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REPUBLIC OF PALAU

SELECTED ISSUES PAPER

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ADDRESSING CLIMATE CHANGE IN PALAU: POLICY OPTIONS AND STRATEGIES

A. Summary

1. **Warming, sea-level rise, ocean acidification, and heavy rainfall events already affect Palau and will likely intensify in the future**. The warming trend observed from the 1950s is expected to continue even with strong mitigation efforts globally. It is also certain that sea-level will continue to rise and the risk of coral bleaching will intensify due to ocean acidification from increased concentrations of carbon dioxide in the atmosphere.

2. **Adaptation can be very effective at reducing the cost of sea-level rise, but it requires careful planning and a balanced mix of protection and planned retreat**. IMF staff estimates sea-level rise can cost as much as 4 percent of GDP annually in 2040 without adaptation. An adaptation strategy that combines protection and planned retreat of areas at risk of inundation would cut the overall cost of sea-level rise (including adaptation costs) by 75 percent to approximately 1 percent of annual GDP by mid-century. The cost of other adaptations can be contained by focusing on cost-effective measures and delaying adaptations that will be cost-effective only in worst case climate outcomes.

3. **To be effective and efficient, adaptation to climate change must be an integral part of development planning**. With many competing needs, the government must carefully allocate resources across all possible uses, including adaptation to climate change, while considering the distributional effects of its programs. This requires: (i) concentrating government efforts and resources in key areas; and (ii) collecting information on the effectiveness of spending across alternative programs and how spending affects distinct groups in society (Bellon and Massetti, 2022a). The government can prioritize adaptation policies with positive externalities, by removing market imperfections and policies that hinder efficient private adaptation, and by ensuring a just transition.

4. **In response to the growing urgency to fight climate change, "green PFM" could be integrated into PFM practices to support climate-sensitive policies in Palau**. Palau is currently formulating a PFM Roadmap that will set the direction for PFM reforms over the next five years and presents a good opportunity to consider how climate considerations could be integrated into PFM systems, commensurate with the authorities' capacity. The PFM Roadmap will be informed by the PEFA assessment results but will also respond to the current fiscal challenges facing Palau. "Greening" PFM systems makes sense only if the basic elements of a functional PFM system are in place and emphasizes that climate consideration should be integrated into existing PFM processes and systems. There are four areas: (i) budget decision making; (ii) fiscal risks management; (iii) project selection processes; and (iv) climate reporting that represent potential 'entry point' opportunities for incorporating climate considerations into PFM systems.

5. Palau's conditional mitigation targets are ambitious. The country's 2015 Intended National Determined Contribution (INDC) aims to reduce energy sector emissions 22 percent below 2005 levels, increase renewable energy share to 45 percent and improve energy efficiency by 35 percent by 2025[1], conditional on international financing. Achieving these targets would put Palau ahead of the linear trajectory to reach net-zero by mid-century. However, baseline emissions are projected to increase, including in the energy sector.

6. To achieve targets, Palau can continue to drive investments towards renewable infrastructure and explore complementary policies. With the introduction of a new solar farm, Palau is expected to increase its renewable generation share to 20 percent in the near future. However, additional solar farms and investment to renew the grid are needed to reach the 2025 targets. Complementary polices, like feebates in the country's transport sector, interconnection standards, and green public procurement strategies can help drive the transition. However, circumventing constraints, such as financing, land capacity and a lack of economies of scale, means Palau should identify financing sources to help achieve strengthen mitigation progress.

7. Carbon pricing can also play a role in reducing emissions, raising revenues, and driving the transition. Palau's effective carbon price on diesel and gasoline are high compared to other island economies. However, a moderate carbon tax could help reduce GHGs and encourage renewable energy while also raising revenues. Revenue recycling can help improve political acceptability and reduce impacts on vulnerable communities from increasing fuel prices.

8. With Palau's reliance on imported goods and tourism, the global mitigation agenda may impact Palau's economy. These impacts may come from three related channels: (i) higher fuel costs; (ii) higher transport/shipping costs; and (iii) increased travel costs that may discourage tourism. The extent of these impacts remains uncertain.

B. Climate Change Impacts and Adaptation[2]

Climate Trends and Projections

9. Increasing temperatures already affects Palau and warming will intensify in the future. The warming trend observed since the 1950s is expected to continue even with strong mitigation efforts globally (Figure 1). With continuation of present trends (SSP2-4.5), the median projections of temperature in 2050 is 1.1 °C higher than in 1985-2014.[3] Palau does not currently observe days with maximum daily temperature above 35 °C –a commonly used threshold for extreme heat—and these extreme temperatures continue not to be observed throughout the century in the scenarios used for this analysis.

[1] UNFCCC, 2015.

[2] Prepared by Emanuele Massetti, Climate Policy Division, FAD

[3] This assessment uses SSP1-2.6, SSP2-4.5, and SSP3-7.0. SSP1-2.6 is in line with the Paris goal to keep global mean temperature increase below 2 ºC with respect to pre-industrial times. SSP2-4.5 represents continuation of present trends. SSP3-7.0 is a high emission scenario.

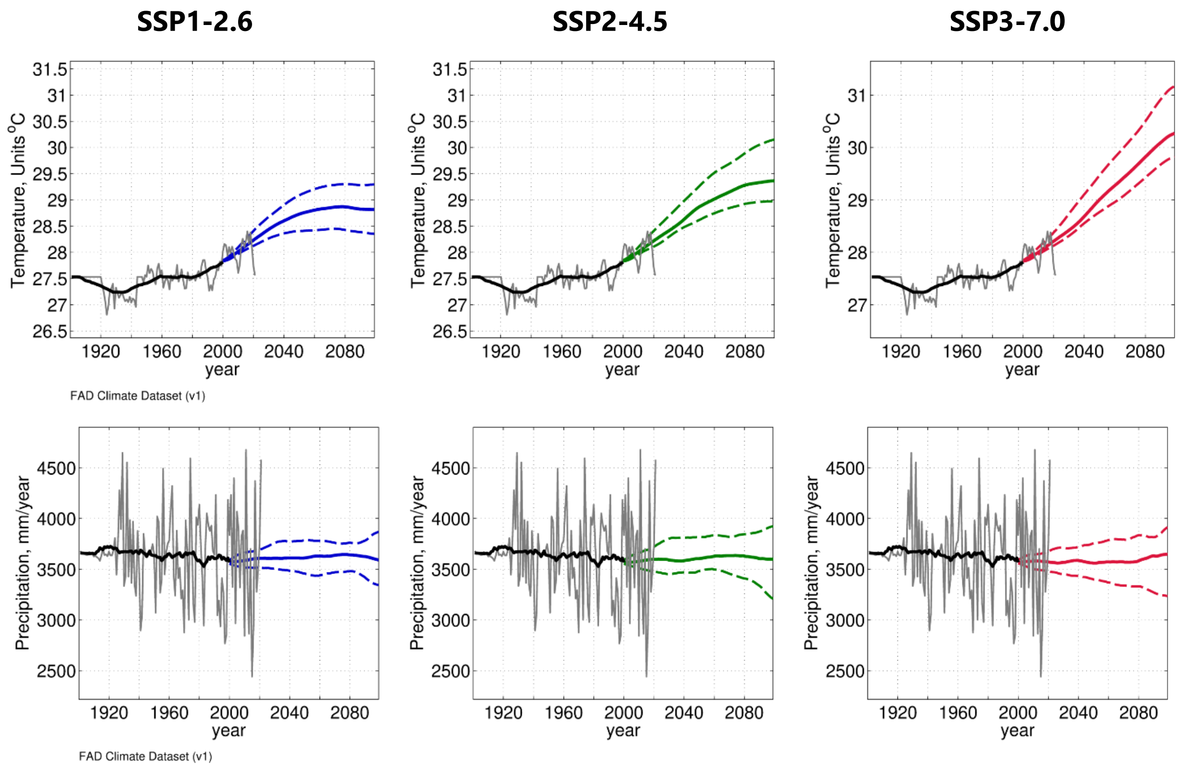
10. There is instead no significant trend in annual total precipitation and future scenarios indicate a small and uncertain increase in precipitation. The projected increase in precipitation is small in percentage terms and when compared to year-to-year rainfall variability (Figure 1). Analysis of high frequency data available from other sources finds that there is low confidence in changes to the frequency of droughts, but high confidence that the frequency and intensity of extreme rainfall events will increase (Australian Bureau of Meteorology and CSIRO, 2014). It cannot be excluded that the increase in precipitation will increase seasonal differences (Australian Bureau of Meteorology and CSIRO, 2014).

11. Palau receives the largest average annual total precipitation of all countries, but very limited storage capacity makes the country susceptible to negative impacts from droughts. Even during its driest years Palau receives much more precipitation than most countries do in their wettest years, but due to limited storage capacity, long periods without precipitation can lead to water shortages with widespread negative impacts. For example, in 2016 three months without precipitation caused severe shortages that required severe conservation efforts.

12. Due to its geographic position and climate, Palau is projected to see less pronounced changes in both temperature and precipitation than most countries (Figure 2). Palau has one of the highest annual mean temperatures in the world, but warming is projected to be relatively modest compared to other countries (Figure 2, panel a). Palau has the highest total annual precipitation among world countries with large year-to-year variation, which makes the projected precipitation change relatively small and uncertain (panel b). As a result, Palau is projected to have one of the least affected climates among all countries (panel c).

13. It is certain that sea-level will continue to increase due to warming of the oceans and melting of ice sheets over land, posing a macro-critical risk. Palau is subject to large high-frequency (weeks) and low-frequency (decades) variability of sea-level that can be of similar magnitude to those expected during this century as a consequence of global warming (Miles et al., 2020). As a result, extrapolation of short-term trends can be misleading. Periods of declining sea-level can occur during a secular trend of increasing baseline sea-level. By 2030, sea-level could increase by an additional 8 to 18 cm relative to its average 1986–2005 level. If emissions follow present trends (SSP2- 4.5) sea-level is projected to increase by 23 to 48 cm above its 1986–2005 level by 2070 (Australian Bureau of Meteorology and CSIRO, 2014, Table 10.6). Uncertainty in base sea-level rise projections is mostly due to unknown speed of ice melting. Due to large inertia, differences in emissions cause little difference in sea-level until at least mid-century.

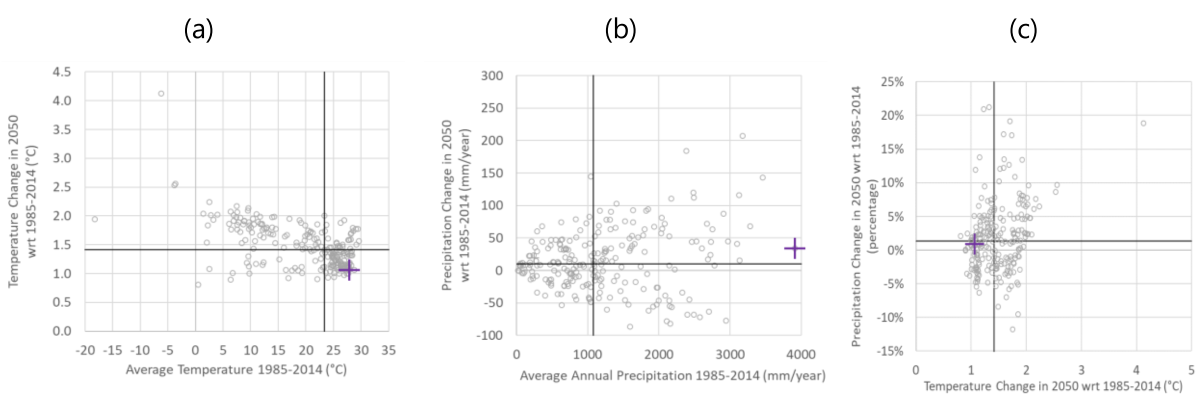
Figure 1. Time Series of Average Annual Temperature (°c), and Total Annual Precipitation



Source: FADCP Climate Dataset (Massetti and Tagklis, 2023), using CRU data (Harris et al., 2020), and CMIP6 data (Copernicus Climate Change Service, Climate Data Store, (2021): CMIP6 climate projections).

Notes: The gray line describes historical mean annual temperature/precipitation based on observations (CRU). The black line describes the 30-year moving average of historical data centered around each 30-year period. Colored lines represent the median and the 80 percent range of temperature and precipitation anomalies (10th and 90th percentiles) added to the CRU value (thick black line in the year 2000). SSP1-2.6 is in line with the Paris goal to keep global mean temperature increase below 2 °C with respect to pre-industrial times. SSP2-4.5 represents continuation of present trends. SSP3-7.0 is a high emission scenario.

Figure 2. Climate Benchmarking



Source: FADCP Climate Dataset (Massetti and Tagklis, 2023), using CRU data (Harris et al., 2020), and CMIP6 data (Copernicus Climate Change Service, Climate Data Store, (2021): CMIP6 climate projections).

Notes: Each circle indicate a country. The cross marks indicate Palau. Projected change in 2050 relative to the 1985-2014 climatology using the SSP2-4.5 emission scenario, median projection. Horizontal and vertical solid lines indicate medians of vertical and horizontal axis, respectively.

14. The risk of coral bleaching will intensify with potential negative effects on biodiversity, fisheries, and tourism. Increased acidity of sea water due to higher carbon dioxide content and increased sea-water temperature will likely have negative impacts on biodiversity. Events like the strong 1998 and 2016 El Niño that contributed to massive coral bleaching and decline of sea life in near shore areas become more likely with increasing temperatures.[4] At the same time, on-going conservation efforts like the Palau National Maritime Sanctuary can contrast these negative trends (Friedlander et al. 2017). The net effect of climate change, development, and conservation effort is difficult to predict. Due to large uncertainties and lack of data the assessment of macro-economic effects from climate change induced biodiversity changes are not included in this analysis.[5]

15. Available data is not suitable to provide a robust assessment of historical trends in neither the frequency nor the strength of tropical cyclones (typhoons) that occasionally hit the country (Australian Bureau of Meteorology and CSIRO, 2014). Climate models project a reduction in future tropical cyclone formation in the areas surrounding Palau, but there is low confidence in this result (Australian Bureau of Meteorology and CSIRO, 2014). Future tropical cyclones are expected to be stronger globally than in the past, which could increase expected damages also in a scenario with fewer storms. Due to large uncertainties, the assessment of expected impacts from climate-change induced changes in tropical cyclones in Palau is not covered by this analysis.

Adaptation to Sea-Level Rise

16. Palau cannot control global sea-level, but it can manage how it affects the country by adapting. Even if efforts to keep global temperature increase in line with the Paris Agreement goals, sea-level will continue increasing throughout this century and beyond. The only practical way for Palau to control the impact of sea-level rise is by adapting. The analysis of sea-level rise impacts, and adaptation options has been traditionally done using complex models that rely on necessary simplifications but provide important insights. There is consensus in this literature that long-term planning of adaptation can be highly effective at containing physical impacts, and costs of sea-level rise. But the transformations needed are complex and require strong governance (Hinket et al., 2018).

17. IMF staff uses the state-of-the-art model Coastal Impact and Adaptation Model (CIAM) to estimate the cost of sea-level rise under alternative adaptation strategies. CIAM is a global model used to estimate the economic cost and benefits of adaptation to sea-level rise (Diaz, 2016). Global coastline is divided into more than 12,000 segments of different length. Each segment is further divided into areas of different elevation. For each segment the model has data on capital, population, and wetland coverage at different elevations. By using science-based projections of local

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[4] NOAA declares third ever global coral bleaching event | National Oceanic and Atmospheric Administration.

[5] For a qualitative discussion of potential impacts see Miles et al. (2020).

sea-level rise, it is possible to estimate the areas that will be inundated and the amount of capital and population at risk. Storms cause periodic inundations on top of sea-level rise.[6]

18. The model calculates the cost of sea-level rise—protection costs plus residual losses—under alternative adaptation options. In a no-adaptation scenario, population does not move until when the sea inundates the area and then moves to higher grounds. Society keeps building and maintaining capital until when inundation causes irreversible losses and capital is abandoned. The cost of sea-level rise is calculated as the sum of the value of capital that is abandoned, demolition costs, and the value of land that is inundated. The disutility cost of reactive migration is monetized and contributes to the cost of sea-level rise. At the opposite, a full-protection scenario assumes that society invests in seawalls and other barriers to avoid inundation from sea-level rise, but storms can still periodically inundate protected areas if protection is not sufficiently strong. Capital and land are not lost, population does not move, but storms periodically cause capital and human losses. The cost of sea-level rise is equal to the cost of protection plus the expected value of the cost of storms. Another adaptation option relies on planned retreat from areas that will be subject to inundation. The goal of retreat is to keep using coastal areas without building new capital and by letting the existing capital depreciate. For example, a coastal road is used until when it needs major retrofitting investment. Then, a new coastal road is built in-land on higher grounds. This strategy accepts that land and some residual value of capital will be lost, but it avoids coastal protection costs. Population gradually moves to higher grounds before areas are inundated. The cost of sea-level rise is equal to the sum of the residual cost of capital, the value of inundated land, and the disutility cost of migration. Other adaptation strategies consider different degrees of protection against storms, and different speed of retreat. For each coastal segment, the model calculates the net present value of each adaptation strategy by summing discounted costs and benefits (avoided damages) over time.[7] The optimal strategy is the strategy with the largest net present value and can differ across coastal segments within the same country. For example, protection is usually the optimal strategy in areas with large existing capital and high population density while retreat is optimal in areas with low capital and population density.

19. Despite many uncertainties and some necessary simplifying assumptions, the model provides a useful framework to systematically think about costs and benefits of alternative adaptation options to sea-level rise. More granular coastal modeling and more accurate mapping of assets can provide a more precise assessment of costs and benefits, but the key insights developed with its baseline version provide a useful starting point to deal with a complex, multidecadal challenge.

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[6] The model does not consider increased risks from river floods, which is not a concern in Palau. See Annex I for additional information.

[7] Loss of life is monetized using the Value of Statistical Life and loss of wetland is monetized using estimates of willingness to pay for biodiversity preservation. The cost of building and maintaining seawalls, and other key parameters are from the literature.

20. The cost of sea-level rise in the no-adaptation scenario is estimated to be as high as 4 percent of GDP in 2040 under the assumption that emissions will follow present trends. Loss of land due to inundation, forced relocation, and storm damages are the main cost components.[8]

21. Adaptation to sea-level rise with protective barriers can be highly effective but planned retreat can be the least-cost option for society. The World Bank estimates that protecting main urban areas in Palau against sea-level rise is highly cost-effective (World Bank, 2016). With these protection in place, the cost of sea-level rise is estimated to equal to 1 percent of GDP, annually, in 2040 (World Bank, 2016). Analysis with the CIAM model assuming optimal adaptation finds costs approximately equal to 1 percent of GDP, annually, throughout the century (Panel b, Box 1). But in the CIAM case the optimal protection strategy is planned retreat. The alternative hypothetical scenario in which all the coastline is protected would require an investment of approximately 2 percent of GDP in 2040 and an upfront investment of up to 5 percent of GDP during the present decade (Panel c, Box1).

22. The analysis relies on the median projection of sea-level rise for an emission scenario along present trends but planned retreat remains the optimal strategy also with faster sea-level rise. Higher emissions do not have a large impact on sea-level rise at least until mid-century, but there is substantial uncertainty on the speed of sea-level rise for any given emission trajectory. For example, melting of the Antarctic and of Greenland ice sheets much faster than consensus scenarios seems unlikely this century but cannot be excluded. Lincke and Hinkel (2018) use a model similar to CIAM and find that planned retreat remains the optimal strategy under a range of alternative modeling options, including a scenario of very fast sea-level rise.

23. Due to the coarse nature of the model, and to large uncertainties in protection costs and avoided damages, these scenarios should not be interpreted as exact estimates of sea-level rise costs. However, World Bank analysis, IMF staff simulations, and many studies in other countries suggest that – if properly managed – sea-level rise costs can be greatly contained. The exact optimal strategy should be assessed case-by-case using high-resolution analysis to estimate costs, scientific uncertainty on sea-level rise, risks from system failure, engineering challenges, and equity issues.

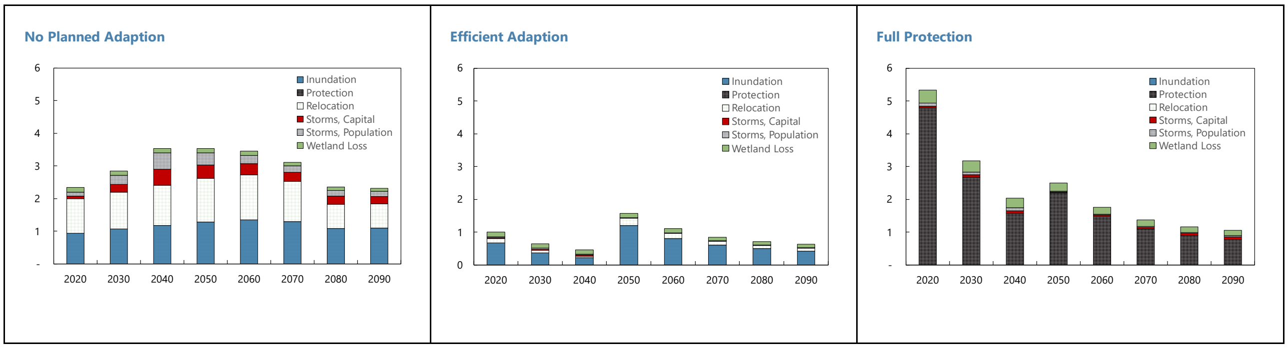
24. Cost-benefit analysis can help in this task by providing a standard framework to estimate social costs and benefits (Bellon and Massetti, 2022a). Conducting CBA for sea-level rise adaptation can be challenging, especially in countries with limited experience, but even preliminary and incomplete assessments are useful to identify trade-offs and the most attractive policy options using a transparent and systematic approach. Best practices can be drawn from coastal protection analysis and policies in the Netherlands, where there is a long-standing tradition of using CBA and Cost-Effectiveness analysis for flood risk management and water governance. This

[8] This exercise uses the median increase of local sea-level in Palau for the RCP 4.5 scenario in Kopp et al (2014). Uncertainty about global warming and the response of land ice sheets to warming is small until 2050 but becomes important in the second half of the century. An assessment of the full range of possible sea-level scenario is beyond the scope of this preliminary analysis and would very likely not alter key policy recommendations.

tradition started in 1954 with the pioneering CBA of the Delta Works by Tinbergen (1954) and continues to this day (CPB, 2017).[9]

Box 1. Cost of Sea-Level Rise (in percentage of GDP)

Using a state-of-the-art model of sea-level rise costs and adaptation, IMF staff estimates the cost of three scenarios: (i) no planned adaptation – society reacts to sea-level rise by relocating, no protection is built and capital losses are large; (ii) Full Protection – society plans construction of protection against sea-level rise by anticipating its effects without relocating people or assets; and (iii) Efficient Adaptation – society plans a mix of protection and retreat anticipating sea-level-rise, by comparing costs and benefits of each option and choosing the strategy with the largest net present value.



Source: CIAM model (Diaz, 2016) and IMF staff estimates.

Notes: While the model provides a useful framework to systematically think about costs and benefits of alternative adaptation options to sea-level rise, its estimates are subject to significant uncertainty, including related to modelling assumptions and projected trajectory of sea-level rise, which is important to consider in policy assessments. The discontinuity in adaptation costs between 2040 and 2050 is due to the nature of the optimization problem, which considers adaptation up to 2050 and after as two distinct problems. For example, loss of land due to inundation is fixed during each adaptation period, but GDP grows, so that inundation loss as a percentage of GDP declines. When a new retreat perimeter is established in 2050, inundation losses increase and then decline following the growing dynamic in GDP. Protection is similarly chosen for a limited time horizon and costs are distributed equally over time. As sea-level rise increases over the century, one can observe a jump in optimal protection investment. Also in this case, the underlying growing dynamic of GDP explains the decline over time of protection costs as a percentage of GDP.

25. Equity-efficiency trade-offs should be estimated and assessed by policy makers. As in all other public policies, adaptation to climate change and adaptation to sea-level rise in particular entails efficiency-equity trade-offs that can be measured using economic tools like CBA but can only be evaluated by policy makers considering society's preferences over equity. Large investment in protection infrastructure can be effective but also very expensive, requiring cuts to other public spending or higher fiscal revenues. Even if adaptation is funded by donors, grants could be used for other development goals. Planned retreat has instead small fiscal costs but requires effective long-term land use planning and it shifts the burden of sea-level rise to the part of the population that lives or owns capital in inundated areas. Planned retreat is chosen as the optimal solution in the example illustrated in Box 1 because it has the largest net present value of all options. This implies

[9] Limitations of CBA under uncertainty are discussed in Bellon and Massetti (2022a). Cost-effectiveness analysis - the choice of the least-cost strategy to attain a desired level of protection - can be an alternative to CBA if outcomes are considered too uncertain by policy makers.

that full compensation of residual damages is theoretically possible, but it may not be neither feasible nor desirable in practice.

Adaptation in Other Sectors

26. Other adaptations will be needed to minimize the impact of intense rainfall and increasing temperature, but their cost is highly uncertain. The World Bank estimates that the incremental cost of making new infrastructure resilient to climate change in Palau is approximately 2 percent, except for roads, which would require a 30 percent cost premium. The high cost of upgrading roads is driven by the need for costly measures to deal with worst-case scenarios. The high cost of upgrading roads suggests that reactive adaptation is optimal – after it becomes clear that the worst outcomes are the most likely (World Bank, 2016, Table 13, p. 47). IMF Staff estimates using World Bank data indicate that adaptation costs to present pluvial and coastal floods risks would be well below 1 percent of GDP, annually, from 2021 to 2040 (Aligishiev, Bellon, and Massetti, 2022).

27. Using the available evidence, it is unlikely that droughts will become more frequent or more intense in Palau, but present risks already warrant corrective actions. There is need for supply-side interventions, for example by increasing water storage capacity and avoiding water distribution losses. As for protection against sea-level rise, CBA can be used to select the optimal mix of interventions with detailed bottom-up analysis. But neglecting demand-side interventions should also be assessed. Efficient water pricing schemes – those that allow to cover the long-run marginal cost of water supply – encourage water conservation and can reduce the scale of intervention on the supply-side (Olmstead and Stavins, 2009).

28. Estimates of adaptation needs can be much larger if they include investments in normal development. In 2015, the authorities estimated Palau's climate change-related cost at $500 million (about 194 percent of 2020 GDP). Many of the investments included in this list have large development benefits but appear to be needed even without climate change. When estimating investment needs in adaptation to climate change, it is useful to focus on costs that can be attributed to climate change. For example, the cost of building new infrastructure should not be counted, as well as the cost of making infrastructure resilient to normal weather shocks. Only the cost of making infrastructure resilient to risks caused by climate change should be counted as an adaptation need. This satisfies the "additionality principle" (Bellon and Massetti, 2022a).

Efficient Adaptation

29. Forecasting all impacts of climate change and all potential remedies requires highly detailed information and is subject to large uncertainties, but it is possible to start from important principles for effective and efficient adaptation policy. The IMF is developing guidance to help countries adapt by integrating climate change in macro-fiscal planning (Gonguet et al. 2021; Bellon and Massetti, 2022a,b; Aligishiev, Bellon, and Massetti, 2022; Sakrak et al. 2022). These principles frame adaptation in terms familiar to economists and in the broader context of sustainable development, with the intent of guiding public investment and enabling efficient private adaptation.

30. Adaptation would be most effective if it is an integral part of development planning. In the Paris Agreement (Article 7), adaptation is established as "the global goal of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development." Investments in climate change adaptation are similar to other investments in development because their common goal is to maximize future welfare given the available resources (Bellon and Massetti, 2022a).

31. With many competing needs, the government must carefully allocate resources across all possible uses, including adaptation to climate change, while considering the distributional effects of its programs. This requires: (i) concentrating government efforts and resources in key areas; and (ii) collecting information on how effective spending is across alternative programs and how spending affects distinct groups in society (Bellon and Massetti, 2022a).

32. The government can prioritize adaptation policies with positive externalities, by removing the market imperfections and policies that hinder efficient private adaptation, and by ensuring a just transition (Box 2). Individuals and firms have strong incentives to adapt because many adaptation benefits tend to be local and private. However, there is a clear role for government intervention when adaptation has large externalities, as in the case of coastal protection or strengthening of public infrastructure. As market inefficiencies and policy failures may limit private adaptation or create distortions, another key role for the government is to continue promoting reforms that ease the efficient use of all resources and ensure competitive access to markets (Bellon and Massetti, 2022a). For example, access to credit markets allows farmers to invest in adaptation and efficient water pricing creates incentives to conserve water.

33. Despite limitations, cost-benefit analysis (CBA) can play an important role in helping decision makers to consistently collect, aggregate, and compare information on public adaptation projects. As exemplified by the analysis of sea-level rise, adaptation investment and policy will typically have trade-offs that would be better assessed by comparing social costs and benefits using a systematic approach. What to do, when, how, and at what cost ultimately relies on ethical choices that should reflect the preferences of each society. However, cost-benefit analysis (CBA), complemented by analysis and correction of distributional impacts, can help decision makers maximize overall social welfare by avoiding wasting scarce resources. To achieve this goal, it is essential that CBA is applied to adaptation as well as to all other development programs in a consistent manner (Bellon and Massetti, 2022a).

34. According to standard CBA rules, only programs with NPV greater than zero should be financed. Competing programs should be ranked using CBA and only programs with the highest ranking should be financed. In the example of adaptation to sea-level rise, retreat is the strategy with the highest net present value. Similar comparisons can be developed when comparing alternative options to strengthen public infrastructure. By consistently investing in projects with the highest returns, governments can maximize the impact of their spending. This means, for example, saving the largest number of lives, providing access to education to the largest number of children, ensuring that the largest possible number of people are above the poverty line, and boosting long-term growth (Bellon and Massetti, 2022a).

35. Compensation might be more efficient than investments in adaptation to achieve society's equity preferences. Full protection of all assets and populations at risks may be very expensive in some cases, as shown in the case of adaptation to sea-level rise. As a result, adaptation projects may have a negative NPV (for example, full protection against sea-level rise is more expensive than no action). While there can be specific reasons to warrant investment even with a negative NPV, the authorities should consider if it is possible to support the affected population in alternative ways. This can take the form of relocation subsidies or other forms of supports with less stringent conditionality (Bellon and Massetti, 2022a). For example, compensation could be used to redistribute the cost of sea-level rise from coastal landowners to society as a whole if planned retreat is cheaper than full protection.

Box 2. Market Imperfections

In imperfectly competitive markets, adaptation is inefficient, and governments should intervene mirroring standard prescriptions for public policy from economic theory.

- Some market imperfections pertain to the nature of the adaptation goods themselves. For example, markets invest sub-optimally in adaptations with large positive externalities and public goods, such as information about climate change, emergency preparedness plans, seawalls, basic research in new materials, and technologies to cope with higher temperature.
- In many instances, resilience depends on networks, such as a system of dikes, a water network, or a transportation network. As adaptation in each part of a network has impacts on the rest of the network that may not be captured, private adaptation will tend to be underprovided. Government coordination may be needed to internalize all the benefits for society.
- The extent of needed cooperation for adaptation projects depends on the extent of the externality that is addressed by the project. Building a more resilient storm water drainage system may only require cooperation at the city level. If risks from sea-level rise are localized, each locality may invest in its own system of protection. The central government can provide adaptations with local effects, but that would be equivalent to a transfer of wealth between regions when projects are financed from national resources. As risks grow in scope and complexity, cooperation might be needed at the national or even the international level, for example to manage floods in transnational rivers. In general, the optimal distribution of responsibilities across levels of government also depends on the existing allocation of responsibilities.
- Other market imperfections affect the broad functioning of the economy and make adaptation to climate change inefficient. For example, a poor business environment and inefficient credit markets hamper opportunities for farmers to invest in new capital to grow crops that are more suitable to the new climate.
- Moral hazard may cause insufficient investment in adaptation if consumers, firms, and local government expect central governments to provide relief. To avoid moral hazard, governments can implement regulations that minimize risk taking. Examples include zoning that prohibits construction in flood zones, building codes, mandatory evacuations, and mandatory insurance.

Box 2. Market Imperfections (Concluded)

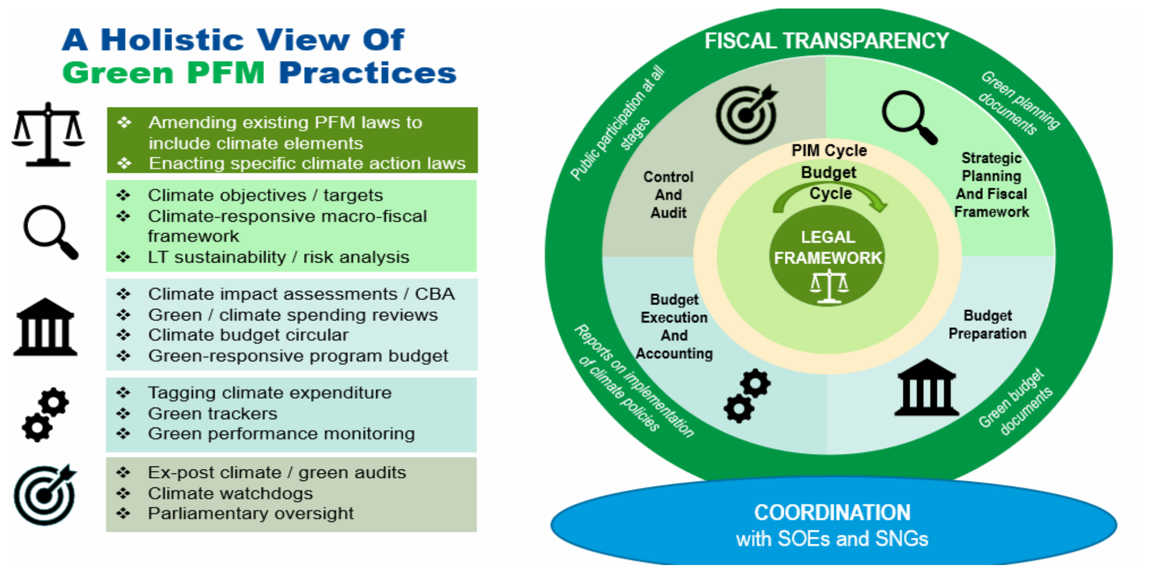
- The government may also consider correcting market distortions resulting from their own policies (policy failure). For example, subsidies to inputs can lead to inefficient use. Of particular concern is subsidized water use, which may worsen water scarcity problems due to climate change. Barriers to international trade also prevent efficient climate-change-induced reallocation of capital, land use, and other resources to maximize their productivity. The government may consider removing these distortions as part of a comprehensive plan to improve the efficiency of the economy, while taking into consideration the distributional implications of these measures.

Source: Massetti and Bellon (2022a)

C. Incorporating Climate Considerations into PFM[10]

36. In response to the growing urgency to fight climate change, "green PFM" aims at adapting existing PFM practices to support climate-sensitive policies. With the cross-cutting nature of climate change and wider environmental concerns, green PFM can be a key enabler of an integrated government strategy to combat climate change. Importantly for small developing states like Palau, with significant constraints on their institutional capacity—human resources, and absorption and implementation–adopting Green PFM practices does not require an entirely new approach. Instead, the idea would be to integrate climate sensitive practices into existing PFM practices and systems, while being careful to prioritize entry points that will be of most value given thin capacity.

Box 3. IMF Green PFM Framework



Source: Staff Climate Notes, 2021

[10] Prepared by Gemma Preston (Senior Economist, FAD) and Paul Seeds (PFM Advisor for Palau, PFTAC)

37. **Palau is currently formulating a PFM Roadmap that will set the direction for PFM reforms over the next five years and presents a good opportunity to consider how climate considerations could be integrated into PFM systems, commensurate with the authorities' capacity**. The PFM Roadmap will be informed by the PEFA assessment results but also respond to the current fiscal challenges facing Palau such as a sharp increase in public debt as a result of the pandemic, elevated fiscal risks due to pension system liabilities and SOEs, as well as large climate change adaptation needs, highlighting the importance of building climate resilience.

38. **Adoption of Green PFM requires countries to consider entry points that are reflective of their current PFM strengths and weaknesses**. "Greening" PFM systems makes sense only if the basic elements of a functional PFM system are in place and emphasizes that climate considerations should be integrated into existing PFM processes and systems. These represent areas where PFM foundations are robust (as determined by the PEFA) but also areas where reforms are nascent and there is opportunity to productively integrate climate considerations. As such, there are four initial priority entry point opportunities for incorporating climate considerations into PFM systems that could be led by the Ministry of Finance in collaboration with other relevant entities.

- **Entry point 1 – Incorporating climate considerations into Budget Decision Making –** The PEFA assessment indicates that Palau's budget preparation process is sound. Building on this foundation, integrating a climate perspective into the budget decision making process, could be relatively straightforward. Adding a climate lens to the budget decision making process would help ensure there is active consideration of the impact of resource allocation decisions on climate adaptation and mitigation efforts. This would require line ministries and agencies to prepare a short analysis (in the form of a qualitative statement, at least initially) on the climate impacts of the proposed policy, including consideration of the connection to mitigation or adaptation efforts. A sequenced approach could apply to first focus on major new decisions, before considering all new decisions. As familiarity and sophistication of the process evolves the details of the impact assessment can also evolve from a qualitative assessment towards a quantitative one, where data is available. Overtime, efforts could also consider existing policies of the government and require these to be examined in a similar way to new policies. Here it would be sensible to target certain ministries and particular programs as a starting point, so that the initial task is not overwhelming and can be refined before a broader rollout. The Turks and Caicos have recently implemented this approach with support from CARTTAC.

- **Entry point 2 - Incorporating climate considerations into the Identification, Management and Reporting of Fiscal Risks –** The PEFA assessment indicates limited practices in fiscal risk analysis, management and reporting. Given the elevated fiscal risks facing Palau since the onset of the pandemic including from SOEs, higher levels of debt and as well as those emanating from climate change and natural disasters, there is considerable scope to step up fiscal risk management practices. As a first step authorities could identify the range of fiscal risks facing Palau and then decide which fiscal risks require more analysis based on the likelihood and impact, if risks were to eventuate. Over time, the information collected through this work could form the basis of a fiscal risk statement that could be published alongside the budget documents. At the same time, this can be done in a measured way that considers country capacity, for example, by focusing on key fiscal risks and developing the sophistication of the analysis over time (i.e., beginning to identify risks qualitatively)

- **Entry point 3 - Climate considerations could be strengthened in infrastructure project selection criteria and costing methodologies –** The PEFA assessment indicates a relative weakness in public investment management particularly in areas related to project appraisal and costing. While project appraisal criteria currently include climate considerations, this could be strengthened, and more importantly climate considerations should be included in costing guidance and methodologies. For example, infrastructure investments will need to be more climate resilient, and this requires investments to be built with more cyclone resilient materials, and in locations that are less exposed to sea level rise (which may have additional land acquisition costs) etc. These kinds of factors should be systematically considered in infrastructure proposal development and incorporated into project costings, helping to inform resource allocation and prioritization decisions around infrastructure planning.

- **Entry point 4 – Enhancing Reporting on Climate Funding –** Reporting processes in Palau are sound and Palau has an established performance reporting framework. Although there is currently a backlog of audited annual financial statements, this is primarily because of delays emanating from the pandemic rather than any identifiable systemic problem with processes. Budget execution reports are timely and produced regularly. There may be some opportunity to build climate reporting into annual budget execution reports by helping the authorities identify funding received for climate initiatives as well as resources devoted by the government to climate initiatives. This could be identified and potentially published in the budget papers accompanied by a narrative outlining the government's climate priorities and policy rationale for funding these initiatives—see Box 4 for an approach developed for the Cook Islands. A second step could involve reporting on the funds actually spent on climate initiatives, which could be explored further depending on the capabilities of the new FMIS. The existing annual performance statements could also be an area where climate spending and intended impacts are published.

Box 4. Budgeting for Climate-Related Public Investment Expenditure in the Budget Papers in the Cook Islands

CIG Climate-Related Capital Investment Expenditure 2022-23 Budget $'000	2021-22	2022-23	2023-24	2024-25	2025-26	Brief Description
Aitutaki Island Plan & Orongo Development Project		500				Establishment of causeway culvert crossings and additional sheet piling to be carried to **climate** proof the land
Pa Enua Government Building Projects	550	500	250	500	300	Buildings and facilities across the Pa Enua are key areas
	400	500	100	-	100	of building infrastructure and are most vulnerable to the
Rarotonga Cyclone Shelters	100	400	100	-		Rarotonga, is prone to severe floods and vulnerable to the impacts of **climate** change, such as rising sea levels and an increasing frequency and intensity of cyclones.
Inland and Coastal Waters Asset Management and Improvement Programme	37					The impacts of unsustainable development, coupled with **climate change**, has led to increasing peak flows that have caused damage as well as erosion following high sea levels and storm events.
Pa Enua Marine Infrastructure Improvement Programme	160	2,660	145	515		Marine transport is the key means of transport for most goods to the Pa Enua and is the only form of passenger transport for some island communities. This requires the provision of robust harbour structures that are resilient to the impacts of **climate change.**
Water and Sanitation Infrastructure Improvement Programme	500	265				The changes to the **climate** currently being experienced, and increased extreme events predicted, expose the islands to regular droughts and resultant water shortages. Inadequate sanitation, increases the impacts by reducing the available water sources for community use.

Climate-Related Capital Investment Expenditure 2022-23 (CIG Funded)	**1,747**	**4,825**	**595**	**1,015**	**400**	
Total Capital Spending CIG	**27,770**	**34,160**	**18,257**	**15,897**	**15,042**	
% of Total Spending	**6%**	**14%**	**3%**	**6%**	**3%**	

Donor Financed Climate-Related Capital Investment Expenditure 2022-23 Budget $'000	2021-22	2022-23	2023-24	2024-25	2025-26	Brief Description
Managing Water Scarcity		1,720				To address the **climate** change-related water security challenges faced by Pacific Island Countries.
Improving Geospatial Data		1,500				This project aims to address existing date gaps by collecting high-resolution topographic data and associated imagery which will support applications such as the assessment of coastal inundation and flooding hazards - informing responses to **climate change**.
Renewable Energy Grant - GEF		170	680			
Renewable Energy Grant - GCF		1,900	2,200	5,000		

Goal 12: Climate Change, Resilience, Renewable Energy and Energy efficiency		400	100			

TOTAL Identifiable Climate related capital investment	**1,747**	**10,515**	**3,575**	**6,015**	**400**	
Real GDP	**339,261**	**504,453**	**531,192**	**503,427**	**411,799**	
As a percent of GDP	**0.5%**	**2.1%**	**0.7%**	**1.2%**	**0.1%**	

Source: IMF Staff, MFEM 2022–23 Budget papers.

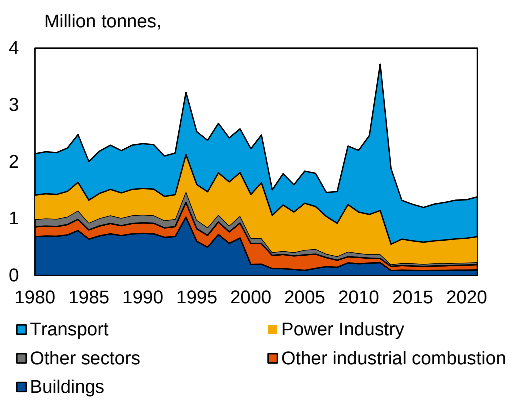
39. **Robust PFM and PIM systems are necessary but not sufficient to access climate finance from large multilateral funds**. Access to climate finance from global funds like the Green Climate Fund, by Palau has been limited to date. Requirements to access climate finance reinforce robust PFM and PIM processes and systems, particularly in strengthening financial reporting, internal controls, and audit. Continuing to strengthen practices in these areas is necessary not only to access climate finance but to ensure limited government resources are spent wisely. At the same time, the

authorities should explore different channels to access finance, including scope to partner with other international institutions and regional accredited entities as well as relationships with bilateral partners to ensure that resources are best targeted.

D. Climate Change Mitigation[11]

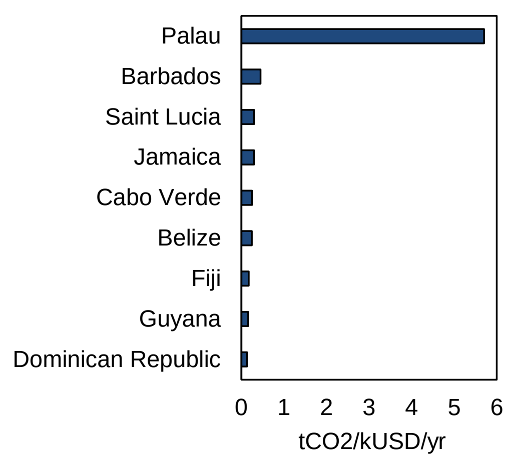
40. Palau has the highest CO2 emissions per capita and emissions intensity rates in the world. CO2 emissions per capita reached 60 tonnes in 2022, almost double the emissions per capita of world's second highest ranked (Qatar).[12] This figure reflects the low population size and high number of tourists who are excluded in the calculation's denominator. Tourism also contributes to the numerator, as the largest contributor to Palau's GHG emissions is the transport sector (Figure 3). While the country has a small fleet of diesel and gasoline cars, most of the transport emissions are from domestic navigation, a highly touristic sector. Similarly, Palau's emissions intensity of output is the highest in the world, reaching 5.7 tonnes of CO2 per USD$1000, and far surpasses other island economies (Figure 4). On a global scale, the country produces less than 0.01 percent of emissions[13], implying the country has a small absolute carbon footprint relative to the rest of the world.

Figure 3. Palau's Historic Greenhouse Gas Emissions



Source: EDGAR (2022).

Figure 4. Emissions Intensities, 2021



Source: EDGAR (2022)

Notes: GDP is in USD.

41. Like most Small Island Developing States (SIDS), Palau is dependent on imported fossil fuels, leaving the country susceptible to international price shocks. Palau's two main diesel generating plants produce the majority of the country's electricity. Diesel for these plants is imported, mostly from Singapore and Korea.[14] As a result, Palau is extremely vulnerable to

[11] Prepared by Danielle Minnett, Climate Policy Division, FAD

[12] EDGAR - The Emissions Database for Global Atmospheric Research (europa.eu)

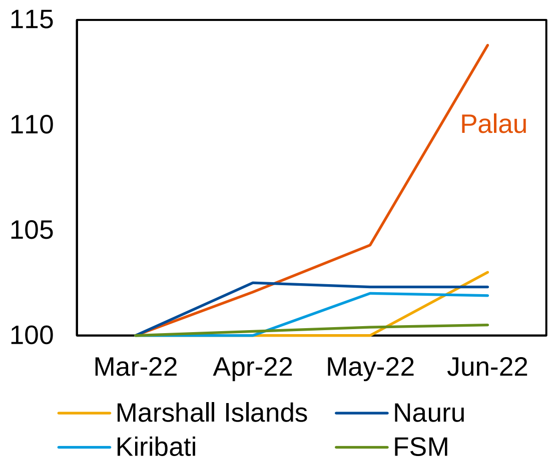
[13] EDGAR, 2022

[14] World Integrate Trade Solution, 2018

international energy price volatility. Last year, Palau's fuel prices rose by almost 15 percent as the global oil market continued to adapt to increased demand for non-Russian fuel (Figure 5). Renewable energy generation is less than 7 percent of the total share of the power sector.[15] However, the Palau Public Utilities Corporation (PPUC) has a 2-megawatt solar farm set to come online this year that should boost the renewable power share to 20 percent. While diesel prices have been trending upwards, transitioning to renewables would allow Palau to take advantage of decreasing solar prices and reduce inflationary impacts from imported fuels.

Figure 5. Retail Fuel Price Trends

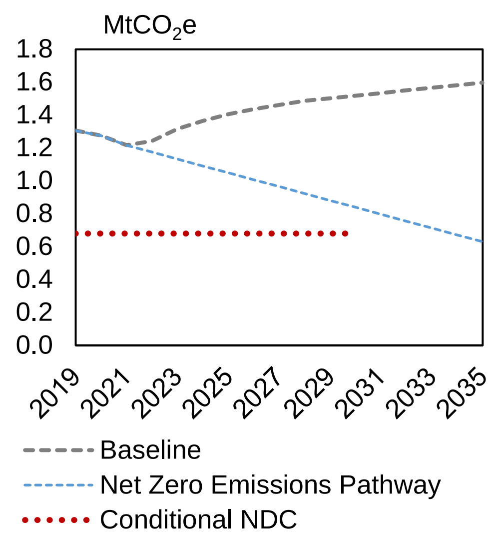
(March 2022 = 100)



Source: ADB Pacific Monitor (2022)

Notes: FSM = Federated States of Micronesia

Figure 6. Palau's Baseline GHG Projections Compared to INDC and Net Zero Pathway



Source: CPAT

Notes: MtCO2e = million tonnes of CO2 equivalent. Excludes land use, land use change and forestry (LULUCF).

42. **By 2025, the country's 2015 Intended National Determined Contribution (INDC) aims to reduce energy sector emissions 22 percent below 2005 levels, increase the renewable energy share to 45 percent and improve energy efficiency by 35 percent**.[16] Achieving these targets are both conditional on international financing and are highly ambitious. With only a year left to reach 2025 emission reduction targets, Palau is far from being on track. Extending these targets to 2030 would still put Palau ahead of the linear trajectory to reach net-zero by mid-century. Instead, baseline emissions are expected to rise (Figure 6). Additionally, the government of Palau has an ambitious goal of generating 100 percent of its electricity from renewable energy sources by 2035[17].

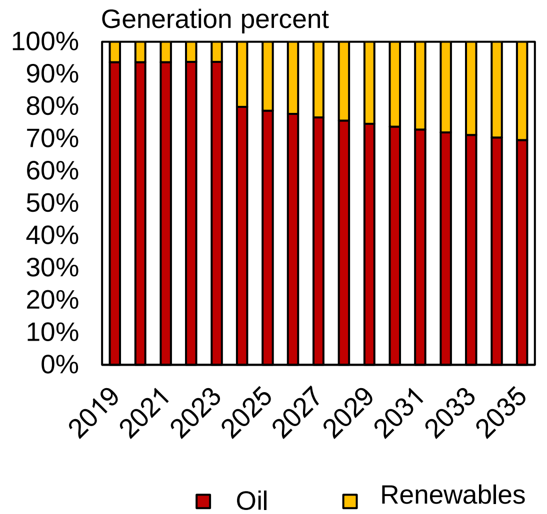
[15] UNSD, 2020.

[16] UNFCCC, 2015.

[17] IRENA, 2022.

43. To meet these targets, Palau will need to continue to drive investments towards renewable infrastructure and explore complementary policies. Palau has the tenth smallest country land mass in Oceania[18], requiring strategic placement of ground mounted PV arrays and investments in rooftop PV.[19] While the renewable energy share is expected to increase following the introduction of the 2023 solar farm (Figure 7), the PPUC plans to invest in an additional solar farm to reach the 45 percent renewable generation target, but further investments will be needed to renew the grid. Moreover, the country is looking at the possibility of floating solar on the ocean, although this technology is only in the piloting stage in other countries. Accompanying renewable policies like net metering and feed-in tariffs are already established in the country (Table 1). Palau could expedite the transition by establishing clear interconnection standards that mandate how installers, contractors, or residents can safely connect renewable energy systems to the electric grid. These mandates can reduce confusion and fast-track connection projects. The country can also build a green public procurement strategy that catalyzes public purchasing power towards goods, services and works with lower environmental impacts.

Figure 7. Electricity Generation by Source



Source: IMF staff calculations using CPAT.

Table 1. Palau: Existing Renewable Energy Policies in Palau

Existing Policies	
Feed-in Tariff	√
Net Metering	√
Tax Reduction/Exemption	√
Public Loans/ Grants	√
Interconnection Standards	
Green Public Procurement Strategy	

Source: National Renewable Energy Laboratory (2015)

44. Once significant renewable infrastructure is established, the country can focus the transition towards the transport sector. Road and marine transportation could be decarbonized by applying a feebate scheme to new vehicle or vessel purchases, where a sliding scale of fees (subsidies) apply to dirty (clean) vehicles/vessels. This is an efficient policy that does not increase prices for the average consumer. The current fleet of vehicles would then be more inclined to transition to electric vehicles (EVs) or low carbon vehicle alternatives like biofuels.[20] Meanwhile, maritime transportation would be more inclined to transition from the current fleet of polluting

[18] World Data, 2023.

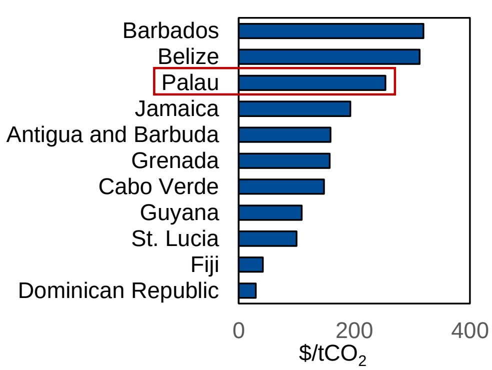
[19] In time, the country may benefit from solar installations that float on the ocean which some countries are piloting.

[20] IRENA, 2022.

high-power outboard gasoline engines towards synthetic gasoline alternatives produced from renewable hydrogen and biomass or hydrogen speedboats and/or battery-powered hydro foiling boats (a recently introduced technology).[21]

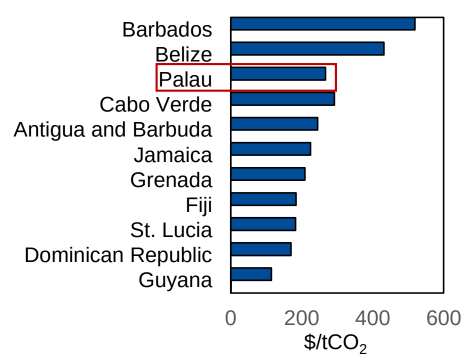
45. Carbon pricing can play a role in reducing emissions, raising revenues, and driving the transition. Palau has a carbon tax on imported liquid petroleum-based products. The tax was recently reduced from the $0.05 per gallon to $0.02 per gallon[22]. Yet, as of 2022, the effective carbon rate on diesel and gasoline is high compared to some other island states (Figure 8 and 9). The Climate Policy Assessment Tool (CPAT) finds that to reach the mid-century net-zero aligned pathway by 2030 through pricing alone, Palau would need an additional economy-wide carbon price of over $200/tCO2, and an even higher rate to reach its current NDC.[23] To read more about CPAT, see Annex II. This level of economy-wide pricing would be considered substantial, especially for a small island developing economy. However, applying some level of additional pricing can play a role in Palau's wider net-zero policy package to help curb carbon consumption and reach harder to abate sectors. For example, a $5/tonne of CO2 economy-wide carbon tax imposed in 2025 that linearly increases to $25/tonne by 2030 could reduce GHGs (Figure 10), while also raising significant revenues of over 10 percent of GDP. These high revenues are indicative of the high level of emissions intensity noted earlier. Subsequently, fuel prices would increase by about 5 percent (Table 2), which means additional policies would be needed to support lower-income households.

Figure 8. Effective Carbon Rates, Diesel, 2022



Source: CPAT, IMF Staff calculations.

Figure 9. Effective Carbon Rates, Gasoline, 2022



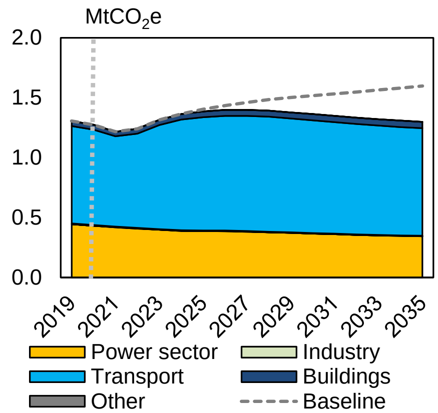
Source: CPAT, IMF Staff calculations.

[21] IRENA, 2022.

[22] PalauGov.pw, 2022

[23] CPAT, 2023

Figure 10. GHG Reductions from Average Effective Carbon Rates Applied to Palau



Source: CPAT

Notes: The carbon tax is applied in 2025 at $5 and increases linearly to $25 by 2030.

Table 2. Palau: Energy price changes for Average Effective Carbon Rates in 2030

Fuel	Unit	BAU	BAU+ Average Effective Carbon Rate	% Change
Gasoline	$/lit	1.23	1.29	5%
Diesel	$lit	1.25	1.32	5%

Source: CPAT

Notes: Results are weighted by consumption.

46. Revenue recycling policies can help to reduce impacts on vulnerable communities from increasing fuel prices. Low-income households can be impacted by carbon pricing. However, leveraging revenue recycling can turn carbon pricing into a progressive strategy. For example, 80 percent of Canadian households receive more money back in transfers than they pay in additional costs from the carbon rate. Ideally, Palau would identify vulnerable households and use revenues to provide cash transfers to these individuals. To improve political acceptability, pricing should be phased in so consumers can adjust appropriately. Moreover, since pricing is a domestic policy, imposing carbon pricing would not increase the price of imports, and pricing would also be passed through to tourists, who would contribute to carbon pricing revenues but would not receive transfers. This would of course have implications for competitiveness and growth, which would need to be considered in setting the appropriate level of carbon pricing.

47. Carbon taxes can increase costs for tourists and can raise concerns around activity moving abroad (i.e., "carbon leakage"). Leakage is not of much concern for firms producing non-traded goods and services (e.g., electricity generation, domestic distribution, and restaurants) nor those where energy makes up a small share of total costs (e.g., financial, and other services). The potential issue lies with energy-intensive, trade-exposed firms— which could include tourism as Palau would compete against countries that do not face this tax increase. Studies have found mixed evidence of leakage but it tends to be small in the industrial sector (see Keen et al. 2021). However, tourism leakage remains under-studied. Still, there are a range of policy options to address leakage in general. Policies relevant to Palau include establishing international coordination on climate mitigation since this removes the cost advantage of traveling to another location or applying the carbon price to emissions above a threshold level since this would still increase the marginal incentive to reduce emissions so long as the threshold is low enough to be impactful.

48. The transition is costly and will require financing. In fact, initial capital cost estimates for achieving 100% renewable energy by 2050 amount to over 179 million USD,[24] more than 80 percent of Palau's GDP. Both the Palau Social Security Administration (SSA) and the Palau Compact Trust Fund (CTF) have recently strengthened their climate-related investment strategies. In 2021, the SSA updated its investment policy where the administration transferred $60 million into climate transition investments that reduce carbon emissions.[25] The SSA's goal is to cut indirect contributions to global carbon emissions by half relative to BAU. In the same year, the CTF signed into the Principles for Responsible Investment (PRI) which is a network of asset owners and investment managers that includes environmental, social, and governance (ESG) into their investment analysis.[26] However, given significant capital costs to transition and Palau's small population, seeking additional grants, soft loans, independent power producers (IPPs), and climate finance will be imperative to strengthen mitigation efforts.

49. Finally, international trends from the global mitigation agenda may have negative impacts on Palau. Palau relies on tourism and imports most of its consumption and investment goods. Strengthened mitigation polices by trading partners may impact Palau's domestic economy through three related channels: (i) increased international fuel prices, which could increase the cost of diesel generation; (ii) increased cost of transport; which would put pressure on Palau's terms of trade as the cost of imports rises; and (iii) more expensive travel. As a remote country that relies on highly polluting transport vessels by air and sea, Palau may see a disproportionate impact on its tourism sector. However, the extent of these impacts remains uncertain.

[24] IRENA, 2022.

[25] ADB, 2022.

[26] ADB, 2022.

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Annex I. The Coastal Impacts and Adaptation Model (CIAM)[1]

1. The Coastal Impact and Adaptation Model (CIAM) is a global optimization model for cost-benefit analysis of adaptation to sea-level rise (SLR) (Diaz, 2016). The model starts from coastal characteristics on more than 12,000 coastal segments covering the entire global coastline from the Dynamic Integrated Vulnerability Assessment model (DIVA), a tool to assess the biophysical and socioeconomic impacts of SLR. The DIVA tool estimates the SLR impacts by considering coastal erosion, coastal flooding, wetland change and saltwater intrusion (DIVA Modeling Framework). For each coastal segment, CIAM develops economic, population, and SLR scenarios. The SLR scenarios are from Kopp et al (2014). On top of SLR, the model considers the expected value of storm surges to include rare but potentially high-impact events.

2. Using data on costs of alternative coastal protections, land values, value of assets along the coastline, the value of statistical life, willingness to pay for preservation of coastal ecosystems, and assumptions on the social cost of relocation, CIAM determines costs and benefits of alternative adaptation strategies (including no adaptation) for each coastal segment. The efficient (optimal) coastal protection strategy has the largest net present value of among all strategies considered by the model. Protection can be full (excluding any inundation also under extreme storm surges), partial (accepting some storm costs) or minimal (with capital and population progressively moving away from the coastline).

3. The model can be used to develop insights on different costs from SLR and different protection strategies (Table A1) in each coastal segment or at different level of aggregation.

[1] The detailed description of the model can be found in Diaz (2016) and the documentation of the model (https://github.com/delavane/CIAM/blob/master/CIAM%20Documentation.pdf)

Table A1. Palau: Cost Specification in the CIAM

Category	Explanation of the Costs	Measurement of Cost[1]
Protection cost	Constructing and maintaining protection (generalized as sea walls) to shield the land behind the sea walls from the SLR-caused inundation.	A function of the coastline length, the height of the sea walls, and the value of the land occupied by the sea walls.
Retreat cost	Relocation of population and assets from the affected areas, including the forced emigration and the planned retreat.	The cost of relocating population and mobile capital in the incremental area of retreat, as well as the cost of demolishing the immobile capital.
Inundation cost	The loss of land and assets due to the SLR-caused inundation.	The cost is based on the extent of land endowment lost and the associated value of the land and the capital stock
Wetland loss cost	The loss of wetland due to the inability to migrate inland naturally, constrained by the rate of SLR and the lack of space.	The wetland losses take two forms, (1) the total service value of the wetland occupied by the sea walls; (2) the service value of the wetland lost related to the rate of SLR.
Flood cost	The damage to population and assets due to extreme surge.	The expected damage associated with the risk of the extreme surge. The likelihood of the extreme events follows the generalized extreme value distribution by using the local surge frequency data from the DIVA tool, while the total land affected by the extreme surge depends on the elevation exposed to a given flood water height.

[1] Measurement of the cost per period. The model optimizes the adaptation strategies over 20 periods

Annex II. The Climate Policy Assessment Tool (CPAT)

1. CPAT provides, on a country-by-country basis for 200 countries, projections of fuel use and CO_2 emissions by major energy sector.[1] This tool starts with use of fossil fuels and other fuels by the power, industrial, transport, and residential sectors[2] and then projects fuel use forward in a baseline case using:

- GDP projections;[3]
- Assumptions about the income elasticity of demand and own-price elasticity of demand for electricity and other fuel products;
- Assumptions about the rate of technological change that affects energy efficiency and the productivity of different energy sources; and
- Future international energy prices.

In these projections, current fuel taxes/subsidies and carbon pricing are held constant in real terms.

2. The impacts of carbon pricing on fuel use and emissions depend on: (i) their proportionate impact on future fuel prices in different sectors; (ii) a simplified model of fuel switching within the power generation sector; and (iii) various own-price elasticities for electricity use and fuel use in other sectors. For the most part, fuel demand curves are based on a constant elasticity specification.

3. The basic model is parameterized using data compiled from the International Energy Agency (IEA) on recent fuel use by country and sector.[4] GDP projections are from the latest IMF forecasts.[5] Data on energy taxes, subsidies, and prices by energy product and country is compiled from publicly available and IMF sources, with inputs from proprietary and third-party sources. International energy prices are projected forward using an average of IEA and IMF projections for coal, oil, and natural gas prices. Assumptions for fuel price responsiveness are chosen to be broadly consistent with empirical evidence and results from energy models (fuel price elasticities are

[1] CPAT was developed by IMF and World Bank staff and evolved from an earlier IMF tool used, for example, in IMF (2019a and b). For descriptions of the model and its parameterization (see IMF (2019b Appendix III, and Parry and others. 2021), and for further underlying rationale see Heine and Black (2019).

[2] International aviation and maritime fuels are excluded from the model and from computations of fossil fuel subsidies.

[3] GDP projections exclude the negate growth effects of global climate change.

[4] IEA (2021). Any fuel consumption that could not be explicitly allocated to a specific sector was allocated apportioned based on the relative consumption by sector in a given country.

[5] A modest adjustment in emissions projections is made to account for partially permanent structural shifts in the economy caused by the pandemic.

typically between -0.5 and -0.8). Carbon emissions factors by fuel product are from IEA. The domestic environmental costs of fuel use are based on IMF methodologies.[6]

4. CPAT is calibrated to be consistent with modeling literature on the key parameters. **CPAT is routinely used for cross-country and individual country assessments of mitigation policies**. Covering over 200 countries, CPAT provides projections of fuel use and CO_2 emissions for the four major energy sectors—power, industry, transport, and buildings.

5. One caveat is that the model abstracts from the possibility of mitigation actions (beyond those implicit in recently observed fuel use and price data) in the baseline, which provides a clean comparison of policy reforms to the baseline. Another caveat is that, while the assumed fuel price responses are plausible for modest fuel price changes, they may not be so for dramatic price changes that might drive major technological advances, or rapid adoption of technologies like carbon capture and storage or even direct air capture, though the future viability and costs of these technologies are highly uncertain. The model also does not explicitly account for the possibility of general equilibrium effects (e.g., changes in relative factor prices that might have feedback effects on the energy sector), and changes in international fuel prices that might result from simultaneous climate or energy price reform in large countries. Parameter values in the spreadsheet are, however, chosen such that the results from the model are broadly consistent with those from far more detailed energy models that, to varying degrees, account for these sorts of factors.

[6] See Parry, Black and Vernon (2021).