SEPTEMBER 2022

GEOSPATIAL COMPANION

Prioritizing Investments in Land-based Climate Mitigation in Papua New Guinea

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Geospatial Companion: Prioritizing Investments in Land-Based Climate Mitigation in Papua New Guinea

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Back cover photo	Rabaul volcano and harbor, East New Britain province of Papua New Guinea. Photo by by JulesR on Pixabay.

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https://www.climatelinks.org/sites/default/files/asset/document/2020_USAID_ProLand_%20Prioritizing-Investments-in-Land-Based-Climate-Mitigation-in-Papua-New-Guinea_0.pdf

Acronyms & Abbreviations

SABL	Special Agriculture Business Lease
PNG	Papua New Guinea
SLOA	Sustainable Landscapes Opportunities Analysis
USAID	United States Agency for International Development

1. Introduction and Purpose

The Papua New Guinea (PNG) geospatial companion complements PNG's Sustainable Landscapes Opportunities Analysis (SLOA), developed in 2020 with the support of USAID's Productive Landscapes activity (ProLand). SLOA analyses are designed to aid USAID Missions in prioritizing climate mitigation programming and co-benefits for highest land-based mitigation impact.

The SLOA methodology developed by ProLand consists of three parts: 1) country-specific greenhouse gas emissions profile; 2) land-based emissions mitigation opportunities, and 3) planning priorities. The following factors are used for prioritization:

- Biophysical potential;
- The feasibility of the opportunity and its likelihood of success.
- The cost per unit of emissions mitigation; and
- Co-benefits of the activity to other sectors.

The SLOA Geospatial Companion (Hereafter "Companion") was created to assist USAID and partners in leveraging the SLOA findings for spatial planning. The SLOA datasets and maps, along with the complementary datasets included, can be used to further analyze and interpret the findings, and to update findings and existing datasets as needed. There will also be flexibility to introduce new layers if/when appropriate according to the availability of new datasets.

The Companion structure mirrors the PNG SLOA chapters 3-7, and the majority of SLOA maps and underlying datasets have been updated or supplemented with additional layers. Since it is important to consider how the information could be combined and utilized practically, Chapter 3 of this Companion provides an example scenario-based analysis to examine potential climate mitigation and conservation benefits in PNG.

Lastly, SLOA Companions, like SLOAs themselves, may be tailored to suit local needs and priorities, which can change over time. Annex 1 includes a list and description of recommended spatial datasets available at the date of completion of this geospatial Companion to benefit further analysis if needed.

2. Complementary SLOA Data and Analysis

2.1 UPDATES AND NEW DATASETS

The development of the SLOA Companion began with a review of PNG spatial data and other relevant data that could support further interpretation and analysis of SLOA findings. The review prompted several updates and additions to the data referenced in the original PNG SLOA. A full data list is provided in Annex 1.

SPATIAL DATA AND MAP UPDATES[1]

Forest Cover and Forest Loss Hotspots

- Updated 2001-2020 datasets for historical forest cover analysis and 2010-2020 "hotspots" based on global annual tree cover loss data (Hansen et al., 2013)

Local Data

- Digital georeferenced data files for forest concessions (DOI-ITAP 2017)
- Special agriculture business lease (SABL) (PNGRIS 2022)
- A Digital Elevation Model (DEM) (PNGRIS, 2021)
- Vegetation (DOI-ITAP 2017)
- Rivers valid as of 2014 based on DOI/ITAP biodiversity analysis (original data source PNGRIS)
- PNG language distribution (Hammarström 2021)

Climate Change

- Global above- and below-ground carbon in 2010 (Spawn et al. 2020)
- Irrecoverable carbon in 2018 (Noon et al. 2022)

Global Datasets

- Updated global population (Landscan/ORNL 2019)
- Wetlands and peatlands (Gumbricht et al. 2017)
- Protected areas (WDPA 2021)

USAID Data

- USAID PNG model provinces (USAID Geocenter 2021)
- Locations of USAID programmatic activities, which can be added-to over time

[1] The recently updated PNG Climate Change and Monitoring Web Portal provides additional layers of information relevant to future national and sub-national planning.

- Updated high value biodiversity areas (based on information from the USAID-funded Lukautim Graun activity)

NEW MAPS

This Companion includes eleven new maps that use the additional datasets listed above. Each map is explained briefly below.

LAND AND RESOURCE GOVERNANCE

PNG's centralized land administration structure is misaligned with its exceptionally diverse and dynamic local customary rules – making land tenure arrangements complex to understand and track. An estimated 90 percent of PNG's land resources are under a customary governance system. Around 2-3 percent of the remaining land area is alienated public land which has been acquired by the Government for their own purposes (USAID, 2021). Few local clans across PNG's 326 local-level government units (LLG) have land documentation or customary land registration.

In the absence of land tenure documentation, data in the Companion include LLG boundaries and language groups as a proxy for customary groups. This is because in PNG, communities and ethnic groups in traditional customary systems identify themselves by their language in addition to traditional land boundaries (DOI-ITAP Biodiversity Assessment, 2017). The spatial distribution of language and community groups can shed light on the diversity of local customary tenure systems (Figure 1 inset) and helps communicate the complexity of land ownership and management. Over 800 different population groups exist in PNG, each with distinct language and traditional land governance rules.

Mapping existing governance systems also reveals frequent overlaps between forest concessions, protected areas and controversial special agricultural business leases (SABL) (Figure 1). Since most land in PNG is held under customary tenure, most of the areas designated to be used for forest or agriculture concessions overlap with traditional systems of land governance. Similarly, most land currently in protected areas or wildlife management areas is under customary tenure. In the past, forest concessions were in some cases granted within large customary land areas, and SABL concessions were established across PNG. Although no new SABL concessions have been granted in the last 10 years, the previously established SABL concessions continue to operate. Historical forest analysis monitoring (including data cited in the SLOA Report and Companion) indicates clear patterns of deforestation in existing SABLs (Figure 6).

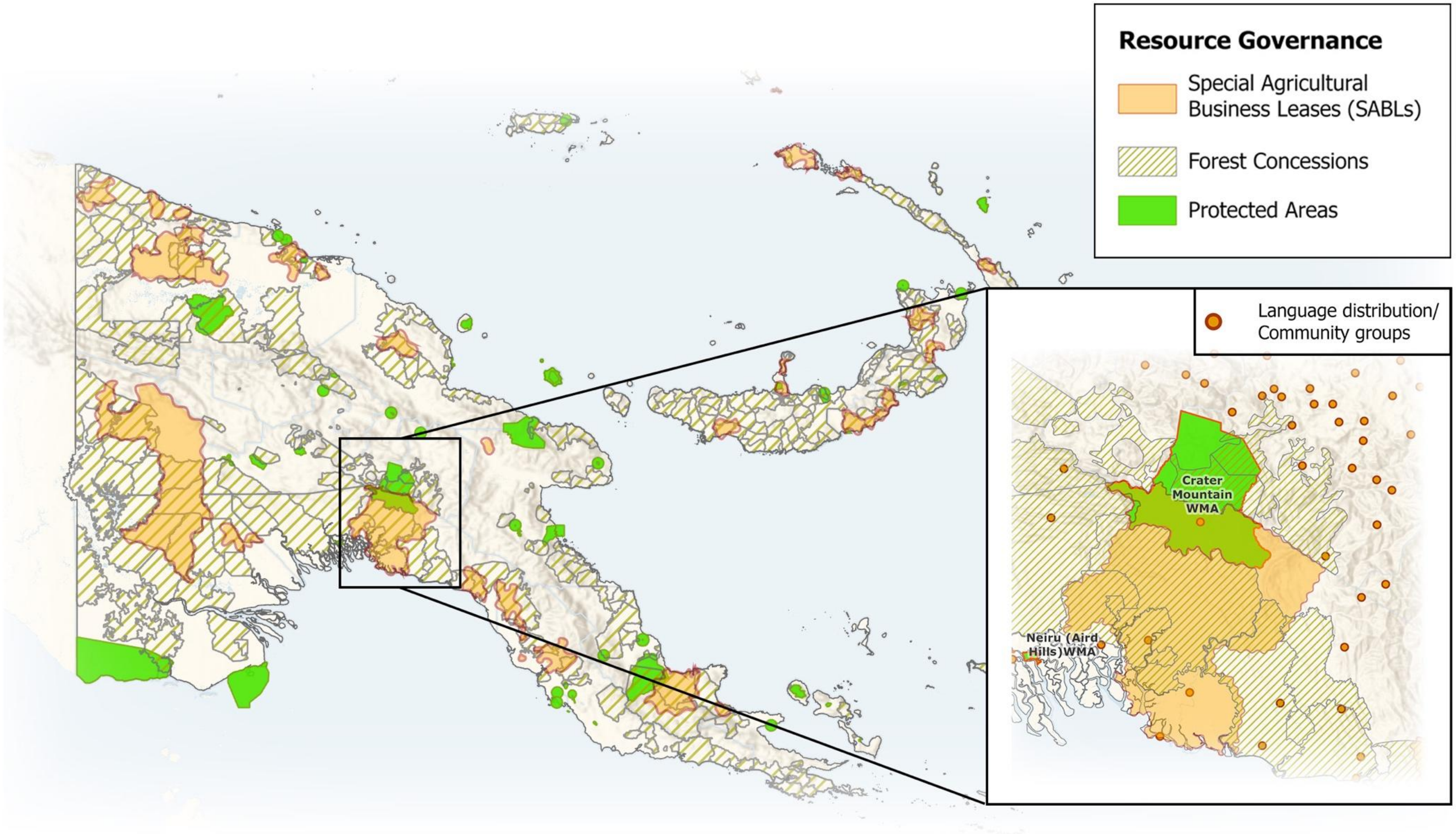

Figure 1: Governance Systems in PNG. *Mapping reveals frequent overlaps between customary land governance systems, forest concessions, protected areas and SABLs.*

ABOVE AND BELOW GROUND CARBON AND IRRECOVERABLE CARBON

The SLOA report references the first harmonized global biomass carbon map (Spawn et al. 2020) for the year 2010, which was developed at 300-meter resolution (Figure 2). A recently published paper by Noon et al. (2022) introduced an approach that identified and mapped the global distribution of "irrecoverable" carbon — defined as vulnerable stored carbon that, if released, could not be restored by the year 2050[2] (Figure 3). Irrecoverable carbon was mapped using an approach that leverages the 2010 biomass carbon map along with new estimates for extent and carbon storage in peatlands, mangroves, and coastal ecosystems. The resulting maps can inform planning at the national and provincial levels, in line with USAID's commitment to help partner countries sequester or avoid 6 billion metric tons of carbon by 2030. Most of PNG's land and coastal areas are identified as high in carbon storage and are relatively high in irrecoverable carbon, with East New Britain, West New Britain, Southern Highlands, Gulf, West Sepik, and Hela among the provinces with the highest irrecoverable carbon estimates.

[2] The 2021 IPCC assessment concluded that global emissions must reach net-zero by 2050 to limit global warming to <1.5 °C above pre-industrial levels.

Figure 2: Aboveground Carbon, 2010. *Areas in darker shades of green show higher aboveground carbon (Spawn et al. 2020).*

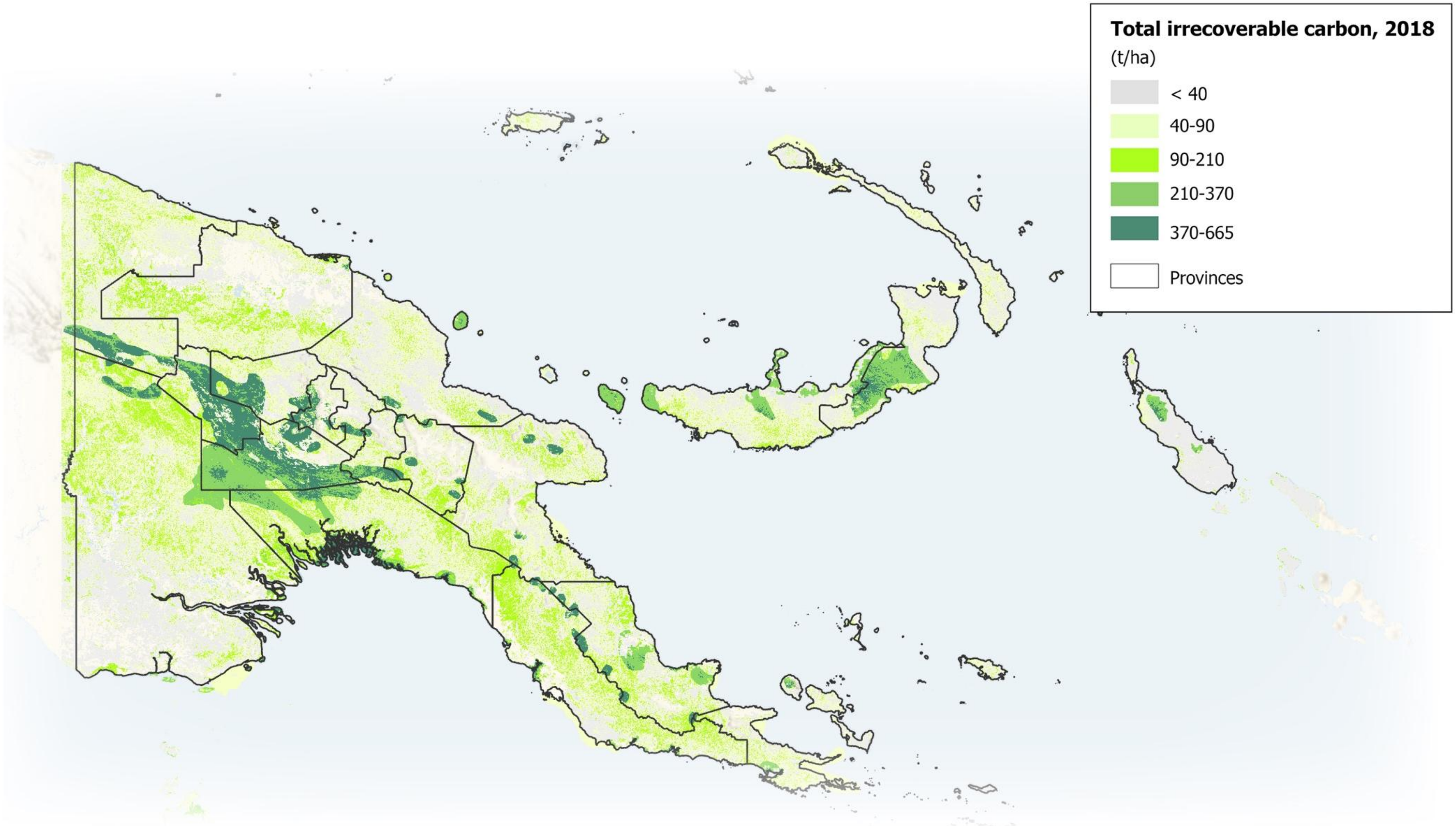

Figure 3: Total irrecoverable carbon, 2018. *"Irrecoverable" carbon is defined as vulnerable stored carbon that, if released, could not be restored by the year 2050. Areas in darkest shades of green show higher total irrecoverable carbon (Noon et al. 2020).*

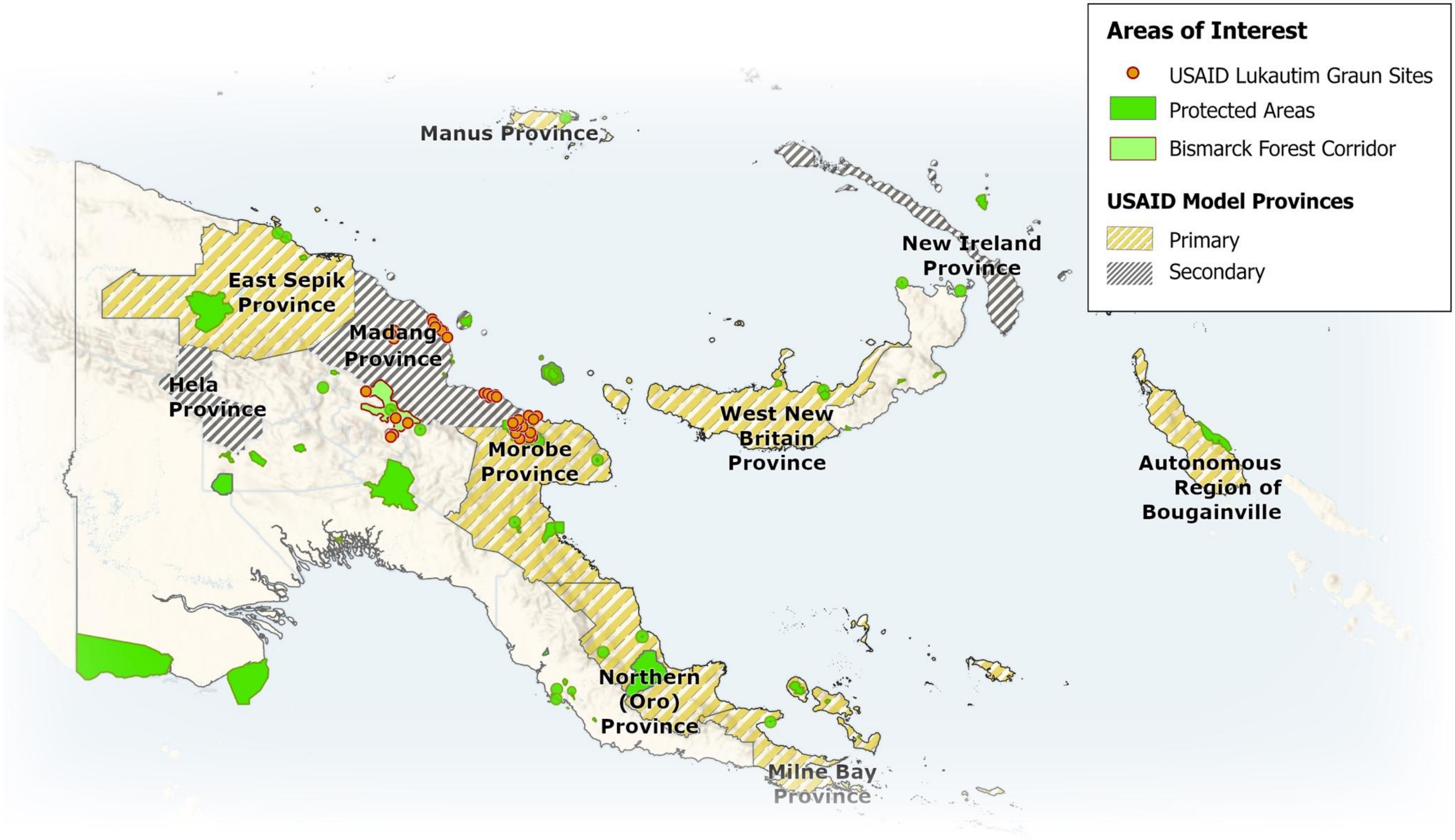

Figure 4: USAID Environmental Programming in PNG, 2021. *Locations of USAID activities and "model" provinces are overlaid on top of protected areas.*

Figure 4 shows USAID's footprint of activities alongside other pertinent information for local decision-making. The map shows 7 primary and 3 secondary "model" provinces where USAID-funded activities could achieve the largest land-based mitigation impact. Primary USAID model provinces are West New Britain, Northern (Oro), Morobe, Milne Bay, Manus, East Sepik and the Autonomous Region of Bougainville. USAID secondary model provinces are New Ireland, Madang, and Hela. Analyzing these datasets together with locations of USAID-funded Lukautim Graun activity (Protect the Environment) locations can help identify potential opportunities for prioritization and integration. Lukautim Graun is focused on biodiversity conservation, with activities located in Milne Bay, Madang, and Morobe provinces.

2.2 FORESTS AND AVOIDED FOREST CONVERSION

The PNG SLOA identifies avoided forest conversion as PNG's second most important pathway for reducing emissions (Griscom et al., 2020: 6). Although PNG has extensive forest cover, the country lost an estimated 4.1percent of tropical rainforest between 2002-2014 (Bryan et al., 2015). Most of the forest cover loss occurred in lowland forests, which cover over half of forest area (Shearman et al., 2008).

The Companion's updated analysis of annual tree cover loss data (Hansen et al., 2013) estimates an almost 3 percent loss of the country's 2000 forest cover between 2001-2020 (using a forest cover definition of >30 percent tree canopy cover), with an estimated 11 percent of that occurring in SABL concessions. The 1 percent difference between the 2000-2014 and 2001-2020 estimates of tropical forest loss can be attributed to the timeframe and different forest cover definitions. To complement the SLOA forest cover loss findings, the tree cover loss data from 2010 until 2020 were filtered to show only contiguous areas of over 5 hectares (Figure 6).

The resulting map shows the areas where there are spatial clusters, or "hotspots" (signaling accelerated tree cover loss) in the last decade. Several large hotspots are located within the SABL concessions, such as in the West Sepik province. These hotspots can be examined online.

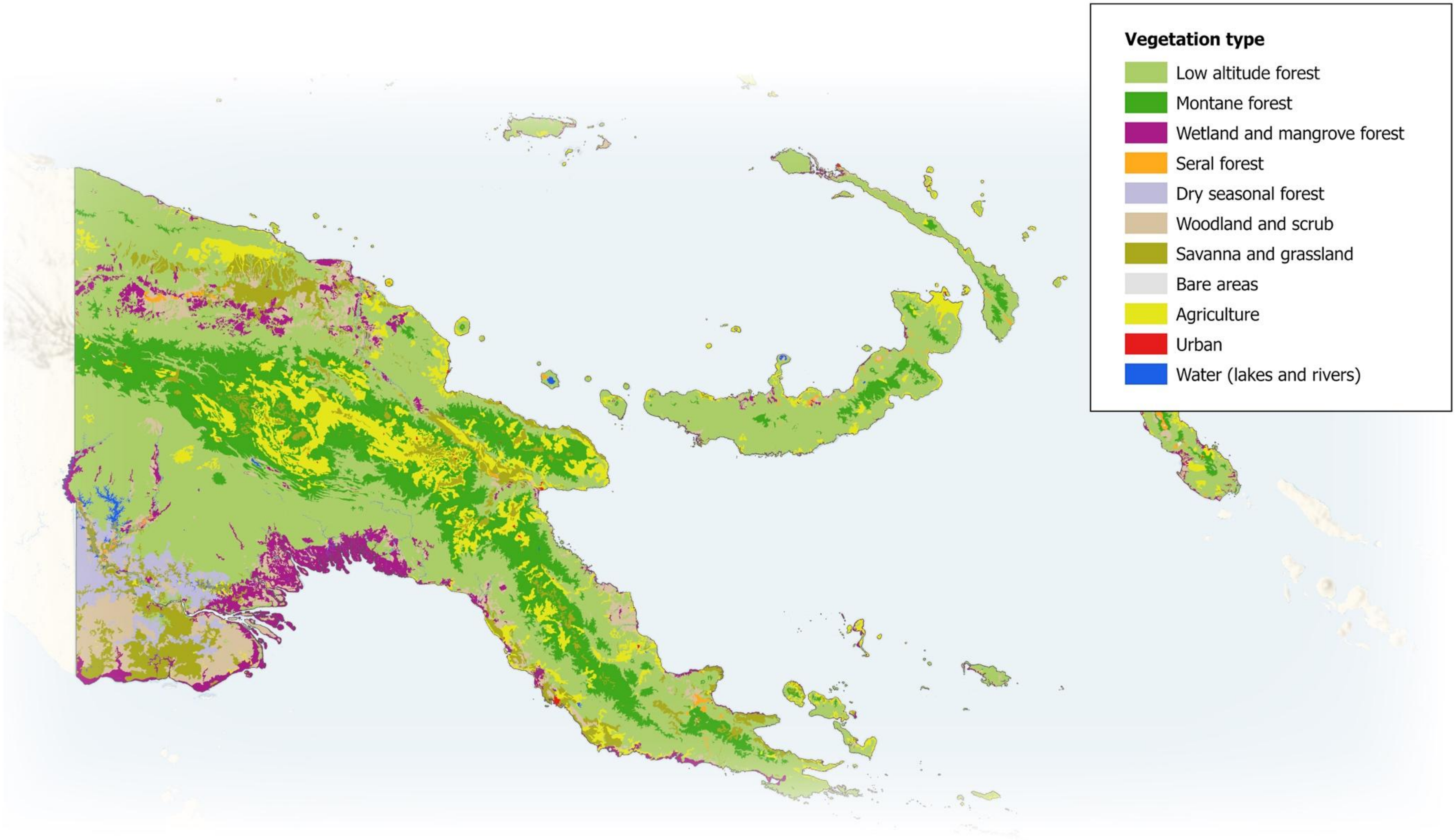

Figure 5: Vegetation Types in PNG. *Vegetation types shown range from different forest types, woodlands and grasslands, mangroves and wetlands, agricultural areas, and urban areas.*

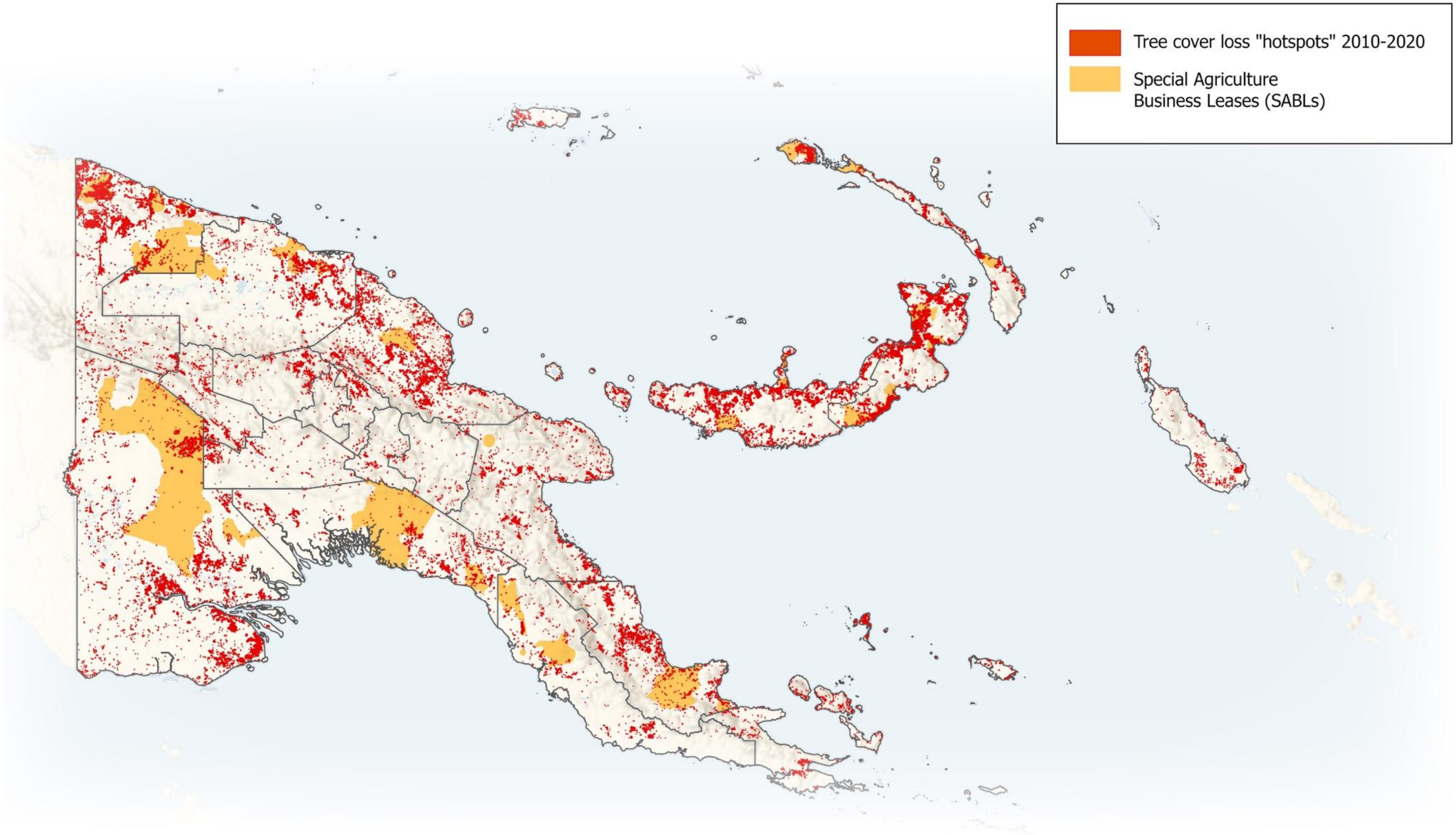

Figure 6: Tree Cover Loss "Hotspots", 2010-2020 in PNG. *Locations of spatial clusters, or "hotspots" of tree cover loss between 2010 and 2020 are shown in red.*

2.3 MANGROVES

Representing an estimated 14 percent of all forest area in PNG (shearman et al. 2008), PNG's mangroves (Figure 7) are carbon rich and are therefore of high importance for climate mitigation. Although PNG is ranked sixth among countries with the most extensive mangrove cover, the country's mangroves are threatened by a high demand for fuelwood in local coastal communities. Although several mangrove planting initiatives have been implemented by local , national or international institutions, most of these initiatives are small and mangroves continue to face high threat.

As noted in the SLOA, PNG lacks updated, country-specific information on mangrove forests. A national mangrove dataset was included in the State of the Forests in PNG (1972-2002) but has not been updated since the report's completion. PNG SLOA estimates are based on Global Mangrove Watch (Bunting et al. 2018) datasets.

2.4 PEAT SWAMP FOREST AND PEATLANDS

Identifying avoiding negative impacts on peatlands is identified in the SLOA as the highest-potential pathway of climate mitigation in PNG. SLOA findings note a remaining data gap on the extent and importance of peatlands for carbon storage in PNG, which suggests the peatland extent in PNG could be underestimated. This has particular relevance for considering PNG's potential for carbon sequestration since peatland landscapes are the most effective at storing carbon.

The 2016 Global Tropical and Subtropical Wetlands Map (Gumbricht et al. 2017) includes updated global spatial datasets of wetlands, peatland extent, and estimated peat depth. As noted in the SLOA, proposed road construction will directly impact peatland areas in several provinces (Alamgir et al. 2019). Peatland is also increasingly at risk of conversion and drainage for oil palm cultivation. In West Sepik and Gulf provinces, several forest cover loss hotspots (Figure 6) overlap with important wetland and peatland areas (Figures 8, 9). Although research on peatlands has generally been minimal in PNG, a new Western Pacific Sustainable Peatland Management (SAGU) project implemented by CIFOR-ICRAF will prioritize conservation of lowland and upland peat areas in the country.

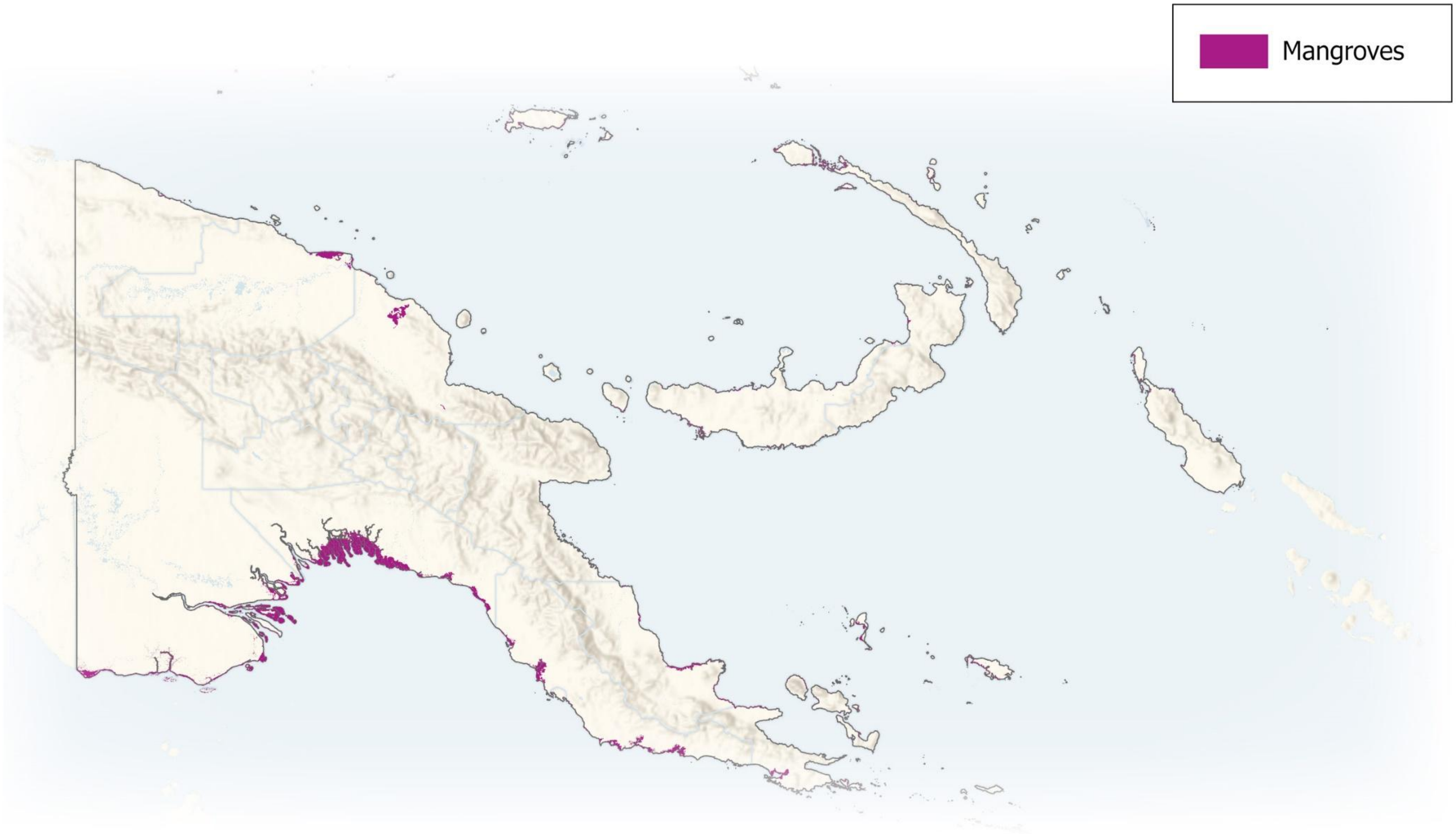

Figure 7: Mangrove Extent in PNG. *Existing mangroves are shown in purple color.*

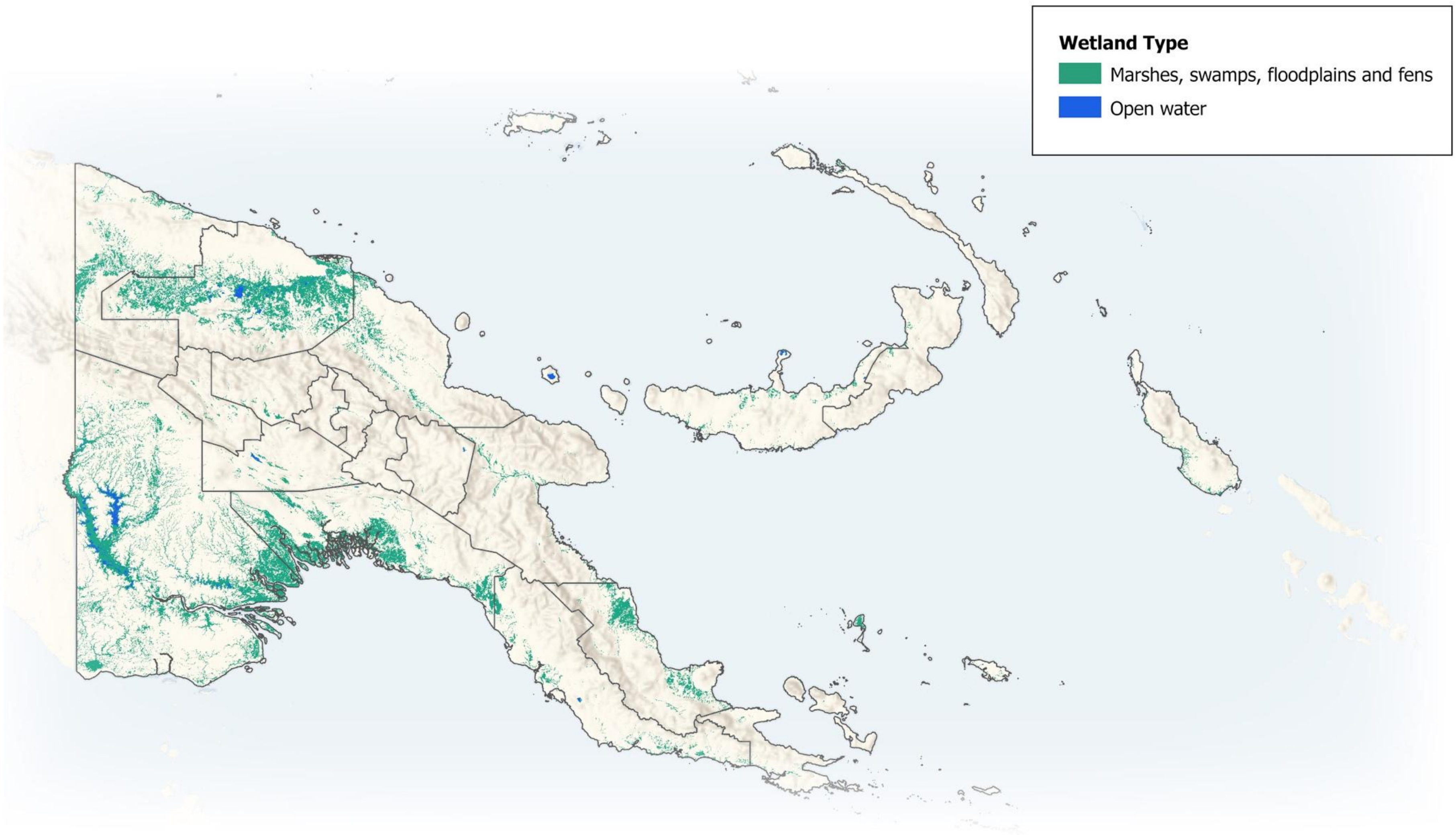

Figure 8: Types of Wetlands in PNG. *Marshes, swamps, floodplains and fens are shown in green and open water is shown in blue.*

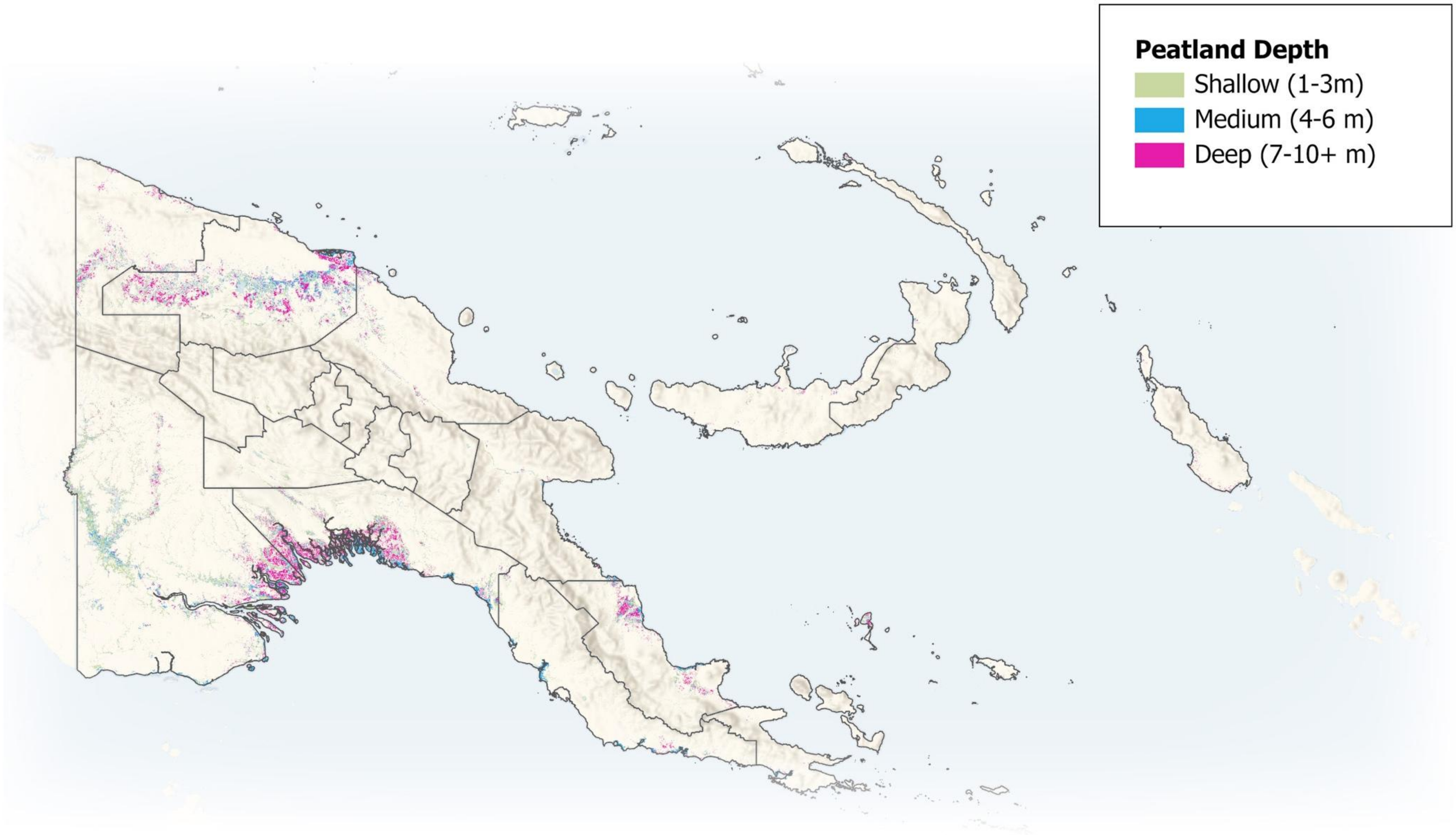

Figure 9: Peatland Depth in PNG. *Peatland depth is shown ranging from shallow (1-3 meters deep) to medium (4-6 meters deep), and deep (7-10+ meters deep).*

3. Example Scenario

Examining different spatial datasets together facilitates more integrated programming; this is especially true when determining locations for potential climate change mitigation and adaptation activities. Geospatial scenario analysis, an approach that explores targeted questions using spatial data, can help to identify and assess geographic priorities alongside other sources of information, like planning data or local knowledge.

A scenario analysis can combine the results of different SLOA findings to address and refine questions related to a Mission or Bureau's programmatic priorities. The scenario analysis could be developed to answer a question like:

Where are potential locations that could maximize climate mitigation with co-benefits specifically for biodiversity conservation?

A possible response to this question can be explored using global biodiversity and climate mitigation information. Figure 10 shows an overlay of areas that contain both high biodiversity value and high irrecoverable carbon (Conservation International, 2021). Based on this analysis, most of PNG's land area has high biodiversity value, and over 70 percent of PNG contains high irrecoverable carbon.

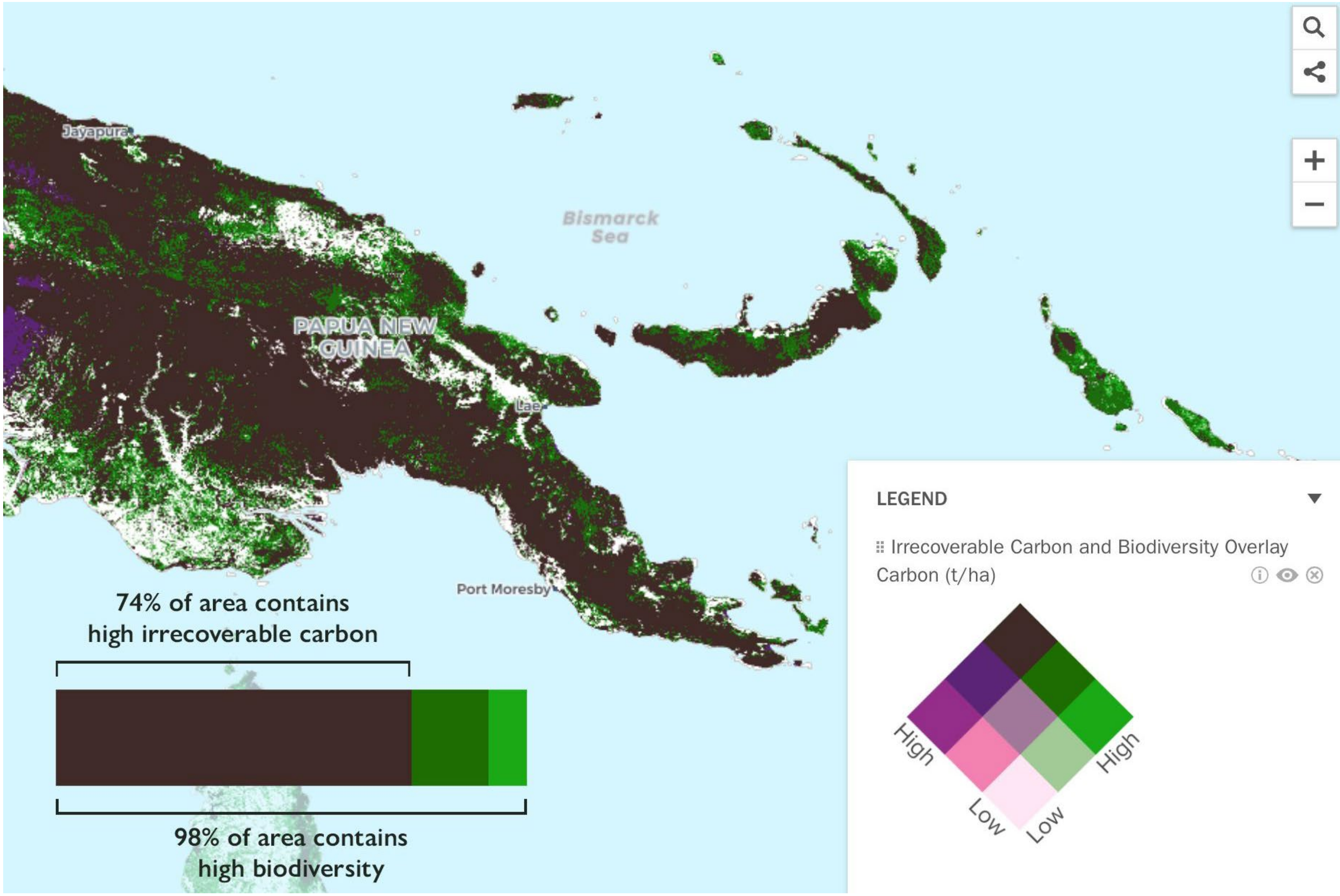

Figure 10: Biodiversity Value and Irrecoverable Carbon in PNG. *Areas of highest biodiversity value and highest irrecoverable carbon are shown in the darkest colors on the map.*

A scenario can go beyond using existing datasets, to incorporate additional factors and parameters adapted to planning needs. The first step in multiple-criteria analysis is to identify factors and assign them values based on their relative importance in the scenario. For example, the following factors could be considered in a co-benefits scenario:

- Distance to roads[3]
- Distance to protected areas
- Distance to intact landscapes
- Highest priorities for carbon sequestration (irrecoverable carbon)

Figure 11 shows an illustrative model of a potential co-benefits scenario that includes these factors, with the highest weight assigned to irrecoverable carbon (40 percent). The highest weight was assigned to irrecoverable carbon in this example based on the global analysis in Figure 10, which suggests more variation in irrecoverable carbon priorities as compared to biodiversity priorities across Papua New Guinea. In this scenario, proximity to both intact landscapes (Potapov et al. 2017) and Protected Areas are used to identify the potential locations that are most important for biodiversity conservation. The resulting map, Figure 12, shows the highest geographic priorities for co-benefits in dark green. According to this scenario, they are Sandaun, Western, Southern Highlands, Gulf, Hela, Enga, Western Highlands, Eastern Highlands, Chimbu, Jiwaka, Madang, Morobe, Oro, East New Britain, West New Britain and East Sepik.

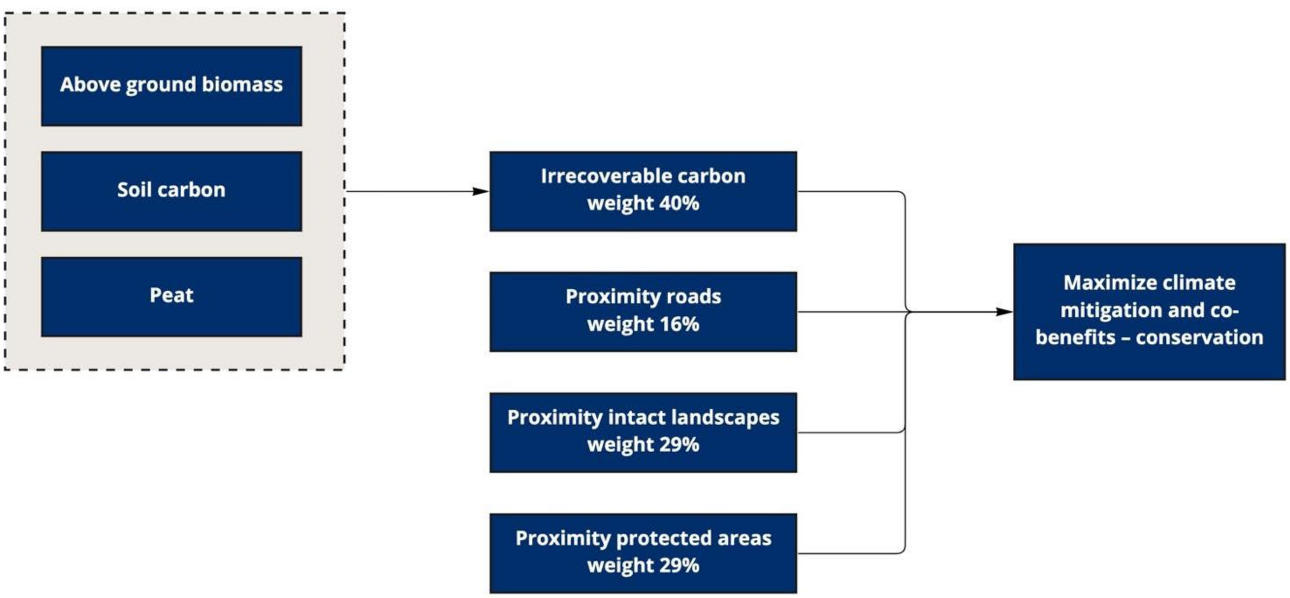

Figure 11: Potential Co-Benefits Scenario Model for PNG. *An illustrative model of a potential co-benefits scenario that includes multiple factors related to biodiversity, carbon sequestration, and human impact.*

[3] The roads proximity criteria used in this example does not account for flood prone areas and other buffer zones identified by PNG Forest Authority. The criteria can be modified as needed to include updated PNG datasets and excluded zones.

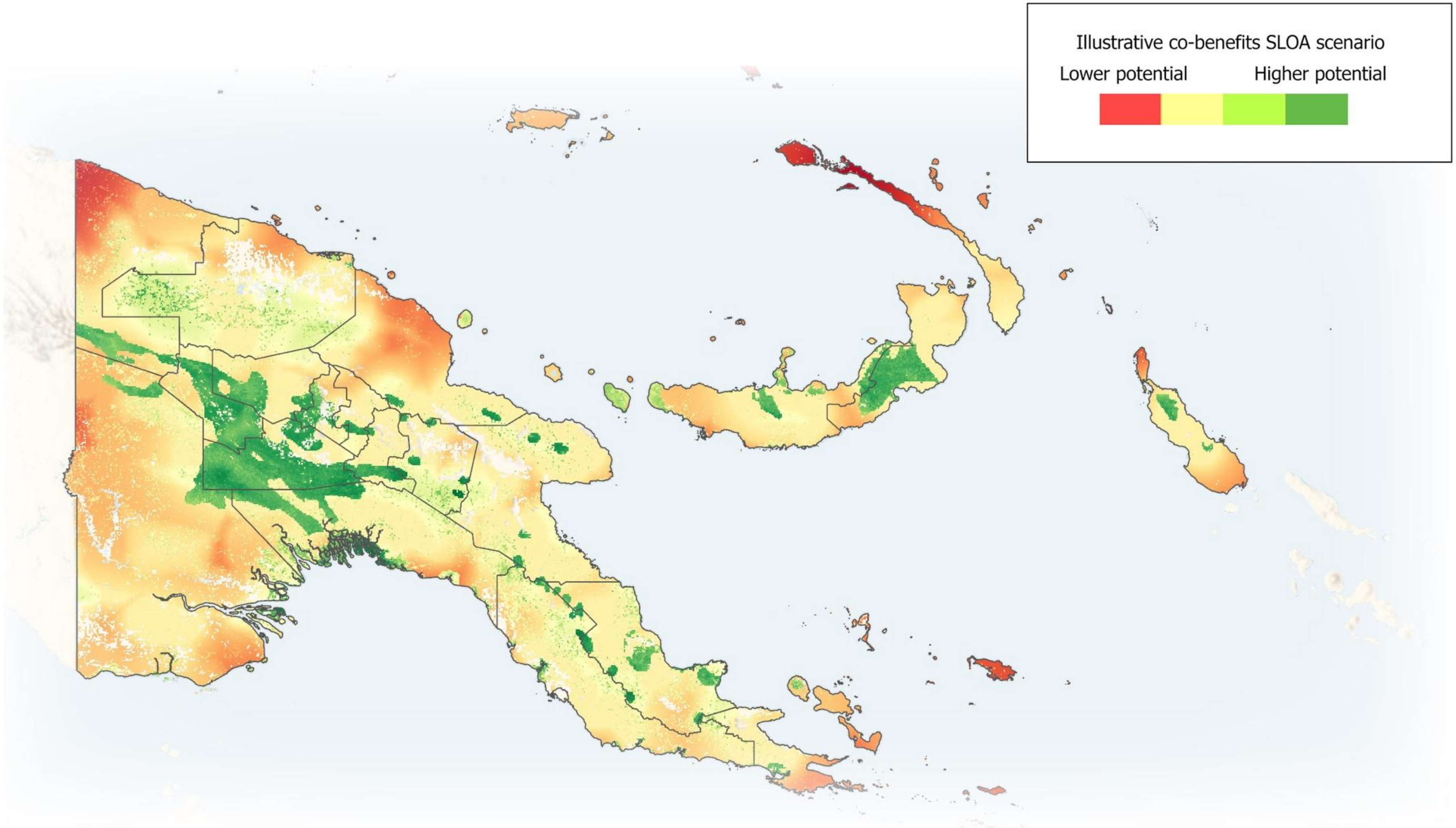

Figure 12: Areas of Highest Potential Co-Benefits for Biodiversity and Carbon Sequestration in PNG. *A map-based output of the model in Figure 11 shows the areas of highest potential co-benefits for biodiversity and carbon sequestration in green. Areas of lowest potential are shown in red.*

4. Conclusion

The SLOA Companion was developed to facilitate the interpretation and practical analysis of the SLOA report findings for USAID/Papua New Guinea and partners. The Companion addresses key SLOA findings and questions, while providing additional insights into historical forest cover dynamics and traditional land and resource governance systems. It also highlights important peatland extent and peat depth data gaps that impact the ability to prioritize mitigation opportunities. The spatial mapping datasets featured in this Companion can be easily updated and adapted as new data and information become available; both to provide additional insights into climate mitigation pathways and also to identify opportunities for cross-sectoral integration.

5. References

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USAID, 2021. Papua New Guinea Land Profile. Available at: https://www.land-links.org/wp-content/uploads/2021/01/PNG-country-profile.pdf

Annex: Spatial Data List

Figure 1: Governance Systems in PNG

- Special Agriculture Business Leases (SABL) – PNGRIS
- Forest concessions – US Dept of Interior International Technical Assistance Program (DOI-ITAP)
- Protected areas – World Database of Protected Areas (WDPA)
- Language distribution based on Hammarström, Harald, et al. "Glottolog 4.5." (2021)

Figure 2: Aboveground Carbon in PNG, 2010

- Spawn, S.A., Sullivan, C.C., Lark, T.J. and Gibbs, H.K., 2020. Harmonized global maps of above and belowground biomass carbon density in the year 2010. *Scientific Data*, 7(1), pp.1-22.

Figure 3: Irrecoverable Carbon in PNG, 2018

- Noon, M.L., Goldstein, A., Ledezma, J.C., Roehrdanz, P.R., Cook-Patton, S.C., Spawn-Lee, S.A., Wright, T.M., Gonzalez-Roglich, M., Hole, D.G., Rockström, J. and Turner, W.R., 2022. Mapping the irrecoverable carbon in Earth's ecosystems. *Nature Sustainability*, *5*(1), pp.37-46.

Figure 4: USAID Environmental Programming in PNG, 2021

- Protected areas – World Database of Protected Areas (WDPA)
- USAID sites and Model Provinces – USAID

Figure 5: Vegetation Types in PNG

- US Dept of Interior International Technical Assistance Program (DOI-ITAP) Biodiversity Assessment (2017), based on Papua New Guinea Forest Inventory Mapping

Figure 6: Tree Cover Loss "Hotspots", 2010-2020 in PNG

- Tree cover loss – Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R. and Kommareddy, A., 2013. High-resolution global maps of 21st-century forest cover change. Science, 342(6160), pp.850-853.
- SABL: PNGRIS

Figure 7: Mangrove Extent in PNG

- Bunting P., Rosenqvist A., Lucas R., Rebelo L-M., Hilarides L., Thomas N., Hardy A., Itoh T., Shimada M. and Finlayson C.M. (2018). The Global Mangrove Watch – a New 2010 Global Baseline of Mangrove Extent. Remote Sensing 10(10): 1669. Doi: 10.3390/rs1010669.
- PNGRIS

Figure 8: Types of Wetlands in PNG

- Gumbricht, T.; Román-Cuesta, R.M.; Verchot, L.V.; Herold, M.; Wittmann, F; Householder, E.; Herold, N.; Murdiyarso, D., 2017, "Tropical and Subtropical Wetlands Distribution version 5", https://doi.org/10.17528/CIFOR/DATA.00058, Center for International Forestry Research (CIFOR).

Figure 9: Peatland Depth in PNG

- Gumbricht, T.; Román-Cuesta, R.M.; Verchot, L.V.; Herold, M.; Wittmann, F; Householder, E.; Herold, N.; Murdiyarso, D., 2017, "Tropical and Subtropical Wetlands Distribution version 5", https://doi.org/10.17528/CIFOR/DATA.00058, Center for International Forestry Research (CIFOR).

Figure 12: Areas of Highest Potential Co-Benefits for Biodiversity and Carbon Sequestration in PNG

- Irrecoverable carbon (combined, above ground biomass, peat, and soil carbon) – Noon, M.L., Goldstein, A., Ledezma, J.C., Roehrdanz, P.R., Cook-Patton, S.C., Spawn-Lee, S.A., Wright, T.M., Gonzalez-Roglich, M., Hole, D.G., Rockström, J. and Turner, W.R., 2022. Mapping the irrecoverable carbon in Earth's ecosystems. Nature Sustainability, 5(1), pp.37-46.
- Proximity to roads – Alamgir, M., Sloan, S., Campbell, M.J., Engert, J., Kiele, R., Porolak, G., Mutton, T., Brenier, A., Ibisch, P.L. and Laurance, W.F., 2019. Infrastructure expansion challenges sustainable development in Papua New Guinea. PloS one, 14(7), p.e0219408.
- Proximity to intact forest landscapes – Potapov, P., Hansen, M.C., Laestadius, L., Turubanova, S., Yaroshenko, A., Thies, C., Smith, W., Zhuravleva, I., Komarova, A., Minnemeyer, S. and Esipova, E., 2017. The last frontiers of wilderness: Tracking loss of intact forest landscapes from 2000 to 2013. Science advances, 3(1), p.e1600821.
    - Reclassified 1-100 and using a continuous function transformation
- Proximity to protected areas- World Database of Protected Areas (WDPA), DOI/ITAP Biodiversity Assessment (2017).

OTHER POTENTIAL DATA SOURCES OF INTEREST

- Roads (Almgir et al. 2018) available online : https://datadryad.org/stash/dataset/doi:10.5061/dryad.3p84s7s
- Global Population produced by Oak Ridge National Laboratory (multiple years) available online: https://landscan.ornl.gov/
- REDD Portal: http://png-nfms.org/portal/
- Atlas of Forest Landscape Restoration Opportunities: https://www.wri.org/applications/maps/flr-atlas/#&init=y

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