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TECHNICAL NOTE ON BANK STRESS TESTING AND CLIMATE RISK ANALYSIS

This paper on the Maldives was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed on December 18, 2023.

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December 18, 2023

TECHNICAL NOTE

BANK STRESS TESTING AND CLIMATE RISK ANALYSIS

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared by IMF staff in the context of the Financial Sector Assessment Program in Maldives. It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations. Further information on the FSAP can be found at http://www.imf.org/external/np/fsap/fssa.aspx

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Glossary

AFS	Available for Sale
AML/CFT	Anti-Money Laundering/Combating the Financing of Terrorism
AR6	Sixth Assessment Report
BCP	Basel Core Principles for Effective Banking Supervision
CAR	Capital Adequacy Ratio
CDS	Credit Default Swap
DDE	Domestic Debt Exchange
FSAP	Financial Sector Assessment Program
FSPN	Financial Sector Policy Note
FC	Foreign Currency
FX	Foreign Exchange
GCM	General Circulation Model
GDP	Gross Domestic Product
GEV	Generalized Extreme Value Distribution
GFC	Global Financial Crisis
HDC	Housing Development Corporation
HFT	Held for Trade
HTM	Held to Maturity
IPCC	Intergovernmental Panel on Climate Change
LC	Local Currency
LCR	Liquidity Coverage Ratio
LLP	Loan Loss Provisioning (flow)
LLR	Loan Loss Reserves (stock)
LTV	Loan-to-Value
MBS	Maldives Bureau of Statistics
MLSA	Maldives Land and Survey Authority
MMA	Maldives Monetary Authority
MoE	Ministry of Environment, Climate Change and Technology
MoF	Ministry of Finance
MoT	Ministry of Tourism
MRPS	Maldives Retirement Pension Scheme
MSME	Micro, Small and Medium-Sized Enterprises
NASA	National Aeronautics and Space Administration
NIM	Net Interest Margin
NOP	Net Open Position
NSFR	Net Stable Funding Ratio
NPL	Nonperforming Loan
NPV	Net Present Value
PPI	Pre-Provision Income
RAM	Risk Assessment Matrix
RCP	Representative Concentration Pathway

rhs	Right hand side
ROA	Return on Assets
ROE	Return on Equity
RW	Risk Weight
RWA	Risk-Weighted Assets
SOE	State-Owned Enterprise
SSP	Shared Socioeconomic Pathway
STeM	Stress Testing Matrix
TaVR	Tail Value at Risk
UN	United Nations

EXECUTIVE SUMMARY[1]

A systemic vulnerability analysis and stress tests were conducted as part of the Maldives FSAP. The vulnerability analysis and stress tests were based on quarterly aggregate balance sheet supervisory data for the eight banks in Maldives as of December 2022. Identified vulnerabilities were subjected to hypothetical extreme but plausible scenarios that were informed by the Risk Assessment Matrix. Risks analyzed were credit risk, liquidity risk and market risk. Credit risks materialized as non-performing loans and pressure on pre-provision income, liquidity risks as deposit outflows, and market risks as changes in interest and exchange rates.

Although the Maldives' economy has rebounded strongly from the pandemic-induced contraction, macro and financial vulnerabilities remain. Fiscal and external vulnerabilities have been elevated, arising from high public debt, increasing fiscal expenditure on debt service and price subsidies, and a widening current account deficit. In addition, continued financial support to state-owned enterprises (SOEs) and a persistent FX shortage in the official markets have contributed to increased domestic fiscal financing needs and further rationing on FX supply to the private sector. Related to these macro developments, systemic financial vulnerabilities have become more prominent, which include an intensified sovereign-bank nexus, high dollarization interacting with FX shortages, shadow banking activities, and weak liquidity management.

Against the backdrop of these macro-financial developments, the FSAP identified a number of systemic vulnerabilities. The main macrofinancial vulnerability stems from high central government and SOE debt that is increasingly financed by banks through increasing holdings of sovereign securities and sharply rising lending to SOEs. Prudential and regulatory policies have further incentivized the accumulation of sovereign debt on bank balance sheets, notably through the zero-risk weight (RW) on domestic sovereign paper, including FX-denominated issues. Moreover, the current trajectory of public debt service, including in foreign currency, combined with a possible drop in FX inflows presents a challenge for managing official reserves and could prompt an exchange range realignment, affecting SOEs and corporates with currency mismatches. Financing of consumer durables by leasing companies, some of which are unregulated, using widespread lease and hire purchase programs leave recurring household payment obligations underreported. Banks are also exposed to large corporate clients, as evidenced by individual banks being close to their single exposure limits. Lastly, management of systemic liquidity needs improvement, reserve requirements would need finetuning, and draft regulation addressing issues contributing to the parallel FX market should be adopted.

The stress tests applied the usual FSAP range for non-complex banking sectors. The quality of supervisory data for stress testing seemed adequate overall although mixed in terms of coverage and granularity. The solvency stress test assumed three macro financial scenarios, increasing in severity. These scenarios were also shared with the banks along with instructions to conduct a

[1] This Technical Note was prepared by Iván Guerra and Javier Uruñuela López, with contributions from Yizhi Xu and Kiran Sastry.

bottom-up stress test, in which banks were given the projections for all macro variables and were asked to apply their own stress testing methods.

- For the *top-down solvency stress tests*, a long-run relationship between non-performing loans and macroeconomic variables in each scenario was estimated using quarterly bank-by-bank panel data for the period 2010-2022. Thus, the credit risk models projected NPL ratios for banks' loan portfolios in local and foreign currency for each stress scenario, and additional provisioning needs were calculated. Apart from provisions, the pre-provision income, taxes, and dividends of banks were also projected to arrive at after-tax income and therefore changes in bank capital. The projected capital adequacy ratios were then obtained applying a projection of risk-weighted assets (RWA).

- The severe scenario of the solvency stress test was augmented by incorporating a *sovereign risk sensitivity analysis*. In addition, a *credit concentration sensitivity analysis* was run to account for the exposure to large corporate clients. Furthermore, in an alternative calculation of capital adequacy, the tests also assumed non-zero risk weights on sovereign securities in foreign currency, thereby increasing RWA substantially and lower capital adequacy ratios.

- The *liquidity stress tests* applied the cash flows-based methodology using long term estimates of outflows by deposit type. In addition, the Basel III Liquidity Coverage Ratio (LCR) was also calculated. Both tests were performed in local and foreign currency.

- *Other sensitivity analysis* accounted for interest rate risk, foreign currency risk, and deposit concentration risk. No interconnectedness stress tests were run, as the interbank market is virtually non-existent.

The stress test results broadly corroborated the identified vulnerabilities and quantified them. While the banking system seems to be resilient to macroeconomic shocks, it is less so to sovereign shocks and/or concentration risk. Banks' solvency was mostly impacted in the severe scenario, which also included a sovereign domestic debt exchange, and by the credit concentration shock simulating the default of the five largest exposures, with required recapitalizations amounting to less than 1 percent of GDP in either case. In addition, a Basel risk weights adjustment of 100 percent on domestic securities in FX also had a considerable impact on capital but not enough for any required recapitalization. In the liquidity stress tests, a couple of banks faced difficulties but only for specific time buckets. Moreover, calculation of the LCR indicated that the banking sector would be compliant with Basel III. However, deposit concentration was also found to be a risk, with the banking system showing vulnerabilities to withdrawals from each bank's five largest depositors. Market risk consisting of interest rate repricing and foreign currency risk was found to be moderate.

The climate risk analysis considered a micro approach that shocks banks' immovable asset-related loans under three climate scenarios. Coastal floods hazard was considered in terms of sea level rise and storm surge with future climate; the latter modeled through windspeed. The exposure included a geographical disaggregation of the economic activity with proxy variables, but not differentiated by banks. Using the damage functions and elevation, the mission team transformed

the coastal flood depth and atoll exposure into a damage rate by atoll; these damage rates were used to compute the interaction between atolls and calculate the aggregate losses at the country level.

While mid-century climate effects on the banking system were found to be mild, the assessment of end-century impacts and insurability issues would require more granular data. Considering the 99th percentile of the country loss distribution for the mid-century, the effects of climate-related events on the banking system were found to be mild. However, they could be significantly exacerbated for the end of the century, mainly due to sea level rise. With rising reinsurance premiums, the country could be challenged in the future by limited or no reinsurance for climate-related events. Improving the granularity and coverage of the data, as well as initiating with climate risk analysis would allow a better understanding of the climate implications in the economy and financial sector. While the analysis leveraged global and local data sources, there is a need for better data granularity for the country and financial system, which would improve the assessment of the climate risk.

Table 1. Maldives: Recommendations on Stress Testing and Climate Risk Analysis

Recommendation	Responsible Authority	Time*
Stress Testing		
Improve integrity and granularity of supervisory data, including data compiled by the Credit Information Bureau (CIB)	MMA	ST
Develop methodologies for solvency, liquidity, and market risk stress tests and engage banks in a dialogue about stress test procedures and results, including banks' own stress tests.	MMA	ST
Implement scenario-based solvency stress tests	MMA	MT
Implement cash flow-based liquidity stress tests	MMA	MT
Granularity of data should be improved to identify stable vs. less-stable deposits toward calculation of the Net Stable Funding Ratio	MMA	ST
Climate Risk Analysis		
Improve granularity and coverage of climate data, geographical exposures of the country and financial system as well as climate-related damages, and foster intra-agency collaboration to support access to existing data.	MoE, MBS, MMA	ST
Initiate climate risk analysis in collaboration with other agencies to assess the effect of actual and future climate conditions on the financial sector and the economy.	MMA	MT

* ST: short term = 1-2 years; MT: medium term = 3-5 years

INTRODUCTION

A. Macrofinancial Developments

1. The Maldives' economy has rebounded strongly from the pandemic-induced contraction, thanks to a robust resumption in tourism, yet vulnerabilities persist. After double-digit growth in 2022, real gross domestic product (GDP) growth is projected at 7.2 percent in 2023 based on IMF's April 2023 *World Economic Outlook*. However, fiscal and external vulnerabilities remain elevated, arising from high public debt, increasing fiscal expenditure on debt service and price subsidies, and a widening current account deficit. Continued financial support to state-owned enterprises (SOEs), particularly for investment projects of the Housing Development Corporation (HDC), has added to fiscal vulnerabilities. As a result, rising fiscal financing needs are being met by domestic debt issuance and monetary financing, increasing the sovereign risk exposure of both the Maldives Monetary Authority (MMA) and the domestic banking system. A worsening shortage on the official Foreign Exchange (FX) market reflects import-intensive investment, pandemic-related increase in public spending, and FX rationing by both MMA and domestic banks. The FX shortage has further fueled a large and well-established parallel market that provides most of the FX needs of importers, implying costs to the private sector and lower tax revenue.

2. Systemic vulnerabilities remain outstanding, which include an intensified sovereign-bank nexus, persistent FX shortages, growing shadow banking, and weak liquidity management. The main macrofinancial vulnerability stems from high central government and SOE debt that is increasingly financed by banks through growing holdings of sovereign securities and sharply rising SOE lending. Meanwhile, banks' appetite for sovereign debt has increased, incentive by current prudential and regulatory policies, notably through the zero-risk weight (RW) on domestic sovereign paper, including FX-denominated issues. Moreover, the current trajectory of public debt service, including in foreign currency, combined with a possible increase in import costs and drop in FX inflows could deplete official reserves and constrain the MMA's ability to maintain its current exchange rate, affecting SOEs and corporates with currency mismatches. Financing of consumer durables by leasing companies, some of which are unregulated, using widespread lease and hire purchase programs, as well as the government's rent-to-own scheme leave recurring household payment obligations underreported—a data gap that should be closed swiftly. Lastly, management of systemic liquidity needs improvement, reserve requirements would need finetuning, and draft regulation addressing issues contributing to the parallel FX markets should be adopted.

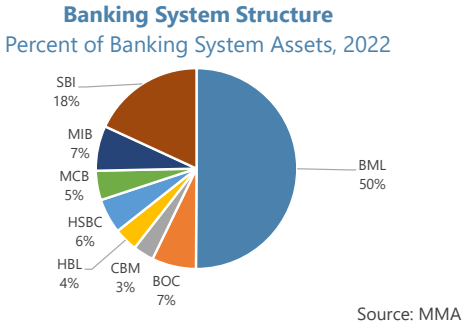
B. Financial System Structure

3. The Maldivian financial system is large relative to the economy and rather concentrated. Banks have a dominant position with more than three-fourths of system assets, while the non-bank financial sector is still nascent and comprised overwhelmingly of the government retirement scheme (MRPS), a insurance and leasing companies. Banking system assets are about 92.1 percent of GDP, and the largest institution, a domestic state-owned bank, holds 50.1 percent of banking system assets. Two more state-owned banks are foreign-owned, two are

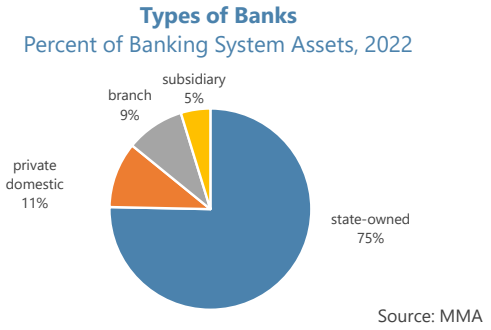
privately-owned domestic banks and the remaining three institutions are branches or subsidiaries of foreign commercial banks (Figure 1).

Figure 1. Maldives: Structure of the Banking System

The local state-owned bank accounts for half of the banking system assets



Two more state-owned banks are foreign-owned, two are privately owned domestic banks, three are branches/subs.



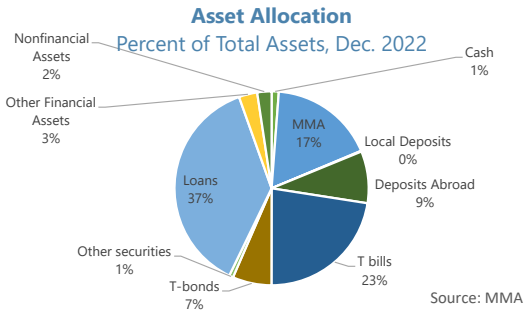
C. Banking System Characteristics

Asset Allocation

4. Banks' asset allocation reflects a growing sovereign-bank nexus. Loan placements have decreased to 37 percent of total system assets in 2022 (down from 60.5 percent in 2010) while investments (mostly in government securities) have grown to a close 30 percent of total assets (up from 16.1 percent in 2010) and to over 50 percent at some banks (Figure 2). This creates substantial exposures to the sovereign but helps explain the high profitability of the system. Loan growth has leveled off to around 5 percent in 2022, down from 18 percent in 2016 with two institutions in retreat. By currency, loan growth is 9.9 percent in local currency and 1 percent in foreign currency. Besides securities investments, recent areas of growth have been personal loans and real estate loans to the detriment of tourism and commercial loans. Banks are increasingly at risk of hitting the high exposure limits with big infrastructure projects, which typically demand foreign currency, another reason why the corporate loan business has cooled off and most institutions now increasingly cater to lower-value, high quantity personal loans. Personal loans are now growing at a 27 percent per year, seven times the yearly growth of tourism loans.

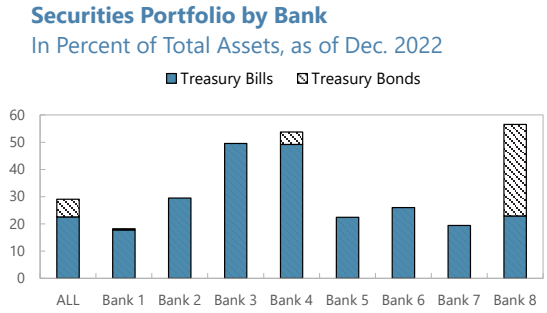
Figure 2. Maldives: Asset Allocation

Loans are 37%, while investments are 30% of total assets



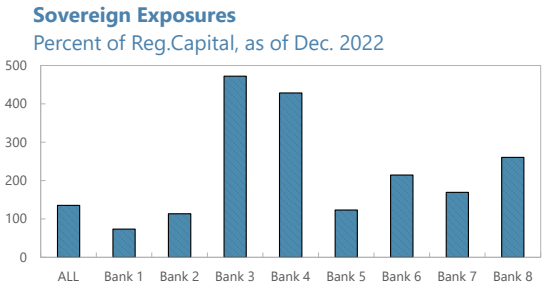
Source: MMA

At some banks, investments are the main line of business



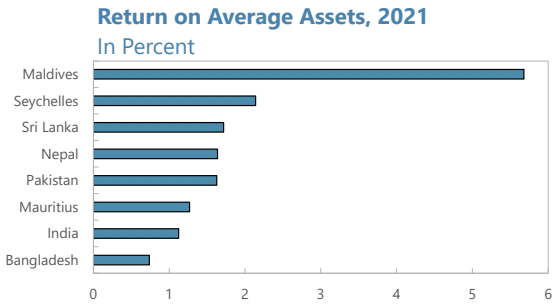
Source: MMA

Which creates substantial exposures to sovereign risk



Source: MMA

But might explain the system's profitability



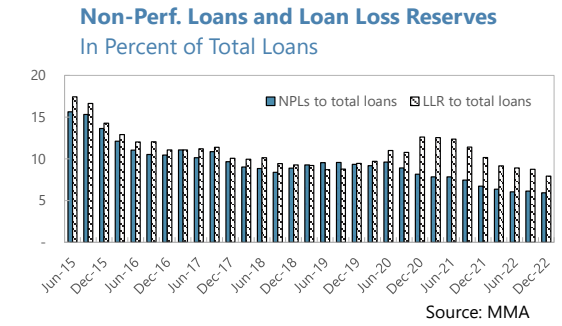
Source: IMF FSI

Asset Quality

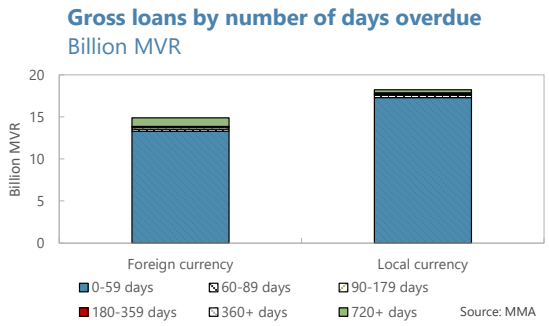
5. Non-performing loans are relatively in check at 5.9 percent of total loans, consistently declining and, in recent years, amply provisioned. While most outstanding loans are still to tourism (34 percent) and construction (18.5 percent) as compared to personal loans (13.7 percent), NPLs are mostly in tourism (60 percent) and commerce (17.3 percent), with NPL ratios of 10.6 and 8.9 percent, respectively. There are also substantial loans over 720 days past due. A few of these NPLs are legacy high value loans to the tourism sector and in foreign currency (FC). Loan dollarization is 45 percent of total loans. Most individuals borrow in local currency, while nonfinancial corporations borrow in foreign currency (Figure 3). NPLs ratios are higher in foreign currency (9.0 percent of foreign currency loans) than in local currency (3.4 percent of local currency loans).

Figure 3. Maldives: Asset Quality

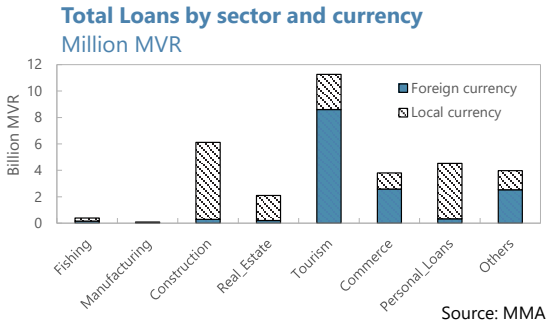
NPLs are low, declining and overprovisioned



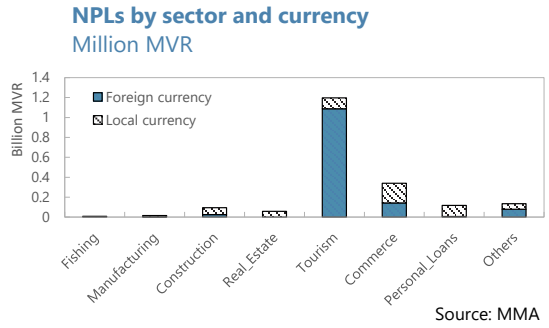
There are substantial non-performing legacy loans in FC



Most loans are in the tourism and construction sectors



Most NPLs are in the tourism and commerce sectors.

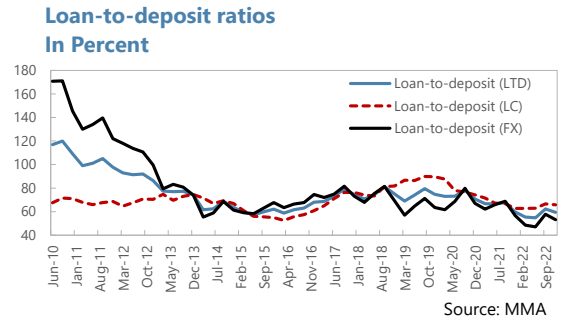


Liquidity and Funding

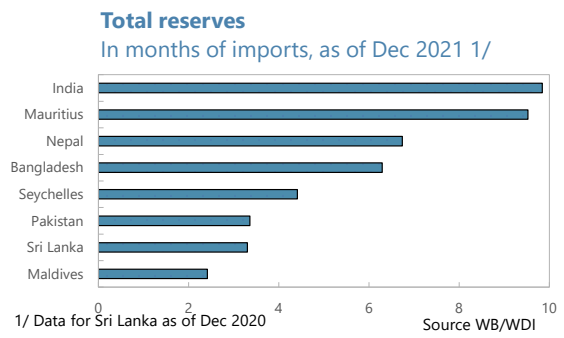
6. As loan growth has slowed, liquidity is ample, especially in local currency, and excess liquidity is placed in government securities, mostly at short maturities. Foreign currency is scarce, as availability is subject to central bank allocation or to a premium in the parallel market. Most, if not all, securities are held to maturity, given short tenors and the lack of a secondary market for government securities, which effectively blurs HFT, AFS and HTM distinctions. Short investment maturities also naturally match the available funding which is also very short term. Deposit dollarization is 49 percent of total deposits (Figure 4).

Figure 4. Maldives: Liquidity and Funding

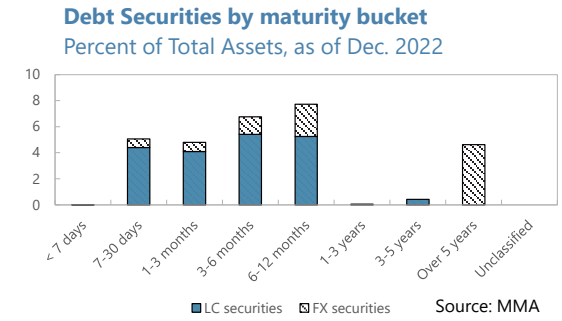
Liquidity is ample, especially in local currency



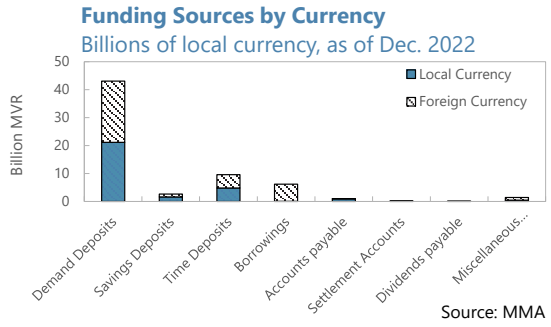
FX availability is scarce, subject to central bank allocation



Excess liquidity is placed in short-term securities



Which mostly matches the short-term funding



Capitalization

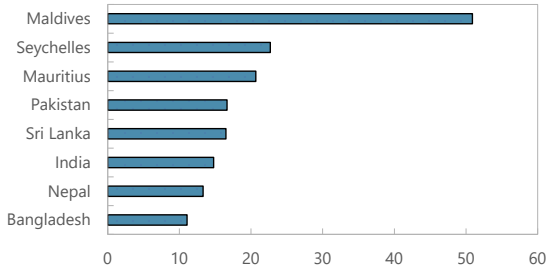
7. The system appears well capitalized, although capital ratios are biased upward by large government paper holdings with zero risk weights. The systemwide capital adequacy ratio (CAR) is 50.9 percent of RWA, well above regional peers, and continues to strengthen, up from 46.8 percent of RWA in December 2021 (Figure 5). High capitalization is led by the three largest banks (75 percent of banking system assets), although there are banks with a CAR as high as 90 percent. However, investments in government securities are zero risk-weighted as in many other jurisdictions. Given that the bank-sovereign nexus has intensified, bank capital is biased upward and could erode rapidly in the event of severe economic shocks causing sovereign stress. Imposing a RW of 100 percent on domestic sovereign securities in FX, as recommended by the FSAP's assessment of compliance with the Basel Core Principles (BCP), would reduce banks' capital ratios significantly. The FSAP team's analysis indicates that initial aggregate CAR would drop to 41.1 percent, should this regulatory measure be implemented.

Figure 5. Maldives: Capitalization

The system appears to be well capitalized.

Capital Adequacy Ratio

Percent of RWAs, as of Dec. 2021

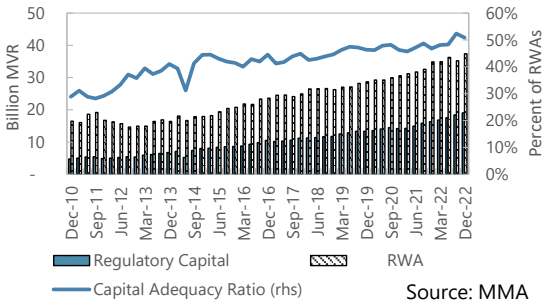


Source: IMF FSI

Regulatory capital has kept pace with RWA.

Regulatory Capital

Billion MVR and Percent of RWAs



Source: MMA

SYSTEMIC RISK ANALYSIS

A. Scope and Data Quality

8. The stress tests applied the usual FSAP range for non-complex banking sectors, with a few exceptions. The mission conducted (i) solvency stress tests (top-down using dedicated credit risk models and bottom-up by banks) and a credit concentration sensitivity analysis; (ii) a sovereign risk sensitivity analysis based on a domestic debt exchange of Maldives T-bills into longer-dated, lower yielding bonds (Table 2); and (iii) a cashflow mismatch liquidity stress test and calculation of the Basel III Liquidity Coverage Ratio as well as a test for deposit concentration risk; and (iv) market risk sensitivity analysis notably an interest rate risk test assessing the impact of maturity mismatches on net interest income under a symmetric increase in loan and funding rates, and foreign currency risk test assessing the impact of an assumed devaluation on banks' FX net open position (NOP). The FSAP did not perform an interconnectedness stress test as there is no functioning interbank market, nor a duration-based test for mark-to-market losses in the securities portfolio due to the very short tenor of sovereign paper.[2] Also, because of a lack of clarity regarding the distinction between stable and non-stable funding, the Basel III Net Stable Funding Ratio was not calculated as part of the liquidity stress tests. Lastly, due to the small size of the NBFI sector and data availability issues due to some institutions being unregulated, it is not included in the stress tests.

[2] In Maldives, hold-to-maturity vs. hold-for-trading distinctions do not apply as all securities are effectively held to maturity even if classified as available for sale, there is no secondary market, and the securities portfolio is very short-term: 56 percent have a duration of up to 6 months and 83 percent of up to 12 months.

9. The quality of supervisory data for stress testing is mixed. Loan data broken down by major economic sector exist only from 2015, and designation by certain types of recipients is unavailable. The FSAP team decided to use longer-dated quarterly series (since 2010) for credit risk modeling,[3] segmented by loans in local currency (mostly to households and MSMEs) and, separately, FX loans (mostly to larger corporates).[4] On the other hand, data on funding and assets are sufficiently granular and complete for conducting a cashflow-based liquidity test and calculating the Basel III Liquidity Coverage Ratio.

B. Macrofinancial Stress Test Scenarios

10. The solvency stress test is predicated on three scenarios (Figure 5) The baseline and the moderate stress scenario reflect the latest projections of the IMF country team for Maldives. The severe stress scenario is a bespoke crisis scenario assuming significant external distress causing a deep, if short-lived, recession that in combination with rising domestic imbalances causes a devaluation (by 20 percent) and a domestic debt exchange of T-bills for bonds (implying a 25 percent reduction in face value). The econometric modeling (see Appendix) found only inflation and import growth (proxy for economic activity)[5] to be significant drivers of banks' NPL ratios (still, the projections for all nine key variables were shared with the banks for their bottom-up stress tests).

11. The solvency stress test considers three macro scenarios. Two scenarios were provided by the IMF country team, while the third (severe stress) scenario was created by the FSAP team (Figure 6).

- A *baseline* scenario for key macroeconomic and financial variables which is based on the IMF's WEO projections as of April 2023;
- A *moderate* stress scenario which assumes about same severity of an external demand shock as the country experienced during the pandemic and consistent with the latest Risk Assessment Matrix (RAM). The decline in real GDP growth from the baseline scenario is three times the pre-pandemic standard deviation, reaching -14.3 percent in 2023;
- A *severe* stress scenario that builds on the moderate scenario and considers a more severe economic downturn, an additional global and domestic tightening of financial conditions, consistent with the RAM, as well as an exchange of domestic debt (treasury bills) held by banks for long-dated bonds at a lower yield, and a one-step devaluation of the exchange rate (by 20 percent). In this scenario, real GDP is contracted by -24.4 percent, although still less severe than the -33.4 percent contraction that Maldives experienced in 2020. [6]

[3] Dynamic fixed effects panel models with logit-transformed NPL ratios and robust standard errors.

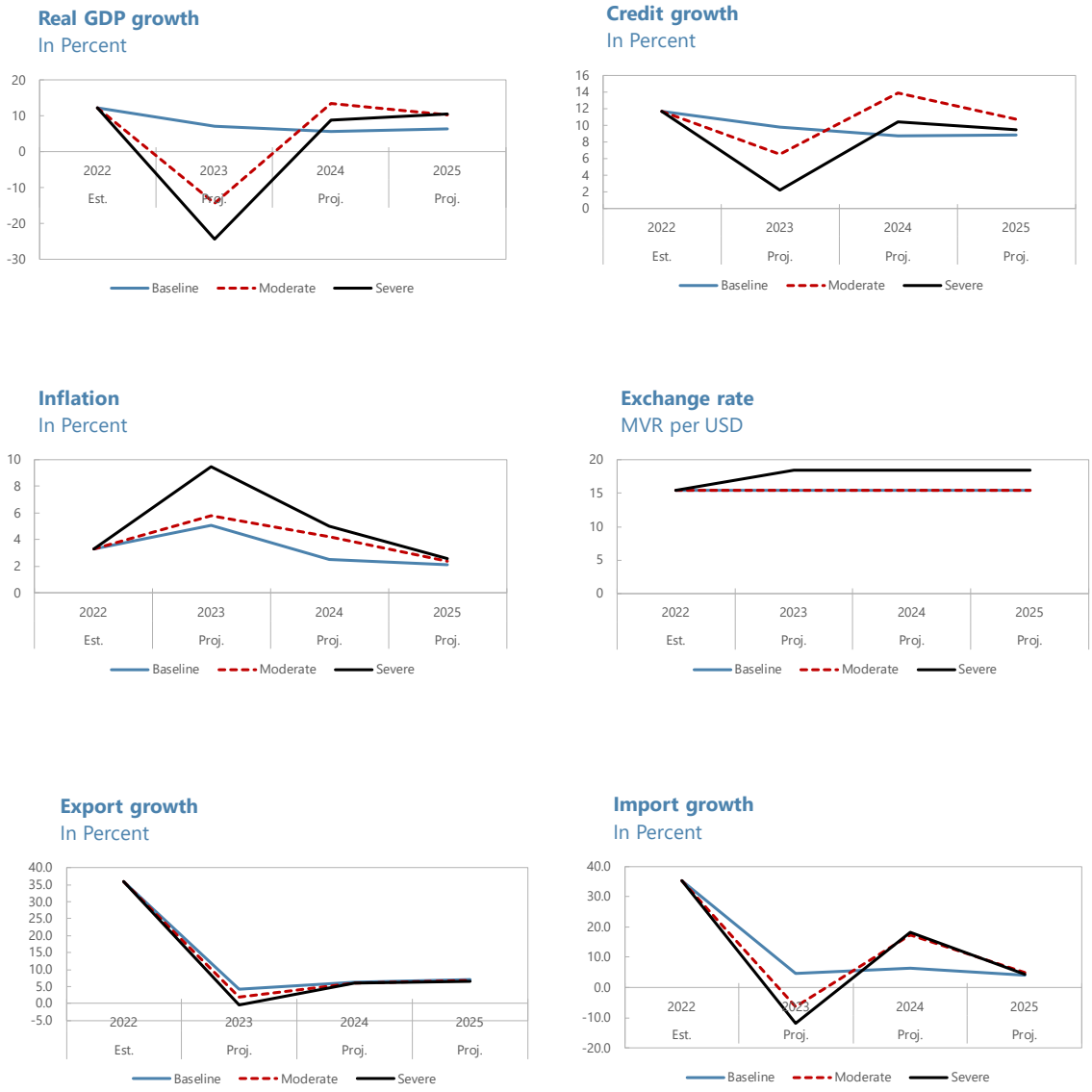
[4] However, two banks show gaps for three quarters each when, incidentally, NPLs were on the rise, and another two have such spotty data that they were excluded from the estimations.

[5] Exports could not be used because they do not include tourism, and GDP is available only at an annual frequency.

[6] To simulate a scenario that resembles significant debt restructuring, the severe scenario incorporates two additional shocks on financial conditions in the Global Projection Model (GPM) simulations that IMF's research department has

(continued)

Figure 6. Maldives: Projected Paths of Macroeconomic Variables in Stress Test Scenarios



Source: IMF staff estimates.

12. The scenarios were also shared with the banks along with other instructions for them to conduct bottom-up stress tests (see Appendix 6). Banks were given the projections for all macro variables and were asked to apply their stress testing methodology (or, if not in place, expert

tailored for individual Asia and Pacific economies, including Pacific Island Countries and small states. The two shocks are respectively a global financial shock that entails further tightening of global financial conditions (200 bps increase in the US treasury term premium, which is similar as experienced during the GFC) and a domestic financial shock (20 percentage points increase in sovereign spreads, which is similar as what was observed by the z-spreads of JPMorgan's Asia Credit Index in early 2020).

judgment) to project key indicators up to three years out, including NPL ratio and loan loss provisions, income components, return on assets, credit and RWA growth, and the capital adequacy ratio. Banks also received instructions on realistic assumptions such as on the development of income components as well as on tax and dividend payments.

SOLVENCY STRESS TESTS

A. Top-Down Stress Test Methodology

Projection of Non-Performing Loans

13. A long-run relationship between non-performing loans and macroeconomic variables was estimated using quarterly bank-by-bank panel data for the period 2010-2022. Initially, NPL ratios by economic sector were regressed against relevant macroeconomic variables. Since sectoral regressions did not produce significant results, the estimation was refocused on estimation by currency given the importance of tourism, dollarization, and availability of foreign exchange for business continuity. This also extended the available time series by about 5 years. Local currency loans can also be used as a proxy for household loans while foreign currency loans are a proxy for corporate loans (see Figure 6). The models used were autoregressive and used a logit transformation of the dependent variable, the NPL ratio, both in local (LC) and foreign currency (FC) and were estimated using panel data estimation with fixed effects.

14. The NPL modeling found only inflation and import growth (as proxy for real GDP growth which was not available on a quarterly basis) to be significant drivers of banks' NPL ratios. Thus, the models were specified as follows:

The NPL LC model did not include lags:

$$NPL\ LC_t = \beta_0 + \beta_1 NPL\ LC_{i,t-1} + \beta_2 Inflation_{i,t} + \beta_3 GImports_{i,t} + \mu_i$$

The NPL FC model included a lagged inflation term but contemporaneous import growth:

$$NPL\ FC_t = \beta_0 + \beta_1 NPL\ FC_{i,t-1} + \beta_2 Inflation_{i,t-1} + \beta_3 GImports_{i,t} + \mu_i$$

The model results proved quite significant (Table 2), and NPL ratios were projected bank-by-bank using the panel data estimation.

15. The credit risk models estimated NPL ratios in LC and FC for each bank and for each scenario for the out-of-sample projection period of 2023 to 2025. Using each scenario's projected credit growth and projected NPL ratios, projected NPL amounts were calculated for each bank and each scenario. To obtain the NPL ratio of the system, the projected NPL amounts were aggregated and set in relation to total credit.

Table 2. Maldives: Credit Risk Satellite Model Estimates

	Lagged NPL Ratio	Inflation Rate	Import Growth
FC NPL Ratio Model	0.888	1.963	-0.138
R^2=0.91	(0.039)***	(0.540)***	(0.054)**
LC NPL Ratio Model	0.867	1,435	-0.098
R^2=0.92	(0.042)***	(0.556)**	(0.028)***

Source: IMF staff calculations

Note: **, *** significant at 5, 1% Lagged Inflation in FC model

Loan Loss Provisioning

16. After NPLs amounts were estimated for the out-of-sample period, additional provisioning was calculated. Some of the necessary assumptions included:

i. 20 percent provisioning on projected additional NPLs in the baseline scenario, 100 percent additional NPL provisioning in the stress scenarios,[7]

ii. no deleveraging of assets (no fire sales of assets—corresponding to assumed credit growth).

Other Assumptions

17. Apart from provisions, the pre-provision income, taxes, and dividends of banks were also projected to arrive at changes in bank capital. The necessary assumptions included:

i. pre-provision income (PPI—net interest income,[8] net fee income and net other income) to (i) increase proportionally with credit growth in the baseline (about half of credit growth); (ii) change broadly with the evolution in PPI during the pandemic for the moderate scenario;[9] and (iii) recede further with an even larger adjustment in the severe scenario (Table 4),

ii. the 25 percent statutory corporate tax rate, and

iii. a 0 percent dividend payout rate.[10]

[7] This appears realistic because the loss given default (LGD) is close to 100 percent due to the protracted foreclosure in the court system and resulting years-long delay in liquidating collateral. Also, during the early pandemic period, banks increased provisioning substantially, resulting in coverage ratios of around 150 percent.

[8] Net interest income (NII) was projected using interest rates on loans and securities from the asset side and the effective interest rate on all liabilities for interest expense to arrive at NII growth rates.

[9] PPI growth was negative in 2020 and then rebounded strongly in 2021. The observed PPI evolution was smoothed in the stress scenarios.

[10] A zero payout rate was assumed because MMA discouraged dividend payouts during the pandemic. Even in the baseline, a number of banks reportedly do not plan to pay dividends. To avoid unequal treatment of banks, the dividend payout rate was set to zero.

Calculation of Impact on Capital Adequacy

18. The projected capital adequacy ratios are obtained through the aforementioned changes in bank capital, a projection of risk-weighted assets (RWA) and a projection of net interest income. The change in the capital ratio is due to the projected change in the numerator—changes in banks' retained earnings obtained from post-tax profits less dividends (which, as mentioned, are assumed to be zero in the stress test)—divided by projected RWA. The change in RWA is modeled for the baseline scenario broadly in line with the average growth rate of RWA during the past decade and for the stress scenarios somewhat lower RWA paths compared due to the lower credit growth (Table 3).[11] To be sure, the projections of the RWA growth paths are derived autonomously within the stress test calculation template and as such subject to some model uncertainty.

19. A test for the risk from credit concentration is also run. The test assumes that the five largest loan exposures in pass category of each bank migrate to substandard (implying an additional provision of 19.5 percent, calculated as 20 percent for substandard minus the existing provision of 0.5 percent on normal loans, assuming no extra provisions made) and, alternatively, to the loss category. The resulting additional provisions are added to the projected provisions under the baseline scenario and profits/changes in capital re-calculated accordingly.

Table 3. Maldives: Pre-Provision Income and Risk-Weighted Assets Growth Paths

PPI and RWA growth rates

In percent per annum

	Dec-23	Dec-24	Dec-25
Baseline scenario			
PPI growth rate	0.9%	1.2%	2.9%
RWA growth rate	11.8%	10.2%	10.2%
Moderate scenario			
PPI growth rate	-4.3%	-3.0%	-0.1%
RWA growth rate	7.7%	16.5%	12.2%
Severe scenario			
PPI growth rate	-8.7%	-6.6%	1.1%
RWA growth rate	17.8%	-0.1%	10.9%

Source: IMF staff estimates

[11] However, during the pandemic, the growth of RWA exceeded that of credit temporarily because banks issued guarantees which, being off-balance items, needed to be converted into RWA.

Integration of Sovereign Risk in Solvency Stress Test

20. Sovereign risk is also incorporated in the solvency stress test. The sovereign sensitivity analysis contemplates an exchange of T-Bills for much longer-dated T-Bonds that also have a lower coupon than the existing securities. Specifically, the test assumes replacing T-Bills (for example, 100 units in Table 4) that have a median residual maturity of about one year with 20-year T-Bonds that have a coupon of only 2.5 percent compared to the average yield on T-Bills of currently 4.4 percent. Assuming that the current yield is also the appropriate discount factor for discounting cash flows in the outer years, the reduction in net present value (NPV) amounts to 24.9 percent. This haircut is applied to the book value of banks' securities holdings and recognized as a loss, which is added to additional provisions in the severe scenario. The sovereign sensitivity analysis depicts the drop of CAR in the severe scenario due to the NPV loss from the debt exchange.

Table 4. Maldives: Sovereign Sensitivity Analysis Assumptions

Sovereing Stress Test	
Amount of T-bills to be replaced.	100
Maturity	20
New Coupon	2.5%
Discount factor	4.4%
Sum of discounted interest payments	32.8
Discounted Principal	42.3
NPV Haircut	24.9

Source: IMF staff estimates.

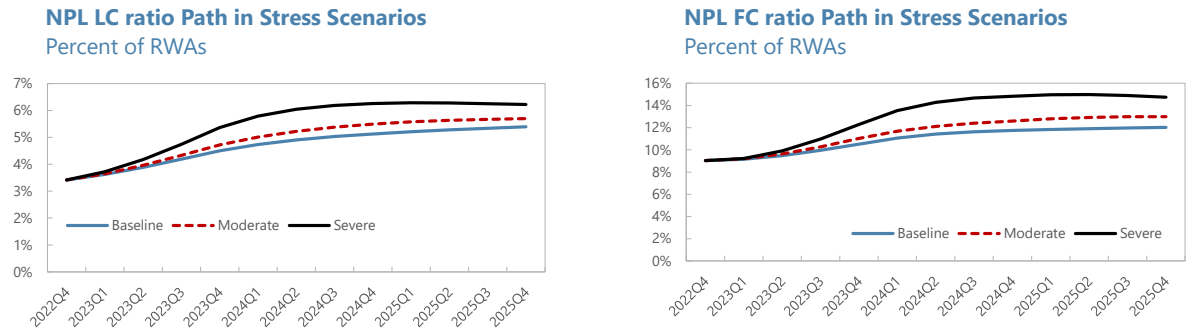
Potential Adjustment to Risk-Weighted Assets

21. In an alternative assessment of capital adequacy, the FSAP team assumed a non-zero RW on sovereign securities in foreign currency, thereby increasing RWA substantially. In line with a recommendation of the BCP assessment, the FSAP team imposed a RW of 100 percent on all government securities in FX instead of the current zero RW. Since a number of banks are not only heavily invested in Maldives government securities in general but also hold large amounts of treasury bills and bonds denominated in foreign currency, their risk-weighted assets increase markedly. The projected CARs for the stress period of 2023-25 are adjusted downward by increasing RWA in all three scenarios and presented as a hypothetical impact adding to the impact assumed under the scenarios.

B. Top-Down Stress Tests Results

22. Banks' NPL ratios are projected to increase slightly in the baseline and moderately under stress. Due to high persistence in historical NPL ratios, including during the pandemic due to forbearance measures, the projected NPL ratios were slow to respond to the imposed macro shocks (notably, higher inflation and lower import growth) in the credit risk models and consequently rose only moderately in the stress scenarios (Figure 7).

Figure 7. Maldives: Satellite Model Projections: Aggregate NPL Ratio

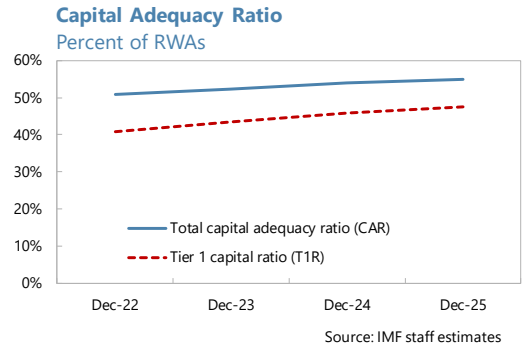


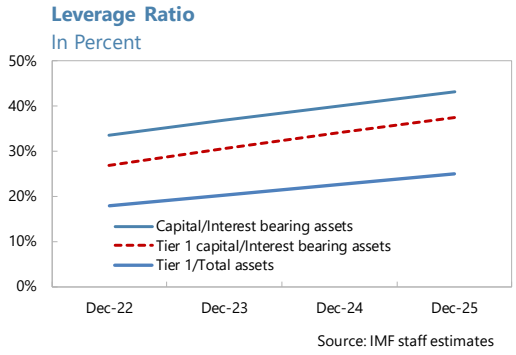
Source: IMF staff estimates.

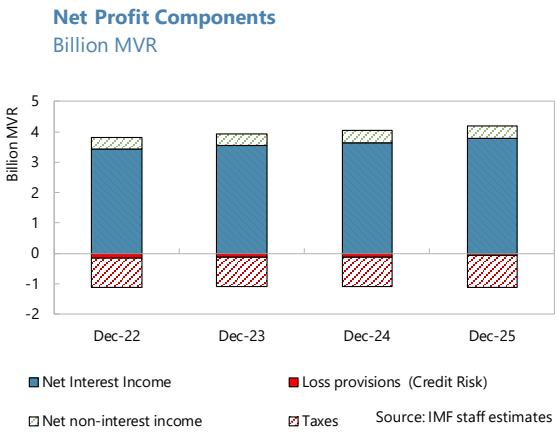
23. The resulting additional loan loss provisions are easily offset by ample pre-provision income. The loan loss provisions on the additional NPLs (100 percent coverage ratio in the stress scenarios) are easily absorbed by the high pre-provision income (net interest income and net fee and commissions income) of banks, primarily due to their wide interest rate margins (Figures 8-10).

24. The results of the solvency stress test corroborate that banks are less vulnerable to credit risk than they are to the impact of a possible unraveling of the sovereign-bank nexus. As detailed in Table 5 summarizing the solvency stress test results, the system's CAR remains largely unchanged in the moderate scenario relative to the baseline because higher projected provisions are easily absorbed by very high pre-provision income even under stress and also offset by assumed lower growth of risk-weighted assets responding to lower credit growth. However, the impact of the assumed domestic debt exchange in the severe scenario causes the system's CAR to drop by as much 12.1 percentage points, with one bank accounting for 3.3 percent of system assets becoming undercapitalized. In all scenarios risk-weighted assets is a major contributor to capital depletion and needs to be accounted for when interpretating the results.

Figure 8. Maldives: Aggregate Capitalization in Baseline Scenario







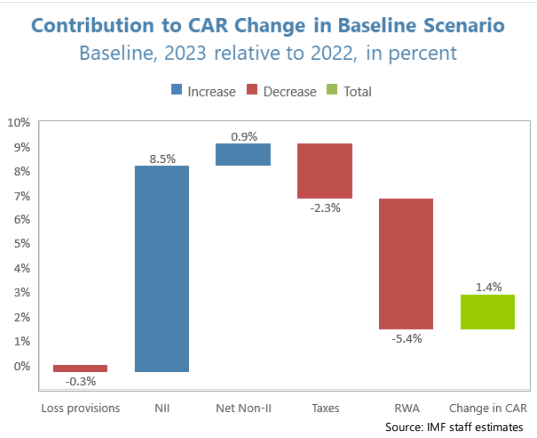
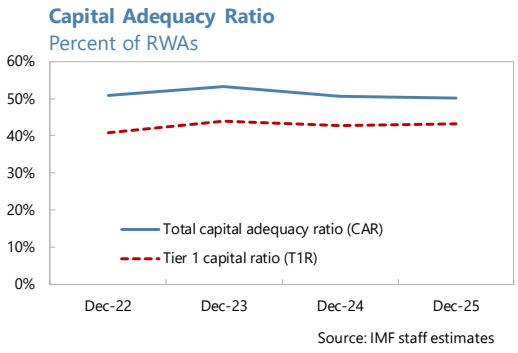
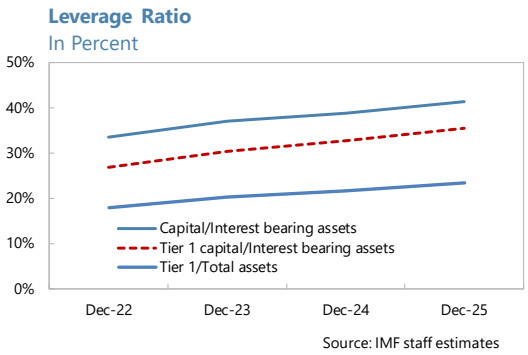
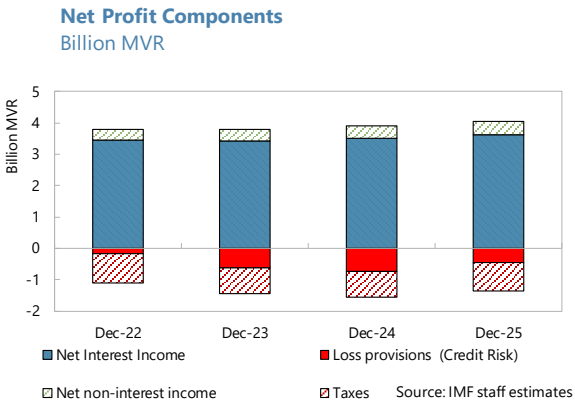


Figure 9. Maldives: Aggregate Capitalization in Moderate Scenario







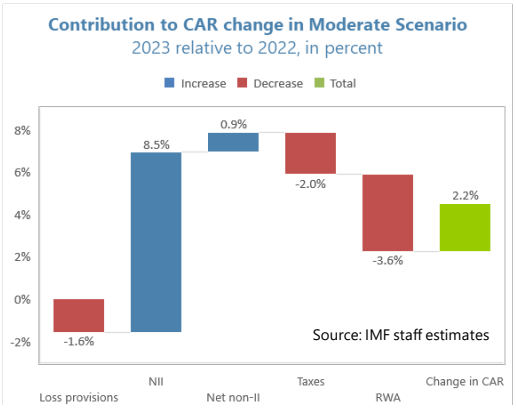
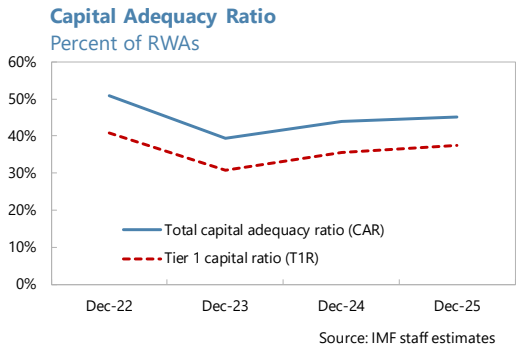
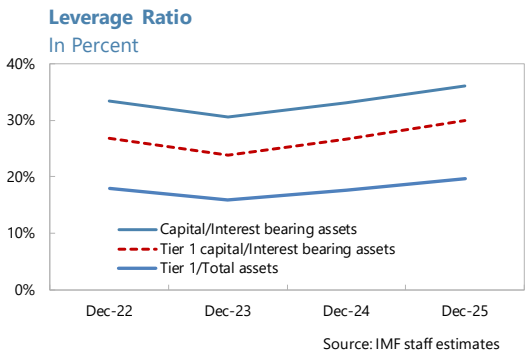
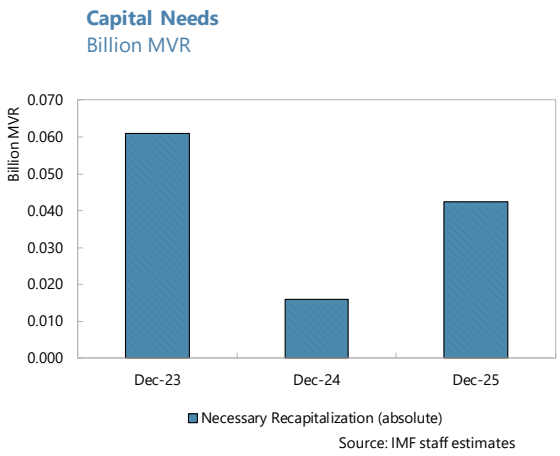


Figure 10. Maldives: Aggregate Capitalization in Severe Scenario

Severe Scenario







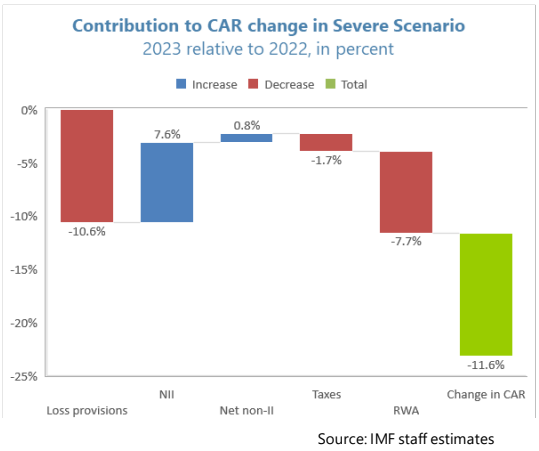


Table 5. Maldives: Summary Solvency Risk Results

CREDIT RISK	Dec. 22	Dec. 23	Dec. 24	Dec. 25
NPL projection foreign currency model		in percent of RWAs		
NPL ratio stress baseline scenario	9.0	10.5	11.8	12.0
Highest NPL ratio of any bank	34.4	41.6	46.1	46.8
NPL ratio stress moderate scenario	9.0	11.0	12.6	13.0
Highest NPL ratio of any bank	34.4	43.2	48.5	49.5
NPL ratio stress severe scenario	9.0	12.3	14.8	14.7
Highest NPL ratio of any bank	34.4	47.0	54.4	54.0
NPL projection local currency model				
NPL ratio stress baseline scenario	3.4	4.5	5.1	5.4
Highest NPL ratio of any bank	27.5	36.1	40.4	42.1
NPL ratio stress moderate scenario	3.4	4.7	5.5	5.7
Highest NPL ratio of any bank	27.5	37.4	42.4	43.6
NPL ratio stress severe scenario	3.4	5.4	6.3	6.2
Highest NPL ratio of any bank	27.5	41.0	46.2	46.2

	Dec. 22	Dec. 23	Dec. 24	Dec. 25
Solvency Stress Tests		in percent of RWAs		
CAR baseline scenario	50.9	52.3	53.9	55.0
CAR moderate scenario	50.9	53.1	50.6	50.2
CAR severe scenario	50.9	39.3	44.0	45.1
Number of banks failing		1		
Pct. of banking system <12% CAR		3.3		
Capital shortfall in % of GDP		0.1		
CAR baseline scenario adjusted for 100% RW on domestic securities in FX	41.1	43.3	45.4	47.0
CAR moderate scenario adjusted for 100% RW on domestic securities in FX	41.1	43.6	42.6	43.0
CAR severe scenario adjusted for 100% RW on domestic securities in FX	41.1	32.7	36.6	38.1

SOVEREIGN RISK		in percent of RWAs		
Drop in CAR (ppt.) due to impact of domestic debt exchange		14.8	8.6	7.8
CREDIT CONCENTRATION RISK		in percent of RWAs		
CAR baseline scenario in 2023	50.9	52.3	53.9	55.0
CAR two-notch downgrade of 5 largest borrowers	50.9	46.7	48.0	49.0
CAR downgrade to loss of 5 largest borrowers	50.9	20.6	21.1	21.6
Number of banks failing		5		
Pct of banking system <12% CAR		27.1		
Capital shortfall in % of GDP		0.7		

Source: IMF staff estimates.

25. As a result of sharply falling capital positions under the severe scenario, several banks would breach the applicable regulatory single exposure limit. The mission assessed whether each bank's single largest exposure would still be within the prudential limit of 15 percent of regulatory capital (30 percent for exposures backed by collateral valued at least at 150 percent of the loan amount, 40 percent for corporate groups) after the hit on capital calculated under the severe scenario. It turns out that in this hypothetical crisis event four banks accounting jointly for 30 percent of system assets would breach the applicable single exposure limit. This finding coincides

with the strong reduction in capitalization under the credit concentration sensitivity analysis and corroborates banks' high vulnerability from exposures to large borrowers, which to alleviate would require even larger capital buffers and/or more frequent syndication of large commercial loans.

26. Associated with the strong sovereign-bank nexus, banks are also vulnerable to non-zero RW on government securities. If a 100 percent RW on domestic FX securities were to be imposed, as recommended by the BCP assessment, the system's CAR would drop by about 9 percentage points, with one additional bank exhausting much of its excess capital buffer when applied to the severe scenario. An optional non-zero RW on government securities in MVR would also have a considerable impact on capitalization given banks' very large holdings of such securities.

27. The standalone sovereign sensitivity analysis simulates the potential fallout from the strong sovereign-bank nexus and indicates large vulnerabilities. As mentioned above, the sensitivity analysis simulates a period of sovereign stress culminating in a domestic debt exchange of Treasury bills into longer-dated and lower-yielding bonds. Consistent with Fund guidance[12] and standard practice in previous FSAPs with sovereign-bank nexus analyses,[13] all T-bills were stressed equally, irrespective of regulatory treatment. Given the lack of a secondary market, or credit default swaps (CDS), a uniform haircut to the face value of T-bills is applied using discounted cash flow analysis and added to projected provisions in the severe scenario. The results indicate a strong impact of such a hypothetical debt operation, with a drop in CAR at the system level by 13.5 percent compared to end-2022, which also accounts for most of the impact under the severe scenario that contemplates this measure (Figure 11).

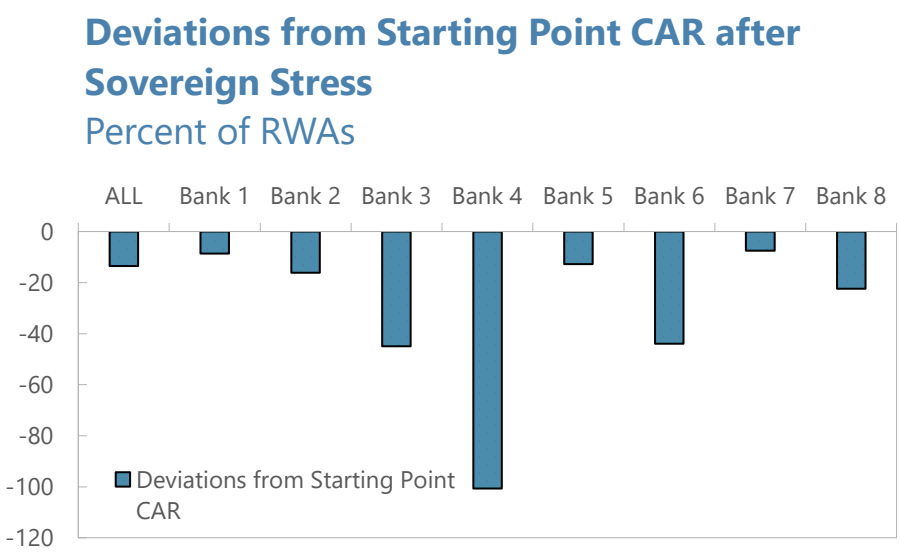
28. Credit concentration risk is found to be high. Assuming a migration of the five largest debtors in pass category to the substandard category did not make any bank violate their capital requirements, and when migrating the five largest debtors to the loss category (implying additional provisions of 99.5 percent in the standard case), a total of five banks jointly accounting for 27.1 percent of system assets became undercapitalized.

29. Indirect credit risk from FX loans appears considerable but cannot be quantified. Most banks do not lend in FX to clients that have no corresponding FX earnings. This said, even borrowers with a natural hedge (e.g., importers selling goods to resorts in foreign currency) may become unhedged if their FX inflow suddenly ceases as occurred temporarily at the beginning of the pandemic, sending the parallel market rate up to around 20 MVR/USD (from its usual range of 17-17.5 MVR/USD). The associated credit risk was and would have to be mitigated by forbearance measures (e.g., a payment moratorium) considering the FX shortage. The impact of such indirect credit risk could not be quantified for lack of necessary borrower-level data.

[12] See IMF WP/19/266 on Sovereign Risk in Macroprudential Solvency Stress Testing

[13] For example, Bahamas (IMF, 2019), South Africa (IMF, 2022a), WAEMU (IMF, 2022b).

Figure 11. Maldives: Standalone Sovereign Sensitivity Analysis Results



Source: IMF staff estimates.

C. Bottom-Up Stress Test Results

30. The results from the bottom-up stress test suggest that the banks generally do not expect a grave impact of the assumed shocks. Complete results were received from seven of the eight banks. These suggest that although several banks expect a pronounced drop in the CAR, specifically in the severe scenario, all banks would remain adequately capitalized under stress. The projected increase in the NPL ratio under stress aligns broadly with the impact of FSAP team's estimates, notably in the severe scenario where most banks' NPL ratio edges up to a similar degree as in the top-down stress test, although two banks expect their rate to more than double. Similarly, banks expect continued high profitability under the baseline and a deteriorating bottom line under stress, with the return on assets being cut about in half at most banks and two banks even expecting negative profits (see Figures 12-14).

31. The analysis of the bottom-up results could benefit from greater standardization to improve comparability across the bottom-up test or even vis à vis the top-down stress test. Specifically, despite clear instructions provided to banks, the following problems and inconsistences occurred:

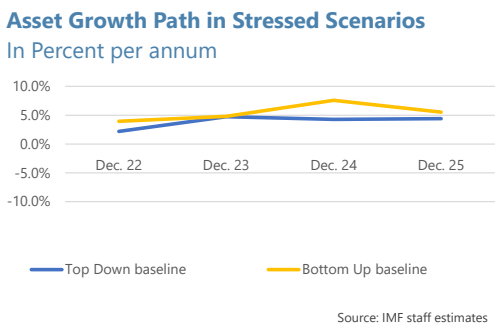
a) *Presentation*: Different banks presented different metrics and in different formats. Some banks presented all metric time series per scenario, while others, all scenario metrics per year.

b) *Consistency*: Not all banks provided the same data requested. One bank did not provide levels of NPLs or gross loans, only ratios. Another bank provided projections for only one scenario, while another provided an additional scenario of its own.

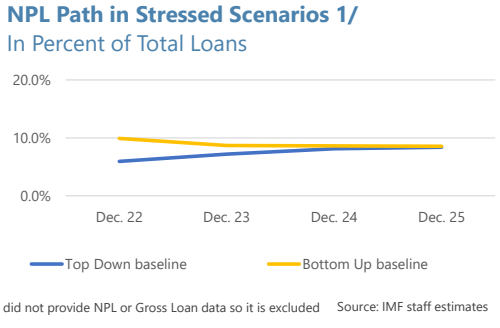
c) *Units*: One bank provided figures in units, another in millions and the rest in thousands.

d) *Initial levels*: Banks' initial levels for 2022 consistently differed from the supervisory data provided by MMA for the FSAP. Therefore, levels were also a source of difference, not just growth rates in the projections.

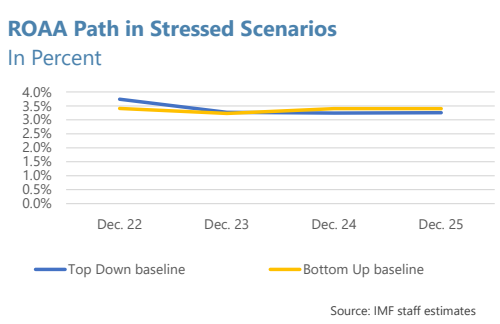
Figure 12. Maldives: Summary Bottom-Up Stress Test Results: Baseline Scenario



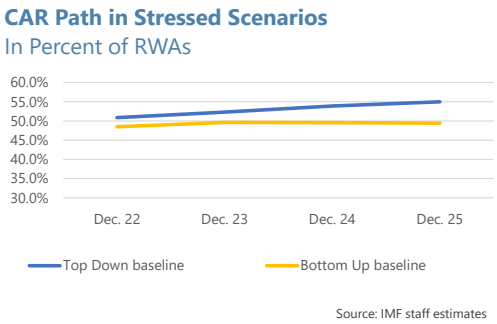
Source: IMF staff estimates



1/ BML did not provide NPL or Gross Loan data so it is excluded Source: IMF staff estimates



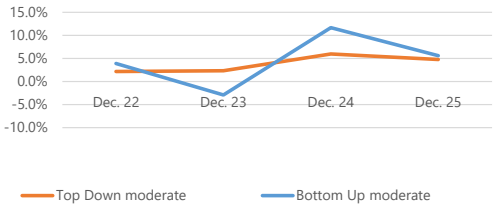
Source: IMF staff estimates



Source: IMF staff estimates

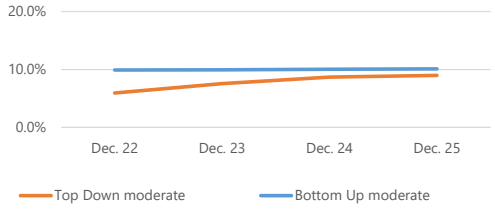
Figure 13. Maldives: Summary Bottom-Up Stress Test Results: Moderate Scenario

Asset Growth Path in Stressed Scenarios
In Percent per annum



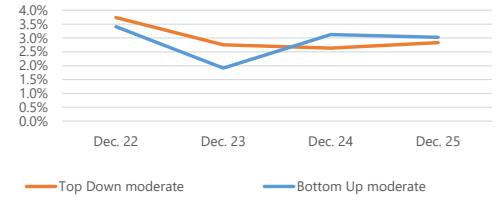
Source: IMF staff estimates

NPL Path in Stressed Scenarios 1/
In Percent of Total Loans



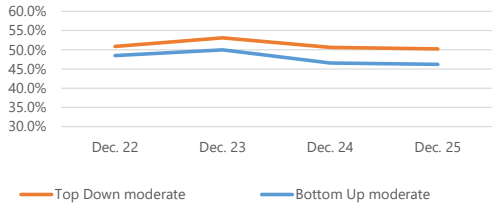
1/ BML did not provide NPL or Gross Loan data so it is excluded Source: IMF staff estimates

ROAA Path in Stressed Scenarios
In Percent



Source: IMF staff estimates

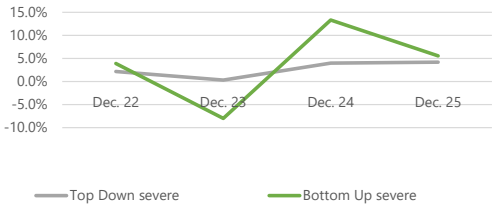
CAR Path in Stressed Scenarios
In Percent of RWAs



Source: IMF staff estimates

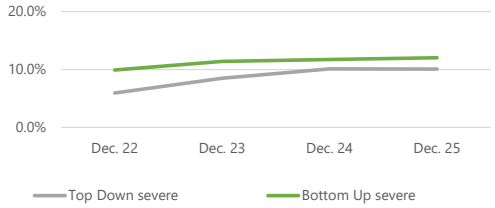
Figure 14. Maldives: Summary Bottom-Up Stress Test Results: Severe Scenario

Asset Growth Path in Stressed Scenarios
In Percent per annum



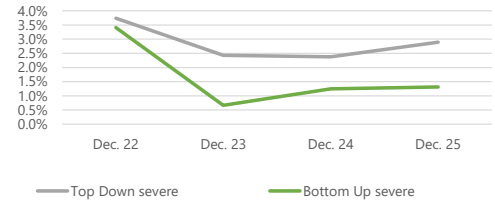
Source: IMF staff estimates

NPL Path in Stressed Scenarios 1/
In Percent of Total Loans



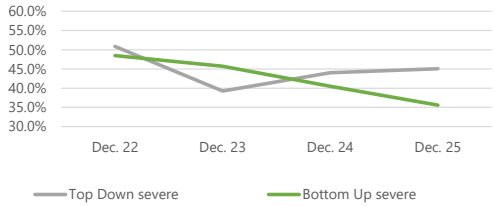
1/ BML did not provide NPL or Gross Loan data so it is excluded Source: IMF staff estimates

ROAA Path in Stressed Scenarios
In Percent



Source: IMF staff estimates

CAR Path in Stressed Scenarios
In Percent of RWAs



Source: IMF staff estimates

LIQUIDITY STRESS TESTS

A. Cashflow-based Liquidity Stress Tests

32. A cashflow-based liquidity stress test was carried out to assess banks' resilience to sudden deposit outflows by using their liquid assets. Under the methodology of the IMF's cashflow-based liquidity stress test, run-off rates indicating the fraction of maturing liabilities that is withdrawn or not rolled over were applied across different funding sources and maturity buckets, also broken down by currency, which led to two sets of results. The run-off rates were modelled after the largest monthly deposit withdrawals since the Global Financial Crisis (GFC). Roll-off rates indicating the fraction of the assets that is converted into a cash inflow and not rolled over by the bank were applied to every type of asset and maturity bucket in line with standard rates used in liquidity stress tests (only 50 percent of loans maturing within 7 days were assumed to be available, with roll-off rates progressively declining).

33. Banks also dispose of counterbalancing capacity that can be used if liquid assets are not sufficient to meet deposit outflows. Cash, bank reserves (we assume excess reserves and half of required reserves[14] to be available) and shorter-term securities were included in banks' counterbalancing capacity at current value, while sales of other securities were subjected to different haircuts that may materialize in fire sale conditions (especially as there is no active secondary market). The run-off and roll-off rates for the different categories and maturity buckets are displayed in Table 6.

34. The cashflow-based liquidity stress test results suggest that while Maldivian banks have ample liquidity, a couple of banks might face some difficulties. Banks are resilient to overall cash outflows and have sufficient counterbalancing capacity to meet aggregate deposit outflows (Table 7). In local currency, only one bank may have insufficient liquidity buffers in the very short term (less than 7 days), with the funding gap in that bucket amounting to 182 million MVR (or 3.1 percent of total assets). The outflow under the local currency (LC) liquidity stress is counterbalanced mostly by cash and reserves. In foreign currency, liquidity buffers at one bank are found to be insufficient to meet potential foreign exchange-related liquidity pressures in the long run (over 5 years), with the funding gap amounting to 605 million MVR (or 4.2 percent of total assets) stemming from long-term borrowing pressures. The outflow under the foreign currency (FC) liquidity stress is counterbalanced mostly by cash and reserves and securities. Assumptions in the methodology apply a 100 percent run-off rate to long-term borrowings, even if these are from the same banking group. More granular categories by maturity buckets would help differentiate the funding sources for a more precise identification of the gap mismatches. A similar caveat applies to the asset side.

[14] During the pandemic, MMA lowered the rate of required reserves in MVR from 10 percent to 7.5 percent and that on required reserves in FX from 10 percent to 5 percent. For simplicity, it is assumed that half or required reserves in either currency would be available as counterbalancing capacity under stress.

Table 6. Maldives: Cashflow-based Stress Test Assumptions

Run-off rates, local currency

	Less than 7 days	7-30 days	1-3 months	3-6 months	6-12 months	1-3 years	3-5 years	Over 5 years	Unclassified
Demand Deposits	10%	5%	1%	1%	0%	0%	0%	0%	0%
Savings Deposits	40%	30%	20%	10%	5%	5%	5%	5%	5%
Time Deposits	40%	30%	20%	10%	5%	5%	5%	5%	5%
Import Deposits and Margin Accounts	100%	100%	100%	100%	100%	100%	100%	100%	100%
Debt Securities	100%	100%	100%	100%	100%	100%	100%	100%	100%
Borrowings	100%	100%	100%	100%	100%	100%	100%	100%	100%
Repurchase Agreements	100%	100%	100%	100%	100%	100%	100%	100%	100%
Accrued Interest Payable	100%	100%	100%	100%	100%	100%	100%	100%	100%
Financial Derivatives	100%	100%	100%	100%	100%	100%	100%	100%	100%
Accounts Payable	100%	100%	100%	100%	100%	100%	100%	100%	100%
Settlement Accounts	100%	100%	100%	100%	100%	100%	100%	100%	100%
Dividends Payable	100%	100%	100%	100%	100%	100%	100%	100%	100%
Miscellaneous Liability Items	100%	100%	100%	100%	100%	100%	100%	100%	100%

Run-off rates, foreign currency

	Less than 7 days	7-30 days	1-3 months	3-6 months	6-12 months	1-3 years	3-5 years	Over 5 years	Unclassified
Demand Deposits	20%	10%	5%	5%	0%	0%	0%	0%	0%
Savings Deposits	30%	15%	15%	10%	5%	5%	5%	5%	5%
Time Deposits	30%	15%	15%	10%	5%	5%	5%	5%	5%
Import Deposits and Margin Accounts	100%	100%	100%	100%	100%	100%	100%	100%	100%
Debt Securities	100%	100%	100%	100%	100%	100%	100%	100%	100%
Borrowings	100%	100%	100%	100%	100%	100%	100%	100%	100%
Repurchase Agreements	100%	100%	100%	100%	100%	100%	100%	100%	100%
Accrued Interest Payable	100%	100%	100%	100%	100%	100%	100%	100%	100%
Financial Derivatives	100%	100%	100%	100%	100%	100%	100%	100%	100%
Accounts Payable	100%	100%	100%	100%	100%	100%	100%	100%	100%
Settlement Accounts	100%	100%	100%	100%	100%	100%	100%	100%	100%
Dividends Payable	100%	100%	100%	100%	100%	100%	100%	100%	100%
Miscellaneous Liability Items	100%	100%	100%	100%	100%	100%	100%	100%	100%

Roll-off rates, local currency

	Less than 7 days	7-30 days	1-3 months	3-6 months	6-12 months	1-3 years	3-5 years	Over 5 years	Unclassified
Debt Securities	100%	100%	100%	100%	100%	100%	100%	100%	100%
Loans & Advances	50%	50%	50%	30%	30%	30%	10%	10%	10%
Repurchase Agreements	100%	100%	100%	100%	100%	100%	100%	100%	100%
Accrued Interest Receivable	100%	100%	100%	100%	100%	100%	100%	100%	100%
Shares and Other Equity Investments	100%	100%	100%	100%	100%	100%	100%	100%	100%
Prepaid Insurance Premiums and Outstanding Claims	100%	100%	100%	100%	100%	100%	100%	100%	100%
Financial Derivatives	100%	100%	100%	100%	100%	100%	100%	100%	100%
Prepayments	100%	100%	100%	100%	100%	100%	100%	100%	100%
Settlement Accounts	100%	100%	100%	100%	100%	100%	100%	100%	100%
Dividends Receivable	100%	100%	100%	100%	100%	100%	100%	100%	100%
Items in Process of Collection	100%	100%	100%	100%	100%	100%	100%	100%	100%
Miscellaneous Asset Items	100%	100%	100%	100%	100%	100%	100%	100%	100%
Non-financial Assets	100%	100%	100%	100%	100%	100%	100%	100%	100%

Roll-off rates, foreign currency

	Less than 7 days	7-30 days	1-3 months	3-6 months	6-12 months	1-3 years	3-5 years	Over 5 years	Unclassified
Debt Securities	100%	100%	100%	100%	100%	100%	100%	100%	100%
Loans & Advances	50%	50%	50%	30%	30%	30%	10%	10%	10%
Repurchase Agreements	100%	100%	100%	100%	100%	100%	100%	100%	100%
Accrued Interest Receivable	100%	100%	100%	100%	100%	100%	100%	100%	100%
Shares and Other Equity Investments	100%	100%	100%	100%	100%	100%	100%	100%	100%
Prepaid Insurance Premiums and Outstanding Claims	100%	100%	100%	100%	100%	100%	100%	100%	100%
Financial Derivatives	100%	100%	100%	100%	100%	100%	100%	100%	100%
Prepayments	100%	100%	100%	100%	100%	100%	100%	100%	100%
Settlement Accounts	100%	100%	100%	100%	100%	100%	100%	100%	100%
Dividends Receivable	100%	100%	100%	100%	100%	100%	100%	100%	100%
Items in Process of Collection	100%	100%	100%	100%	100%	100%	100%	100%	100%
Miscellaneous Asset Items	100%	100%	100%	100%	100%	100%	100%	100%	100%
Non-financial Assets	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: IMF staff estimates.

Table 7. Maldives: Cashflow-based Stress Test Results

Only one bank may face insufficient LC buffers within 7 days

LC Results

	Less than 7 days	7-30 days	1-3 months	3-6 months	6-12 months	1-3 years	3-5 years	Over 5 years	Unclassified
Bank 1	P	P	P	P	P	P	P	P	P
Bank 2	P	P	P	P	P	P	P	P	P
Bank 3	P	P	P	P	P	P	P	P	P
Bank 4	P	P	P	P	P	P	P	P	P
Bank 5	P	P	P	P	P	P	P	P	P
Bank 6	P	P	P	P	P	P	P	P	P
Bank 7	NP	P	P	P	P	P	P	P	P
Bank 8	P	P	P	P	P	P	P	P	P

Source: IMF staff estimates
Note: P=Pass, NP=Not pass

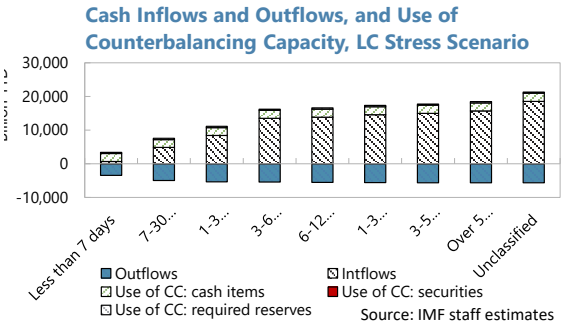
Another bank's parent borrowing appears as a long term mismatch

FC Results

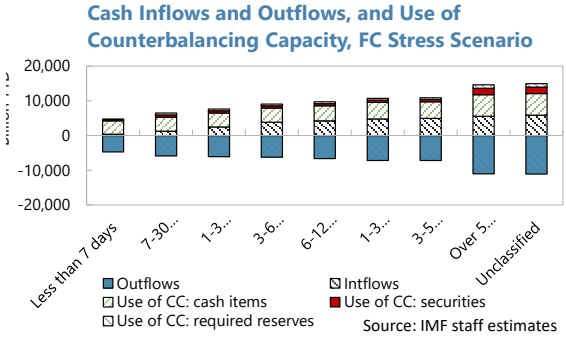
	Less than 7 days	7-30 days	1-3 months	3-6 months	6-12 months	1-3 years	3-5 years	Over 5 years	Unclassified
Bank 1	P	P	P	P	P	P	P	P	P
Bank 2	P	P	P	P	P	P	P	P	P
Bank 3	P	P	P	P	P	P	P	P	P
Bank 4	P	P	P	P	P	P	P	P	P
Bank 5	P	P	P	P	P	P	P	P	P
Bank 6	P	P	P	P	P	P	P	P	P
Bank 7	P	P	P	P	P	P	P	P	P
Bank 8	P	P	P	P	P	P	P	NP	P

Source: IMF staff estimates
Note: P=Pass, NP=Not pass

The LC stress is counterbalanced mostly by cash and reserves



The FC stress is counterbalanced by cash, reserves and securities



Source: IMF staff estimates.

B. Liquidity Coverage Ratio

32. The Basel III Liquidity Coverage Ratio (LCR) was calculated using government securities as proxies for HQLA. The standardized Basel stress scenario factors for haircuts, outflows and inflows were applied.[15] However, for the LCR, Basel guidelines typically restrict HQLA to securities with liquid markets that allow for cash conversion at little or no loss of value. In the case of Maldives, there are no such markets, so HQLAs were proxied by central government securities. Furthermore, since 98 percent of bank securities investments are in central government securities (and the remaining 2 percent in securities issued by non-residents), all of those investments (both in local currency and FX) were deemed HQLA. However, only securities that mature within 30 days were included as HQLA. The Basel III Net Stable Funding Ration (NSFR) could not be calculated due to insufficient information at MMA for the computation of stable funding.

33. The results of the LCR calculation indicate that the banking sector as a whole would be compliant with the Basel III regulation. The ratios for the LCR in LC and FC were calculated to be 254 and 235 percent, respectively (Table 8). However, one bank fails the test in FC. the lowest ratios

[15] See Basel (2013)

calculated for any bank stood at 157.1 percent and 79.9 percent, respectively, indicating a substantial dispersion across the banking system.

Table 8. Maldives: Summary Liquidity Stress Test Results

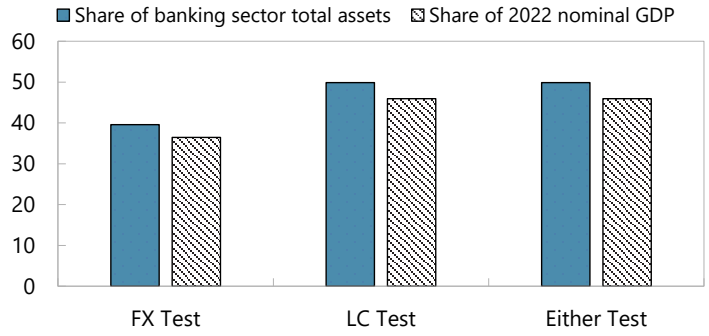
LIQUIDITY RISK	
Number of banks failing cashflow-based test in either currency	2
Banks failing the cashflow test in either currency in % of system assets	25.3
Banks failing the cashflow test in either currency in % of GDP	23.3
Basel III Liquidity Coverage Ratio, MVR	253.8
Basel III Liquidity Coverage Ratio, USD	235.1
DEPOSIT CONCENTRATION RISK	
Number of banks failing test in either currency	7
Assets of banks failing the test in % of banking system assets	49.9
Assets of banks failing the test in % of GDP	46

C. Deposit Concentration Sensitivity Analysis

34. A deposit concentration risk analysis shows the banking system's vulnerability to full deposit withdrawals of each bank's five largest depositors. In this test, banks are allowed to use their cash inflow within 7 days to cover deposit withdrawals by large depositors. As conversions between FX and local currency cash inflow could become difficult at such a scale, the analysis is done separately on banks' local currency and FX balance sheets. The result shows seven banks (49.9 percent of total banking sector assets) would not be able to withstand runs on either local currency or FX deposits by five largest depositors, suggesting an inordinate deposit concentration in the system (Table 8 and Figure 15). However, some banks contend that certain deposits may not be withdrawn as they represent cash collateral that must be maintained for as long as the loan exposure exists.

Figure 15. Maldives: Share of Banks that Failed Largest Five Depositors Outflows Test

In Percent



Source: IMF staff estimates.

OTHER SENSITIVITY ANALYSES

A. Interest Rate Risk

35. Interest rate risk was assessed by assuming a symmetric increase in rates on assets and funding, indicating that this type of risk is manageable for the banking system. An interest rate risk sensitivity analysis assuming a symmetric increase on interest-bearing assets and liabilities with residual maturities of up to one year by 200 basis points—a standard assumption in FSAP market risk sensitivity analyses—caused a moderate drop in capitalization of 1.2 percentage point (compared to the baseline scenario projection for end-2023) on account of a maturity mismatch between assets and liabilities (Table 9 and Figure 16). The maturity mismatch is mitigated by the relatively short maturities of loans and securities, with 58 percent of interest-bearing assets maturing within one year (91 percent for liabilities). [16]

B. Foreign Currency Risk in Balance Sheets

36. Foreign currency risk in the balance sheet is contained for most banks. This is evidenced by moderate changes in the Net Open Position (NOP) upon the assumed devaluation by 20 percent contemplated in the severe scenario. However, two banks breach the upper limit to the NOP, which is wider than in other countries, already at present (Table 9 and Figure 16).[17] In addition, a large bank that is short in FX (reportedly in part due to clients' credit card use abroad) would see its NOP become even more negative and close in on the lower single currency limit.

Table 9. Maldives: Summary Market Risk Sensitivity Analysis Results

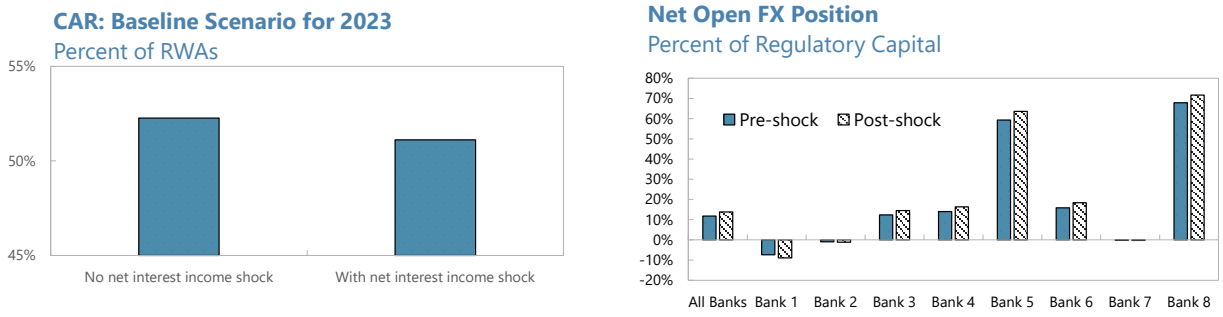
INTEREST RATE REPRICING RISK	in percent of RWAs
CAR after increase of interest rates by 200 basis points	51.1
FOREIGN CURRENCY RISK	
Number of banks breaching NOP limits after 20% devaluation	2
Assets of banks failing the test in % of banking system assets	23.3
Assets of banks failing the test in % of GDP	20.1

Sources: IMF staff estimates.

[16] Under the assumption of a debt exchange made in the sovereign risk sensitivity analysis, the interest rate risk is no longer negligible.

[17] According to MMA's Prudential Regulation on Foreign Currency Exposure Limits, the foreign currency open position exposure for all currencies shall not exceed 40 percent of a bank's capital base, and the single currency open position exposure shall not exceed 25 percent of a bank's capital base for a long position, and 15 percent for a short position. Banks may apply, in writing, to the MMA for a temporary exemption stating the reason/s for the excess position and indicating how and when the excess position will be corrected.

Figure 16. Maldives: Market Risk Sensitivity Analysis Results



Source: IMF staff estimates.

CLIMATE RISK ANALYSIS

A. Physical Climate Risk Context of the Maldives

37. Maldives is exceptionally vulnerable to climate change, mainly due to rising sea levels, which will exacerbate coastal flooding. The recent experience with COVID-19-related disruptions to travel highlights the economy's vulnerability to large swings in global tourism, as it was with the Tsunami to the destruction from natural disasters. However, in contrast to the pandemic, where the Maldives benefitted from a global fiscal and monetary loosening in response to the crisis, future climate emergencies are likely going to be met in an environment of reduced buffers (fiscal and FX), higher interest rates, reduced economic prospects, and much higher levels of public and external debt.

Maldives Vulnerability to Climate Change	
Key elements highlighting Maldives vulnerability to climate change	80 percent of Maldives' islands are less than one meter above sea level
	90 percent of the islands report flooding annually
	97 percent of the islands report shoreline erosion
	64 percent of the islands report severe erosion
	50 percent of the housing structure are within 100 meters of the coastline

38. Adaptation measures must keep up with future climate conditions to prevent damage from climate-related events, such as coastal floods. Although adaptation projects like higher elevation and coastal protections are on the government's agenda, resort operators must also contribute to achieving broader geographical coverage. Due to future sea levels, the storm surge height might surpass the actual elevation and protection levels. The most destructive natural disaster recorded was the 2004 Tsunami, followed by hydrological climate-related events (EM-DAT, 2008). The most common climate-related events

Climate-related events				
Year	**Type**	**Persons affected**	**Damages ('000 USD,**	**Affected Atolls**
1987	Flood	300	15,454	
1991	Storm	23,849	64,465	
2007	Flood	1,649		Dh, GDh, L, Th
2019	Flood	1,800		GA, HDh, L, Th
2021	Storm	1,320		

are floods, with coastal-related events as the most destructive and extreme precipitation events the most frequent (World Bank, 2021). With climate change, the intensity of these disasters will likely increase. It could also have indirect damages and spillover effects with other events, such as coral bleaching (due to water rising temperatures) or beach erosion).

B. Climate Scenarios

39. The climate risk analysis uses information from the Intergovernmental Panel on Climate Change (IPCC). The IPCC is the UN body for assessing the science related to climate change, providing regular assessments of the scientific basis of climate change, its impact, future risks, and options for adaptation and mitigation. Its Sixth Assessment Report (AR6) focuses on five climate scenarios, SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 (IPCC, 2021). The first number refers to the assumed Shared Socioeconomic Pathway (SSP), and the second to the Representative Concentration Pathway (RCP). While the SSP states the development of socioeconomic factors (such as population, economic growth, urbanization, and technology), the RCP describes different future levels of greenhouse gases and other radiative forcings. The scenarios used in the analysis correspond to (SSP2) Middle of the Road, (SSP3) Regional Rivalry, and (SSP5) Fossil-fueled Development (Riahi et al., 2017). While the data for sea level rise considers all the General Circulation Models (GCM), the data storm surge data considers three GCMs. These three GCMs better depict the windspeed conditions in the Maldives used to model storm surges, while the sea level decision on using all GCMs results from the nature of the phenomenon.

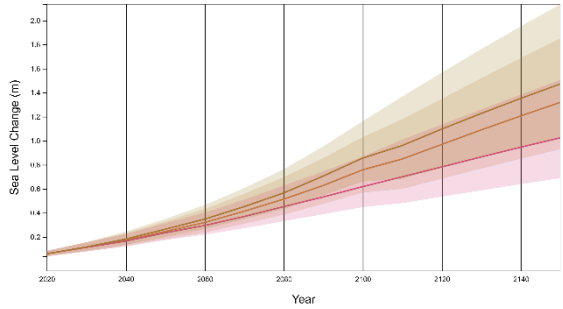
40. Sea level rise could reach critical levels by the end of the century with no adaptation. Median sea level rise for the mid-of-century does not have significant differences between scenarios, but end-of-century levels can reach concerning increases in levels above 1.5 meters. For mid-of-century, sea level rise does not have significant variability between the different climate scenarios, with levels between 0.14 to 0.62 and an average of the median between the SPP2, SSP3, and SSP5 scenarios of 0.25 (Figure 17, left). Low-likelihood and high-impact scenarios are similar, with a seal level rise between 0.16 - 0.62 for SSP5 RCP8.5 and 0.12-0.46 for SSP1 RCP2.6 (Figure 17, right). While there is not yet an agreement on the effects of sea level rise on the Maldivian geography due to the potential of Atolls to sustain sea level rise and even growth through the geomorphological process, which builds land (World Bank, 2021), with 80 percent of the land mass below a 1-meter elevation and newly developed areas with a 2-meter height, low-confidence, high-impact scenarios for the end of the century could be catastrophic for the country (Storlazzi et al., 2018).

Figure 17. Maldives: Sea Level Rise Under Different Climate Scenarios

For mid-century, the sea level height does not differ between scenarios…

SSP2, SPP3 and SSP5

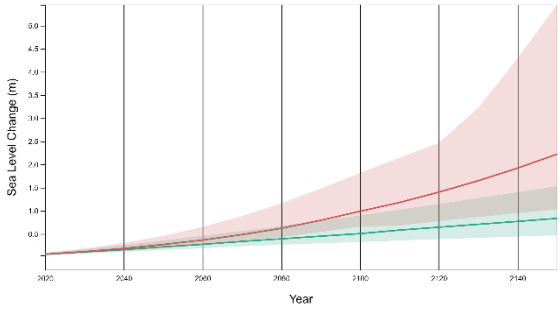
Change in mm; location Male



…even in extreme scenarios, the difference between scenarios is pronounced only toward end-century

SSP1 and SSP5: low-likelihood, high-impact

Change in mm; location Male



Source: IPCC AR 6 - NASA *Sea level projection tool.*

C. Methodology

41. The climate risk analysis estimates a shock to physical capital from coastal floods under different climate scenarios, leveraging authorities' and global data at the level of administrative Atolls. The analysis considers three components for the assessment, the hazards projections, exposure, and vulnerability, aggregated to administrative Atolls, given that was the lowest granularity available for two of the variables used in the exposure (Figure 18). For hazard projections, we modeled coastal floods built by combining storm surges (Biffis & Wang, 2022) and sea level rise. The exposure comes from country-level GDP disaggregated by industry, with proxy variables from the Maldives Bureau of Statistics (MBS) and the Ministry of Tourism (MoT). On vulnerability, we consider damage functions and the flooded fraction of the Atoll.

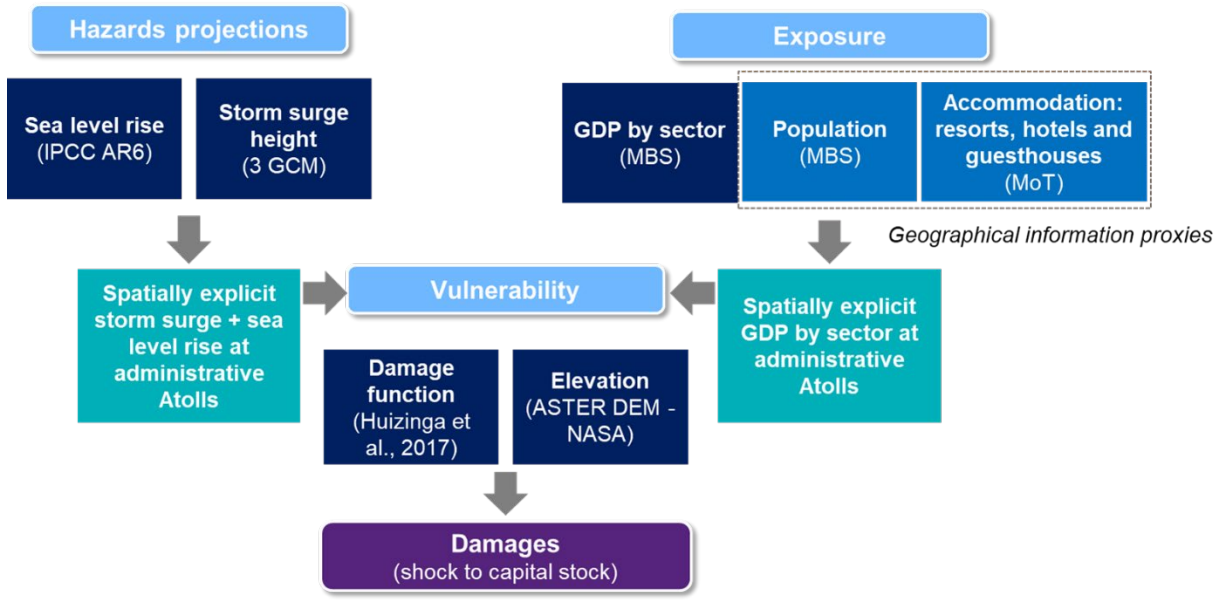
42. The analysis considers a micro approach that captures the sensitivity of banks' portfolios to coastal flooding tail events. The approach only considers physical risk analysis (Adrian et al., 2022) and captures the effects on the banks' portfolios through direct industry damages. Due to unavailability of standardized geographical exposure data for the banking sector, the analysis considers the impact of a by-sector damage rate on the banks' physical immovable assets exposure, although not geographically differentiated. In addition to the direct impact analyzed in the analysis, banks could see an indirect impact through effects on households' and corporates' income that could reduce their capacity to pay creditors after being affected by a climate event.

43. Climate and elevation data was assigned to a subset of the islands, considering "inhabited" and resort islands. To define the exposed areas, the analysis starts with all the islands available from the Maldives Land and Survey Authority (MLSA). Then the next step was to filter the inhabited and resort islands, the latter identified by using the information available on resort islands from The President's Office (2023), with a total of 345 islands (22.18 percent of the total islands). The

analysis used the remaining islands to match each island's sea level rise and storm surge gridded parameters and then added them up to the administrative Atoll (Figure 19). Also, considering these islands, the analysis built the flooded fraction parameter by considering gridded elevation data (NASA, 2019) and estimating the percentage of grids flooded within an Atoll with different coastal flood levels, i.e., from the total number of elevation grids in an Atoll calculate the percentage of grids with a lower elevation than of the coastal flood depth.

44. Coastal floods consider the storm surge tail distribution plus sea level rise as the risk parameter for hazard projections. The estimates include the storm surge parameter on top of the 5th and 95th percentiles of sea level rise (Figure 20), with the latter only affecting future climate scenarios and set to mid-century (2050) for the analysis and to end-century (2100), which, however, is not considered for the impact on the banking system. The storm surge component comes from downscale data from Biffis and Wang (2022), using the relation of windspeed and height from Lin et al. (2010). For each Atoll, the hazard parameter considers the geographical grid nearest to the inhabited and resort islands of the Atoll and then aggregates to the Atoll. For the sea level rise, the aggregation is through the mean; for the storm surge, the parameters are used to fit a Generalized Extreme Value distribution (GEV) using maximum likelihood (Appendix 7). The leading risk factor in the three climate scenarios is sea level rise. The estimation corresponds to the annual maxima series, so the associate probability exceedance probability is annual, and, therefore, the impact is also annual.

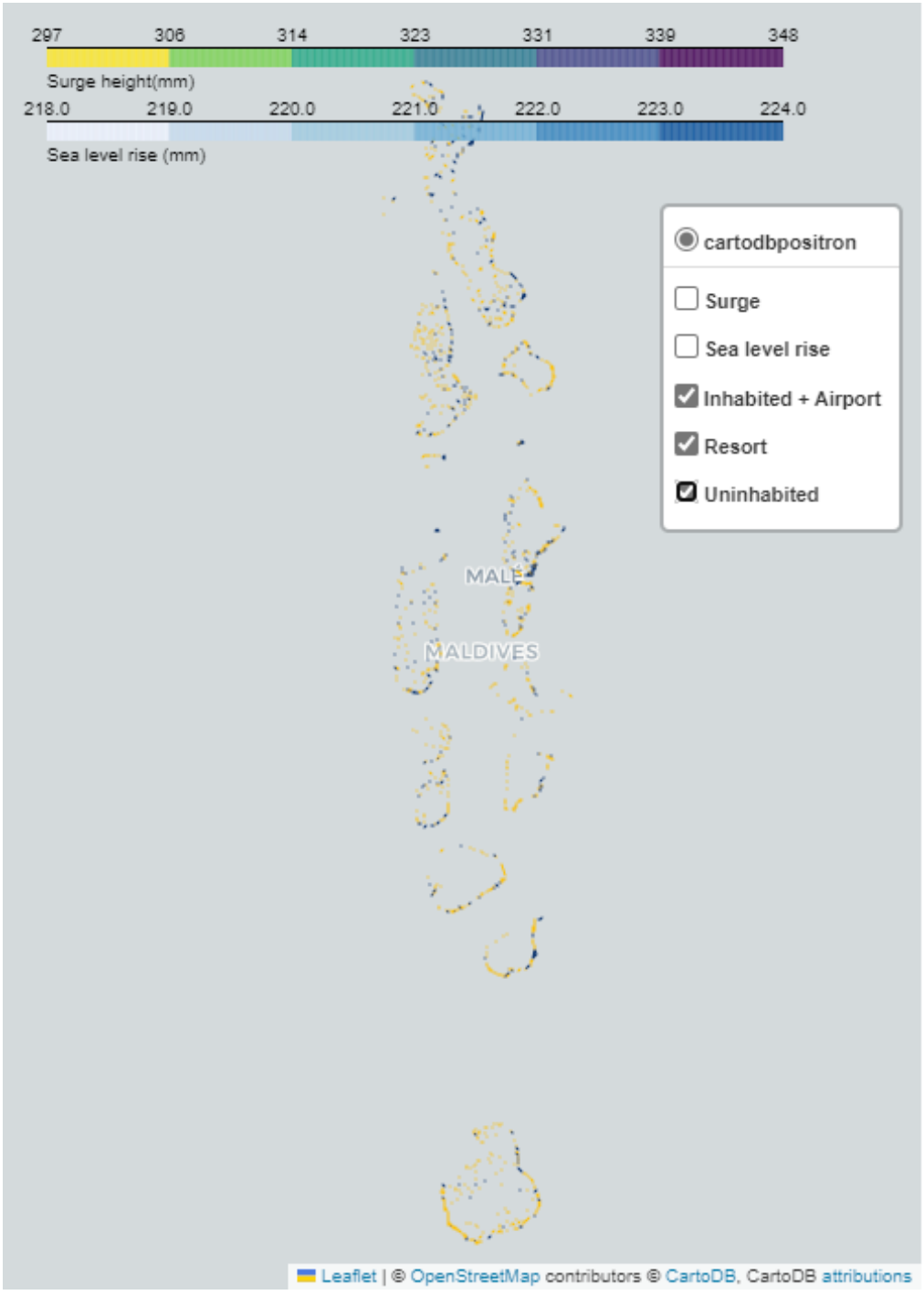
Figure 18. Physical Risk Analysis Framework



Source: IMF staff estimates.

Figure 19. Maldives: Islands Subset and Climate Data Matching

We start by considering all the islands in the country…



Source: MLSA.

Figure 19. Islands Subset and Climate Data Matching (Continued)

…which are filtered to inhabited and resort islands

Source: MLSA.

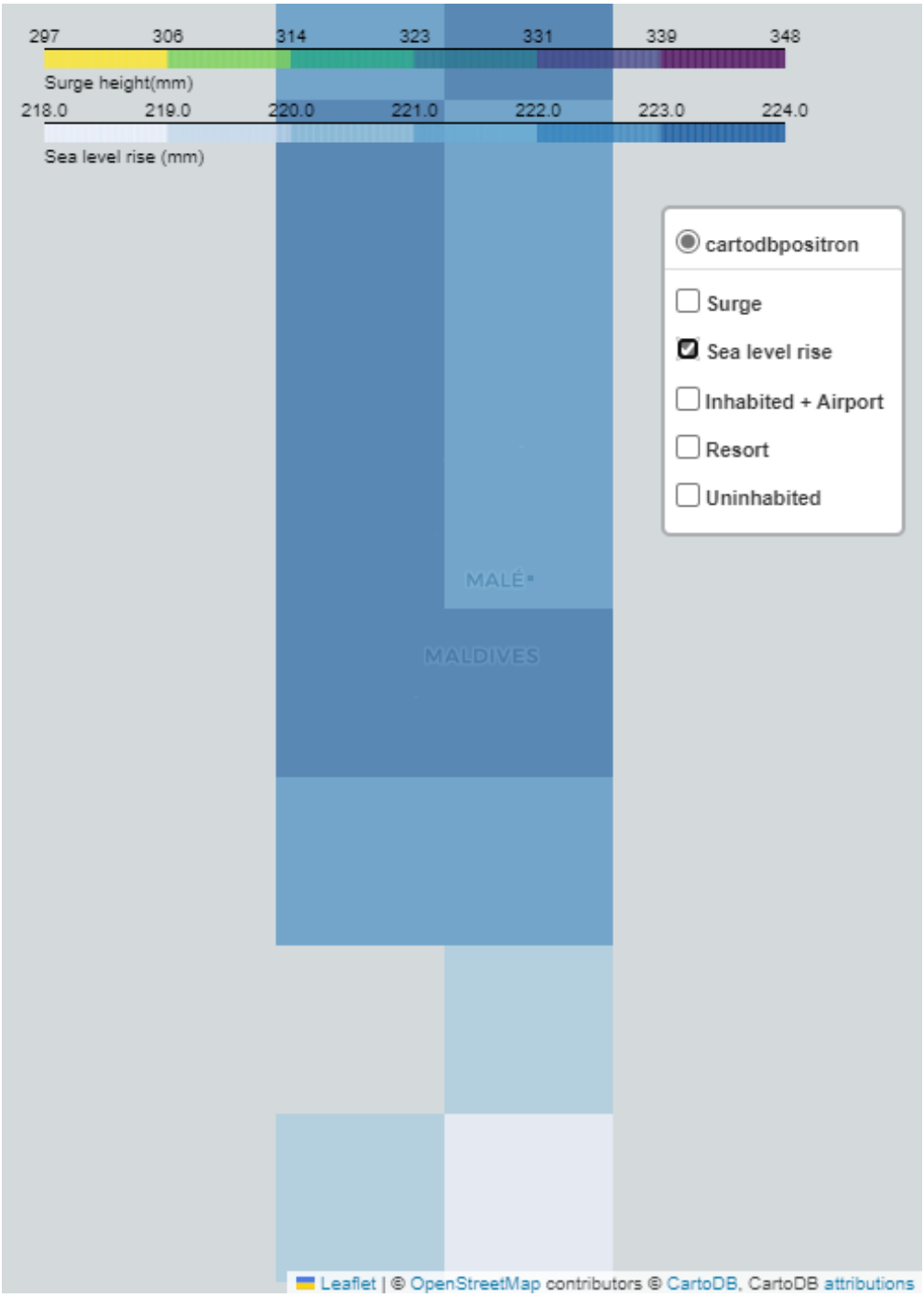
Figure 19. Islands Subset and Climate Data Matching (Continued)

The islands are matched to the storm surge grids (~10x10 km, 0.1 degrees) …

Source: MLSA; Biffis & Wang (2022).

Figure 19. Islands Subset and Climate Data Matching (Concluded)

… and the sea level rise grids (~100x100 km, 1 degree)



Source: MLSA; IPCC AR 6 - NASA Sea level projection tool.

Figure 20. Maldives: Coastal Flood Estimates

Average storm surge and median sea level rise of all Atolls

In mm, height of storm surge by return period + sea level rise, 2050

Average storm surge and 95th percentile sea level rise of all Atolls

In mm, height of storm surge by return period + sea level rise, 2050

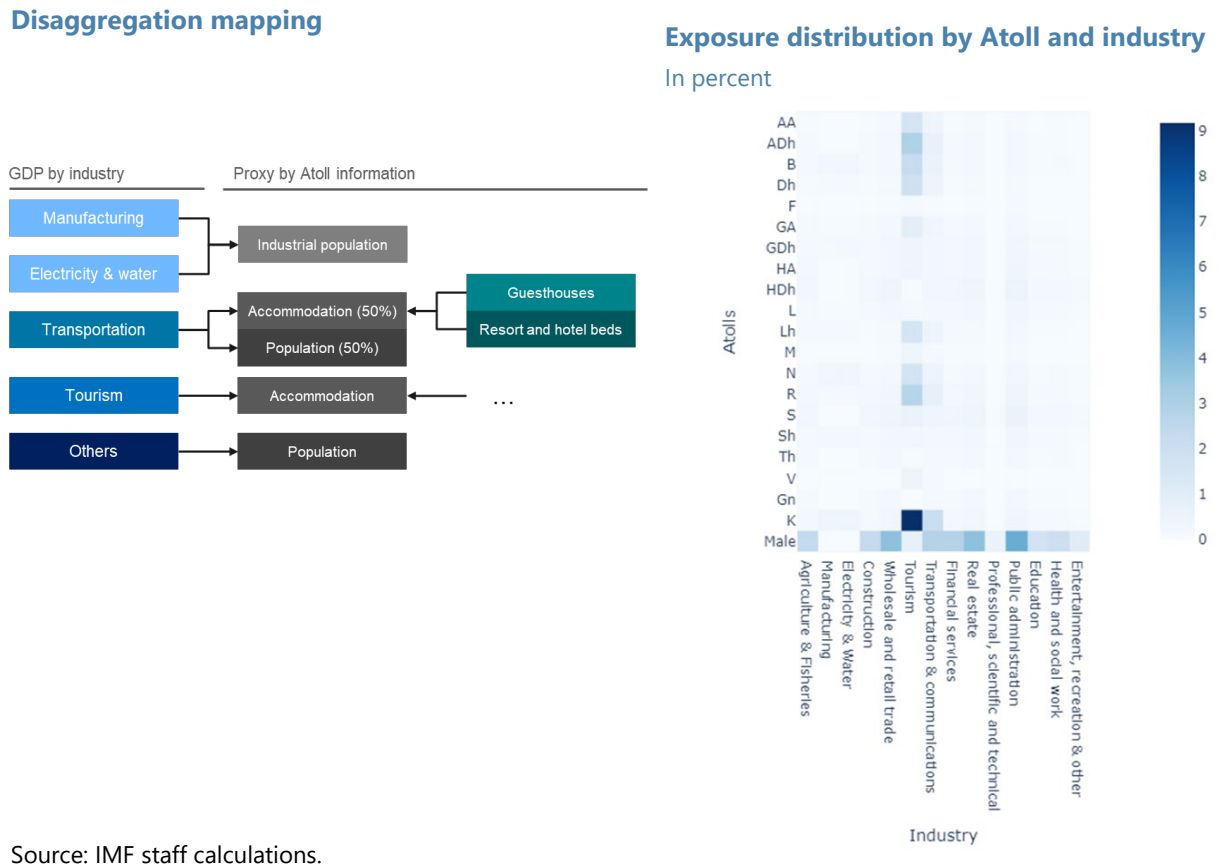
Source: IMF staff calculation.

45. Three different climate scenarios are foreseen in the climate risk analysis and used to explore extreme future conditions. The analysis uses the future climate conditions for SSP2-4.5, SSP3-7.0, and SSP5-8.5. Although financial stability analyses are short-term (3.-5 years), the extreme climate conditions aim to explore the what-if scenario of the actual and future climate conditions impacting the actual economic and geographical footprint. This assumption avoids trying to incorporate forecasting geographical explicit economic conditions that would introduce substantial model uncertainty on top of the climate models' uncertainty. While banks could quickly modify the geographical footprint of their short-term loan exposures, long-term loans, such as mortgages and construction, would slowly transition as the loans mature, and they incorporate climate observations and new climate projections into their business models, which would be critical for financial stability.

46. The exposure was built by disaggregating the economic activity using spatial proxies by industry. The analysis disaggregates the national GDP by economic activity/industry available from the MBS, which major components are Tourism (~26%) and Transportation (~11%). For this, the analysis uses the higher geographical granularity available from the MBS and the MoT to create proxy variables. From the MBS, we use data from the Census 2014 at the island level for population and the Atoll level for industrial islands population. From the MoT information, the accommodation

variable considers the sum of the number of resort and hotel beds by Atoll, and the guesthouses, with the latter only considered as a unit given to the different tourism expenditures derived in this modality. With the three variables by Atoll, the GDP is geographically disaggregated and used as percentage of the capital stock exposure (Figure 21, left). The Greater Male area and Kaafu Atoll represent the main exposures for economic activity (Figure 21, right). Population is a commonly used variable in disaggregated GDP datasets, but it might not capture the reality of every country. Specifically, for a tourism-based economy, such as the Maldives, the accommodation variable allows us to describe the geographical footprint of this sector, which islands are not considered in the population available statistics from the authorities.

Figure 21. Maldives: Geographical Exposure



Source: IMF staff calculations.

Notes: Administrative Atolls names in Appendix 12

47. Differentiating damage rates by sectorial damage functions account for the differences between industries. The analysis uses the damage functions from Huizinga et al. (2017) for Asia to estimate differentiated damage rates considering the coastal flood height for each Atoll (Figure 22). The estimation is done for the three scenarios and the six return periods. Then, the next step is to multiply by the corresponding flooded fraction in the Atoll for each return period. By integrating the different damage functions by industry, some industries would be more resilient to

the climate phenomenon than others. The estimation produces five differentiated damage rate distributions by Atoll and scenario[18] for mid and end-century, which by construction are mapped to each of the industries available in the exposure.

Figure 22. Maldives: Damage Rates Estimations

Average coastal flood of all Atolls

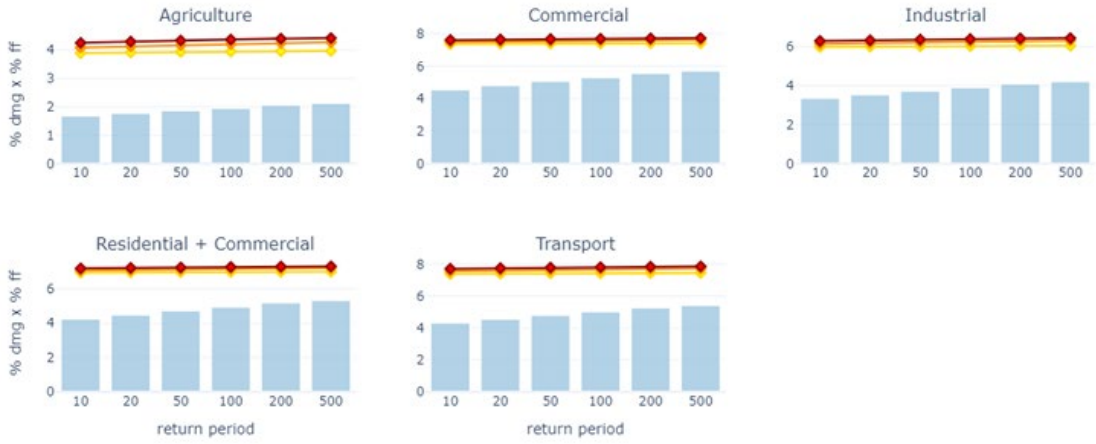
In mm, storm surge GEV + Sea level rise, 95th percentile

Mapping of industries to damage functions

Industry	Dmg. Function by sector
Agriculture & Fisheries	Agriculture
Transportation	Transport
Manufacturing, Electricity & Water	Industrial
Construction, Tourism, Real estate	Residential + Commercial
Others	Commercial

Average damage rate of all Atolls

In percent, damage rate by sector, 95th 2050



Source: IMF staff calculations.

48. Losses were computed by considering the geographical interaction between the Atolls and industries. With damage rates by return periods for each Atoll, the estimation considers the interaction between Atolls with an independence assumption. Using a Monte-Carlo simulation, the analysis computes the joint distribution for the country from the individual Atolls. This process

[18] Figure 22 shows the estimation considering the average coastal flood parameter for all Atolls just for illustrative purposes; the estimation was done for each Atoll and scenario, differentiating the median and 95th percentile for sea level rise.

involves sampling from the damage rates distribution for each Atoll and multiplying by the corresponding exposure (Appendix 8). As the climate parameters become more severe and the estimates go from mid to end-century, the losses drastically increase, with the loss distributions showing fatter tails (Appendix 9 and 10). For the shock, the analysis considers the TVaR ninety-nine of the country distribution (Table 10) and the corresponding components by industry.

Table 10. Maldives: TVaR$_{99}$ Impact to Capital Stock

In percent of total capital stock; 10,000 simulations

		Percentage damage to capital stock			
		Current (A)	Future (B)		
Parameters		Historical	SSP2 4.5	SSP3 7.0	SSP5 8.5
mid-century	median	2.48	3.24	3.33	3.37
	95th	2.48	3.75	3.85	3.91
end-century	Median	2.48	4.38	5.22	5.45
	95th	2.48	6.06	21.18	22.20

49. The analysis considers the immovable asset-related loans, the damage levels for mid-century 95th percentile, and assume no insurance coverage. We used construction, real estate, and tourism categories, which are directly backed by physical assets and represent 60 percent of the total loan portfolio in December 2020. In some cases, the physical asset is not just backing the loan but constitutes the source of repayment, such as in the Tourism sector for which the resorts backed the loans. For construction-specific loans, the land would be the asset that starts backing the loan; as the disbursements are done, the backing asset would consider the construction advance and ultimately become the source of repayment either from the resort operation or for the sale or rent of the finished building. In either case, the damage to the immovable physical asset would directly diminishing the value of the assets backing the loans, which, as stated before, could also be the source of repayment. While insurance is required and would usually cover fully or partially direct damages to the assets (some caveats could apply to land and recovered land), we assume that there is no recovery from the insurance.

50. The link to the banking system is derived by applying the capital stock damage rate by affected industries to the physical asset-related portfolios and calculating the additional provisions. The industry damage rates are weighted by the loan categories related to immovable assets to obtain an immovable asset damage rate by each bank to impact the performing and non-performing loans on each institution. The approach assumes a recovery rate of only 5 percent and no insurance coverage (given that under adverse developments, re-insurance of risks by foreign institutions would no longer be available); the impacted performing loans are correspondingly provisioned to a level of 95 percent. For affected non-performing loans, the provisions correspond to the excess over the banks' current coverage ratio relative to the target of 95 percent.

D. Results

51. The physical risk analysis suggests no material mid-century impact on the banking system but great uncertainty toward more extreme conditions for the end of the century, for which the conditions could be critical. Sea level rise would be the leading factor aggravating coastal floods, directly impacting the population and the economy, mainly through the impact on the tourism-related infrastructure. For mid-century, the coastal flood damages could reach levels of 3.24 percentage damage to capital stock for SSP2 4.5 and SSP5 8.5 in the 99th percentile of the loss distribution with the 95th percentile of sea level rise, which will be around 0.5 percentage points higher than with the median sea level rise. Mid-century estimates show an increase in damages, with respect to historical conditions, from 53-60 percent under the different climate scenarios for the 95th percentile sea level distribution. The results for damages for the end of the century suggest an increase from 130-734 percent in SSP5 8.5 and 80-153 percent in SSP2 4.5 (Figure 23, left)[19]. Due to the high uncertainty toward the end of the century and strong assumptions regarding the adaptation measures in the country, which have been considered for public and private infrastructure development since the 2004 Tsunami, the focus is on the mid-century levels for estimating the impact on the financial system.

52. The damages could reach up to 3.37 percent of the capital stock, with a mild impact on the financial sector for a mid-century coastal flood, but other risks may arise from indirect impacts. The impact is estimated from the direct damages to capital stock under mid-century conditions, which can range from 3.24 to 3.37 percent of the capital stock and reach levels beyond 20 percent for the end-century on SSP3 and SSP5 (Figure 23, left). When directly impacting the loans related to physical immovable assets of the banks by increasing loan loss provisions (Figure 23, right), the impact is found to be mild, with a 0.5 percentage point decline in the banking system's CAR (up to 0.9 percentage points at individual banks). These results need to be interpreted with caution, given the high uncertainty about the climate data and estimates, limited data to model the geographical exposures, as well as the possible indirect damages and spillover effects in Maldives' tourism-dependent economy. Considering direct and indirect effects, as well as other climate conditions beyond coastal flooding phenomena, can lead to higher impacts[20] and worse economic and financial system outcomes. Nevertheless, the levels that could be reached by the end of the century point to continue with adaptation and mitigation measures in the economy and the financial system.

53. In the short term, the local insurance market may observe an increase in reinsurance prices but limited or no reinsurance access in the long run, which could impact the functioning of the financial system. The Maldivian insurance market relies on international reinsurance for climate-related coverage, so the main effect will be higher reinsurance rates or the inability to get reinsurance for climate-related events, specifically coastal flooding. Global insured losses have been increasing by 5-7 percent annually since 1992 due to the severity of events and the

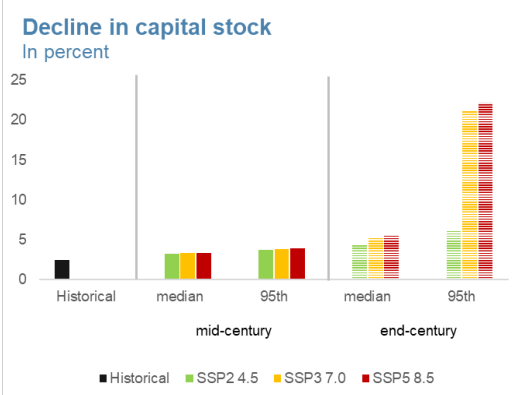
[19] Appendix 10 has the details on the impact of the different scenarios.

[20] Mahfuz & Suphachol (2014) estimate an average economic damage of 2.3 percent of GDP.

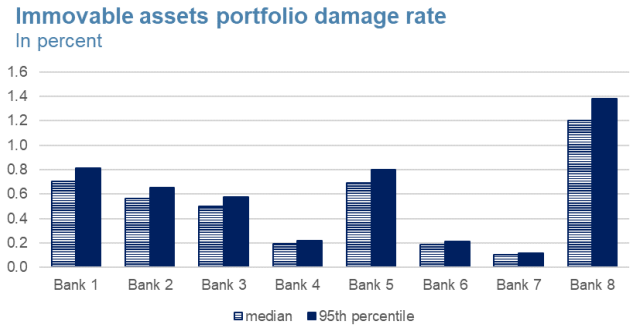
accumulation of insured asset values in exposed areas, urbanization, and rising populations. On top of this, high inflation and cost of capital will further increase reinsurance rates, which would then be transferred to insurers, affecting insurance rates in local markets (Swiss Re, 2023). The ultimate effect of climate change could be the reinsurance market pulling out of the country for climate-related events. With the country insurers relying on reinsurance for covering natural catastrophes and minor possibilities for diversification, this would lead to insurers limiting or not offering coverage. In the case of a lack of reinsurance, banks would need to cope with climate-related losses directly instead of transferring the risks. Further granularity on the claims process, such as type of event, its intensity, and time to settlement, will give greater details in the interactions between the banks and insurers, and better information on the reinsurance conditions would allow the authorities to understand the appetite of the reinsurance market to insure the Maldivian market and the dependence of the banking system on insurance products.

Figure 23. Maldives: Results of Climate Risk Analysis

While for end-century, the damage could reach a concerning level…



…the impact on the banking system for the mid-century will be mild



Source: IMF Staff calculations.

E. Recommendations

54. There is a need to improve granularity and coverage of the data required for climate risk analysis. As the country is vulnerable to climate change, the FSAP team recommends that the authorities collect further data to understand better the implications of climate-related events for the economy and the financial system and enhance data access between the different agencies. On the hazards, the MoE should be the main agency to expand the hazards coverage beyond coastal floods and promote access to locally available data and country-specific studies, which use regional or country datasets. For exposures, there is a need to develop geographical granularity for the country and the financial system, which should involve the MBS for country statistics and the MMA for the financial sector, considering banking, insurance, and other supervised institutions. The MBS, MMA, and other relevant agencies should collaborate for a deeper understanding of vulnerability; this is the relationship between climate-related events intensities and losses. Authorities should consider, among others, the effects on households, government relief transfers, insurance claims,

and reinsurance conditions to better quantify climate-related events' implications, which will allow to understand better direct and indirect impact.

55. The authorities should also initiate climate risk analysis in collaboration with other agencies to assess the effect of actual and future climate conditions on the financial sector and the economy. As further data becomes available in the country, the MMA should begin efforts to develop a framework for climate risk analysis. Global datasets should be leveraged while local sources become available and prioritized the analysis for industries with more significant effects on the Maldivian economy and the financial system.

Appendix I. Selected Economic Indicators, 2019–2028

	2019	2020	2021 Prel.	2022 Proj.	2023	2024	2025	2026	2027	2028
Output and prices	(Annual percentage change)									
Real GDP	6.9	-33.4	41.7	12.3	7.2	5.7	6.5	5.9	5.5	5.1
Inflation (end-of-period) 1/	1.7	-2.0	0.2	3.3	5.1	2.5	2.1	2.0	2.0	2.0
Inflation (period average) 1/	1.3	-1.6	0.2	2.6	5.2	2.8	2.2	2.0	2.0	2.0
GDP deflator	-1.1	0.2	1.7	2.6	5.2	2.8	2.2	2.0	2.0	2.0
Central government finances	(In percent of GDP)									
Revenue and grants	26.4	26.4	25.7	30.6	29.6	29.1	28.6	28.5	28.4	28.4
Expenditure and net lending	33.0	49.9	39.5	41.7	38.7	37.6	34.2	33.3	32.9	32.0
Overall balance	-6.6	-23.5	-13.8	-11.1	-9.1	-8.5	-5.7	-4.8	-4.4	-3.6
Overall balance excl. grants	-7.9	-25.2	-15.0	-12.2	-10.5	-9.2	-6.3	-5.4	-5.0	-4.2
Financing	6.6	23.5	13.8	11.1	9.1	8.5	5.7	4.8	4.4	3.6
Foreign	1.1	4.4	6.2	2.7	2.1	1.8	0.5	1.5	-0.2	0.2
Domestic 2/	5.5	19.2	7.6	8.3	7.0	6.7	5.2	3.3	4.6	3.5
of which: Unsecured financing 3/	...	...	...	...	1.0	...	...	...	...	...
Primary balance	-4.8	-20.7	-11.3	-7.5	-5.6	-5.0	-2.4	-1.6	-1.3	-0.7
Public and publicly guaranteed debt	78.8	154.4	120.1	114.9	108.9	108.0	103.5	99.1	95.4	91.6
Monetary accounts	(Annual percentage change)									
Broad money	9.5	14.2	26.2	15.1	10.8	8.7	8.9	8.0	7.6	7.2
Domestic credit	3.4	34.4	8.8	20.7	10.7	12.3	11.9	11.0	10.7	10.1
Balance of payments	ı percent of GDP, unless otherwise indicate									
Current account	-26.6	-35.5	-7.9	-18.1	-16.0	-14.2	-12.8	-9.7	-9.1	-8.5
Of which:										
Exports	6.4	6.9	5.3	6.3	5.8	5.6	5.5	5.5	5.5	5.4
Imports	-49.2	-45.7	-44.4	-52.1	-48.3	-47.3	-45.2	-43.5	-43.4	-42.9
Tourism receipts (in nonfactor services, net)	56.4	37.4	64.5	64.5	61.3	61.3	61.3	61.3	61.3	61.3
Income (net)	-10.0	-8.2	-9.1	-9.2	-8.9	-8.3	-8.0	-7.6	-7.4	-7.1
Current transfers	-10.4	-9.6	-7.9	-8.1	-9.4	-8.9	-8.7	-8.6	-7.9	-7.5
Capital and financial account (including e&o)	27.4	41.7	4.6	18.5	12.3	14.5	13.2	9.1	11.0	9.8
Of which:										
General government, net	1.9	4.0	3.8	3.9	0.5	1.9	-0.4	0.7	-0.9	-0.5
Banks and other sectors, net	3.5	15.6	-4.9	-0.1	1.0	0.3	0.3	0.3	0.3	0.3
Overall balance	0.7	6.2	-3.3	0.4	-3.7	0.3	0.3	-0.7	1.9	1.4
Gross international reserves (in millions of US$; e.o.p.)	754	985	806	828	566	591	615	549	724	859
In months of GNFS imports	3.7	3.4	2.1	2.0	1.3	1.2	1.2	1.0	1.3	1.4
Exchange Rate (rufyiaa/US$, e.o.p.)	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4
Memorandum items:										
GDP (in millions of rufiyaa)	86,259	57,569	83,000	95,655	107,936	117,319	127,720	137,924	148,361	159,065
GDP (in millions of U.S. dollars)	5,598	3,736	5,386	6,207	7,004	7,613	8,288	8,950	9,628	10,322
Tourism bednights (000')	10,689	3,985	10,073	11,727	12,356	13,294	14,557	15,772	16,897	17,925
Tourist arrivals (000')	1,703	556	1,322	1,675	1,765	1,899	2,141	2,319	2,485	2,636
Tourism bednights (% change)	12.8	-62.7	152.8	16.4	5.4	7.6	9.5	8.3	7.1	6.1
Tourist arrivals (% change)	14.7	-67.4	137.8	26.7	5.4	7.6	12.7	8.3	7.1	6.1
Dollarization ratio (FC deposits in percent of broad money)	52.9	45.8	...	...	...	...	...	...	...	...

Sources: Maldivian authorities and IMF staff projections.
1/ CPI-Male definition.
2/ Domestic financing includes MMA advances, SDF contribution and India's USD 250 million bond from the State Bank of India branch in Male.
3/ Unsecured financing includes possible new sources of domestic financing or negotiated official bilateral financing as higher external financing costs are limiting options to tap international capital markets.

Appendix II. Financial Soundness Indicators, 2019–2022

Maldives: Financial Soundness Indicators, 2020Q2-2022Q4

(In percent, unless otherwise specified)

	2020Q2	2020Q3	2020Q4	2021Q1	2021Q2	2021Q3	2021Q4	2022Q1	2022Q2	2022Q3	2022Q4
Core FSIs											
Regulatory capital to risk-weighted assets	47.93	48.19	46.27	45.76	47.17	48.75	46.84	48.16	48.28	52.41	50.88
Tier 1 capital to risk-weighted assets	44.07	42.94	40.97	42.05	41.47	39.86	36.42	44.05	42.22	43.87	40.84
Nonperforming loans net of provisions to capital	2.22	1.39	0.08	-0.32	0.13	-0.03	0.46	-0.71	-0.71	-0.57	0.23
Common Equity Tier 1 capital to risk-weighted assets	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital to assets (leverage ratio)	22.66	21.46	19.03	19.07	18.51	17.73	15.78	18.58	17.88	19.18	17.80
Nonperforming loans to total gross loans	9.63	8.92	8.16	7.84	7.85	7.46	6.73	6.38	6.05	6.15	5.94
Loan concentration by economic activity	86.84	86.79	87.79	88.60	89.23	89.52	88.78	88.07	87.71	86.84	86.52
Provisions to nonperforming loans	88.31	92.25	99.51	101.97	99.16	100.21	96.45	106.02	106.46	105.22	97.74
Return on assets	3.09	3.44	2.50	4.72	4.93	6.12	5.68	5.92	5.39	5.30	5.02
Return on equity	8.86	9.75	7.50	15.86	16.33	20.18	19.71	20.60	18.75	18.27	17.19
Interest margin to gross income	71.15	72.57	71.65	62.14	61.22	55.69	58.05	57.38	59.30	61.18	62.14
Noninterest expenses to gross income	29.56	28.70	31.76	28.55	27.92	24.91	28.86	31.43	29.24	28.70	31.64
Liquid assets to total assets	44.59	39.07	42.56	43.43	42.54	42.35	46.44	48.26	48.88	45.16	45.20
Liquid assets to short-term liabilities	69.94	67.02	69.73	69.40	68.66	67.37	72.02	73.85	74.60	72.25	71.76
Net open position in foreign exchange to capital 1/	9.13	5.21	-9.25	-8.65	-10.08	5.58	6.07	-5.25	-5.69	-5.66	5.95
Additional FSIs											
Large exposures to capital	53.94	58.45	70.17	60.59	70.68	72.67	68.20	44.81	47.18	46.75	49.52
Gross asset position in financial derivatives to capital	0.00	0.00	2.35	1.33	1.27	1.20	2.10	1.02	0.98	0.93	0.90
Gross liability position in financial derivatives to capital	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trading income to total income	3.67	3.76	3.59	3.55	3.20	2.92	3.06	3.89	3.74	3.75	3.66
Personnel expenses to noninterest expenses	39.19	40.03	37.22	32.55	34.71	34.48	34.41	30.69	31.29	31.38	31.13
Customer deposits to total (noninterbank) loans	134.21	124.62	137.24	145.37	145.88	143.72	165.04	177.89	180.92	158.93	166.76
FX loans to total loans	48.45	48.28	47.61	47.63	47.56	47.91	47.05	45.46	44.60	45.55	44.96
FX liabilities to total liabilities	50.59	52.45	54.98	55.18	52.63	51.96	54.37	55.25	55.03	52.77	54.59
Credit growth to private sector	6.46	7.46	8.86	8.62	9.57	8.19	4.20	2.23	1.60	-0.53	4.52
Residential real estate loans to total gross loans	5.31	5.30	5.37	5.43	5.33	5.21	5.15	5.24	5.24	5.19	5.26
Commercial real estate loans to total gross loans	0.6	0.5	0.5	0.3	0.2	0.2	0.3	0.3	0.4	0.3	0.4

Source: IMF Financial Soundness Indicators.
1/ The net open position in foreign currency measures the foreign currency mismatch for the deposit taking institutions to identify exposure to exchange rate risk, which takes into account both on- and off- balance-sheet positions.

Appendix III. Risk Assessment Matrix

Risks	Likelihood (High, Medium, Low)	Impact of Risk (High, Medium, Low)	Policy Response
Systemic regional instability causes financial market dislocations and adverse cross-border spillovers bring about a widening of the parallel market exchange rate spread and an increase sovereign debt stress. Potential 'twin-crisis' risks rise from the banking sector's large sovereign-bank nexus, risks to the exchange rate peg as, and financial sector exposure to regional sovereigns.	**Medium**	**High.** Banks' capital could erode rapidly in the event of sovereign stress considering that RWs on banks' sovereign debt exposure are zero and that sovereign debt represents roughly 30 percent of banks' total assets. Maldives is also highly dollarized economy and financial system and abandoning the peg, or re-pegging at a depreciated rate, would exert significant pressure on banks and the economy.	Reduce domestic financing needs and adjust the RW on banking sector sovereign debt exposure. Reduce excess liquidity in the system and implement measures to reduce the level of dollarization in the economy.
Intensification of military conflicts, commodity price shock, and supply chain disruptions. Emergence or escalation of regional conflict(s) and resulting economic sanctions exacerbate disruptions in trade remittances, tourism, FDI and financial flows, thereby decreasing domestic growth, tightening financial conditions and affecting confidence.	**Medium**	**High.** Slower growth and damage to business confidence would adversely impact investment and consumption. Global financial tightening threatens FX stability and external debt sustainability. As risk of sovereign distress increases, banks are facing spillover risks through the sovereign-bank nexus.	Extend support measures: (i) asset purchase program to support liquidity in bond markets and compress risk premia and (ii) provide liquidity support to banks. To mitigate risks emanating from the sovereign-bank nexus, the authorities should implement fiscal consolidation to reduce financial needs and adjust banks' RWs on sovereign debt exposures.
Abrupt global slowdown or domestic economic shock. A		**High:** a global slowdown or domestic shock would disrupt tourist arrivals	Provide targeted and temporary fiscal support to the most

Risks	Likelihood (High, Medium, Low)	Impact of Risk (High, Medium, Low)	Policy Response
global downturn, or a domestic security incident leading to a shock to tourism, would reverberate through trade and financial channels.	**Medium**	from key source countries, putting pressure on FX reserves and the budget deficit.	vulnerable and hardest-hit workers and businesses, and if necessary, keep financial conditions accommodative to support banks.
Extreme climate events. Extreme climate events cause more severe than expected damage to infrastructure (especially in smaller vulnerable economies) and loss of human lives and livelihoods, amplifying supply chain disruptions and inflationary pressures, causing water and food shortages, and reducing medium-term growth.	**Medium**	**High:** Disruption in tourism and other economic activity, damage to properties from coastal flooding, higher food and energy inflation weakening debtor capacity to repay obligations.	Establish contingent financing plans with development partners. With clear criteria of exceptional circumstances, provide targeted and temporary assistance to affected groups and sectors. Prioritize public investment in disaster-resistant infrastructure and sustainable growth. Identify financial sector exposures to physical risks from climate change.

Appendix IV. Stress Testing Matrix

BANKING SECTOR: SOLVENCY RISK		
1. Institutional Perimeter	Institutions included	• All 8 domestic banks
	Market share	• 100 percent of banking system assets
	Data and baseline date	• Supervisory data as of December 2022
2. Channels of Risk Propagation	Methodology	• IMF stress testing framework
	Satellite models for macro-financial linkages	• Model-based forecast of main macroeconomic and financial variables. • Satellite panel data models for bank-level NPL ratios • Bottom-up stress test: Banks were asked to use their own models or to apply expert judgment and estimate impact of FSAP stress test scenarios on NPL ratio, income and CAR.
	Stress test horizon	• 3 years (end-2022 to end-2025).
3. Tail Shocks	Scenario analysis	• Macro scenarios include a baseline, a moderate and a severe stress scenario, with macro-financial variables (tourist arrivals, bed-nights, real GDP growth, exports, imports, lending rate, consumer inflation). • **Baseline scenario:** Latest baseline scenario of the APD country team. • **Moderate scenario**: Latest adverse scenario of the APD country team that is built on an economic downturn in advanced countries important to economic activity in Maldives. • **Severe scenario:** Bespoke adverse scenario involving a significant economic deterioration, depreciation of the MVR against the U.S. dollar (i.e., abandoning the peg), leading to a twin- coupled with a period of extreme sovereign stress and debt restructuring.

	Sensitivity analysis	• **Credit Risk** *Derived from projection of NPL ratio based on satellite models that include as regressors inflation and import growth, and assumptions about credit growth.* *An increase in NPLs in the following areas:* Local currency loan portfolio (mostly household and SME loans) Foreign currency loan portfolio (mostly corporate loans) *Default of largest 5 borrowers* • **FX-induced Credit Risk** ○ ***Severe scenario*** (currency devaluation): The team proposes to calibrate the scenario to historical volatility and analyze effect of: a. Loans to unhedged borrowers in FX (data on indirect currency risk permitting) • **Sovereign Risk** ○ ***Severe scenario*** *(domestic debt exchange):* a large exogenous shock leads to a period of severe sovereign stress. Debt sustainability concerns limit external commercial and official sector support. The scenario assumes a restructuring of domestic debt where T-bills and any other outstanding domestic government bonds (excl. MMA) are converted into a new bond on financial terms comparable to that given to the MMA in the most recent securitization of MMA claims (20-year maturity at an interest rate of 2.5 percent, equating to a 24.9 percent value loss applied as a haircut to the face value).
4. Risks and Buffers	Risks/factors assessed	• Total credit losses, pre-provision profit, repricing gap, shocks to the credit quality of sectoral and large exposures, domestic debt exchange (DDE) losses, losses from maturity and currency mismatches
	Behavioral adjustments	• Assumptions for pre-provision income growth and credit growth in scenarios as well as for income taxes paid, dividend payouts, maturity

		mismatch related repricing gap, NOP upon devaluation
5. Regulatory and Market-based Standards and Parameters	Calibration of risk parameters	• Projections of bank-by-bank NPL ratios based on satellite panel data regressions were used in combination with projections for credit growth, pre-provision income, income taxes, dividends, and regulatory information to project banks' solvency positions in each scenario.
	Regulatory/Accounting and Market-Based Standards	• Minimum CAR hurdle rate: 12 percent
BANKING SECTOR: LIQUIDITY RISK		
1. Institutional Perimeter	Institutions included	• All 8 domestic banks
	Market share	• 100 percent of total banking sector assets and liabilities
	Data and baseline date	• Supervisory data as of December 2022
2. Channels of Risk Propagation	Methodology	• Cash-flow-based using maturity buckets • Withdrawals of five largest deposits of each bank
3. Risks and Buffers	Risks	• Funding liquidity shock
	Buffers	• Counterbalancing capacity
4. Tail Shocks	Size of the shock	• Assumptions for run-off rates on funding sources and roll-off rates on assets to estimate the funding gap based on historical volatility
5. Regulatory and Market-based Standards and Parameters	Regulatory standards	• Hurdle metrics: funding gap used for pass/fail result
6. Reporting Format for Results	Output presentation	• Funding gap by bank, aggregated • Number of banks that are found to be illiquid and their aggregate share in system assets
BANKING SECTOR: MARKET RISK		
1. Tail Shocks	Sensitivity analysis	• **Interest Rate Risk** *Income Effect* - Parallel shifts in interest rates of interest-bearing assets and liabilities, using the maturity buckets supplied for the liquidity stress test • **Currency Risk**

		○ ***Severe scenario*** (currency devaluation): The team analyzed effect of: - Net Open Position (direct currency risk effect)
BANKING SECTOR: CLIMATE RISK ANALYSIS		
Institutions included	• All 8 domestic banks	
Data	• Islands shapefiles from the MLSA • Population by island, and industrial population by island from the MBS • Tourism sector data on number of beds for hotel and resorts, and number of guesthouses by administrative Atolls from the MoT • Projection of coastal floods levels, which considers: ○ Storm surge estimated from (Biffis & Wang, 2022) ○ Sea level rise data from IPCC AR 6 • Elevation data from ASTER-DEM NASA • Supervisory data as December 2022	
Methodology	• Micro approach on the sensitivity of banks' portfolios to coastal flood tail events. • Hazards: coastal floods modeled from the storm surge tail distribution plus sea level rise from future climate scenarios SSP2-4.5, SSP3-7.0, and SSP5-8.5. • Exposure: built by disaggregating economic activity by industry using spatial explicit proxies and used as a proxy of the capital stock geographical distribution. • Vulnerability: Huizinga et al. (2017) floods damage function, which relates flood depth to percentage damage to physical assets and was differentiated by industry • Country losses were computed by applying the industry damages rates by administrative Atolls weighting by the corresponding capital stock distribution, considering the geographical interactions between administrative Atolls with a Monte Carlo simulation assuming administrative Atolls as independent. • The impact by banks was computed by applying the damages by affected industries to the immovable asset-related portfolios and calculating the additional provisions assuming no insurance coverage.	

Appendix V. FSAP Macro Variables for the Baseline, Moderate and Severe Scenarios

(In percent)	Est.		Proj.	
	2022	2023	2024	2025
Real GDP growth				
Baseline	12.3	7.2	5.7	6.5
Moderate	12.3	-14.3	13.4	10.4
Severe	12.3	-24.4	8.8	10.5
Inflation rate (eop)				
Baseline	3.3	5.1	2.5	2.1
Moderate	3.3	5.8	4.2	2.4
Severe	3.3	9.5	5	2.6
Bank lending rate				
Baseline	10.9	10.9	10.9	10.9
Moderate	10.9	12.5	11.2	10.9
Severe	10.9	16.3	13.2	10.9
Exchange rate (MVR per USD)				
Baseline	15.4	15.4	15.4	15.4
Moderate	15.4	15.4	15.4	15.4
Severe	15.4	18.5	18.5	18.5
Credit growth				
Baseline	11.7	9.8	8.7	8.9
Moderate	11.7	6.6	13.9	10.7
Severe	11.7	2.2	10.4	9.5
Fiscal balance (percent of GDP)				
Baseline	-11.1	-9.1	-8.5	-5.7
Moderate	-11.1	-18.2	-13.9	-9.6
Severe	-11.1	-22.1	-19.5	-15.1
Total Arrival (thousand)				
Baseline	1675.26	1765.199	1899.109	2140.794
Moderate	1675.26	753.752	1214.506	1602.94
Severe	1675.26	676.116	893.058	1221.722
Exports Growth (percent)				
Baseline	35.952	4.122	6.295	6.945
Moderate	35.952	1.86	6.095	6.708
Severe	35.952	-0.403	5.909	6.486

Source: IMF staff estimates.

Appendix VI. Bottom-Up Stress Test: Instructions and Assumptions

Banks were asked to apply their own stress test methodologies, if available, or to exert expert judgment to project key variables. Specifically, the following variables were to be projected for a three-year period under each of the three scenarios through end-2025:

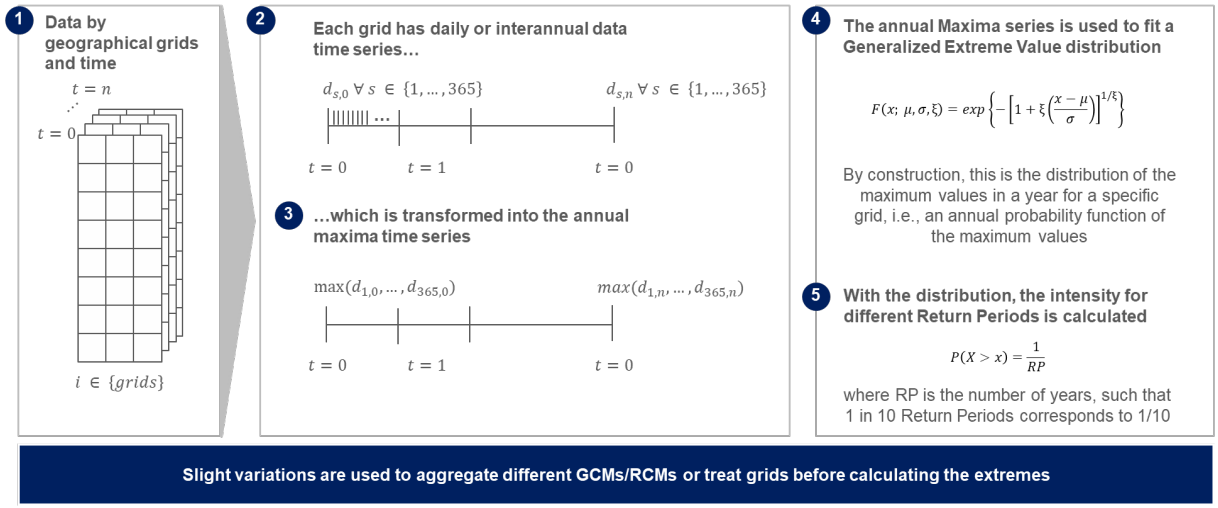
- Loans, other assets (total assets) as well as deposits and other liabilities (total liabilities)
- NPLs and NPL ratio
- Loan loss provisions on additional NPLs
- Pre-provision income (i.e., net interest income, net fee income, net other income)
- Pre-tax income (i.e., pre-provision income and provisioning)
- Income tax paid, post-tax income and effective tax rate applied
- Dividend payout and payout ratio
- Change in retained earnings relative to retained earnings at end-2022
- Risk-weighted assets
- Regulatory capital (Tier 1, total capital), capital adequacy ratio, leverage ratio (MMA definition)

Banks were asked to explain the methodology used in projecting the above variables in a short separate note accompanying the stress test results.

Banks were subject to the following assumptions:

- No deleveraging was permitted (e.g., asset sales to generate additional revenue)
- Provisions applied on additional NPLs should grow in line with the severity of the scenarios (i.e., the provisions under the severe scenario must be higher than those under the moderate scenario, and the latter than under the baseline scenario).
- Similarly, pre-provision income should be lowest under the severe scenario (and lower under the moderate scenario than the baseline scenario).
- Banks should apply a realistic income tax payment under each scenario.
- Dividend payouts should be lower under the moderate and severe scenarios than under the baseline scenario.

Appendix VII. Climate Data Treatment Process



Source: IMF staff.

Appendix VIII. Monte-Carlo Simulation Process

1 Random uniform distributions

Generate i independent random numbers from uniform distribution, one for each Atoll, such as

$$X_i \sim U[0,1]$$

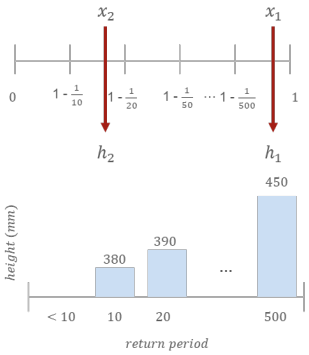
$$i \in \{atolls\}$$

Put the random uniforms into a vector, given by

$$\boldsymbol{x} = \begin{bmatrix} x_1 \\ \vdots \\ x_{21} \end{bmatrix}$$

2 Mapping to empirical distribution

Each element x_i is mapped to the corresponding Atoll empirical distribution



We end with a surge height vector, with a height h_i for each Atoll

3 Calculating capital stock damages

From the heights, we compute the damages by industry and Atoll for each element h_i, deriving a matrix of losses

$$\boldsymbol{h} = \begin{bmatrix} h_1 \\ \vdots \\ h_{21} \end{bmatrix} \Rightarrow \boldsymbol{D} = \begin{bmatrix} d_{1,1} & \cdots & d_{1,s} \\ \vdots & \ddots & \vdots \\ d_{i,1} & \cdots & d_{i,s} \end{bmatrix}$$

$$i \in \{atolls\} \text{ and } s \in \{industries\}$$

We aggregate the percentage losses by industry and Atoll to obtain the country capital stock loss, i.e., one observation of the country capital stock loss distribution

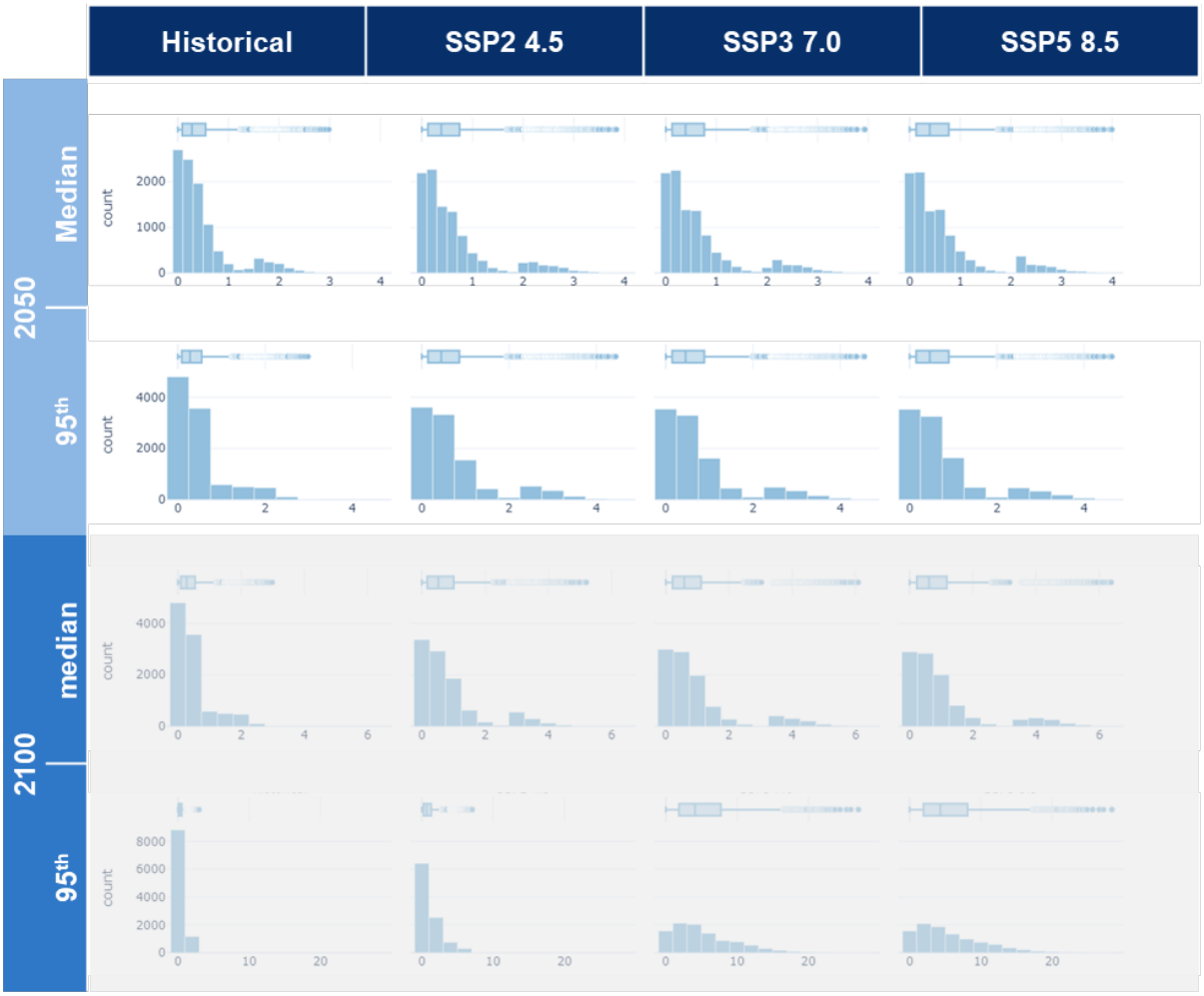
4 Iterate K times to get a country loss distribution

Source: IMF staff.

Appendix IX. Loss Distributions

Capital Stock Loss Distribution

In percent of total capital stock; 10,000 simulations



Note: the historical loss distributions are scaled in each line to be comparable with future climate loss distributions

Source: IMF staff calculations.

Appendix X. Impact of Coastal Floods on the Capital Stock

In percent; 10,000 simulations

	Percentage damage to capital stock, mid-century median sea level rise										Damages as percentage of GDP			
	Current (A)	Future (B)			Effects of climate change						Damage to capital / GDP			
Percentiles	Historical	SSP2 4.5	SSP3 7.0	SSP5 8.5	C = B-A in % pts.			C = C/A in % pts.			Historical	SSP2 4.5	SSP3 7.0	SSP5 8.5
90	1.49	2.03	2.08	2.11	0.54	0.59	0.62	36.24	39.60	41.61	7.10	9.67	9.91	10.05
95	1.81	2.38	2.43	2.47	0.57	0.62	0.66	31.49	34.25	36.46	8.62	11.33	11.57	11.76
98	2.09	2.74	2.82	2.86	0.65	0.73	0.77	31.10	34.93	36.84	9.95	13.05	13.43	13.62
99	2.26	2.97	3.04	3.09	0.71	0.78	0.83	31.42	34.51	36.73	10.76	14.14	14.48	14.71
99.5	2.45	3.19	3.29	3.33	0.74	0.84	0.88	30.20	34.29	35.92	11.67	15.19	15.67	15.86
99.8	2.60	3.37	3.47	3.51	0.77	0.87	0.91	29.62	33.46	35.00	12.38	16.05	16.52	16.71
Average Annual Loss	0.34	0.46	0.47	0.47	0.11	0.12	0.13	32.31	35.56	37.61	1.64	2.17	2.23	2.26

	Percentage damage to capital stock, mid-century 95th percentile sea level rise										Damages as percentage of GDP			
	Current (A)	Future (B)			Effects of climate change						Damage to capital / GDP			
Percentiles	Historical	SSP2 4.5	SSP3 7.0	SSP5 8.5	C = B-A in % pts.			C = C/A in % pts.			Historical	SSP2 4.5	SSP3 7.0	SSP5 8.5
90	1.49	2.35	2.41	2.45	0.86	0.92	0.96	57.72	61.74	64.43	7.10	11.19	11.48	11.67
95	1.81	2.75	2.82	2.87	0.94	1.01	1.06	51.93	55.80	58.56	8.62	13.10	13.43	13.67
98	2.09	3.17	3.26	3.31	1.08	1.17	1.22	51.67	55.98	58.37	9.95	15.10	15.52	15.76
99	2.26	3.43	3.52	3.58	1.17	1.26	1.32	51.77	55.75	58.41	10.76	16.33	16.76	17.05
99.5	2.45	3.69	3.80	3.86	1.24	1.35	1.41	50.61	55.10	57.55	11.67	17.57	18.10	18.38
99.8	2.60	3.90	4.02	4.07	1.30	1.42	1.47	50.00	54.62	56.54	12.38	18.57	19.14	19.38
Average Annual Loss	0.34	0.53	0.54	0.55	0.18	0.20	0.21	52.99	57.05	59.67	1.64	2.51	2.58	2.62

	Percentage damage to capital stock, end-century median sea level rise										Damages as percentage of GDP			
	Current (A)	Future (B)			Effects of climate change						Damage to capital / GDP			
Percentiles	Historical	SSP2 4.5	SSP3 7.0	SSP5 8.5	C = B-A in % pts.			C = C/A in % pts.			Historical	SSP2 4.5	SSP3 7.0	SSP5 8.5
90	1.49	2.76	3.41	3.57	1.27	1.92	2.08	85.23	128.86	139.60	7.10	13.14	16.24	17.00
95	1.81	3.22	3.93	4.11	1.41	2.12	2.30	77.90	117.13	127.07	8.62	15.33	18.72	19.57
98	2.09	3.71	4.49	4.69	1.62	2.40	2.60	77.51	114.83	124.40	9.95	17.67	21.38	22.33
99	2.26	4.02	4.85	5.07	1.76	2.59	2.81	77.88	114.60	124.34	10.76	19.14	23.10	24.14
99.5	2.45	4.32	5.15	5.38	1.87	2.70	2.93	76.33	110.20	119.59	11.67	20.57	24.52	25.62
99.8	2.60	4.56	5.43	5.68	1.96	2.83	3.08	75.38	108.85	118.46	12.38	21.72	25.86	27.05
Average Annual Loss	0.34	0.62	0.75	0.79	0.27	0.41	0.44	79.25	118.34	128.32	1.64	2.94	3.58	3.75

	Percentage damage to capital stock, end-century 95th percentile sea level rise										Damages as percentage of GDP			
	Current (A)	Future (B)			Effects of climate change						Damage to capital / GDP			
Percentiles	Historical	SSP2 4.5	SSP3 7.0	SSP5 8.5	C = B-A in % pts.			C = C/A in % pts.			Historical	SSP2 4.5	SSP3 7.0	SSP5 8.5
90	1.49	3.97	11.71	12.27	2.48	10.22	10.78	166.44	685.91	723.49	7.10	18.91	55.76	58.43
95	1.81	4.57	14.03	14.72	2.76	12.22	12.91	152.49	675.14	713.26	8.62	21.76	66.81	70.10
98	2.09	5.21	16.84	17.65	3.12	14.75	15.56	149.28	705.74	744.50	9.95	24.81	80.19	84.05
99	2.26	5.64	18.97	19.89	3.38	16.71	17.63	149.56	739.38	780.09	10.76	26.86	90.34	94.72
99.5	2.45	5.98	20.76	21.78	3.53	18.31	19.33	144.08	747.35	788.98	11.67	28.48	98.86	103.72
99.8	2.60	6.32	22.24	23.32	3.72	19.64	20.72	143.08	755.38	796.92	12.38	30.10	105.91	111.05
Average Annual Loss	0.34	0.88	2.75	2.88	0.53	2.40	2.53	153.84	696.24	734.91	1.64	4.17	13.07	13.71

Source: IMF staff calculations.

Appendix XI. Impact of Previous Events

In percent

Damages as percentage of GDP		
Flood (1987)	**Storm (1991)**	**Tsunami (2004)**
4.25	12.28	38.32

Note: Tsunami estimates correspond to damages over current GDP

*Estimate

Source: EM-DAT

Appendix XII. Administrative Atolls Codes and Names

Code	Administrative Atoll name
AA	Alifu Alifu
ADh	Alifu Dhaalu
B	Baa
Dh	Dhaalu
F	Faafu
GA	Gaafu Alifu
GDh	Gaafu Dhaalu
HA	Haa Alifu
HDh	Haa Dhaalu
L	Laamu
Lh	Lhaviyani
M	Meemu
N	Noonu
R	Raa
S	Seenu
Sh	Shaviyani
Th	Thaa
V	Vaavu
Gn	Gnaviyani
K	Kaafu
Male	Male

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