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Vulnerabilities of Global Supply Chains to Agricultural Production Disruptions Caused by Individual and Compound Climate Shocks

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Climate change induced extreme precipitation poses a significant threat to agricultural production. Such impacts extend beyond local agricultural production regions, generating remote and cross-sector impacts that disrupt global supply chains (GSCs). While the direct impacts of extreme precipitation on agricultural production have been widely studied, how such local impacts cascade through supply chain networks to remote places remains elusive, partly because of the complex interdependencies within the global trade systems. To address this, we propose a **R**esilience **E** nhancement in **S**upply **C**hains **U**nder **E**nvironmental **S**hocks (**RESCUES**) framework. RESCUES couples an agricultural production loss model with a dynamic recursive economic network model. It allows us to identify channels through which the impacts of climate change on agricultural production propagate along GSCs to interconnected sectors and regions. We design nine climate shock scenarios (i.e., dry, wet, and compound precipitation anomalies with extreme, severe, and moderate levels of severity) using the latest Coupled Model Intercomparison Project Phase 6 (CMIP6) under two Shared Socioeconomic Pathways (SSPs) scenarios (SSP126 and SSP585). We then use RESCUES to simulate the GSCs dynamics over 2016-2050 under these nine scenarios. We find that direct agricultural losses driven by local precipitation anomalies can spread through GSCs to a wider range of countries and regions across the globe, creating large spatial spillover effects with direct and indirect economic losses. We estimate that the averaged per event total value-added (VA) losses caused by compound extremes is around $20.4/22.6 billion under SSP126/585, followed by dry extremes ($16.4/15.0 billion) and wet extremes ($8.7/11.6 billion). Moreover, the global distribution of direct and indirect losses exhibits high spatial heterogeneity. Countries with large agricultural outputs tend to have both high direct and indirect VA losses, especially in China, India, the United States, Russia, and Brazil. In contrast, poorer countries, such as Tanzania, Sudan, Myanmar, Yemen, Afghanistan, and Nepal, experience relatively larger direct losses, while rich regions heavily dependent on agricultural imports, including Hong Kong, Qatar, and Singapore, suffer relatively larger indirect losses. Considering that nations frequently implement export restrictions to ensure food self-sufficiency, we further design a hypothetical scenario to assess the global trade and economic impacts of near-term (2025-2030) agricultural export restrictions in four key food production regions (China, India, the United States, and Indonesia) under extreme precipitation anomalies. Our study highlights the importance of an integrated and comprehensive assessment of the risk footprint of climate change-related shocks, encompassing both direct and indirect impacts on GSCs.