Revisión sistemática de literatura: estrategias de adaptación al cambio climático en el sector cafetalero

Review Paper - draft

A systematic review on climate change and coffee production: Adaptation practices and resilience strategies

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Abstract

As significant impacts of climate change are increasingly considered unavoidable, adaptation has become a policy priority. Climate change presents a series of challenges to the agricultural sector. Specifically, coffee production systems are predicted to face changes in suitability areas, as well as increased vulnerability to pests and diseases. In this systemic literature review we take stock of coffee adaptation strategies to climate change.

Keywords: coffee (*Coffea*); climate change; adaptation; resilience.

1. Introduction

Extreme climate events and changes in seasonal weather patterns combine to make it clear that climate change[1] is not a future scenario but a current reality. Climate change is striking harder

[1] The UNFCCC adopts a definition which illustrates the relationship between climate change and climate variability: "Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

and more rapidly than many expected (IPCC 2021). Under current global policy commitments to reduce emissions, temperatures are on track to increase by at least 2.7°C towards the end of the century—almost twice what climate experts have warned is the limit to avoid the most severe economic, social and environmental consequences (WEF 2020). With the increasing recognition of the impacts of global environmental change, climate policy discussions are slowly shifting from a focus on mitigation (reducing greenhouse gas (GHG) emissions and increasing carbon stocks to slow the speed of climate change) to adaptation (adjustments to minimise potential damage and maximise potential benefits).

The impacts of climate change on agriculture call for adaptation strategies

Climate change threatens agricultural production and food systems in a number of ways, including reduction of crop yields (Sue Wing et al. 2021), losses in nutritional value of crops (Leisner 2020), damage and loss from increased intensity and frecuency of climate extremes (FAO 2021a; Cottrell et al. 2019), changes in aptitude and landscape suitability (IPCC 2014), shifts in species distribution and composition (Barange et al. 2018), increased vulnerability to pests and disease (IPPC Secretariat 2021), increase in food safety concerns (FAO 2020). The impacts of climate change are complex and cascading: "Increases in global mean surface temperature […] affect processes involved in desertification (water scarcity), land degradation (soil erosion, vegetation loss, wildfire, permafrost thaw) and food security (crop yield and food supply instabilities). Changes in these processes drive risks to food systems, livelihoods, infrastructure, the value of land, and human and ecosystem health" (IPCC 2019).

Agriculture continues to bear the brunt of disaster impacts, particularly climate-related ones (FAO 2021a). From 2008 to 2018, agriculture – including crops, livestock, forestry, fisheries and aquaculture – absorbed 26% of the overall impact caused by medium- to large-scale geophysical, climate-related and hydrological disasters in low- and lower-middle-income countries (FAO 2021a). Severely affected by climate extremes and variability, agri-food systems also contribute to climate change, emitting up to 34 % of global GHGs (Crippa et al. 2021). However, agriculture has the potential to transform from being part of the problem, to part of the solution to the climate crisis (Colloff et al. 2021; Ollinaho and Kröger 2021). The sector has significant potential to offer emissions reductions and carbon sinks while also supporting sustainable development, thus combining climate change mitigation and adaptation.

Coffee supports the livelihoods of approximately 100 million people throughout the world, mainly smallholder farmers with landholdings of 5 hectares or less (Rhiney et al. 2021). In 2014 alone, an estimated 26 million farmers in 52 countries cultivated more than 8.5 million tons of coffee, accruing a value of USD39 billion in those countries (Hirons et al. 2018). Shade-grown coffee constitutes an agroforestry system recognised for the provision of ecosystem services that play specific roles in adaptating to climate change (van Noordwijk 2019).

As with all segments of society, the COVID-19 pandemic has exacerbated pressure on a pre-existing situation of vulnerability. Despite coffee's economic importance to low-income countries around the globe, the sector has over the decades faced a series of shocks and stresses, including institutional reforms, market price volatilities, extreme climate events, and plant diseases and pests (Rhiney et al. 2020; McCook 2019; Bacon et al. 2017; Avelino et al. 2015). For the coffee sector, the COVID-19 pandemic goes beyond its public health risk to place pressure on production (from access limitations to the fields to limited access to seasonal labour) as well as changes in patterns of consumption (Rhiney et al. 2021).

Adaptation, an emerging field

Climate change adaptation can be defined as "adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change" (IPCC 2018). In this sense, adaptation refers to a wide array of strategies to build capacities to respond and cope with change. Adaptive capacity, which is employed in the literature with reference to climate change but not only, can be widely understood as the ability to adapt to changing circumstances (Peterson et al. 2021; Engle 2011).

Another concept that has gained prominence in recent discussions on climate change and development challenges is resilience. Resilience discussions tend to focus on a system's capacity to recover or "bounce back" after an external perturbation. The *United Nations Common Guidance on Helping Build Resilient Societies* defines resilience as the ability of individuals, households, communities, cities, institutions, systems and societies to prevent, anticipate, absorb, adapt and transform when necessary, efficiently and effectively, when facing a wide range of risks while maintaining an acceptable level of functioning without compromising long-term prospects for sustainable development, peace and security, human rights and well-being for all (UN 2021). Enhancing the resilience of agrifood systems implies strengthening their capacities and those of their actors to prevent, anticipate, absorb, adapt and transform when struck by shocks and stresses (FAO 2021b).

To simplify a complex discussion, resilience speaks more to 'shocks' (an extreme event, such as a tropical cyclone, flooding, drought), whilst adaptation tends to talk more to slow-onset and progressive 'stresses' (e.g. changes in temperature and precipitation patterns, sea-level rise, changes in weather patterns). Climate change implies a combination of shocks and stresses, short-term extreme events and long term, slow-onset drivers of change. Thus, we want to capture both adaptation and resilience discussions of coffee production under the umbrella concept of climate change adaptation for our review.

In general, research in the field of climate change adaptation is relatively young. Attempts to develop a typology of adaptation strategies have sought to highlight patterns and trends (Berrang-Ford et al. 2013), to evaluate the effectiveness of adaptation practices (Owen 2020) or to discuss "trade-offs" between different strategies (Dutilly and Hainzelin 2019). In the field of natural resource management and disaster risk reduction, adaptation measures are typically divided into "hard" measures (physical and tangible measures, including infrastructure and engineering such as dams, water barriers and containment walls to control flooding, for example) and "soft" measures (intangible measures that come from decision-making, policy, capacity development) (Hannah 2016). This distinction could be applied to adaptation in agriculture, with hard measures referring to concrete interventions in the farm plot (e.g. change of varieties, diversification, pruning, fertilisation and pest management), and soft measures referring to policy and enabling environment (e.g. risk transfer, capacity development, social protection). According to one recent systemic review (Wiréhn 2018), farm-based adaptation measures appear to be more abundant and more discussed than policy-driven adaptation in the scientific literature.

Discussions of adaptation in agriculture have emphasised the need for transformation so that agri-food systems can pass from being part of the problem to part of the solution (Tittonell 2020; Gosnell et al. 2019). Callouts for transformative adaptation (Fedele et al. 2019) have placed particular emphasis on the role of agroecology (Wezel et al. 2020), diversification (Peterson-Rockney et al. 2021), locally adapted solutions (Sinclair and Coe 2019), and the human right to a healthy environment (Ituarte-Lima et al. 2020).

There exists a vast array of adaptation strategies in agriculture, including changing crop type or location, development of new technologies and modernisation, improving water management, migration, insurance, reform of pricing schemes, adoption of new technologies, extension services, diversification, among others (Kurukulasuriya and Rosenthal 2003). Studying climate change adaptation in agriculture is an ambitious endeavour considering the wealth of coping strategies that characterize this sector, which is highly dependent on climatic conditions. In fact, if we define agriculture as the favouring of certain plants over others due to the benefits human society derives from them, then agrobiodiversity stands as witness to society's adaptation capacities over the past 10,000 years.

These are part of the nuances we would like to capture by performing a systemic review of coffee's different adaptation and resilience strategies. It is challenging to assess the effectiveness of adaptation strategies, not only because of the need for options by context but also because of diverging monitoring and evaluation methods. However, the systemic review method can contribute to research in agriculture and climate science (El Chami et al. 2020) by providing an integral overview of climate change adaptation for coffee production. As such, the primary research question for this systemic literature review is: "What are the adaptation and resilience practices and strategies of coffee to climate change?"

2. Methodology

This systemic literature review follows the guidelines and standards for evidence synthesis in environmental management (Collaboration for Environmental Evidence 2018). The systematic review convention disaggregates the primary research question into definable components known as PICO or PECO (Population; Intervention/Exposure; Comparison; Outcome). The PICO/PECO elements which guide the search terms, as detailed in Table 1. The research team agreed upon search terms and proceeded to trial them in three major search engines (notably, Web of Science, Scopus and ScienceDirect) (Table 2). To avoid incompatibility issues between different engines, search operators such as wildcards, Booleans and braces were avoided.

Table 1. PICO/PECO breakdown of primary research question on the adaptation and resilience of coffee production to climate change

PICO/PECO	Description	Keywords
Population	Coffee production All species of *Coffea* All geographical locations Any production system, from smallholder to largescale intensive production, from agroforestry to no-shade production Coffee value chains from production to post-harvest transformation to consumption and market distribution	Coffee (*Coffea Arabica; Coffea canephora; Coffea liberica*) Shade-grown coffee Coffee agroforestry systems Coffee plantations

Interventions	Adaptation measures in agricultural production, food value chains and governance in response to climate change Resilience capacities (including livelihood diversification) Innovation, technology adoption Transitions and transformation Policy and market innovations Field interventions on the farm level Non-agricultural income	Adaptation strategies Resilience Coping capacities Risk reduction, anticipatory action, prevention
Comparators	Benefits and effectiveness of adaptation measures on different coffee systems and value chains, as compared to no intervention	Baseline, scenarios
Outcomes	Agronomic benefits in production (yields and cup quality) Effectiveness in provision of ecosystem services Socio-economic benefits and livelihood improvements	Ecosystem services Livelihood diversification Yield improvements Cup quality

Table 2. Development, trial, refinement and screening of search terms

The systematic review complemented results from the three academic research databases with results from searchs throughout a list of websites and organisation websites the team retained relevant to the study (Table 3), including the first 50 responses for the full review from each search website.

Table 3. List of academic database sources and websites used.

Academic databases	**Search websites**	**Organizational websites**
Web of Science Scopus ScienceDirect	Google GoogleScholar Pre-print archives (ArchivX)	FAO International Coffee Organization Center for International Forestry Research (CIFOR) World Agroforestry (ICRAF) World Adaptation Science Programme: https://wasp-adaptation.org/

The review team screened all literature retrieved using the study inclusion criteria as follows: *i)* relevant subjects (all countries/regions; any scale, from field to regional; any coffee agrosystems including smallholders and large-scale systems), *ii)* type of intervention (farm level improvements and agronomical practices, such as pruning, external inputs, increasing diversity; post-production interventions such as policy and market innovations; governance and resilience building), *iii)* comparator (compares future outcomes with baseline outcomes), *iv)* method (qualitative research, surveys, controlled experiments, biophysical modelling, etc.), *v)* outcomes (studies that consider the change in crop suitability, performance, variability, sustainability).

3. Results

In progress

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