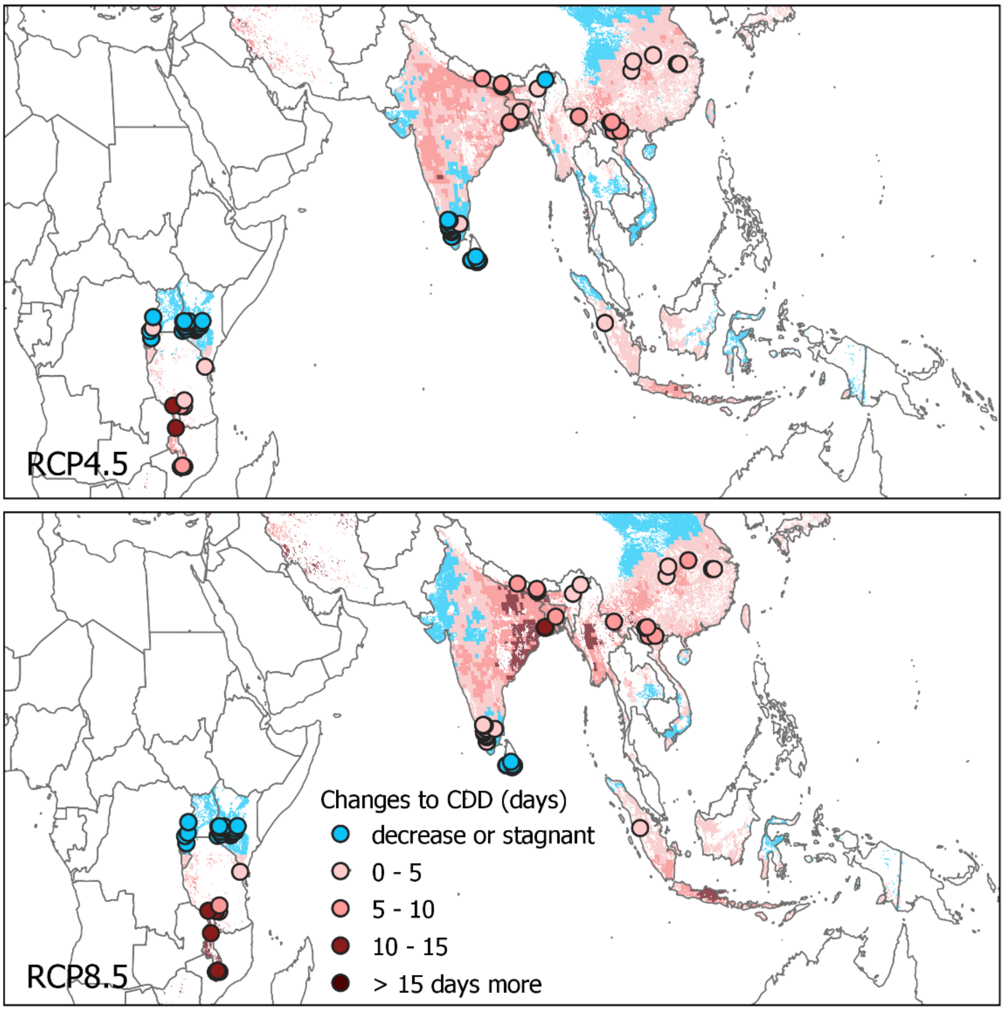
Supplementary Figure 7 Changes to Consecutive Dry Days (CDD) in days in 2050 compared to 2010 for Fairtrade coffee producers (points) and other coffee production areas (other areas)



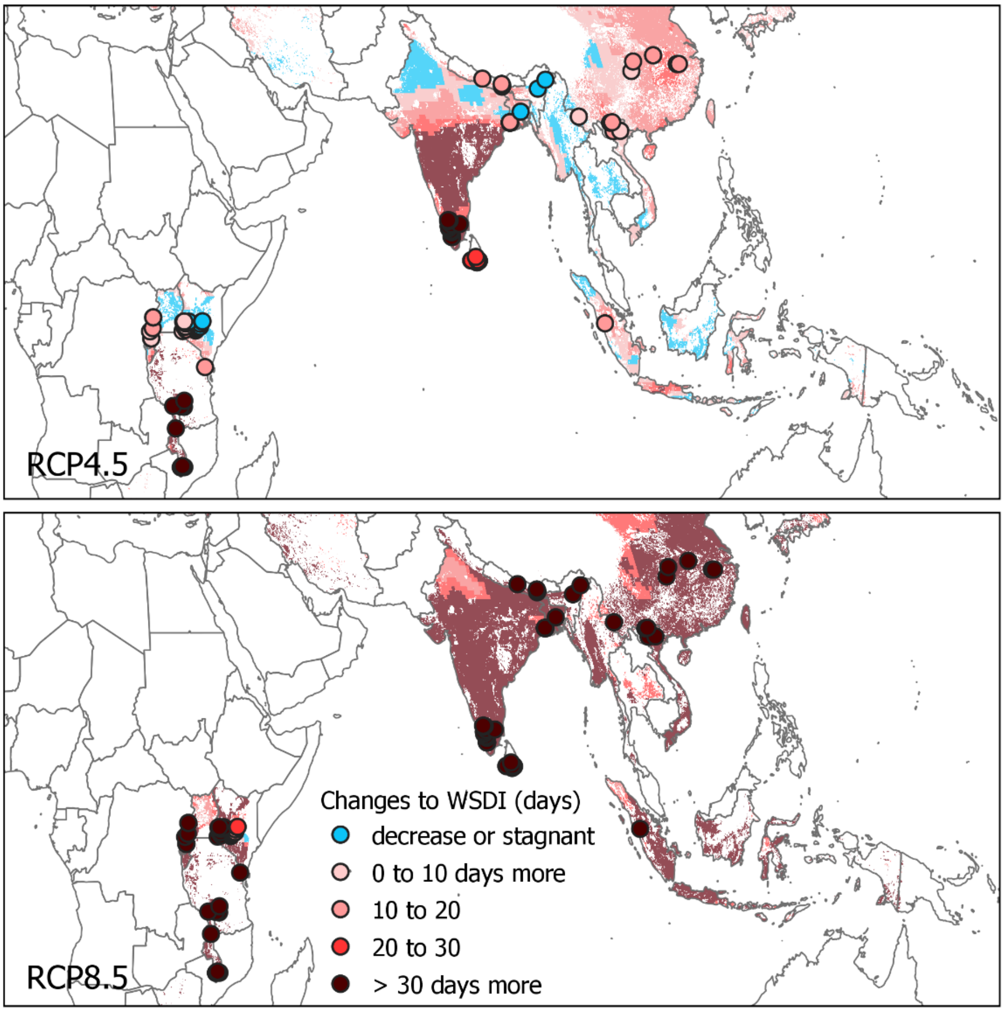
Supplementary Figure 8 Changes to the Warm Stress Duration Index (WSDI) in days in 2050 compared to 2010 for Fairtrade coffee producers (points) and other coffee production areas (other areas)



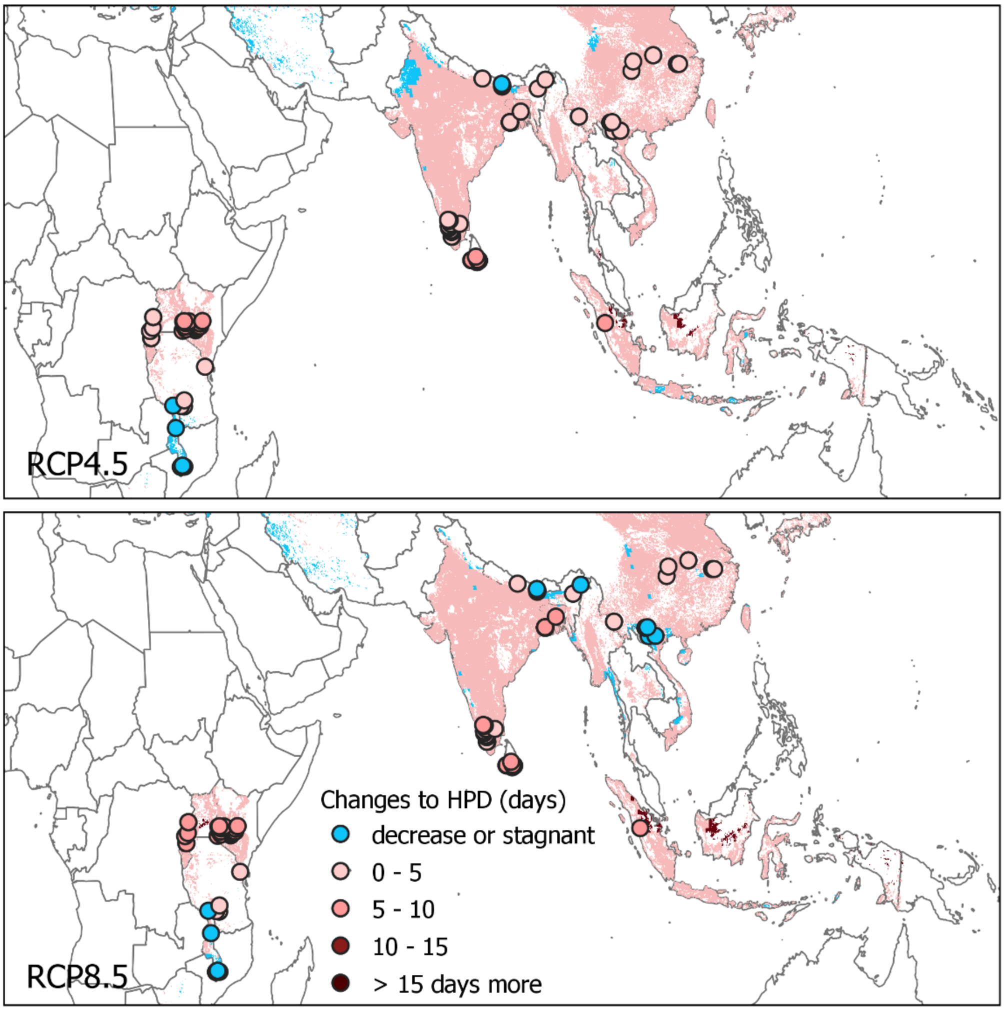
Supplementary Figure 9 Changes to the Heavy Precipitation Days (HPD) in days in 2050 compared to 2010 for Fairtrade coffee producers (points) and other coffee production areas (other areas)



Supplementary Figure 10 Changes to Consecutive Dry Days (CDD) in days in 2050 compared to 2010 for Fairtrade tea producers (points) and other tea production areas (other areas)



Supplementary Figure 11 Changes to the Warm Stress Duration Index (WSDI) in days in 2050 compared to 2010 for Fairtrade tea producers (points) and other tea production areas (other areas)



Supplementary Figure 12 Changes to the Heavy Precipitation Days (HPD) in days in 2050 compared to 2010 for Fairtrade tea producers (points) and other tea production areas (other areas)

10.2 Summarized impacts per region and countries

Supplementary Table 1. Summarized climate change impacts on Fairtrade banana producers in % of all producers in the region or country. An increase means an increase in the index, and the number of days over a threshold means that so many producers will experience impact above such threshold.

	CDD				WSDI				HPD			
Country	Increase RCP4.5	Increase RCP8.5	>5 days RCP4.5	>5 days RCP8.5	Increase RCP4.5	Increase RCP8.5	>10 days RCP4.5	>10 days RCP8.5	Increase RCP4.5	Increase RCP8.5	>5 days RCP4.5	>5 days RCP8.5
Caribbean and Central America	96	99	2	8	27	100	17	100	1	0	0	0
Costa Rica	100	100	0	0	0	100	0	100	100	0	0	0
Dominican Republic	100	100	2	2	18	100	7	100	0	0	0	0
Mexico	100	100	0	100	0	100	0	100	0	0	0	0
Nicaragua	100	100	0	0	100	100	0	100	0	0	0	0
Panama	0	100	0	0	0	100	0	100	0	0	0	0
Saint Lucia	0	0	0	0	100	100	100	100	0	0	0	0
St Vincent and the Grenadines	100	100	0	0	100	100	100	100	0	0	0	0
South America	7	24	0	0	64	100	22	100	86	91	5	27
Colombia	21	72	0	0	0	100	0	100	73	73	15	73
Ecuador	0	0	0	0	100	100	100	100	100	100	3	18
Peru	0	0	0	0	94	100	8	100	89	100	0	0
South and East Asia	0	0	0	0	99	100	99	100	100	99	99	99
Sri Lanka	0	0	0	0	100	100	100	100	100	100	100	100
Thailand	0	0	0	0	0	100	0	100	100	0	0	0
West Africa	14	70	0	0	4	100	0	100	33	33	0	0
Cameroon	0	0	0	0	0	100	0	100	100	100	0	0
Ghana	18	100	0	0	0	100	0	100	0	0	0	0
Ivory Coast	0	100	0	0	100	100	0	100	0	0	0	0
Senegal	100	100	0	0	0	100	0	100	100	100	0	0
All Fairtrade producers	32	51	0	2	45	100	19	100	54	57	6	17

Supplementary Table 2. Summarized climate change impacts on Fairtrade cocoa producers in % of all producers in the region or country. An increase means an increase in the index, and the number of days over a threshold means that so many producers will experience impact above such threshold.

	CDD				WSDI				HPD			
Country	increase RCP4.5	increase RCP8.5	>5 days RCP4.5	>5 days RCP8.5	Increase RCP4.5	Increase RCP8.5	>10 days RCP4.5	>10 days RCP8.5	Increase RCP4.5	Increase RCP8.5	>5 days RCP4.5	>5 days RCP8.5
Caribbean and Central America	100	99	0	1	64	100	57	100	0	0	0	0
Belize	100	100	0	0	100	100	100	100	0	0	0	0
Costa Rica	100	100	0	0	0	100	0	100	0	0	0	0
Dominican Republic	100	100	0	0	79	100	70	100	0	0	0	0
Haiti	100	100	0	0	0	100	0	100	0	0	0	0
Honduras	100	100	0	18	100	100	100	100	0	0	0	0
Nicaragua	100	86	0	0	14	100	0	100	0	0	0	0
Panama	100	100	0	0	0	100	0	100	0	0	0	0
Central and East Africa	2	2	0	2	87	100	87	100	98	98	13	79
Madagascar	100	100	0	100	100	100	100	100	0	0	0	0
Sao Tome & Principe	0	0	0	0	100	100	100	100	100	100	0	0
Uganda	0	0	0	0	84	100	84	100	100	100	16	100
South America	13	18	5	8	22	100	15	100	99	100	50	72
Bolivia	100	100	100	100	100	100	100	100	100	100	0	0
Colombia	0	40	0	0	0	100	0	100	100	100	59	73
Ecuador	27	27	0	0	100	100	63	100	100	100	0	41
Peru	6	9	1	5	1	100	0	100	99	99	64	84
South and East Asia	0	69	0	0	96	100	65	100	100	96	26	26
India	0	100	0	0	100	100	100	100	100	100	0	0
Papua New Guinea	0	0	0	0	100	100	0	100	100	100	100	100
Vietnam	0	50	0	0	50	100	0	100	100	50	0	0

West Africa	65	97	0	2	11	100	0	96	25	59	5	0
Cameroon	0	26	0	0	0	100	0	100	100	26	0	0
Ghana	94	100	0	0	0	100	0	100	0	84	0	0
Ivory Coast	43	96	0	2	16	100	0	93	37	37	9	0
Liberia	100	100	0	0	0	100	0	100	100	100	0	0
Sierra Leone	63	100	0	15	63	100	0	100	100	85	0	0
Togo	0	49	0	0	0	100	0	100	51	51	0	0
All Fairtrade producers	61	89	0	2	17	100	7	97	31	60	8	8

Supplementary Table 3. Summarized climate change impacts on Fairtrade coffee producers in % of all producers in the region or country. An increase means an increase in the index, and the number of days over a threshold means that so many producers will experience impact above such threshold.

	CDD				WSDI				HPD			
Country	increase RCP4.5	increase RCP8.5	>5 days RCP4.5	>5 days RCP8.5	Increase RCP4.5	Increase RCP8.5	>10 days RCP4.5	>10 days RCP8.5	Increase RCP4.5	Increase RCP8.5	>5 days RCP4.5	>5 days RCP8.5
Caribbean and Central America	80	93	4	38	71	100	26	100	0	0	0	0
Costa Rica	23	23	0	0	77	100	77	100	0	0	0	0
Dominican Republic	100	100	0	0	100	100	100	100	0	0	0	0
El Salvador	100	100	100	100	100	100	0	100	0	0	0	0
Guatemala	68	100	0	24	59	100	0	100	0	0	0	0
Haiti	100	100	0	0	0	100	0	100	0	0	0	0
Honduras	98	100	0	65	100	100	6	100	0	0	0	0
Mexico	75	100	5	71	76	100	1	99	0	0	0	0
Nicaragua	100	100	3	12	66	100	57	100	0	0	0	0
Central and East Africa	29	21	0	0	45	100	34	100	100	100	38	60
Burundi	100	100	0	0	0	100	0	100	100	100	0	0
Congo (Democratic Republic)	0	0	0	0	60	100	0	100	100	100	0	100
Ethiopia	0	0	0	0	8	100	8	100	100	100	8	8
Guinea	100	0	0	0	100	100	0	100	100	100	0	0
Kenya	0	0	0	0	26	100	0	100	100	100	100	100
Malawi	100	100	100	100	100	100	100	100	0	100	0	0
Rwanda	21	1	0	0	93	100	54	100	100	100	0	46
Sao Tome & Principe	0	0	0	0	100	100	100	100	100	100	0	0
Tanzania	97	82	0	0	100	100	100	100	100	100	0	58
Uganda	40	0	0	0	63	100	60	100	100	100	34	87
South America	20	33	7	13	18	100	2	93	84	90	56	61
Bolivia	100	100	98	98	98	100	76	100	66	100	0	0
Brazil	99	100	78	98	2	100	0	29	1	0	0	0
Colombia	4	24	0	0	21	100	1	100	94	95	83	83

Ecuador	0	0	0	0	100	100	0	100	100	100	0	0
Peru	23	30	0	10	14	100	1	94	88	99	33	48
South and East Asia	42	53	2	14	55	100	23	100	97	97	43	5
China	100	100	100	100	0	100	0	100	100	100	0	0
East Timor	100	100	0	0	100	100	0	100	100	100	0	0
India	62	100	0	44	100	100	100	100	100	100	0	0
Indonesia	8	11	3	8	8	100	0	100	97	97	92	0
Laos	0	0	0	0	0	100	0	100	0	0	0	0
Papua New Guinea	0	13	0	0	100	100	0	100	100	100	0	100
Thailand	100	100	0	100	0	100	0	100	100	100	0	0
Vietnam	9	72	0	0	90	100	3	100	100	90	0	0
All Fairtrade producers	35	35	2	8	45	100	27	99	85	86	37	48

Supplementary Table 4. Summarized climate change impacts on Fairtrade tea producers in % of all producers in the region or country. An increase means an increase in the index, and the number of days over a threshold means that so many producers will experience impact above such threshold.

	CDD				WSDI				HPD			
Country	increase RCP4.5	increase RCP8.5	>5 days RCP4.5	>5 days RCP8.5	Increase RCP4.5	Increase RCP8.5	>10 days RCP4.5	>10 days RCP8.5	Increase RCP4.5	Increase RCP8.5	>5 days RCP4.5	>5 days RCP8.5
Central and East Africa	15	13	12	13	63	100	29	100	88	88	78	87
Kenya	0	0	0	0	52	100	14	100	100	100	100	100
Malawi	100	100	100	100	100	100	100	100	0	0	0	0
Rwanda	0	0	0	0	100	100	0	100	100	100	0	100
Tanzania	100	100	87	99	100	100	100	100	15	15	0	0
Uganda	26	0	0	0	100	100	70	100	100	100	0	100
South and East Asia	60	73	55	57	97	100	96	100	100	97	23	80
Bangladesh	100	100	0	100	0	100	0	100	100	100	0	100
China	100	100	13	58	100	100	85	100	100	100	0	0
India	79	97	76	76	97	100	97	100	99	96	0	80
Indonesia	100	100	0	0	100	100	100	100	100	100	100	100
Nepal	100	100	100	100	100	100	100	100	100	100	0	0
Sri Lanka	0	0	0	0	100	100	100	100	100	100	92	92
Vietnam	100	100	100	100	100	100	96	100	100	26	0	0
All Fairtrade producers	25	27	22	23	70	100	44	100	90	90	65	85

10.3 Systematic Review Document References

Document Title	Year	Document Number
HH Survey WACP	2018	1
SPO Survey	2018	2
FGD Guide	2018	3
Impact Monitoring HH Questionnaire 2016	2016	4
Impact Monitoring SPO Questionnaire 2016	2016	5
Impact Monitoring HH Questionnaire 2017	2017	6
Impact Monitoring SPO Questionnaire 2017	2017	7
Impact Monitoring HH Questionnaire 2018	2018	8
Impact Monitoring SPO Questionnaire 2018	2018	9
Appendix 1_Premium Use Categories for Environmental Analysis	?	10
CODImpact 2014-2017	2019	11
1612-Fairtrade Theory of Change	2016	12
2016-Fairtrade-Global-Strategy-web	2016	13
CC PROJECTS Sept 2019 FINAL VERSION	2019	14
CC Strategy Action Plan_Final	2010	15
Climate Change and Fairtrade Making the Links	2011	16
Climate Change and Fairtrade Position Paper	2010	17
Climate Change STRATEGY_Approved LT	2010	18
CSA position	2015	19
Fairtrade and Environment Final 2017-08	2017	20
2016_02_23_cartilha_climate_change	2015	21
Fairtrade and the Carbon Market	2015	22
Fairtrade Climate Standard	2015	23
Fairtrade Minimum Price and Premium	2015	24
Fairtrade positioning on climate change	2016	25

Fairtrade-Climate-Change-Programme_fact sheet	2015	26
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