LATIN AMERICA
AND CARIBBEAN

World Bank Group

COUNTRY CLIMATE AND DEVELOPMENT REPORT

HONDURAS

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Appendix A

A.1. Alignment between Country Vision, Government Plan, and Sustainable Development Goals

Country Vision Objectives	Government Plan 2010–2022 Sectors and Axis	Agenda 2030 Sustainable Development Goals (SDGs)	
1. An educated, healthy Honduras with no extreme poverty, and with consolidated systems of social security	1. Well-Being and Social Development	SDG 1	End poverty in all its forms everywhere.
		SDG 3	Ensure healthy lives and promote the well-being of all at all ages.
		SDG 4	Ensure inclusive, equitable, high-quality education and promote lifelong learning opportunities for all.
		SDG 6	Ensure the availability and sustainable management of water and sanitation for all.
		SDG 7	Ensure access to affordable, reliable, sustainable, and modern energy for all.
	A: Nutritional and Food Security	SDG 2	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.
2. A country that develops within a democracy, with safety, and without violence	2. A More Just, Peaceful, and Inclusive Society	SDG 11	Make cities and human settlements inclusive, safe, resilient, and sustainable.
		SDG 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels.
	A: Promotion and Respect of Human Rights	SDG 5	Achieve gender equality and empower all women and girls.
3. A productive Honduras that creates opportunities and worthwhile jobs, harnessing its resources in a sustainable way that minimizes the vulnerability of the environment	3. Economic, Inclusive, and Sustainable Growth	SDG 8	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.
	4. Infrastructure and Logistics Development	SDG 9	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.
	A: Protection and Conservation of the Environment	SDG 12	Ensure sustainable consumption and production patterns.
		SDG 13	Take urgent action to combat climate change and its impacts.
		SDG 14	Conserve and sustainably use the oceans, seas, and other marine resources for sustainable development.
		SDG 15	Protect, restore, and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss.
4. A transparent, responsible, efficient, and competitive modern state	5. Democratic Governance and Development	SDG 10	Reduce inequality within and among countries.
		SDG 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels.

Source: Government of Honduras, *República de Honduras Visión de País 2010–2038 y plan de Nación 2010–2022* (2010); United Nations, *Transforming our world: the 2030 agenda for sustainable development (2015).*

A.2. Strategic Areas, Sectors, and Objectives of the Plan for Reconstruction and Sustainable Development

Strategic areas	Sectors	Objectives
Development and Social Welfare	Healthy Life	Guarantee the enjoyment of physical and mental health through rapid recovery from the health crisis caused by the COVID-19 pandemic and aggravated by natural disasters, with an approach based on genuine respect for human rights.
	Good-Quality and Inclusive Education	Ensure the prompt rehabilitation of educational establishments under the human rights-based approach, and increase the coverage and quality of education.
	Good-Quality Housing	Safeguard the right to decent housing through comprehensive, decent, and resilient solutions, based a human rights-based approach and conferring legal certainty to owners over their property.
	Social Protection and Inclusion	Improve the targeting and efficiency of social protection and inclusion programs, with a gender and human rights-based approach and with a life cycle perspective and strategies to improve the management of social services.
Empowerment and Transformation of the Productive Sectors	Restoration of Agriculture Sector	Promote rapid repair of the damage to the agricultural sector and promote its reactivation, with improvements in competitiveness and productivity made in a sustainable manner, in order to improve rural families' incomes and help them overcome poverty.
	Industry and Commerce Recovery	Promote the recovery of industry and commerce and increase their sustainable and inclusive growth potential, especially of micro, small and medium enterprises (MSMEs).
	Reactivation of Tourism	Repair the damage suffered at some of Honduras's most important tourist sites, and facilitate the recovery of income levels and employment in tourism, with a vision of competitiveness and sustainable growth.
Infrastructure Modernization and Resilience	Better Infrastructure and Transport	Renovate ground transport and move toward the construction of a resilient, modern road network that facilitates the achievement of the country's economic objectives by reducing travel time and cost for both passengers and cargo.
	Greater Coverage and Efficiency of Electricity	Upgrade the public electricity system infrastructure, with a strong vision to achieve efficiency, managerial transparency, and financial sustainability, and end the system's current role as a fiscal burden.
	Narrowing of the Digital Gap	Develop and maintain a robust, extensive national telecommunications system that contributes to reducing the country's digital divide by ensuring that the poorest and most isolated population groups have affordable access, for the purposes of education and productive enterprise.
	Improved Coverage and Quality of Water and Sanitation	Rehabilitate and rebuild drinking water and basic sanitation systems, as well as irrigation and flood protection systems, for the benefit of the entire population, particularly the poorest residents of rural areas and marginalized urban areas.
Environment, Risk Management, and Climate Change		Define a broad framework for the environment, climate change, and risk management so that the country is less vulnerable to extreme natural phenomena, in an inclusive and participatory way, especially at the local and regional levels.

Source: http://prds.hn.
Note: This table is based solely on the plan for reconstruction and sustainable development. MSMEs = micro, small, and medium enterprises

A.3. Nationally Determined Contribution (NDC) Adaptation Commitments

- By 2021, Honduras will present its first Adaptation Communication.
- By 2022, Honduras will have completed the process of preparing the National Adaptation Program (NAPA), in order to operationalize the National Adaptation Plan (PNA), in line with the measures identified in this NDC.
- In 2023, the National Water Policy will have been developed and the Water Authority created, in addition to the strengthening of the National Meteorological Network.
- By 2030, protected area management plans will have been updated with the adaptation component.
- By 2025, the country's Participatory Tables for Agrifood will have been formed and strengthened, in adaptation measures, with their early-warning systems functioning.
- By 2023, the Infrastructure Sector Adaptation Strategy will have been prepared and the adaptation component will have been incorporated into the designs of new road structures.
- By 2025, the Municipal Land Management Plans (PMOT), the Municipal Development Plans (PDM), or both, will have been updated with a focus on adaptation and a gender-based approach.
- By 2023, an adaptation strategy for the electricity transmission and distribution system will have been implemented and a measurement, reporting, and verification (MRV) system for adaptation in the country will have been established.
- By 2025, there will be financing mechanisms for the adaptation actions of vulnerable groups (women, youth, and indigenous peoples and Afro-descendants (IPADs)).

Source: Government of Honduras, Honduras Nationally Determined Contribution, first update (2021)

A.4. Adaptation and Mitigation Objectives of the National Strategy for Climate Change

Strategic Objectives for Adaptation

Incidence Area	Strategic Objective for Adaptation	
Water resources	1	Reduce the impacts of more frequent and more intense droughts caused by declining rainfall and reinforce the recharge of aquifers.
	2	Reduce the alteration of ecological flows, considering the effects of climate change on river systems.
	3	Prevent and avoid the deterioration in water quality caused by contamination, considering the effects of climate change on the volume of available water.
Agriculture, soils, and food security	4	Facilitate the adaptation of farmers to climate change by improving the resilience of crops and pastures under thermal and water stress, and preventing or reducing the incidence of pests and diseases brought by climate change.
	5	Avoid erosion, loss of productivity and eventual desertification of soils under the effects of climate change.
	6	Preserve and improve nutritional quality and contribute to the food security of the population under conditions of climate change.

Forests and biodiversity	7	Preserve the long-term function, structure, and composition of ecosystems to improve their adaptive capacity to climate change.
	8	Prevent the loss of broadleaf and coniferous forests to fires and forest pests, under conditions of climate change.
	9	Implement effective forest management to enhance protection and production in the face of changes in richness, functionality, and symbiotic relationships as a result of climate change.
Coastal and marine systems	10	Preserve the structure and dynamics of marine and coastal ecosystems, considering the effects of climate change, particularly the rise in sea level and changes in air and sea surface temperatures.
Human health	11	Reduce the incidence and geographical distribution of human diseases caused by the effects of climate change manifestations.
Risk management	12	Reduce the risks and impacts associated with the occurrence of hydrometeorological events, whose frequency, intensity, and duration are increasing as a result of climate change.
	13	Promote the design, development, construction, and deployment of more appropriate infrastructure and facilities, in terms of resistance and versatility, in order to better adapt them to the current and projected effects of climate change.
	14	Strengthen the civil security and governance of the nation, preventing, reducing, and addressing in an appropriate and timely way the temporary or permanent displacement of human populations for climate change-related reasons.
Hydroelectric energy	15	Facilitate the adaptation of hydroelectric energy sources in the face of the impacts of climate change already observed and projected.

Source: Comité Técnico Interinstitucional del Cambio Climático (CTICC), *ESTRATEGIA NACIONAL DE CAMBIO CLIMÁTICO HONDURAS (2022)*

Strategic Objectives for Mitigation

» Reduce and limit greenhouse gas emissions to voluntarily contribute to climate change mitigation, and strengthen collateral processes of socioeconomic and environmental sustainability at the national level.

» Strengthen the synergy between mitigation and adaptation measures to facilitate a better adjustment of socio-natural systems to the manifestations and impacts of climate change and prevent the adverse effects of response measures.

Source: Comité Técnico Interinstitucional del Cambio Climático (CTICC), (2022). ESTRATEGIA NACIONAL DE CAMBIO CLIMÁTICO HONDURAS

A.5. Methodology for Macro Assessment

Box A5.1: Data gaps and methodological shortcomings

» **There is a critical information gap in the understanding of the quantitative impacts of disasters caused by natural hazards on the Honduras's economic sectors and on the livelihoods of affected population groups.** Severe methodological constraints hamper further modeling of climate risk impacts in Honduras, and large knowledge gaps remain that prevent a more accurate assessment. Although every effort was made to obtain the most comprehensive and reliable information available for this Country Climate and Development Report (CCDR), several gaps remain.

- **Limited data availability on natural hazard risks.** For the purposes of this report, data on natural hazard risks could be obtained only for a subset of the natural hazards Honduras experiences—excess rain (XsR), tropical cyclones (TC), and earthquakes (EQ). There are no robust loss models available to offer probabilistic estimates of future losses associated with other important climate change-related risks such as excess heat, drought, landslides, and wildfires. This leaves out an assessment of the impacts of droughts on the agriculture sector. Floods might arise from excess rain, but the available model—the Caribbean Catastrophe Risk Insurance Facility's SPHERA—does not include agriculture sector exposure. Exposure of crops is included in the model that simulates losses from EQ and TC, but it accounts for only 1.23 percent of total exposure and may not capture the whole impact on the sector.

- **Linking climate change to natural hazards.** There is currently no quantitative information on the likely impact of climate change on the severity and frequency of natural hazards in Honduras. Exceedance curves used in this CCDR are estimated based on historically observed patterns and are not linked to specific climate change scenarios. Scenarios presented below on climate-change induced increases in the severity and frequency of weather events are strictly hypothetical and for illustration purposes only.

- **No information on direct output losses.** The available data on natural hazard risks focus on the value of damage, that is, the destruction of physical capital. However, in addition to such damage and its long-term detrimental effects on growth, there can also be immediate losses resulting from foregone output, for instance, when a crop is destroyed, or service providers are unable to operate in inclement weather. A holistic impact-modeling framework that combines information on physical capital damage and output losses, and translates into foregone income at the household level, is not available in Honduras.

- **No linkages between the macro modeling and sectoral analysis.** Statistics on the economic impact of disasters are collected and reported as a total sum for all sectors, and do not fully capture the impact on individual sectors. As a result, there is limited understanding of the extent to which natural hazards impact the various sectors and subsectors in Honduras. In addition to the lack of data, the parallel work on sectoral analyses under this CCDR did not allow for integrating them into the macro modeling. Further analysis should aim to link the results of the sectoral analysis into the macro modeling, in particular, to assess the fiscal implications of the policy options proposed. This could help guide the intersectoral prioritization or resource allocation across sectors.

- **Limited information on impacts in agriculture.** There is no readily available Honduras-specific data on the simulations impact of climate change (for example, temperature rise) on agricultural output and the yields of major crops to enable the assessment of the impact on productivity. Although such estimates are available at the *regional* level,[a] they are not suitable for modeling the impact in Honduras because a) they are dominated by the economic structure of large agriculture exporters in the region whose production systems are very different from those in Honduras; for example, the crops covered accounted for only 22.44 percent of Honduras's value of crop production in 2018 and do not include coffee (53 percent of Honduras's value of crop production) or fruits, and b) they are based on an assumption of increasing land surface suitable for agriculture, which is not consistent with Honduras's agriculture sector plans (despite often informal expansions of agricultural land (see section 4.2). Further, for the purpose of the macro modeling that uses MFMoD, this report did not employ the Central America and Honduras-specific impacts of climate change on yields, agriculture production, and area planted based on the International Food Policy Research Institute's IMPACT model[b] because the estimates of climate change impact on agriculture value-added were not available.

» **No behavioral impacts.** A more dynamic modeling framework, including country-specific behavioral parameters, would be better suited for considering endogenous adjustment behavior by firms and households that likely have an important impact on disaster vulnerability in the medium to long term. This also ignores household reactions (to disaster losses) that have potentially important implications for long-term growth, such as migration and schooling decisions that affect the availability, formation and directional flow of human capital.

» **No information on public investment needs.** There is currently no quantification of public investment needs for implementing Honduras's NDC commitments. In addition, a long-term strategy with specific financing needs is currently unavailable, limiting long-term planning.

» **Country-specific estimates on the efficiency of adaptation investment and reconstruction patterns are not available, and therefore global estimates and assumptions were substituted.** Obtaining precise country-specific information would be important to more accurately determine the optimal level of adaptation investment and better assess economic damage from delayed reconstruction.

» See section A.5 in the appendix for more information on the methodology and assumptions used for modeling the impacts of climate shocks and climate change in chapter 3.

Source: World Bank Group staff assessment
Note: MFmoD = Macro Fiscal Model Framework with climate feature extension; NDC = Nationally Determined Contribution.
[a] For background information, see Petr Havlik and Hugo Valin, *Climate Change Impacts and Mitigation in the Developing World: An Integrated Assessment of the Agriculture and Forestry Sectors*, Policy Research Working Paper 7477 (Washington, DC: World Bank Group, 2015).
[b] See Michael Morris, Ashwini Rekha Sebastian, and Viviana Maria Eugenia Perego, *Future Foodscapes: Re-imagining Agriculture in Latin America and the Caribbean* (Washington, DC: World Bank Group, 2020); Arie Sanders *et al.*, *Climate Change, Agriculture, and Adaptation Options for Honduras*, IFPRI Discussion Paper 01827 (Washington, DC: International Food Policy Research Institute, 2019); and Sherman Robinson *et al.*, *The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT)*, IFPRI Discussion Paper 01483, (Washington, DC: International Food Policy Research Institute, 2015).

Methodology and Assumptions

The World Bank's Macro Fiscal Model Framework with climate feature extension (MFMod-C) was used for all macroeconomic modeling scenarios. MFMod-C is a macrostructural model designed for a detailed, whole-economy analysis and provides in-depth exploration of future economic and debt pathways. The model also allows for a precise description of tax revenues, spending, and fiscal rules and for combining physical risks and transitional risks. It permits a coherent estimation of damage from climate shocks as well as the impacts of rising temperature on growth and productivity, and it enables an examination of adaptation and mitigation policy alternatives through the consideration of economic and fiscal trade-offs.

An important strength of the MFMod scenario analysis system is its ability to track the out-of-equilibrium behavior of an economy. This attribute makes it a preferred tool when the aim is to understand, predict, and lay out a transition path following a climate or policy shock. Its careful respect of budget and physical constraints in the economy allows for an evaluation of climate effects side by side with other policy priorities such as economic growth, inflation, unemployment, and current account and fiscal sustainability. Climate features embedded in the model include modeling how economic activity affects climate, and modeling how the climate affects the economy. The model also includes natural capital accounts and simulations regarding mitigation as well as adaptation policies.

The approach follows the modeling work done by Burns *et al*. in Jamaica.[1] It takes a probabilistic approach by drawing natural disaster losses for the period 2022–2050 from a set of damage exceedance curves for natural disasters. Each scenario is run in 10,000 iterations to generate median, upper-bound (best 5 percent of outcomes), and lower-bound (worst 5 percent of outcomes) cumulative losses as deviations from a baseline with no natural disasters.

Natural hazards. Disaster risk is derived using loss exceedance curves provided by the Caribbean Catastrophe Risk Insurance Facility based on its SPHERA model.[2] Exceedance curves, it should be noted, combine losses from just three types of disasters—earthquakes, excess rain, and tropical cyclones. Thus, the scope of the modeling exercise is limited to these three disaster types, even though many other perils hit the country, from droughts and excess heat, to epidemics and pandemics. Exceedance curves are based only on destroyed capital, not output losses. What this means is that all GDP losses shown in the modeling results are *indirect* and result from the destruction of physical capital. By contrast, *direct* losses through forgone output as a result of a disaster—for instance, destroyed crops or the closure of businesses due to inclement weather—are not taken into account. Earthquake risk, which contributes to the base load of disaster risk but is not susceptible to climate change, is kept constant across all scenarios.

Reconstruction. All scenarios assume that Honduras will rebuild destroyed capital after a natural disaster. However, a cap is imposed at 50 percent of total public investment (public and private) in a given year. This is not a fiscal or financial constraint because, in principle, reconstruction investment could exceed total investment if resources were reallocated. It should rather be interpreted as a constraint on the implementation capacity of reconstruction projects, where the ability of the public and private sectors to rebuild the capital stock depends directly on their ability to carry out regular investment.

Losses caused by the natural disasters are split as follows: Out of total losses, 23 percent are public infrastructure to be repaired at the government's expense; 49 percent are private sector infrastructure, with reconstruction financed through reallocation from private savings; and 28 percent are residential. Residential reconstruction is assumed to be financed 50/50 from private savings and reduced private consumption, corresponding to the approximate share of residential real estate owned by poor residents (US$5.50, purchasing power parity line), who likely would not be able to rely on savings for reconstruction. In addition, it is assumed that the government undertakes relief efforts in the immediate aftermath of a disaster, the cost of which is assumed to be proportional to the disaster losses, amounting to 15 percent of their total value.

In all scenarios except for D2, all additional government spending due to a natural disaster is financed entirely from within the budget through reallocation from other spending items.[3] Following the work of Burns *et al*., reconstruction of damage is capped at 50 percent of the total value of public investment in the baseline setting of the model (scenarios C1, D1, and D2 relax this constraint to 70 percent).[4] This is a critical parameter because it determines the point at which damage become too large to repair within a given year and thus results in additional output losses in subsequent years. There are currently no estimates in the literature of the empirical magnitude of the parameter, so the simulations use the same generic value as Burns and colleagues but add a sensitivity analysis by allowing for accelerated reconstruction in scenarios C1, D1, and D2. The following table summarizes the scenario-specific parameters for each of the scenarios discussed in chapter 3.

[1] Andrew Burns, Charl Jooste, and Gregor Schwerhoff, *Macroeconomic Modeling of Managing Hurricane Damage in the Caribbean: The Case of Jamaica*, Policy Research Working Paper No. 9505 (Washington, DC: World Bank Group), https://openknowledge.worldbank.org/handle/10986/34982.

[2] Caribbean Catastrophe Risk Insurance Facility (CCRIF), *The CCRIF Tropical Cyclone Model—SPHERA: System for Probabilistic Hazard Evaluation and Risk Assessment*, Segregated Portfolio Company note (Grand Cayman, Cayman Islands: CCRIF, 2019), https://www.ccrif.org/sites/default/files/riskprofiles/TC_Annex1_r2.pdf.

[3] Detailed descriptions of the scenarios can be found in section 3.1.

[4] Burns *et al.*, *Macroeconomic Modeling of Managing Hurricane Damage*.

TABLE A5.2. Assumptions for Macro Scenarios of Natural Disaster Impact

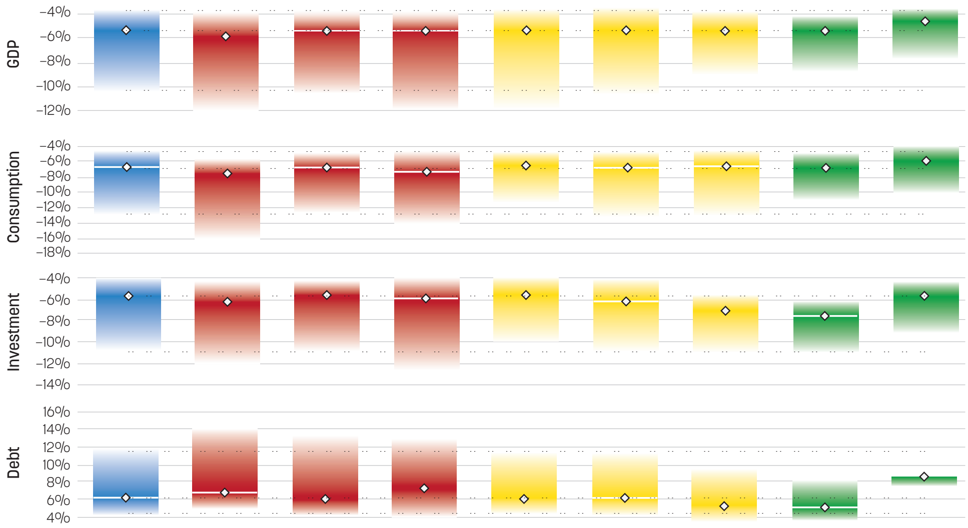
	Baseline	Climate Change (CC) impact			Policy options			Fiscal policy	
Scenario	**A**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**	**D1**	**D2**
	No policy	10% increase in TC and XSR damage	More frequent, but less intense XsR	Less frequent, but more intense TC	Accelerated reconstruction	Post-disaster transfer	Adaptation investment	C1, 2, 3 combined	C1, 2, 3 combined with proactive fiscal policy
Disaster risk	Baseline	20% uniform increase in losses from TC and XsR	Intensity of flooding events decreases, but frequency increases	Intensity of TC increases, but frequency decreases	Baseline	Baseline	Baseline	Baseline	Baseline
Spending									
Reconstruction	Capped at 50% of public investment p.a.				Raise maximum to 70% of public investment p.a.	Capped at 50% of public investment p.a.		Raise maximum to 70% of public investment p.a.	
Post-disaster transfer	0	0	0	0	0	20% of damage to private residences	0	20% of damage to private residences	
Adaptation	0	0	0	0	0	0	20% of capital stock		
Financing									
Reallocation	All disaster-related costs are financed through reallocation within the budget								0
Insurance		0	0	0	0	0	0	0	Coverage for 30% of total losses
Debt		0	0	0	0	0	0	0	In the short term, insurance premiums and uninsured losses are covered through new debt
New revenue		0	0	0	0	0	0	0	Gradual increase of direct tax revenue by 0.25% of GDP

Note: CC = climate change; GDP = gross domestic product; p.a. = per annum; TC = tropical cyclone; XsR = excess rain.

TABLE A5.3. Summary of simulation scenario result

	Base Line	Impact of CC (Illustrative)	Adaptation Strategies	Proactive fiscal policy
	A	B1, B2, B3	C1, C2, C3	D1, D2
Assumptions	Natural disaster impact in line with stochastic distribution of past disaster incidence (1000 iterations)	Variations in natural disaster risk for illustrative purposes: Uniform +10% increase in damages from excess rain and tropical storms (B1), less intense, but more frequent excess rain events as predicted by IPPC assuming constant total losses (B2), more intense, but less frequent tropical storms as predicted by IPCC assuming constant total losses (B3)	Different adaptation strategies, all financed from within the budget (no additional expenditure): Accelerated reconstruction capacity, raising the model cap of reconstruction spending in a year from 50% to 70% of public investment (C1), a post-disaster transfer to households equivalent to 20% of their damages (C2), investment in adaptation to protect the capital stock up to 20% of total damages (C3)	D1 is a combination of adaptation measures from C1, C2, and C3, all financed from within the budget. D2 adds a financing strategy using disaster risk insurance for quick liquidity in the event of a disaster, borrowing in the short-term to finance adaptation, and medium-term revenue generation reaching 0.25 percent of GDP pa. by 2030

Results in terms of cumulative losses by 2050



	Base Line (A)	Impact of CC (B1–B3)	Adaptation Strategies (C1–C3)	Proactive fiscal policy (D1–D2)
Key messages	Even without CC, natural hazards weigh heavily on the macrofiscal outlook. Impact is driven by years with severe events when damages cannot be repaired quickly.	CC would further add to macroeconomic disruptions and risks, though serious knowledge gaps remain on the magnitude of such effects. Effects are likely to differ by natural hazard type, and the negative growth effects of increased event severity outweigh those of higher event frequency.	Accelerated reconstruction capacity reduces downside risk from natural disasters but aggravates opportunity costs from within budget reallocation in a zero-sum budget scenario. Post-disaster transfers are a social necessity, and can have important 2nd round effects on growth and consumption that are not captured by the macro model (e.g. avoiding emergency asset sales, school dropouts, emigration). Adaptation investment reduces downside risk from large events, but also diverts resources from productive investment if financed through reallocation within the budget	Combining adaptation with a proactive fiscal strategy improves outcomes for GDP, consumption and investment, with the largest improvements in downside risk. The fiscal strategy alleviates tradeoffs between adaptation and other development priorities. A carbon tax can be an efficient instrument to finance such a strategy with additional mitigation effects and health related co-benefits

Source: World Bank staff calculations, see section A.5 in the appendix for the methodology and a detailed discussion of each scenario.
Note: Estimation of the cumulative impact by 2050 of excess rain (XsR), tropical cyclones (TC), and earthquakes (EQ) on GDP, private consumption, investment, and public debt relative to a hypothetical baseline with no impact of these natural hazards. The bars mark the estimated stochastic range from the 5th to the 95th percentile of natural hazard outcomes, measured in terms of impact on GDP, private consumption, investment, and public debt. The results for GDP, consumption, and investment are in percent, while the results for debt are expressed in percentage points of GDP. The white diamonds indicate median outcomes, and the dotted lines show the 5th percentile, median, and 95th percentile under the baseline scenario, for ease of comparison. For example, in panel a, the median impact implies that by 2050, 50 percent of the time, the cumulative GDP loss from XSR, TC, and EQ under the baseline scenario A is expected to be above 5.4 percent. Detailed definitions of each scenario can be found in section A.5 of the appendix.

Box A.5.2 Damage from Natural Hazards and Resulting Fiscal Contingent Liabilities

The stochastic distribution of damage from natural hazards is estimated from outputs of full probabilistic catastrophe models for geological (earthquake: EQ) and hydrometeorological/climate (tropical cyclone: TC, and excess rainfall: XsR hazards). The EQ model does not include damage by tsunamis, while the TC model quantifies damage from wind and storm surge. Losses are reported in terms of a stochastic distribution of nationwide damage to both public and private infrastructure that has been updated to 2020, with an adjustment of the exposure based on GDP growth. Average combined losses are 2.3 percent of GDP in terms of damage to infrastructure in a given year, and excess rain accounts for the most significant losses in the median year, at 1.4 percent of GDP. However, damage from tropical cyclones dominates the downside risk, with losses exceeding 13.7 percent of GDP and 27.1 percent of GDP every 100 and 500 years (return periods; table B3.2.1).

TABLE B3.2.1 Estimated results on Contingent Liabilities for diverse natural hazards

	EQ	TC	XsR	Total
Mean	0.2%	0.4%	1.7%	2.3%
Median	0.0%	0.0%	1.4%	1.7%
Every 10 years	0.2%	0.3%	3.5%	4.4%
Every 100 years	4.7%	13.7%	6.3%	16.2%
Every 500 years	12.3%	27.1%	8.2%	29.0%

Source: World bank staff estimations
Note: EQ = earthquake; TC = tropical cyclone; XsR = excess rainfall.

Not all reconstruction costs are borne by the government. Contingent liabilities (CLs) due to natural hazards arise from the following:

» **Emergency and rehabilitation expenditures.** Based on historical data, these are estimated at 15 percent of total reconstruction costs;

» **Reconstruction of public assets and infrastructure.** Based on the available information on sector distribution and ownership, this accounts for approximately 23 percent of total reconstruction costs; and

» **Indirect contingent liabilities for potential support to vulnerable populations and households to help them repair the damage to their dwellings.** Although this is a government decision, demands for such payments are politically difficult to resist in the aftermath of a major disaster. Damage to residential real estate is estimated to account for 28 percent of total reconstruction costs, and roughly half of residential real estate in Honduras belongs to economically vulnerable populations, so the maximum contingent liability is estimated at 14 percent of total reconstruction costs. In the following simulations, there is no support to households in the baseline scenario, although in scenarios C2, D1, and D2 a transfer that is equivalent to 20 percent of residential real estate damage is added.

Based on these assumptions, total CLs from EQ, TC, and XsR—including emergency and rehabilitation and reconstruction expenditures—represent, with an annual probability of 1 percent, at least 8.5 percent of GDP (13.1 percent on average for the 1 percent worst outcomes). This rises to at least 16.1 percent (22 percent on average) in the worst 0.2 percent (1-in-500 years) outcomes. The risk assessment is summarized in table B3.2.2. These figures are split between 28.8 percent short-term financing needs and 71.2 percent reconstruction in the medium and long term.

TABLE B3.2.2. Risk Assessment of Contingent Liabilities: Total and Split Among Phases (US$, millions and percent of GDP)

Metric	Total	Emergency	Recontruction		
			Total	Public assests and infrastructure	Housing support
AAL	290.6 (1.23%)	83.6 (0.35%)	207.1 (0.87%)	128.3 (0.54%)	78.8 (0.33%)
VaR1%	2,018 (8.5%)	581 (2.5%)	1,438 (6.1%)	891 (3.8%)	547 (2.3%)
TVaR1%	3,108 (13.1%)	894 (3.8%)	2,214 (9.4%)	1,372 (5.8%)	842 (3.6%)
VaR0.2%	3,818 (16.1%)	1,098 (4.6%)	2,720 (11.5%)	1,685 (7.1%)	1,035 (4.4%)
TVaR0.2%	5,209 (22%)	1,498 (6.3%)	3,711 (15.7%)	2,299 (9.7%)	1,412 (6.0%)

Source: World Bank staff estimations.
Note: The risk assessments of total contingent liabilities (CLs), disaggregated by post-disaster phases, use the following three risk metrics: Average Annual Loss (AAL), Value at Risk (VaRα), and Tail Value at Risk (TVaRα). α is the annual exceedance probability linked to the metrics. The assumptions, in particular, the ratio of CLs to national reconstruction losses, are to be confirmed with the government of Honduras.

A.6. Assumptions and Caveats of the Joint MFMod-C and Microsimulation Poverty Analysis

In the microsimulation model, the CCDR makes six important assumptions that are crucial to explaining long-term poverty reduction trends:

» **Given the data limitations, it is not possible to quantitively assess the impact of climate change on the severity and frequency of disaster risks.** Without this information, no macro or micro model can reliably predict the likely impacts of climate change on disaster risks, macro outcomes, and poverty. This is not a feature of the Macro Fiscall Model Framework with climate feature extension (MFMod-C) microsimulation model, but rather an effect of the lack of data. Although it is not possible to incorporate any future climate change, the baseline scenario does include "climate" because it is based on observed historical patterns of natural hazards (with no changes in the incidence or intensity of those events). The microsimulation model therefore did not add potential poverty impacts based on hypothetical climate scenarios that induced a higher frequency or intensity of hazards (scenario B1–B3), because, given the lack of data, they would be merely hypothetical.

» **Honduras, as in the past, continues to be affected by climate-induced natural hazards, with no accelerating climate change and no change in the incidence or intensity of those events.** Since the model follows a stochastic approach to capture the probability[5] of ending up with better or worse outcomes, future disasters caused by natural hazards are milder or worse than historical disasters. The baseline scenario is defined as the median of the 1,000 simulated scenarios.

» **No policies are implemented to mitigate the adverse poverty and distributional impacts of natural hazards in the baseline.** Reconstruction and emergency response are made mainly via budget reallocation from nonessential public investment (capital redeployment is capped at 0.5 percent of public investment, 15 percent of damage is pure disaster management cost), and there are no adaptation or mitigation policies in place. There is no change to total expenditure in response to a disaster. The safety net is assumed not to expand or improve during the next 30 years.

[5] This is a model with an Exceedance Probability function, which describes the probability that various levels of loss will be exceeded. For example, if we simulate 10,000 years of droughts, the largest loss will have a 0.01% chance of being exceeded.

- **Nonlabor income, which includes capital but excludes remittances and social transfers, is assumed to be constant in real terms.** No specific growth is assumed as there is insufficient information to infer a plausible growth rate. Also, capital income is not properly measured in the household survey so the model cannot accurately analyze its regressivity. The real value of current public transfers is maintained.

- **Structural relationships remain constant over the period.** The macrostructural model produces projections of employment levels and real wages by sector to feed the microsimulation exercise. To do so, Okun's ratios are applied to convert sectoral value-added into employment levels based on the historical relationship between employment and value-added. Therefore, changes in sectoral employment completely mirror changes in sectoral value-added.

- **No new remittance-receiving households.** Based on the projected changes in real remittances, the microsimulation model adjusts the real value of remittances for all remittance-receiving households but does not include new receivers. Precise specific information about remittance-receiving households would be important to accurately model such an expansion of coverage.

In addition to the data limitations and shortcomings of the macroeconomic modeling described in box 3.1 that permeate the microsimulation model, further methodological caveats remain for a more accurate poverty assessment. Despite the effort made at comprehensive poverty analysis, several caveats remain. Five in particular are:

- **No impacts on asset losses and household consumption.** Based on the 2019 household survey, 42 percent of residential housing is owned by the poor, but there is insufficient information about the value of the housing and how this has been damaged by past natural hazards to infer likely future trends. In addition, the latest consumption data available for the country (2004) are outdated, so it is difficult to assess the differential impact of consumption loss on households of varying income levels.

- **Lack of projections of relative prices of food.** The macroeconomic model produces projections of overall consumer price index inflation but not projections of food inflation, limiting the microsimulation model's ability to assess how changes in relative prices (that is, food versus nonfood) can affect affordability and household welfare, both monetary and nonmonetary. This is a critical transmission channel of climate shocks in Honduras because food inflation can exacerbate food insecurity and disproportionately affects the poor, who use a larger share of their budgets on food. For example, in a parallel exercise, simulation results for 2019 show that food inflation of 9 percent can lead to a 2.4 percentage points increase in poverty. Therefore, the simulated results on poverty presented here should be considered a lower bound, as the effect might be underestimated.

- **Geographical heterogeneity is captured in neither the MFMod-C nor the microsimulation models.** Although a disaster may affect a particular area and involve a small share of the population, the model aggregates the impact only at the *country* level. Notwithstanding this limitation, as mentioned before, the model has some heterogeneity because employment and wages are disaggregated by 10 sectors. As workers are reallocated across sectors for each projected year, the model estimates the probability of being reallocated into new sectors based on individual characteristics.

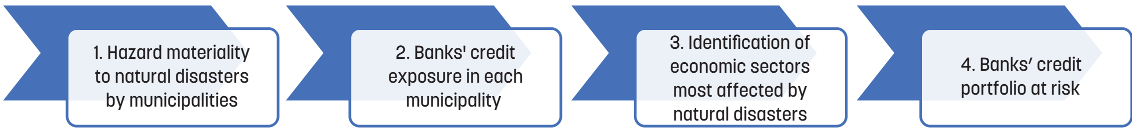
- **The lack of data disaggregated by ethnicity and race limits the ability to assess the impacts on ethnic groups and minorities.** This analysis is important because indigenous peoples and Afro-descendants remain largely absent in policy-making and programming largely because of their statistical invisibility, institutionalized structural discrimination, and limited voice and agency to demand change.

- **No assessment of the distributional impact of taxes and public spending is included.** Further customization of the microsimulation model is required to produce an ex-ante analysis of the distributional impact of taxes and spending, such as the Commitment to Equity Approach (see box note). Thus, the impacts of policy scenarios that include taxation (scenario D2) are currently insufficient to draw complete and concrete policy recommendations. A fuller assessment of the entire fiscal policy is needed.

A.7. Methodology of Financial System Analysis

A.7.1 Methodology for Estimating the Natural Disaster-Specific Debt-at-Risk in Each Municipality

Estimation Steps



An example for assessing banks' debt-at-risk | Natural disaster: Drought | Municipality: Colón

1. Municipality A (Colón) has a high hazard mapping for droughts.

2. Banks lend % of their total credit portfolio to the municipality of Colón.

3. Assessment based on empirical literature and historical events shows that droughts affect mostly the agriculture sector, which represents % of banks' credit portfolio in the municipality of Colón.

4. – % of banks' agriculture credit portfolio in the municipality of Colón is at risk of potentially damaging and life-threatening floods that are expected to occur at least once in the next 10 years.

This methodology is similar to the work of Calice and Miguel,[6] which gives preliminary estimates of the exposure to physical risks for eight countries in Latin America and the Caribbean. The sectoral mapping used in that report follows the one proposed by the authors of this CCDR (step 3 in the diagram above), allowing for the direct comparison of the exposure to physical financial risks in Honduras with that of other countries in the region. Moreover, the sectoral mapping proposed by Calice and Miguel follows an identification that is similar to what historical events in Central America suggest. The following figure shows the distribution of economic losses from 13 large-scale, natural disasters that affected Belize, Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua during the 1974–2020 period.

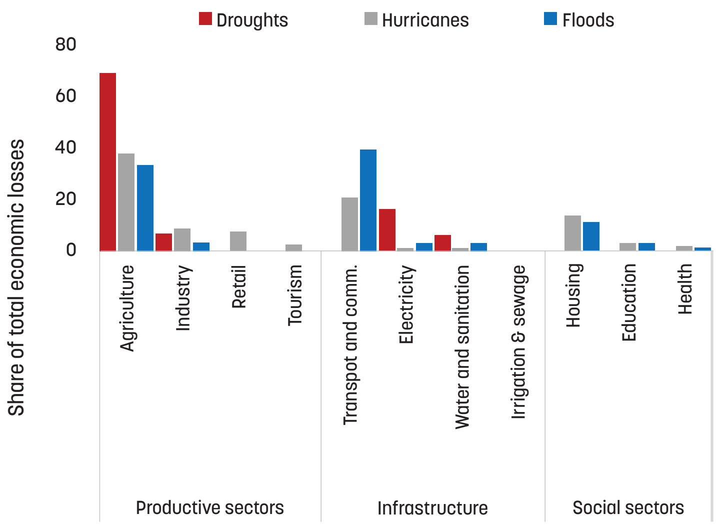
[6] Pietro Calice and Faruk Miguel, Climate-Related and Environmental Risks for the Banking Sector in Latin America and the Caribbean: A Preliminary Assessment, Policy Research Working Paper 9694s (Washington, DC: World Bank Group, 2021), https://www.ccrif.org/sites/default/files/riskprofiles/TC_Annex1_r2.pdf.

PHYSICAL RISKS SECTORAL MAPPING

a. Physical risks sectoral mapping: Most affected sectors, ISIC Rev 3.1

Natural Disasster	*Most affected sectors*
Hurricane	A 01 – Agriculture, hunting and related service activities
	B – Fishing
	F – Construction
	K – Real estate, renting and business activities
	H – Hotels and restauratns
	C 11 – Extaction of crude petroleum and natural gas
Flood	A 01 – Agriculture, hunting and related service activities
	F – Construction
	K – Real estate, renting and business activities
	H – Hotels and restauratns
Drought	A – Agriculture, hunting and forestry

b. Weighted average distribution of economic losses by economic sector



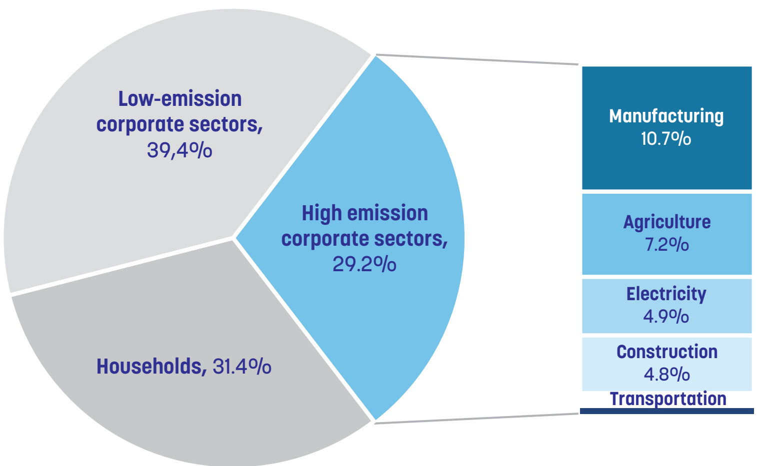
Sources: Panel a: Pietro Calice and Faruk Miguel, *Climate-Related and Environmental Risks for the Banking Sector in Latin America and the Caribbean: A Preliminary Assessment*, Policy Research Working Paper 9694 (Washington, DC: World Bank Group, 2021); Panel b: Natural disaster impact evaluations from the United Nations Economic Commission for Latin America and the Caribbean (CEPAL).
Note: comm. = communication; ISIC = International Standard Industrial Classification of All Economic Activities.

A.7.2 Share of Bank Credit Portfolio to Nonfinancial Corporations Potentially Exposed to Selected Physical Risks

Department	Droughts		Floods				Hurricanes
	Low	Medium	Very Low	Low	Medium	High	High
Cortés	2.00	0.01	0.00	0.04	0.13	7.01	7.20
Francisco Morazán	0.99	0.00	6.69	0.01	0.01	0.00	6.71
Choluteca	0.60	0.00	0.12	0.01	0.00	0.72	0.84
Copán	0.65	0.04	0.32	0.20	0.49	0.01	1.01
Yoro	0.75	0.00	0.07	0.03	0.00	0.83	0.93
Atlántida	0.28	0.00	0.00	0.43	0.03	0.21	0.69
Santa Bárbara	0.12	0.04	0.10	0.04	0.06	0.06	0.28
Olancho	0.39	0.00	0.11	0.22	0.20	0.01	0.54
Comayagua	0.26	0.00	0.22	0.26	0.00	0.00	0.48
El Paraíso	0.27	0.00	0.12	0.20	0.01	0.01	0.35
Other departments	0.78	0.12	1.08	0.20	0.16	0.32	1.78
All departments	**7.07**	**0.21**	**8.81**	**1.64**	**1.10**	**9.19**	**20.81**
	7.28		**20.73**				

Source: World Bank elaboration based on data from Comisión Nacional de Bancos y Seguros (CNBS) and ThinkHazard!, thinkhazard.org.
Note: Physical risks are derived from natural hazards and climate change that cause economic costs and financial losses. The Atlantic hurricane season runs from June 1 to November 30, encompassing the North Atlantic Ocean, Caribbean Sea, and Gulf of Mexico.

FIGURE A7.3. Banking Sector Exposure to High Emission Sectors (% of total banking sector loans, end-2020)



Source: World Bank elaboration based on United Nations Framework Convention on Climate Change Greenhouse Gas Inventory data and Financial Sector Supervisory Authority in Honduras (Comisión Nacional de Bancos y Seguros) data.
Note: High-emission corporate sectors in Honduras are transport, agriculture, electricity generation, mineral products, and waste management.

A.8. Results: Deviation of Moderate and Extreme Poverty under Different Adaptation Scenarios

a. 2030

		Moderate poverty		Extreme poverty	
		p50	p95	p50	p95
Baseline (no policy changes, historical disaster risk pattern)	(level)	39.6		19.2	
A. Baseline with stochastic distribution	(Deviation from baseline)	0.0	0.8	0.0	0.8
C1 Accelerated reconstruction		0.1	0.3	0.0	0.2
C2 Post-disaster transfer*		–2.3	–1.9	–1.9	–1.7
C3 Adaptation investment		0.4	0.7	0.3	0.4
D1 Combined C1, C2, and C3*		–2.6	–2.6	–2.0	–2.1
D2, D1 with proactive fiscal policy		–2.4	–2.6	–2.0	–2.1
D3, D1 with proactive fiscal policy—CCT**		–6.3	–6.6	–2.8	–3.0

a. 2050

		Moderate poverty		Extreme poverty	
		p50	p95	p50	p95
Baseline (no policy changes, historical disaster risk pattern)	(level)	36.7		17.1	
A. Baseline with stochastic distribution	(Deviation from baseline)	0.0	1.6	0.0	0.9
C1 Accelerated reconstruction		–0.1	–0.6	–0.1	–0.3
C2 Post-disaster transfer*		–3.1	–3.6	–2.0	–2.4
C3 Adaptation investment		–0.2	–0.5	0.0	–0.2
D1 Combined C1, C2, and C3*		–3.3	–3.7	–2.1	–2.4
D2, D1 with proactive fiscal policy		–3.3	–3.8	–2.1	–2.4
D3, D1 with proactive fiscal policy—CCT**		–4.9	–5.5	–2.3	–2.6

Source: World Bank staff calculations

Note: Column A: "baseline" shows a scenario where the country follows a similar growth pattern as in the past, the country is affected by climate-induced natural hazards with the same incidence and intensity, and no additional policy changes are made. The model follows a stochastic approach. In scenario A, the median is the baseline scenario, and information on the stochastic distribution of results in the worst 5 percent of outcomes is added. Results in scenarios C1 to D3 show deviations at the median and at the 95th percentile. CCT = conditional cash transfer; p = percentage points.

*Scenarios C2, D1, and D2 include the simulation of a universal cash transfer.

**Scenario D3 includes the simulation of a targeted cash transfer.

A.9. CLEAR water diagnosis for Honduras, compared to countries in Central America and the Dominican Republic